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EDEXCEL INTERNATIONAL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Principles of Chemistry (1)

International GCSE Chemistry Topic 1

165 questions · 1437 marks · Mark schemes included

Pearson Edexcel International GCSE (9–1) Chemistry 4CH1, Papers 1C, 1CR, 2C & 2CR, June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.
Click any row below to jump straight to that sub-topic or question.
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Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

165 questions · 1437 marks · 9 sub-topics

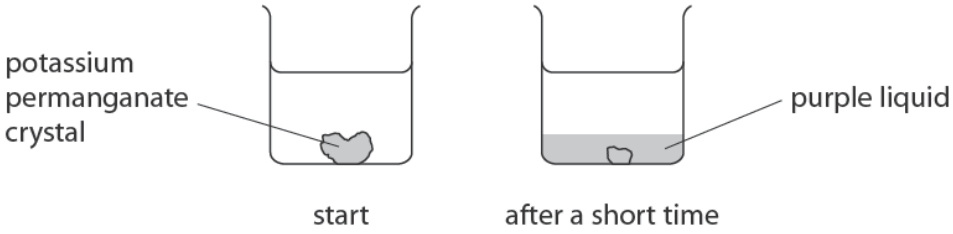
SUB-TOPIC 1a

STATES OF MATTER

Sub-topic 1a · 25 questions · 165 marks · lowest tariff first

1 Potassium permanganate is a purple solid that is soluble in water.

A crystal of potassium permanganate is placed in a beaker containing water.



(a) After a short time, the crystal becomes smaller and the liquid at the bottom of the beaker becomes purple.

Which statement explains this observation?

(1)

☒ **A** the crystal condenses in the water

☒ **B** the crystal dissolves in the water

☒ **C** the crystal evaporates in the water

☒ **D** the crystal melts in the water

(b) The beaker is left until there is no further change in the appearance of the liquid.

(i) Which statement describes the final appearance of the liquid?

(1)

☒ **A** all of the liquid is purple

☒ **B** none of the liquid is purple

☒ **C** only the bottom half of the liquid is purple

☒ **D** only the top half of the liquid is purple

(ii) Which process causes this change in appearance?

(1)

☒ **A** condensation

☒ **B** crystallisation

☒ **C** diffusion

☒ **D** evaporation

(c) The formula of potassium permanganate is $KMnO_4$

How many different elements are there in potassium permanganate?

(1)

☒ **A** 3

☒ **B** 4

☒ **C** 6

☒ **D** 7

(Total for Question 1 = 4 marks)

2 The table gives the melting and boiling points of four pure substances, W, X, Y and Z.

	Melting point in °C	Boiling point in °C
W	–7	60
X	660	2500
Y	180	1330
Z	115	445

Use data from the table to answer the questions.

(a) (i) Which substance is a gas at 100 °C?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(ii) Which substance is a liquid for the largest range of temperature?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(iii) Which substance is a liquid at 1000 °C and a gas at 2000 °C?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(b) Substance Y does not conduct electricity when solid but does conduct electricity when molten.

Give the type of bonding in substance Y.

(1)

.....

.....

(c) Suggest how the melting point of a pure substance changes when an impurity is added.

(1)

.....

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.....

(Total for Question 2 = 5 marks)

1 Substances can exist as solids, liquids or gases.

(a) (i) Give the change of state that occurs when a substance melts.

(1)

.....

(ii) Complete the word equation for the sublimation of iodine.

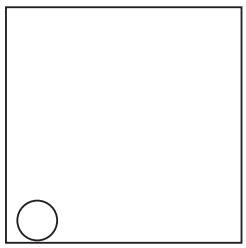
iodine (s) → iodine (.....)

(1)

(b) The circle in the diagram represents a particle.

Complete the diagram to show the arrangement of particles in a gas.

(1)



(c) The table lists some statements about particles.

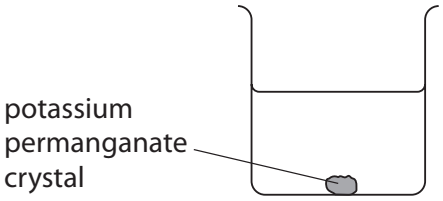
Place ticks (✓) in boxes to show which two statements are correct for water particles.

(2)

Statement	Tick
the particles only vibrate	
the particles do not move	
the particles have no gaps between them	
the particles move randomly	
the particles have more energy than in ice	
the particles have a regular arrangement	

(Total for Question 1 = 5 marks)

2 A potassium permanganate crystal is placed in a beaker of water.



After several days a coloured solution forms.

(a) Give the names of the two processes that cause the coloured solution to form.

(2)

1 .....

2 .....

(b) The formula of potassium permanganate is $KMnO_4$

(i) How many different types of atom are in $KMnO_4$?

(1)

☒ **A** 3

☒ **B** 4

☒ **C** 6

☒ **D** 7

(ii) Calculate the relative formula mass (M_r) of $KMnO_4$

(1)

M_r = ...

(c) Potassium permanganate can be used as an oxidising agent.

State what is meant by the term **oxidising agent**.

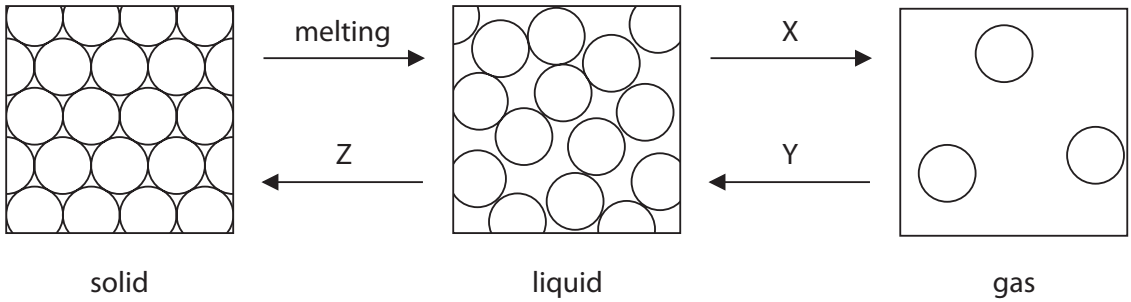
(1)

.....

.....

(Total for Question 2 = 5 marks)

1 The diagram shows how the particles are arranged in the three states of matter.



(a) Use words from the box to identify the changes of state X, Y and Z.

condensing	cooling	crystallising	diffusing
evaporating	freezing	heating	

(3)

X .....

Y .....

Z .....

(b) Describe the differences in the movement of particles in solids and gases.

(2)

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(Total for Question 1 = 5 marks)

2 The solubility of a solid depends on the solvent used.

(a) State one other factor that affects the solubility.

(1)

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(b) A student wants to find the solubility of a salt in water.

The steps in the student's method are not in the correct order.

Step A gently heat the evaporating basin and solution to remove all the water

Step B filter to obtain 50.0 cm^3 of saturated solution

Step C record the mass of the evaporating basin and salt solution

Step D record the mass of an empty evaporating basin

Step E record the mass of the evaporating basin and the dry salt

Step F put 50.0 cm^3 of water into a beaker

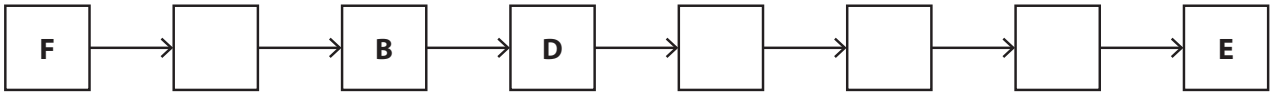
Step G add the salt to the water a little at a time and stir until no more dissolves

Step H pour the 50.0 cm^3 of saturated salt solution into the evaporating basin

(i) The flowchart shows the correct order of some of the steps.

Complete the flowchart by putting the remaining steps in the correct order.

(2)



(ii) These are the student's results.

mass of empty evaporating basin = 60.5 g

mass of evaporating basin and dry salt = 78.1 g

Calculate the solubility of the salt in grams per 100 g of water.

[1.00 cm^3 of water has a mass of 1.00 g]

(2)

solubility = ... grams per 100 g of water

(Total for Question 2 = 5 marks)

1 This question is about the three states of matter, solid, liquid and gas.

(a) Solids, liquids and gases can be changed from one state to another.

The box gives the names of some changes of state.

condensing	evaporation	melting	sublimation

Use words from the box to complete the sentences.

Each word may be used once, more than once or not at all.

(i) The change from solid to liquid is called .....

(1)

(ii) The change from liquid to gas is called .....

(1)

(iii) The change from solid to gas is called .....

(1)

(b) Describe the arrangement and the movement of particles in a solid.

(3)

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.....

(Total for Question 1 = 6 marks)

2 (a) The boxes list changes that may happen in a laboratory and the names of some changes.

Draw one straight line from each change to its correct name.

(3)

Change	Name of change
ice turns into water	diffusion
solid carbon dioxide turns directly into a gas	dissolving
a solute is stirred into a solvent	evaporation
	freezing
	melting
	sublimation

(b) A student has two solids, X and Y.

One of these solids is a pure substance and the other is a mixture.

Describe how the student could identify which solid is pure and which is a mixture by measuring a physical property of each solid.

(3)

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.....

(Total for Question 2 = 6 marks)

1 This question is about states of matter.

(a) Use the words solid, liquid or gas to give the initial and final state of matter for each of the changes listed in the table.

The first one has been done for you.

(3)

Change	Initial state	Final state
melting	solid	liquid
sublimation		
condensing		
evaporation		

(b) Particles in a solid are closely packed, arranged in a regular pattern and vibrate about fixed positions.

Describe the arrangement and movement of the particles in a gas.

(3)

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(Total for Question 1 = 6 marks)

2 (a) (i) State the meaning of the term **solute**.

(1)

.....

.....

(ii) State the meaning of the term **solvent**.

(1)

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.....

(b) Explain what is meant by a saturated solution.

(2)

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(c) A dark purple liquid is diluted by adding water.

The diluted liquid becomes a pale purple colour.

Explain the process that causes this change.

Refer to particles in your answer.

(2)

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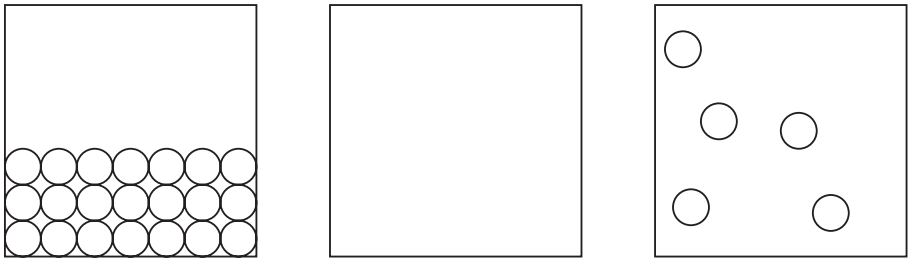
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(Total for Question 2 = 6 marks)

1 This question is about the three states of matter, solid, liquid and gas.

(a) The diagram shows how particles of a substance are arranged in two of these states.



solid liquid gas

(i) Complete the diagram to show how particles are arranged in the liquid state.

(1)

(ii) Identify the state of matter that contains particles with the least energy.

(1)

.....

(b) The table shows two changes of state.

Complete the table by giving the name of each change of state.

(2)

Change of state	Name
solid to liquid	
solid to gas	

(c) Explain why hot water evaporates more quickly than cold water.

(2)

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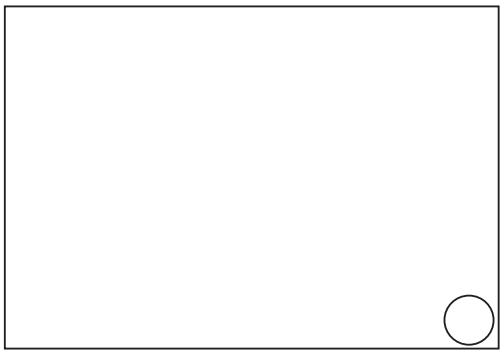
(Total for Question 1 = 6 marks)

1 This question is about oxygen.

(a) Oxygen can be stored in tanks as a liquid or as a gas.

(i) Complete the diagram to show the arrangement of six more particles in a gas.

(1)



(ii) Give a reason why a tank can store much more oxygen as a liquid.

(1)

.....

.....

(iii) Identify a hazard when storing oxygen as a gas.

(1)

.....

.....

(b) Sulfur burns in oxygen to form sulfur dioxide.

(i) Give one observation that can be made when sulfur burns in oxygen.

(1)

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.....

(ii) Some universal indicator is added to sulfur dioxide.

Explain the final colour of the universal indicator.

(2)

.....

.....

.....

.....

(Total for Question 1 = 6 marks)

1 The three states of matter are solid, liquid and gas.

(a) Substances can change from one state to another.

The box gives some words about changes of state.

condensing	cooling	evaporation
freezing	heating	melting	sublimation

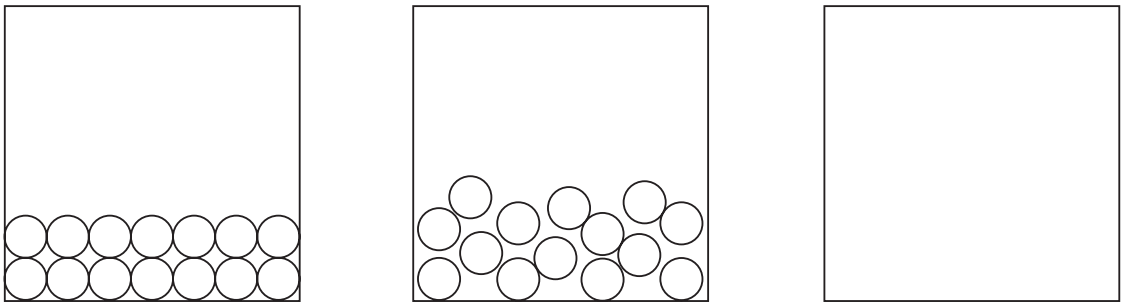
Complete the table by giving the correct word from the box for each change of state.

You may use each word once, more than once or not at all.

(3)

Change of state	Name of change
from liquid to solid	
from gas to liquid	
from solid to gas	

(b) The diagram shows two states of matter for a substance.



solid liquid gas

Each circle represents an atom of the substance.

(i) Complete the diagram by drawing six circles to represent atoms in the gas state.

(1)

(ii) Which statement is correct about this substance?

(1)

☒ **A** the atoms move randomly in the gas state

☒ **B** the atoms move randomly in the solid state

☒ **C** the atoms are in fixed positions in the gas state

☒ **D** the atoms are in fixed positions in the liquid state

(c) Complete the equation, by adding the state symbols, for the conversion of water into ice.

(1)

H_2O(.....) → H_2O(.....)

(Total for Question 1 = 6 marks)

1 This question is about the three states of matter, solid, liquid and gas.

(a) Solids, liquids and gases can be changed from one state to another.
The box gives the names of some changes of state.

condensing	evaporation	freezing
melting	sublimation	

Use words from the box to answer the questions.

(i) Give the name of the change from liquid to solid.

(1)

.....

(ii) Give the name of the change from liquid to gas.

(1)

.....

(iii) Give the name of the change from solid to gas.

(1)

.....

(b) Describe the arrangement, movement and energy of the particles in a gas.

(3)

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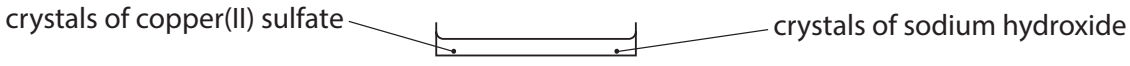
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(Total for Question 1 = 6 marks)

3 Copper(II) sulfate and sodium hydroxide react to form the insoluble solid copper(II) hydroxide.
Crystals of copper(II) sulfate and sodium hydroxide are placed at opposite ends of a container of water.
Solid copper(II) hydroxide forms after several minutes.

The diagram shows the container at the start and after several minutes.



At the start



After several minutes

(a) Name the two processes that must occur before the copper(II) hydroxide forms.

(2)

1 .....

2 .....

(b) The experiment is repeated with the water at a higher temperature.

Explain, in terms of particles, why the copper(II) hydroxide takes less time to form.

(2)

.....

.....

.....

.....

(c) The formula of copper(II) hydroxide is $Cu(OH)_2$

(i) Give the number of different elements in copper(II) hydroxide.

(1)

.....

(ii) Give the charge on the copper ion in $Cu(OH)_2$

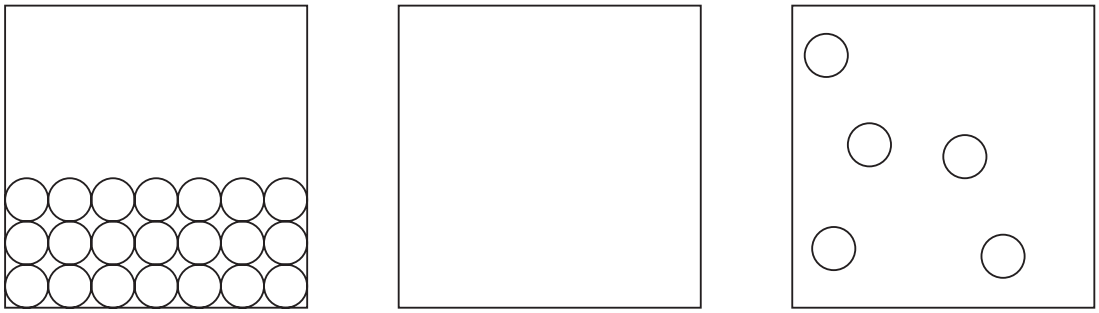
(1)

.....

(Total for Question 3 = 6 marks)

2 This question is about states of matter.

(a) The diagram shows how the particles of a substance are arranged in two different states.



solid liquid gas

(i) Complete the diagram to show how particles are arranged in the liquid state.

(1)

(ii) Identify the state of matter in which the particles have the most energy.

(1)

(b) The state symbols (s), (l), (g) and (aq) are often used in chemistry.

The table shows some physical changes.

Complete the table by giving the state symbol before and after each change.

(3)

	State symbol	
Physical change	**before change**	**after change**
water evaporates		
crystals of iodine sublime		
ice melts		

(c) Explain why hot water evaporates more quickly than cold water.

(2)

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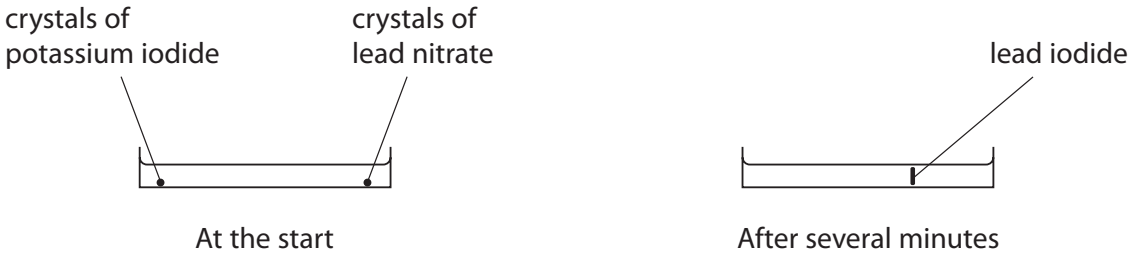
(Total for Question 2 = 7 marks)

3 Lead nitrate and potassium iodide react to form the insoluble solid lead iodide.

Crystals of lead nitrate and potassium iodide are placed at opposite ends of a container of water.

Solid lead iodide forms after several minutes.

The diagram shows the container at the start and after several minutes.



(a) Name the two processes that occur before the solid lead iodide forms.

(2)

1 .....

2 .....

(b) Explain why solid lead iodide takes less time to form when the reaction is repeated using water at a higher temperature.

(2)

.....

.....

.....

.....

(c) The formula for lead nitrate is $Pb(NO_3)_2$

(i) Give the number of different elements in lead nitrate.

(1)

.....

.....

(ii) Give the charge on the lead ion in $Pb(NO_3)_2$

(1)

.....

(d) Complete the chemical equation for the reaction between lead nitrate and potassium iodide.

(1)

$Pb(NO_3)_2(aq)$ + ... $KI(aq) \rightarrow PbI_2(s)$ + ... $KNO_3(aq)$

(Total for Question 3 = 7 marks)

3 This question is about states of matter.

(a) The box gives words relating to changes of state.

condensation	cooling	evaporation
freezing	melting	sublimation

Complete the table by giving the correct word from the box for each change of state.

(3)

Change of state	Name of change
solid to liquid	
solid to gas	
liquid to solid	

(b) When ammonia gas and hydrogen chloride gas mix, they react together to form a white solid called ammonium chloride.

The equation for the reaction is

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

A teacher soaks a piece of cotton wool in concentrated ammonia solution and another piece of cotton wool in concentrated hydrochloric acid.

The teacher places the two pieces of cotton wool at opposite ends of a glass tube at the same time.

After several minutes, a white ring of solid ammonium chloride forms.

cotton wool soaked in concentrated ammonia solution

white ring of ammonium chloride

cotton wool soaked in concentrated hydrochloric acid

(i) State the name given to the spreading out of gas particles.

(1)

.....

(ii) State how the diagram shows that the particles of ammonia gas are travelling at higher speeds than the particles of hydrogen chloride gas.

(1)

.....

.....

(iii) Gas particles travel at high speeds.

Give a reason why the white ring of ammonium chloride takes several minutes to form.

(1)

.....

.....

(iv) Concentrated ammonia solution and concentrated hydrochloric acid are corrosive.

Give one safety precaution the teacher should take.

(1)

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.....

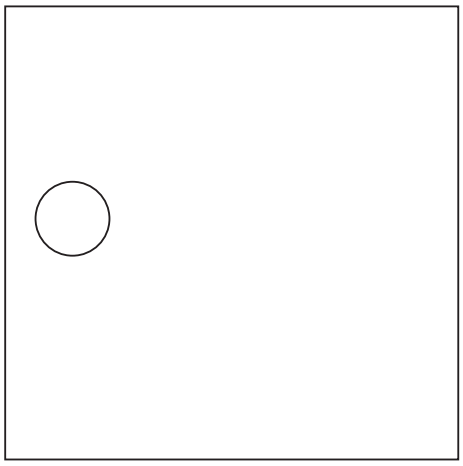
(Total for Question 3 = 7 marks)

1 A substance can exist in three states of matter, solid, liquid or gas.

When a liquid evaporates at room temperature it changes into a gas.

(a) Complete the diagram to show the arrangement of another four particles in a gas.

(1)



(b) Explain why heating a liquid causes it to evaporate more quickly.

(2)

.....

.....

.....

.....

(c) When the temperature decreases, water in the gas state changes to a liquid.

(i) Give the name of this change of state.

(1)

.....

(ii) Write an equation, including state symbols, to show the change of state of water from a gas to a liquid.

(1)

.....

(d) Describe the arrangement and movement of particles in a solid.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

3 This question is about a compound called potassium permanganate.

(a) A teacher makes a saturated solution of potassium permanganate using this method.

The teacher adds 25 cm^3 of water at 50 °C to a beaker.

The teacher then adds solid potassium permanganate one spatula at a time, while stirring, until the solution is saturated.

(i) Give the meaning of the term **saturated solution**.

(1)

.....

.....

(ii) Give a reason why crystals form when the saturated solution cools from 50 °C to room temperature.

(1)

.....

.....

(b) The teacher pours 25 cm^3 of a saturated solution of potassium permanganate at room temperature into an evaporating dish.

The teacher leaves the solution until all the water has evaporated.

The teacher records the mass of the evaporating dish and the mass of the evaporating dish with the dry crystals.

mass of evaporating dish = 64.10 g

mass of evaporating dish with dry crystals = 65.35 g

Calculate the solubility of potassium permanganate in grams per 100 g of water.

[1.00 cm^3 of water has a mass of 1.00 g]

(2)

solubility = ... g per 100 g of water

(c) The equation shows the thermal decomposition of potassium permanganate.

$$2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$$

(i) Describe a test to show that oxygen gas is produced.

(1)

.....

.....

(ii) Calculate the M_r of K_2MnO_4

(1)

M_r = ...

(d) Potassium permanganate is an oxidising agent.

Give a reason why potassium permanganate is an oxidising agent.

(1)

.....

.....

(Total for Question 3 = 7 marks)

3 Sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) are both gases.

The two gases react together to form solid sulfur and water.

(a) (i) Complete the chemical equation for the reaction.

(2)

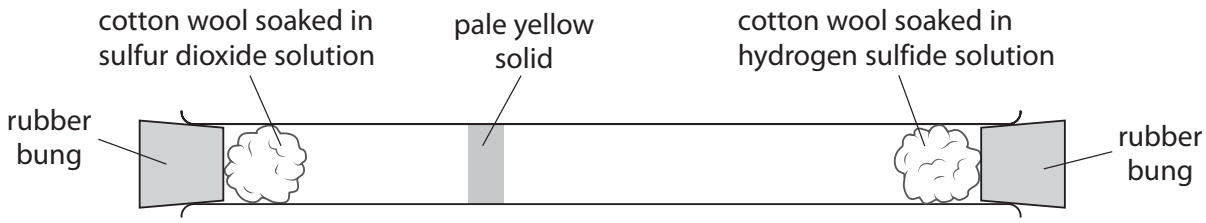
$$2H_2S(\ldots\ldots) + SO_2(\ldots\ldots) \rightarrow \ldots\ldots S(s) + \ldots\ldots H_2O(\ldots\ldots)$$

(ii) State why the sulfur dioxide is reduced in the reaction.

(1)

.....

(b) The diagram shows apparatus used to compare the speed at which particles of the two gases diffuse.



The two pieces of cotton wool and rubber bungs are put in position at the same time.

A pale yellow solid soon forms.

(i) Explain how the diagram shows that hydrogen sulfide gas diffuses more quickly than sulfur dioxide gas.

(2)

.....

.....

.....

.....

.....

.....

(ii) Deduce a relationship between the relative formula mass (M_r) of a gas and the speed at which a gas diffuses.

Use the A_r values to help you.

[A_r values: H = 1 S = 32 O = 16]

(3)

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.....

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.....

.....

.....

(Total for Question 3 = 8 marks)

4 A student investigates the solubility of potassium nitrate in water.
She measures the masses of potassium nitrate that dissolve in 25 cm^3 of water at different temperatures.

The table shows the student's results. One of the results is anomalous.

Temperature in °C	10	20	30	40	50	60	70
Mass of potassium nitrate in g	8.0	10.0	12.5	16.0	17.5	26.5	34.0

(a) (i) Plot the results on the grid.

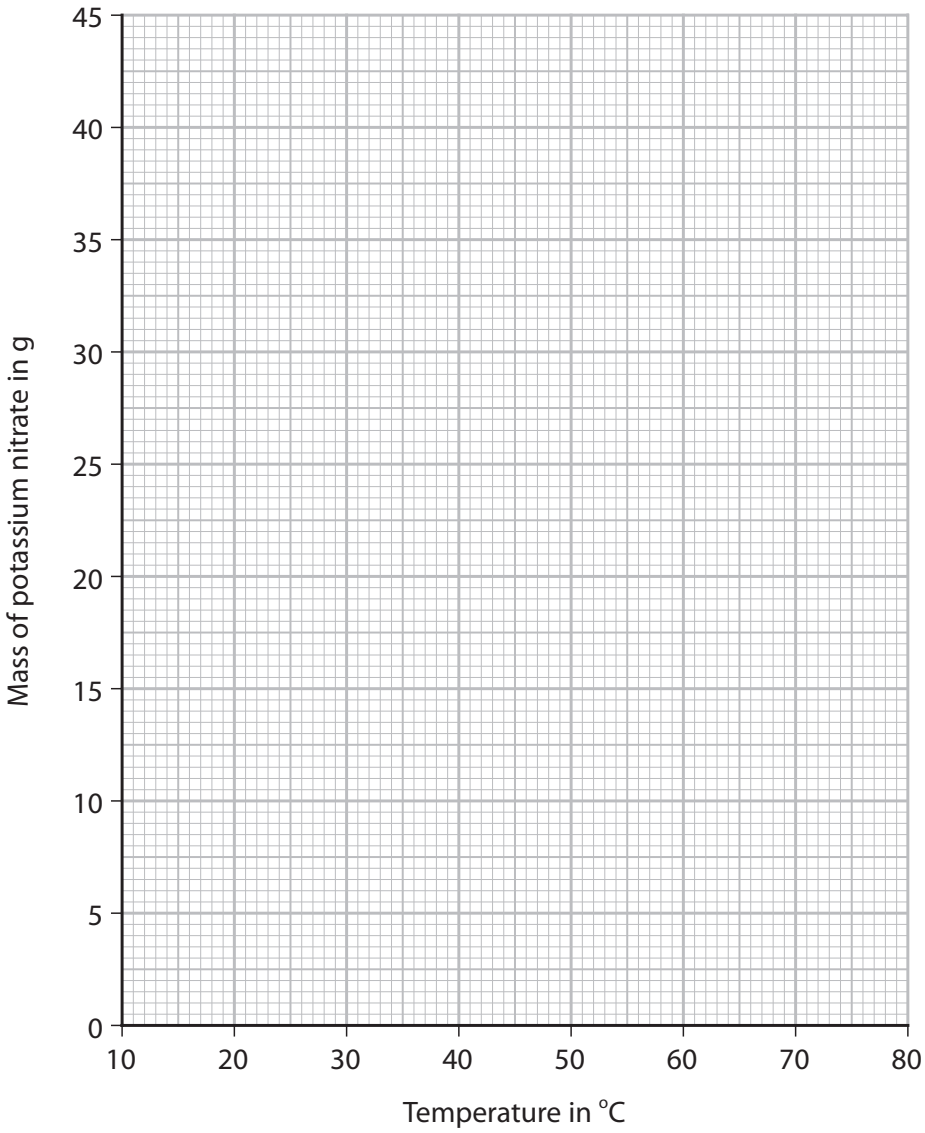
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Ignoring the anomalous result, draw a curve of best fit.

(1)



(b) Suggest **two** possible mistakes that could have caused the anomalous result.

(2)

1 .....

.....

2 .....

.....

(c) Use your graph to find the maximum mass of potassium nitrate that dissolves in 25 cm^3 of water at 75 °C.

Show on your graph how you obtained your answer.

(2)

mass = ... g

(d) Use your graph to calculate the solubility of potassium nitrate in g per 100 g of water at 25 °C.

[1.0 cm^3 of water has a mass of 1.0 g]

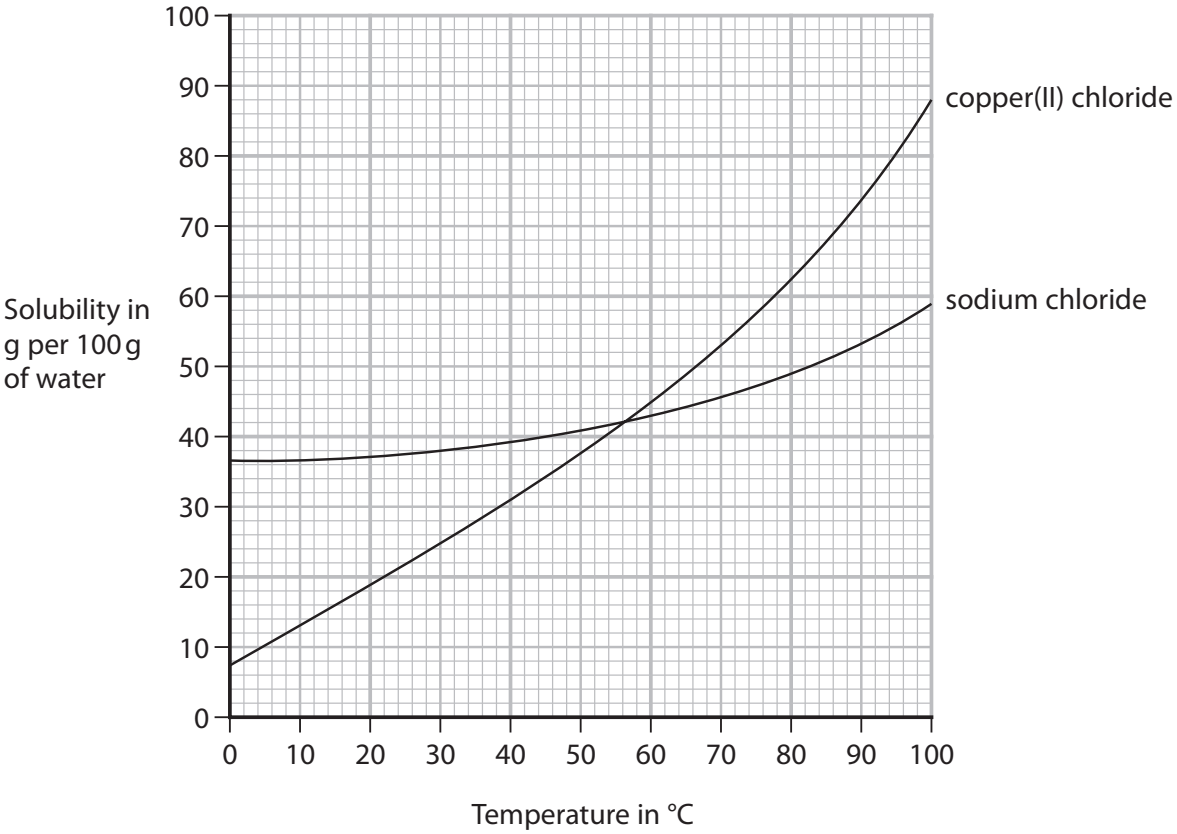
(2)

solubility = ... g per 100 g of water

(Total for Question 4 = 9 marks)

3 This question is about solubility.

(a) The graph shows the solubilities of copper(II) chloride and sodium chloride at different temperatures.



(i) Determine the temperature at which copper(II) chloride and sodium chloride have the same solubility.

Show on the graph how you obtained your answer.

(2)

temperature = ... °C

(ii) A saturated solution of copper(II) chloride in 100 g of water is cooled from 40 °C to 10 °C.

Determine the mass, in grams, of copper(II) chloride that crystallises.

(2)

mass of copper(II) chloride = ... g

(b) A student uses this method to determine the solubility of potassium chloride in water at room temperature.

- record the mass of an empty evaporating basin
- pour some saturated potassium chloride solution into the evaporating basin
- record the mass of the evaporating basin and saturated potassium chloride solution
- heat the evaporating basin to remove all the water
- record the mass of the evaporating basin and the dry potassium chloride

The table shows the student's results.

	Mass in grams
evaporating basin	58.1
evaporating basin and saturated potassium chloride solution	78.2
evaporating basin and dry potassium chloride	63.2

(i) Calculate the mass of dry potassium chloride obtained.

(1)

mass = ... g

(ii) Calculate the mass of water removed.

(1)

mass = ... g

(iii) Calculate the solubility of potassium chloride in grams per 100 grams of water.

(2)

solubility = ... g per 100 g of water

(iv) Suggest why the student's method is **not** suitable for determining the solubility of hydrated copper(II) sulfate.

(1)

.....

.....

(Total for Question 3 = 9 marks)

4 The table shows the maximum mass of potassium nitrate (KNO_3) and the maximum mass of sodium nitrate ($NaNO_3$) that dissolves in 25 cm^3 of water at different temperatures.

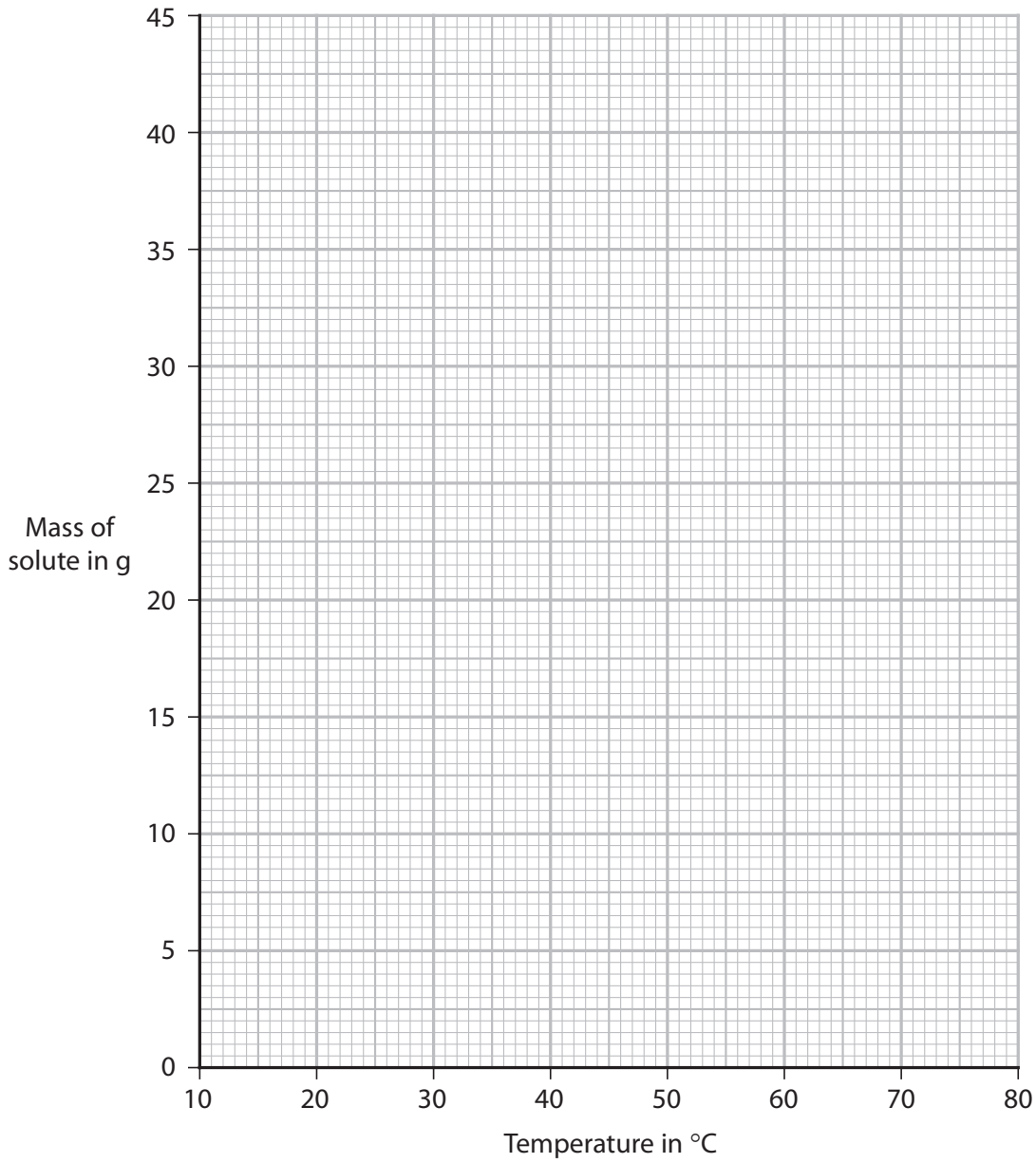
Temperature in °C	10	25	40	60	75
Mass of potassium nitrate in g	5	10	16	28	39
Mass of sodium nitrate in g	21	23	26	31	35

(a) (i) Plot the data for potassium nitrate and for sodium nitrate on the grid.

(2)

(ii) Draw and label a curve of best fit for KNO_3 and for $NaNO_3$

(2)



(b) The graph shows the temperature at which the maximum mass dissolved is the same for each solute.

Determine this temperature.

(1)

temperature = ... °C

(c) Use your graph to calculate the solubility, in g per 100 g of water, of sodium nitrate at 30 °C.

[1.0 cm^3 of water has a mass of 1.0 g]

(2)

solubility of sodium nitrate in g per 100 g of water = ...

(d) 25 cm^3 of a saturated solution of potassium nitrate is cooled from 50 °C to 20 °C.

Use your graph to determine the mass, in grams, of potassium nitrate that crystallises.

Show your working on the graph.

(3)

mass = ... g

(Total for Question 4 = 10 marks)

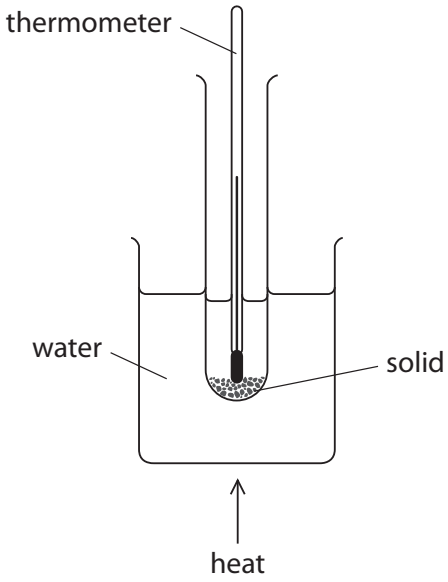
2 (a) The box lists words that may be used to explain the term **saturated solution**.

solute	solvent	temperature

Explain, using all the words in the box, the term **saturated solution**.

(2)

(b) The diagram shows the apparatus a student uses to make a saturated solution.



This is the student's method.

Step 1 add 4.5 g of solid to a boiling tube

Step 2 measure exactly 10.0 cm^3 of pure water and pour into the boiling tube

Step 3 place the boiling tube in the beaker of water and heat gently, stirring the mixture continuously until all the solid dissolves

Step 4 remove the boiling tube from the beaker and allow it to cool

Step 5 record the temperature when crystals start to form in the boiling tube

The recorded temperature shows when the solution becomes saturated.

(i) Name the piece of apparatus that the student should use in Step 2 to measure exactly 10.0 cm^3 of pure water.

(1)

.....

(ii) Suggest why the boiling tube is not heated directly using a Bunsen burner in Step 3.

(1)

.....

.....

(iii) Suggest how the student could improve the reliability of her recorded temperature in Step 5.

(1)

.....

.....

.....

(iv) In Step 5, crystals start to form at 26 °C.

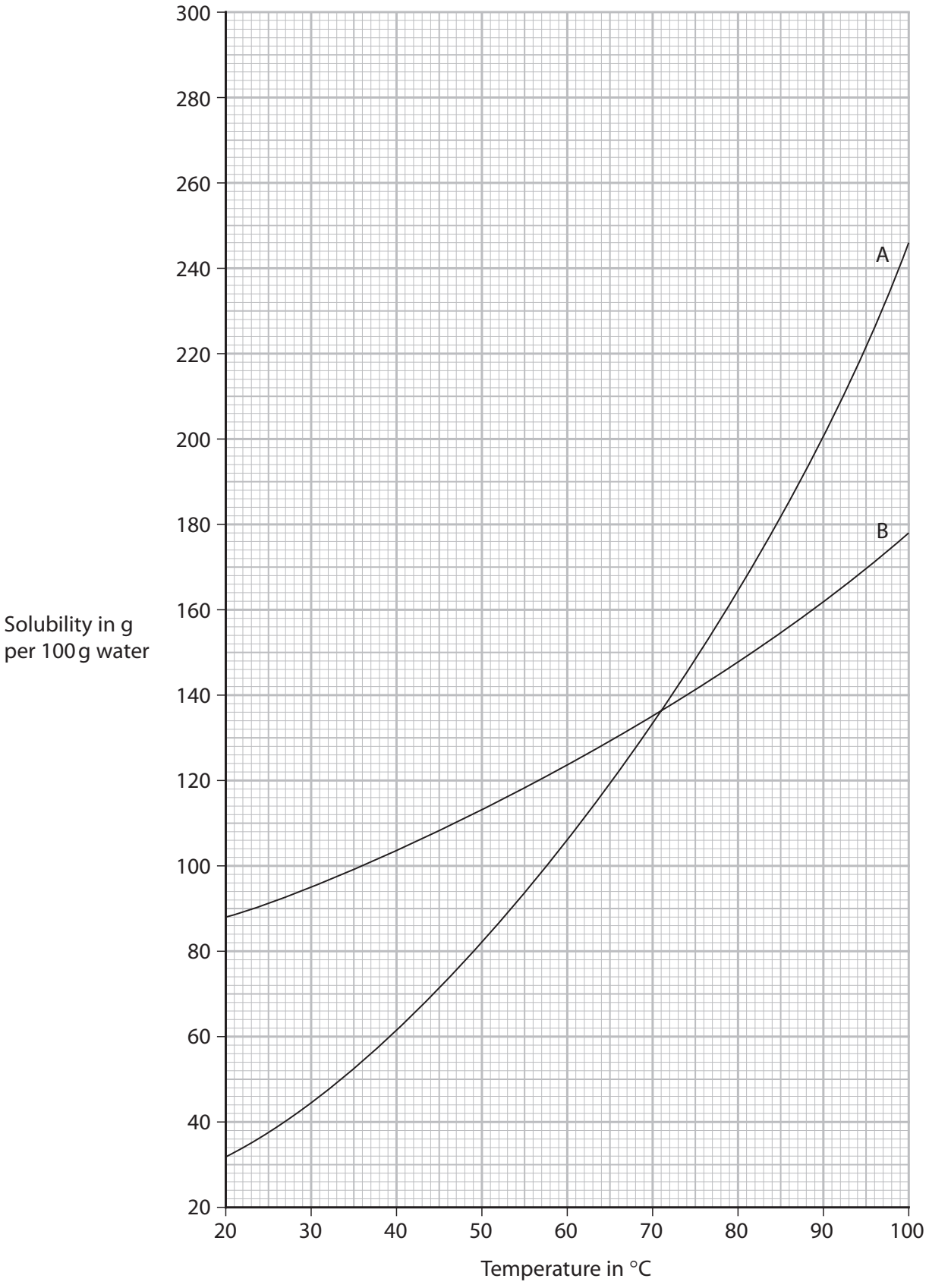
Calculate the solubility of the solid, in g per 100 g of water, at 26 °C.

[1.0 cm^3 of pure water has a mass of 1.0 g]

(2)

solubility = ... g per 100 g of water

(c) The solubility curves for two solids, A and B, are shown on the grid.



(i) State the temperature when A and B have the same solubility.

(1)

temperature = ... °C

(ii) Calculate the mass of B that will dissolve in 250 g of water at 60 °C.

Show your working.

(2)

mass = ... g

(iii) Suggest why the values for the solubility of A and B may be less accurate at 95 °C than at lower temperatures.

(1)

.....

.....

.....

(Total for Question 2 = 11 marks)

SUB-TOPIC 1b

ELEMENTS, COMPOUNDS AND MIXTURES

Sub-topic 1b · 34 questions · 269 marks · lowest tariff first

1 This question is about elements, compounds and mixtures.

(a) Name the element that burns with a lilac flame.

(1)

.....

(b) Name the technique used to separate the mixture of colours in black ink.

(1)

.....

(c) The box gives the names of some substances.

air	bromine	magnesium	neon	sodium chloride	sulfur

Choose substances from the box to answer these questions.

(i) Identify the compound.

(1)

.....

(ii) Identify the mixture.

(1)

.....

(iii) Identify the non-metal element that is a solid at room temperature.

(1)

.....

(Total for Question 1 = 5 marks)

1 A student is given a mixture of salt solution and sand.

She wants to obtain pure water from the mixture.

(a) She separates the sand from the salt solution.

Which method of separation should she use?

(1)

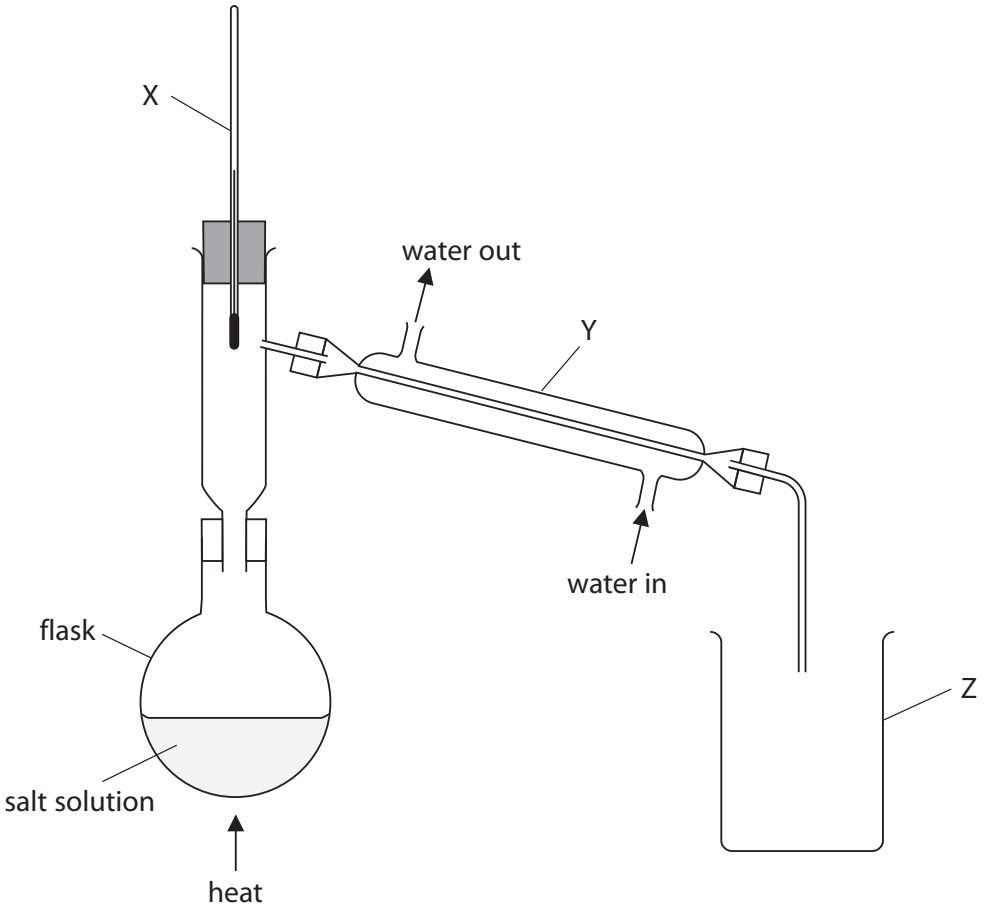
☒ **A** crystallisation

☒ **B** filtration

☒ **C** fractional distillation

☒ **D** simple distillation

(b) The student then uses this apparatus to obtain pure water from the salt solution.



(i) Name the pieces of apparatus labelled X, Y and Z.

(3)

X .....

Y .....

Z .....

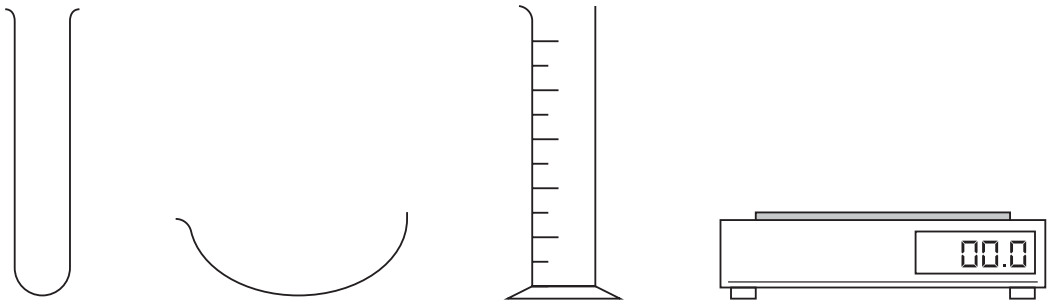
(ii) State what remains in the flask when the separation is complete.

(1)

.....

(Total for Question 1 = 5 marks)

1 The diagram shows some pieces of apparatus.



A B C D

(a) Complete the table by giving the name of each piece of apparatus.

(4)

Letter	Name
A	
B	
C	
D	

(b) Which piece of apparatus can be used to measure the volume of a liquid?

(1)

☒ **A**

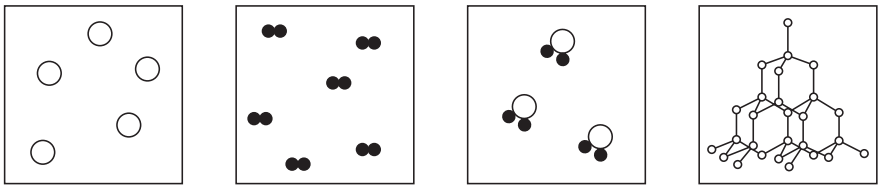
☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 5 marks)

1 (a) The diagram shows the particles in four substances, A, B, C and D.



A **B** **C** **D**

(i) Which substance contains single atoms of one element?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Which substance is a compound?

(1)

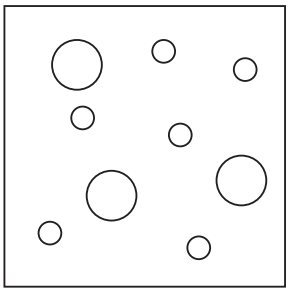
- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(iii) Which substance could have the formula H_2?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) The diagram shows the particles in substance E.



E

Give two reasons why substance E is a mixture.

(2)

1 .....

.....

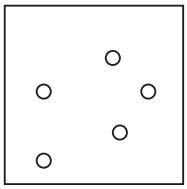
2 .....

.....

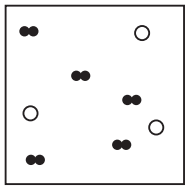
(Total for Question 1 = 5 marks)

1 Substances can be classified as elements, mixtures or compounds.

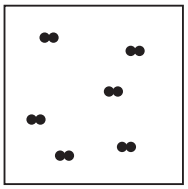
(a) Each box represents an element, a mixture or a compound.



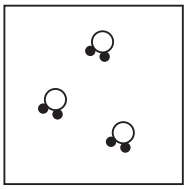
Box 1



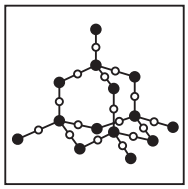
Box 2



Box 3



Box 4



Box 5

(i) Which box represents a mixture?

(1)

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(ii) Which two boxes represent elements?

(1)

☒ **A** 1 and 2

☒ **B** 2 and 3

☒ **C** 1 and 3

☒ **D** 3 and 4

(iii) Explain why Box 5 represents a compound.

(2)

.....

.....

.....

.....

(b) The Periodic Table contains all the known elements.

(i) How are the elements arranged in the Periodic Table?

(1)

- ☒ **A** increasing mass number
- ☒ **B** increasing number of neutrons
- ☒ **C** increasing number of protons
- ☒ **D** increasing reactivity

(ii) Elements in the same group have the same number of

(1)

- ☒ **A** electrons in the outer shell
- ☒ **B** electron shells
- ☒ **C** neutrons
- ☒ **D** protons

(Total for Question 1 = 6 marks)

1 (a) The box gives some methods used in the separation of mixtures.

chromatography	crystallisation	evaporation
filtration	fractional distillation	simple distillation

Use words from the box to answer these questions.

(i) Identify the method used to obtain pure water from sea water.

(1)

.....

(ii) Identify the method used to separate the dyes in a food colouring.

(1)

.....

(iii) Identify the method used to obtain ethanol from a mixture of ethanol and water.

(1)

.....

(b) Complete the sentences by writing a suitable word in each blank space.

(3)

When salt is added to water and stirred until no more will ..... , a saturated solution forms.

The salt is the ..... .

The water is the ..... .

(Total for Question 1 = 6 marks)

1 The box lists some substances.

air	bromine	carbon	copper	glucose
nitrogen	oxygen	sulfur	water	

Choose substances from the box to answer these questions.

Each substance may be used once, more than once or not at all.

(a) Name a metallic element.

(1)

.....

(b) Name a compound.

(1)

.....

(c) Name a mixture.

(1)

.....

(d) Name an element that is a gas at room temperature.

(1)

.....

(e) Name an element that forms a basic oxide.

(1)

.....

(f) Name two elements that are in the same group of the Periodic Table.

(1)

.....

(Total for Question 1 = 6 marks)

3 Some sugar is added to cold water in a beaker.

After some time, all the sugar dissolves and spreads throughout the water.

(a) (i) Name the process that occurs which causes the sugar to spread throughout the water.

(1)

.....

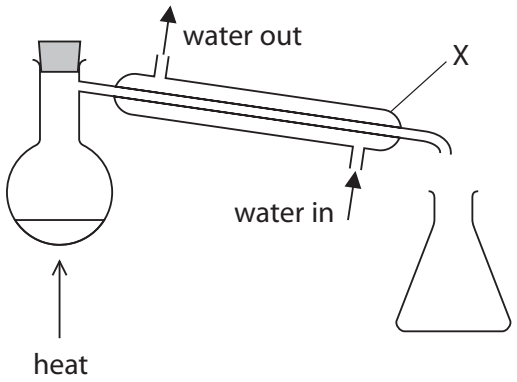
(ii) State two ways to make the sugar dissolve more quickly.

(2)

1 .....

2 .....

(b) Pure water can be obtained from the sugar solution using this apparatus.



(i) Name the process used to obtain pure water from the sugar solution.

(1)

.....

(ii) Explain the purpose of the piece of apparatus labelled X.

(2)

.....

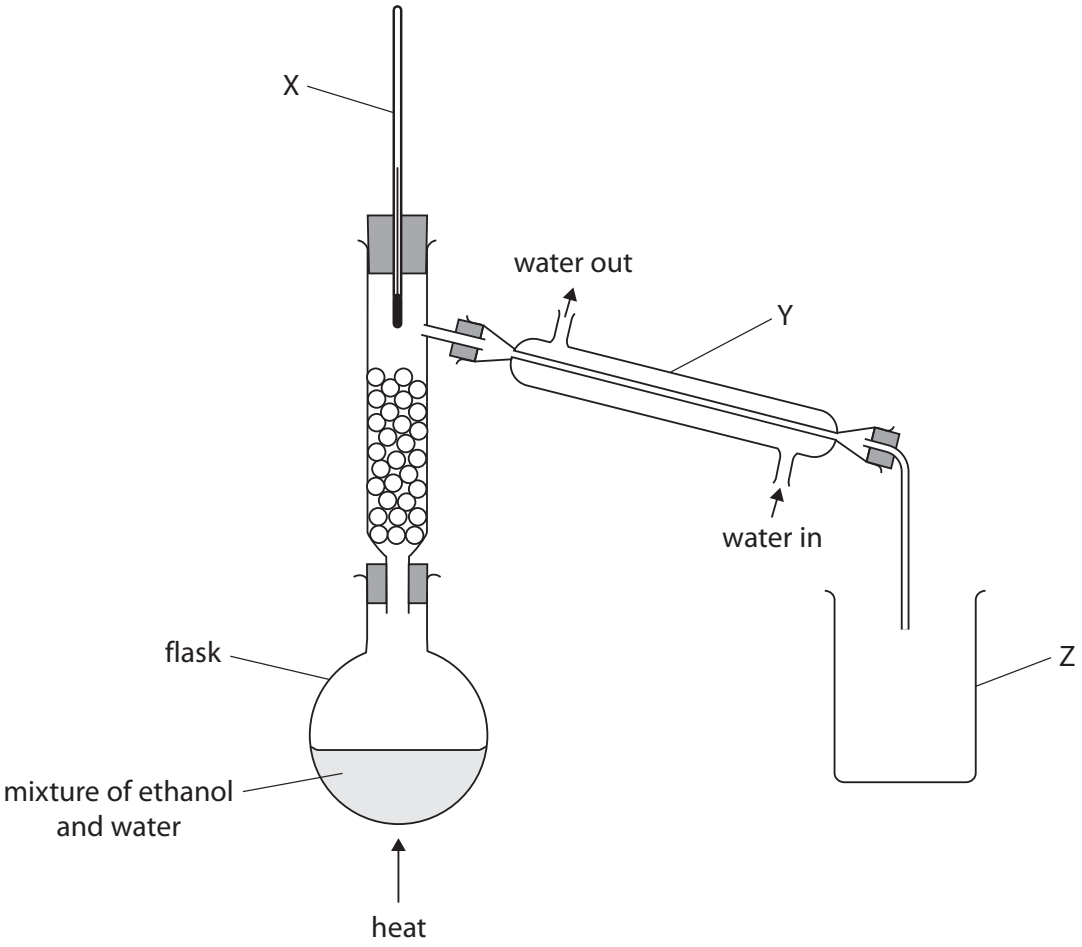
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.....

.....

(Total for Question 3 = 6 marks)

3 A teacher uses this apparatus to separate a mixture of ethanol and water.



(a) Give the name of this method of separation.

(1)

- ☒ **A** chromatography
- ☒ **B** crystallisation
- ☒ **C** filtration
- ☒ **D** fractional distillation

(b) Name the pieces of apparatus labelled X, Y and Z.

(3)

X .....

Y .....

Z .....

(c) Give a physical test that the teacher could do to find out if the ethanol produced is pure.

(2)

.....

.....

.....

.....

(Total for Question 3 = 6 marks)

1 This question is about elements, compounds and mixtures.

(a) The box gives the names of some substances.

calcium	fluorine	helium	neon
petrol	silicon	water	

Choose a substance from the box to answer each of these questions.

(i) Give the name of a compound.

(1)

.....

(ii) Give the name of a mixture.

(1)

.....

(iii) Give the name of a diatomic molecule.

(1)

.....

(iv) Give the name of a metal element.

(1)

.....

(b) (i) Name the technique used to separate crude oil into fractions.

(1)

.....

(ii) Give one use of the kerosene fraction.

(1)

.....

.....

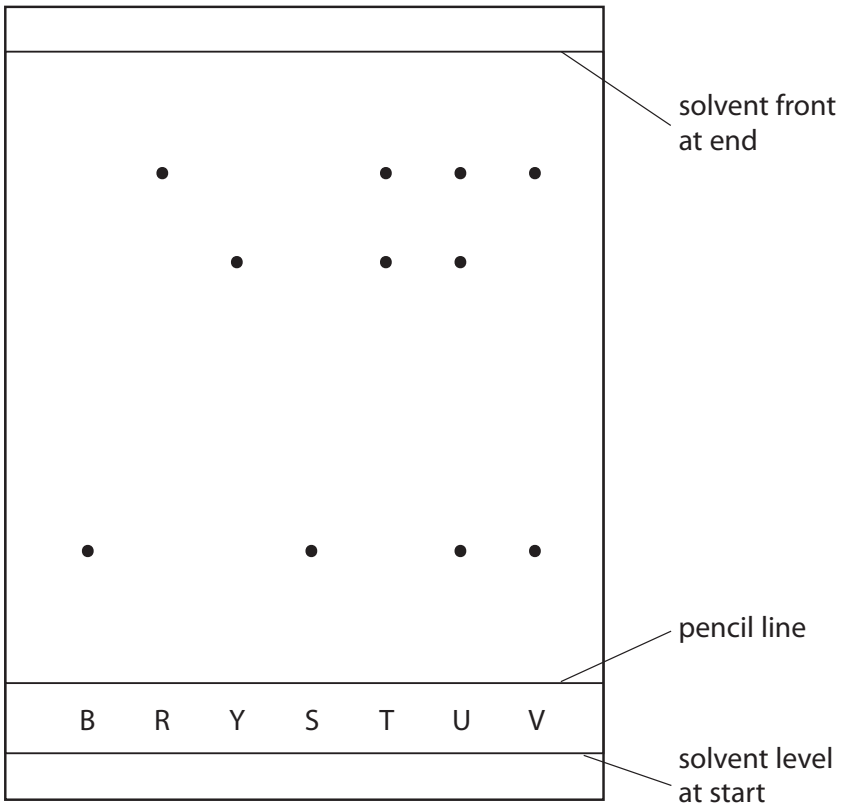
(Total for Question 1 = 6 marks)

2 In a chromatography experiment a student uses samples of three pure food dyes, blue (B), red (R) and yellow (Y).

He also uses samples of four unknown substances, S, T, U and V.

The student puts a small drop of each substance on the pencil line.

The diagram shows the student's chromatogram at the end of the experiment.



(a) Which of the unknown substances contains only one food dye?

(1)

☒ **A** substance S

☒ **B** substance T

☒ **C** substance U

☒ **D** substance V

(b) Explain which pure food dyes are in substance V.

(2)

.....

.....

.....

.....

(c) (i) Calculate the R_f value of the yellow food dye Y.

(3)

R_f = ...

(ii) State how the chromatogram suggests that the yellow food dye Y is less soluble in the solvent than the red food dye R.

(1)

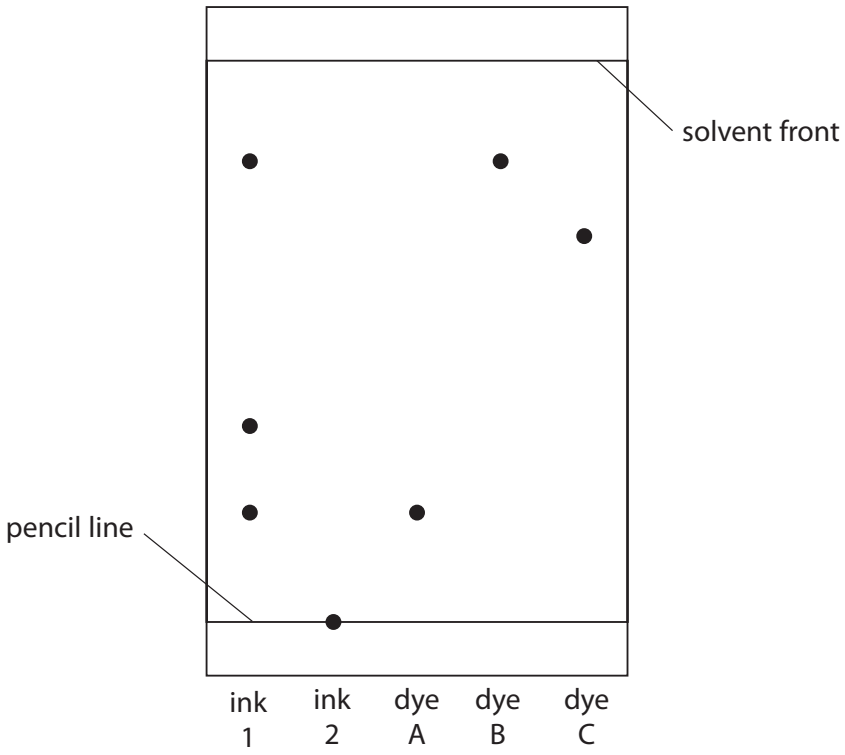
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(Total for Question 2 = 7 marks)

2 A student does a chromatography experiment using ink 1, ink 2, and three known dyes A, B and C. The student uses water as the solvent.

The diagram shows the student's chromatogram.



(a) Deduce what conclusions can be made about the composition of ink 1.

(2)

(b) (i) Give one conclusion that can be made about ink 2.

(1)

(ii) Suggest how the student could change the experiment to find the composition of ink 2.

(1)

.....

.....

(c) Calculate the R_f value of dye C, giving your answer to 2 significant figures.

(3)

R_f value = ...

(Total for Question 2 = 7 marks)

1 The box shows the names of some substances.

bromine	carbon dioxide	copper	iodine
methane	nitrogen	sulfur dioxide	water

(a) Complete the table by choosing substances from the box that match the description.

Each substance may be used once, more than once or not at all.

(5)

Description	Substance
a good conductor of electricity	
an element that has a basic oxide	
a substance used as a fuel	
a major cause of acid rain	
a non-metallic element that is a solid at room temperature	

(b) Describe a test for carbon dioxide.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

1 This question is about mixtures and compounds.

(a) The box gives some methods used to separate mixtures.

chromatography	crystallisation
fractional distillation	simple distillation

Choose methods from the box to answer the following questions.

Each method may be used once, more than once or not at all.

(i) Identify a method to separate a single food dye from a mixture of food dyes.

(1)

.....

(ii) Identify a method to separate gasoline from crude oil.

(1)

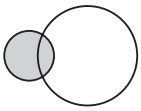
.....

(iii) Identify a method to separate water from copper(II) sulfate solution.

(1)

.....

(b) The diagram represents a molecule.



Explain why this molecule is a compound.

(2)

.....

.....

.....

.....

(c) The molecular formula of another compound is $C_3H_5N_3O_9$

(i) State the number of different elements in $C_3H_5N_3O_9$

(1)

.....

(ii) Determine the number of atoms in a molecule of $C_3H_5N_3O_9$

(1)

.....

(Total for Question 1 = 7 marks)

2 This question is about elements, mixtures and compounds.

(a) Which of these is the formula of a molecule of an element?

(1)

- ☒ **A** O
- ☒ **B** Cl_2
- ☒ **C** HCl
- ☒ **D** H_2O

(b) Which method can be used to separate an insoluble solid from a liquid?

(1)

- ☒ **A** crystallisation
- ☒ **B** evaporation
- ☒ **C** filtration
- ☒ **D** simple distillation

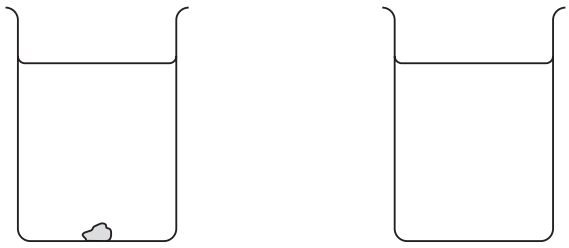
(c) Give the name of a method used to separate a mixture of liquids with different boiling points.

(1)

.....

(d) A student adds a crystal of substance X to some water in a beaker and leaves the beaker for one day.

The diagram shows the beaker immediately after adding the crystal, and after one day.



immediately after adding crystal

after one day

(i) Which equation gives the correct state symbols for a process that occurs in the beaker?

(1)

☒ **A** X(s) → X(l)

☒ **B** X(s) → X(g)

☒ **C** X(aq) → X(s)

☒ **D** X(s) → X(aq)

(ii) Which other process occurs in the beaker?

(1)

☒ **A** boiling

☒ **B** condensing

☒ **C** diffusion

☒ **D** sublimation

(iii) After one day the student does two tests on the liquid in the beaker.

The table shows the student's results.

Test	Result
flame test	lilac flame
addition of acidified barium chloride solution	white precipitate

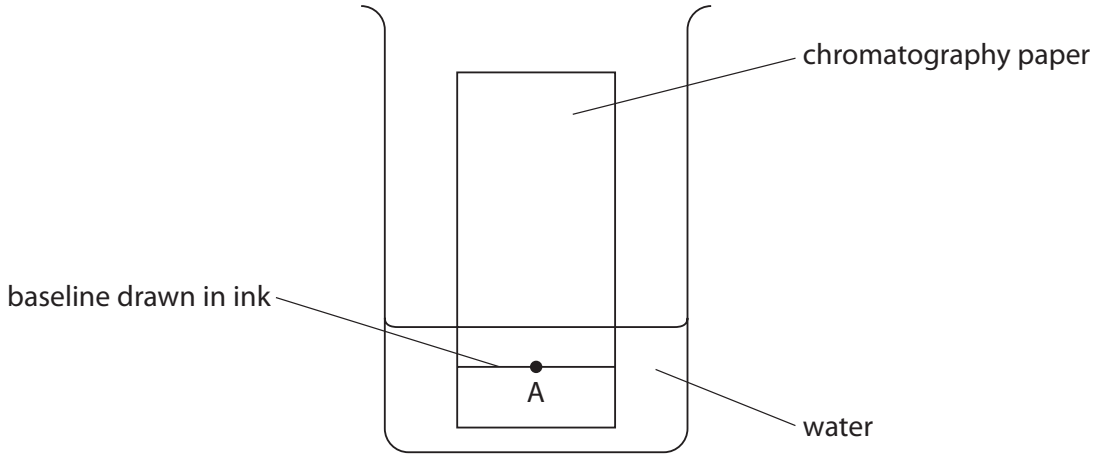
Identify substance X.

(2)

.....

(Total for Question 2 = 7 marks)

4 A student uses this apparatus to investigate the dyes in a food colouring A.



(a) Explain two mistakes that the student makes when setting up the apparatus.

(4)

1 .....

.....

.....

.....

2 .....

.....

.....

.....

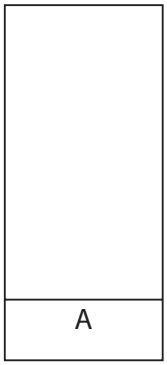
(b) The student repeats the experiment, but with no mistakes.

The table shows the R_f values for the two dyes in food colouring A.

Dye	R_f value
blue	0.50
yellow	0.25

(i) Complete the chromatogram for food colouring A by adding and labelling the dyes.

(2)



(ii) Give a reason why the blue dye has a larger R_f value than the yellow dye.

(1)

.....

.....

(Total for Question 4 = 7 marks)

1 The box gives some methods that are involved in the separation of mixtures.

chromatography	crystallisation	dissolving	evaporating
filtering	fractional distillation	simple distillation	

(a) Use words from the box to identify the method involved in each of these separations.

(i) Give the best method for obtaining gasoline from crude oil.

(1)

.....

(ii) Give the best method for separating the dyes in black ink.

(1)

.....

(iii) Give the best method for obtaining pure water from seawater.

(1)

.....

(b) A sample of solid hydrated copper(II) sulfate can be obtained from a mixture of copper(II) oxide and copper(II) sulfate.

Complete the passage by using words from the box.

(4)

The mixture of copper(II) oxide and copper(II) sulfate can be separated by first

..... the copper(II) sulfate in distilled water.

The copper(II) oxide is then removed by

..... .

Some of the water from the copper(II) sulfate solution is then removed by

..... .

A pure sample of hydrated copper(II) sulfate is then obtained by

..... .

(Total for Question 1 = 7 marks)

1 The box gives the names of some substances.

bromine	chlorine	diamond	ethene
iodine	lithium	methane	water

(a) Complete the table by choosing a substance from the box that matches each description.

Each substance may be used once, more than once or not at all.

(5)

Description	Substance
a good conductor of electricity	
an element that is a liquid at room temperature	
a substance that can be used to form a polymer	
an element that forms a basic oxide	
a substance that has a giant covalent structure	

(b) Describe a test for chlorine.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

5 Chromatography is used to separate the components in a mixture.

(a) Diagram 1 shows the apparatus used to separate the different dyes in a food colouring.

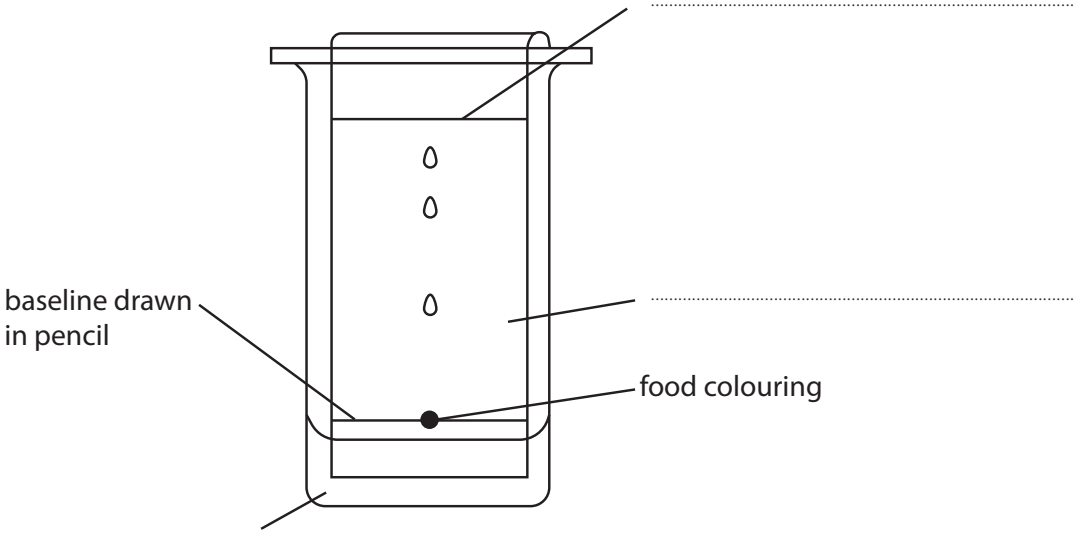


Diagram 1

(i) Complete the diagram by adding the missing labels.

(3)

(ii) Give a reason why the baseline is drawn in pencil.

(1)

(b) Diagram 2 shows a chromatogram produced from four different food colourings, W, X, Y and Z.

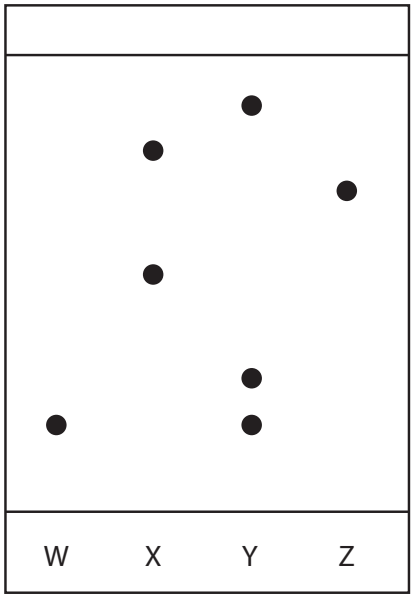


Diagram 2

(i) Which two food colourings contain the same dye?

(1)

- ☒ **A** W and X
- ☒ **B** W and Y
- ☒ **C** X and Z
- ☒ **D** Y and Z

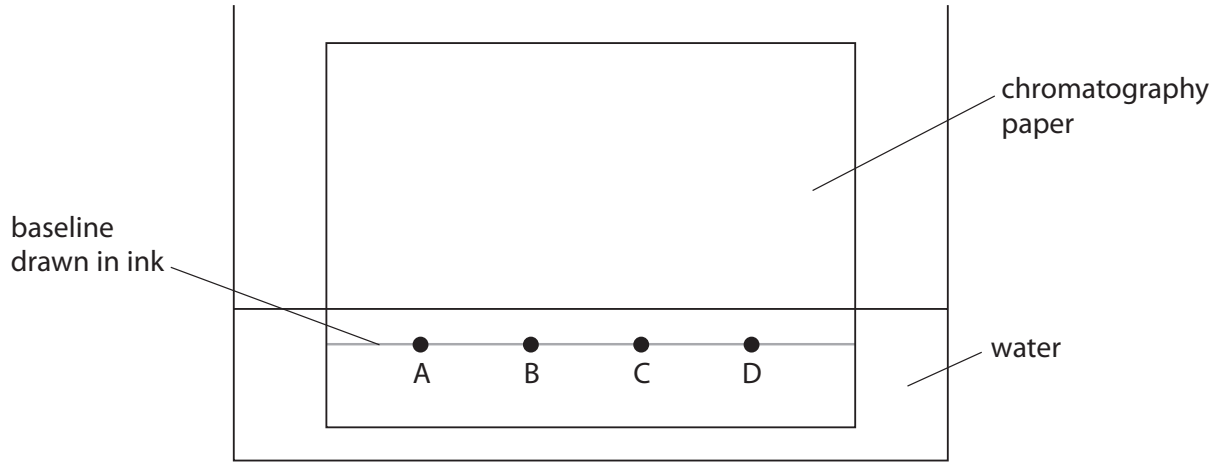
(ii) Calculate the R_f value of the dye in food colouring W.

(2)

R_f = ...

(Total for Question 5 = 7 marks)

4 A student uses this apparatus to investigate the colours in four different inks, A, B, C and D.



(a) Explain two mistakes the student made when setting up his experiment.

(4)

1 .....

.....

.....

.....

2 .....

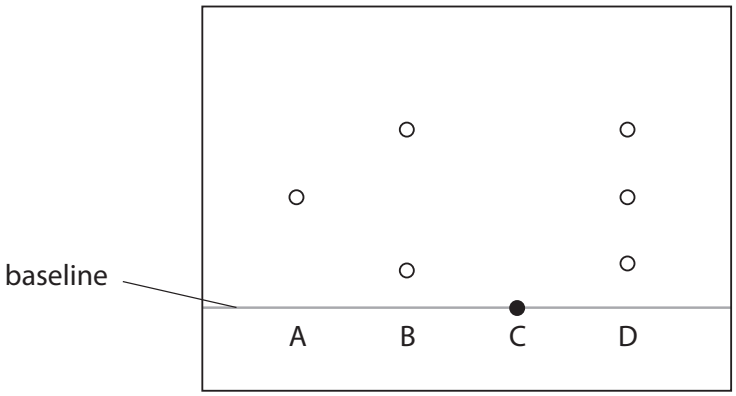
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.....

(b) Another student does the experiment but does not make any mistakes.

The diagram shows her results.



(i) State how many colours ink D contains.

(1)

.....

(ii) State which of the inks tested could be mixed together to make ink D.

(1)

.....

(iii) Explain which of the inks tested is insoluble in water.

(2)

.....

.....

.....

.....

(Total for Question 4 = 8 marks)

3 This question is about chromatography.

Two students carry out separate chromatography experiments to find the R_f values for five different food dyes, A, B, C, D and E.

(a) State two things that should be the same in both experiments so that the students can compare their results fairly.

(2)

1 .....

2 .....

(b) After doing the experiments the students calculate the R_f value for each food dye.

The table shows their results.

Dye	Student 1 R_f value	Student 2 R_f value
A	0.45	0.45
B	0.63	0.64
C	0.00	0.00
D	0.83	1.20
E	0.30	0.30

(i) State what can be concluded about dye C.

(1)

.....

(ii) Explain which R_f value cannot be correct.

(2)

.....

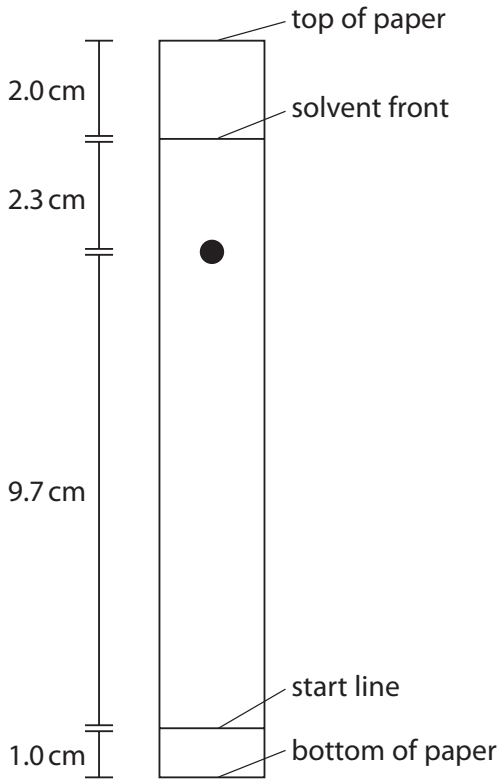
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(c) The diagram shows a chromatogram for a different food dye.

Some distances are shown on the diagram.



Calculate the R_f value for this food dye.

Give your answer to two significant figures.

(3)

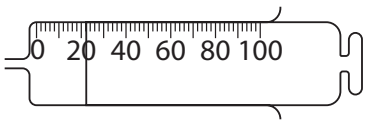
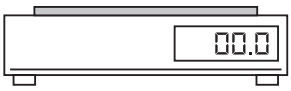
R_f = ...

(Total for Question 3 = 8 marks)

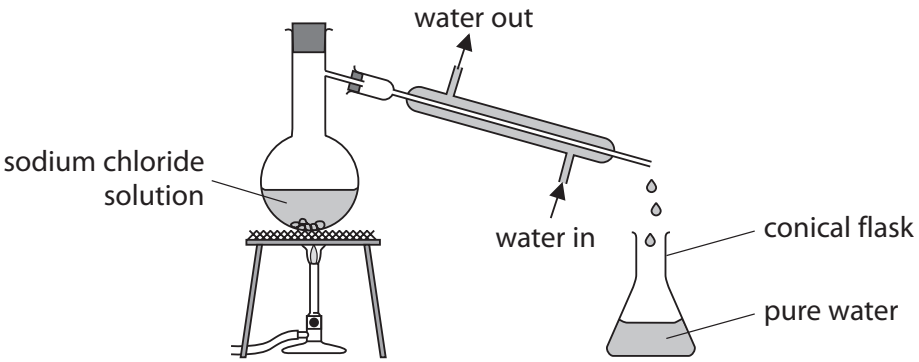
2 This question is about apparatus used in the laboratory.

(a) Complete the table by giving the name of each piece of apparatus and a unit used for the quantity it measures.

(2)

Apparatus	Name	Unit
		
		

(b) The diagram shows apparatus used to obtain pure water from sodium chloride solution by simple distillation.



(i) Explain why it is necessary for water to flow continuously in and out of the apparatus.

(2)

.....

.....

.....

.....

(ii) Describe a chemical test to show that the sodium chloride solution contains chloride ions.

(2)

.....

.....

.....

.....

(iii) Describe a physical test to show that the liquid in the conical flask is pure water.

(2)

.....

.....

.....

.....

(Total for Question 2 = 8 marks)

2 This question is about mixtures and compounds.

(a) The box gives some techniques used to separate mixtures.

crystallisation	filtration
fractional distillation	simple distillation

The table lists some substances and mixtures.

Complete the table using words from the box to show the best technique to obtain the named substance from each mixture.

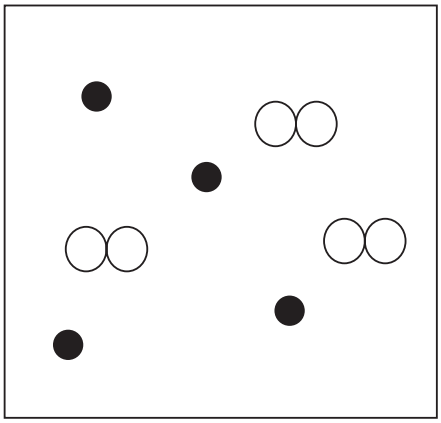
Each technique may be used once, more than once or not at all.

(3)

Substance	Mixture	Technique
solid sodium chloride	aqueous sodium chloride	
water	aqueous copper(II) sulfate	
sand	sand and water	

(b) State how the box represents a mixture.

(1)



.....

.....

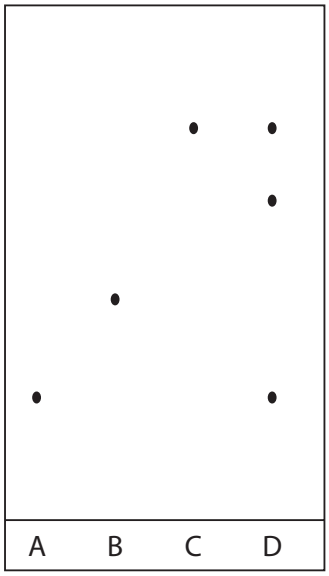
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(c) Food colourings are mixtures of food dyes.

A student uses paper chromatography to separate the food dyes contained in food colouring D.

The student places spots of three food dyes A, B and C and food colouring D on chromatography paper.

The diagram shows the appearance of the paper after the experiment.



Describe the composition of food colouring D.

(2)

(d) A compound has the formula $Ca(HCO_3)_2$

(i) Determine the number of different elements in $Ca(HCO_3)_2$

(1)

(ii) Determine the number of atoms in the formula of $Ca(HCO_3)_2$

(1)

(Total for Question 2 = 8 marks)

3 This question is about elements, mixtures and compounds.

(a) The box gives some methods used to separate mixtures.

crystallisation	filtration
fractional distillation	simple distillation

Choose methods from the box to answer these questions.

(i) Identify a method to remove sand from a mixture of sand and seawater.

(1)

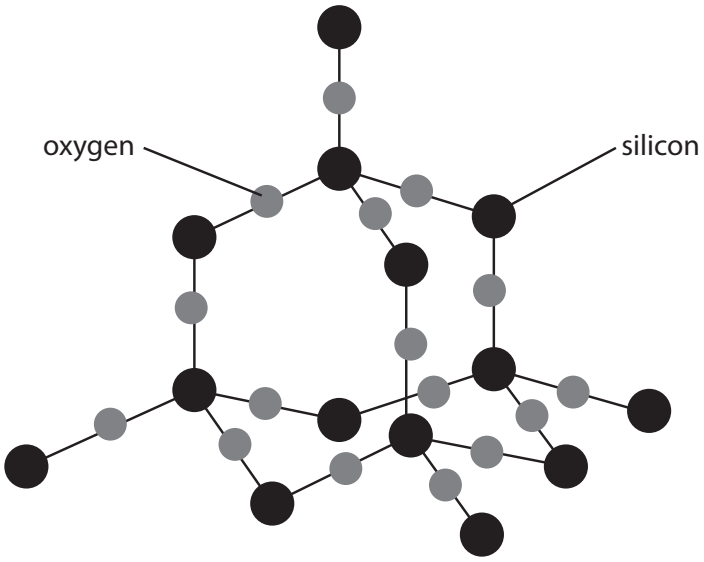
.....

(ii) Identify a method to separate a mixture of liquids with different boiling points.

(1)

.....

(b) The diagram shows part of the structure of silicon dioxide.



Explain why silicon dioxide is a compound.

(2)

.....

.....

.....

.....

(c) The molecular formula of the compound insulin is $C_{257}H_{383}N_{65}O_{77}S_6$

(i) Determine the number of different elements in $C_{257}H_{383}N_{65}O_{77}S_6$

(1)

.....

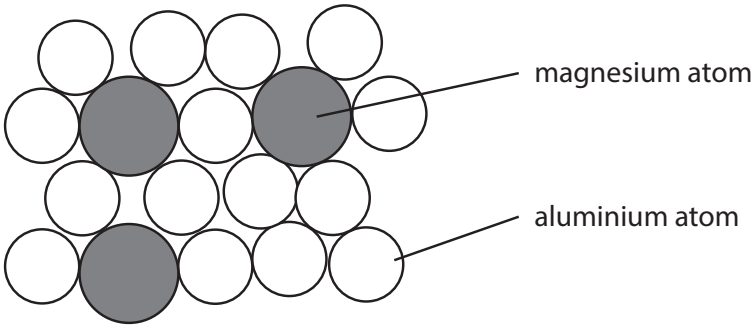
(ii) Determine the number of atoms in a molecule of $C_{257}H_{383}N_{65}O_{77}S_6$

(1)

number of atoms = ...

(d) Magnalium is a mixture of magnesium atoms and aluminium atoms.

The diagram shows a sample of magnalium.



Calculate the percentage of magnesium atoms in this sample.

(2)

percentage = ... %

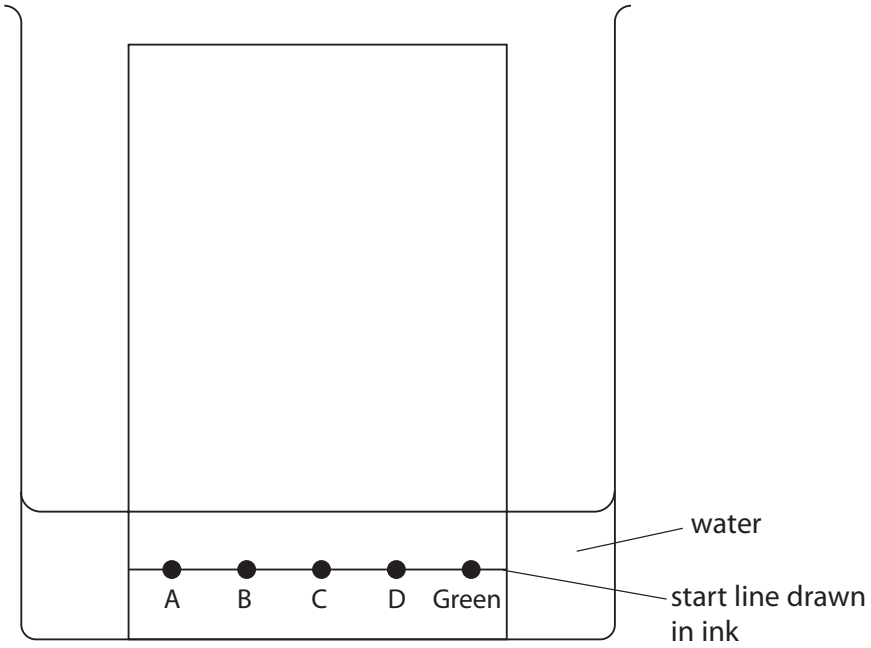
(Total for Question 3 = 8 marks)

2 Chromatography is used to analyse mixtures.

A student does a chromatography experiment to analyse the composition of green food colouring in sweets.

She places four known dyes, A, B, C and D, and the green food colouring on chromatography paper.

The diagram shows the student's apparatus at the start of her experiment.



(a) The diagram shows that the student makes two mistakes when setting up her apparatus.

State the two changes that the student should make so that her experiment works.

(2)

1 .....

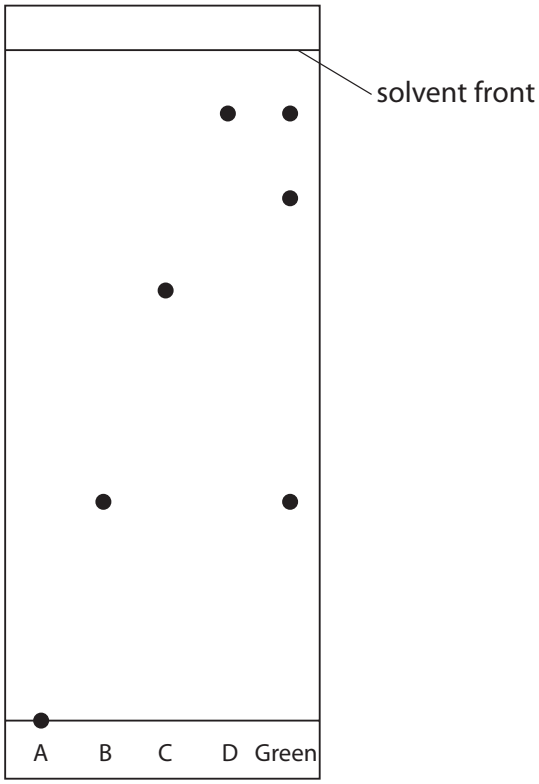
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2 .....

.....

(b) Another student does the chromatography experiment correctly.

The diagram shows her chromatogram at the end of the experiment.



(i) Explain what the chromatogram shows about the composition of the green food colouring.

(3)

(ii) The distance between the start line and the spot for dye C is 6.2 cm.

Calculate the R_f value of dye C.

(3)

R_f value = ...

(iii) Suggest why dye A does not move.

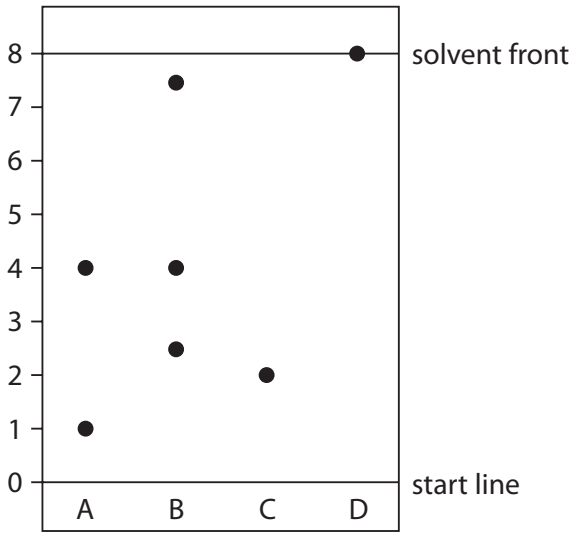
(1)

.....

.....

(Total for Question 2 = 9 marks)

3 The diagram shows a chromatogram of the food dyes in four different food colourings, A, B, C and D.



(a) (i) Give the letter of the food colouring that contains three different food dyes.

(1)

.....

(ii) Give the letters of the two food colourings that contain the same dye.

(1)

.....

(iii) Using the scale on the diagram, determine the R_f value of the dye in food colouring C.

(2)

R_f = ...

(iv) Give a reason why the dye in food colouring D moves the furthest from the start line.

(1)

.....

.....

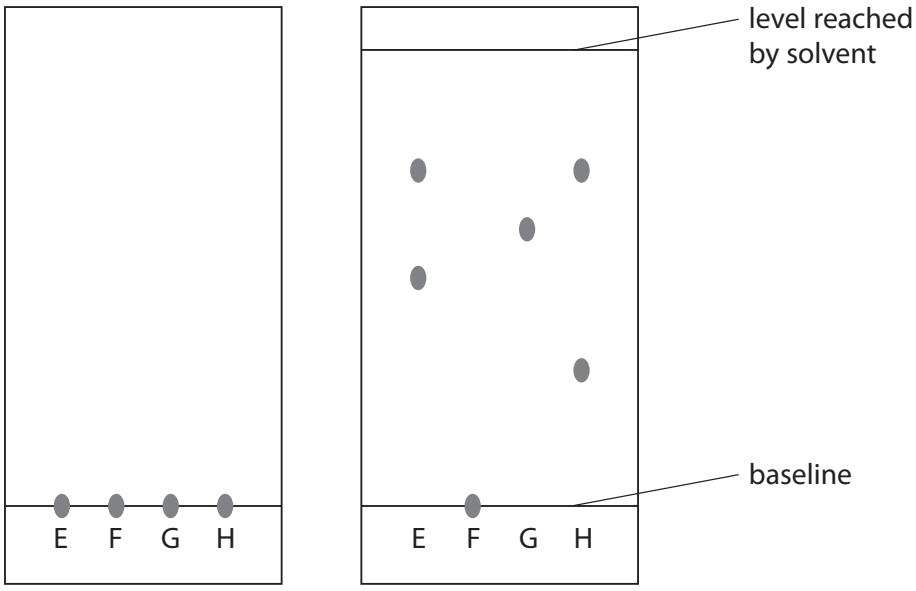
(b) Describe how a student could obtain a chromatogram similar to the one shown in the diagram.

(4)

(Total for Question 3 = 9 marks)

5 A student uses paper chromatography in an experiment to separate the dyes in four different felt tip pens, E, F, G and H.

The diagram shows the appearance of the paper before and after the experiment.



(a) (i) The chromatography paper is placed in a solvent. Explain why the spots on the baseline are placed above the level of the solvent.

(2)

(ii) Explain which two felt tip pens contain the same dye.

(2)

(iii) The student thought that both F and G contained only one dye.

Explain why the student can only be certain about one of these dyes.

(2)

.....

.....

.....

.....

(b) Calculate the R_f value for the dye in G.

Show your working.

(3)

R_f value = ...

(Total for Question 5 = 9 marks)

5 This question is about the separation of mixtures.

(a) The box gives some methods used to separate mixtures.

crystallisation	filtration	fractional distillation	simple distillation

Complete the table by giving the correct method from the box for each separation.

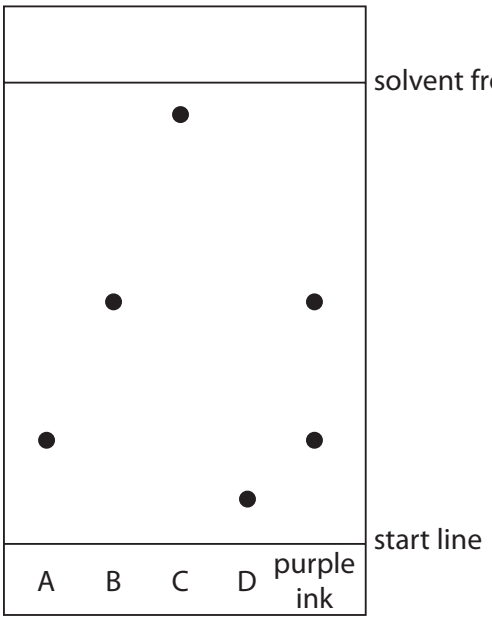
Each method can be used once, more than once or not at all.

(4)

Separation	Method
insoluble solid from a liquid	
pure water from a solution	
liquid from a mixture of liquids with different boiling points	
soluble solid from a solution	

(b) A student uses chromatography to analyse the composition of purple ink.

The diagram shows the student's chromatogram at the end of the experiment.



(i) Explain which dyes are contained in the purple ink.

(2)

.....

.....

.....

.....

(ii) Explain which dye is least soluble in the solvent.

(2)

.....

.....

.....

.....

(c) A different chromatography experiment is set up.

A spot of food colouring is placed on the start line.

A food dye in the colouring has an R_f value of 0.72

The distance between the start line and the solvent front is 120 mm.

Calculate the distance the food dye moves from the start line.

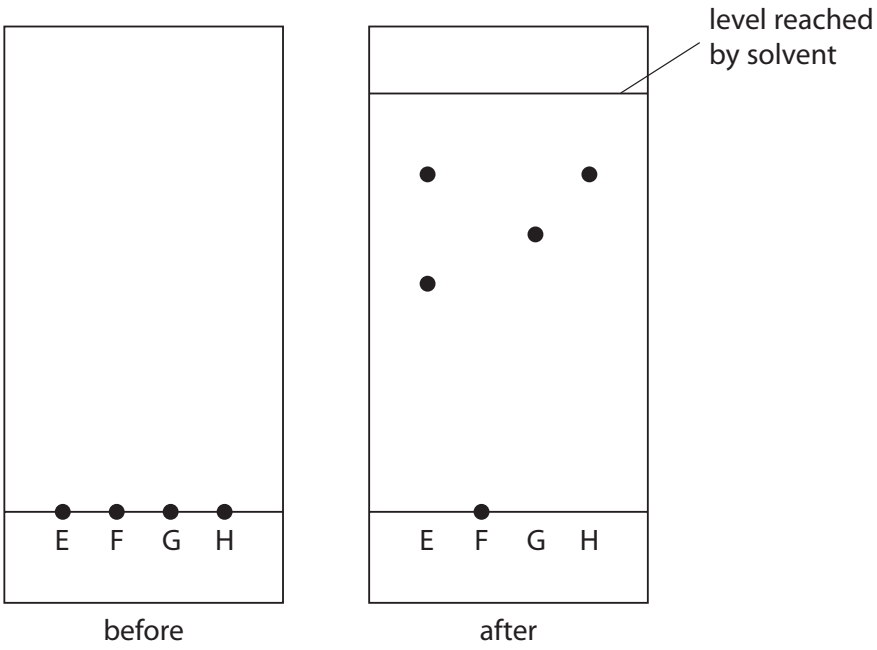
(2)

distance = ... mm

(Total for Question 5 = 10 marks)

4 A student uses paper chromatography in an experiment to separate the dyes in four different food colourings, E, F, G and H.

The diagram shows the appearance of the paper before and after the experiment.



(a) (i) Describe how the student should complete the experiment after putting a spot of each food colouring on the paper.

(3)

(ii) Deduce the number of dyes in food colouring H.

(1)

.....

(iii) Suggest why food colouring F does not move during the experiment.

(1)

.....

.....

(iv) Explain which two food colourings contain the dye that is likely to be the most soluble in the solvent.

(2)

.....

.....

.....

.....

(b) Determine which food colouring contains a dye with R_f value closest to 0.67

Show your working.

(3)

(Total for Question 4 = 10 marks)

2 (a) The box shows some changes of state.

boiling	condensation	evaporation
freezing	melting	sublimation

The table lists some physical changes.

Complete the table using words from the box to show the change of state for each physical change.

(4)

Physical change	Change of state
water to ice	
steam to water	
solid wax to liquid wax	
iodine crystals to iodine vapour	

(b) A student plans to obtain salt crystals from a mixture of salt and sand.

The student adds pure water to the mixture to dissolve the salt.

(i) State two things the student could do to make the salt dissolve quickly.

(2)

1 .....

2 .....

(ii) State what the student should do next to separate the sand from the salt solution.

(1)

.....

.....

(iii) Describe how the student can obtain pure dry crystals of salt from the salt solution.

(4)

(Total for Question 2 = 11 marks)

4 A student does an experiment to identify the dyes in inks A, B, C, D and E.

The student uses this apparatus.

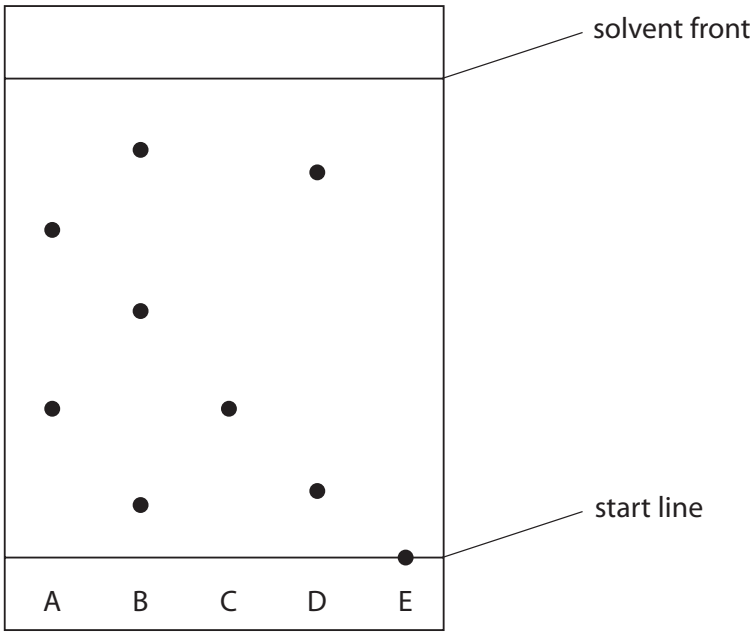
- a piece of chromatography paper
- a beaker
- a solvent
- inks A, B, C, D and E

(a) Describe how the student should set up the apparatus and do the experiment.

You may use a diagram to help your answer.

(5)

(b) The chromatogram shows the results for inks A, B, C, D and E.



(i) Explain which ink contains a dye that is insoluble in the solvent.

(2)

(ii) Explain which inks contain the same dye.

(2)

(iii) Describe how the student can use the chromatogram to determine the R_f value for the dye in ink C.

You do **not** need to calculate the R_f value.

(2)

.....

.....

.....

.....

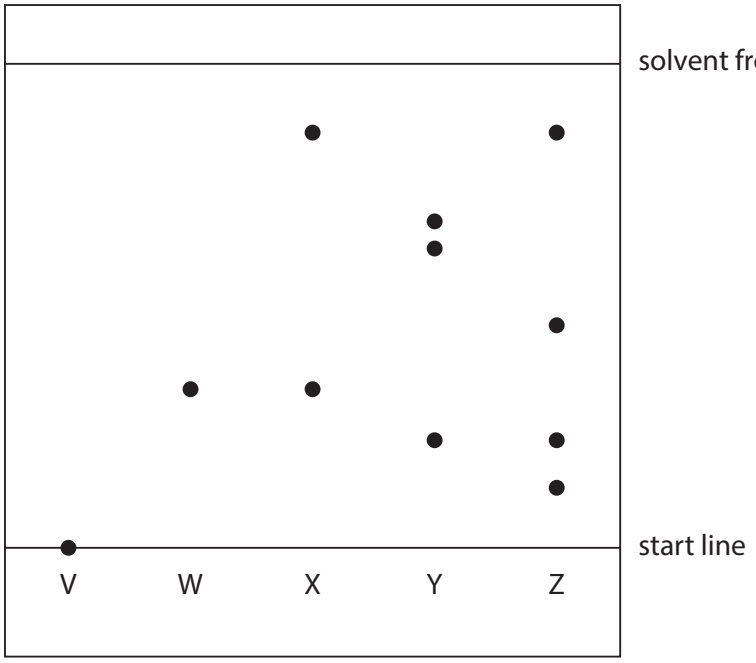
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(Total for Question 4 = 11 marks)

3 A student uses paper chromatography to investigate the dyes in five different inks, V, W, X, Y and Z.

The chromatogram shows the results of the investigation.



(a) Explain why the start line on the paper is drawn in pencil rather than in ink.

(2)

(b) Explain which two inks contain the dye that is most soluble in the solvent.

(2)

(c) Explain how the chromatogram shows that

- W contains only one dye
- V may contain more than one dye

(3)

.....

.....

.....

.....

.....

.....

(d) Calculate the R_f value for the dye in W.

Give your answer to two significant figures.

(4)

R_f value = ...

(Total for Question 3 = 11 marks)

3 A student uses paper chromatography to investigate the dyes in five different inks, V, W, X, Y and Z.

This is what she uses.

- a beaker
- a piece of chromatography paper with a pencil line drawn near the bottom of the paper
- a solvent
- inks V, W, X, Y and Z

(a) Describe how the student should set up and carry out her experiment.

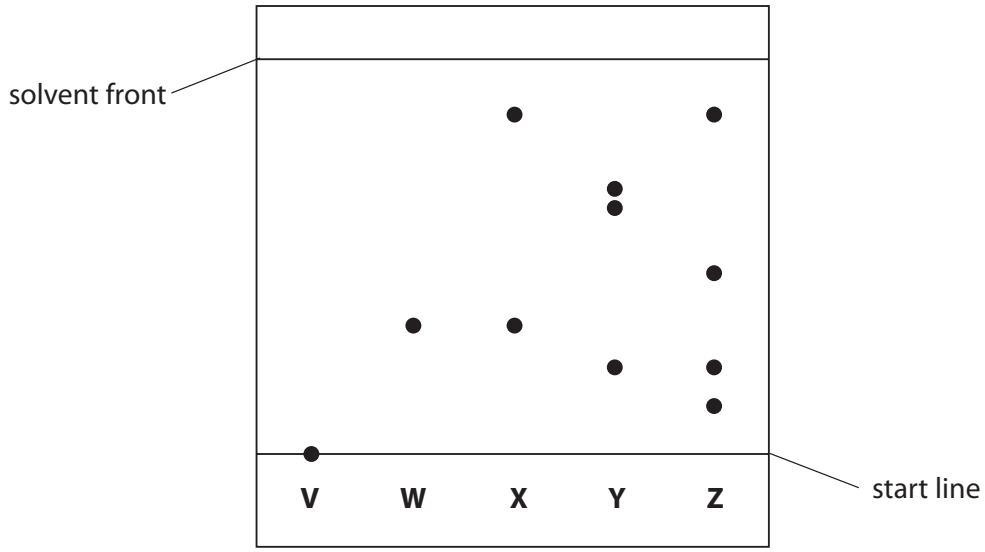
You may draw a diagram to help with your answer.

(4)

(b) Explain why the line on the paper is drawn in pencil rather than in ink.

(2)

(c) The chromatogram shows the results for inks V, W, X, Y and Z.



(i) Explain which ink contains a dye that is insoluble in the solvent.

(2)

(ii) Explain which two inks contain the dye that is likely to be the most soluble in the solvent.

(2)

(iii) Explain which two inks may contain only one dye.

(2)

.....

.....

(d) One dye in ink Y moves 4.3 cm when the solvent front moves 6.5 cm.

Calculate the R_f value for this dye.

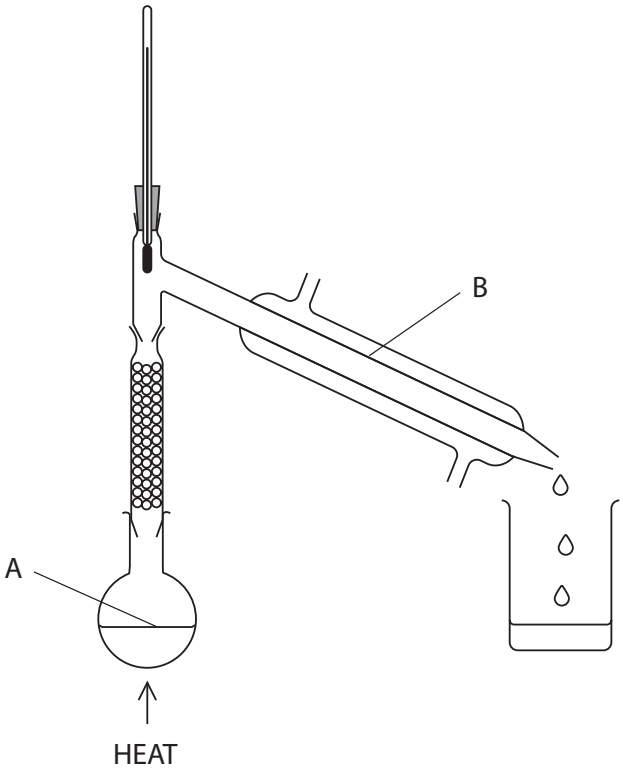
Give your answer to 2 significant figures.

(3)

R_f value = ...

(Total for Question 3 = 15 marks)

10 A teacher uses this apparatus to separate a mixture of ethanol and water.



(a) (i) Name this method of separation.

(1)

.....

(ii) Name the change of state taking place at A.

(1)

.....

(iii) Name the change of state taking place at B.

(1)

.....

(b) The mixture contains 15.5 cm^3 of ethanol.

1.0 cm^3 of ethanol has a mass of 0.79 g.

One mole of ethanol contains 6.00×10^{23} molecules.

[M_r of ethanol = 46]

(i) Calculate the amount, in moles, of ethanol in 15.5 cm^3 of ethanol.

(2)

amount = ... mol

(ii) Calculate the number of molecules of ethanol in 15.5 cm^3 of ethanol.

(1)

number of molecules = ...

(c) After five minutes, the teacher collects a sample of colourless liquid in a new beaker.

(i) Describe a chemical test to show that the colourless liquid contains water.

(2)

.....

.....

.....

.....

(ii) Describe a physical test to show if the colourless liquid is pure water.

(2)

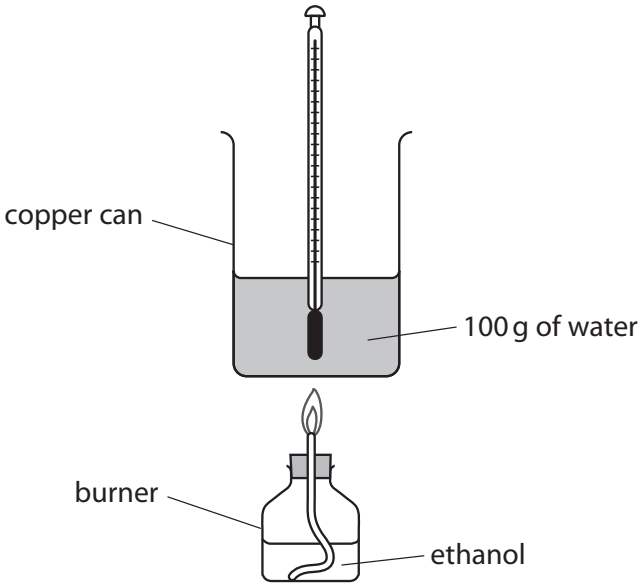
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(d) The teacher uses this apparatus to heat 100 g of water.



He records the temperature of the water before and after heating.

temperature of water before heating = 21.0 °C

temperature of water after heating = 70.5 °C

(i) Calculate the heat energy change (*Q*) in joules.

[specific heat capacity of water is 4.2 J/g/°C]

(3)

Q = ... J

(ii) The student burns 0.0200 mol of ethanol.

Use this information and your value for *Q* to calculate the molar enthalpy change (ΔH), in kJ/mol, for the combustion of ethanol.

Include a sign in your answer.

(2)

ΔH = ... kJ/mol

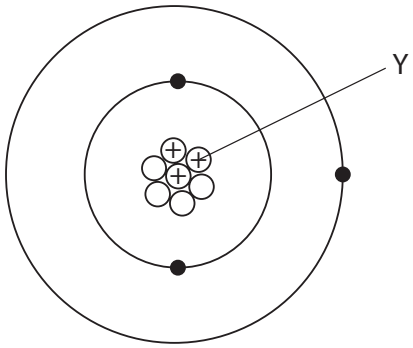
(Total for Question 10 = 15 marks)

SUB-TOPIC 1c

ATOMIC STRUCTURE

Sub-topic 1c · 23 questions · 170 marks · lowest tariff first

1 The diagram shows an atom of an element.



(a) (i) What is the name of the particle labelled Y?

(1)

- ☒ **A** electron
- ☒ **B** ion
- ☒ **C** neutron
- ☒ **D** proton

(ii) Give the mass number of this atom.

(1)

.....

(iii) Name this element.

Use the Periodic Table on page 2 to help you.

(1)

.....

(b) There are two isotopes of this element.

Give one way, in terms of sub-atomic particles, that these isotopes are the same and one way that they are different.

(2)

same .....

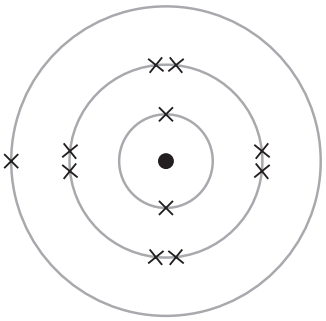
.....

different .....

.....

(Total for Question 1 = 5 marks)

1 The diagram shows the electronic configuration of an atom of an element.



(a) Name the part of the atom that contains the protons and neutrons.

(1)

(b) Give the number of protons in this atom.

(1)

(c) Give the number of the group that contains this element.

(1)

(d) Give the number of the period that contains this element.

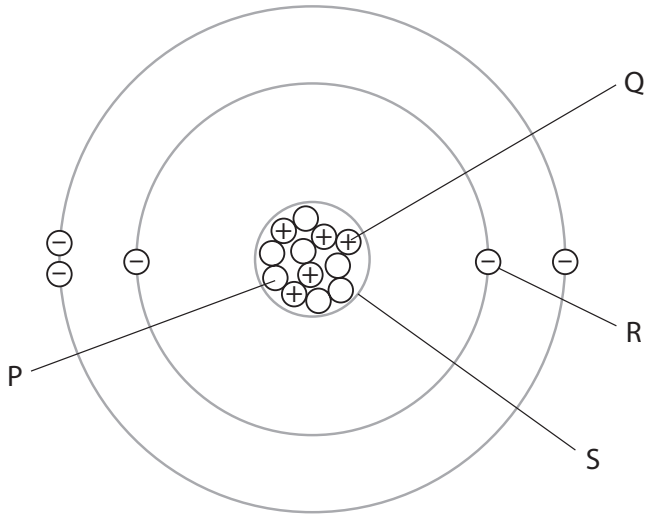
(1)

(e) Give the charge on the ion formed from this atom.

(1)

(Total for Question 1 = 5 marks)

1 The diagram shows the sub-atomic particles in an atom of an element.



(a) (i) Give the name of each of the sub-atomic particles labelled P, Q and R.

(3)

P .....

Q .....

R .....

(ii) Give the name of the part of the atom labelled S.

(1)

.....

(b) Give the name of this element.

(1)

.....

(Total for Question 1 = 5 marks)

1 This question is about atomic structure.

(a) The table shows the number of protons, neutrons and electrons in five species, V, W, X, Y and Z.

The letters represent the species but are **not** symbols from the Periodic Table.

Species	Number of protons	Number of neutrons	Number of electrons
V	29	38	27
W	12	12	12
X	9	10	10
Y	6	6	8
Z	7	7	10

Choose letters from the table to answer these questions.

Each letter may be used once, more than once or not at all.

(i) Which species is an atom?

(1)

.....

(ii) Which species is an ion with a positive charge?

(1)

.....

(iii) Which species is an ion with a 3– charge?

(1)

.....

(b) (i) State what is meant by the term **atomic number**.

(1)

.....

.....

(ii) State what is meant by the term **mass number**.

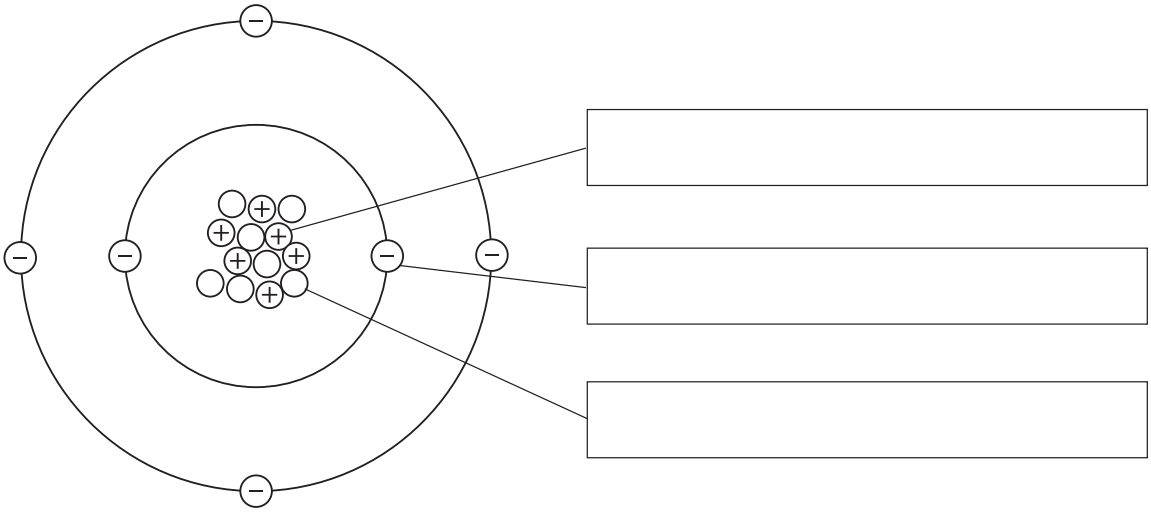
(1)

.....

.....

(Total for Question 1 = 5 marks)

1 The diagram shows the particles in an atom of an element.



(a) The box gives the names of some particles.

electron	ion	molecule	neutron	proton

Use words from the box to label the diagram.

(3)

(b) Give the mass number of this atom.

(1)

.....

(c) Complete the sentence about isotopes.

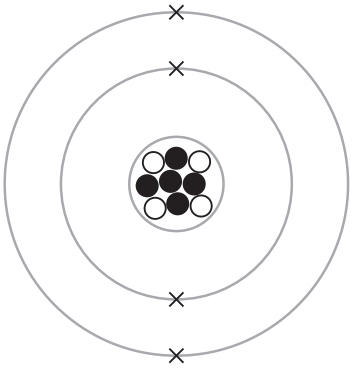
(2)

Isotopes are atoms that have the same number of .....

but have a different number of ..... .

(Total for Question 1 = 6 marks)

1 The diagram shows the particles in the atom of an element.



Key

○ particle Y

● particle Z

(a) Particle Y is a proton.

What is particle Z?

(1)

☒ **A** an electron

☒ **B** a molecule

☒ **C** a neutron

☒ **D** a nucleus

(b) Which of these has the smallest mass?

(1)

☒ **A** an electron

☒ **B** a neutron

☒ **C** a nucleus

☒ **D** a proton

(c) What is the mass number of this atom?

(1)

☒ **A** 4

☒ **B** 5

☒ **C** 9

☒ **D** 13

(d) What is the atomic number of this atom?

(1)

☒ **A** 4

☒ **B** 5

☒ **C** 9

☒ **D** 13

(e) (i) Identify the element that contains this atom.

(1)

.....

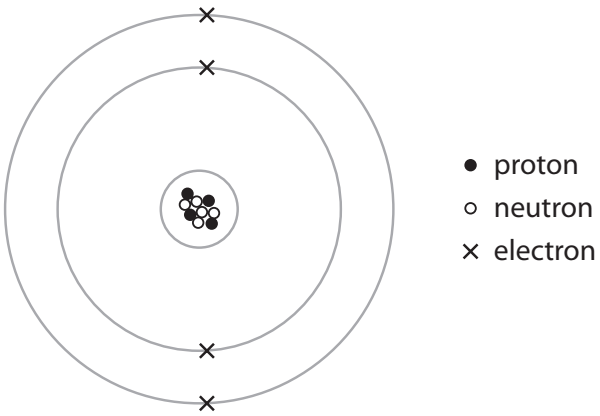
(ii) State what is formed when this atom loses its outer shell electrons.

(1)

.....

(Total for Question 1 = 6 marks)

1 (a) The diagram represents an atom of an element.



Use numbers from the box to complete the table.

You may use each number once, more than once or not at all.

2	4	5	9	10

(4)

Atomic number of this atom	
Mass number of this atom	
Period number of this element	
Number of electrons in the 2+ ion formed from this atom	

(b) In terms of sub-atomic particles, state a similarity and a difference for isotopes of the same element.

(2)

similarity

.....

.....

difference

.....

.....

(Total for Question 1 = 6 marks)

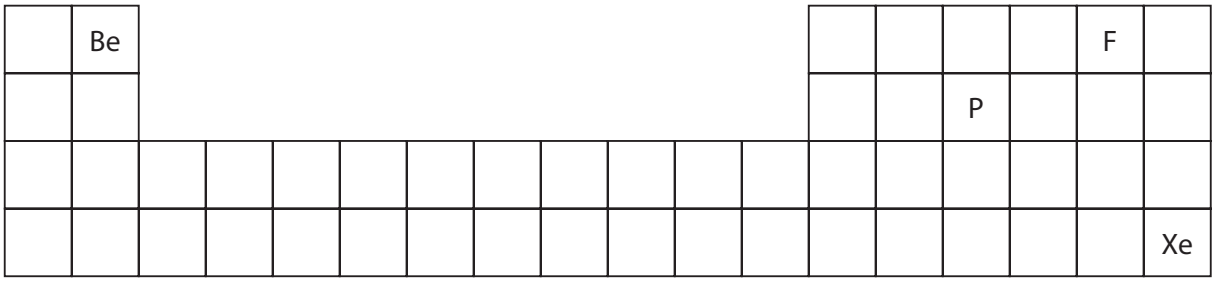
1 (a) The table lists three subatomic particles.

Complete the table by giving the missing information.

(2)

Subatomic particle	Relative mass	Relative charge
proton		+1
neutron		
electron	0.0005	

(b) The diagram shows the position of some elements in the Periodic Table.



Use the Periodic Table on page 2 to help you answer this question.

(i) How are elements arranged in the Periodic Table?

(1)

- ☒ **A** increasing atomic number
- ☒ **B** increasing melting point
- ☒ **C** increasing reactivity
- ☒ **D** increasing relative atomic mass

(ii) Which statement is correct about the position of phosphorus, P, in the Periodic Table?

(1)

- ☒ **A** Group 2 and Period 5
- ☒ **B** Group 3 and Period 5
- ☒ **C** Group 5 and Period 2
- ☒ **D** Group 5 and Period 3

(iii) Explain which of the four elements in the diagram is least reactive.

(2)

.....

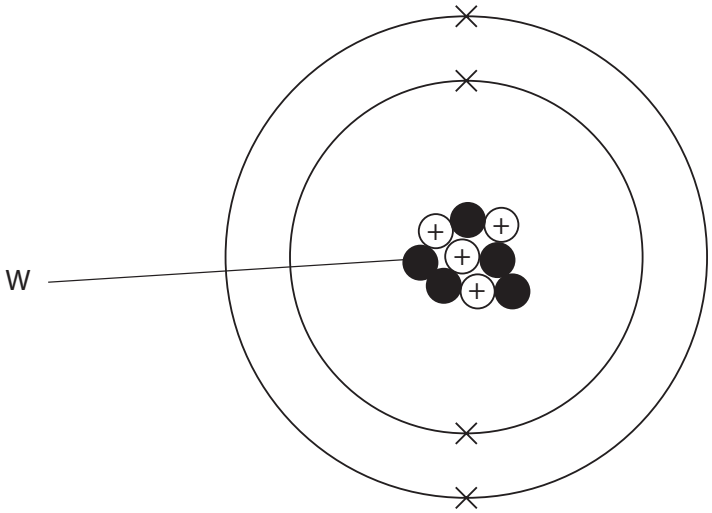
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(Total for Question 1 = 6 marks)

2 (a) The diagram represents an atom of an element.



(i) What is the name of the particle labelled W?

(1)

- ☒ **A** electron
- ☒ **B** ion
- ☒ **C** neutron
- ☒ **D** proton

(ii) What is the mass number of this atom?

(1)

- ☒ **A** 4
- ☒ **B** 5
- ☒ **C** 9
- ☒ **D** 13

(b) These are the symbols for the two isotopes of lithium.

$^{6}_{3}Li$ $^{7}_{3}Li$

(i) In terms of sub-atomic particles, give one similarity and one difference between the two isotopes.

(2)

similarity

.....

.....

difference

.....

.....

(ii) A sample of lithium contains 7.5% of $^{6}_{3}Li$ and 92.5% of $^{7}_{3}Li$

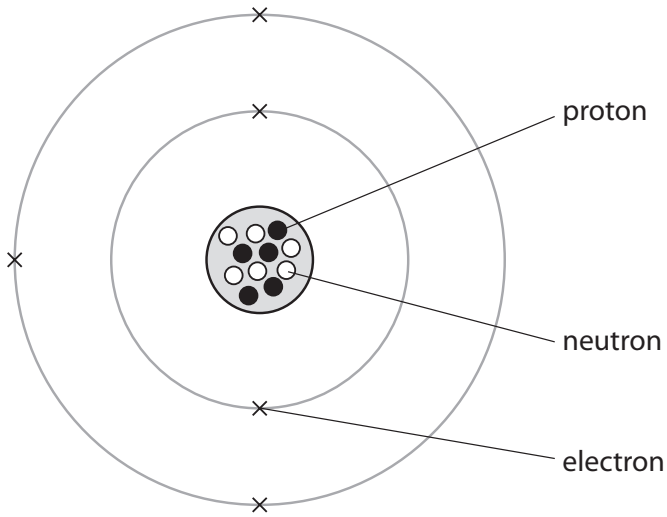
Calculate the relative atomic mass (A_r) of this sample of lithium.

(2)

A_r = ...

(Total for Question 2 = 6 marks)

2 The diagram represents an atom of boron.



(a) Use information from the diagram to complete the table.

The first row has been done for you.

(5)

atomic number	5
mass number	
number of neutrons	
group in the Periodic Table that contains boron	
period in the Periodic Table that contains boron	
electronic configuration of an atom of boron	

(b) Boron has two isotopes, boron-10 and boron-11.

A sample of boron contains 18.7% of boron-10 and 81.3% of boron-11.

Calculate the relative atomic mass of this sample of boron.

(2)

relative atomic mass = ...

(Total for Question 2 = 7 marks)

2 Thallium, Tl, is an element in Group 3 and Period 6 of the Periodic Table.

The atomic number of thallium is 81

(a) How many electrons are there in the outer shell of an atom of thallium?

(1)

☒ **A** 3

☒ **B** 6

☒ **C** 13

☒ **D** 81

(b) A thallium ion has a charge of 3+

How many electrons are there in this thallium ion?

(1)

☒ **A** 3

☒ **B** 78

☒ **C** 81

☒ **D** 84

(c) A sample of thallium contains two isotopes.

The table shows the mass number and percentage abundance of each isotope in the sample.

Isotope	Mass number	Percentage abundance (%)
thallium-203	203	30.80
thallium-205	205	69.20

(i) Give the number of protons and the number of neutrons in one atom of the thallium-205 isotope.

(2)

number of protons .....

number of neutrons .....

(ii) Calculate the relative atomic mass of this sample of thallium.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(Total for Question 2 = 7 marks)

4 (a) State the meaning of the term **atomic number**.

(1)

.....

.....

(b) An atom of element X contains 14 protons, 14 electrons and 15 neutrons.

(i) Which of these is the mass number of this atom?

(1)

☒ **A** 14

☒ **B** 15

☒ **C** 28

☒ **D** 29

(ii) Explain which group of the Periodic Table element X belongs to.

(2)

.....

.....

.....

.....

(c) The table shows the composition of a sample of a different element, Y, containing three isotopes.

Mass number of isotope	Percentage of isotope in sample
32	95.0
33	0.75
34	4.25

Using information from the table, calculate the relative atomic mass (A_r) of this sample of element Y.

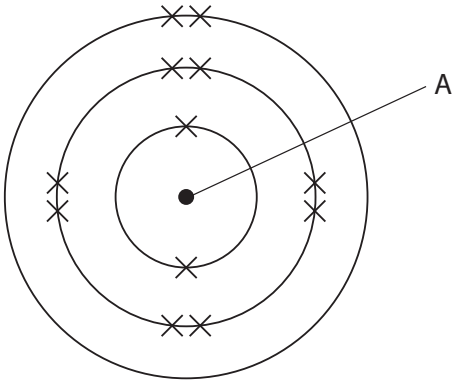
Give your answer to one decimal place.

(3)

A_r = ...

(Total for Question 4 = 7 marks)

1 (a) The diagram shows the electronic configuration of an atom of an element.



Complete the table by giving the missing information.

(3)

Name of the part of this atom labelled A	
Number of the group that contains this element	
Number of the period that contains this element	

(b) The table gives information about four different species, W, X, Y and Z.

Species	Number of protons	Number of neutrons	Number of electrons
W	2	2	2
X	13	14	10
Y	17	18	17
Z	17	20	17

(i) Give the mass number of W.

(1)

.....

(ii) Give a reason why X has a 3+ charge.

(1)

.....

.....

(iii) Explain why Y and Z are isotopes of the same element.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

1 The table shows the composition of five species that are either atoms or ions.

Species	Number of protons	Number of neutrons	Number of electrons
A	1	0	1
B	3	3	3
C	3	4	3
D	9	10	10
E	13	14	13

(a) Use the table to answer these questions.

You may use each letter once, more than once, or not at all.

(i) Give the letter of the species that is a negative ion.

(1)

.....

(ii) Give the letter of the species that has a full outer shell of electrons.

(1)

.....

(iii) Give the letter of the species that has an atomic number equal to its mass number.

(1)

.....

(b) Explain why species B and C are atoms of the same element with identical chemical properties.

(2)

.....

.....

.....

.....

.....

.....

(c) A proton has a mass of 1.6726×10^{-24} g.

A neutron has a mass of 1.6740×10^{-24} g.

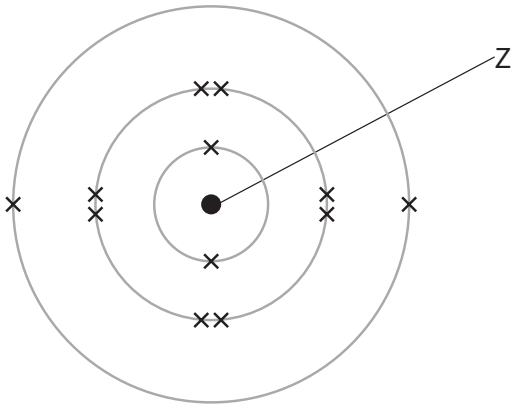
Calculate the mass, in grams, of the nucleus of an atom of species C.

(2)

mass = ... g

(Total for Question 1 = 7 marks)

2 The diagram shows the electronic configuration of an atom of an element.



(a) Complete the table by giving the missing information about this atom.

(5)

name of the part of this atom labelled Z	
number of protons in this atom	
number of the group that contains this element	
number of the period that contains this element	
the charge on the ion formed from this atom	

(b) This element has three isotopes.

The table shows the mass number and percentage abundance of each isotope in a sample of this element.

Mass number	Percentage abundance (%)
24	79.2
25	10.0
26	10.8

Calculate the relative atomic mass (A_r) of this element.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(Total for Question 2 = 8 marks)

4 (a) The table shows the number of protons, neutrons and electrons in species F, G and H.

	Species F	Species G	Species H
number of protons	7	7	7
number of neutrons	7	8	7
number of electrons	7	7	10

(i) Give the mass number of F.

(1)

.....

(ii) Give the electronic configuration of G.

(1)

.....

(iii) Explain why F and G are isotopes of the same element.

Refer to subatomic particles in your answer.

(2)

.....

.....

.....

.....

(iv) Explain why H is a negative ion.

Refer to subatomic particles and their charges in your answer.

(2)

.....

.....

.....

.....

(b) A sample of carbon contains atoms of mass number 12 and 13

The table shows the percentages of these atoms in the sample.

Mass number	Percentage (%)
12	98.930
13	1.070

Calculate the relative atomic mass (A_r) of this sample of carbon.

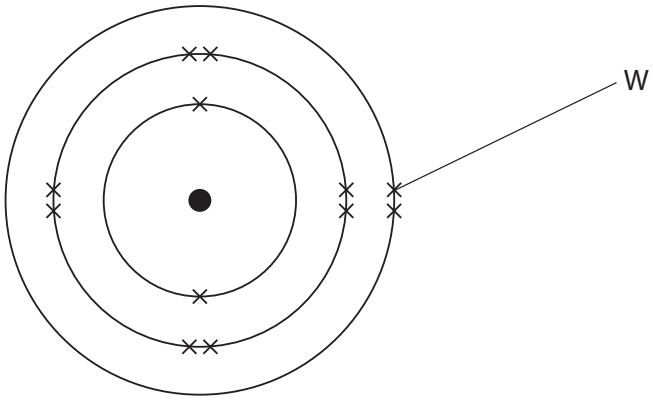
Give your answer to two decimal places.

(2)

relative atomic mass = ...

(Total for Question 4 = 8 marks)

3 (a) The diagram represents an atom of an element.



(i) What is the particle labelled W?

(1)

- ☒ **A** electron
- ☒ **B** neutron
- ☒ **C** nucleus
- ☒ **D** proton

(ii) An atom of this element contains 13 neutrons.

What is the mass number of this element?

(1)

- ☒ **A** 12
- ☒ **B** 13
- ☒ **C** 25
- ☒ **D** 49

(iii) State why atoms have no overall charge.

(1)

.....

.....

.....

(iv) What is the charge on the ion usually formed from this element?

(1)

- ☒ **A** 1+
- ☒ **B** 2+
- ☒ **C** 1–
- ☒ **D** 2–

(b) There are two isotopes of the element lithium.

$^{6}_{3}Li$ $^{7}_{3}Li$

(i) State why both isotopes react in the same way.

(1)

.....

.....

(ii) A sample of lithium contains 7.60% $^{6}_{3}Li$ and 92.4% $^{7}_{3}Li$

Calculate the relative atomic mass, A_r, of this sample of lithium.

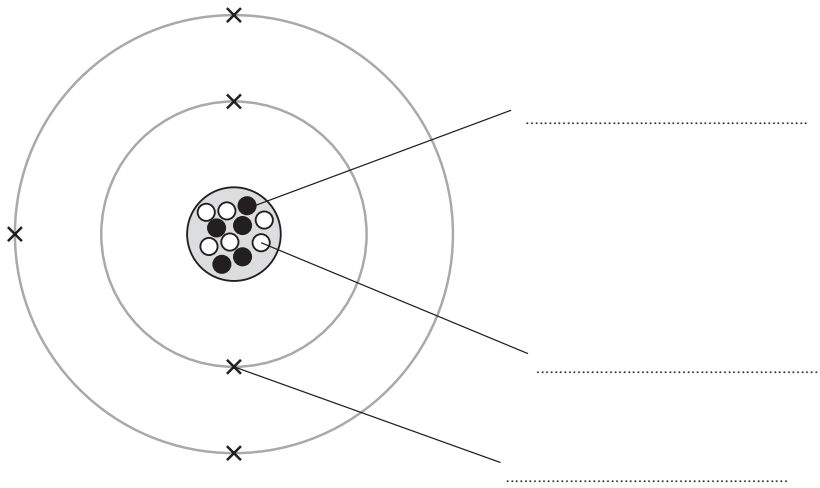
Give your answer to two decimal places.

(3)

A_r = ...

(Total for Question 3 = 8 marks)

1 The diagram represents an atom of an element.



(a) Label the three subatomic particles on the diagram.

(3)

(b) Use information from the diagram to complete the table for this element.

(4)

mass number	
group number	
period number	
electronic configuration	

(c) Give the name of this element.

(1)

.....

(Total for Question 1 = 8 marks)

2 (a) Table 1 shows some relative masses and charges of subatomic particles.

Complete table 1 by giving the missing information.

(2)

	Electron	Proton	Neutron
Relative mass	0.0005		
Relative charge			0

Table 1

(b) Table 2 gives the number of protons, neutrons and electrons in atoms and ions of some elements.

The letters are **not** the symbols of the elements.

Atom or ion	Protons	Neutrons	Electrons
P	3	4	2
Q	5	5	5
R	5	6	5
S	7	7	7
T	8	8	8
U	8	8	10

Table 2

(i) What is the atomic number of P in table 2?

(1)

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 7

(ii) What is the mass number of U in table 2?

(1)

- ☒ **A** 8
- ☒ **B** 16
- ☒ **C** 18
- ☒ **D** 26

(iii) Give the letter in table 2 that represents an element in Group 5 of the Periodic Table.

(1)

.....

(c) Q and R represent isotopes of the same element.

(i) Explain, in terms of subatomic particles, why Q and R are isotopes.

(2)

.....

.....

.....

.....

(ii) A sample containing the isotopes Q and R has this percentage composition by mass.

Q = 20.6 % R = 79.4 %

Calculate the relative atomic mass (A_r) of this sample of the element.

Give your answer to one decimal place.

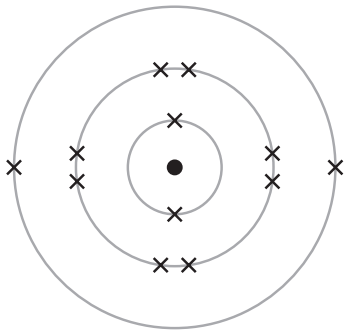
(3)

A_r = ...

(Total for Question 2 = 10 marks)

3 The diagram represents an atom of element Z.

Z is not the symbol of the element.



(a) (i) Give the number of the group to which element Z belongs.

(1)

.....

(ii) Give the number of the period to which element Z belongs.

(1)

.....

(iii) Give the formula of the compound that forms when Z reacts with fluorine.

(1)

.....

(b) One mole of Z contains 6.0×10^{23} atoms.

Calculate the number of electrons in one mole of atoms of element Z.

Give your answer in standard form.

(2)

number of electrons = ...

(c) A sample of element Z contains three isotopes. The table shows the numbers of particles in the nucleus of each isotope and the percentage abundance of each isotope.

Isotope	Number of protons	Number of neutrons	Percentage abundance
1	12	12	79.0
2	12	13	10.0
3	12	14	11.0

Use the information in the table to calculate the relative atomic mass (A_r) of element Z.

Give your answer to one decimal place.

(4)

A_r = ...

(d) Deduce the name of element Z.

(1)

.....

(Total for Question 3 = 10 marks)

2 (a) Table 1 gives some information about three subatomic particles.

(i) Complete Table 1 by giving the missing information.

(3)

Subatomic particle	Relative mass	Relative charge
electron	0.0005	
proton		+1
neutron	1	

Table 1

(ii) Give the name of the part of the atom containing protons and neutrons.

(1)

.....

(b) Table 2 shows the numbers of protons, neutrons and electrons in the species U, V, W, X, Y and Z.

Species	Number of protons	Number of neutrons	Number of electrons
U	8	10	8
V	9	10	10
W	11	12	10
X	11	12	11
Y	12	12	12
Z	12	13	12

Table 2

Use the information in Table 2 to answer these questions.

Each species may be used once, more than once or not at all.

(i) Give the letter of the species that has six electrons in its outer shell.

(1)

.....

(ii) Give the mass number of Z.

(1)

.....

(iii) Give the letter of the species that is a positive ion.

(1)

.....

(iv) Give the letters of the two species that are isotopes of the same element.

(1)

.....

(c) A sample of neon contains two isotopes, ^{20}Ne and ^{22}Ne

The relative abundances of the two isotopes in the sample are

^{20}Ne 91.2% ^{22}Ne 8.80%

Calculate the relative atomic mass of this sample of neon.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(Total for Question 2 = 11 marks)

5 (a) Complete the table to show the relative mass and relative charge of a proton and a neutron.

(2)

	Proton	Electron	Neutron
Relative mass		1/2000	
Relative charge		–1	

(b) Magnesium has three isotopes.

(i) State the meaning of the term **isotopes**.

(2)

(ii) The symbol for an atom of one isotope of magnesium is

$^{26}_{12}Mg$

Give the number of protons, neutrons and electrons in one atom of this isotope.

(2)

number of protons

number of neutrons

number of electrons

(iii) A sample of magnesium contains these percentages of the three isotopes.

Mg-24 = 79.00 % Mg-25 = 10.00 % Mg-26 = 11.00 %

Use this information to show that the relative atomic mass of magnesium is 24.32

(2)

(iv) One mole of magnesium has a mass of 24.32 g.
There are 6.022×10^{23} atoms in one mole.

Calculate the mass, in grams, of one atom of magnesium.

Give your answer to 4 significant figures.

(2)

mass = ... g

(c) The equation for the reaction between magnesium and oxygen is

$$2Mg + O_2 \rightarrow 2MgO$$

Determine the maximum amount, in moles, of magnesium oxide that can be produced from 0.50 mol of magnesium and 0.20 mol of oxygen.

(1)

amount = ... mol

(Total for Question 5 = 11 marks)

4 This question is about atoms and ions.

(a) Table 1 shows some information about sub-atomic particles.

Complete Table 1 by giving the missing information.

(3)

	Relative mass	Relative charge
Neutron		0
Proton	1	
Electron		–1

Table 1

(b) Table 2 shows the numbers of protons, neutrons and electrons in species A, B, C, D, E and F.

Species	Number of protons	Number of neutrons	Number of electrons
A	13	14	13
B	1	0	1
C	9	10	10
D	7	7	10
E	20	20	18
F	18	22	18

Table 2

Use the information in Table 2 to answer these questions.
Each species may be used once, more than once or not at all.

(i) Give the letter of the species that has 3 electrons in its outer shell.

(1)

.....

(ii) Give the letter of the species that is an ion with a 3– charge.

(1)

.....

(iii) Give the letter of the species with a mass number of 19

(1)

.....

(c) A sample of lithium contains two isotopes, ^{6}Li and ^{7}Li.

In terms of sub-atomic particles, give one similarity and one difference between these isotopes.

(2)

similarity

.....

.....

difference

.....

.....

(d) A sample of magnesium contains 79.0% of ^{24}Mg, 10.0% of ^{25}Mg and 11.0% of ^{26}Mg.

Calculate the relative atomic mass, A_r, of this sample of magnesium.

Give your answer to one decimal place.

(3)

A_r = ...

(Total for Question 4 = 11 marks)

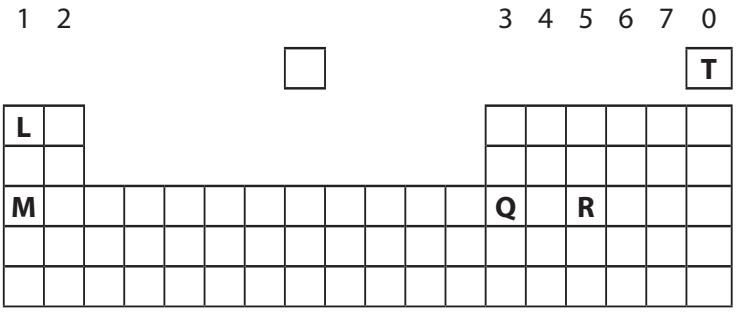
SUB-TOPIC 1d

THE PERIODIC TABLE

Sub-topic 1d · 11 questions · 74 marks · lowest tariff first

2 The diagram shows part of the Periodic Table, with elements represented by the letters L, M, Q, R and T.

The letters in the diagram represent elements but are **not** their chemical symbols.



(a) Give the letter from the diagram that represents a noble gas.

(1)

(b) Elements L and M are in the same group.

State why they have similar chemical reactions.

(1)

(c) An atom of element Q has 31 protons.

Use this information to explain how you can determine the number of protons in an atom of element R.

(2)

(Total for Question 2 = 4 marks)

1 In this question the answer to each part is a number.

(a) Give the pH value of a neutral solution.

(1)

.....

(b) Give a pH value of a weakly acidic solution.

(1)

.....

(c) Give the number of the Group in the Periodic Table that contains the elements that do **not** readily react.

(1)

.....

(d) Give the number of different elements present in glucose, $C_6H_{12}O_6$

(1)

.....

(Total for Question 1 = 4 marks)

5 In 1937 an airship full of hydrogen gas flew from Germany to America.

(a) Which property of hydrogen makes it a suitable gas to use in an airship?

(1)

- ☒ **A** colourless
- ☒ **B** insoluble in water
- ☒ **C** low density
- ☒ **D** no smell

(b) Explain why helium is now used in airships instead of hydrogen.

(2)

(c) Hydrogen is used to manufacture ammonia, NH_3

Hydrogen is reacted with nitrogen using an iron catalyst.

(i) Give a chemical equation for this reaction.

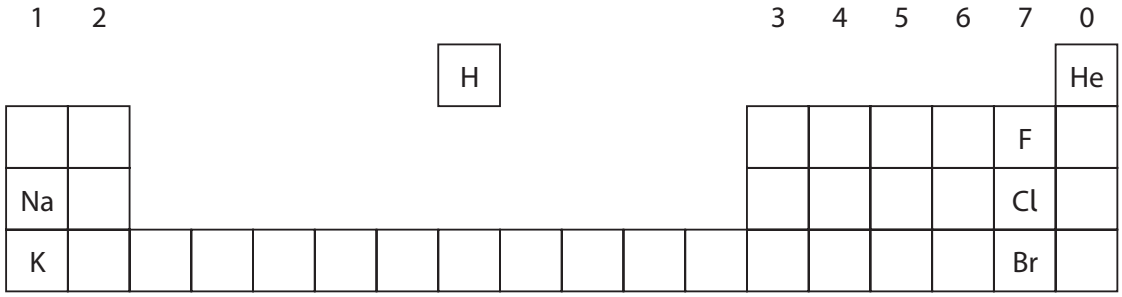
(1)

(ii) State why a catalyst is used in this reaction.

(1)

(Total for Question 5 = 5 marks)

2 The diagram shows the positions of some elements in the Periodic Table.



(a) Use symbols from this table to answer these questions.

Each symbol may be used once, more than once or not at all.

(i) Give the symbol of a metal.

(1)

.....

(ii) Give the symbol of a noble gas.

(1)

.....

(iii) Give the symbol of a liquid at room temperature.

(1)

.....

(iv) Give the symbols of the two elements in Period 3

(1)

..... and .....

(b) Deduce the electronic configuration of Na

(1)

.....

(Total for Question 2 = 5 marks)

1 Use the Periodic Table to help you answer this question.

(a) Identify the element with atomic number 7

(1)

(b) Identify a solid non-metallic element in Period 3

(1)

(c) Name an element in Group 7 that is a liquid at room temperature.

(1)

(d) State the relative atomic mass of the element that is in Group 4 and Period 4

(1)

(e) Which row shows the most reactive element in Group 1 and Group 7?

(1)

	Most reactive element in Group 1	Most reactive element in Group 7
☒ **A**	lithium	fluorine
☒ **B**	francium	astatine
☒ **C**	lithium	astatine
☒ **D**	francium	fluorine

(Total for Question 1 = 5 marks)

1 Use the Periodic Table to help you answer this question.

(a) (i) Name the element with atomic number 14

(1)

.....

(ii) Name the element with a relative atomic mass of 11

(1)

.....

(iii) Name the element in Group 2 and Period 3

(1)

.....

(b) (i) Determine the number of neutrons in a phosphorus atom with mass number 31

(1)

.....

(ii) State the electronic configuration of an aluminium atom.

(1)

.....

(iii) State why neon is unreactive.

(1)

.....

.....

(Total for Question 1 = 6 marks)

1 This question is about chemical elements.

Use the Periodic Table to help you answer this question.

(a) (i) Identify the element with atomic number 5

(1)

.....

(ii) Give the symbol of a metallic element in Period 3

(1)

.....

(iii) Identify the element whose atoms contain 14 protons.

(1)

.....

(iv) Identify the element whose atoms have the electronic configuration 2.5

(1)

.....

(v) Give the name of the compound formed between oxygen and the element with atomic number 13

(1)

.....

(b) The position of an element in the Periodic Table can be used to predict its properties.

(i) Which group contains elements that are all unreactive?

(1)

☒ **A** Group 2

☒ **B** Group 5

☒ **C** Group 6

☒ **D** Group 0

(ii) Which of these is the least reactive element in Group 1?

(1)

☒ **A** caesium

☒ **B** lithium

☒ **C** potassium

☒ **D** sodium

(Total for Question 1 = 7 marks)

1 Use the Periodic Table to help you answer this question.

(a) (i) Name the element with atomic number 14.

(1)

.....

(ii) Name the element in Group 2 and Period 3.

(1)

.....

(iii) Name an element that is a liquid at room temperature.

(1)

.....

(iv) Give the electronic configuration of an atom of phosphorus.

(1)

.....

(v) Give the formula of sodium sulfide.

(1)

.....

(b) Explain, in terms of electron configuration, why neon is unreactive.

(2)

.....

.....

.....

.....

(Total for Question 1 = 7 marks)

1 Use the Periodic Table to answer these questions.

(a) (i) Give the name of the element with atomic number 16

(1)

(ii) Give the name of the element with relative atomic mass 9

(1)

(iii) Give the name of the element in Group 3 and Period 2

(1)

(iv) Give the electronic configuration of an atom of silicon.

(1)

(b) Explain, in terms of electron configuration, why sodium is more reactive than lithium.

(3)

(Total for Question 1 = 7 marks)

5 (a) Chlorine, bromine and iodine are elements in the Periodic Table.

Explain how the position of these elements in the Periodic Table depends on their electronic configurations.

(2)

(b) Chlorine reacts with methane to form CH_3Cl and HCl

(i) State the condition necessary for this reaction.

(1)

(ii) Give the equation for this reaction.

(1)

(iii) The bonds in a molecule of CH_3Cl are covalent.

Explain, in terms of electrostatic attractions, what is meant by a covalent bond.

(2)

(iv) Draw a dot-and-cross diagram for a molecule of CH_3Cl

Show only the outer electrons of the atoms.

(2)

H

H C Cl

H

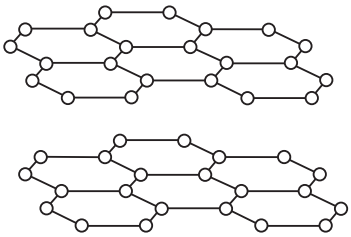
(v) CH_3Cl has a simple molecular structure.

Explain why CH_3Cl has a low boiling point.

(2)

(c) Graphite is another substance that contains covalent bonds.

The diagram shows the structure of graphite.



Most covalent substances do not conduct electricity.

Explain why graphite is able to conduct electricity.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 5 = 12 marks)

4 The diagram shows the positions of some elements in part of the Periodic Table.

Na												Al			S	Cl	
K																	Xe
												In					

(a) (i) Give the symbol of a metal from the diagram.

(1)

.....

(ii) Give the symbol of an element from the diagram that forms an acidic oxide.

(1)

.....

(b) Give a similarity in the electron configurations of Al and In.

(1)

.....

.....

(c) Explain which element in the diagram is unreactive.

(2)

.....

.....

.....

.....

(d) A teacher adds a small piece of sodium to a glass trough containing water and universal indicator.

The universal indicator changes colour.

The equation for the reaction is

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

(i) Explain the final colour of the universal indicator.

(2)

.....

.....

.....

.....

(ii) The teacher repeats the experiment with potassium instead of sodium.

Give one similarity and one difference observed with potassium.

(2)

similarity

.....

.....

difference

.....

.....

(iii) The reaction with sodium produces 0.036 g of hydrogen gas.

One mole of hydrogen gas contains 6.0×10^{23} molecules.

Calculate the number of molecules of hydrogen gas produced in the reaction with sodium.

Give your answer to two significant figures.

(3)

number of molecules of hydrogen gas = ...

(Total for Question 4 = 12 marks)

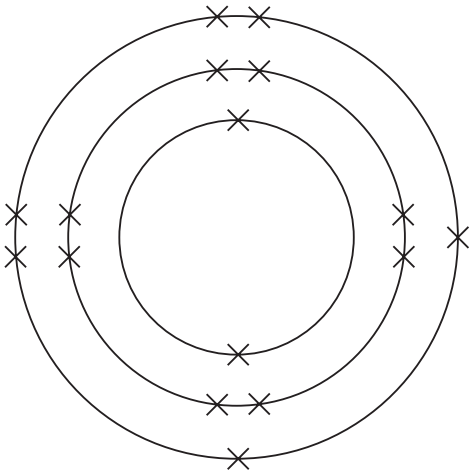
SUB-TOPIC 1e

CHEMICAL FORMULAE, EQUATIONS AND CALCULATIONS

Sub-topic 1e · 27 questions · 285 marks · lowest tariff first

1 This question is about sulfur.

(a) The diagram represents the electronic configuration of an atom of sulfur.



(i) Which period of the Periodic Table contains sulfur?

(1)

- ☒ **A** 2
- ☒ **B** 3
- ☒ **C** 4
- ☒ **D** 6

(ii) What is the charge on a sulfide ion?

(1)

- ☒ **A** 1+
- ☒ **B** 2+
- ☒ **C** 1–
- ☒ **D** 2–

(b) When a mixture of sulfur and zinc is heated to a high temperature a reaction occurs, forming the compound zinc sulfide, ZnS

(i) Give a reason why the mixture of sulfur and zinc needs heating before a reaction occurs.

(1)

.....

.....

(ii) Calculate the relative formula mass (M_r) of zinc sulfide.

[for Zn, $A_r = 65$ for S, $A_r = 32$]

(1)

M_r = ...

(Total for Question 1 = 4 marks)

7 A sample of a gaseous hydrocarbon, X, has a volume of 600 cm^3 at room temperature and pressure (rtp).

(a) Calculate the amount, in moles, of hydrocarbon X in the sample.

[molar volume of a gas = 24 000 cm^3 at rtp]

(2)

amount of hydrocarbon X = ... mol

(b) The mass of the sample of hydrocarbon X is 1.45 g.

Show that the relative molecular mass (M_r) of X is 58

(2)

M_r = ...

(c) Hydrocarbon X is an alkane.

Show that the molecular formula of X is C_4H_{10}

(1)

(d) Give the displayed formula of the branched-chain isomer of hydrocarbon X.

(1)

(Total for Question 7 = 6 marks)

7 (a) Explain the meaning of the term **thermal decomposition**.

(2)

.....

.....

.....

.....

(b) The equation for the thermal decomposition of potassium hydrogencarbonate is

$$2KHCO_3 \rightarrow K_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of K_2CO_3 that could be produced from the thermal decomposition of 2.50 g of $KHCO_3$

(4)

maximum mass of K_2CO_3 = ... g

(Total for Question 7 = 6 marks)

8 The concentration of NaClO(aq) in a solution of bleach is found by reacting it with hydrochloric acid.

The equation for the reaction is

$$NaClO(aq) + 2HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + Cl_2(g)$$

An excess of dilute hydrochloric acid is added to 4.00 cm^3 of bleach solution.

60.0 cm^3 of chlorine gas is produced.

(a) Explain a safety precaution that should be taken when doing this experiment.

(2)

.....

.....

.....

.....

(b) (i) Calculate the amount, in moles, of chlorine gas produced.
Assume one mole of chlorine gas occupies 24 000 cm^3.

(2)

amount of chlorine = ... mol

(ii) Determine the amount, in moles, of NaClO in 4.00 cm^3 of bleach.

(1)

amount of NaClO = ... mol

(iii) Calculate the concentration, in mol/dm^3, of the bleach solution.

(2)

concentration = ... mol/dm^3

(Total for Question 8 = 7 marks)

7 This question is about reactions involving gases.

(a) Potassium carbonate reacts with dilute hydrochloric acid to produce carbon dioxide gas.

The equation for the reaction is

$$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + CO_2(g)$$

Calculate the volume, in cm^3, of carbon dioxide gas produced when 6.9 g of potassium carbonate reacts with excess dilute hydrochloric acid.

[M_r of K_2CO_3 = 138]

[molar volume of CO_2 at rtp = 24 dm^3]

(3)

volume = ... cm^3

(b) This reaction involving gases is in dynamic equilibrium at a temperature of 225 °C.

$$H_2(g) + CO_2(g) \rightleftharpoons CO(g) + H_2O(g) \qquad \Delta H = +41\ kJ/mol$$

(i) Predict the effect on the yield of CO(g) at equilibrium when the temperature is increased without changing the pressure.

Give a reason for your answer.

(2)

(ii) Predict the effect on the yield of CO(g) at equilibrium when the pressure is increased without changing the temperature.

Give a reason for your answer.

(2)

(Total for Question 7 = 7 marks)

4 Calcium phosphate is an ionic compound with the formula $Ca_3(PO_4)_2$

(a) (i) What is the total number of atoms in the formula $Ca_3(PO_4)_2$?

(1)

- ☒ **A** 8
- ☒ **B** 11
- ☒ **C** 13
- ☒ **D** 19

(ii) What are the correct charges on the ions in calcium phosphate?

(1)

- ☒ **A** Ca^{2+} and PO_4^{2-}
- ☒ **B** Ca^{2+} and PO_4^{3-}
- ☒ **C** Ca^{3+} and PO_4^{2-}
- ☒ **D** Ca^{3+} and PO_4^{3-}

(b) (i) Calculate the relative formula mass (M_r) of $Ca_3(PO_4)_2$

(2)

M_r of $Ca_3(PO_4)_2$ = ...

(ii) Calculate the percentage by mass of calcium in calcium phosphate.

(2)

percentage = ...%

(c) Calcium hydroxide can react with phosphoric acid to form calcium phosphate.

Complete the equation for this reaction.

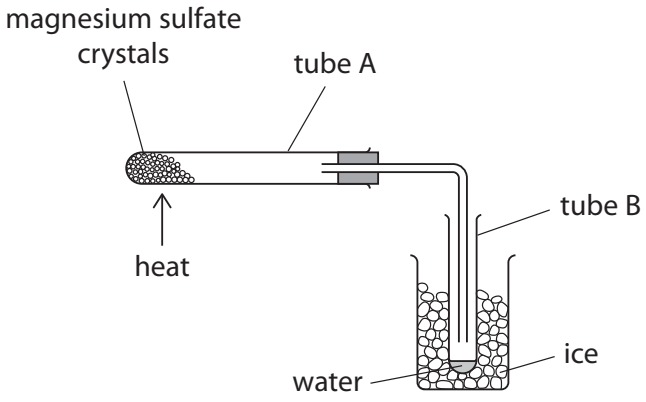
(1)

.....$Ca(OH)_2$ + ...H_3PO_4 → .....$Ca_3(PO_4)_2$ + ...H_2O

(Total for Question 4 = 7 marks)

7 Magnesium sulfate crystals have the formula $MgSO_4.xH_2O$

A student uses this apparatus to heat tube A and collect water of crystallisation in tube B.



The student records the mass of tube B at the start and every minute for 6 minutes.

The table gives the student's results.

Time in minutes	Mass of tube B in g
0	15.8
1	16.5
2	17.6
3	19.2
4	20.4
5	22.1
6	22.1

(a) (i) Give a reason why the student surrounds tube B with ice.

(1)

.....

.....

(ii) State how the student knows when all the water of crystallisation has been given off.

(1)

.....

.....

(b) Describe a chemical test the student can use to show that the liquid in tube B contains water.

(2)

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.....

(c) The decomposition of hydrated magnesium sulfate is shown in the equation.

$$MgSO_4.xH_2O \rightarrow MgSO_4 + xH_2O$$

At the end of the reaction, the mass of $MgSO_4$ remaining in the tube is 6.0 g.

Use this mass and the results in the table to calculate x in $MgSO_4.xH_2O$

[for $MgSO_4$, $M_r = 120$ for H_2O, $M_r = 18$]

(4)

x = ...

(Total for Question 7 = 8 marks)

11 The gas burned in a Bunsen burner is methane.

The equation for the complete combustion of methane is

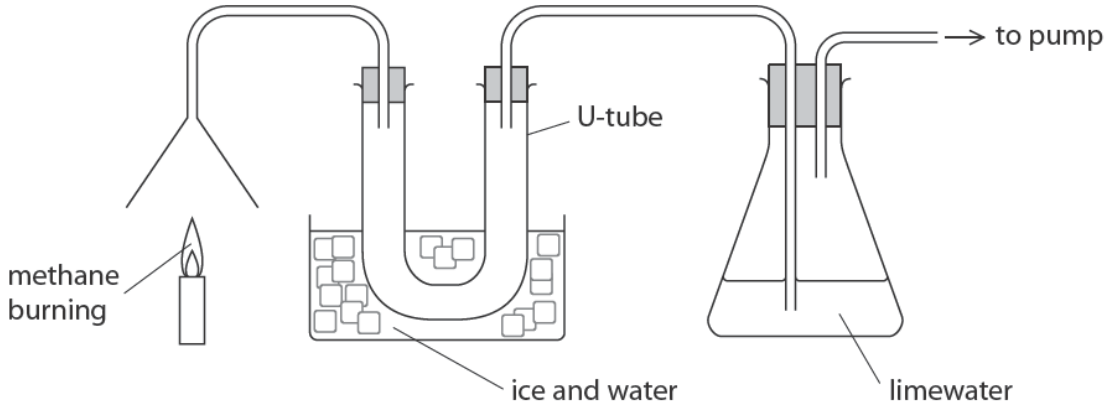
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

(a) Calculate the mass of oxygen required to react with 32 g of methane.
[M_r of methane = 16]

(2)

mass of oxygen = ... g

(b) The diagram shows methane burning in air. It also shows how the two gases formed are collected and tested.



(i) Explain why water collects in the U-tube.

(2)

.....

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(ii) Describe how anhydrous copper(II) sulfate is used to test for water.

(2)

(iii) Explain the change in appearance of the limewater.

(3)

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(Total for Question 11 = 9 marks)

10 (a) A student is given a pure sample of sodium carbonate crystals and is told that the formula of the crystals is $Na_2CO_3.xH_2O$

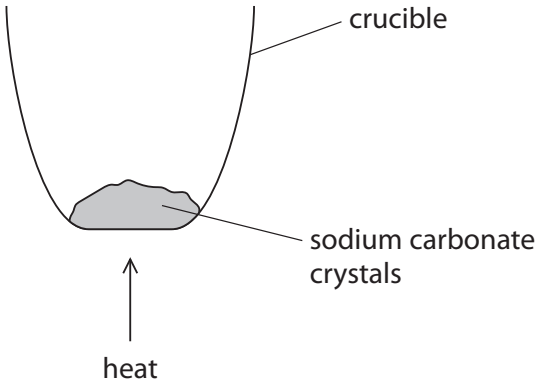
State what xH_2O in the formula shows about the sodium carbonate crystals.

(1)

.....

.....

(b) The student uses this apparatus to find the value of x in $Na_2CO_3.xH_2O$



This is the student's method.

- find the mass of an empty crucible without a lid
- add some sodium carbonate crystals $Na_2CO_3.xH_2O$ to the crucible
- find the total mass of the crucible and sodium carbonate crystals
- heat the crucible to remove water from the crystals
- allow the crucible and contents to cool down
- find the mass of the cold crucible and contents

These are the student's results.

	Mass in grams
empty crucible	22.75
crucible and sodium carbonate crystals $Na_2CO_3.xH_2O$	29.71
cold crucible and contents	25.93

(i) Calculate the mass of sodium carbonate left after heating and cooling.

(1)

mass of sodium carbonate = ... g

(ii) Calculate the mass of H_2O lost from the sodium carbonate crystals during heating.

(1)

mass of H_2O = ... g

(iii) Show that the student's results suggest that the formula of the sodium carbonate crystals is $Na_2CO_3.7H_2O$

[M_r of Na_2CO_3 = 106 M_r of H_2O = 18]

(3)

(c) The student's teacher says that the correct formula of the sodium carbonate crystals is $Na_2CO_3.10H_2O$

(i) The student did not make any mistakes in their measurements.

Explain what could have caused the student's value for *x* to be too low.

(2)

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.....

(ii) Describe how the student could improve the method to obtain a more accurate value for *x*.

(2)

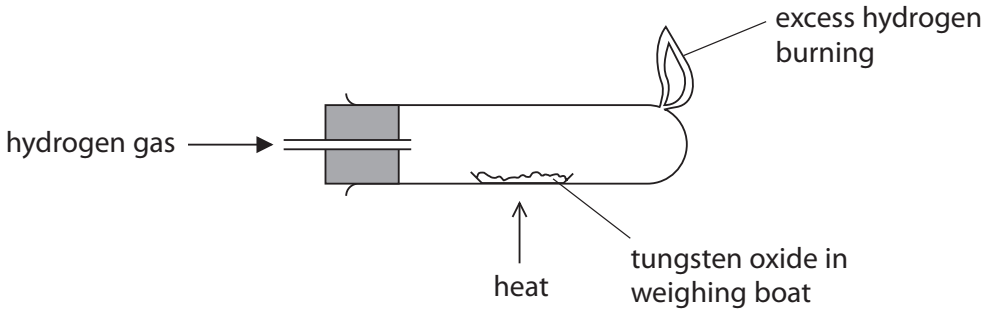
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(Total for Question 10 = 10 marks)

11 This question is about the reduction of tungsten oxide, WO_3

(a) A teacher uses this apparatus to reduce tungsten oxide.



This is the teacher's method.

- record the mass of a weighing boat
- add tungsten oxide and record the mass again
- heat the weighing boat and tungsten oxide strongly for two minutes and then allow to cool
- record the mass of the weighing boat and its contents

(i) Complete the equation by adding the state symbols.

(2)

$$WO_3(\ldots\ldots) + 3H_2(\ldots\ldots) \rightarrow W(\ldots\ldots) + 3H_2O(\ldots\ldots)$$

(ii) Give an addition to the method to check that the tungsten oxide has been completely reduced.

(1)

.....

.....

(iii) The table shows the teacher's results.

	Mass in g
empty weighing boat	14.72
weighing boat and tungsten oxide	17.04
weighing boat and tungsten	16.56

Use the teacher's results to show that the empirical formula of tungsten oxide is WO_3

[for tungsten, $A_r = 184$ for oxygen, $A_r = 16$]

(3)

(iv) The teacher wears eye protection and a lab coat during the experiment.

Give one other safety precaution the teacher should take.

(1)

.....

.....

(b) In industry, tungsten oxide is reduced on a large scale using hydrogen.

The percentage yield of tungsten is 73.5%

This is the equation for the reaction.

$$WO_3 + 3H_2 \rightarrow W + 3H_2O$$

Calculate the mass, in tonnes, of tungsten that is produced when 2784 tonnes of tungsten oxide are reacted with an excess of hydrogen.

[1 tonne = 1×10^6 g]

[for tungsten, $A_r = 184$ for oxygen, $A_r = 16$]

(3)

mass of tungsten = ... tonnes

(Total for Question 11 = 10 marks)

9 This question is about the oxides of lead.

(a) Yellow lead oxide (PbO) can be reacted with hydrogen to produce lead.

(i) Complete the equation for the reaction by adding the missing state symbols.

(1)

$$PbO(s) + H_2(\ldots\ldots) \rightarrow Pb(\ldots\ldots) + H_2O(\ldots\ldots)$$

(ii) What is the charge on the lead ion in PbO?

(1)

☒ **A** 1–

☒ **B** 1+

☒ **C** 2–

☒ **D** 2+

(iii) Explain why the reaction of yellow lead oxide with hydrogen is a redox reaction.

(2)

(iv) Describe a physical test to show that the water produced in this reaction is pure.

(2)

(b) When red lead oxide (Pb_3O_4) is heated, yellow lead oxide forms.

The equation for the reaction is

$$2Pb_3O_4 \rightarrow 6PbO + O_2$$

A scientist heats a known mass of red lead oxide in a crucible in a fume cupboard.

The scientist leaves the crucible to cool, then records the total mass of the crucible and its contents.

(i) Describe what the scientist should do next to make sure that all the red lead oxide has reacted.

(2)

.....

.....

.....

.....

(ii) The red lead oxide used in the reaction has a mass of 5.48 g.

Calculate the maximum mass of yellow lead oxide that could form.

[M_r of Pb_3O_4 = 685 M_r of PbO = 223]

(3)

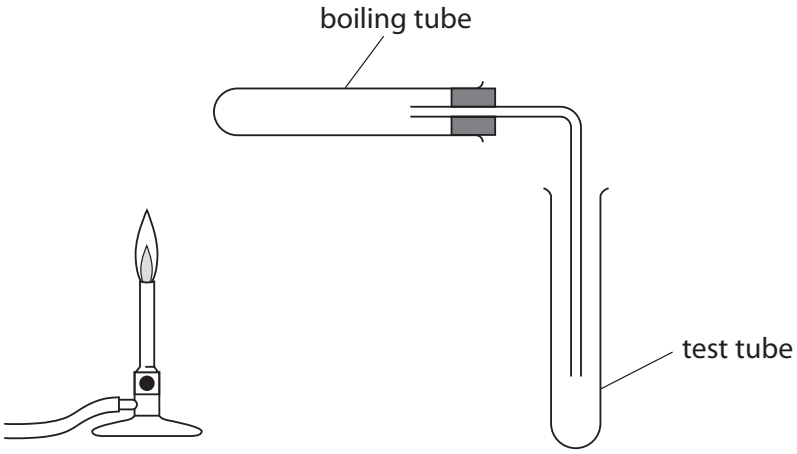
maximum mass of PbO = ... g

(Total for Question 9 = 11 marks)

5 This question is about metal carbonates.

When heated, some metal carbonates decompose to form a metal oxide and carbon dioxide gas.

(a) A student is given three solid metal carbonates, a timer, some limewater and this apparatus.



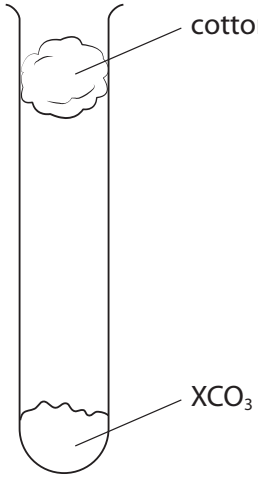
Describe a method the student can use to find out which metal carbonate decomposes fastest when heated.

(4)

(b) A student is given a solid metal carbonate with the formula XCO_3

X represents the symbol of a Group 2 metal.

A student uses this apparatus to heat a sample of XCO_3 until it all decomposes.



The equation for the decomposition of XCO_3 is

$$XCO_3 \rightarrow XO + CO_2$$

The student records the mass of XCO_3 and the mass of carbon dioxide that escapes through the cotton wool plug.

These are the student's results.

mass of XCO_3 = 7.40 g

mass of CO_2 = 2.20 g

(i) Give a reason why the student uses a cotton wool plug.

(1)

.....

.....

(ii) Calculate the amount, in mol, of carbon dioxide produced.

[for carbon dioxide $M_r = 44$]

(1)

amount of carbon dioxide = ... mol

(iii) Use the equation to determine the amount, in mol, of XCO_3 that decomposed.

(1)

amount of XCO_3 = ... mol

(iv) Use the mass of XCO_3 and your answer to (b)(iii) to calculate the relative formula mass (M_r) of XCO_3

(2)

M_r of XCO_3 = ...

(v) Use your answer to (b)(iv) and the Periodic Table on page 2 to determine the identity of the Group 2 metal X.

Show your working.

(2)

identity of X = ...

(Total for Question 5 = 11 marks)

12 This question is about the metal tantalum, Ta.

Tantalum metal can be produced by heating tantalum chloride ($TaCl_5$) and hydrogen gas in a furnace.

The other product of the reaction is hydrogen chloride.

(a) Complete the equation for the reaction.

(1)

..... $TaCl_5(s)$ + ... $H_2(g)$ → ..... $Ta(s)$ + ... $HCl(g)$

(b) As tantalum chloride is heated, the mass of solid in the furnace decreases leaving tantalum as the only solid product.

The table shows the mass of solid in the furnace at one-hour intervals.

Time in hours	Mass of solid in the furnace in kg
0	2510
1	2207
2	1960
3	1506
4	1329
5	1267
6	1267
7	1267

(i) State how the data in the table shows that the reaction is complete.

(1)

.....

.....

(ii) Use the data to show that the formula of tantalum chloride is $TaCl_5$

[for tantalum, $A_r = 181$ for chlorine, $A_r = 35.5$]

(3)

QUESTION 12 CONTINUES ON NEXT PAGE.

(c) Another method of extracting tantalum is by reacting tantalum(V) oxide with carbon.

This is the equation for the reaction.

$$Ta_2O_5(s) + 5C(s) \rightarrow 2Ta(s) + 5CO(g)$$

(i) Explain why this is a redox reaction.

(2)

.....

.....

.....

.....

(ii) 2000 mol of tantalum(V) oxide is heated with 500 000 g of carbon.

Show by calculation that the carbon is in excess.

[for carbon, $A_r = 12$]

(2)

(iii) Calculate the maximum mass, in grams, of tantalum that can be obtained from 2000 mol of tantalum(V) oxide.

[for tantalum, $A_r = 181$]

(2)

mass = ... g

(Total for Question 12 = 11 marks)

11 This question is about sodium sulfate, Na_2SO_4

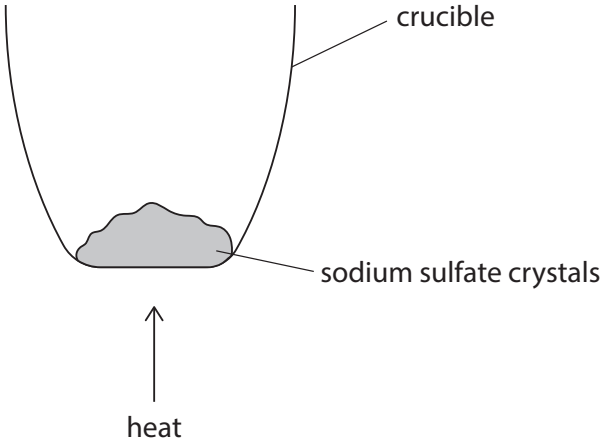
(a) A teacher finds an unlabelled bottle containing a white solid.

Describe tests to show that the white solid is sodium sulfate.

(5)

(b) A student has a sample of crystals of hydrated sodium sulfate, $Na_2SO_4.xH_2O$

The student uses this apparatus to find the value of x in $Na_2SO_4.xH_2O$



This is the student's method.

- find the mass of the empty crucible
- add some hydrated sodium sulfate crystals to the crucible
- find the total mass of the crucible and hydrated sodium sulfate crystals
- heat the crucible to remove water from the crystals
- find the mass of the crucible and its contents every 2 minutes for 10 minutes

The table shows the student's results.

	Mass in grams
mass of empty crucible	23.57
mass of empty crucible and $Na_2SO_4.xH_2O$	26.79
mass after 2 minutes	26.34
mass after 4 minutes	25.73
mass after 6 minutes	25.23
mass after 8 minutes	24.99
mass after 10 minutes	24.99

(i) State how the results show that all the water has been removed from the crystals.

(1)

.....

.....

(ii) Calculate the mass of anhydrous sodium sulfate remaining after heating.

(1)

mass of anhydrous sodium sulfate = ... g

(iii) Calculate the mass of water lost from the sodium sulfate crystals during heating.

(1)

mass of water = ... g

(iv) Use the student's results to calculate x in the formula $Na_2SO_4.xH_2O$

[for Na_2SO_4, $M_r = 142$ for H_2O, $M_r = 18$]

(3)

x = ... J

(Total for Question 11 = 11 marks)

10 Nitric acid (HNO_3) is used in the production of fertilisers.

Nitric acid is manufactured in three stages.

Stage 1 ammonia reacts with oxygen in the presence of a platinum catalyst to produce nitrogen monoxide gas, NO, and water.

Stage 2 nitrogen monoxide gas reacts with more oxygen to produce nitrogen dioxide gas, NO_2.

Stage 3 nitrogen dioxide gas reacts with water to produce nitric acid and more nitrogen monoxide gas.

(a) (i) Complete the chemical equation for the reaction in stage 1.

(1)

.....NH_3 + ...O_2 $\rightleftharpoons$ .....NO + ...H_2O

(ii) Give the meaning of the symbol $\rightleftharpoons$

(1)

.....

.....

(iii) State the purpose of the platinum catalyst.

(1)

.....

.....

(b) Give a chemical equation for the reaction of nitrogen monoxide and oxygen in stage 2.

(1)

.....

(c) (i) The equation for the reaction in stage 3 is

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Calculate the maximum mass, in tonnes, of nitric acid that could be produced in this reaction from 11.5 tonnes of nitrogen dioxide.

[1 tonne = 1.0×10^6g]

(4)

mass of nitric acid = ... tonnes

(ii) Suggest what use can be made of the nitrogen monoxide gas formed in stage 3.

(1)

.....

.....

.....

QUESTION 10 CONTINUES ON NEXT PAGE

(d) When copper(II) oxide reacts with dilute nitric acid, copper(II) nitrate is produced.

The equation for the reaction is

$$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$$

0.200 mol of nitric acid reacts with excess copper(II) oxide.

A mass of 15.3 g of copper(II) nitrate is produced.

Calculate the percentage yield of copper(II) nitrate.

[M_r of copper(II) nitrate = 187.5]

(3)

percentage yield = ... %

(Total for Question 10 = 12 marks)

9 Sodium hydrogencarbonate ($NaHCO_3$) is also known as baking soda.

Baking soda can be used to make cakes increase in size in an oven.

This is the equation for the reaction that takes place when baking soda is heated.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

(a) (i) What type of reaction is this?

(1)

☒ **A** combustion

☒ **B** decomposition

☒ **C** oxidation

☒ **D** reduction

(ii) Suggest why the reaction makes the cakes increase in size.

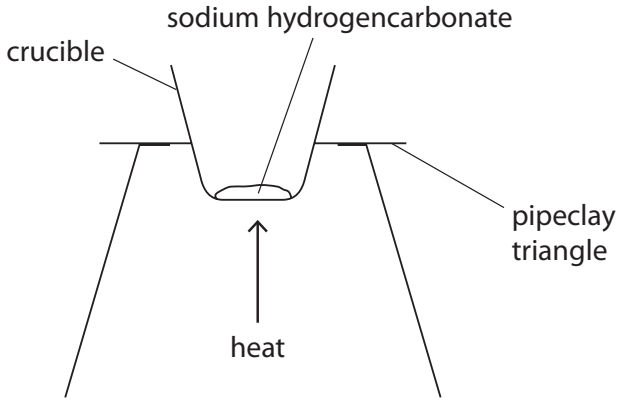
(1)

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.....

.....

(b) A student uses this apparatus to investigate the reaction that takes place when sodium hydrogencarbonate is heated.



This is the student's method.

- weigh a crucible and record the mass
- add some sodium hydrogencarbonate to the crucible, reweigh it and record the mass
- heat the crucible and contents for five minutes, then allow to cool before weighing and recording the mass
- heat the crucible and contents again for a further three minutes, then allow to cool before weighing and recording the mass

(i) Give a reason why the crucible and contents are heated for a further three minutes.

(1)

.....

.....

.....

(ii) The student considered using a lid on the crucible in the experiment.

Suggest an advantage and a disadvantage of using a lid on the crucible.

(2)

advantage .....

.....

.....

disadvantage .....

.....

.....

(c) The table shows some of the student's results.

mass of crucible and sodium hydrogencarbonate in g	29.75
mass of empty crucible in g	26.50

(i) Calculate the mass of sodium hydrogencarbonate that the student uses.

(1)

mass = ... g

(ii) Using this equation, calculate the maximum mass of sodium carbonate (Na_2CO_3) that could form in the student's reaction.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

[M_r of $NaHCO_3 = 84$ M_r of $Na_2CO_3 = 106$]

(3)

maximum mass = ... g

(d) In a second experiment, the student uses a larger mass of sodium hydrogencarbonate.

She calculates that she should obtain 4.8 g of sodium carbonate.

She actually obtains 4.2 g of sodium carbonate.

(i) Calculate the percentage yield from the student's experiment.

(2)

percentage yield = ... %

(ii) Other than spillages, suggest a possible reason why the student's actual yield is less than expected.

(1)

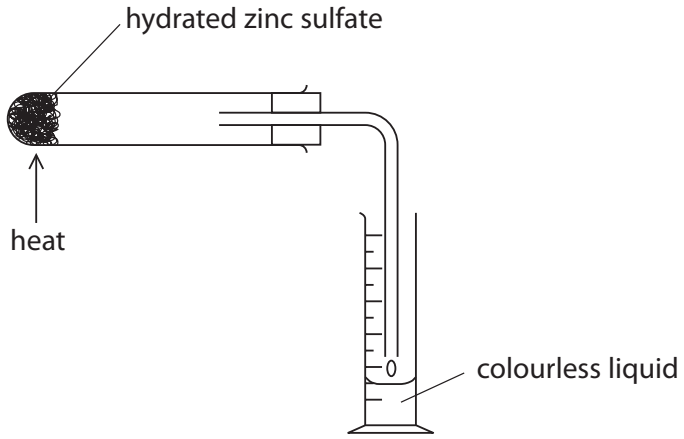
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(Total for Question 9 = 12 marks)

11 A student uses this apparatus to heat crystals of hydrated zinc sulfate and collect the liquid produced.



(a) (i) Describe a chemical test to show that the colourless liquid contains water.

(2)

(ii) Describe a physical test to show the colourless liquid is pure water.

(2)

(b) The equation for the decomposition of hydrated zinc sulfate is

$$ZnSO_4 \cdot 7H_2O(s) \rightarrow ZnSO_4(s) + 7H_2O(l)$$

The student records these masses.

mass of boiling tube = 41.64 g

mass of boiling tube + $ZnSO_4 \cdot 7H_2O$ = 54.46 g

Calculate the maximum volume, in cm^3, of pure water that could be produced.

Give your answer to 1 decimal place.

[1.00 cm^3 of pure water has a mass of 1.00 g]

[M_r of $ZnSO_4 \cdot 7H_2O$ = 287 M_r of H_2O = 18]

(5)

maximum volume of pure water = ... cm^3

(c) In an experiment using a different mass of $ZnSO_4 \cdot 7H_2O$ the maximum volume of pure water that could be produced is 8.5 cm^3.

The student collected the pure water and calculated the percentage yield to be 20.3 %.

(i) Calculate the volume, in cm^3, of pure water collected.

(1)

volume of pure water = ... cm^3

(ii) Explain an improvement to the apparatus that would increase the percentage yield of pure water.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 11 = 12 marks)

8 This question is about the oxides of some elements in Group 4 of the Periodic Table.

(a) When 5.34 g of lead(II) carbonate are heated, lead(II) oxide and carbon dioxide are formed.

This is the equation for the reaction.

$$PbCO_3(s) \rightarrow PbO(s) + CO_2(g)$$

(i) Give the name for this type of reaction.

(1)

.....

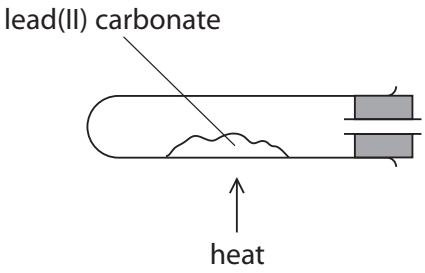
(ii) Calculate the maximum mass of lead(II) oxide that can be formed from 5.34 g of lead(II) carbonate.

[for $PbCO_3$, $M_r = 267$ for PbO, $M_r = 223$]

(2)

maximum mass = ... g

(b) The diagram shows apparatus used to heat lead(II) carbonate.



(i) Complete the diagram to show what needs to be added to the apparatus to test that the gas released is carbon dioxide.

(2)

(ii) Give the result of the test.

(1)

.....

.....

(c) Silicon dioxide (SiO_2) and carbon dioxide both contain covalent bonds.

Silicon dioxide is a solid with a high melting point. Carbon dioxide is a gas at room temperature.

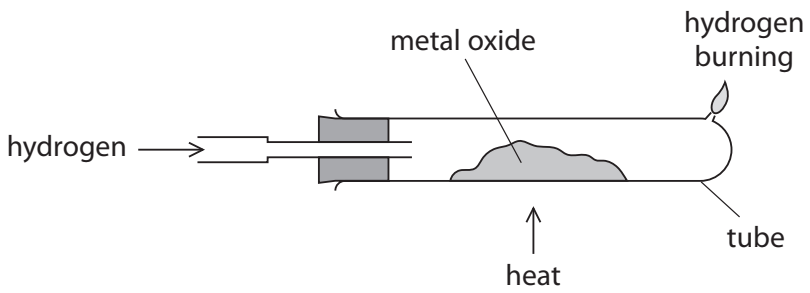
Explain why silicon dioxide has a much higher melting point than carbon dioxide.

Refer to structure and bonding in your answer.

(6)

(Total for Question 8 = 12 marks)

9 A scientist uses this apparatus in an experiment to reduce a metal oxide to a metal.



Before heating the mass of the empty tube and the mass of the tube and the metal oxide are recorded.

After heating, the tube is allowed to cool and the mass of the tube and its contents is recorded again.

(a) (i) State why the reaction of the metal oxide to form a metal is described as a reduction reaction.

(1)

.....

.....

(ii) State why it is important to relight the hydrogen at the end of the tube if the flame goes out.

(1)

.....

.....

(iii) Explain why it is important to continue passing hydrogen into the tube and burning the hydrogen at the end of the tube until the contents have cooled.

(2)

.....

.....

.....

.....

(iv) Describe what should be done next to ensure that all the metal oxide has been converted into the metal.

(2)

.....

.....

.....

.....

(b) In this experiment a mass of 4.14 g of metal is formed from 4.46 g of the metal oxide.

(i) Calculate the amount, in moles, of oxygen atoms in the sample of the metal oxide.

(2)

amount of oxygen atoms = ... mol

(ii) The formula of the metal oxide is MO, where M represents the symbol of the metal.

Deduce the amount, in moles, of M in the sample of the metal oxide.

(1)

amount of M = ... mol

(iii) Calculate the relative atomic mass of M.

(2)

relative atomic mass of M = ...

(iv) Use the Periodic Table to identify metal M.

(1)

.....

(Total for Question 9 = 12 marks)

4 Caffeine is a stimulant found in coffee, tea and some soft drinks.

(a) The molecular formula of caffeine is $C_8H_{10}N_4O_2$

(i) Determine the number of atoms in one molecule of caffeine.

(1)

.....

(ii) Calculate the relative formula mass (M_r) of caffeine.

(2)

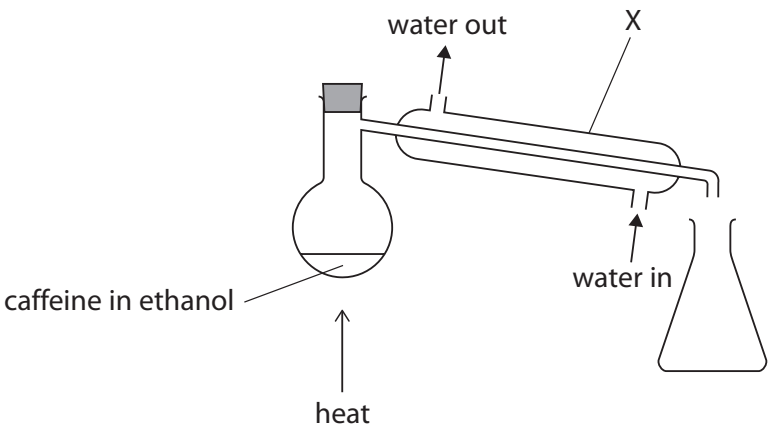
M_r = ...

(iii) Give the empirical formula for caffeine.

(1)

.....

(b) Ethanol can be obtained from a solution of caffeine in ethanol using this apparatus.



(i) Give the name of the method of separation shown in the diagram.

(1)

.....

(ii) Describe what happens to the ethanol vapour in apparatus X.

(2)

.....

.....

.....

.....

(c) Calcium bromide is an ionic compound.

The table shows the formulae and melting points of caffeine and calcium bromide.

Name	Formula	Melting point in °C
caffeine	$C_8H_{10}N_4O_2$	235
calcium bromide	$CaBr_2$	730

The relative formula mass of calcium bromide is similar to the relative formula mass of caffeine.

Explain why calcium bromide has a much higher melting point than caffeine.

(5)

(Total for Question 4 = 12 marks)

10 The table gives information about some lead compounds.

Compound	Formula	Appearance	Solubility in water
lead(II) oxide	PbO	yellow solid	insoluble
lead(IV) oxide	PbO_2	brown solid	insoluble
red lead oxide	Pb_3O_4	red solid	insoluble
lead(II) nitrate	$Pb(NO_3)_2$	white solid	soluble

(a) When a sample of red lead oxide is heated, it changes into a yellow solid and a gas forms that relights a glowing splint.

Complete the word equation for this reaction.

(2)

red lead oxide → ..... + ...

(b) A sample of one of the oxides of lead contains 86.6% lead and 13.4% oxygen by mass.

Show by calculation that the sample is lead(IV) oxide, PbO_2

[A_r of Pb = 207 A_r of O = 16]

(3)

(c) Red lead oxide reacts with warm dilute nitric acid.

(i) Complete the chemical equation for the reaction.

Pb_3O_4(.....) + $4HNO_3$(.....) → .....$Pb(NO_3)_2$(aq) + PbO_2(s) + ...H_2O(l)

(2)

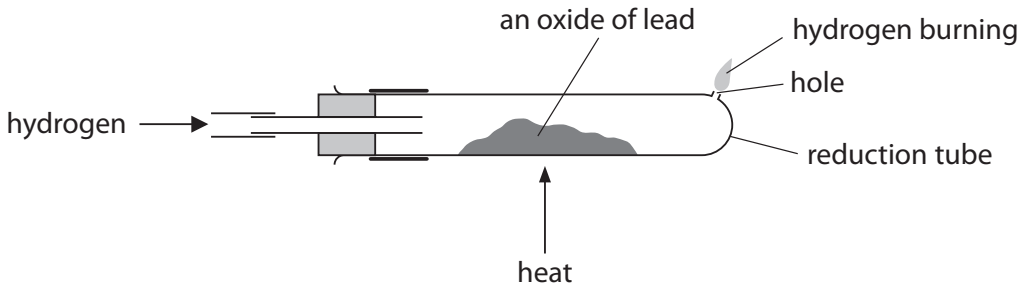
(ii) A student is given a sample of solid red lead oxide and some dilute nitric acid.

Describe how the student could obtain a pure dry sample of lead(II) nitrate crystals.

(6)

(Total for Question 10 = 13 marks)

10 (a) The diagram shows the apparatus a teacher uses to determine the formula of an oxide of lead.



This is the teacher's method.

Step 1 find the mass of the reduction tube

Step 2 add some of the lead oxide to the reduction tube

Step 3 find the mass of the reduction tube and lead oxide

Step 4 pass hydrogen gas over the lead oxide and ignite the hydrogen at the hole

Step 5 heat the lead oxide strongly for 10 minutes

Step 6 keep passing hydrogen through the reduction tube until the tube and contents are cool

Step 7 find the new mass of the reduction tube and its contents

(i) Give a reason why hydrogen is passed through the reduction tube until the tube and contents are cool.

(1)

.....

.....

(ii) Describe what the teacher should do next to make sure all the lead oxide has been reduced to lead.

(2)

.....

.....

.....

.....

(b) The teacher completes the experiment and obtains these results.

mass of reduction tube = 23.50 g
mass of tube + lead oxide = 28.64 g
mass of tube + lead = 28.16 g

(i) Calculate the mass of lead formed.

(1)

mass of lead = ... g

(ii) Calculate the mass of oxygen removed from the lead oxide.

(1)

mass of oxygen = ... g

(iii) Determine the empirical formula of the lead oxide.

(4)

empirical formula of the lead oxide .....

(c) The insoluble salt lead(II) chloride ($PbCl_2$) can be prepared by reacting a solution of lead(II) nitrate with dilute hydrochloric acid.

(i) Complete the equation for the reaction by adding the state symbols.

(1)

$$Pb(NO_3)_2(.....) + 2HCl(.....) \rightarrow PbCl_2(.....) + 2HNO_3(.....)$$

(ii) Show that the maximum mass of lead(II) chloride that can be made from 0.0370 mol of hydrochloric acid is about 5 g.

[M_r of $PbCl_2$ = 278]

(3)

maximum mass = ... g

(Total for Question 10 = 13 marks)

7 This question is about copper and copper compounds.

(a) A sample of copper contains two isotopes.

- Cu-63 with relative abundance 69.5%
- Cu-65 with relative abundance 30.5%

(i) State what is meant by the term **isotopes**.

(2)

.....

.....

.....

.....

(ii) Calculate the relative atomic mass (A_r) of this sample of copper.

Give your answer to three significant figures.

(3)

A_r of copper = ...

(b) When copper(II) carbonate is heated, copper(II) oxide and carbon dioxide are formed.

(i) What is the name of this type of reaction?

(1)

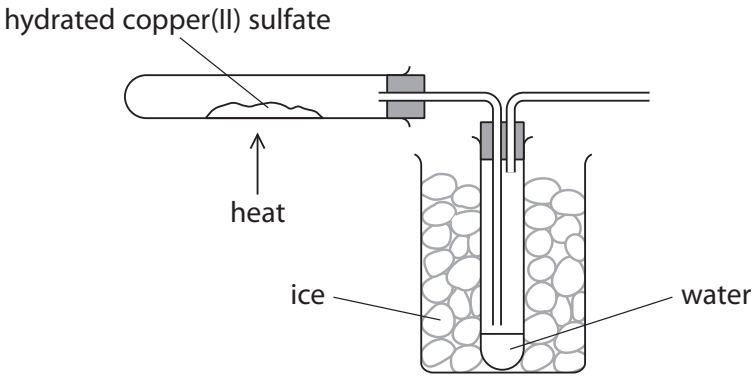
- ☒ **A** decomposition
- ☒ **B** neutralisation
- ☒ **C** oxidation
- ☒ **D** reduction

(ii) Which colour change occurs during this reaction?

(1)

- ☒ **A** blue to black
- ☒ **B** blue to white
- ☒ **C** green to black
- ☒ **D** green to orange

(c) A student uses this apparatus to find the value of x in the formula $CuSO_4.xH_2O$



This is the student's method.

- find the mass of an empty boiling tube
- add hydrated copper(II) sulfate to the tube and record the new mass
- heat the hydrated copper(II) sulfate until it changes colour
- allow the tube to cool and record the mass again

The table shows the student's results.

mass of empty tube in g	20.52
mass of tube and $CuSO_4.xH_2O$ in g	31.77
mass of tube and $CuSO_4$ in g	28.20

(i) Calculate the mass of $CuSO_4$ formed.

(1)

mass of $CuSO_4$ = ... g

(ii) Calculate the mass of water formed.

(1)

mass of water = ... g

(iii) Show that the value of x is approximately 4

[M_r of $CuSO_4$ = 159.5 M_r of H_2O = 18]

(3)

(iv) The actual value of x is 5

Give a reason why the calculated value of x is lower than the actual value.

(1)

.....

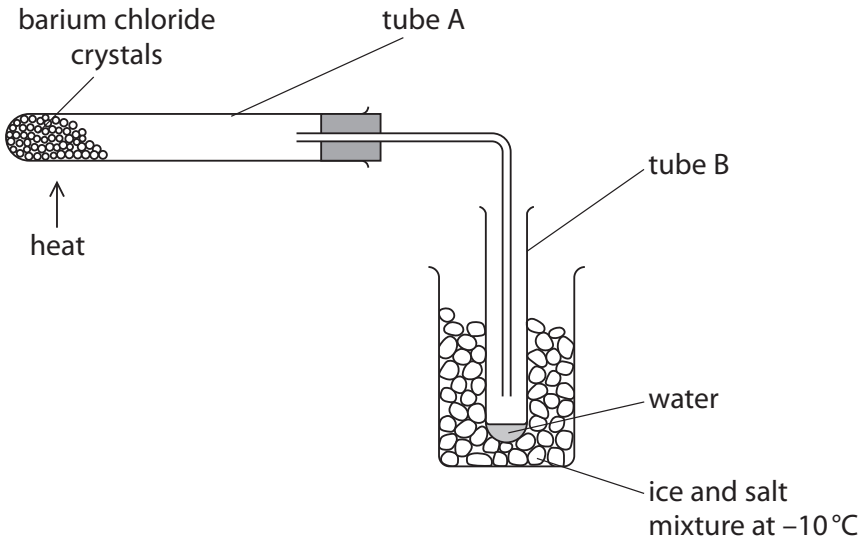
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(Total for Question 7 = 13 marks)

12 This question is about hydrated compounds.

Crystals of hydrated barium chloride ($BaCl_2.xH_2O$) contain water of crystallisation.

A student uses this apparatus to remove and collect the water from some crystals.



This is the student's method.

Step 1 record mass of tube A when empty

Step 2 place a sample of hydrated barium chloride crystals in tube A and record new mass

Step 3 heat tube A

Step 4 allow tube A to cool and record mass

Repeat steps 3 and 4 until the mass recorded in step 4 is constant.

These are the student's results.

mass of tube A = 10.55 g

mass of tube A and $BaCl_2.xH_2O$ = 16.65 g

final mass of tube A and $BaCl_2$ = 15.75 g

(a) (i) Give a reason why the student repeats steps 3 and 4 until the mass is constant.

(1)

.....

.....

(ii) Calculate the mass of $BaCl_2$ that forms in tube A.

(1)

.....

(iii) Calculate the mass of water lost.

(1)

.....

(iv) Determine the value of x in $BaCl_2.xH_2O$

Show your working.

[for $BaCl_2$, $M_r = 208$ for H_2O, $M_r = 18$]

(3)

x = ...

(b) Describe a physical test to show that the water in tube B is pure.

(2)

.....

.....

.....

.....

QUESTION 12 CONTINUES ON NEXT PAGE

(c) A sample containing 0.02 mol of hydrated copper(II) sulfate is heated using the same apparatus.

The products of the reaction are anhydrous copper(II) sulfate and water.

This is the equation for the reaction.

$$CuSO_4.5H_2O(s) \rightleftharpoons CuSO_4(s) + 5H_2O(l)$$

(i) Give the meaning of the symbol $\rightleftharpoons$

(1)

.....

(ii) Describe how the reaction can be used to show that a liquid contains water.

(2)

.....

.....

.....

.....

(iii) Calculate the maximum number of water molecules in tube B after the sample of hydrated copper(II) sulfate has completely reacted.

One mole of any substance contains 6×10^{23} particles.

(2)

maximum number of molecules = ...

(Total for Question 12 = 13 marks)

9 This question is about different hydrated forms of sodium sulfate.

(a) A compound has the formula $Na_2SO_4.7H_2O$

(i) How many different elements are there in the formula $Na_2SO_4.7H_2O$?

(1)

- ☒ **A** 3
- ☒ **B** 4
- ☒ **C** 5
- ☒ **D** 10

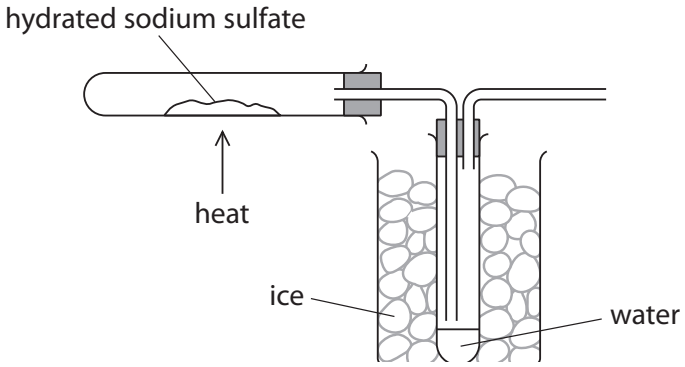
(ii) What is the total number of atoms in the formula $Na_2SO_4.7H_2O$?

(1)

- ☒ **A** 10
- ☒ **B** 22
- ☒ **C** 27
- ☒ **D** 28

(b) Another hydrated form of sodium sulfate has the formula $Na_2SO_4.xH_2O$

A student uses this apparatus to find the value of x.



This is the student's method.

- find the mass of an empty tube
- add solid hydrated sodium sulfate to the tube
- find the mass of the tube and hydrated sodium sulfate
- heat the tube for several minutes
- allow the tube to cool and find the mass of the tube and contents

(i) Describe what the student should do next to make sure that all the water is removed from the hydrated sodium sulfate.

(2)

(ii) Explain the role of the ice in the beaker.

(2)

(iii) Describe how the student could prove that the liquid collected is pure water.

(2)

(c) The table gives the student's results.

Mass of empty tube in g	15.83
Mass of tube and $Na_2SO_4.xH_2O$ in g	23.88
Mass of tube and Na_2SO_4 in g	19.38

Use the student's results to calculate the value of x.

[for Na_2SO_4, $M_r = 142$ for H_2O, $M_r = 18$]

(5)

x = ...

(Total for Question 9 = 13 marks)

11 This question is about the reduction of metal oxides.

(a) Solid oxides of copper can be reduced by reacting them with methane gas.

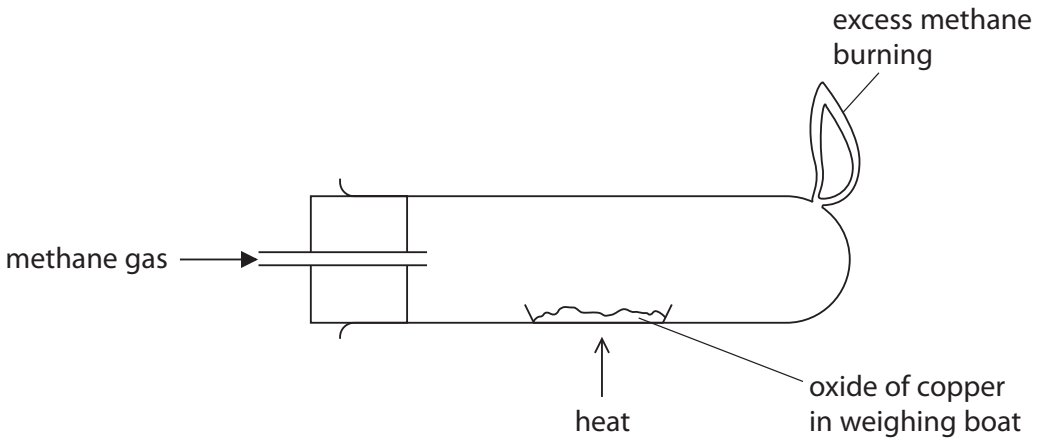
Complete the equation for the reaction between copper(II) oxide and methane.

Include state symbols.

(2)

.....CuO(.....) + ...CH_4(.....) → .....Cu(.....) + ...CO_2(.....) + ...H_2O(.....)

(b) A teacher uses this apparatus to demonstrate the reaction between a different oxide of copper and methane.



(i) The teacher heats the oxide of copper until the reaction is complete.

The table shows the teacher's results.

	Mass in g
empty weighing boat	15.05
weighing boat + oxide of copper	18.63
weighing boat + copper	18.23

Use the teacher's results to show that the empirical formula of this oxide of copper is Cu_2O

(4)

(ii) The teacher wears safety glasses and a lab coat during the demonstration.

Give one other safety precaution that she should take.

(1)

.....

.....

(c) Iron forms when iron(III) oxide is heated with carbon.

The equation for the reaction is

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(i) State how the equation shows that iron(III) oxide is reduced.

(1)

.....

.....

(ii) State why carbon monoxide should not be released into the atmosphere.

(1)

.....

.....

(iii) Calculate the maximum mass, in tonnes, of iron that can be produced when 30.0 tonnes of iron(III) oxide are reacted with an excess of carbon.

[1 tonne = 1.0×10^6 g]

(4)

mass = ... tonnes

(iv) A mixture of 25 000 mol of iron(III) oxide and 840 000 g of carbon is heated.

Use this equation to show that the iron(III) oxide is in excess.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(2)

(Total for Question 11 = 15 marks)

11 This question is about the reactions of some compounds of lead.

(a) Lead can be extracted from lead(II) sulfide, PbS, in two stages.

Stage 1 lead(II) sulfide is heated in air and reacts with oxygen to produce lead(II) oxide, PbO, and sulfur dioxide

Stage 2 lead(II) oxide is heated with carbon in a furnace

(i) Write a chemical equation for the reaction in stage 1.

(2)

.....

(ii) Give a reason why sulfur dioxide should not be released into the atmosphere.

(1)

.....

.....

.....

(iii) This is the equation for stage 2.

$$2PbO + C \rightarrow 2Pb + CO_2$$

A mass of 892 tonnes of lead(II) oxide is heated in a furnace with an excess of carbon.

Calculate the maximum mass, in tonnes, of carbon dioxide that could be released into the atmosphere.

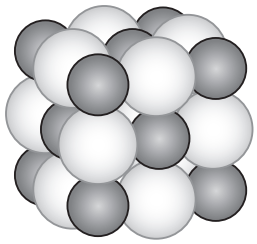
[1 tonne = 1×10^6 g]

[for PbO, $M_r = 223$ for CO_2, $M_r = 44$]

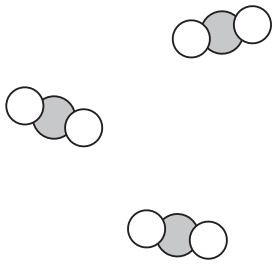
(3)

mass = ... tonnes

(iv) The diagram shows the structures of lead(II) sulfide and sulfur dioxide.



Lead(II) sulfide



Sulfur dioxide

Explain, in terms of bonding and structure, why lead(II) sulfide is a solid with a very high melting point at room temperature and why sulfur dioxide is a gas at room temperature.

(5)

lead(II) sulfide

sulfur dioxide

QUESTION 11 CONTINUES ON NEXT / BACK PAGE.

(b) A different oxide of lead contains 90.7% by mass of lead and 9.3% by mass of oxygen.

Determine the empirical formula of this oxide of lead.

(4)

empirical formula = ...

(Total for Question 11 = 15 marks)

SUB-TOPIC 1f

IONIC BONDING

Sub-topic 1f · 11 questions · 129 marks · lowest tariff first

7 The formation of ions and covalent bonds involves electrons.

The table gives the electronic configurations of atoms of hydrogen, lithium and chlorine.

Element	Electronic configuration of atom
hydrogen	1
lithium	2.1
chlorine	2.8.7

(a) Describe the different roles of electrons in the formation of

- ions in lithium chloride
- covalent bonds in hydrogen chloride

(3)

(b) Explain why lithium chloride has a higher melting point than hydrogen chloride.

Refer to structure and bonding in your answer.

(5)

(Total for Question 7 = 8 marks)

4 This question is about ionic compounds.

(a) The table shows the formulae of some positive and negative ions, and the formulae of some compounds containing these ions.

	Mg^{2+}	Al^{3+}	NH_4^+
S^{2-}	MgS	Al_2S_3	
NO_3^-		$Al(NO_3)_3$	NH_4NO_3
CO_3^{2-}	$MgCO_3$		$(NH_4)_2CO_3$

(i) Complete the table by giving the three missing formulae.

(3)

(ii) Give the name of the compound with the formula NH_4NO_3

(1)

.....

(b) Sodium oxide, Na_2O, is an ionic compound.

The sodium and oxide ions are held together by ionic bonds.

(i) State the meaning of the term **ionic bond**.

(2)

.....

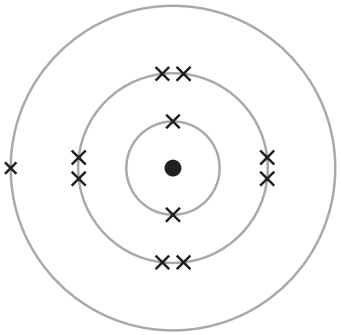
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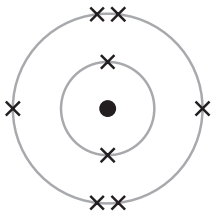
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(ii) The diagram shows the arrangement of the electrons in a sodium atom and in an oxygen atom.

sodium atom



oxygen atom



Draw diagrams in the boxes to show the arrangement of the electrons in the ions of sodium oxide.

Include the charges on the ions.

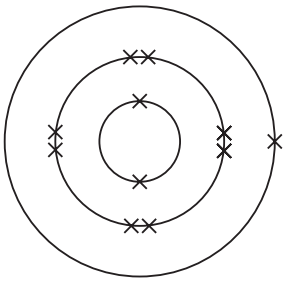
(3)

sodium ion	oxide ion	sodium ion

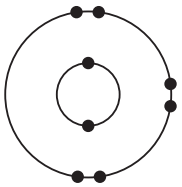
(Total for Question 4 = 9 marks)

6 This question is about sodium oxide, Na_2O

(a) The diagram shows the electronic configuration of atoms of sodium and oxygen.



Sodium



Oxygen

Describe the changes in the electronic configuration of the atoms of sodium and oxygen to form the ions in sodium oxide.

(3)

.....

.....

.....

.....

.....

.....

(b) Calculate the relative formula mass (M_r) of sodium oxide, Na_2O, using information from the Periodic Table.

(1)

M_r = ...

(c) Explain why solid sodium oxide does not conduct electricity.

(2)

.....

.....

.....

.....

(d) Give a test to show that sodium oxide contains sodium ions.

(2)

.....

.....

.....

.....

(e) When sodium oxide is heated it reacts to form sodium metal and sodium peroxide, Na_2O_2

Complete the equation for this reaction.

(1)

$Na_2O \rightarrow$

(Total for Question 6 = 9 marks)

8 This question is about ionic compounds.

(a) The table gives the formulae of some positive and negative ions, and the formulae of some compounds containing these ions.

	Na^+	Mg^{2+}
Cl^-		
O^{2-}	Na_2O	MgO
N^{3-}	Na_3N	

(i) Complete the table by giving the missing formulae.

(3)

(ii) Give the name of the compound with the formula MgO

(1)

.....

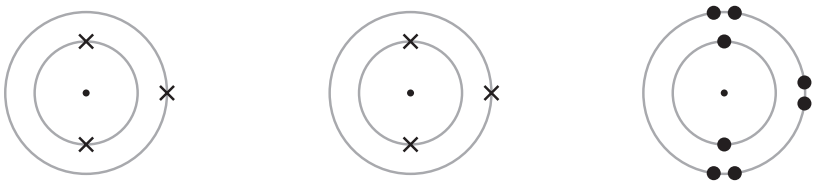
(iii) Calculate the relative formula mass (M_r) of Na_3N

[for Na, $A_r = 23$ for N, $A_r = 14$]

(1)

M_r = ...

(b) The diagram shows the arrangement of electrons in atoms of lithium and in an atom of oxygen.



lithium atom lithium atom oxygen atom

(i) Describe the changes in the electron configurations of lithium and oxygen when these atoms form lithium oxide, Li_2O

(2)

(ii) Lithium oxide has a giant ionic structure.

Explain why lithium oxide has a high melting point.

(3)

(Total for Question 8 = 10 marks)

5 This question is about the element phosphorus and some of its compounds.

(a) The atomic number of phosphorus is 15

Give the electronic configuration of an atom of phosphorus.

(1)

.....

(b) Calcium phosphide is an ionic compound used in pest control.

The formula of a calcium ion is Ca^{2+}

Explain why the formula of calcium phosphide is Ca_3P_2

(2)

.....

.....

.....

.....

(c) Calcium phosphide can be produced by heating calcium phosphate with carbon.

(i) Complete the equation for the reaction.

(1)

$$Ca_3(PO_4)_2 + \text{.....} C \rightarrow Ca_3P_2 + \text{.....} CO$$

(ii) Explain the role of carbon in the reaction.

(2)

.....

.....

.....

.....

(d) Calcium phosphide reacts with water to form calcium hydroxide and phosphine, PH_3

Give a chemical equation for this reaction.

(2)

(e) Explain why calcium phosphide has a high melting point.

You should refer to structure and bonding in your answer.

(3)

(Total for Question 5 = 11 marks)

6 This question is about ionic and covalent compounds.

(a) The table gives the formulae of some positive ions, some negative ions and some compounds containing these ions.

	NH_4^+	Zn^{2+}	Al^{3+}
Cl^-	NH_4Cl	$ZnCl_2$	
SO_4^{2-}	$(NH_4)_2SO_4$		$Al_2(SO_4)_3$
N^{3-}		Zn_3N_2	AlN

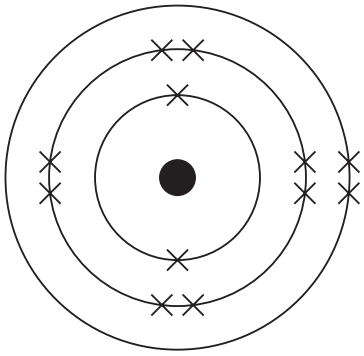
(i) Complete the table by giving the three missing formulae.

(3)

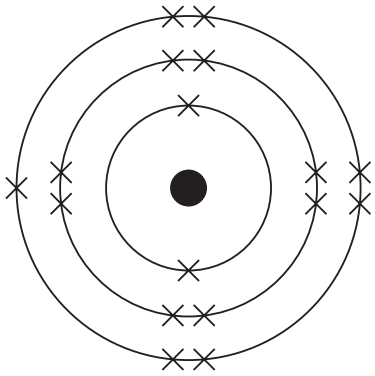
(ii) Give the name of the compound with the formula $Al_2(SO_4)_3$

(1)

(b) The diagram shows the arrangement of electrons in an atom of magnesium and an atom of chlorine.



Magnesium



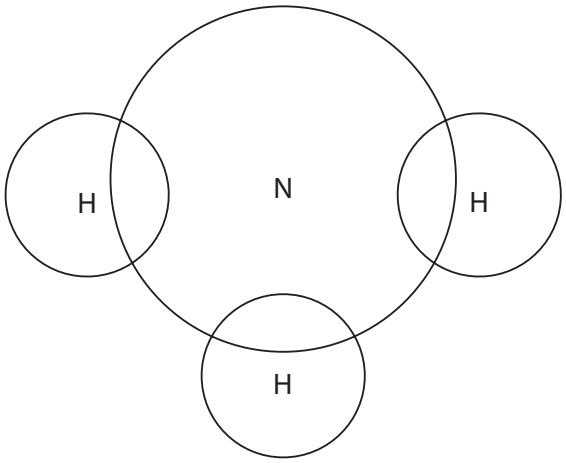
Chlorine

Describe, in terms of electrons, what happens when magnesium atoms and chlorine atoms form magnesium chloride.

(3)

(c) (i) Complete the dot-and-cross diagram to show the outer shell electrons in a molecule of ammonia.

(2)



(ii) Describe the forces of attraction in a covalent bond.

(2)

(Total for Question 6 = 11 marks)

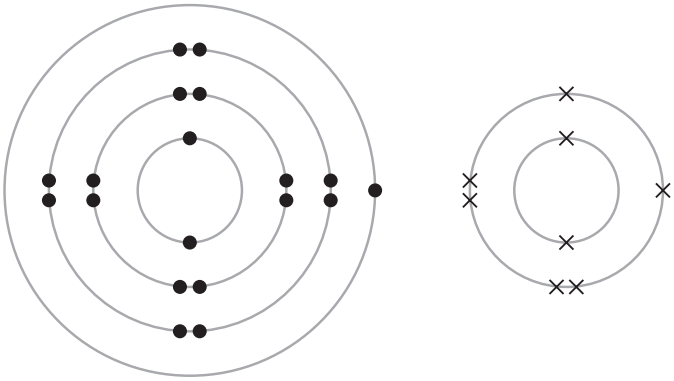
4 This question is about ionic compounds.

(a) State the formula of the cation and the anion in magnesium sulfate.

(2)

cation ..... anion .....

(b) The diagram shows the electronic configuration of a potassium atom and an oxygen atom.



potassium oxygen

Potassium oxide (K_2O) is an ionic compound.

Draw the electronic configuration of a potassium ion and an oxide ion.

Show the charge on each ion.

(3)

potassium ion

oxide ion

(c) A sample of solid potassium oxide is added to water.

A reaction occurs and a colourless solution forms.

When a few drops of phenolphthalein indicator are added to the solution it turns pink.

(i) Identify the ion responsible for the colour change.

(1)

.....

(ii) Give a chemical equation for the reaction between potassium oxide and water.

(1)

.....

(d) Explain why ionic compounds conduct electricity when molten or in aqueous solution, but not when in the solid state.

(2)

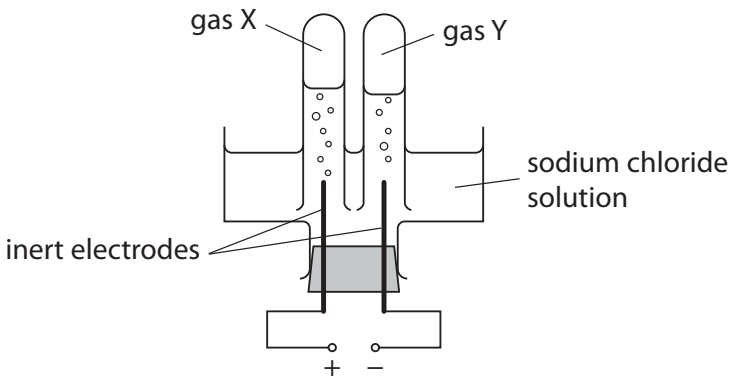
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(e) The diagram shows the apparatus a teacher uses to demonstrate the electrolysis of a concentrated aqueous solution of sodium chloride.



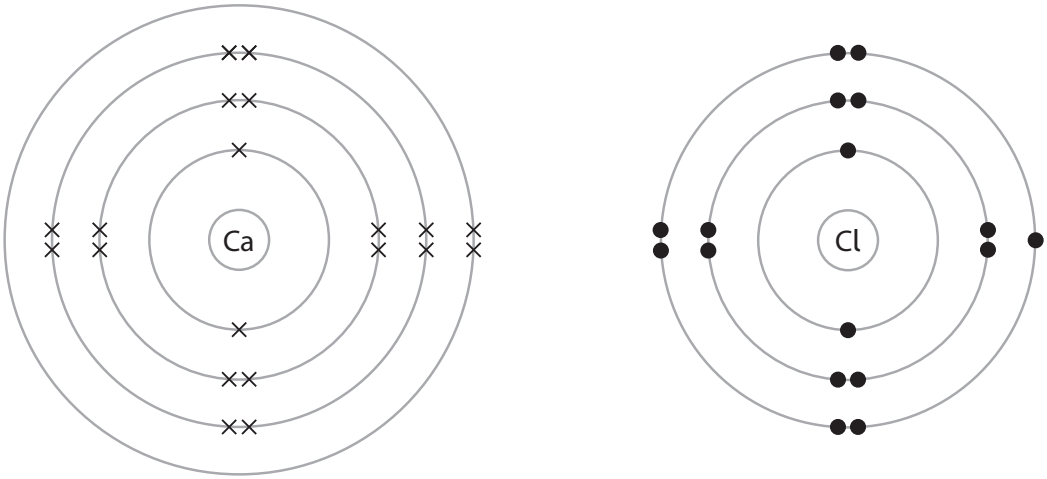
During the electrolysis two gases, X and Y, are formed. One of the gases produces a squeaky pop when tested with a lighted splint.

Use ionic half-equations to identify X and Y.

(4)

(Total for Question 4 = 13 marks)

8 (a) The diagram shows the arrangement of electrons in an atom of calcium and in an atom of chlorine.



Describe, in terms of electrons, what happens when calcium reacts with chlorine to form the ionic compound calcium chloride, $CaCl_2$

(3)

(b) Describe tests to show that an aqueous solution of calcium chloride contains calcium ions and chloride ions.

(4)

calcium ions .....

.....

.....

.....

chloride ions .....

.....

.....

.....

(c) Solid calcium chloride does not conduct electricity. Aqueous solutions of calcium chloride do conduct electricity.

A student uses this method to investigate how the conductivity of a solution changes when calcium chloride is dissolved in pure water.

Step 1 add 100 cm^3 of pure water to a beaker

Step 2 add one spatula of solid calcium chloride to the beaker

Step 3 stir the solution

Step 4 measure the conductivity of the solution

Step 5 repeat until nine spatulas of solid calcium chloride have been added

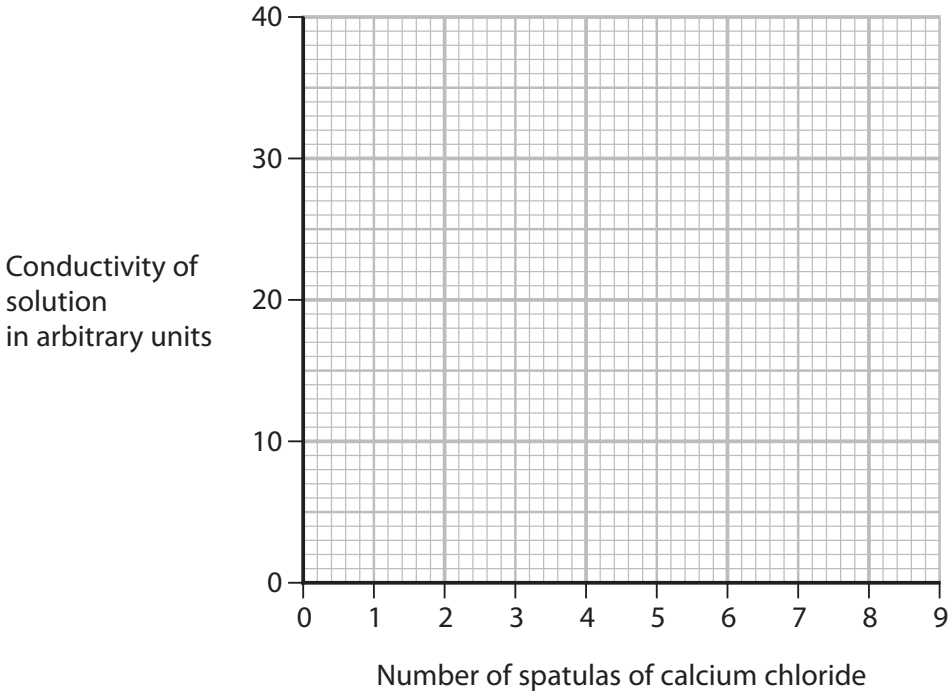
The table shows the student's results.

Number of spatulas of calcium chloride	Conductivity of solution in arbitrary units
0	0
1	6
2	12
3	12
4	24
5	30
6	36
7	36
8	36
9	36

(i) Plot the results on the grid and draw two straight lines of best fit.

Ignore the anomalous result.

(3)



(ii) State the trend shown on the graph for the first six spatulas of calcium chloride.

(1)

.....

.....

(iii) Suggest an error the student could have made to cause the anomalous result.

(1)

.....

.....

(d) Describe another way to make solid calcium chloride conduct electricity.

(2)

.....

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.....

(Total for Question 8 = 14 marks)

5 This is a question about metals and their compounds.

(a) State one property of metals.

(1)

.....

(b) Mercury is the only metal that is liquid at room temperature.

Describe the difference in the movement of particles in liquid mercury and in a solid metal.

(2)

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.....

(c) Magnesium is a metal that burns in air.

(i) State one observation made during the combustion of magnesium metal.

(1)

.....

.....

(ii) State one chemical property of the product of combustion that can be used to classify magnesium as a metal.

(1)

.....

.....

(d) In the absence of air, magnesium reacts with sulfur to form the ionic compound magnesium sulfide, MgS

(i) Give a reason why the reaction needs to be done in the absence of air.

(1)

.....

.....

(ii) Describe, in terms of electrons, the formation of the ions in magnesium sulfide.

Give the charges on the ions.

(3)

(iii) Explain why magnesium sulfide has a very high melting point.

(3)

(iv) Magnesium sulfide reacts with hydrochloric acid to form magnesium chloride and hydrogen sulfide gas, H_2S

Give the chemical equation for this reaction.

(2)

(Total for Question 5 = 14 marks)

9 (a) The table shows the formulae of some positive and negative ions, and the formulae of some compounds containing these ions.

	Cl^-	O^{2-}	SO_4^{2-}
Na^+		Na_2O	Na_2SO_4
NH_4^+	NH_4Cl		
Zn^{2+}	$ZnCl_2$		$ZnSO_4$

(i) Complete the table by giving the formulae of the missing compounds.

(3)

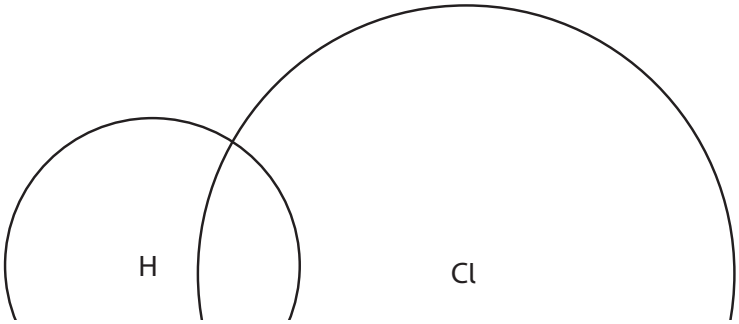
(ii) Give the name of the compound with the formula $ZnSO_4$

(1)

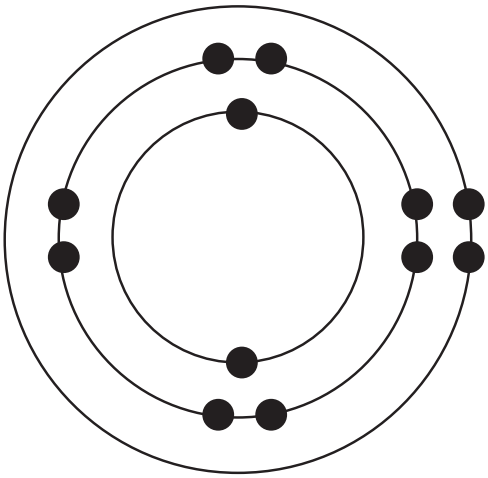
(b) Hydrogen chloride and magnesium chloride have different types of bonding and have different structures.

(i) Complete the dot-and-cross diagram to show the outer shell electrons in a molecule of hydrogen chloride.

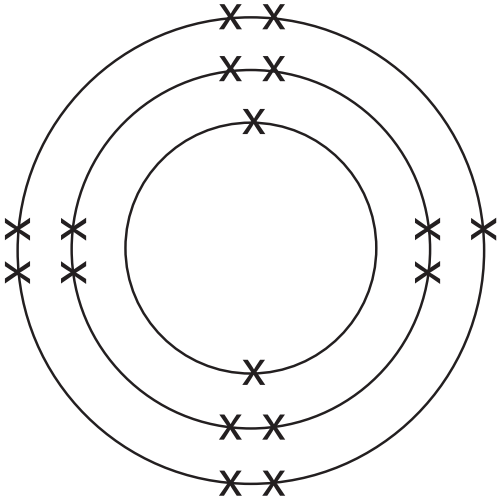
(2)



(ii) The diagram shows the electronic configuration of a magnesium atom and of a chlorine atom.



magnesium



chlorine

Draw the electronic configuration of a magnesium ion and of a chloride ion in the boxes.

Show the charge on each ion.

(3)

magnesium ion	chloride ion

(iii) Explain why magnesium chloride has a much higher melting point than hydrogen chloride.

Refer to structure and bonding in your answer.

(5)

(Total for Question 9 = 14 marks)

3 This question is about Group 2 elements and their compounds.

(a) A sample of magnesium contains three isotopes.

Mass number of isotope	24	25	26
Percentage abundance (%)	76.5	10.5	13.0

(i) State, in terms of subatomic particles, what is meant by the term **isotopes**.

(2)

.....

.....

.....

.....

(ii) Calculate the relative atomic mass (A_r) of magnesium.

Give your answer to one decimal place.

(3)

A_r = ...

(b) Which of these compounds is an insoluble solid?

(1)

☒ **A** calcium nitrate

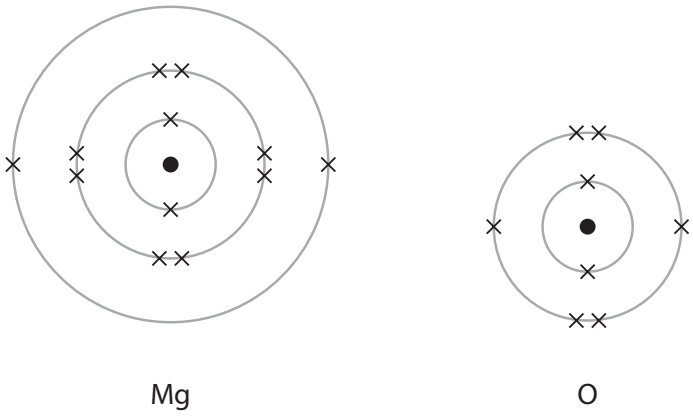
☒ **B** calcium sulfate

☒ **C** magnesium nitrate

☒ **D** magnesium sulfate

(c) Magnesium oxide is an ionic compound.

The diagrams show the atoms of magnesium and oxygen.



Mg O

Draw diagrams to show the structure of each ion in magnesium oxide.

Include the charge on each ion.

(3)

(d) The table lists some substances and shows which substance conducts electricity.

Substance	Conducts electricity?
water	no
solid magnesium chloride	no
aqueous magnesium chloride	yes

Explain these observations.

Refer to structure and bonding in your answer.

(5)

(e) A concentrated aqueous solution of magnesium chloride is electrolysed.

Chlorine forms at the positive electrode.

(i) Give the half-equation for the reaction at the positive electrode.

(1)

.....

(ii) Give a reason why this reaction is classified as oxidation.

(1)

.....

.....

(Total for Question 3 = 16 marks)

SUB-TOPIC 1g

COVALENT BONDING

Sub-topic 1g · 18 questions · 165 marks · lowest tariff first

2 The table shows properties of four substances, A, B, C and D.

Substance	Melting point in °C	Boiling point in °C	Conducts electricity when solid	Conducts electricity when molten
A	800	1465	no	yes
B	327	1749	yes	yes
C	232	573	no	no
D	3550	4830	no	no

(a) Use information from the table to identify these substances.

(i) Which substance could be a metal?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(ii) Which substance could be diamond?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(iii) Which substance is a gas at 600 °C?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) One of the substances in the table is a compound with the formula $C_{10}H_{16}N_2O_3S$

(i) Give the number of different elements in $C_{10}H_{16}N_2O_3S$

(1)

.....

(ii) Determine the number of atoms in a molecule of $C_{10}H_{16}N_2O_3S$

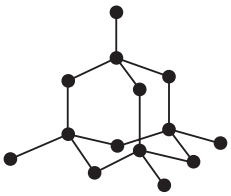
(1)

.....

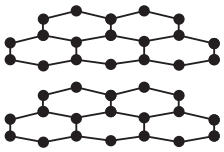
(Total for Question 2 = 5 marks)

8 Diamond, graphite and C_{60} fullerene are all forms of the element carbon.

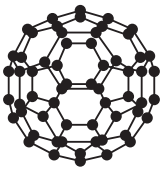
The diagram shows the structures of these three substances.



diamond



graphite



C_{60} fullerene

(a) Explain why graphite conducts electricity.

(2)

(b) Explain why diamond is hard but graphite is soft.

(2)

(c) Doctors use C_{60} fullerene to deliver medicines to certain parts of the body, so that the medicine does not damage other parts of the body.

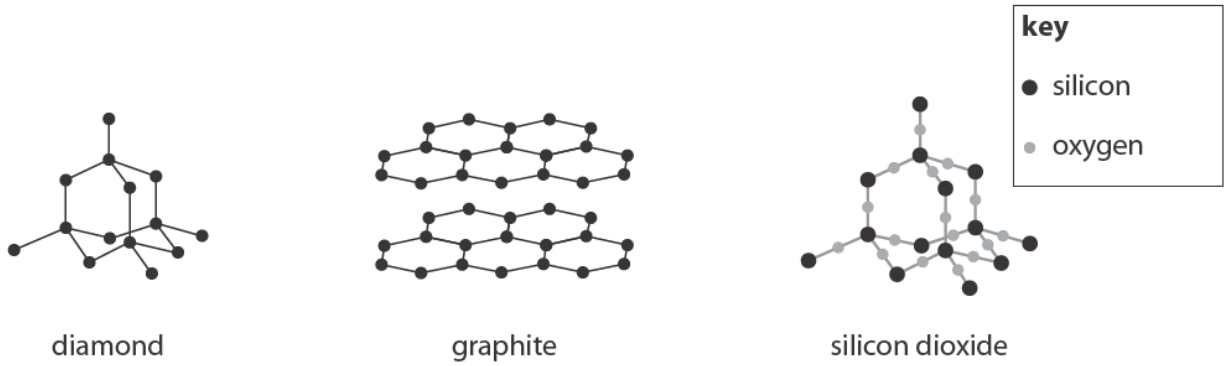
Suggest why C_{60} fullerene is suitable for this purpose.

(1)

(Total for Question 8 = 5 marks)

7 Diamond, graphite and silicon dioxide all have giant covalent structures.

The diagram shows the structures of these three substances.



diamond graphite silicon dioxide

(a) Explain why silicon dioxide has a high melting point.

(2)

(b) Explain why graphite conducts electricity.

(2)

(c) State why diamond is hard but graphite is soft.

(2)

(Total for Question 7 = 6 marks)

9 Halon 1301 is a compound used in some fire extinguishers.

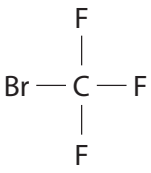
Halon 1301 has the percentage composition by mass of

C 8.05% Br 53.69% F 38.26%

(a) Show, by calculation, that the empirical formula of this compound is $CBrF_3$

(2)

(b) The diagram shows the displayed formula of a molecule of Halon 1301.



Draw a dot-and-cross diagram to show all the outer electrons in this molecule.

(2)

(c) The boiling point of Halon 1301 is −58 °C.

Explain why Halon 1301 has a low boiling point.

(2)

(Total for Question 9 = 6 marks)

3 The table gives some information about three substances, X, Y and Z.

Substance	Melting point	Conducts electricity when solid	Conducts electricity when molten	Type of bonding	Type of structure
X	low	no	no	covalent	simple molecular
Y	high	no	no		
Z	high	no	yes		

(a) Complete the table by giving the missing information.

(4)

(b) Explain why substance X has a low melting point.

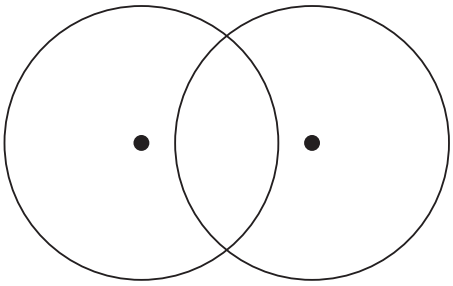
(2)

(Total for Question 3 = 6 marks)

10 This question is about substances with covalent bonds.

(a) (i) Draw a dot and cross diagram to show the outer shell electrons in a molecule of nitrogen, N_2

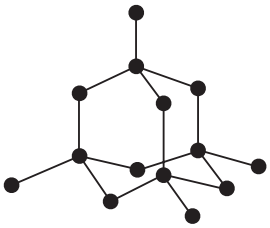
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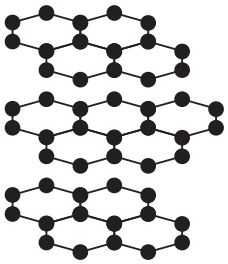
(ii) Describe the forces of attraction in a covalent bond.

(2)

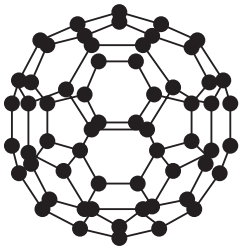
(b) The diagram shows three different structures of carbon.



Structure A



Graphite



C_{60} fullerene

(i) Name structure A.

(1)

.....

(ii) Graphite and C_{60} fullerene contain covalent bonds, but have different structures.

Explain why C_{60} fullerene has a much lower melting point than graphite.

Refer to structure and bonding in your answer.

(4)

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(Total for Question 10 = 9 marks)

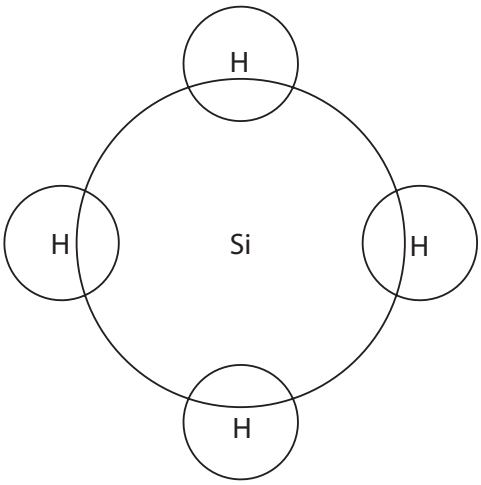
6 Silicon hydride (SiH_4) and silicon dioxide (SiO_2) both contain covalent bonds but they have different structures.

(a) Describe the forces of attraction in a covalent bond.

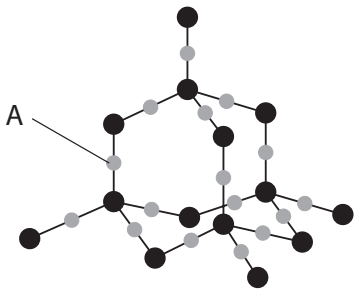
(2)

(b) Complete the diagram to show the outer shell electrons in a molecule of silicon hydride (SiH_4).

(1)



(c) The diagram represents part of the structure of silicon dioxide (SiO_2).



(i) State how the diagram shows that the atom labelled A is oxygen, not silicon.

(1)

(ii) Silicon hydride has a simple molecular structure.

Silicon dioxide has the same type of structure as diamond.

Explain why silicon dioxide has a much higher melting point than silicon hydride.

Refer to structure and bonding in your answer.

(4)

(d) Silicon hydride reacts with oxygen to form silicon dioxide and water.

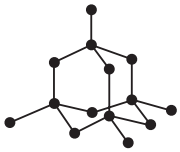
Write a chemical equation for the reaction between silicon hydride and oxygen.

(1)

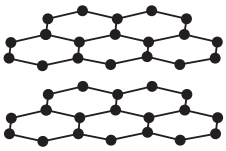
(Total for Question 6 = 9 marks)

8 Diamond and graphite are made of carbon atoms, joined together by covalent bonds.

The diagram shows their structures.



diamond



graphite

(a) State, in terms of electrostatic attractions, what is meant by a covalent bond.

(2)

(b) Explain why diamond has a high melting point.

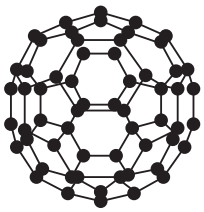
(3)

(c) Explain why graphite is a good conductor of electricity.

(2)

(d) C_{60} fullerene is a molecule made of 60 carbon atoms.

The diagram shows the structure of C_{60} fullerene.



One mole of atoms contains 6.0×10^{23} atoms.

Determine the number of atoms in one mole of C_{60} fullerene.

Give your answer in standard form.

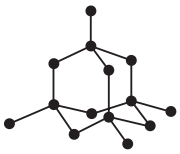
(2)

number of atoms = ...

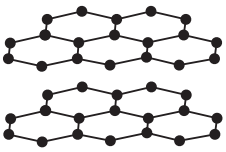
(Total for Question 8 = 9 marks)

8 Diamond and graphite are two naturally-occurring forms of carbon.

They both have giant covalent structures.



diamond



graphite

(a) Explain, with reference to its bonding, why diamond has a high melting point.

(3)

(b) Explain why graphite is soft and is a conductor of electricity.

Refer to structure and bonding in your answer.

(6)

(Total for Question 8 = 9 marks)

8 Diamond and graphite are giant covalent structures made of carbon atoms.

The diagram shows their structures.



Diamond Graphite

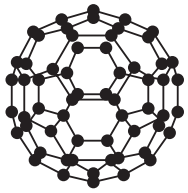
(a) Discuss the differences between diamond and graphite.

Refer to structure and bonding, electrical conductivity and hardness in your answer.

(6)

(b) C_{60} fullerene is a simple molecular substance made of 60 carbon atoms.

The diagram shows its structure.



The table shows the approximate melting points of diamond, graphite and C_{60} fullerene.

Substance	Approximate melting point in °C
diamond	4000
graphite	3600
C_{60} fullerene	600

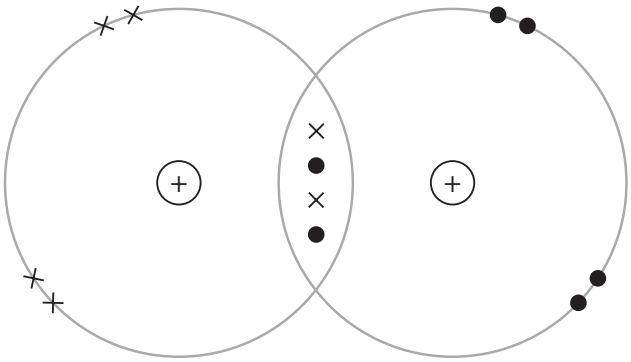
Explain why C_{60} fullerene has a much lower melting point than diamond and graphite.

(4)

(Total for Question 8 = 10 marks)

9 This question is about substances that contain covalent bonds.

(a) The diagram represents a molecule of oxygen.



Describe the forces of attraction in a covalent bond.

(2)

(b) The table shows the boiling points of three Group 7 elements.

	Boiling point in °C
fluorine	–188
chlorine	–34
bromine	59

Explain the trend in the boiling points.

(3)

(c) Graphite is a naturally-occurring form of carbon.

Explain why graphite is soft and conducts electricity.

Refer to structure and bonding in your answer.

(5)

(Total for Question 9 = 10 marks)

9 (a) Diamond is a naturally-occurring form of carbon.

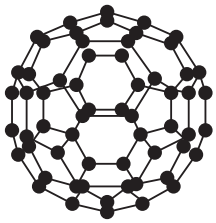
It has a giant molecular structure.

Explain, with reference to its structure and bonding, why diamond has a high melting point.

(3)

(b) C_{60} fullerene is another form of carbon.

The diagram shows a molecule of C_{60} fullerene.



(i) Explain why C_{60} fullerene has a much lower melting point than diamond.

(2)

(ii) C_{60} fullerene is used by doctors when injecting medicines into their patients.

C_{60} fullerene allows medicines, which might damage some parts of the body, to reach the part of the body where they are needed.

Suggest why C_{60} fullerene is suitable for this purpose.

(1)

(c) Graphite is another naturally-occurring form of carbon.
Graphite can be used in pencils because it is soft and can leave marks on paper.
Graphite can also be used as a conductor of electricity.

Explain why graphite is soft and conducts electricity.
Refer to structure and bonding in your answer.

(5)

(Total for Question 9 = 11 marks)

8 (a) Carbon dioxide changes directly from a solid to a gas without becoming a liquid.

(i) Give the name of the change of state from solid to gas.

(1)

.....

(ii) Describe the test for carbon dioxide gas.

(2)

.....

.....

.....

.....

(b) Carbon dioxide is a simple molecular covalent substance.

Explain why carbon dioxide turns from a solid to a gas at a very low temperature.

(2)

.....

.....

.....

.....

.....

.....

(c) Diamond and graphite are both giant covalent substances made up of carbon atoms.

- diamonds are used in cutting tools
- graphite is used in pencils to make marks on paper

Explain, with reference to structure and bonding, why each substance is suitable for its particular use.

(6)

(Total for Question 8 = 11 marks)

10 This question is about carbon and its compounds.

(a) (i) Draw a dot-and-cross diagram to show the outer shell electrons in a molecule of carbon dioxide, CO_2

(2)

(ii) The atoms in carbon dioxide are held together by covalent bonds.

Describe the forces of attraction in a covalent bond.

(2)

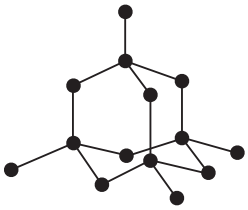
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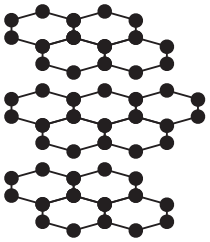
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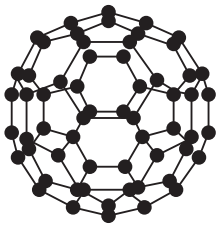
(b) The diagram shows three different structures of carbon.



diamond



graphite



C_{60} fullerene

(i) Explain why graphite conducts electricity.

(2)

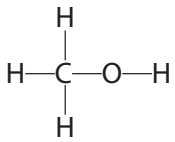
(ii) Explain why diamond has a much higher melting point than C_{60} fullerene.

Refer to structure and bonding in your answer.

(5)

(Total for Question 10 = 11 marks)

5 (a) The diagram shows the displayed formula of the organic compound methanol, CH_3OH



(i) Determine the number of atoms in one molecule of methanol.

(1)

.....

(ii) State why methanol is not a hydrocarbon.

(1)

.....

.....

(b) The atoms in methanol are held together by covalent bonds.

(i) State what is meant by the term **covalent bond**.

(2)

.....

.....

.....

.....

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of methanol.

Show only the outer electrons of each atom.

(2)

(c) Another organic compound has the percentage composition by mass

C = 38.7% H = 9.7% O = 51.6%

(i) Calculate the empirical formula of this compound.

(3)

empirical formula = ...

(ii) The relative molecular mass (M_r) of the compound is 62

Determine the molecular formula of the compound.

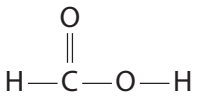
(2)

molecular formula = ...

(Total for Question 5 = 11 marks)

5 This question is about organic compounds.

(a) The diagram shows the displayed formula of methanoic acid.



(i) Give the total number of atoms in one molecule of methanoic acid.

(1)

.....

(ii) Determine the relative molecular mass (M_r) of methanoic acid.

(1)

M_r = ...

(iii) Explain why methanoic acid is not a hydrocarbon.

(2)

.....

.....

.....

.....

(b) The atoms in methanoic acid are held together by covalent bonds.

(i) State, in terms of electrostatic attractions, what is meant by the term **covalent bond**.

(2)

.....

.....

.....

.....

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of methanoic acid.

Show only the outer electrons of each atom.

(3)

(c) Calculate the empirical formula of the organic compound with this composition by mass.

C = 52.2% H = 13.0% O = 34.8%

(3)

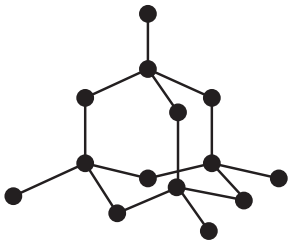
empirical formula = ...

(Total for Question 5 = 12 marks)

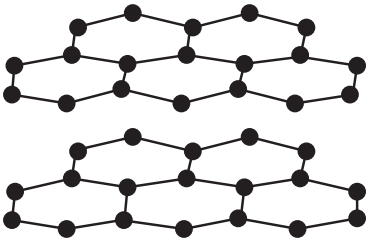
11 Diamond and graphite are both forms of the element carbon.

Diamond and graphite both have covalent bonds and giant covalent structures.

The diagram represents the structure of diamond and the structure of graphite.



diamond



graphite

(a) Give a reason why diamond is an element.

(1)

.....

.....

(b) Describe the forces of attraction in a covalent bond.

(2)

.....

.....

.....

.....

(c) (i) Explain why graphite conducts electricity.

(2)

.....

.....

.....

.....

(ii) Explain why diamond is hard but graphite is soft.

(4)

(d) Another form of carbon has molecules with the formula C_x

x represents the number of carbon atoms in each molecule.

Each molecule of C_x has a mass of 1.40×10^{-21} g.

One mole of C_x contains 6.02×10^{23} molecules.

Calculate the M_r of C_x and the value of x

[for carbon, $A_r = 12$]

(3)

M_r = ...

x = ...

(Total for Question 11 = 12 marks)

8 This question is about the covalent compounds hydrogen chloride and silicon dioxide.

(a) Describe the forces of attraction in a covalent bond.

(2)

(b) Hydrogen chloride has the formula HCl

(i) Draw a dot-and-cross diagram to show the bonding in a hydrogen chloride molecule.

Show only the outer shell electrons in each atom.

(2)

(ii) Explain why the boiling point of hydrogen chloride is low.

(2)

(c) The diagram shows part of the structure of silicon dioxide.



(i) Give a reason why particle A represents an oxygen atom.

(1)

(ii) This is the equation for the reaction between silicon dioxide and calcium oxide.

$$SiO_2 + CaO \rightarrow CaSiO_3$$

Give a reason why silicon dioxide reacts with calcium oxide.

(1)

(iii) Silicon dioxide has the same structure as diamond.
Silicon dioxide is very hard and has a very high melting point.

Explain these properties.

Refer to the structure and bonding of silicon dioxide in your answer.

(5)

(Total for Question 8 = 13 marks)

SUB-TOPIC 1h

METALLIC BONDING

Sub-topic 1h · 3 questions · 30 marks · lowest tariff first

4 This question is about metals.

(a) Which statement describes metallic bonding?

(1)

☒ **A** electrostatic attraction between oppositely charged ions

☒ **B** electrostatic attraction between the nuclei of two atoms and a pair of electrons shared between them

☒ **C** electrostatic attraction between positively charged particles and delocalised electrons

☒ **D** electrostatic attraction between atoms

(b) Aluminium is malleable and can be easily shaped to make saucepans used for cooking food.

State two other properties of aluminium that make it suitable for saucepans used for cooking food.

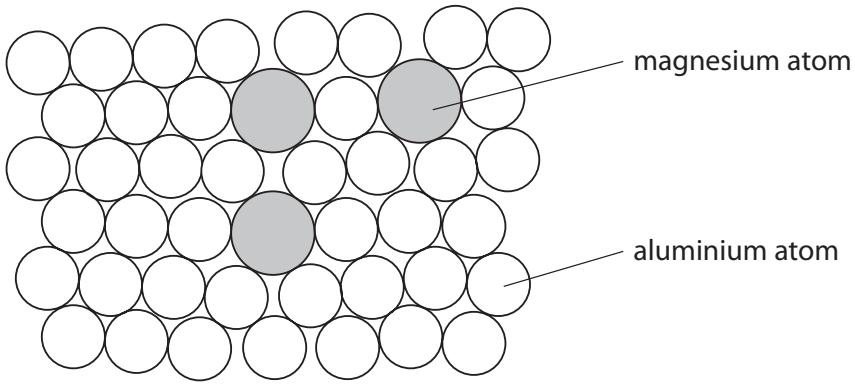
(2)

1 .....

2 .....

(c) Magnalium is an alloy of aluminium and magnesium.

The diagram shows how the atoms are arranged in this alloy.



(i) State what is meant by the term **alloy**.

(1)

.....

.....

(ii) Explain why magnalium is harder than aluminium.

(3)

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(Total for Question 4 = 7 marks)

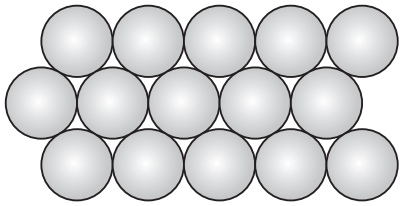
5 This question is about metals and metal compounds.

(a) The method used to extract a metal depends on the reactivity of the metal.

Explain which method is used to extract sodium metal from sodium chloride.

(2)

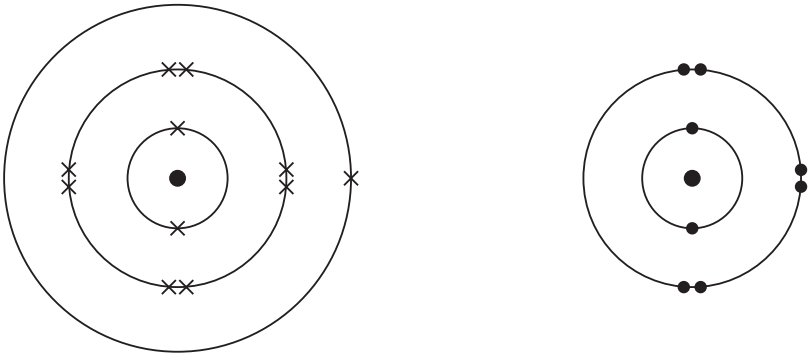
(b) The diagram shows the arrangement of particles in a pure metal.



Explain why pure metals are soft.

(2)

(c) The diagram shows the electronic structure of an atom of sodium and an atom of oxygen.



Sodium Oxygen

Describe, in terms of electrons, what happens when sodium reacts with oxygen.

(2)

.....

.....

.....

.....

(d) The table shows the melting points of sodium and sodium oxide.

	Melting point in °C
Sodium	98
Sodium oxide	1132

Explain why sodium and sodium oxide have different melting points.

In your answer you should refer to:

- the structures of sodium and sodium oxide
- the forces between the particles

(5)

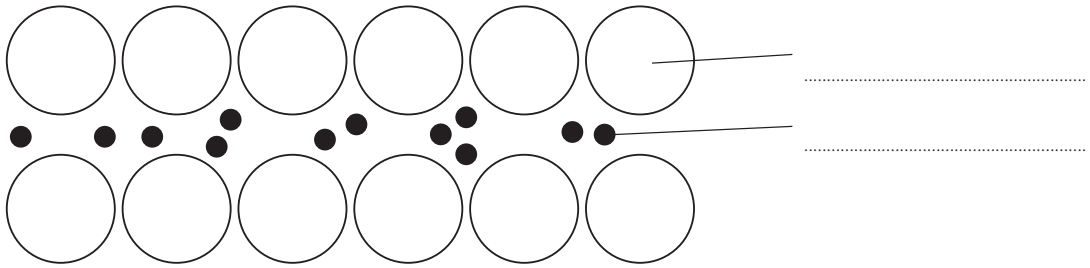
(Total for Question 5 = 11 marks)

3 This question is about magnesium metal and its compounds.

(a) (i) The diagram represents the structure of magnesium.

Complete the diagram by adding the labels.

(2)



(ii) Explain why magnesium is malleable.

(2)

(b) Magnesium burns in oxygen gas to form solid magnesium oxide.

(i) Complete the chemical equation for the reaction by balancing the equation and adding the state symbols.

(2)

.....Mg(s) + O_2(.....) → .....MgO(.....)

(ii) Give a reason why magnesium is oxidised in this reaction.

(1)

(c) A student uses this method to make a solution of magnesium chloride.

Step 1 measure 25 cm^3 of dilute hydrochloric acid into a beaker

Step 2 add magnesium powder a little at a time

Step 3 keep adding magnesium powder until it is in excess

Step 4 remove the excess magnesium powder by filtration

This is the equation for the reaction.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(i) Give a reason why the student uses magnesium powder rather than magnesium ribbon.

(1)

.....

.....

(ii) Give a reason why the student adds an excess of magnesium in step 3.

(1)

.....

.....

(iii) Calculate the minimum mass of magnesium needed to react with 25.0 cm^3 of 2.00 mol / dm^3 hydrochloric acid.

[for Mg, A_r = 24]

(3)

mass = ... g

(Total for Question 3 = 12 marks)

SUB-TOPIC 1i

ELECTROLYSIS

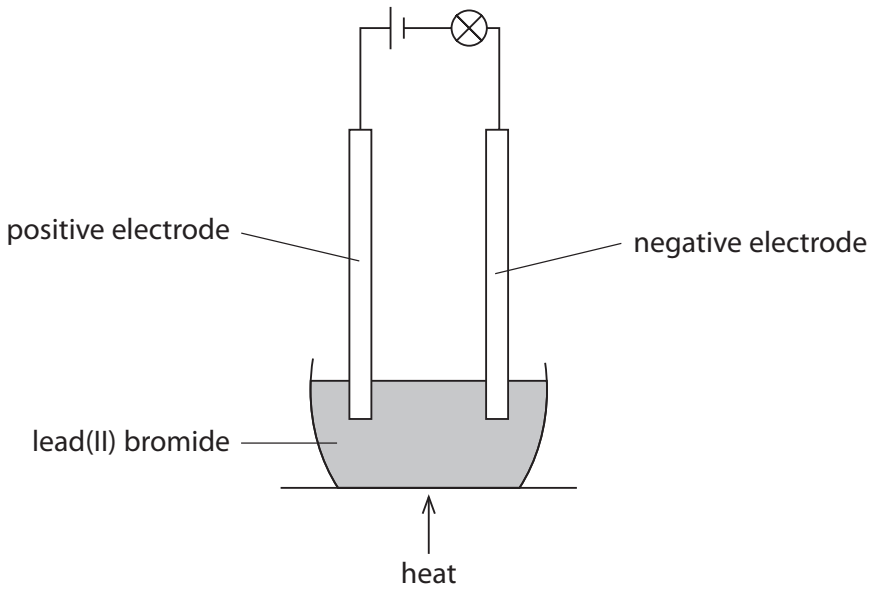
Sub-topic 1i · 13 questions · 150 marks · lowest tariff first

4 This question is about the metal, lead.

(a) Explain why metals, such as lead, are malleable.

(2)

(b) A teacher uses this apparatus in a fume cupboard to demonstrate the electrolysis of lead(II) bromide.



The lead(II) bromide is heated until it melts.

When the lead(II) bromide melts, the lamp lights.

One of the products of this electrolysis is lead.

(i) State why solid lead(II) bromide does not conduct electricity.

(1)

(ii) Bromine is formed by the oxidation of bromide ions at the positive electrode.

Complete the ionic half-equation for the oxidation of bromide ions.

(1)

$2Br^- \rightarrow$ ..... + ...

(iii) Explain why lead metal forms at the negative electrode.

(2)

.....

.....

.....

.....

(iv) The teacher stops heating the mixture and allows it to solidify.

Suggest why the lamp stays alight.

(1)

.....

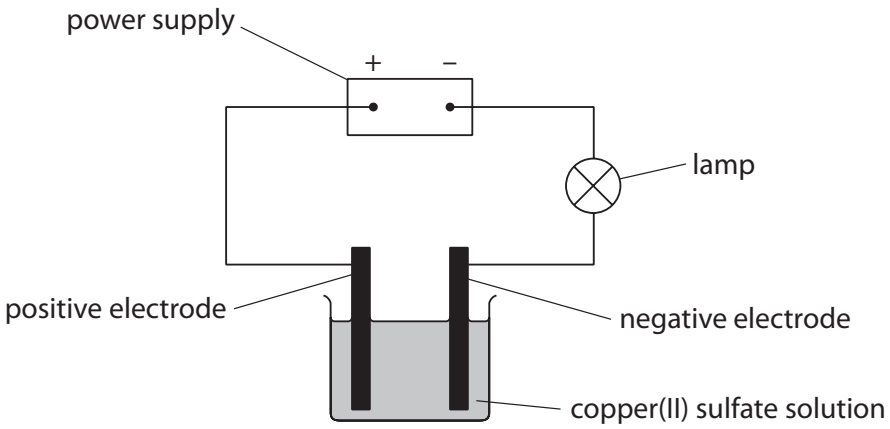
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(Total for Question 4 = 7 marks)

5 When copper(II) sulfate solution is electrolysed, copper forms at the negative electrode.

A student uses this apparatus to investigate the electrolysis of copper(II) sulfate solution.



(a) Describe how the student could test a sample of copper(II) sulfate solution to show that it contains copper(II) ions.

(2)

(b) Describe how copper metal forms at the negative electrode.

(3)

(c) State the appearance of the copper that forms on the negative electrode.

(1)

.....

(d) Oxygen forms at the positive electrode.

(i) Give a test for oxygen.

(1)

.....

.....

(ii) Complete the half-equation for the formation of oxygen at the positive electrode.

(2)

$2H_2O \rightarrow$ ..... + ... + ...

(iii) State why the formation of oxygen at the positive electrode is an oxidation reaction.

(1)

.....

.....

(Total for Question 5 = 10 marks)

3 This question is about copper and its compounds.

(a) Copper is a metal used for electrical wiring.

Explain why copper is a good conductor of electricity.

(2)

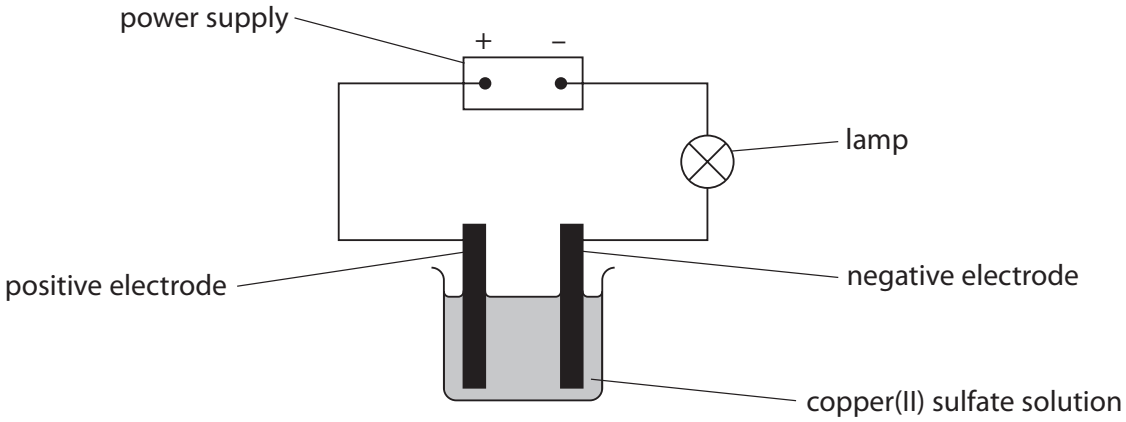
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(b) This apparatus is used to investigate the electrolysis of copper(II) sulfate solution with graphite electrodes.



Copper forms at the negative electrode and oxygen forms at the positive electrode.

(i) State what would be observed at each electrode.

(2)

negative electrode .....

positive electrode .....

(ii) The ionic half-equation for the reaction at the negative electrode is

$$Cu^{2+} + 2e^{-} \rightarrow Cu$$

State why this is a reduction reaction.

(1)

.....

.....

(iii) Explain why the copper(II) sulfate solution becomes paler blue during the electrolysis.

(2)

.....

.....

.....

.....

(c) When hydrated copper(II) sulfate crystals are heated, anhydrous copper(II) sulfate forms.

A mass of 12.5 g of hydrated copper(II) sulfate crystals is heated in a crucible until all the water of crystallisation is removed.

A mass of 8.0 g of anhydrous copper(II) sulfate forms.

Show by calculation that the formula of hydrated copper(II) sulfate is $CuSO_4.5H_2O$

[M_r of $CuSO_4$ = 159.5 M_r of H_2O = 18]

(4)

(Total for Question 3 = 11 marks)

4 This question is about magnesium and magnesium compounds.

(a) Magnesium burns in oxygen to form magnesium oxide.

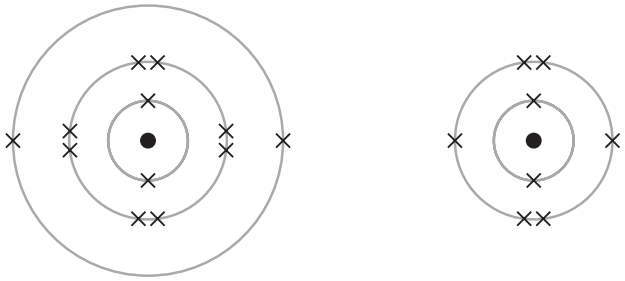
State two observations that would be seen during the reaction.

(2)

1 .....

2 .....

(b) The diagram shows the electron configurations of a magnesium atom and an oxygen atom.



magnesium atom oxygen atom

Describe the changes in the electronic configurations when magnesium reacts with oxygen to form the ionic compound magnesium oxide, MgO

(2)

.....

.....

.....

.....

.....

.....

(c) Magnesium can be produced by the electrolysis of molten magnesium chloride.

(i) State why magnesium cannot be produced by heating magnesium oxide with carbon.

(1)

.....

.....

(ii) Explain the different ways that magnesium and magnesium chloride conduct electricity.

(4)

magnesium

magnesium chloride

(d) During the electrolysis of molten magnesium chloride, magnesium is formed at the negative electrode.

The ionic half-equation for the reaction is

$$Mg^{2+} + 2e^- \rightarrow Mg$$

(i) State why this is a reduction reaction.

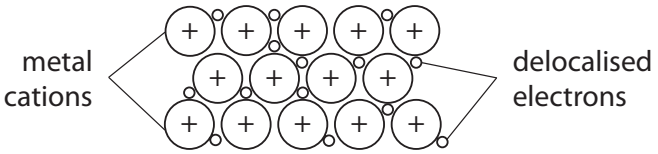
(1)

(ii) Write an ionic half-equation for the formation of chlorine at the positive electrode.

(1)

(Total for Question 4 = 11 marks)

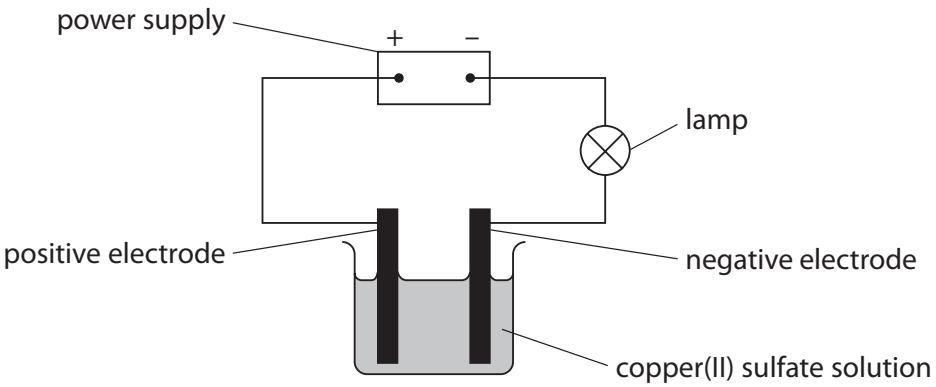
4 (a) The diagram represents the structure of copper metal.



Explain three properties of copper that make it a suitable metal to use in electrical wiring.

(5)

(b) The diagram shows the electrolysis of copper(II) sulfate solution, using graphite electrodes.



Copper forms at the negative electrode and oxygen forms at the positive electrode.

(i) Give the formula of the copper ion and the formula of the sulfate ion in copper(II) sulfate.

(1)

copper ion

.....

sulfate ion

.....

(ii) State what would be seen at the positive electrode.

(1)

.....

.....

(iii) Give a test for oxygen.

(1)

.....

.....

(iv) Give an ionic half-equation for the formation of oxygen at the positive electrode.

(2)

.....

(v) Suggest why the copper(II) sulfate solution contains some OH^- ions.

(1)

.....

.....

.....

(Total for Question 4 = 11 marks)

5 This question is about metals.

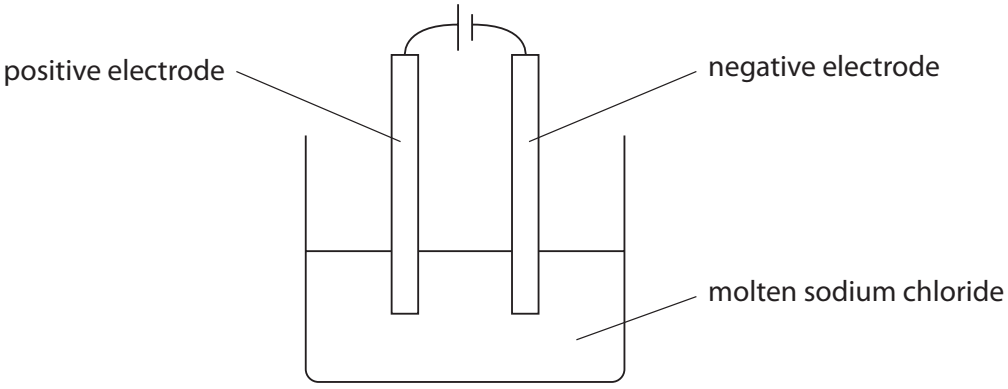
(a) Explain why metals are malleable.

(2)

(b) Sodium metal is extracted by the electrolysis of molten sodium chloride.

Sodium metal forms at the negative electrode and chlorine gas forms at the positive electrode.

The diagram represents this electrolysis.



(i) Explain why molten sodium chloride conducts electricity.

(2)

(ii) Explain how sodium metal forms at the negative electrode.

(2)

(iii) Write an ionic half-equation for the formation of chlorine gas at the positive electrode.

(1)

.....

(iv) Give a reason why sodium metal does not form in the electrolysis of an aqueous solution of sodium chloride.

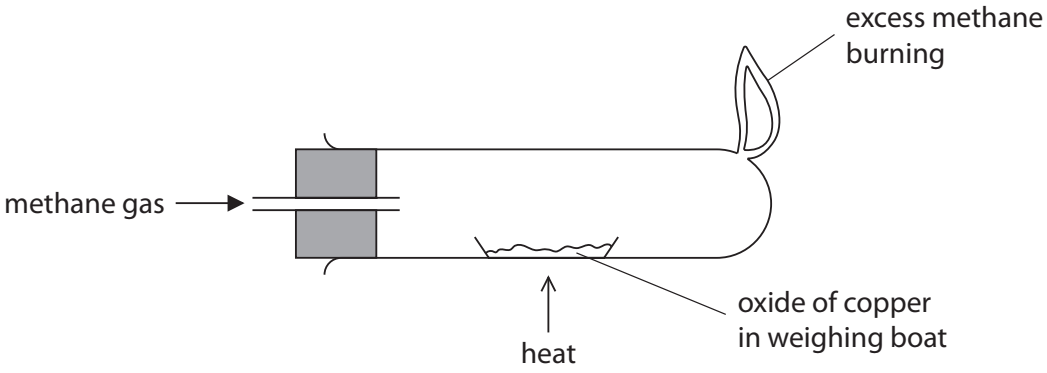
(1)

.....

.....

(c) Copper can be produced by reacting an oxide of copper with methane.

The diagram shows the apparatus used.



The oxide of copper is heated until the reaction is complete.

The table shows the results.

	Mass in g
empty weighing boat	17.25
weighing boat + oxide of copper	22.02
weighing boat + copper	21.06

Use the results to show that this oxide has the empirical formula CuO

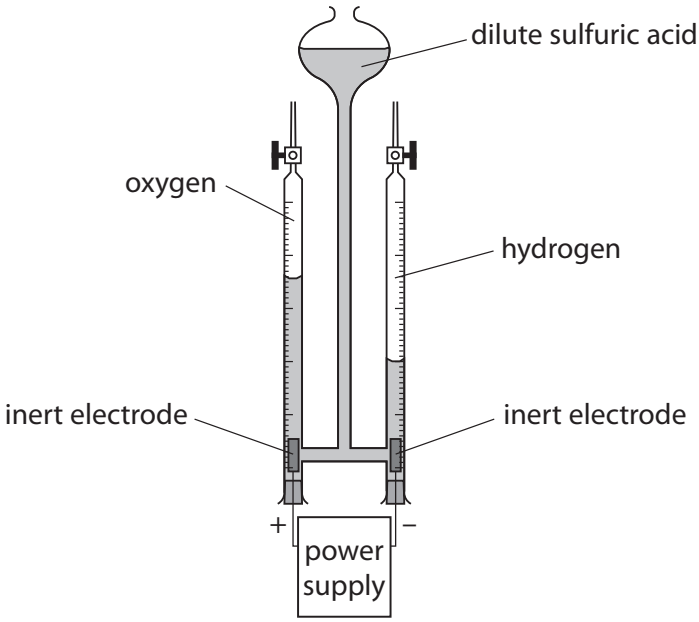
[for Cu, A_r = 63.5 for O, A_r = 16]

(3)

(Total for Question 5 = 11 marks)

6 This question is about electrolysis.

(a) This apparatus is used to collect the gases produced when an electric current passes through dilute sulfuric acid.



(i) Name a suitable material for the inert electrodes.

(1)

.....

(ii) Give a test to show that the gas produced at the positive electrode is oxygen.

(1)

.....

.....

(iii) Give a test to show that the gas produced at the negative electrode is hydrogen.

(1)

.....

.....

(iv) Give an ionic half-equation for the formation of hydrogen at the negative electrode.

(1)

.....

(v) The oxygen gas in the tube has a volume of 17.8 cm^3 at rtp.

Calculate the mass, in grams, of oxygen gas in the tube.

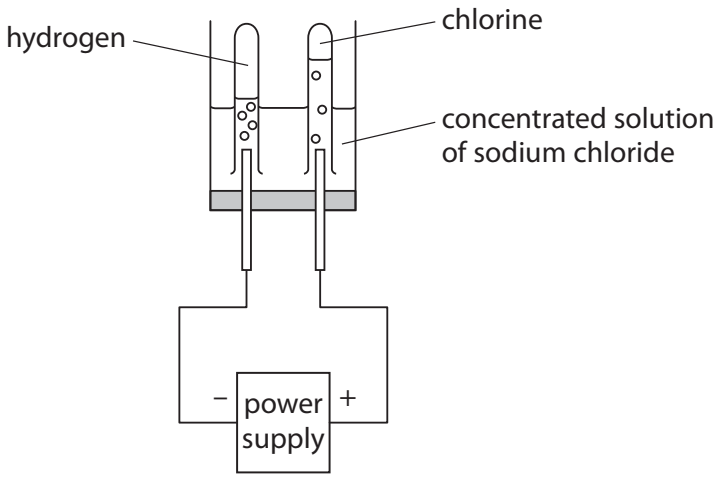
Give your answer to 3 significant figures.

[for O_2 at rtp, molar volume = 24 000 cm^3]

(3)

mass of oxygen = ... g

(b) This apparatus is used to electrolyse a concentrated solution of sodium chloride.



(i) Give a reason why sodium chloride solution conducts electricity.

(1)

(ii) The positive ions in the solution are H^+ and Na^+.

Give a reason why hydrogen forms at the negative electrode rather than sodium.

(1)

(iii) A sample of the solution is taken from near the negative electrode. The sample is tested with universal indicator.

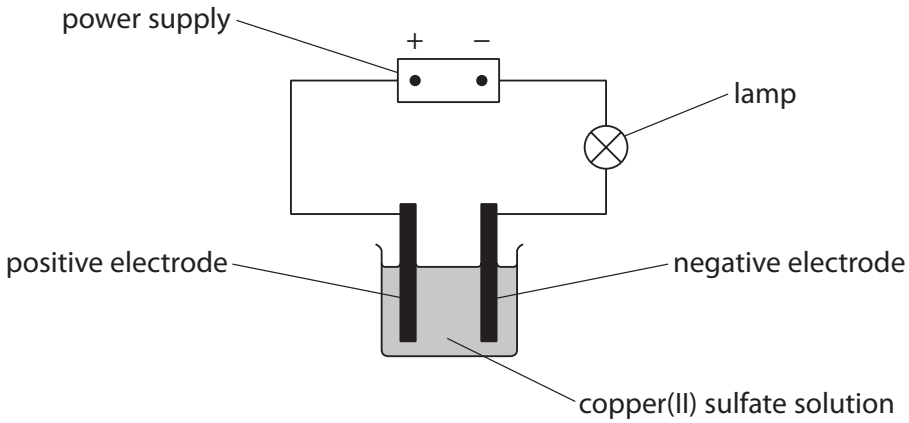
Explain the final colour of the universal indicator.

(2)

(Total for Question 6 = 11 marks)

6 This question is about the electrolysis of copper(II) sulfate solution.

(a) The diagram shows the apparatus used for the electrolysis.



A student records the total increase in mass of the negative electrode every minute for 8 minutes.

The table shows the results.

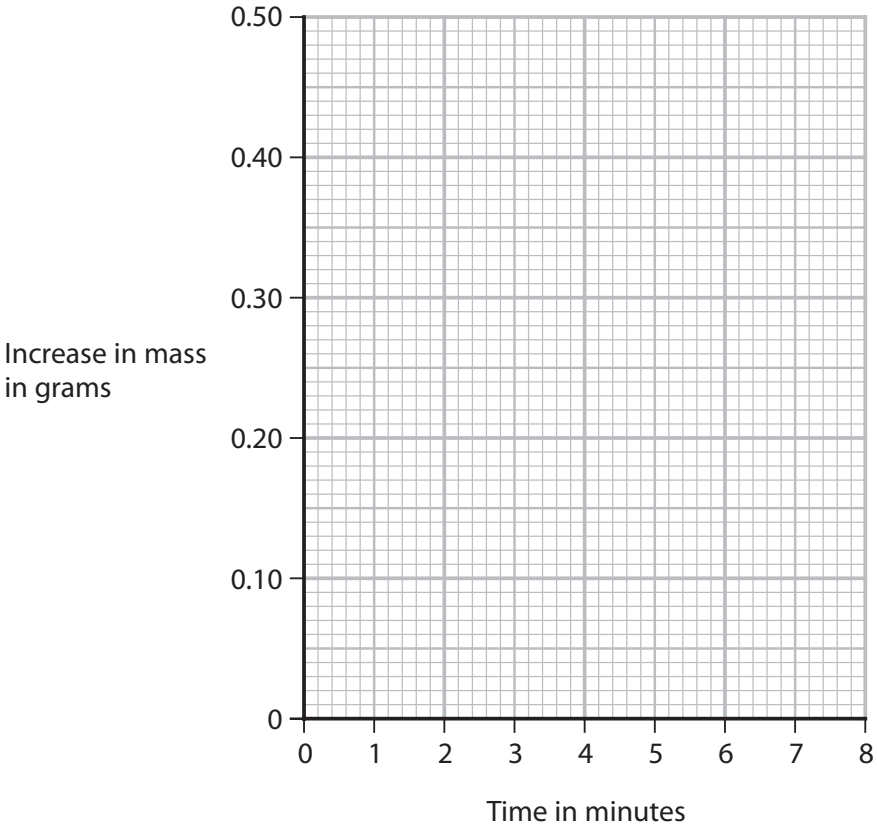
Time in minutes	Total increase in mass of the negative electrode in grams
0	0.00
1	0.15
2	0.27
3	0.34
4	0.39
5	0.41
6	0.42
7	0.42
8	0.42

(i) Plot the student's results.

(1)

(ii) Draw a curve of best fit.

(1)



(iii) Explain the shape of the graph.

(2)

.....

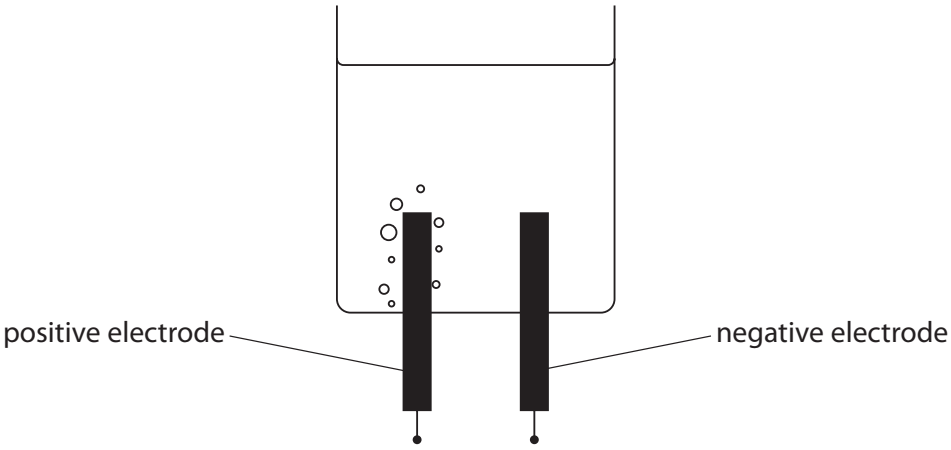
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(b) The product at the positive electrode is oxygen gas.

(i) The student repeats the electrolysis using different apparatus.



Describe how the student should collect a sample of pure oxygen at the positive electrode.

(2)

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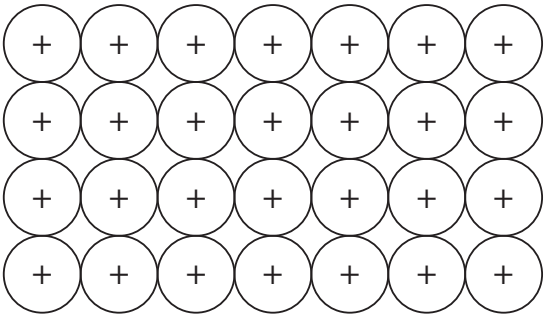
(ii) Give an ionic half-equation for the formation of oxygen.

(2)

.....

(c) The wire used to connect the power supply to the electrodes is made of copper metal.

The diagram shows the arrangement of the ions in a metal.



(i) Metals that are malleable can also be stretched to form long, thin wires.

Suggest why metals can be stretched to form wires.

(2)

(ii) Explain why metals conduct electricity.

(2)

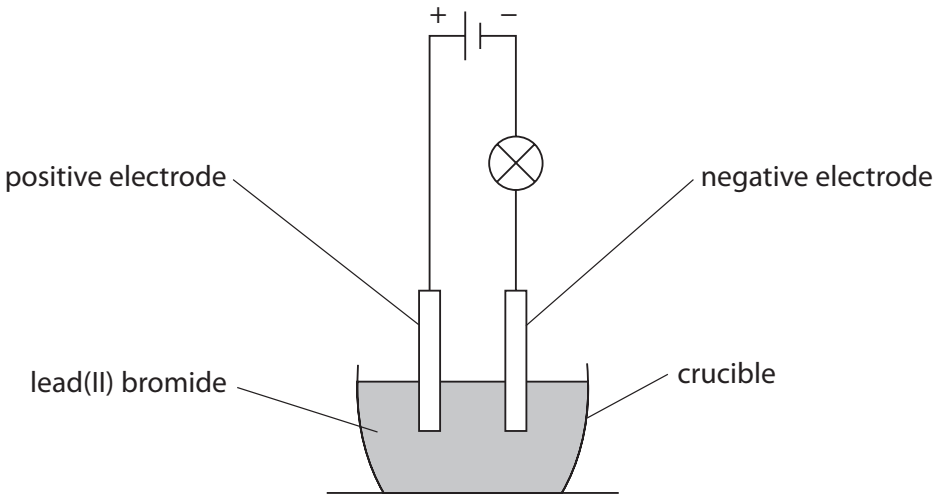
(Total for Question 6 = 12 marks)

6 A teacher prepares the insoluble salt lead(II) bromide ($PbBr_2$) by mixing solutions of lead(II) nitrate and sodium bromide.

(a) Describe what the teacher should do next to obtain a pure, dry sample of lead(II) bromide.

(3)

(b) The teacher then sets up a circuit in a fume cupboard using the pure, dry sample of lead(II) bromide.



Explain why the lamp does not light when the lead(II) bromide is solid.

(2)

(c) The teacher heats the lead(II) bromide.

When the lead(II) bromide is molten, the lamp lights and bromine forms at the positive electrode.

(i) State what observation would be made at the positive electrode.

(1)

(ii) Explain how bromide ions in the molten lead(II) bromide become bromine molecules at the positive electrode.

(4)

(d) Write an ionic half-equation for the reaction that occurs at the negative electrode.

Include state symbols in your equation.

(2)

(Total for Question 6 = 12 marks)

3 (a) Explain why metals conduct electricity but covalent compounds do not conduct electricity.

(4)

(b) Hydrogen chloride, HCl, is a covalent substance.

When hydrogen chloride is added to water, a solution of dilute hydrochloric acid is formed.

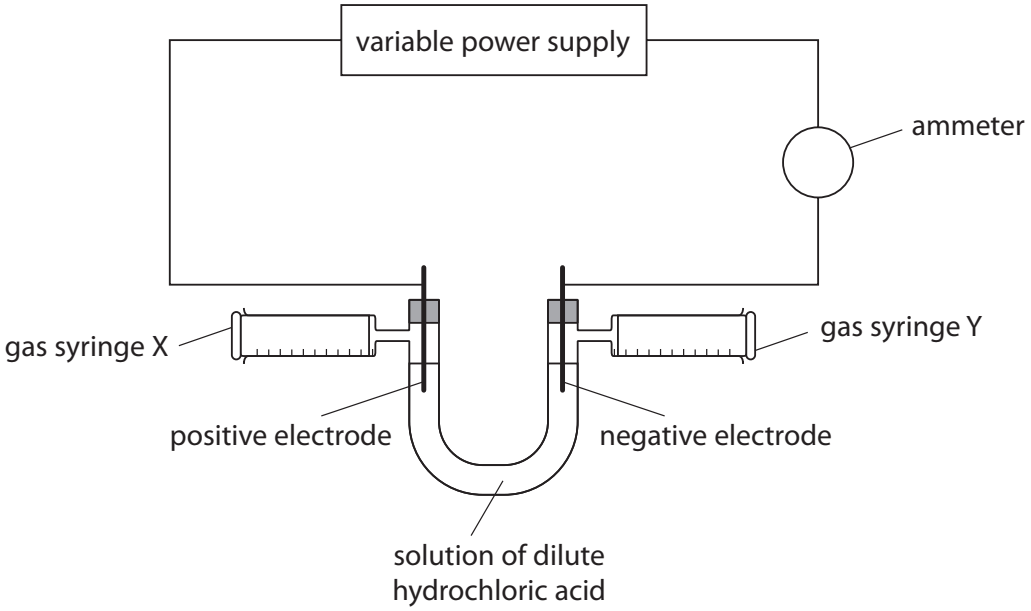
This solution does conduct electricity.

Name the type of particle in the solution of the dilute hydrochloric acid that allows it to conduct electricity.

(1)

(c) The teacher uses this apparatus to investigate the electrolysis of a solution of dilute hydrochloric acid.

The ammeter measures the current.



The teacher wants to find out if there is a relationship between current and volume of gas collected at each electrode.

She adjusts the power supply until the current is 0.1 amp.

After 5 minutes she records the volume of gas collected in syringe X and syringe Y.

The teacher repeats the experiment several times, using a different current each time.

The table gives the teacher's results for syringe Y.

Current in amp	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Volume of gas in cm^3	8	15	22	25	37	44	52	60

(i) Plot the results for syringe Y.

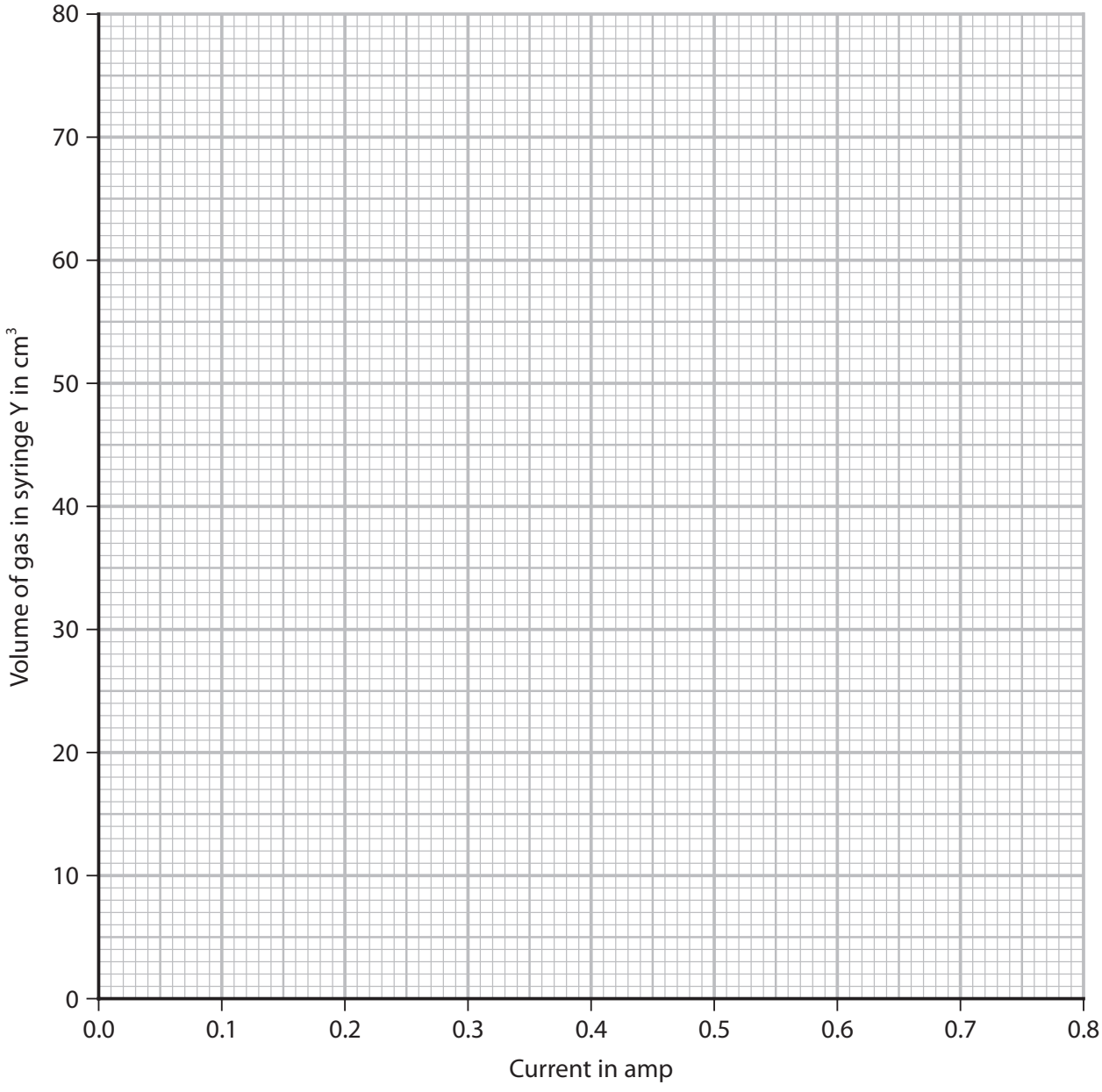
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Draw a line of best fit.

(1)



(iv) Explain a possible cause of the anomalous result, other than misreading the apparatus.

(2)

(v) Deduce the relationship between current and volume of gas collected in syringe Y.

(1)

(d) The ionic half-equation for the reaction that produces the gas in syringe X is

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The ionic half-equation for the reaction that produces the gas in syringe Y is

$$2H^+ + 2e^- \rightarrow H_2$$

(i) Suggest how these ionic half-equations show that the volume of chlorine collected in syringe X should be the same as the volume of hydrogen collected in syringe Y.

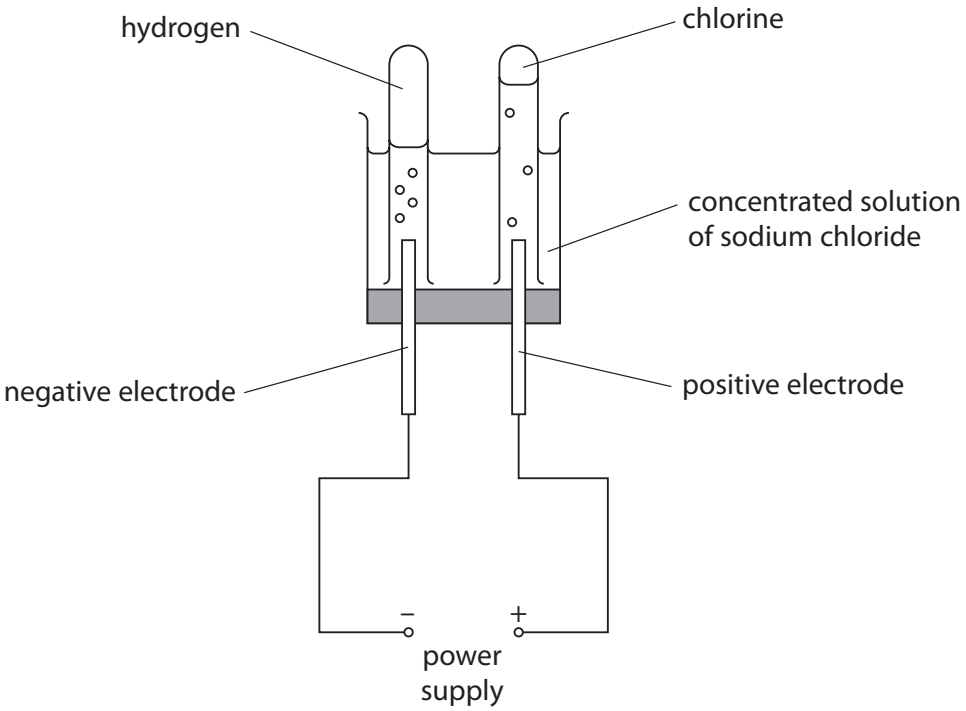
(1)

(ii) Suggest why the volume of chlorine collected in syringe X is always less than the volume of hydrogen collected in syringe Y.

(1)

(Total for Question 3 = 13 marks)

6 The diagram shows how hydrogen gas and chlorine gas can be prepared in the laboratory by electrolysis of a concentrated solution of sodium chloride.



(a) (i) Give a test for hydrogen gas.

(1)

.....

.....

(ii) Give a test for chlorine gas.

(2)

.....

.....

.....

.....

(b) The ionic half-equation for the formation of chlorine at the positive electrode is

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

(i) State why this reaction is an oxidation reaction.

(1)

.....

.....

(ii) Give the ionic half-equation for the formation of hydrogen at the negative electrode.

(1)

.....

(iii) State why it is safer to do this electrolysis in a fume cupboard.

(1)

.....

.....

(iv) Suggest why the volume of chlorine collected during this electrolysis is less than the volume of hydrogen collected.

(1)

.....

.....

.....

(c) In the chemical industry, chlorine can be produced by the electrolysis of molten sodium chloride.

The overall equation for this reaction is

$$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$$

(i) Explain why sodium chloride needs to be molten rather than solid for electrolysis to occur.

(2)

.....

.....

.....

.....

.....

.....

(ii) Calculate the maximum volume, in dm^3, of chlorine gas at rtp that can be obtained from 23.4 tonnes of molten sodium chloride.

[1 tonne = 10^6 g]

[M_r of NaCl = 58.5]

[molar volume of chlorine at rtp = 24 dm^3]

Give your answer in standard form.

(4)

volume = ... dm^3

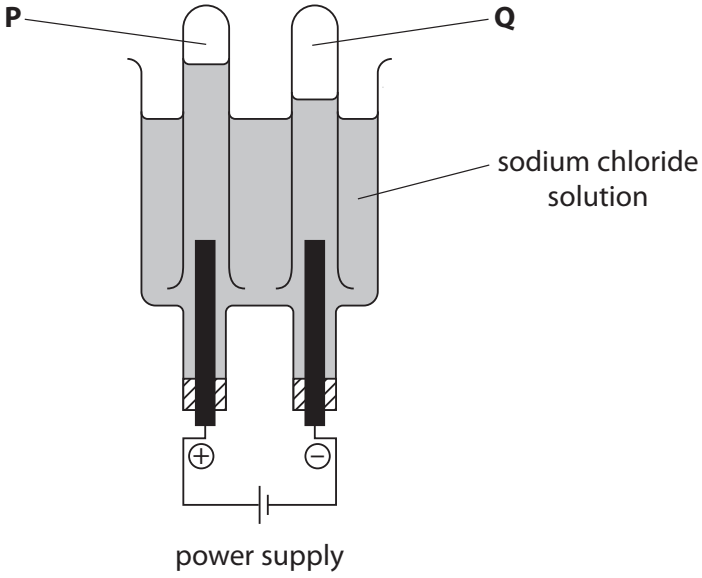
(Total for Question 6 = 13 marks)

7 (a) Sodium chloride is an ionic compound.

Explain why sodium chloride conducts electricity when it is molten or in solution, but not when it is solid.

(2)

(b) A solution of sodium chloride can be electrolysed using this apparatus.



(i) If the solution is dilute, a significant amount of oxygen collects at **P**.

Complete the ionic half-equation for this reaction.

(1)

.....H_2O → .....H^+ + ...O_2 + ...e^-

(ii) If the solution is concentrated, chlorine is the main product that collects at **P**.

This is the ionic half-equation for the reaction.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

State why this is an oxidation reaction.

(1)

(c) The gas that collects at **Q** is hydrogen.

(i) Give a test for hydrogen.

(1)

(ii) Explain how hydrogen gas forms at the negative electrode.

(3)

(d) Hydrogen reacts with oxygen to form water.

The equation shows the covalent bonds in the molecules.

$$2H—H + O=O \rightarrow 2H—O—H$$

The table gives the bond energies.

Bond	H—H	O=O	O—H
Bond energy in kJ / mol	436	498	463

(i) Use the equation and the values in the table to calculate the enthalpy change, ΔH, for the reaction.

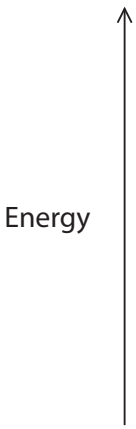
Include a sign in your answer.

(3)

$\Delta H =$ ..... kJ

(ii) Complete the diagram to show the energy levels of the reactants and products, and the enthalpy change, ΔH.

(3)



(Total for Question 7 = 14 marks)

6 A scientist reacts lead(II) nitrate solution with sodium bromide solution.

This is the equation for the reaction.

$$Pb(NO_3)_2(aq) + 2NaBr(aq) \rightarrow PbBr_2(s) + 2NaNO_3(aq)$$

(a) Describe how the scientist could obtain a pure dry sample of lead(II) bromide ($PbBr_2$) from the reaction mixture.

(3)

(b) The scientist reacts an excess of lead(II) nitrate solution with 25 cm^3 of sodium bromide solution of concentration 2.0 mol/dm^3.

(i) Show that the amount of sodium bromide used is 0.050 mol.

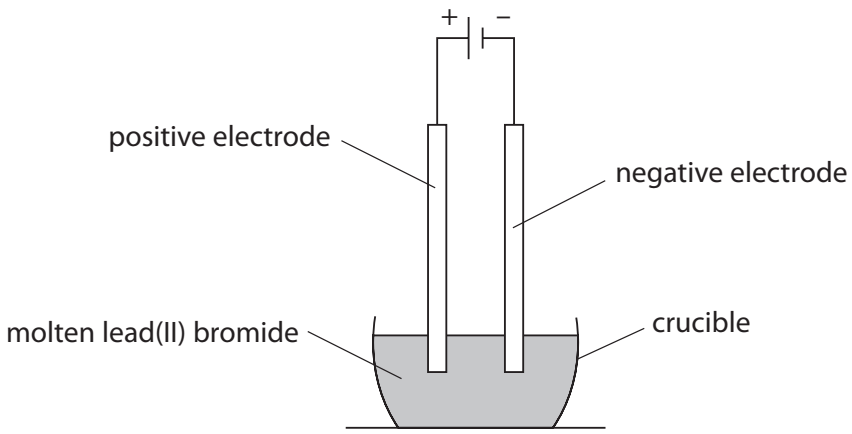
(1)

(ii) Show that the maximum theoretical mass of lead(II) bromide is approximately 9 g.

[for $PbBr_2$ $M_r = 367$]

(2)

(c) The scientist electrolyses molten lead(II) bromide using this apparatus.



(i) Explain why lead(II) bromide needs to be molten rather than solid for electrolysis to occur.

(3)

(ii) The electrolyte is at a temperature of 400 °C.

Explain a suitable material for the electrodes.

(2)

(iii) Give the half-equation that occurs at the negative electrode.

(1)

.....

(d) Bromine forms at the positive electrode.

This is the half-equation for the reaction at the positive electrode.

$$2Br^- \rightarrow Br_2 + 2e^-$$

(i) State what is observed at the positive electrode.

(1)

.....

.....

(ii) State why the half-equation represents an oxidation reaction.

(1)

.....

.....

(Total for Question 6 = 14 marks)

MARK SCHEMES

official Pearson Edexcel mark schemes

Question number	Answer	Notes	Marks
1 (a)	**B** (the crystal dissolves in water) A is not correct as the crystal does not condense C is not correct as the crystal does not evaporate D is not correct as the crystal does not melt		**1**
(b) (i)	**A** (all of the liquid is purple) B is not correct as the crystal will remain dissolved C is not correct as the particles will have diffused throughout the whole of the liquid D is not correct as the particles will have diffused throughout the whole of the liquid		**1**
(ii)	**C** (diffusion) A is not correct as condensation describes the process of a gas changing into a liquid B is not correct as crystallisation describes the process of a soluble solid forming from a solution C is not correct as evaporation describes the process of a liquid changing into a gas		**1**
(c)	**A** (3) B is not correct as there are only 3 elements present not 4 C is not correct as there are only 3 elements present not 6 D is not correct as there are only 3 elements present not 7		**1**
		Total	**4**

Question number	Answer	Notes	Marks
2 (a) (i)	A A is the correct answer because 100°C is above the boiling point of W B is not the correct answer because X is a solid at 100°C C is not the correct answer because Y is a solid at 100°C D is not the correct answer because Z is a solid at 100°C		1
(ii)	B B is the correct answer because X is a liquid for 1840°C A is not the correct answer because W is a liquid for 67°C C is not the correct answer because Y is a liquid for 1150°C D is not the correct answer because Z is a liquid for 330°C		1
(iii)	C C is the correct answer because Y is a liquid at 1000°C and a gas at 2000°C A is not the correct answer because W is a gas at 1000°C and at 2000°C B is not the correct answer because X is a liquid at 1000°C and 2000°C D is not the correct answer because Z is a gas at 1000°C and at 2000°C		1
(b)	ionic	**ALLOW** electrovalent	1
(c)	the (impure) substance will melt over a range of temperatures	**ALLOW** the (impure) substance will have a lower melting point	1
			5 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a) (i)</td><td>(from) solid to liquid</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>iodine (s) → iodine (g)</td><td></td><td>1</td></tr>
<tr><td>(b)</td><td>(diagram showing) particles well spread out with none touching</td><td></td><td>1</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><th>Statement</th><th>Tick</th></tr>
<tr><td>the particles only vibrate</td><td></td></tr>
<tr><td>the particles do not move</td><td></td></tr>
<tr><td>the particles have no gaps between them</td><td></td></tr>
<tr><td>the particles move randomly</td><td>✓</td></tr>
<tr><td>the particles have more energy than in ice</td><td>✓</td></tr>
<tr><td>the particles have a regular arrangement</td><td></td></tr>
</table>
tick in 4th box (1)
tick in 5th box (1)

if more than two ticks deduct 1 mark for each incorrect tick</td><td></td><td>2</td></tr>
</table>

(Total for Question 1 = 5)

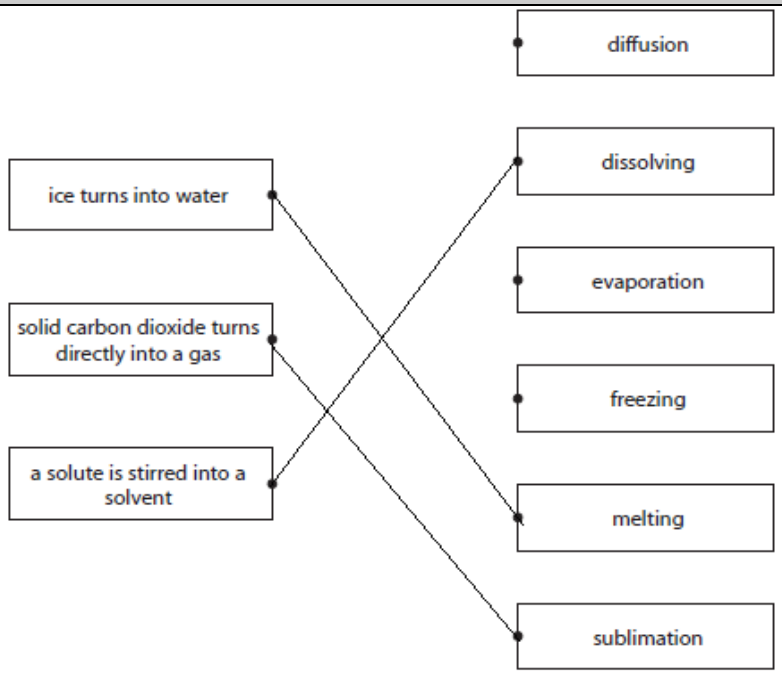
Question number	Answer	Notes	Marks
2 (a)	**M1** dissolving **M2** diffusion	Answers can be in either order IGNORE dilution	2
(b) (i)	**A** 3 B is incorrect as there are not 4 different types of atoms in $KMnO_4$ C is incorrect as there are not 6 different types of atoms in $KMnO_4$ D is incorrect as there are not 7 different types of atoms in $KMnO_4$		1
(ii)	(M_r = 39 + 55 + 16 x 4 =) 158		1
(c)	(something that) gives oxygen (to another substance)/takes/gains electrons (from another substance) OWTTE	ALLOW oxygen donor ALLOW electron acceptor ALLOW (something that) causes another substance to be oxidised/to lose electrons OWTTE ALLOW (something that) is reduced (in a reaction) ALLOW increases the oxidation number (of another species) OWTTE	1
			Total 5

Question number	Answer	Notes	Marks
1 (a)	X evaporating Y condensing Z freezing	ALLOW evaporation ALLOW condensation	3
(b)	**M1** solid particles vibrate about a fixed position **M2** gas particles move randomly	REJECT do not move **ALLOW** gas particles move rapidly/quickly/freely	2
			Total 5

Question number	Answer	Notes	Marks
2 (a)	temperature	ALLOW volume/amount of solvent IGNORE concentration IGNORE stirring	1
(b) (i)	**M1** G in correct place **M2** H C A in correct places		2
(ii)	**M1** mass of dry salt (= 78.1 − 60.5 =) 17.6 (g) **M2** solubility = (17.6 × 2) = 35.2 (g per 100 g of water)	ALLOW ECF from M1 correct answer with no working scores 2	2

(Total for Question 2 = 5 marks)

Question number	Answer	Notes	Marks
1 a (i)	melting		1
(ii)	evaporation		1
(iii)	sublimation		1
b	A description that refers to three of the following points **M1** (particles) close together **M2** (particles) regularly arranged **M3** (particles) do not move around **M4** (particles) vibrate (about a fixed position)	 **ALLOW** tightly packed/ touching **ALLOW** arranged in a lattice **M1** and **M2** can be scored from a diagram **ALLOW** do not move freely **IGNORE** references to fixed shape and volume	 3 **Total 6**

Question number	Answer	Notes	Marks
2 (a)		1 mark for each correct line form boxes on left If more than one line from a box on left column do not award mark for that box	3 cler
(b)	a description including M1 measure the melting point M2 if fixed/sharp melting point the substance is pure M3 if melts over range of temperatures the substance is a mixture	ALLOW measure boiling point for M1 and substitute b.p. for m.p in M2 and boils for melts in M3 ALLOW max 2 if reference to freezing point as opposed to melting point	3 grad

Total for Q2 = 6 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td><table><tr><th>Start</th><th>End</th></tr><tr><td>solid</td><td>liquid</td></tr><tr><td>solid</td><td>gas</td></tr><tr><td>gas</td><td>liquid</td></tr><tr><td>liquid</td><td>gas</td></tr></table></td><td>Award 1 mark for each correct row

ALLOW gas to solid for sublimation</td><td>3</td></tr>
<tr><td>(b)</td><td>A description that refers to any three of the following points

M1 irregular /random arrangement (of particles)

M2 large gaps between them /far apart /widely spaced

M3 random movement / move freely

M4 move (very) quickly</td><td>

ALLOW spread out

IGNORE references to kinetic energy</td><td>3</td></tr>
<tr><td colspan="4">6 marks</td></tr>
</table>

Question number	Answer	Notes	Marks
2 (a) (i)	(solute is) the substance/solid that dissolves (in a solvent) OWTTE		1
(ii)	(solvent is) the substance/liquid the solute/solid/substance dissolves in OWTTE		1
(b)	**M1** (saturated solution) contains as much dissolved solute/solid/substance as possible OWTTE **M2** at a particular temperature		2
(c)	**M1** process called diffusion **M2** particles spread out (evenly throughout water/solution/liquid)	**ALLOW** particles move from area of high concentration to area of low concentration	2

Total for Question 2 = 6 marks

Question number	Answer	Notes	Marks
1 (a) (i)	particles should be close together and should fill from the bottom of the box, most particles should touch with a minimum of 2 random rows of particles	ALLOW particles filling the whole box IGNORE the size of the particles REJECT a regular arrangement	1
(ii)	solid		1
(b)	solid to liquid melting solid to gas sublimation	 ALLOW subliming	2
(c)	An explanation that links the two points. M1 (particles / molecules have) more (kinetic) energy M2 can overcome / break the (intermolecular) forces/forces (between water molecules)	 ALLOW hot water has more (kinetic) energy ALLOW (particles / molecules) move faster IGNORE vibrate more ALLOW can overcome / break the bonds (between water molecules) OR to break away from one another OR to escape more easily IGNORE references to collisions, activation energy or rate of reaction	2
			Total for question = 6

Question number	Answer	Notes	Marks
1 (a) (i)	six particles should be arranged randomly	max of two particles should touch ALLOW between 5 and 10 particles	1
(ii)	particles are (much) closer together	ALLOW the density is (much) greater / less space between particles / packed more tightly	1
(iii)	Any one from: high pressure risk of explosion oxidising agent risk in contact with combustible materials	 ALLOW risk of fire IGNORE flammable	1
(b) (i)	blue flame	ALLOW choking /pungent gas produced / sulfur darkens	1
(ii)	M1 (final colour) red/orange/yellow M2 an acidic solution/an acid/sulfurous acid is formed	IGNORE any original colour ALLOW sulfuric acid ALLOW sulfur dioxide is acidic ACCEPT the solution formed contains hydrogen ions	2
			Total for question = 6

Question number	Answer	Notes	Marks
1 (a)	from liquid to solid freezing from gas to liquid condensing from solid to gas sublimation	 ALLOW condensation ALLOW subliming	3
(b) (i)	**6** circles similar size randomly arranged none touching	At least one circle in top/bottom of box	1
(ii)	A (the atoms move randomly in the gas state) B is not correct since atoms do not move randomly in the solid state C is not correct since atoms are not in a fixed position in the gas state D is not correct since atoms are not in a fixed position in the liquid state		1
(c)	$H_2O(l)$ $H_2O(s)$	ALLOW upper case/lower case	1
		Total = 6	

Question number	Answer	Notes	Marks
1 (a) (i)	freezing		1
(ii)	evaporation		1
(iii)	sublimation		1
(b)	Any 3 from M1 (particles) are far apart M2 (particles) are randomly / irregularly arranged M3 (particles) have (almost) total freedom of movement /move freely M4 particles have high/higher energy M1 comment on spacing M2 comment on arrangement M3 comment on moving M4 comment on energy	 ALLOW no arrangement ALLOW random motion	3
			Total = 6

Question number	Answer	Notes	Marks
3 (a)	M1 dissolving /dissolves /dissolution? M2 diffusion /diffuses	can be either way round	2
(b)	M1 particles **move** faster M2 so particles **collide** and react after a shorter period of time	ALLOW particles have **more** kinetic energy ALLOW diffuse **faster** ALLOW **more** frequent collisions	2
(c) (i)	3 /three		1
(ii)	2+ / Cu^{2+}	ALLOW +2 /Cu^{+2}	1
			Total = 6

Question number	Answer	Notes	Marks
2 (a) (i)	Particles should be close together and should fill from the bottom of the box, some particles should touch	**ALLOW** particles filling the whole box **IGNORE** the size of the particles **REJECT** a regular arrangement	1
(ii)	Gas	**ALLOW** gaseous	1
(b)	**M1** (water evaporates) l to g **M2** (crystals of iodine sublime) s to g **M3** (ice melts) s to l	**ALLOW** words for M1, M2 and M3	3
(c)	**M1** (particles / molecules have) more energy **M2** to overcome / break the forces (between water molecules)	**ALLOW** water has more energy **ALLOW** (particles / molecules have) move faster **IGNORE** vibrate more **ALLOW** to overcome / break the bonds (between water molecules) **OR** to break away from one another **OR** so escape more easily **IGNORE** references to collisions or activation energy	2

Question number	Answer	Notes	Marks
3 (a) (i)	M1 dissolving M2 diffusion	Answers can be in either order	2
(b) (i)	An explanation that links any two of the following points M1 crystals dissolve faster M2 (potassium iodide/ lead nitrate/ water) particles move faster / (lead/ iodide) ions move faster / rate of diffusion increases M3 therefore (lead and iodide) ions/ particles meet / collide after a shorter period of time/ sooner	**ALLOW** (potassium iodide /lead nitrate/ water) particles have more energy **ALLOW** molecules in place of particles if referring to water **IGNORE** references to more collisions or more energetic collisions	2
(c) (i) (ii)	3 / three 2+ /+2	 **ALLOW** Pb^{2+}	1 1
(d)	$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$	**ALLOW** multiples and fractions	1
			7 marks

Question number	Answer	Notes	Marks
3 (a)	solid to liquid **melting** solid to gas **sublimation** liquid to solid **freezing**		3
(b) (i)	diffusion	ALLOW diffusing	1
(ii)	Any one from: ammonia travels further (in the same time) the ammonium chloride / (white) ring / solid forms further away from the ammonia the ammonium chloride / (white) ring / solid forms closer to the hydrochloric acid		1
(iii)	Any one from: gas particles move in random directions gas particles collide with air particles / each other gas particles collide with the wall of the tube		1
(iv)	Any one from: eye protection / wear safety glasses / goggles wear gloves apron / lab coat	ALLOW put a bung / cork in both ends	1
			Total for question = 7 marks

Question number	Answer	Notes	Marks
1 (a)	Four more particles (randomly spaced and) far apart	**IGNORE any lines or arrows** **ACCEPT** more than four particles as long as they are far apart REJECT any particles touching	1 GR
(b)	An explanation that links the following two points **M1** (mean kinetic) energy of particles increases **M2** more particles have enough energy to escape /more particles overcome the (intermolecular) forces (of attraction) holding them together	 **ALLOW** particles move faster/more quickly IGNORE particles vibrate more IGNORE it has more energy/ heat energy increases **ALLOW** particles escape more quickly/more easily IGNORE more collisions REJECT breaking of bonds **ALLOW** molecules /atoms for particles in **M1** and **M2**	2 EXP
(c) (i)	condensation/condensing		1 CL
(ii)	$H_2O(g) \rightarrow H_2O(l)$	**ACCEPT** multiples Formula must be correct **ALLOW** steam(g) → water(l) water(g) → water(l) **Water vapour(g)** →water(l) **ALLOW** upper case letters for state symbols **Ignore missing brackets**	1 GR
(d)	**M1** **regular** arrangement of particles/particles closely packed **M2** (particles) vibrate around a fixed position/vibrate only	ALLOW particles in a regular lattice	2 EXP
			Total 7

Question number	Answer	Notes	Marks
3 (a) (i)	(a solution that) has as much solute/solid/substance as possible dissolved (at a particular temperature) OWTTE	ALLOW No more solute will dissolve	1
(ii)	the solubility decreases (as the temperature decreases)		1
(b)	M1 (mass of potassium permanganate) 1.25 (g) M2 (solubility of potassium manganate) 5 (g/100g)	 ALLOW M1×4 5 (g/100g) no working scores 2 marks	2
(c) (i)	glowing splint/spill relights	REJECT burning/lit splint	1
(ii)	197	IGNORE any units given	1
(d)	any one from: electron acceptor/gains electrons oxygen donor/loses oxygen	IGNORE ‘oxidises another substance whilst being reduced itself’	1
			Total = 7

Question number	Answer	Notes	Marks
3 (a) (i)	$2H_2S$ (**g**) + SO_2 (**g**) → **3** S (s) + **2** H_2O (**l**) M1 all state symbols correct M2 balancing correct	 ALLOW upper case ALLOW multiples/fractions	2
(ii)	(sulfur dioxide is reduced because it) loses oxygen	IGNORE references to electrons	1
3 (b) (i)	Explanation linking following points M1 sulfur/(pale yellow) solid forms nearer to sulfur dioxide side/closer to left OWTTE ORA M2 so hydrogen sulfide particles moved / diffused further (in same time) OWTTE ORA		2
(ii)	M1 M_r of H_2S = (1 + 1 + 32) = 34 M2 M_r of SO_2 = (32 +16 + 16) = 64 M3 statement of relationship eg the higher the Mr the slower the gas diffuses	 ACCEPT reverse argument	3

Total marks for Question 3 = 8

Question number	Answer	Notes	Marks
4 (a) (i)	all points plotted correctly to the nearest grid line		
(ii)	point at 50 °C and 17.5 g circled on grid/in table	**ALLOW** ECF from incorrect plotting	
(iii)	smooth curve of best fit		
(b)	Any two from **M1** less than 25 cm^3 of water was used **M2** the temperature was less than 50 °C **M3** not enough potassium nitrate was added **M4** the solution was not stirred	**ALLOW** ECF from incorrect plotting and incorrect point circled for **M1** and **M2** only	

Question number	Answer	Notes	Marks
4 (c)	**M1** curve extended to 75 °C **M2** correct mass read from graph to the nearest grid line	expected answer around 39 to 40 g 0 marks if curve not extended	
(d)	**M1** mass at 25 °C read from graph to nearest grid line **M2** mass from graph multiplied by 4	expected answer around 44 g **ALLOW** ECF from incorrect plotting	**Total**

Question number	Answer	Notes	Marks
3 (a) (i)	M1 working shown on graph M2 56 (°C)	 ALLOW any value between 56 and 57 inclusive.	2
(ii)	M1 31-13 M2 18 (g)	 ALLOW ecf if one incorrect reading in M1 correct answer of 18g with or without working scores 2	2
(b) (i)	5.1 (g)		1
(ii)	15 (g)		1
(iii)	M1 5.1÷15 **OR** 0.34 (g) **OR** answer to (i) ÷ answer to (ii) M2 34 (g) **OR** answer to M1 × 100	 correct answer of 34 (g) with or without working scores 2	2
(iv)	Any one from M1 (hydrated) copper(II) sulfate would become anhydrous copper sulfate M2 (hydrated) copper(II) sulfate would lose water	 ALLOW the (hydrated) crystals would decompose	1
			Total for question = 9

Question number	Answer	Notes	Marks
4 (a) (i)	**M1** all points plotted correctly to the nearest + or – half a small square for KNO_3 **M2** all points plotted correctly to the nearest + or – half a small square for $NaNO_3$		2
(ii)	**M1** smooth curve of best fit for KNO_3 **M2** smooth curve of best fit for $NaNO_3$	If KNO_3 and $NaNO_3$ are not labelled or labelled incorrectly lose 1 mark if curves are correct but allow ECF for (c) and (d) if the curves are the wrong way round	2
(b)	temperature where their lines cross (expected value approximately 68 °C)		1
(c)	**M1** mass at 30 °C read from graph (expected value approximately 24 g) **M2** 4 x answer to **M1** (expected value approximately 96 g)		2
(d)	**M1** mass at 50 °C read from graph (expected value approximately 21 g) **M2** mass at 20 °C read from graph (expected value approximately 8 g) **M3** **M1** – **M2** (expected value approximately 13 g)	Need to show working on the graph for **M1** and **M2** to score but allow **M3** for **M1** - **M2**	3
			Total 10

Question number	Answer	Notes	Marks
2 (a)	Explanation containing following ideas (A saturated solution is one which contains) M1 as much solute as possible in (a certain volume of) the solvent OWTTE M2 at a particular / given / constant temperature OWTTE		2
2 (b) (i)	(volumetric) pipette/burette		1
(ii)	(water / solution) would be heated too quickly OR (water / solution) might spit out or be lost OWTTE	ALLOW (water / solution) might boil or evaporate	1
(iii)	repeat (and find the mean temperature)		1
(iv)	M1 4.5 (g solid in 10 g water) M2 (so solubility = 4.5 x 10) = 45 (g per 100 g of water)	ALLOW M1×10 45 with no working scores 2	2

.

Question number	Answer	Notes	Marks
2 (c) (i)	71 (°C)	ALLOW 70-72(°C)	1
(ii)	M1 (from curve) 124 g of solid B dissolves in 100 g water M2 (so 124 x 2.5) = 310 (g dissolves in 250 g water)	ALLOW 123-125 g ALLOW ecf from M1 307.5-312.5 with no working scores 2 marks ALLOW M1×2.5 If solid A used 1 mark for correct answer of 262-268g	2
(iii)	some water may have been lost/evaporated OWTTE		1

Total marks for Question 2 = 11

Question number	Answer	Notes	Marks
1 (a)	potassium	**ALLOW** K	1
(b)	(paper) chromatography		1
			1
(c) (i)	sodium chloride	**ALLOW** NaCl	1
(ii)	air		1
(iii)	sulfur	**ALLOW** S	
			Total 5

Question number			Answer	Notes	Marks
1	(a)		**B** filtration is the correct answer because it will enable sand to be separated from salt solution **A** is not correct because crystallisation will not enable sand to be separated from salt solution **C** is not correct because fractional distillation will not enable sand to be separated from salt solution **D** is not correct because simple distillation will not enable sand to be separated from salt solution		1 comp
	(b)	(i)	X is a thermometer Y is a (Liebig) condenser Z is a beaker		3 cler
		(ii)	salt		1 cler

Total for Q1 = 5

Question number	Answer	Notes	Marks
1 (a)	**M1** A test tube / boiling tube **M2** B evaporating basin **M3** C measuring cylinder **M4** D (top-pan) balance	 **ALLOW** evaporating dish/crystallising dish **ALLOW** (weighing) scale(s) **ALLOW** weighing machine	4 Grad
(b)	**C** A is incorrect as a test tube cannot measure a volume of liquid B is incorrect as an evaporating basin cannot measure a volume of liquid D is incorrect as a balance measures mass not volume		1 Comp **Total 5**

Question number	Answer	Notes	Marks
1 (a) (i)	**A** A is the correct answer because A contains one element and the atoms are not joined to other atoms. B is incorrect because B contains molecules of an element. C is incorrect because C contains molecules of a compound D is incorrect. D contains an element but the atoms are joined together to form a giant covalent structure.		1
(ii)	**C** C is the correct answer because C contains atoms of two different elements chemically bonded together. A is incorrect because A is an element. B is incorrect because B is an element. D is incorrect because D is an element.		1
(iii)	**B** B is correct because B shows two atoms of the same element chemically bonded together e.g. H_2 A is incorrect because A contains atoms of an element C in incorrect because C contains molecules of a compound with the formula e.g. H_2O D is incorrect because C contains a giant covalent structure that could have the formula C		1
(b)	**M1** two different elements **M2** not (chemically) joined / (chemically) bonded together	**ALLOW** two different types of/sizes of atom.	2
			5

Question number	Answer	Notes	Marks
1 (a) (i)	B box 2 The only correct answer is B because box 2 contains two different particles in the same space that are not chemically joined A is not correct because box A shows an element C is not correct because box C shows an element D is not correct because box 4 shows a compound		1
(ii)	C Boxes 1 and 3 The only correct answer is C because boxes 1 and 2 contain one type of atom only. A is not correct because box 2 shows a mixture B is not correct because box 2 shows a mixture D is not correct because box 4 shows a compound		1
(iii)	**M1** (box 5 shows) two (different) elements **M2** (chemically) bonded (together)	**ALLOW** two (different) types of atoms **REJECT** mixture for M1 **ALLOW** (chemically) combined/joined (together) **M2** DEP on mention of elements/atoms in **M1**	2
(b) (i)	C number of protons The only correct answer is B because the elements in the periodic table are arranged in order of proton number A is not correct because elements are not arranged in order of mass number B is not correct because elements are not arranged in order of the number of neutrons D is not correct because elements are not arranged in order of reactivity		1
(ii)	A electrons in the outer shell The only correct answer is A because elements in the same group of the periodic table have the same number of electrons in the outer shell. B Is not the correct answer because elements in the same period have the same number of shells C elements in the same group do not have the same number of neutrons D is not the correct answer because elements in the same group do not have the same number of protons		1

Question number	Answer	Notes	Marks
1 (a) (i)	simple distillation	**REJECT** fractional distillation **REJECT** distillation	1
(ii)	chromatography		1
(iii)	fractional distillation		1
(b)	**M1** dissolve **M2** solute **M3** solvent		3
			Total 6

Question number		Answer	Notes	Marks
1	(a)	copper		1
	(b)	glucose/water		1
	(c)	air		1
	(d)	nitrogen/oxygen		1
	(e)	copper		1
	(f)	oxygen and sulfur	in either order	1

(Total for Question 1 = 6)

Question number	Answer	Notes	Marks
3 (a) (i)	diffusion		1
(ii)	Any two from **M1** stir (the mixture) **M2** heat (the mixture) **M3** grind the sugar or break into smaller pieces or increase its surface area	**ALLOW** shake/swirl **ALLOW** any description of heating	2
(b) (i)	(simple) distillation	**REJECT** fractional distillation **ALLOW** distilling OWTTE	1
(ii)	An explanation that links the following two points **M1** (water/ vapour/ steam / gas) is cooled **M2** and condenses **OR** in the condenser		2
			Total 6

Question number	Answer	Notes	Marks
3 (a)	**D (fractional distillation)** A is not the answer as this technique is not chromatography B is not the answer as this technique is not crystallisation C is not the answer is this technique is not filtration		1
(b)	X = thermometer Y = (Liebig) condenser Z = beaker		3
(c)	M1 measure / test the boiling point M2 a pure substance has a fixed boiling point / boiling point of 78°C	ALLOW boil the ethanol IGNORE a pure substance has a fixed melting point IGNORE any incorrect temperature ALLOW a pure substance will not boil over a range of temperatures ALLOW if it boils over a range of temperatures it is impure	2
		Total = 6	

Question number	Answer	Notes	Marks
1 (a) (i)	water	**ALLOW** H_2O	1
(ii)	petrol		1
(iii)	fluorine	**ALLOW** F_2	1
(iv)	calcium	**ALLOW C**a	1
(b) (i)	fractional distillation	**ALLOW** fractionating / fractionation **IGNORE** distillation alone	1
(II)	aircraft fuel / jet fuel / (aero)plane fuel /aviation fuel	must mention fuels, not just aircraft etc. ALLOW fuel for lamps/for heaters/ for stoves	1
			Total 6

Question number	Answer	Notes	Marks
2 (a)	**A** substance S is the correct answer because S only contains one dye as it produces only one spot **B** is not correct because T does not only contain one dye as it produces two spots **C** is not correct because U does not only contain one dye as it produces three spots **D** is not correct because V does not only contain one dye as it produces two spots		1 comp
(b)	explanation containing following points M1 (V contains) blue/B and red/R (dyes) M2 because V has spots at same height as those from blue/B and red/R OWTTE		2 grad
(c) (i)	M1 correct measurement of distance moved by spot Y M2 correct measurement of distance moved by solvent M3 use and evaluation of R_f = $\frac{\text{distance moved by spot Y}}{\text{distance moved by solvent}}$	ALLOW 5.7-6.1 ALLOW 8.7-9.1 ALLOW 1-4 sig fig ALLOW ECF from M1 M2 only if $R_f < 1$	3 exp
(ii)	spot from yellow food dye/Y does not move as far as spot from red food dye/R OWTTE	ORA	1 exp

Total for Q2 = 7

Question number	Answer	Notes	Marks
2 (a)	Any two from the following: M1 contains 3 dyes M2 contains (dye) A M3 contains (dye) B M4 does not contain (dye) C / contains an unknown dye OWTTE		2
(b) (i)	(Ink 2) is insoluble (in solvent/water)	ALLOW does not contain (dye) A/B/C	1
(ii)	(repeat) using different solvent	ALLOW named alternative solvent eg alcohol/ethanol	1
(c)	M1 correct measurement of distance moved by spot AND correct measurement of distance moved by solvent M2 use and evaluation of R_f = distance moved by spot / distance moved by solvent front M3 answer to 2 sig fig	ALLOW 5.4-5.6 ALLOW 7.9-8.1 Expected: 5.5 / 8.0 = 0.6875 = 0.69 ALLOW ECF from M1 M2 correct answer with no working scores 3	3
			(Total for Question 2 = 7)

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td>
<table>
<tr><th>Information</th><th>Substance</th></tr>
<tr><td>a good conductor of electricity</td><td>copper</td></tr>
<tr><td>an element that has a basic oxide</td><td>copper</td></tr>
<tr><td>a substance used as a fuel</td><td>methane</td></tr>
<tr><td>a major cause of acid rain</td><td>sulfur dioxide</td></tr>
<tr><td>a non-metallic element that is a solid at room temperature</td><td>iodine</td></tr>
</table>
</td><td>ALLOW correct formulae</td><td>5</td></tr>
<tr><td>(b)</td><td>A description which refers to the following points

M1 bubble/add (the gas/carbon dioxide) into limewater

M2 (limewater) turns cloudy/milky</td><td>ACCEPT calcium hydroxide

ACCEPT white precipitate

M2 dep on use of limewater/calcium hydroxide in M1</td><td>2

Total 7</td></tr>
</table>

Question number	Answer	Notes	Marks
1 (a) (i)	chromatography		1
(ii)	fractional distillation		1
(iii)	simple distillation		1
(b)	M1 two / different elements M2 (chemically) joined / bonded together	ALLOW (two) different atoms ALLOW a description of bonding	2
(c) (i)	4		1
(ii)	20		1
			Total for question = 7 marks

Question number	Answer	Notes	Marks
2 (a)	**B** (Cl_2) A is not the correct answer as the symbol O is for atoms of oxygen not molecules C is not the correct answer as HCl is a compound D is not the correct answer as H_2O is a compound		1
(b)	**C** (filtration) A is not the correct answer as crystallisation is not used to separate an insoluble solid from a liquid B is not the correct answer as evaporation will not separate an insoluble solid from a liquid D is not the correct answer as simple distillation is used to separate a solvent from a solution		1
(c)	fractional distillation	REJECT distillation REJECT simple distillation	1
(d) (i)	**D** ($X(s) \rightarrow X(aq)$) A is not the correct answer as (l) is not the correct final state symbol B is not the correct answer as (g) Is not the final state symbol C is not the correct answer as the state symbols are the wrong way round		1
(ii)	**C** (diffusion) A is not the correct answer as boiling does not occur in the beaker B is not the correct answer as condensing does not occur in the beaker D is not the correct answer as sublimation does not occur in the beaker		1
(iii)	M1 potassium / K^+ M2 sulfate / SO_4^{2-}	potassium sulfate scores 2 K_2SO_4 scores 2 KSO_4 alone scores 1 ALLOW in either order If name correct ignore incorrect formula	2
			Total for question = 7

Question number	Answer	Notes	Marks
4 (a)	M1 baseline has been drawn in ink	ALLOW baseline is not drawn in pencil	4
	M2 and will therefore interfere with / contaminate the results	ALLOW will move up the paper / will get mixed up with A / will produce other colours /affect results / will smudge /ink is soluble	
	M3 the water level is above A/the baseline	ALLOW water level is too high / A is under water	
	M4 and therefore A will mix with/dissolve in the water	ALLOW A will wash off the paper IGNORE references to lid	
(b) (i)	M1 one spot about ¼ of the way between the baseline and the top of the paper / solvent front and one spot about ½ way M2 the lower spot labelled yellow and the higher spot labelled blue	ALLOW answers that show solvent front	2
(ii)	the blue food colouring/it is more soluble (in water) ORA as long as yellow food colouring is referred to	IGNORE blue colour/it travels further up the paper	1
			Total for question = 7

Question number	Answer	Notes	Marks
1 (a) (i)	<u>fractional</u> distillation		1
(ii)	chromatography		1
(iii)	simple distillation	**ACCEPT** distillation	1
(b)	**M1** A mixture of copper(II) oxide and copper(II) sulfate can be separated by first dissolving the copper(II) sulfate in distilled water. **M2** The copper(II) oxide is then removed by filtering **M3** Some of the water from the copper(II) sulfate solution is then removed by evaporating **M4** A pure sample of hydrated copper(II) sulfate is then obtained by crystallisation	 **ACCEPT** filtration **ACCEPT** evaporation **ACCEPT** simple distillation **ACCEPT** crystallising	4
			Total 7

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td>
<table>
<tr><th>Description</th><th>Substance</th></tr>
<tr><td>a good conductor of electricity</td><td>lithium</td></tr>
<tr><td>an element that is a liquid at room temperature</td><td>bromine</td></tr>
<tr><td>a substance that can be used to form a polymer</td><td>ethene</td></tr>
<tr><td>an element that forms a basic oxide</td><td>lithium</td></tr>
<tr><td>a substance that has a giant covalent structure</td><td>diamond</td></tr>
</table>
</td><td>ALLOW Li

ALLOW Br/Br_2
REJECT Br^-

ALLOW C_2H_4

ALLOW Li</td><td>5</td></tr>
<tr><td>(b)</td><td>A description that refers to the following two points

M1 (use damp blue) litmus paper

M2 (litmus paper) bleached/turns white

Ignore gas/solution</td><td>ALLOW universal indicator paper

ACCEPT blue litmus paper turns red and then bleached

IGNORE gas/solution

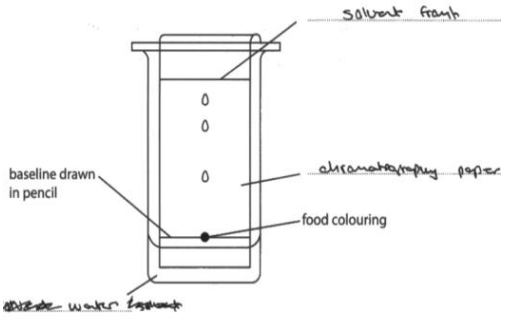
ALLOW
M1 bromide solution
M2 turns brown

REJECT iodide solution

M2 dep on M1

Red litmus paper turns blue then bleaches/turns white scores M1 only</td><td>2

Total 7</td></tr>
</table>

Question number	Answer	Notes	Marks
5 (a) (i)	clockwise from bottom left M1 solvent M2 solvent front M3 chromatography paper  Diagram 1	 ALLOW water ALLOW paper ALLOW chromatogram	3
(ii)	pencil is not soluble / insoluble	ACCEPT pencil will not dissolve ALLOW pencil will not run (up the chromatogram)	1
(b) (i)	**B (W and Y)** A is not the correct answer because W and X do not have a spot at the same height C is not the correct answer because X and Z do not have a spot at the same height D is not the correct answer because Y and Z do not have a spot at the same height		1
(ii)	M1 distance moved by the dye from 1.1 to 1.4 (cm) distance moved by the solvent 6.5 (cm) M2 distance moved by the dye ÷ distance moved by the solvent and correctly evaluated	 e.g. 0.17 / 0.18 / 0.2(0) / 0.22 ALLOW any number of sig figs as long as it is correctly rounded. ALLOW ECF from M1	2
			total for question = 7

Question number	Answer	Notes	Marks
4 a	Explanations that link together the following two pairs of points: **M1** baseline has been drawn in ink **M2** and therefore it will interfere with /contaminate the results **M3** the water level is above the ink spots **M4** and therefore the inks will mix with the water	 **ACCEPT** not drawn in pencil **ACCEPT** will produce other colours/will move up the paper/will get mixed up with the ink samples **ALLOW** pencil will not interfere with the results/ pencil will not dissolve **ACCEPT** too high/above the baseline **ACCEPT** the spots are under water **ACCEPT** the inks will dissolve in the water / the inks will wash off the paper	**4**
b (i)	3		**1**
(ii)	A **AND** B		**1**
(iii)	An explanation that links together the following two points: **M1** C **M2** because the spot/ink did not move (up)	 **ACCEPT** did not spread/stayed on the baseline **M2** DEP on **M1**	**2**
		Total	**8**

Question number	Answer	Notes	Marks
3 (a)	**M1** (same) solvent **M2** (same type of chromatography) paper	**ALLOW** (same) named solvent eg water **IGNORE** reference to size/length **of paper** **ALLOW** reference to use of pencil (for start line)/spots must start on horizontal line /solvent must start below line or spots **ALLOW** same distance travelled by solvent **IGNORE** distance of line from bottom of paper **IGNORE** amount/volume/concentration of solvent /references to size/volume of dyes or spots /references to temperature/time	2
3 (b) (i)	C is insoluble (in the solvent)		1
(ii)	**M1** Student 2 and dye D/(R_f value) 1.20 **M2** because R_f value must be less than 1 / cannot be greater than 1	ALLOW spot cannot move further than solvent front OWTTE	2

Question number	Answer	Notes	Marks
3 (c)	**M1** (R_f =) $\frac{9.7}{12}$ **M2** = 0.808(33..) **M3** = 0.81 (to 2 SF)	0.808(33..) with no working scores **M1** and **M2** **ALLOW M2** ECF if used 10.7 or 13 and R_f < 1 **ALLOW** 1 mark for $\frac{12}{9.7}$ = 1.2(37..) **ALLOW M3** ECF **M2** (must be correct to 2 SF) 0.81 with no working scores 3	3

Total for Question 3 = 8 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td><table><tr><th>Apparatus</th><th>Unit</th></tr><tr><td>(gas) syringe</td><td>cm^3</td></tr><tr><td>(top pan) balance OR (weighing) scales</td><td>g OR mg</td></tr></table></td><td>ALLOW ml
ALLOW words e.g.grams
ALLOW weighing machine
ALLOW kg

1 mark each correct row/column
Mark horizontally or vertically (whichever benefits the candidate)</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>M1 to cool (the water vapour/steam)

M2 so the water vapour/steam condenses</td><td>ALLOW to keep condenser cool

ALLOW so the water vapour/steam becomes liquid</td><td>2</td></tr>
<tr><td>(ii)</td><td>M1 add silver nitrate/$AgNO_3$ (solution)

M2 white precipitate</td><td>IGNORE addition of nitric acid but REJECT addition of hydrochloric/sulfuric acid for M1

M2 dep on use of silver nitrate</td><td>2</td></tr>
<tr><td>(iii)</td><td>M1 measure its boiling point

M2 (boiling point is) 100°C

OR

M1 measure its freezing point

M2 (freezing point is) 0°C</td><td>ALLOW boil it

ALLOW freeze it</td><td>2</td></tr>
</table>

Total for question 2 = 8 marks

Question number	Answer	Notes	Marks
2 (a)	crystallisation simple distillation filtration	 REJECT distillation	3
(b)	(the box contains) (2) different substances /elements	IGNORE type of particle REJECT compounds	1
(c)	Any two from: M1 D contains 3 food dyes M2 food colouring D contains A and C M3 food colouring D does not contain B / food colouring D contains another dye (which is not A. B or C)		2
(d) (i)	4		1
(ii)	11		1
			Total for question = 8

Question number	Answer	Notes	Marks
3 (a) (i)	filtration		1
(ii)	fractional distillation		1
(b)	M1 (two) different atoms / elements M2 joined / bonded together	ACCEPT atoms/elements of silicon and oxygen REJECT M2 intermolecular forces / ionic bonds	2
(c) (i)	5 / five		1
(ii)	788		1
(d)	M1 (3 ÷ 18) × 100 M2 16.7%	ALLOW ecf from M1 e.g. (3 ÷ 15) × 100 = 20% scores 1 mark ALLOW 2 or more sig figs as long as a percentage sum and correctly rounded.	2
			total for question = 8

Question number	Answer	Notes	Marks
2 (a)	**M1** level of the water must be below the dyes/start line **M2** the start line must be drawn in pencil	**ACCEPT** dyes/start line should be above water level	2
2 (b) (i)	2 marks for any two conclusions from (the green food colouring) **M1** contains (dye) B and (dye) D **M2** contains an unknown dye **M3** does not contain A or C **M4** contains three dyes and 1 mark for a correct explanation of given conclusion for the green food colouring eg (explanation for **M1**) because has spots at same level (as B and D) eg (explanation for **M2**) because has a spot at different level (from A B C D) eg (explanation for **M3**) because has no spots at same level (as A and C) eg (explanation for **M4**) because has three spots	 ALLOW is not pure	3
(ii)	**M1** (distance moved by solvent correctly measured) = 9.5 (cm) **M2** use of $R_f = \frac{\text{distance moved by the dye C}}{\text{distance moved by the solvent}}$ **M3** evaluation of R_f	**ALLOW** a tolerance of ±2mm eg $\frac{6.2}{9.5}$ **ALLOW** ECF from **M1** eg $\frac{(6.2)}{(9.5)} = 0.65(3)$ **ALLOW** 1-4 sig fig **ALLOW** ECF from **M2**	3
(iii)	(dye A) is not soluble in water	**ALLOW** solvent for water	1

Question number	Answer	Notes	Marks
3 (a) (i)	B		1
(ii)	A and B		1
(iii)	M1 2 and 8 M2 0.25	0.25 without working scores 2 **ALLOW** M1 for 1.8-2.2 and 8 and **ALLOW** M2 ECF as long as correctly evaluated to at least 2 SF (Special case if used ruler and then) 1.4-1.7 and 5.9-6.2 used no M1 but ALLOW M2 ECF as long as correctly evaluated to at least 2 SF	2
(iv)	the dye is the most soluble (in the solvent/water)		1
(b)	Any four from M1 draw start line in pencil M2 use same food colourings/use same solvent/use same (type of chromatography) paper M3 place (spots/samples of) A, B, C, D/food colourings on the start line OWTTE M4 (place paper in beaker) with start line above solvent OWTTE M5 (remove paper/stop experiment) when solvent almost reaches top of paper / when spots stop moving OWTTE M6 mark solvent front (on paper) M7 (remove paper from beaker and) allow to dry	**ALLOW** water for solvent throughout **ALLOW** dye for food colouring throughout **IGNORE** length of paper	4

Total for question 3 = 9 marks

Question number	Answer	Notes	Marks
5 (a) (i)	An explanation that links the following two points **M1** They will not dissolve/diffuse into the solvent (at the bottom of beaker) OWTTE **M2** so that the dyes can travel up the paper	**ALLOW** dye in place of spot throughout question 5 **ALLOW** water	2
(ii)	An explanation that links the following two points **M1** E and H **M2** as the dye is/both have a spot at the same level/travelled the same distance/same Rf value	 **M2** dep on **M1**	2
(iii)	An explanation that links the following two points **M1** The student can only be certain about G containing one dye as only one spot **M2** As F is insoluble/not moved (so you cannot tell how many dyes it has) OWTTE		2
(b)	**M1** distance from baseline to solvent level in mm = 65 **M2** distance from baseline to spot/dye in mm = 39 **M3** (R_f value = 39 ÷ 65 =) 0.6	 **ACCEPT** any value between 38 and 41 inclusive **ACCEPT** any value between 0.57 and 0.64 **M3** not awarded if value is incorrectly rounded	3
			Total 9

Question number	Answer	Notes	Marks
5 (a)	**Method** filtration simple distillation **or** fractional distillation fractional distillation crystallisation	**ALLOW** filtering **ALLOW** distillation **REJECT** simple distillation or distillation	4
(b) (i)	M1 A and B M2 because they are the same height /moved the same distance up the paper / have the same R_f values as the spots in the purple ink	M2 dep on M1 correct or missing	2
(ii)	M1 D M2 because the spot is closest to the start line /travelled the least distance (from the start line) / has the lowest R_f value	M2 dep on M1 correct or missing	2
(c)	Example calculation M1 120 × 0.72 M2 86 / 86.4 (mm)	Correct answer of 86 or 86.4 (mm) with or without working scores 2	2
			10 marks

Question number	Answer	Notes	Marks
4 (a) (i)	A description including any three of the following **M1** pour some solvent into a beaker /chromatography tank **M2** place the paper in the solvent so that the food colourings are above the level of the solvent **M3** leave the paper until the solvent reaches the level shown in the diagram/ has moved to near the top of the paper OWTTE **M4** take the paper out and leave to dry	**M1** and **M2** can be scored from a labelled diagram **ALLOW** any named solvent	3
(ii)	one/1		1
(iii)	(F/it is) insoluble (in the solvent)/ does not dissolve (in the solvent)		1
(iv)	**M1** E and H **M2** they contain a dye that moved the furthest (distance up the paper)/ is closest to the solvent front / has the greatest R_f value	**M2** dep on **M1**	2
(b)	**M1** distance moved by solvent = 59-61mm **and** distance moved by the dye = 37-41mm **M2** distance moved by the dye ÷ distance moved by the solvent ≈ 0.67 **M3** (the dye in food colouring) G	**ALLOW** distances in cm e.g. 6cm and 4cm If paper has been printed on A4 distances will be 51-53mm and 33-37mm **ALLOW** alternative methods	3 **Total 10**

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td><table><tr><th>Change</th><th>Change of state</th></tr><tr><td>water to ice</td><td>freezing</td></tr><tr><td>steam to water</td><td>condensation</td></tr><tr><td>solid wax to liquid wax</td><td>melting</td></tr><tr><td>iodine crystals to iodine vapour</td><td>sublimation</td></tr></table></td><td>ALLOW condensing

ALLOW subliming</td><td>4</td></tr>
<tr><td>(b) (i)</td><td>M1 heat

M2 stir / mix</td><td>ALLOW use hot water
IGNORE add more water

ALLOW grind / crush the solid / mixture</td><td>2</td></tr>
<tr><td>(ii)</td><td>filter</td><td>ALLOW a description of filtration</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>4</td></tr>
</table>

(iii)	A description that refers to four of the following points: **M1** heat / boil (the solution) **M2** evaporate some of the water **M3** leave / cool (the solution to crystallise) **M4** pour off excess liquid **OR** filter (to obtain crystals) **M5** suitable method of drying the crystals	**IGNORE** any steps before heating the solution **ALLOW** until crystals form on the end of a glass rod **ALLOW** until crystals first start to form **ALLOW** until the solution is saturated **M3** dep on **M1** **M4** dep on crystals having been formed **IGNORE** references to washing e.g. place in an oven / leave to dry /use filter paper / kitchen towel / / desiccator / heat to dryness If solution heated until **all** the water evaporates / heated until **all** the water has been removed / heated to **dryness** award **M1** and **M5** If the solution is left to evaporate **all** of the water only **M5** can be awarded.	**Total 11**

Question number	Answer	Notes	Marks
4 (a)	M1 draw a line in pencil (just above the bottom of the paper) M2 put a spot of each ink on the line (before contact with solvent) M3 pour some solvent in the beaker M4 place the paper in the beaker so the spots are above the solvent M5 leave until the solvent has risen up the paper (nearly to the top)	 ALLOW water for solvent ALLOW water for solvent ALL marks can be scored/supported from a labelled diagram	5
(b) (i)	M1 E M2 because it stayed on the start line/did not travel up paper	 ALLOW didn't move/ Rf value =0 M2 dep on M1	2
(ii)	M1 A and C M2 because they both (have a spot) at the same height OWTTE	 ALLOW travelled same distance/same Rf value M2 dep on M1	2
(iii)	M1 measure the distance from the start line to the spot and the distance from the start line to the solvent front M2 distance moved by the spot ÷ distance moved by the solvent	 M2 subsumes M1 Allow 2 marks for a correct calculation method	2
		Total = 11	

Question number	Answer	Notes	Marks
3 (a)	An explanation that links the following two points **M1** ink would dissolve in the solvent/pencil would not dissolve in the solvent **M2** ink would travel/run/smudge/produce spots on the chromatogram which would interfere with the results/ pencil would not produce spots on the chromatogram so would not interfere with the results OWTTE	 **ALLOW** ink is soluble/pencil is insoluble **ALLOW** unable to calculate Rf value	2
(b)	An explanation that links the following two points **M1** X and Z **M2** as they both have a dye that travelled the furthest up the paper	 **M2** dep on **M1**	2
(c)	An explanation that links the following three points **M1** (W contains only one dye) produces only one spot **M2** V is insoluble/not soluble **M3** (V may contain more than one dye) as it has not moved (from the start line)/not separated		3
(d)	**M1** measurement to spot W = 2.2 cm/ 22 mm or 2.3cm/ 23mm **M2** measurement to solvent front = 6.9 cm/ 69 mm **M3** (R_f value =) $\frac{2.2}{6.9}$ OR $\frac{2.3}{6.9}$ more than 2 sig figs **M4** 0.32/0.33	**ALLOW** within range of 2.2-2.3 cm **ALLOW** ecf on incorrect measurements in **M1** and **M2** **ALLOW** ecf corrected to 2 sig figs	4 **Total 11**

Question number	Answer	Notes	Marks
3 a	A description/diagram which makes reference to the following points **M1** put (separate) spots of each of the inks on the (pencil) line. OWTTE **M2** pour some solvent into the bottom of the beaker OWTTE **M3** place the paper in the beaker so that the spots are (just) above the level of the solvent OWTTE **M4** leave until the solvent has risen up the paper (to the top/near the top and then take paper out) OWTTE	**ALLOW** water for solvent throughout If diagram shows solvent above pencil line only **M1 and M2** can be scored **DO NOT ALLOW M3** if words and diagram contradict each other **ALLOW** leave until inks stopped separating OWTTE **ALLOW** leave until spots/dyes stopped moving OWTTE **IGNORE** references to leaving for a specified length of time	4

Question number	Answer	Notes	Marks
3 b	An explanation which links the following two points **M1** ink would/might dissolve in the solvent **OR** pencil would not dissolve in the solvent **M2** ink would interfere with/contaminate the results OWTTE **OR** pencil would not interfere with/contaminate the results OWTTE	**ALLOW** water for solvent **ALLOW** would produce spots/other colours/get mixed up with inks/move up the paper OWTTE **IGNORE** smudge/run **ALLOW** pencil would not produce spots/not produce other colours/not get mixed up with the inks/not move up the paper OWTTE	2

Question number	Answer	Notes	Marks
3 c (i)	For all parts of 3c an explanation which links each of the two points **M1** V **M2** as it stayed on the start line/did not move	**ALLOW** blob/dot/mark OWTTE for spot **ACCEPT** did not produce spots/did not separate **ALLOW** has R_f value of 0 **M2 DEP on M1**	2
(ii)	**M1** X and Z **M2** as they both have a dye/spot that travelled the furthest (up the paper)	**ALLOW** both have spot closest to solvent front **ALLOW** have highest R_f value(s) **M2 DEP on M1**	2
(iii)	**M1** V and W **M2** as they both only form one spot (on the paper)	**ACCEPT** as W only has one spot and cannot tell about V (as it does not move/is insoluble) **ACCEPT** reference to the other inks/X, Y, Z form more than one spot **M2 DEP on M1**	2

Question number	Answer	Notes	Marks
3 d	• Working or equation for R_f value • Calculating the R_f value • Giving the answer to 2 significant figures		3
	M1 $\frac{4.3}{6.5}$	Award one mark if correct equation for finding R_f value seen	
	M2 0.6615	**ACCEPT** any number of sig fig	
	M3 0.66	must be 2 sig fig 0.66 with no working scores 3 correct answer given to 3 or more sig fig with no working scores 2 **M3 subsumes M2** can score **M2 and M3** **ECF** provided use 4.3 and 6.5 and do a division	
			Total 15

Question number			Answer	Notes	Marks
10	(a)	(i)	fractional distillation	**ALLOW** distillation **REJECT** simple distillation	1
		(ii)	evaporation	**ALLOW** evaporating /boiling	1
		(iii)	condensation	**ALLOW** condensing	1
	(b)	(i)	**M1** (mass ethanol 15.50 × 0.79 =) 12.245 (g) **M2** (moles ethanol = 12.245 ÷ 46 =) 0.266 (mol) **OR** **M1** (1 cm^3 ethanol = 0.79 ÷ 46 =) 0.0172 mol **M2** (15.5 cm^3 ethanol = 0.0172 × 15.5 =) 0.267 (mol)	**ALLOW** any number of significant figures except 1 **ALLOW** ecf from **M1** **ALLOW** any number of significant figures except 1 **ALLOW** ecf from **M1** correct answer with or without working scores 2.	2
		(ii)	answer from (b)(i) × 6 × 10^{23} e.g. (0.266 × 6.0 x 10^{23} =) 1.60 x 10^{23}	**ALLOW** any number of significant figures except 1 **ALLOW** answer in ordinary form	1

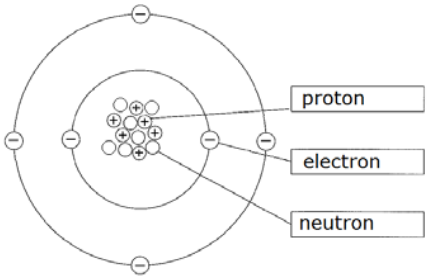
Question number	Answer	Notes	Marks
10 (c) (i)	**M1** add anhydrous copper sulfate **M2** turns blue	**ALLOW** add white copper sulfate **M2** dependent on **M1** **ALLOW** **M1** add anhydrous cobalt chloride/ cobalt chloride paper **M2** turns pink **M2** dependent on **M1**	2
(ii)	**M1** measure boiling point **M2** is 100°C	**ALLOW** melting/freezing point is 0°C for both marks	2
10 (d) (i)	**M1** $\Delta T = 49.5°C$ **M2** $Q = mc\Delta T$ **OR** $100 \times 4.2 \times 49.5$ **M3** 20 790 J	correct answer with or without working scores 3 **ALLOW** ecf from **M1** **ALLOW** 20 800	3
(ii)	**M1** 20.790 kJ **M2** (20.790 ÷ 0.0200 =) -1039.5 (kJ/mol)	**ALLOW** answer to 10(c)(i) ÷ 1 000 **ALLOW** any number of significant figures from 3 **ALLOW M1** ÷ 0.0200 as long as answer is negative. **REJECT** incorrect rounding. **REJECT** positive answer.	2
			15

Question number	Answer	Notes	Marks
1 (a) (i)	**D** **D** is the correct answer because protons occur in the nucleus and have a positive charge. **A** is not the correct answer since electrons occur in the energy levels. **B** is not the answer since ions do not occur in the nucleus. **C** is not the correct answer since neutrons have no charge.		1
(ii)	7		1
(iii)	lithium	**ALLOW** Li	1
(b) (i)	M1 same number of protons M2 different number of neutrons	**ALLOW** same number of electrons **IGNORE** references to mass number and atomic number.	2
			5 marks

Question number	Answer	Notes	Marks
1 (a)	nucleus	**ACCEPT** nuclei	1
(b)	11 / eleven		1
(c)	1 / one / group 1		1
(d)	3 / three / period 3		1
(e)	+1 / 1+	**ACCEPT** + / Na^+ / positive 1 **IGNORE** positive alone	1
			Total 5

Question number	Answer	Notes	Marks
1 (a) (i)	P neutron Q proton R electron		3
(ii)	nucleus	ALLOW nuclei	1
(b)	boron	ALLOW B	1
			Total 5

Question number	Answer	Notes	Marks
1 (a) (i)	W		1
(ii)	V		1
(iii)	Z		1
(b) (i)	the number of protons (in the nucleus)	IGNORE reference to electrons ALLOW amount of protons	1
(ii)	(the sum of) the number of protons and neutrons (in the nucleus)	ALLOW amount of protons and neutrons	1
			total for question = 5

Question number	Answer	Additional guidance	Marks
1 (a)		1 mark for each correct answer	3
(b)	13		1
(c)	**M1** protons **M2** neutrons	**IGNORE** electrons	2
		Total	**6**

Question number	Answer	Notes	Marks
1 (a)	C Neutron The only correct answer is C because the nucleus contains protons and neutrons. Protons are identified as the white dots A is not correct because electrons occur in the shells B is not correct because a molecule is not a particle found in the nucleus D is not correct because the nucleus contains protons **and** neutrons		1
(b)	A Electron The only correct answer is A because electrons have a relative mass of 1/1836 compared to a proton or a neutron B is not correct because a neutron has a relative mass of 1 C in not correct because the nucleus contains 4 protons and 5 neutrons D is not correct because a proton has a relative mass of 1		1
(c)	C 9 The only correct answer is C because the mass number is the sum of the protons and neutrons A is not correct because the atomic number is 4 B is not correct because 5 is the number of neutrons D is not correct because 13 is the total number of protons, neutrons and electrons		1
(d)	A 4 The only correct answer is A because the atomic number is equal to the number of protons which is 4 B is not correct because 5 is the number of neutrons C is not correct because 9 is the total number of particles in the nucleus D is not correct because 13 is the total number of protons, neutrons and electrons		1
(e) (i)	beryllium/Be		1
(ii)	(positive) ion	**ALLOW** ecf from the element given in (e)(i) **ACCEPT** any positive beryllium ion (or other ecf ion) **REJECT** any negative ion	1

Question number	Answer	Notes	Marks
1 (a)	Atomic number of this atom **4** Mass number of this atom **9** Period number of this element **2** Number of electrons in the 2+ ion formed from this atom **2**	1 mark each correct answer	4
(b)	Similarity = number of protons Difference = number of neutrons	**ALLOW** both isotopes have 4 protons **ALLOW** references to electrons **ALLOW** stated examples eg one isotope has 5 neutrons, the other has 6 neutrons If similarity: same atomic number and difference: different mass number **ALLOW** 1 mark	2

Total for question 1 = 6 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td>
<table>
<tr><th>Subatomic particle</th><th>Relative mass</th><th>Relative charge</th></tr>
<tr><td>proton</td><td>1</td><td>+1</td></tr>
<tr><td>neutron</td><td>1</td><td>0</td></tr>
<tr><td>electron</td><td>0.0005</td><td>−1</td></tr>
</table>
</td><td>All 4 correct = (2)
2 or 3 correct = (1)
0 or 1 correct = (0)</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>A increasing atomic number

B is incorrect as elements are not arranged in order of increasing melting point
C is incorrect as elements are not arranged in order of increasing reactivity
D is incorrect as elements are not arranged in order of increasing relative atomic mass</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>D Group 5 Period 3

A is incorrect as phosphorus is not in Group 2 and Period 5
B is incorrect as phosphorus is not in Group 3 and Period 5
C is incorrect as phosphorus is not in Group 5 and Period 2</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>M1 Xe / xenon

M2 because it has a full outer shell (of electrons) / 8 electrons in the outer shell</td><td>M2 dep on M1

IGNORE refs to noble gas</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td>Total 6</td></tr>
</table>

Question number	Answer	Notes	Marks
2 (a) (i)	C (neutron) A is not the correct answer because electrons are not in the nucleus B is not the correct answer as ions are not in the nucleus D is not the correct answer as protons have a positive charge		1
(ii)	C (9) A is not the correct answer because the proton number = 4 B is not the correct answer as there are 5 neutrons D is not the correct answer because 13 is the number of protons + neutrons + electrons		1
(b) (i)	similarity = number of protons/proton number difference = number of neutrons	ALLOW number of electrons ALLOW one has 3 neutrons and the other has 4 neutrons IGNORE reference to atomic number and mass numbers	2
(ii)	M1 ((7.5 × 6) + (92.5 × 7)) ÷ 100 M2 6.925/6.93/6.9	 ALLOW 2 or more significant figures Answer 6.925/6.93/6.9 without working scores 2 marks Answer of 7 with correct method scores M1 Answer of 7 without working scores 0	2
			Total marks for question 2 = 6

Question number	Answer	Notes	Marks
2 (a)	atomic number 5 mass number 11 number of neutrons 6 group in the Periodic table that contains boron 3 period in the Periodic table that contains boron 2 electronic configuration of an atom of boron 2, 3	**ACCEPT** $1s^2\ 2s^2\ 2p^1$	5
(b)	• Sum of masses multiplied by percentages • Division by 100 to give final answer **M1** (18.7 x 10) + (81.3 x 11) **OR** 1081.3 **M2** 10.8 **OR** answer from **M1** divided by 100	**ACCEPT** 1080 and 1081 **ACCEPT** 10.81 and 10.813 Correct answer without working scores 2 11 without working scores 0 11 with correct working scores 1	2 **Total 7**

Question number	Answer	Notes	Marks
2 (a)	**A** 3 B is incorrect as there are not 6 electrons in the outer shell of a thallium atom C is incorrect as there are not 13 electrons in the outer shell of a thallium atom D is incorrect as 81 is the total number of electrons in a thallium atom not the number in the outer shell		1 Comp
(b)	**B** 78 A is incorrect as there are not 3 electrons in a thallium ion C is incorrect as 81 is the number of electrons in a thallium atom not a thallium ion D is incorrect as there are not 84 electrons in a thallium ion		1 Comp

Question number	Answer	Notes	Marks
2 (c) (i)	**M1** (number of protons) 81 **M2** (number of neutrons) 124	**ACCEPT** eighty-one **ACCEPT** one hundred and twenty-four	2 CI
(ii)	• calculate sum of mass numbers multiplied by percentage abundances • divide answer by 100 • give answer to one decimal place Example calculation **M1** (203 x 30.8) + (205 x 69.2) **OR** 20438.4 **M2** 20438.4 ÷ 100 **OR** 204.384 **M3** 204.4	 **ACCEPT** 4, 5 or 6 sig fig **ACCEPT** 5 or 6 sig fig (203 x 0.308) + (205 x 0.692) **OR** 204.384 with or without working scores **M1** and **M2** Correct answer to 1 d.p. with or without working scores 3 marks	3 Exp **Total 7**

Question number	Answer	Notes	Marks
4 (a)	number of protons (in nucleus of atom)	**IGNORE** references to electrons	1
4 (b) (i)	**D** 29 is correct because mass number = total number of protons and neutrons = 14 + 15 = 29 **A** is incorrect because 14 is the number of protons **B** is incorrect because 15 is the number of neutrons **C** is incorrect because 28 is the number of protons + the number of electrons		1
4 (b) (ii)	**M1** (group) 4 **M2** because 4 electrons in outer shell	 **ALLOW** electronic configuration is 2.8.4	2

Question number	Answer	Notes	Marks
4 (c)	**M1** $\frac{(32 \times 95.0) + (33 \times 0.75) + (34 \times 4.25)}{100}$ OR $\frac{(3040) + (24.75) + (144.5)}{100}$ **M2** = 32.0925 **M3** = 32.1 (1 dp)	 32.09(25) with no working scores 2 **ALLOW** 1 mark for 3209.25 **ALLOW** M2 ECF M1 if minor error in calculation using all 3 isotopes correct answer to 1 dp with or without working scores 3 **ALLOW M3** ECF **M2** (must be correct to 1 dp)	3

Total for Question 4 = 7 marks

Question number	Answer	Notes	Marks
1 (a)	name of the part of this atom labelled A nucleus number of the group that contains this element 2 number of the period that contains this element 3		3
(b) (i)	4		1
(ii)	(species X has) three more protons than electrons / three fewer electrons than protons	ALLOW (the atom which formed species X has) lost three electrons IGNORE refs to Group 3	1
(iii)	M1 same number of protons / both have 17 protons M2 different number of neutrons / one has two neutrons more / one has 18 neutrons and the other has 20 neutrons	IGNORE all refs to electrons ALLOW "same atomic number, different mass number" for (1) mark	2
			Total for question = 7

Question number	Answer	Notes	Marks
1 (a) (i)	D		1
(ii)	D		1
(iii)	A		1
(b)	M1 (they are both atoms of the same element because they both have the) same number of protons M2 (they have the same chemical properties because they both have the) same electron configuration	ALLOW same atomic number ALLOW same number of electrons IGNORE same number of electrons in the **outer shell** IGNORE any mention of neutrons	2
(c)	M1 $(3\times1.6726\times10^{-24})+(4\times1.6740\times10^{-24})$ M2 1.1714×10^{-23}	1.17138×10^{-23} without working scores 2 answer must be in correct standard form ALLOW any number of significant figures from 2 and correctly rounded ALLOW ecf for M2 as long as the numbers are added possible answers 1 mark for 3.3466×10^{-24} 1.00398×10^{-23}	2
		Total = 7	

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td>
<table>
<tr><td>name of the part of the atom labelled Z</td><td>nucleus</td></tr>
<tr><td>number of protons in this atom</td><td>12</td></tr>
<tr><td>number of the group that contains this element</td><td>2</td></tr>
<tr><td>number of the period that contains this element</td><td>3</td></tr>
<tr><td>charge on the ion formed from this atom</td><td>2+</td></tr>
</table>
</td><td>ACCEPT +2 / Mg^{2+}</td><td>5</td></tr>
<tr><td>(b)</td><td>
• calculate sum of mass numbers multiplied by percentage abundances
• divide answer by 100
• give answer to one decimal place

Example calculation

M1 (24 x 79.2) + (25 x 10.0) + (26 x 10.8) OR 2431.6

M2 2431.6 ÷ 100 OR 24.316

M3 24.3
</td><td>
REJECT if correct working given but incorrectly evaluated

ALLOW ECF from M1

(24 x 0.792) + (25 x 0.100) + (26 x 0.108) OR 24.316 with or without working scores M1 and M2

ALLOW ECF from M2 if calculated answer is to 1dp
</td><td>3

Total 8</td></tr>
</table>

Question number	Answer	Notes	Marks
4 (a) (i)	14		1
(ii)	2.5	**REJECT** any charge shown **IGNORE** brackets	1
(iii)	**M1** same number of protons **M2** different numbers of neutrons	**IGNORE** references to numbers of electrons	2
(iv)	**M1** (three) more electrons than protons **M2** electrons have a negative charge and protons have a positive charge	**REJECT** incorrect numbers of electrons	2
(b)	**M1** (98.930 × 12) + (1.070 × 13) ÷ 100 **M2** 12.01	**ALLOW** 1 mark for 1201.07 if not divided by 100 as long as given to 2dp correct answer to 2 decimal places with or without working scores 2 marks.	2
			8

Question number	Answer	Notes	Marks
3 (a) (i)	**A** (electron) B is not the correct answer because neutrons exist in the nucleus. C is not the correct answer because particle W is not a nucleus. D is not the correct answer because protons exist in the nucleus.		1
(ii)	**C** (25) A is not the correct answer as the proton number is 12 B is not the correct answer as the number of neutrons is 13 D is not the correct answer as the number of protons, neutrons and electrons is not 49		1
(iii)	(atoms have the) same number of protons and electrons		1
(iv)	**B** (2+) A is not the correct answer as this atom will not form an ion with a + charge. C is not the correct answer as this atom will not form an ion with a - charge. D is not the correct answer as this atom will not form an ion with a 2- charge.		1
(b) (i)	(both isotopes have) the same number of electrons / the same electron configuration	IGNORE same number of protons / same number of electrons in the outer shell	1
(ii)	M1 (7.60 × 6) + (92.4 × 7) M2 692.4÷100 OR 6.924 M3 6.92	Answer of 6.92 scores 3 ACCEPT (6 × 0.076) + (7 × 0.924) ALLOW ecf if use of 6 and 7 in calculation	3
			Total for question = 8

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>1 (a)</td><td>M1 •_____ proton

M2 o_____ neutron

M3 x_____ electron</td><td>must be in the right order

if proton and neutron in wrong order allow one mark for M1 & M2.</td><td>3</td></tr>
<tr><td>(b)</td><td><table><tr><td>mass number</td><td>11</td></tr><tr><td>group number</td><td>3</td></tr><tr><td>period number</td><td>2</td></tr><tr><td>electronic configuration</td><td>2,3</td></tr></table></td><td></td><td>4</td></tr>
<tr><td>(c)</td><td>boron</td><td>ALLOW B</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>Total 8</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td>
<table>
<tr><th></th><th>Electron</th><th>Proton</th><th>Neutron</th></tr>
<tr><td>Relative mass</td><td>0.0005</td><td>1</td><td>1</td></tr>
<tr><td>Relative charge</td><td>–1</td><td>+1</td><td>0</td></tr>
</table>
ALLOW - +
</td><td>All 4 correct 2 marks
2 or 3 correct 1 mark</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>B (3)

A is incorrect as 2 is not the atomic number of P
C is incorrect as 4 is not the atomic number of P
D is incorrect as 7 is the mass number of P</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>B (16)

A is incorrect as 8 is the atomic number of U
C is incorrect as 18 is not the mass number of U
D is incorrect as 26 is not the mass number of U</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>S</td><td>ALLOW nitrogen/N/N_2</td><td>1</td></tr>
<tr><td>(c) (i)</td><td>An explanation that links the following two points

M1 (Q and R have) same number of protons/ both have 5 protons

M2 (but) different numbers of neutrons/ (Q has) 5 neutrons and (R has) 6 neutrons/R has an extra neutron</td><td>IGNORE same number of electrons

IGNORE references to atomic and mass numbers</td><td>2</td></tr>
<tr><td>(ii)</td><td>M1 20.6 × 10 + 79.4 x 11 OR 1079.4

M2 $\frac{20.6 \times 10 + 79.4 \times 11}{100}$ OR $\frac{1079.4}{100}$ OR 10.794

M3 10.8</td><td>ALLOW ecf if incorrect mass numbers used

10.8 without working scores 3

10.79/10.794 without working scores 2

Use of 5 and 6 = 5.8 scores 2
Use of 15 and 16 = 15.8 scores 2
Use of 5 and 5 =5.0 scores 1</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td>Total 10</td></tr>
</table>

Question number	Answer	Notes	Marks
3 (a) (i)	2	**ALLOW** two	1
(ii)	3	**ALLOW** three	1
(iii)	ZF_2	**ALLOW** MgF_2 ALLOW F_2Mg ALLOW F_2Z REJECT $MgFl_2$ Penalise incorrect case or superscripts	1
(b)	**M1** $12 \times 6.0 \times 10^{23}$ **M2** 7.2×10^{24}	**ALLOW** ecf if incorrect number of electrons x 6.0×10^{23} **ALLOW** ecf if /12 ONLY rather than x12 giving $5(.0) \times 10^{22}$	2 4
(c)	**M1** (isotopic masses) 24, 25 and 26 **M2** $79.0 \times 24 + 10.0 \times 25 + 11.0 \times 26$ **OR** 2432 **M3** $\frac{79.0 \times 24 + 10.0 \times 25 + 11.0 \times 26}{100}$ **OR** $\frac{2432}{100}$ **OR** 24.32 **M4** 24.3	**M2** subsumes **M1** **ALLOW** ecf if incorrect mass numbers used 12.3 scores 3 with working 24.3 without working scores 4 24.32 without working scores 3 M4 scores only if numbers from the table are used.	
(d)	magnesium	**ALLOW** Mg	1
			Total 10

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a) (i)</td><td>
<table>
<tr><th>Sub-atomic particle</th><th>Relative mass</th><th>Relative charge</th></tr>
<tr><td>electron</td><td>0.0005</td><td>−1</td></tr>
<tr><td>proton</td><td>1</td><td>+1</td></tr>
<tr><td>neutron</td><td>1</td><td>0</td></tr>
</table>
</td><td>1 mark for each correct answer

ACCEPT minus one
REJECT - unqualified

ACCEPT one
ALLOW +1

ACCEPT zero/none/ no charge</td><td>3</td></tr>
<tr><td>(ii)</td><td>nucleus</td><td></td><td>1</td></tr>
<tr><td>(b) (i)</td><td>U</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>25</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>W</td><td></td><td>1</td></tr>
<tr><td>(iv)</td><td>Y and Z</td><td></td><td>1</td></tr>
</table>

Question number	Answer	Notes	Marks
2 (c)	• sum of masses multiplied by percentages • division by 100 • answer given to 1 decimal place Example calculation **M1** (91.2 x 20) + (8.80 x 22) **OR** 2017.6 **M2** 2017.6 ÷ 100 **OR** 20.176 **M3** 20.2 **OR** answer from **M2** given to 1d.p.	Correct answer of 20.2 with or without working scores 3 **ACCEPT** 2018 **ACCEPT** 20.18 correct answer without working scores 3 20.176 and 20.18 without working score 2 2020 scores **M1** and **M3** 20 without working scores 0 20 with correct working scores 2	3 **Total 11**

Question number	Answer	Notes	Marks
5 (a) (i)	relative mass proton 1 relative mass neutron 1 relative charge proton +1 relative charge neutron 0	All 4 correct scores 2 2 or 3 correct scores 1	2
(b) (i)	M1 atoms (of the same element) with the same number of protons M2 but different numbers of neutrons	ALLOW atoms with the same atomic number ALLOW atoms with the same number of electrons ALLOW but different mass numbers	2
(ii)	M1 number of protons and electrons = 12 M2 number of neutrons = 14		2
(iii)	$\frac{(24 \times 79) + (25 \times 10) + (26 \times 11)}{100}$ scores 2 marks M1 multiplies each mass number by the percentages M2 adds multiples together and divides by 100	(24 x 0.79) + (25 x 0.10) + (26 x 0.11) scores both marks	2
(iv)	M1 $24.32 \div (6.022 \times 10^{23})$ M2 4.039×10^{-23}	ALLOW ecf from M1 as long as answer is given to 4 sig figs Correct answer of 4.039×10^{-23} g to 4 sig sigs scores 2 with or without working	2
(c)	(moles of MgO) = 0.40		1
			Total for question = 11

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a)</td><td><table><tr><th>Relative mass</th><th>Relative charge</th></tr><tr><td>1</td><td>0</td></tr><tr><td>1</td><td>+1</td></tr><tr><td>0.0005 to 0.0006 or 1/1800 to 1/2000</td><td>-1</td></tr></table></td><td>REJECT any sign for the relative mass</td><td>3</td></tr>
<tr><td>(b) (i)</td><td>A</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>D</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>C</td><td></td><td>1</td></tr>
<tr><td>(c)</td><td>similarity number of protons OR number of electrons /electron configuration /3 protons

difference number of neutrons /3 or 4 neutrons</td><td>ALLOW same atomic number and different mass number for 1 mark if no other mark awarded</td><td>2</td></tr>
<tr><td>(d)</td><td>M1 ((79×24)+(10×25)+(26×11))÷100

M2 24.32

M3 24.3</td><td>ALLOW ecf from M2 to 1dp

24.3 scores 3 marks</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td>Total = 11</td></tr>
</table>

Question number	Answer	Notes	Marks
2 a	T		**1**
b	they have the same number of electrons in their outer shell **OR** they have one electron in the outer shell	**ACCEPT** they have the same number of valence electrons/ they have one valence electron **ACCEPT** outer energy level **ALLOW** they need to lose 1 electron from the outer shell/ to gain a full outer shell	**1**
c	An explanation linking the following two points: **M1** 33 **M2** because the atomic number of R is two more (than Q) **OR** because R is two places to the right / two places further on/along (in the period)	 **ALLOW** R has two more protons than Q **ACCEPT** for each successive element (in the period) there is one more (proton) /the atomic number increases by one **ACCEPT** they are in the same period but Q is in group 3 and R is in group 5 **IGNORE** reference to electrons	**2**
		Total	**4**

Question number	Answer	Notes	Marks
1 (a)	7		1
(b)	any value ≥4 but <7		1
(c)	0	ALLOW Group 8	1
(d)	3		1

(Total for Question 1 = 4 marks)

Question number	Answer	Notes	Marks
5 a	**C** (it has a low density) A is not correct as the colour of the gas is irrelevant B is not correct as the solubility of the gas is irrelevant D is not correct as the smell of the gas is irrelevant		**1**
b	**M1** helium is inert / helium does not react (with air/oxygen) **M2** hydrogen is flammable/explosive (in air/oxygen)	**ALLOW** helium is unreactive **ALLOW** helium is not flammable/ not explosive	**2**
c i	$N_2 + 3H_2 \rightarrow 2NH_3$	**ACCEPT** reversible arrow **IGNORE** Fe if added to both sides of the equation	**1**
ii	to increase the rate of reaction / to speed up the reaction / to produce a reaction pathway that has a lower activation energy	**ALLOW** to lower the activation energy / to make it easier to break the (covalent) bonds (in the molecules)	**1**
		Total	**5**

Question number	Answer	Notes	Marks
2 (a) (i)	Na/K	**ACCEPT** sodium/potassium	1
(ii)	He	**ACCEPT** helium	1
(iii)	Br	**ACCEPT** bromine **REJECT** bromide	1
(iv)	Na **and** Cl	**ACCEPT** sodium and chlorine **REJECT** chloride	1
(b)	2.8.1	**ACCEPT** 2,8,1 or 2 8 1 **ALLOW** diagram of atom showing correct electron configuration.	1
			Total 5

Question number		Answer	Notes	Marks
1	(a)	nitrogen	ALLOW N/N_2	1
	(b)	silicon/Si or phosphorus/P or sulfur/S		1
	(c)	bromine		1
	(d)	73		1
	(e)	The only correct answer is D as francium is the most reactive element in Group 1 and fluorine is the most reactive element in Group 7 A is not correct because lithium is not the most reactive element in Group 1 B is not correct because astatine is not the most reactive element in Group 7 C is not correct because lithium is not the most reactive element in Group 1 and astatine is not the most reactive element in Group 7		1

Total marks for Question 1 = 5

Question number	Answer	Notes	Marks
1 (a) (i)	silicon	**ALLOW** Si	1
(ii)	boron	**ALLOW** B	1
(iii)	magnesium	**ALLOW** Mg	1
(b) (i)	16 / sixteen		1
(ii)	2.8.3 / 2,8,3	**ACCEPT** diagram showing correct electron configuration **ALLOW** correct electron configuration using s and p notation	1
(iii)	does not (easily) gain/lose/share electrons	**ALLOW** full outer shell/energy level **ALLOW** 8 electrons in outer shell/energy level	1
			Total 6

Question number	Answer	Notes	Marks
1 (a) (i)	Boron/B		1 cler
(ii)	Na/Mg/Al		1 cler
(iii)	Silicon/Si		1 cler
(iv)	Nitrogen/N	ALLOW N_2	1 cler
(v)	aluminium oxide	ALLOW Al_2O_3	1 cler
(b) (i)	**D** Group 0 is correct because Group 0 contains elements that are all unreactive **A** is not correct because Group 2 does not contain elements that are all unreactive **B** is not correct because Group 5 does not contain elements that are all unreactive **C** is not correct because Group 6 does not contain elements that are all unreactive		1 comp
(ii)	**B** lithium is correct because lithhium is the least reactive element in Group 1 **A** is not correct because caesium is not the least reactive element in Group 1 **C** is not correct because potassium is not the least reactive element in Group 1 **D** is not correct because sodium is not the least reactive element in Group 1		1 comp

Total for Q1 = 7 marks

Question number	Answer	Notes	Marks
1 (a) (i)	silicon	**ALLOW** Si	1
(ii)	magnesium	**ALLOW** Mg	1
(iii)	bromine	**ALLOW** mercury / Hg **ALLOW** Br / Br_2 **REJECT** bromide / Br^-	1
(iv)	2,8,5 / 2.8.5	**ACCEPT** diagram showing electron configuration	1
(v)	Na_2S	**ALLOW** $Na^+{}_2S^{2-}$	1
(b)	An explanation that links the following two points **M1** full outer shell / 8 electrons in outer shell / (electron configuration) 2.8 **M2** (so) does not need to lose or gain (or share) electrons / $e^{(-)}$		2
			Total 7

Question number	Answer	Notes	Marks
1 (a) (i)	sulfur	**ALLOW** S	1
(ii)	beryllium	**ALLOW** Be	1
(iii)	boron	**ALLOW** B	1
(iv)	2,8,4 / 2.8.4	**ACCEPT** diagram showing electron configuration	1
(b)	An explanation that links the following three points		3
	M1 the outer shell is further from the nucleus in sodium/sodium has more shells/sodium has a larger atomic radius ORA	**ALLOW** a sodium atom is larger than a lithium atom **ALLOW** Li 2,1 Na 2,8,1	
	M2 there is less attraction to the nucleus for the **outer** electron/**outer** shell in sodium ORA	**ALLOW** there is more shielding in sodium ORA	
	M3 so the (outer) **electron** is more easily lost ORA	**IGNORE** electrons (plural) in M1 and M2 but do not allow electrons in M3	
			Total 7

Question number	Answer	Notes	Marks
5 (a)	Any two from M1 all in Group 7/same group M2 because all have 7/same number of electrons in outer shell M3 the number of shells determines the Period they are in		2 Grad
(b) (i)	Ultraviolet radiation	ALLOW UV radiation ALLOW ultraviolet light /UV light/ultraviolet rays/UV rays	1 cler
(ii)	$Cl_2 + CH_4 \rightarrow CH_3Cl + HCl$	ALLOW multiples	1 Grad
(iii)	M1 attraction between shared pair of electrons M2 and nuclei of the two/both atoms (in the bond) **OR** M1 bonding/shared pair of electrons M2 attracted to (both) nuclei of atoms (in the bond)	ALLOW M1 attraction of (two) nuclei M2 for shared/bonded pair of electrons (between them)	2 Exp
(iv)	M1 the four shared pairs of electrons between carbon and the other four atoms M2 rest of molecule correct including the three lone pairs of electrons around chlorine atom	M2 DEP M1 ALLOW any combination of dots and crosses	2 Grad
(v)	M1 weak forces of attraction between molecules/weak intermolecular forces M2 little (heat) energy needed to overcome them	ALLOW weak bonds between molecules /weak intermolecular bonds IGNORE less energy 0 marks if implication is that covalent bonds are weak/broken	2 Exp

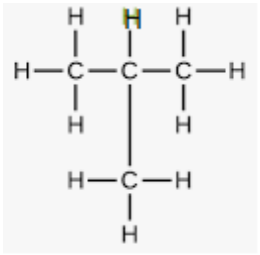
(c)	Explanation including M1 (one) electron (per carbon atom) delocalised M2 (so) free to move (between layers)	IGNORE sea of electrons /free electrons M2 DEP on mention of electrons 0 marks if mention of ions in graphite	2 Exp

Total Q5 = 12

Question number	Answer	Notes	Marks
4 (a) (i)	Any one from: Na K Al In	**ALLOW** names of elements Apply list principle	1
(ii)	Any one from S Cl	**ALLOW** names of elements	1
(b)	same number / three electrons in the outer shell	**ALLOW** valence shell	1
(c)	M1 Xe or xenon M2 as it has a full outer shell (of electrons)	 ALLOW has eight electrons in outer shell ACCEPT does not (easily) gain/lose/share electrons M2 dep on M1	2
(d) (i)	M1 (universal indicator turns) blue or purple M2 because an alkali is produced	 **ACCEPT** OH^- / hydroxide ions are produced **ALLOW** sodium hydroxide is a base / a base is produced	2
(ii)	(similarity) any one from: (both) effervesce melt / turn into a sphere move on surface universal indicator turns the same colour (difference) any one from: potassium gives a lilac flame potassium moves faster potassium effervesces faster	 **ALLOW** fizzes/bubbles **ALLOW** float **ALLOW** both disappear/get smaller/dissolve **ALLOW** faster/more vigorous reaction for potassium **ALLOW** reverse arguments for sodium	2
(iii)	Example calculation M1 (moles of hydrogen) 0.036÷2 **OR** 0.018 mol M2 0.018 × 6.0×10^{23} **OR** 1.08×10^{22} molecules M3 1.1×10^{22}	correct answer with no working scores 3 marks **ALLOW** ECF M1 × 6.0×10^{23} **ALLOW** ECF M2 but must be to 2 sig figs 2.16×10^{22} scores 1 2.2×10^{22} scores 2	3

Total for question 4 = 12 marks

Question number	Answer	Notes	Marks
1 (a) (i)	B (3) A is not the correct answer because sulfur is not in period 2 C is not the correct answer because sulfur is not in period 4 D is not the correct answer because sulfur is not in period 6		1
(ii)	D (2−) A is not the correct answer because the charge on a sulfide ion is not 1+ B is not the correct answer because the charge on a sulfide ion is not 2+ C is not the correct answer because the charge on a sulfide ion is not 1−		1
(b) (i)	the reaction has a high activation energy	ALLOW to give zinc and sulfur enough energy to react ALLOW speeds reaction up/increases rate of reaction/reacts quicker ALLOW the reaction is very slow at room temperature IGNORE unreactive/does not react ALLOW gains kinetic energy	1
(ii)	97	IGNORE any units given	1
			Total marks for question 1 = 4

Question number		Answer	Notes	Marks
7	(a)	M1 use of amount in moles = $\frac{\text{volume of gas}}{\text{molar volume}}$ M2 correct evaluation Example calculation M1 amount in moles = $\frac{600}{24000}$ M2 = 0.025 (mol)	0.025 with no working scores 2 REJECT 0.03 for M2	2
	(b)	M1 statement/use of amount in moles = $\frac{\text{mass}}{Mr}$ M2 substitution and correct evaluation: $Mr = \frac{1.45}{0.025} = 58$		2
	(c)	molecular formula = C_4H_{10} = (4 x 12) + (10 x 1) = 58 OR alkane general formula = C_nH_{2n+2} so M1 (nx12) + (2n+2)x1 = 58 so 14n = 56 M2 n =4 so C_4H_{10}		1
	(d)			1

(Total for Question 7 = 6)

Question number	Answer	Notes	Marks
7 (a)	**M1** breaking up/down of a compound/substance OWTTE **M2** by heat(ing)	**REJECT** elements **REJECT** any references to heat being given out/exothermic	2
(b)	examples of calculation of maximum mass of K_2CO_3 **M1** M_r of $KHCO_3$ = 100 AND M_r of K_2CO_3 = 138 **M2** 200 g $KHCO_3$ produces 138 g K_2CO_3 **M3** 2.50 g $KHCO_3$ produces $\frac{138 \times 2.50}{200}$ = **M4** 1.725 (g K_2CO_3) OR **M1** M_r of $KHCO_3$ = 100 AND M_r of K_2CO_3 = 138 **M2** amount $KHCO_3 = \frac{2.50}{100}$ = 0.025 (mol) **M3** amount $K_2CO_3 = \frac{0.025}{2}$ = 0.0125 (mol) **M4** mass K_2CO_3 (= 0.0125 x 138) = 1.725 (g)	**ALLOW** 2 or more SF **M2 M3 M4 ECF M1** correct answer with or without working scores 4 **ALLOW** 2 or more SF **M2 M3 M4 ECF M1** correct answer with or without working scores 4 3.45/3.46/3.5/6.9 scores 3	4

Total for Question 7 = 6 marks

Question number	Answer	Additional guidance	Marks
8 (a)	An explanation using either of the following linked pairs: **M1** use a fume cupboard **M2** because chlorine is toxic/poisonous OR **M1** wear goggles/safety glasses/gloves **M2** because acid/bleach (may be) irritant/corrosive	 **IGNORE** chlorine is dangerous/harmful/irritant **IGNORE** laboratory coats	2
(b) (i)	**M1** 60 ÷ 24 000 **M2** 0.0025 (mol)	 0.0025 with no working scores 2 marks **REJECT** 0.003 for **M2**	2
(ii)	0.0025 **OR** answer to **M2** from (i)		1
(iii)	**M1** (0.0025 ÷ 4.00) × 1000 **M2** 0.625 (mol/dm^3)	Mark CSQ on (b)(ii) **ACCEPT** any number of sig fig except 1 (unless ECF answer is exactly 1 sig fig correct answer with no working throughout (b) scores 2 marks	2
		Total	**7**

Question number	Answer	Notes	Marks
7 (a)	calculation with following steps M1 calculation of $n(K_2CO_3)$ M2 deduction of $n(CO_2)$ and vol(CO_2) by multiplying by 24 (dm^3) M3 correct evaluation of volume in cm^3 Example calculation M1 $n(K_2CO_3)$ = 6.9 ÷ 138 OR 0.05 M2 vol(CO_2) = 0.05 x 24 (dm^3) M3 1200 (cm^3)	 Mark ECF from M1 correct answer with no working scores 3 1.2 scores 2 marks	3 Exp
(b) (i)	M1 higher yield of CO M2 because (equilibrium shifts to the right as the forward) reaction is endothermic	ACCEPT more CO is produced IGNORE references to Le Chatelier's Principle eg increasing temperature favours the forward reaction M2 DEP M1 correct or missing	2 Exp
(ii)	M1 no effect (on yield) OWTTE M2 because equal numbers of moles/molecules (of gas) on both sides	 M2 DEP M1 correct or missing	2 Exp

Total for Q7 = 7

Question number	Answer	Notes	Marks
4 (a) (i)	**C (13)** A is incorrect as there are not 8 atoms B is incorrect as there are not 11 atoms D is incorrect as there are not 19 atoms		1
(ii)	**B (Ca^{2+} and PO_4^{3-})** A the charges are incorrect C the charges are incorrect D the charges are incorrect		1
(b) (i)	**M1** Use of addition of Ca = 40 P = 31 O = 16 **M2** $(40 \times 3 + 31 \times 2 + 16 \times 8 =)$ 310		2
(ii)	**M1** $\frac{40 \times 3 \times 100}{310}$ **M2** 39 (%)	**ALLOW** ecf for M_r incorrectly calculated **ALLOW** 1 mark for 13 (%) if working shown **ALLOW** any number of sig figs except 1 e.g. 38.7 for 2 marks or 12.9 for 1 mark	2
(c)	$3Ca(OH)_2 + 2H_3PO_4 \rightarrow (1)Ca_3(PO_4)_2 + 6H_2O$	**ALLOW** multiples and fractions	1
			Total 7

Question number	Answer	Notes	Marks
7 (a) (i)	any **one** from: M1 to condense the water vapour M2 to ensure all the water collects in the tube (as a liquid)	 ALLOW condense steam/condense gas NOT cools water NOT stops water evaporating	1
(ii)	When the mass doesn't change / is constant/stops increasing	Accept: the last two results are the same Accept: balance reading stays the same	1
(b)	M1 add anhydrous/white copper(II) sulfate/sulphate M2 which turns (from white to) blue	ALLOW anhydrous/white copper sulfate/sulphate ALLOW add anhydrous/blue cobalt chloride ALLOW which turns (from blue to) pink M2 dep on M1	2
(c)	M1 (mass of water) = 6.3g M2 (moles of $MgSO_4$) = 0.05 M3 (moles of H_2O) 0.35 M4 x=7	Ecf for incorrect mass of water M1 can be awarded from moles of H_2O in M3 Answer of 7 on its own scores 4 marks	4
		Total = 8	

Question number	Answer	Notes	Marks
11 a	• calculate moles of methane • calculate mass of oxygen Example calculation **M1** $n[CH_4]$ = 32 ÷ 16 OR 2 (mol) **M2** mass of O_2 = 128 (g) **OR** answer to **M1** x 2 x 32 **OR** **M1** 16 g (of methane) require 64 g (of oxygen) **M2** 32 g require 128 (g)	correct answer scores 2	**2**
b i	An explanation that links together the following two points: **M1** the water vapour/steam condenses **M2** because it is cooled (by the mixture of ice and water)	**ACCEPT** because (mixture of ice and water) is at a low temperature/ is cold **ALLOW** (the mixture of ice and water) is below the boiling point of water/below 100 °C	**2**
ii	A description that links together the following two points: **M1** white (anhydrous copper(II) sulfate) **M2** turns blue (in the presence of water)		**2**

iii	An explanation that links together the following three points: **M1** the limewater turns milky **M2** (because) carbon dioxide /CO_2 (is present) **M3** (and) calcium carbonate/$CaCO_3$/ an insoluble substance is formed	**ACCEPT** cloudy **ALLOW** white precipitate forms A word or chemical equation scores **M2** and **M3**	**3**
		Total	**9**

Question number	Answer	Notes	Marks
10 (a)	contain water of crystallisation /are hydrated		1
10 (b) (i)	3.18g		1
(ii)	3.78g		1
(iii)	calculation with following steps **M1** calculate moles of Na_2CO_3 **M2** calculate moles of H_2O **M3** divide each by smaller to obtain ratio 1 : 7 example calculation: **M1** $\frac{3.18}{106} = 0.03$ **M2** $\frac{3.78}{18} = 0.21$ **M3** $\frac{0.03}{0.03} : \frac{0.21}{0.03} = 1 : 7$ Alternative method: **M1** (If formula is $Na_2CO_3.7H_2O$ products will form in ratio) 106 g Na_2CO_3 : 126 g H_2O **M2** so mass of water that forms with 3.18 g Na_2CO_3 should = $\frac{(126 \times 3.18)}{106}$ **M3** = 3.78 g so formula is correct	**ALLOW** ECF from (i) **ALLOW** ECF from (ii)	3
(c) (i)	explanation including **M1** not heated crystals (for long) enough **M2** so not all water removed/evaporated OWTTE		2
(ii)	**M1** repeat heating (and cooling) **M2** until constant mass OWTTE	**ALLOW** heat for longer	2

Total for Question 10 = 10 marks

Question number	Answer	Notes	Marks
11 (a) (i)	M1 $WO_3(s) + 3H_2(g)$	**ALLOW** upper case	2
	M2 $W(s) + 3H_2O(g \text{ or } l)$		
(ii)	heat again to constant mass OWTTE		1
(iii)	M1 (mass of tungsten =) 1.84g AND (mass of oxygen =) 0.48g		3
	M2 (moles of tungsten) = $\frac{1.84}{184}$ or 0.01 AND (moles of oxygen) = $\frac{0.48}{16}$ or 0.03	M2 subsumes M1 **ALLOW** M2 ECF from incorrect masses	
	M3 therefore ratio is 1:3	M3 dep on M2 **ALLOW** ECF from incorrect M2 only if does give 1:3 when rounded	
(iv)	Any one from		1
	M1 **u**se a safety screen	**ALLOW** heat proof/safety gloves	
	M2 **p**osition the class some distance from the apparatus OWTTE	**ALLOW** tie back hair	
	M3 **d**o the experiment in a fume cupboard		
(b)	Example calculation M1 moles of tungsten oxide = $(2784 \times 10^6 \div 232)$ = 12 000 000 M2 maximum mass of tungsten = (12 000 000 × 184) = 2208000000 g **OR** 2208 tonnes M3 mass of tungsten (considering 73.5% yield) = (73.5 × 2208 ÷ 100) = 1622.88 (tonnes)	correct answer without working scores 3 **ALLOW** any number of significant figures ≥2 throughout **ALLOW** other correct methods **ALLOW** working in megamoles **ALLOW** ECF M1×184 **ALLOW** ECF from M2	3

Total for question 11 = 10 marks

Question number	Answer	Notes	Marks
9 (a) (i)	$PbO(s) + H_2(g) \rightarrow Pb(s) + H_2O(l$ **OR** $g)$	**ALLOW** upper case letters for state symbols	1
(ii)	**D** 2+ A is incorrect as the charge on the lead ion is not 1- B is incorrect as the charge on the lead ion is not 1+ C is incorrect as the charge on the lead ion is not 2-		1
(iii)	An explanation that links either pair of the two points **M1** lead oxide is reduced **and** hydrogen is oxidised **M2** lead oxide loses oxygen **and** hydrogen gains oxygen **OR** **M1** lead oxide loses oxygen so is reduced **M2** hydrogen gains oxygen so is oxidised	 **ACCEPT** lead oxide is the oxidising agent and hydrogen is the reducing agent **ACCEPT** lead ions gain electrons and hydrogen loses electrons **ACCEPT** lead ions gain electrons so are reduced **ACCEPT** hydrogen loses electrons so is oxidised **ALLOW** oxidation number of lead / Pb^{2+} decreases from +2 to 0 so is reduced for M1 Oxidation number of hydrogen increases from 0 to +1 so is oxidised for M2	2
(iv)	A description that refers to the following two points: **M1** measure the boiling point (of the water) **M2** (boiling point is) 100 °C	 **ALLOW** boil it **/** measure the freezing point / freeze it **ACCEPT** (freezing point is) 0 °C	2

(b)	(i)	An explanation that links the following two points: **M1** heat the crucible **M2** repeat until constant mass is obtained	 **ALLOW** repeat the experiment heat to constant mass scores 2	2 3
	(ii)	**M1** (moles of Pb_3O_4 =) 5.48 ÷ 685 **OR** 0.008(00) **M2** (moles of PbO =) 0.008(00) x 3 **OR** 0.024(0) **M3** (mass of PbO =) 0.024 x 223 = 5.352 (g)	correct final answer without working scores 3 **ALLOW** ecf as long as an attempt has been made to find moles **ALLOW** answer to M1(if no **M2**) or **M2** x 223 **ALLOW** any number of sig figs except 1	 **Total 11**

Question number	Answer	Notes	Marks
5 (a)	M1 (put the carbonate in the boiling tube) and the limewater in the test tube M2 heat the carbonate and time how long it takes for the limewater to turn cloudy OWTTE M3 repeat with the same mass / amount / number of moles of another carbonate M4 (the carbonate which decomposes the fastest) will turn the limewater cloudy in the least time	 **ACCEPT** repeat with another carbonate using same volume of limewater OWTTE To score M4 reference to limewater turning cloudy must be mentioned at least once somewhere in answer	4
(b) (i)	to prevent loss of solid/XCO_3/carbonate/XO	**ALLOW** so <u>only</u> carbon dioxide/gas can escape	1
(ii)	0.05		1
(iii)	0.05	**ALLOW** ECF from (ii)	1
(iv)	M1 7.40 ÷ 0.05 M2 148	correct answer with or without working scores 2 **ALLOW** ECF from (iii)	2
(v)	M1 A_r of metal = 148-60 **OR** 88 M2 metal is strontium / Sr	If (iv) correct strontium/Sr scores 2 without working **ALLOW** ECF from (iv) **ALLOW** ECF from M1 as long as answer is nearest Group 2 metal	2

Total for question 5 = 11 marks

Question number	Answer	Notes	Marks
12 (a)	$2TaCl_5(s) + 5H_2(g) \rightarrow 2Ta(s) + 10HCl(g)$	ALLOW multiples or fractions	1
(b) (i)	the last (3) masses are the same	ALLOW mass does not change / mass becomes constant	1
(ii)	M1 mass of chlorine = 1243 (kg) M2 1 267 000 ÷ 181 and 1 243 000 ÷ 35.5 M3 7000 moles of tantalum and 35 014 moles of chlorine (so 1:5 ratio)	 ALLOW calculation done in kilomoles e.g. 1267 ÷ 181 and 1243 ÷ 35.5 e.g. ratio 7 : 35 moles M3 subsumes M1 and M2 no M2 or M3 for upside down calculation or use of atomic numbers	3
(c) (i)	M1 carbon is oxidised and tantalum oxide is reduced M2 carbon gains oxygen and tantalum oxide loses oxygen OR M1 carbon gains oxygen and is oxidised M2 tantalum oxide loses oxygen and is reduced	Penalise tantalum is reduced or tantalum loses oxygen once only REJECT tantalum loses oxygen and is reduced ALLOW correct symbols and formulae throughout ACCEPT correct changes in oxidation numbers	2

(ii)	M1 (5 × 2000 =) 10 000 moles of carbon is needed M2 (10 000 × 12 =) 120 000 g of carbon is needed (which is less than 500 000 g) OR M1 (500 000 ÷ 12) of carbon is 41 667 moles M2 which is enough to react with (41 667 ÷ 5 =) 8333 moles of tantalum oxide OR M1 (5 × 2000 =) 10 000 moles of carbon is needed M2 (500 000 ÷ 12) is more than 41 667 moles of carbon	(12 × 2000 =) 24 000 g (5 × 24 000 =) 120 000 g of carbon is needed (500 000 ÷ 5) is 100 000 g which is enough to react with (100 000 ÷ 12 =) 8333 moles of tantalum oxide	2
(iii)	M1 (2 × 2000 =) 4000 moles of tantalum M2 (4000 × 181=) 724 000 g of tantalum	ALLOW ECF for incorrect moles e.g. 2000 × 181 = 362 000 scores 1 1000 × 181 = 181 000 scores 1 4000 × 362 = 1 448 000 scores 1	2
			total for question = 11

Question number	Answer	Notes	Marks
11 (a)	sodium ions M1 do a flame test M2 yellow / orange flame sulfate ions M3 (make a solution and) add hydrochloric acid M4 add barium chloride solution M5 white precipitate	 ALLOW any description of a flame test ALLOW HCl / nitric acid / HNO_3 REJECT sulfuric acid ALLOW $BaCl_2$ / barium nitrate / $Ba(NO_3)_2$ M5 dep on M4	5
(b) (i)	the last two results are the same	ALLOW mass is constant ALLOW heat to constant mass	1
(ii)	1.42 g		1
(iii)	1.80 g		1

(iv)	M1 1.42÷142 **OR** 0.01 M2 1.8÷18 **OR** 0.10 M3 0.10÷0.01=10	Answer of 10 or $Na_2SO_4.10H_2O$ scores 3	3
			Total = 11

Question number	Answer	Notes	Marks
10 (a) (i)	$4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$	**ACCEPT** multiples and fractions	1
(ii)	reversible (reaction)	**ACCEPT** reaction that goes both ways / both forwards and backwards reactions occur **IGNORE** references to equilibrium	1
(iii)	to increase the rate of the reaction / to speed up the reaction OWTTE	**IGNORE** references to lowering the activation energy	1
(b)	$2NO + O_2 \rightarrow 2NO_2$	**ACCEPT** multiples and fractions	1
(c) (i)	• calculate M_r of NO_2 and HNO_3 • calculate the amount, in moles, of NO_2 • calculate the amount, in moles, of HNO_3 • calculate the mass in tonnes of HNO_3 Example calculation **M1** M_r of NO_2 = 46 M_r of HNO_3 = 63 **M2** $n(NO_2) = 11.5 \times 10^6 \div 46$ **OR** 250 000 (mol) **M3** $n(HNO_3) = \frac{2 \times 25\,0000}{3}$ **OR** 167 000 / 170 000 **M4** (167 000 x 63 g) = 10.5 (tonnes)	**ALLOW** working in megamoles i.e. 11.5 ÷ 46 **OR** 0.25 **ALLOW** ECF from incorrect Mr of NO_2 calculator answer 166666.66 **ALLOW** working in megamoles i.e. $\frac{2 \times 0.25}{3}$ **OR** 0.167 / 0.17 **ALLOW** ECF from M2 10.5 (tonnes) with no working scores 4 **ACCEPT** 10.7 (if 170 000 used) **ALLOW** ECF from M3 **ALLOW** ECF from incorrect M_r of HNO_3	4
(ii)	can be (re)used in stage 2 / to make more nitrogen dioxide (in stage 2) / can be used to make more nitric acid	**IGNORE** can be recycled/reused unless qualified	1

Question number	Answer	Notes	Marks
10 (d)	• calculate the amount, in moles, of copper(II) nitrate • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the percentage yield Example calculation **M1** nCu(NO$_3$)$_2$ formed = 15.3 ÷ 187.5 **OR** 0.0816 **M2** theoretical nCu(NO$_3$)$_2$ = 0.200 ÷ 2 **OR** 0.100 **M3** (% yield) = $\frac{(0.0816 \times 100)}{(0.100)}$ = 81.6 (%) Alternative method • calculate the theoretical yield, in moles, of copper(II) nitrate • calculate the theoretical mass of copper nitrate that should be formed • calculate the percentage yield Example calculation **M1** theoretical nCu(NO$_3$)$_2$ = 0.200 ÷ 2 **OR** 0.100 **M2** theoretical mass of copper nitrate = 0.1 x 187.5 = 18.75 **M3** (% yield) = $\frac{15.3}{18.75}$ x 100 = 81.6 (%)	**ALLOW** 0.082 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2 **ALLOW** 18.8 **ACCEPT** 82 (%) Mark M3 CSQ on M1 and M2 40.8 scores 2 81.6(%) with no working scores 3 marks	3 **Total 12**

Question number	Answer	Notes	Marks
9 (a) (i)	**B** decomposition **A** is not correct because when sodium hydrogencarbonate is heated combustion does not take place C is not correct because when sodium hydrogencarbonate is heated oxidation does not take place D is not correct because when sodium hydrogencarbonate is heated reduction does not take place		1 comp
(ii)	(because) carbon dioxide/gas is produced/given off		1 grad
9 (b) (i)	to obtain a constant mass OWTTE / to show the reaction is complete OWTTE	ACCEPT to ensure only Na_2CO_3 is left (in crucible) ACCEPT to ensure all the $NaHCO_3$ has reacted /decomposed	1 exp
(ii)	M1 advantage: to stop any solid/Na_2CO_3/$NaHCO_3$ spitting out/being lost M2 disadvantage: the gas(es)/CO_2/H_2O/steam could not easily escape OWTTE	REJECT references to stopping gases escaping	2 exp

Question number	Answer	Notes	Marks
9 (c) (i)	3.25 (g)		1 exp
(ii)	• calculate moles of $NaHCO_3$ • use equation to determine moles of Na_2CO_3 • multiply by M_r to find mass of Na_2CO_3 Example calculation: M1 3.25 ÷ 84 **OR** 0.0387 (mol) M2 0.0387 ÷ 2 **OR** 0.01935 (mol) M3 0.01935 x 106 = 2.05 (g) **OR** • use of equation to relate mass of $NaHCO_3$ to mass of Na_2CO_3 • shows how to find mass of Na_2CO_3 using 3.25g $NaHCO_3$ • correct evaluation of answer Example calculation: M1 (2x84)/168 (g) $NaHCO_3$ → 106 (g) Na_2CO_3 M2 3.25 (g $NaHCO_3$)→ (106÷168) x 3.25 (g Na_2CO_3) M3 2.05 (g Na_2CO_3)	mark CQ on (i) ALLOW any number of sig figs except 1 2.05 (g) without working scores 3 marks 4.1 (g) without working scores 2 marks mark CQ on (i)	3 exp
9 (d) (i)	M1 percentage yield = 4.2÷4.8 **OR** 0.875 M2 = (0.875 x 100) = 87.5 (%)	ACCEPT 88 (%) Correct answer without working scores 2	2 grad
(ii)	any one from M1 sodium hydrogencarbonate was impure M2 not all sodium hydrogencarbonate reacted/decomposed		1 grad

Total Q9 = 12 marks

Question number	Answer	Notes	Marks
11 (a) (i)	M1 add anhydrous copper sulfate M2 turns (from white) to blue	ALLOW add white copper sulfate M2 dep on copper sulfate in M1 ALLOW M1 add anhydrous / blue cobalt chloride M2 turns (from blue) to pink M2 dep on cobalt chloride in M1	2
(ii)	M1 measure the boiling point / freezing point M2 100 °C / 0°C	ALLOW boil it or freeze it Value must match property	2
(b)	M1 mass of hydrated zinc sulfate = 54.46-41.64 **OR** 12.82 g M2 Moles of hydrated zinc sulfate = 12.82÷287 **OR** 0.0447 M3 Moles H_2O = 0.0447×7 **OR** 0.313 M4 Mass H_2O = 5.63 g M5 Volume H_2O 5.6 cm^3	 ALLOW M1÷287 ALLOW M2×7 ALLOW M3×18 Must be 1dp ALLOW M4 to 1dp Correct answer of 5.6 cm^3 to 1dp with or without working scores 5 marks	5
(c) (i)	1.7	ALLOW 2 or more significant figures REJECT incorrect rounding	1
(ii)	M1 stand the measuring cylinder in a beaker of ice OR	ALLOW any way of cooling the measuring	2

		cylinder or delivery tube	
	M1 replace the delivery tube with a (Liebig) condenser	ALLOW add a condenser IGNORE add a stopper / bung	
	M2 less water / water vapour / steam lost	ALLOW more water (vapour) / steam condenses ALLOW less water evaporates	
			Total for question = 12

Question number	Answer	Notes	Marks
8 (a) (i)	(thermal) decomposition		1
(ii)	**M1** amount of $PbCO_3 = \frac{5.34}{267} = 0.02(00)$ (mol) **M2** mass of PbO = 0.02(00) x 223 = 4.46 (g)	Correct answer without working scores 2 **ACCEPT** alternative methods	2
(b) (i)	**M1** diagram showing delivery tube going into test tube containing liquid **M2** limewater labelled	REJECT if sealed with a bung	2
(ii)	(limewater) turns cloudy/milky	**ALLOW** white precipitate (ii) dep on mention of limewater in either (i) or (ii)	1
(c)	An explanation that links six of the following points **M1** silicon dioxide has a giant (covalent) structure **M2** covalent bonds are (very) strong **M3** (in silicon dioxide) many covalent bonds need to be broken **M4** a large amount of energy/more energy is required to break the bonds in silicon dioxide **M5** carbon dioxide has a simple molecular structure/is a simple molecule **M6** the forces between the molecules/intermolecular forces (in carbon dioxide) are weak **M7** very little energy/less energy is needed to overcome the forces between the molecules/intermolecular forces (in carbon dioxide)	No **M3 or M4** if reference to intermolecular forces in silicon dioxide No **M6 or M7** if any reference to weak covalent bonds or breaking of covalent bonds in carbon dioxide Accept bonds between molecules weak A statement such as 'more energy is needed to break the bonds in silicon dioxide than to overcome the forces between the molecules/intermolecular forces (in carbon dioxide)' scores **M4** and **M7**	6
			Total 12

Question number	Answer	Notes	Marks
9 (a) (i)	the metal oxide/it loses oxygen	**ACCEPT** metal ions gain electrons Ignore metal oxide gains electrons	1
(ii)	(the gas would escape and) it is flammable/could cause a fire/could cause an explosion		1
(iii)	An explanation that links the following two points **M1** to stop oxygen/air entering the tube OWTTE **M2** as some of the metal would change back to the metal oxide/be oxidised/react with oxygen OWTTE		2
(iv)	A description that refers to the following two points **M1** reheat the tube and contents(and reweigh when cool) **M2(** repeat) until constant mass is obtained OWTTE	 ALLOW repeat the instructions/repeat what I did Reheat to constant mass scores 2	2
(b) (i)	**M1** mass of oxygen = 4.46 – 4.14 **OR** 0.32 (g) **M2** (moles of oxygen atoms = 0.32 ÷ 16 =) 0.02(0)	correct answer without working scores 2 **ALLOW** ecf on incorrect mass of oxygen atoms	2
(ii)	(moles of M =) 0.02(0)	**ALLOW** ecf as long as an attempt has been made to find moles	1
(iii)	**M1** (A_r of M =) 4.14 ÷ 0.02(0) **M2** 207	**ALLOW** ecf from (ii) **207 without working scores 2** **ALLOW** ecf on incorrect mass of M or incorrect moles -use of 4.46 gives 223 (scores 1)	2
(iv)	Pb/lead	**ALLOW** ecf on incorrect A_r of M as long as calculation in (ii) and/or (iii) is viable Use of 4.46 gives 223 Francium (scores 1)	1
			Total 12

Question number	Answer	Notes	Marks
4 (a) (i)	24		1
(ii)	**M1** $12 \times 8 + 1 \times 10 + 14 \times 4 + 16 \times 2$ **M2** 194	correct answer of 194 scores 2 No ECF	2
(iii)	$C_4H_5N_2O$	**ALLOW** atoms in any order	1
(b) (i)	(simple) distillation	**REJECT** fractional distillation	1
(ii)	A description that refers to two of the following points **M1** (the condenser/X) **cools** the (ethanol) vapour **M2** so it **condenses OR** forms **liquid** (ethanol)		2
(c)	**M1** calcium bromide is a giant (ionic) lattice/structure **M2** with many/strong electrostatic attractions between (oppositely charged) ions **M3** caffeine has a simple molecular structure **M4** caffeine has weak intermolecular forces /weak forces between molecules **M5** more energy is needed to break the electrostatic attractions (in calcium bromide) than to overcome the intermolecular forces (in caffeine) OWTTE	**ALLOW** many/strong ionic bonds No **M2** if covalent bonds or IMF given here **ALLOW** simple covalent structure **REJECT** weak forces between bonds No **M5** if reference to breaking covalent bonds No **M5** if reference to incorrect bonds	5
			Total 12

Question number	Answer	Notes	Marks
10 (a)	M1 red lead oxide → lead(II) oxide + M2 oxygen	must have (II) ACCEPT answers in either order If formulae given allow 1 mark for O_2 even if formula for lead(II) oxide is incorrect	2 grad
10 (b)	• dividing percentages by A*r* • correct results of divisions • divide by smallest to obtain correct ratio/EF Example of calculation: Pb O M1 86.6÷207 13.4÷16 M2 0.42 0.84 M3 (0.42÷0.42 =)1 (0.84÷0.42 =) 2	0 marks if division by atomic numbers or calculation upside down ACCEPT alternative methods	3 exp
(c) (i)	M1 Pb_3O_4 (s) + $4HNO_3$ (aq) M2 $2Pb(NO_3)_2$(aq) + $2H_2O$	both state symbols required ALLOW upper case letters for state symbols both numbers required	2 grad

10	(c)	(ii)	description that makes reference to the following three points: M1 warm/heat (nitric) acid M2 add/mix/react (red) lead oxide (and stir) M3 filter to obtain lead(II) nitrate solution **AND** three of the following points: M4 heat/boil (lead(II) nitrate) solution/filtrate M5 until crystals form in a cooled sample/on a glass rod OWTTE M6 leave solution to cool / leave solution for more crystals to form M7(and then) filter off crystals/lead nitrate M8 suitable method of drying the crystals eg using filter paper/using paper towel/in a warm oven	REJECT boil IGNORE references to adding excess(red) lead oxide ALLOW to remove lead(IV) oxide/PbO_2 ALLOW to remove (unreacted/excess) red lead oxide/Pb_3O_4 If heat to dryness only M4 can be scored ACCEPT to crystallisation point/to form a saturated solution /until crystals start to form /to remove some of the water M5 DEP M4 ACCEPT decant off the solution M7 DEP M6 IGNORE references to washing REJECT hot oven or any method of direct heating eg Bunsen ALLOW leave to dry but not just dry the crystals No M8 if crystals are washed after drying	6 exp

Total for Q10 = 13 marks

Question number	Answer	Notes	Marks
10 (a) (i)	so that the (hot) lead does not react with oxygen/air (converting back into lead oxide)	**ACCEPT** so that lead is not oxidised (back to lead oxide)	1
(ii)	M1 repeat the heating M2 until the mass remains constant/ does not change	**ACCEPT** heat to constant mass for both marks	2
(b) (i)	4.66 (g)		1
(ii)	0.48 (g)		1
(iii)	• calculate the moles of lead and oxygen • divide by the smaller number • calculate the whole number ratio • give the empirical formula Example calculation **M1** $\frac{4.66}{207}$ and $\frac{0.48}{16}$ **OR** 0.0225 and 0.03(00) **M2** $\frac{0.0225}{0.0225}$ and $\frac{0.03(00)}{0.0225}$ **OR** 1:1.33 **M3** 1 x 3 and 1.33 x 3 **OR** 3:4 **M4** Pb_3O_4	Division by atomic numbers or upside down calculation scores 0 3:4 ratio without working scores 3 Pb_3O_4 without working scores 4 **ALLOW** ECF from incorrect masses.	4

Question number	Answer	Notes	Marks
10 (c) (i)	$Pb(NO_3)_2$ (aq) + 2HCl (aq) → $PbCl_2$ (s) + $2HNO_3$ (aq)	**ALLOW** any combination of uppercase and lowercase letters	1
(ii)	• calculate the amount of $PbCl_2$ • multiply the moles by the M_r of $PbCl_2$ • evaluation to show that the value is about 5 g Example calculation **M1** $n(PbCl_2) = \frac{0.0370}{2}$ **OR** 0.0185 (mol) **M2** mass of $PbCl_2$ = 0.0185 x 278 (g) **M3** 5.143 (g)	**MAX 1** for 0.0370 x 278 if no division by 2 in **M1** **ALLOW** any number of sig figs 5.1, 5.14 and 5.143 g without working score 3 5 g without working scores 0 **ALLOW** alternative methods	3
			Total 13

Question number	Answer	Notes	Marks
7 (a) (i)	**M1** atoms of the same element / atoms with the same number of protons /atoms with the same atomic number	**REJECT** different number of electrons **IGNORE** same number of electrons	2
	M2 (with a) different number of neutrons / different mass number		
(ii)		correct answer without working scores 3	3
	M1 (63 x 69.5) + (65 x 30.5) **OR** 6361		
	M2 their **M1** ÷ 100 **OR** 63.61		
	M3 63.6	**ALLOW** answer to **M2** to 3 sig figs 63.61 without working scores 2	
(b) (i)	**A** decomposition B is incorrect as it is not a neutralisation reaction C is incorrect as it is not an oxidation reaction D is incorrect as it is not a reduction reaction		1
(ii)	**C** green to black A is incorrect as copper(II) carbonate is not blue B is incorrect as copper(II) carbonate is not blue and copper(II) oxide is not white D is incorrect as copper(II) oxide is not orange		1
(c) (i)	(28.20 – 20.52 =) 7.68		1
(ii)	(31.77 – 28.20 =) 3.57		1

(iii)	**M1** 7.68 ÷ 159.5 **OR** 0.04815 **M2** 3.57 ÷ 18 **OR** 0.1983 **M3** 0.1983 ÷ 0.04815 **OR** 4.12	correct answer without working scores 3 **ALLOW** ecf from (i) and/or (ii) for **M1** and **M2**; and **M3** provided the answer rounds to 4 **REJECT** incorrect rounding in **M1** or **M2** **ALLOW** any number of sig figs in **M1** and **M2** except 1 Penalise 1 sig fig once only	3
(iv)	not all the water was removed (from the hydrated copper(II) sulfate)	**ALLOW** the (hydrated copper(II) sulfate) was not heated for long enough **ALLOW** not all the water left the tube (that was being heated) **ALLOW** not all the (hydrated copper sulfate) reacts	1 **Total 13**

Question number	Answer	Notes	Marks
12 (a) (i)	to make sure all the water is given off/evaporates	ALLOW to make sure the reaction is complete	1
(ii)	5.2(0 g)		1
(iii)	0.9(0 g)		1
(iv)	M1 moles of $BaCl_2$= 5.2 ÷ 208 OR 0.025 M2 moles of H_2O = 0.9 ÷ 18 OR 0.05(0) M3 0.05(0) ÷ 0.025 = 2	ALLOW ecf from (ii) ALLOW ecf from (iii) ALLOW ecf from M1 and M2 as long as the answer is an integer Correct answer without working scores 3	3
(b)	M1 (measure the) boiling point M2 100°C	ALLOW freezing point ALLOW 0°C for freezing point	2
(c) (i)	reversible	ALLOW the reaction goes in both directions IGNORE equilibrium	1
(ii)	M1 add water to anhydrous copper sulfate M2 which turns (from white) to blue	ALLOW white copper sulfate M2 dep on mention of anhydrous/white copper sulfate Max 1 mark if incorrect starting colour	2
(iii)	M1 moles of water = 0.02 x 5 **OR** 0.1 M2 molecules of water = 6×10^{22}	ALLOW ecf from M1 Correct answer without working scores 2 1.2×10^{22} scores 1	2
			Total for question = 13

Question number	Answer	Notes	Marks
9 (a) (i)	**B** 4 A is incorrect as there are not 3 different elements in $Na_2SO_4.7H_2O$ C is incorrect as there are not 5 different elements in $Na_2SO_4.7H_2O$ D is incorrect as there are not 10 different elements in $Na_2SO_4.7H_2O$		1
(ii)	**D** 28 A is incorrect as there is not a total of 10 atoms in $Na_2SO_4.7H_2O$ B is incorrect as there is not a total of 22 atoms in $Na_2SO_4.7H_2O$ C is incorrect as there is not a total of 27 atoms in $Na_2SO_4.7H_2O$		1
(b) (i)	A description that refers to the following two points **M1** heat the sodium sulfate (again) **M2** (repeat) until there is no further change in mass	 **ACCEPT** 'heat to constant mass' for both marks	2
(ii)	An explanation that links the following two points **M1** to cool the (water) vapour **M2** so it condenses / forms liquid/water	 **ACCEPT** steam	2
(iii)	A description that refers to the following two points **M1** heat (the water) / measure the boiling point **M2** (if it) boils at 100 °C (it is pure water) / boiling point is 100 °C	 **ALLOW** find the freezing point /melting point? **REJECT** evaporate **ALLOW** freezes/ melts at 0°C **IGNORE** chemical test even if incorrect	2

(c)	**M1** mass of Na_2SO_4 (= 19.38 – 15.83) = 3.55 (g) **M2** mass of H_2O (= 23.88 – 19.38) = 4.50 (g) **M3** amount of Na_2SO_4 (= 3.55 ÷ 142) = 0.025 (mol) **M4** amount of H_2O (= 4.50 ÷ 18) = 0.25 (mol) **M5** x (= 0.25 ÷ 0.025) = 10 OR **M1** mass of Na_2SO_4 (= 19.38 – 15.83) = 3.55 (g) **M2** mass of H_2O (= 23.88 – 19.38) = 4.50 (g) **M3** mass of water combined with 1 mole of sodium sulfate = $\frac{142}{3.55} \times 4.50 = 180$ (g) **M4** moles of H_2O = 180 ÷ 18 **M5** therefore, x = 10	Correct answer without working scores 5 **ALLOW** ECF from incorrect **M1** **ALLOW** ECF from incorrect **M2** **ALLOW** an integer ECF on **M3** & **M4** **ACCEPT** alternative correct methods	5
			Total 13

Question number	Answer	Notes	Marks
11 (a)	**4** CuO (**s**)+ CH_4 (**g**)→ **4** Cu (**s**)+ CO_2 (**g**) + **2** H_2O (**l/g**) **M1** correct balancing **M2** correct state symbols	**ALLOW** multiples and fractions	2
(b) (i)	**M1** Mass copper 3.18g **and** mass oxygen 0.40g **M2** Moles copper = 3.18/63.5 **OR** 0.0500 moles **M3** Moles oxygen = 0.40/16 **OR** 0.025 moles **M4** Ratio of moles Cu:O is 2:1	 **M2** and **M3** allow ecf from **M1** **M4** is dep on **M2** and **M3**	4
(ii)	Any one from: **M1** Use a safety screen **M2** Position the class some distance from the apparatus **M3** Do the experiment in a fume cupboard **M4** Set fire to the (excess) methane gas straight away	 **ALLOW** tie hair back **ALLOW** wear heat-proof gloves	1
(c)(i)	(Iron (III) oxide) loses oxygen	**ALLOW** iron loses oxygen **IGNORE** any reference to electrons.	1
(ii)	Carbon monoxide is poisonous / toxic **OR** carbon monoxide reduces the ability of the blood to carry oxygen	**ALLOW** carbon monoxide binds to haemoglobin in the blood	1

(iii)	• calculate M_r of Fe_2O_3 • calculate the amount, in moles, of Fe_2O_3 • calculate the amount, in moles, of Fe • calculate the mass in tonnes of Fe Example calculation **M1** M_r of Fe_2O_3 = 160 **M2** $n(Fe_2O_3)$ = 30.0 x 10^6 ÷ 160 **OR** 187,500 moles **M3** n(Fe) = 187,500 x 2 **OR** 375,000 moles **M4** 375,000 x 56 = 21 tonnes	Correct answer of 21 tonnes scores 4 marks with or without working **ALLOW** ecf from **M1** (incorrect M_r) **ALLOW** working in megamoles **ALLOW** ecf from M1 **ALLOW** working in megamoles **ALLOW** ECF from M2 **ALLOW** ecf from M3	4
(iv)	**M1** 840,000g is 70,000 moles of carbon **M2** therefore need 23,333 moles Fe_2O_3 (but we have 25,000 which is an excess) **OR** **M1** Need 75,000 moles carbon **M2** 900,000g of carbon is needed (and have 840,000g of carbon so iron(III) oxide is in excess as carbon is the limiting reactant) **OR** **M1** need 75,000 moles of carbon **M2** have 840,000÷12 **OR** 70,000 moles of carbon (so iron(III) oxide is in excess as carbon is the limiting reactant)		2

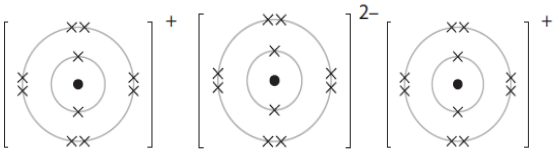
Question number	Answer	Notes	Marks
11 (a) (i)	$2PbS + 3O_2 \quad 2PbO + 2SO_2$ M1 formulae of O_2 and SO_2 M2 rest of equation correctly balanced	 M2 dep on M1 ALLOW multiples/fractions	2
(ii)	(sulfur dioxide causes) acid rain / breathing problems	ALLOW named breathing problems such as asthma ALLOW other effects of acid rain such as killing fish, damage to stonework, killing plants	1
(iii)	M1 (moles lead(II) oxide) = 892 000 000 ÷ 223 OR 4 000 000 moles M2 (moles of carbon dioxide) = 2 000 000 M3(mass of carbon dioxide) = 88 (tonnes)	ALLOW calculations done in megamoles throughout ALLOW M1÷2 88 (tonnes) scores 3 marks	3
(iv)	any 5 from: lead(II) sulfide M1 giant ionic structure/lattice M2 strong (ionic) bonds OR strong electrostatic forces (between oppositely charged) ions M3 which take a lot of energy to break / overcome sulfur dioxide M4 simple molecular/covalent structure M5 weak intermolecular forces OR weak forces between molecules M6 which take little energy to overcome	 REJECT molecules/covalent bonds/ intermolecular forces for all three marks M3 dep on M2 REJECT ions/ionic bonds for all 3 marks ALLOW molecules NOT particles/atoms NOT weak IMF between atoms M6 dep on M5	5
(b)	M1 90.7÷207 and 9.30÷16 M2 0.438 (moles of lead) and 0.581 (moles of	NOT atomic numbers ALLOW 9.30÷32 for ecf	4

	oxygen) M3 ratio of moles = 1:1.33 M4 empirical formula is Pb_3O_4	Answer must be 2sf or more ALLOW 1.3 ALLOW ecf from ratio shown to produce formula	
		Total = 15	

Question number	Answer	Notes	Marks
7 (a)	description including (formation of ions in lithium chloride involves) M1 lithium (atom) losing electron M2 chlorine (atom) gaining an electron (formation of covalent bonds in hydrogen chloride involves) M3 sharing a pair of electrons (one electron from each atom)	ALLOW correct dot-and-cross diagrams for ions for M1 and M2 ALLOW correct dot-and-cross diagram showing shared pair in hydrogen chloride for M3	3

7	(b)	explanation including five of the following points: (lithium chloride) M1 giant (ionic) structure M2 strong (electrostatic) forces of attraction M3 between oppositely charged ions (hydrogen chloride) M4 simple molecular structure M5 weak intermolecular forces of attraction M6 more (heat/thermal) energy needed to overcome forces/break bonds in lithium chloride (than intermolecular forces in hydrogen chloride) OWTTE	 ALLOW giant lattice ALLOW strong bonds ACCEPT positive and negative ions If any reference to molecules/atoms/covalent bonds/intermolecular forces/metallic bonds cannot score M2 M3 M6 ALLOW weak bonds between molecules ACCEPT reverse argument If description/implication of breaking covalent bonds in hydrogen chloride cannot score M5 M6	5

(Total for Question 7 = 8)

Question number	Answer	Notes	Marks
4 (a) (i)	<table><tr><th></th><th>Mg^{2+}</th><th>Al^{3+}</th><th>NH_4^+</th></tr><tr><td>S^{2-}</td><td>MgS</td><td>Al_2S_3</td><td>$(NH_4)_2S$</td></tr><tr><td>NO_3^-</td><td>$Mg(NO_3)_2$</td><td>$Al(NO_3)_3$</td><td>NH_4NO_3</td></tr><tr><td>CO_3^{2-}</td><td>$MgCO_3$</td><td>$Al_2(CO_3)_3$</td><td>$(NH_4)_2CO_3$</td></tr></table>	1 mark for each correct formula	3
(ii)	ammonium nitrate		1
(b) (i)	**M1** electrostatic (force of) attraction **M2** between oppositely charged ions	**ALLOW** electrostatic force **ACCEPT** between positive and negative ions **ACCEPT** between cations and anions	2
(ii)	 **M1** correct electron arrangement of both sodium ions **M2** correct electron arrangement of the oxide ion **M3** correct charges on all ions (with or without brackets)	If only outer shells shown correctly scores 1 mark **ACCEPT** dots in place of crosses or any combination of dots and crosses for **M1** and **M2**	3
			Total 9

Question number	Answer	Notes	Marks
6 (a)	Any three from: M1 sodium (atom) loses electron(s) M2 oxygen (atom) gains electron(s) M3 sodium loses 1 electron AND oxygen gains 2 electrons OR M3 (both atoms become ions with configuration) 2.8	any mention of sharing of electrons scores 0	3
(b)	62		1
(c)	Any two from: M1 (sodium oxide has) ions / (giant) ionic structure M2 ions / electrons cannot flow / move M3 no delocalised electrons		2
(d)	M1 flame test M2 yellow colour	ALLOW any description of a flame test ALLOW orange or yellow-orange M2 dep on M1 or mention of flame	2
(e)	$2Na_2O \rightarrow 2Na + Na_2O_2$		1
			Total for question = 9 marks

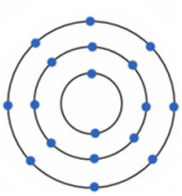
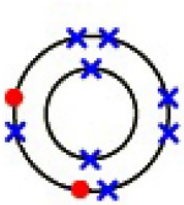
Question number	Answer	Notes	Marks
8 (a) (i)	M1 NaCl M2 $MgCl_2$ M3 Mg_3N_2	Penalise once only for incorrect case or superscript numbers ALLOW symbols reversed e.g. N_2Mg_3 ALLOW correct charges on ions e.g $Mg^{2+}(Cl^-)_2$	3
(ii)	magnesium oxide	Spelling must be correct	1
(iii)	83	IGNORE units	1
(b) (i)	M1 lithium changes (from 2.1) to 2 M2 oxygen changes (from 2.6) to 2.8	ALLOW (two) lithium (atoms) lose one electron ALLOW oxygen (atom) gains two electrons No marks if mention of sharing electrons	2
(ii)	An explanation that links the three points M1 strong (electrostatic) forces of attraction M2 between oppositely charged ions M3 which require a lot of energy to break	ALLOW strong ionic bonds IGNORE more energy 0 marks if any mention of covalent bonds, intermolecular forces or molecules	3
			Total for question = 10

Question number	Answer	Notes	Marks
5 (a)	2.8.5		1
(b)	**M1** formula of phosphide ion is P^{3-} **M2** charges on three calcium/Ca^{2+} ions balance / cancel out charges on two phosphide/P^{3-} ions OWTTE	ALLOW P^{-3} ALLOW charge on phosphide ion is 3-/-3 ALLOW reference to three calcium atoms each lost two electrons /(total of) six electrons which were gained by two phosphorus atoms (to attain full outer shells) OWTTE Any reference to sharing of electrons/covalent bonding scores 0	2
(c) (i)	$Ca_3(PO_4)_2$ + **8** C → Ca_3P_2 + **8** CO		1
(ii)	explanation including **M1** (carbon acts as a) reducing agent **M2** (because) calcium phosphate/$Ca_3(PO_4)_2$ loses oxygen	ALLOW (because) carbon gains oxygen / is oxidised ALLOW carbon removes oxygen from calcium phosphate/$Ca_3(PO_4)_2$ IGNORE references to reactivity series / displacement reactions M2 DEP M1 correct or missing	2
(d)	$Ca_3P_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2PH_3$ **M1** all formulae correct **M2** correct balancing	 M2 DEP M1 ALLOW multiples and fractions	2

(e)	explanation including **M1** giant (ionic) structure **M2** strong forces of attraction between oppositely charged ions **M3** which require a lot of (heat/thermal) energy to break/overcome	 ACCEPT giant (ionic) lattice ACCEPT between Ca^{2+} and P^{3-} ACCEPT between positive and negative ions ALLOW strong ionic bonds IGNORE more energy 0 marks if any mention of covalent bonds, intermolecular forces or molecules	3

(Total for Question 5 = 11 marks)

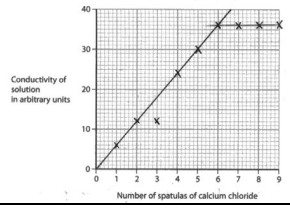
Question number	Answer	Notes	Marks
6 (a) (i)	$AlCl_3$ $ZnSO_4$ $(NH_4)_3N$	ALLOW formula in reverse NOT molecular formula Penalise symbol letters/size of subscripts once only	3
(ii)	aluminium sulfate	ALLOW aluminium sulphate	1
(b)	M1 magnesium loses electrons M2 chlorine gains electrons M3 magnesium loses two electrons and two chlorines each gain one electron	ALLOW magnesium gives/transfers electrons to chlorine for M1,M2 NOT chloride gains electrons M3 assumes M1,M2 ALLOW correct ionic equations	3
(c) (i)	M1 two electrons between each nitrogen and hydrogen atom M2 two non-bonding electrons	 M2 dep on M1	2
(ii)	M1 (electrostatic) forces of attraction between shared pair(s) of electrons M2 and the nuclei	 REJECT nucleus (must be plural) REJECT intermolecular forces for both marks	2
		Total = 11	

Question number	Answer	Notes	Marks
4 (a)	M1 (cation) Mg^{2+} M2 (anion) SO_4^{2-}	ALLOW 1 mark if formulae correct but in wrong order	2
(b)	M1 potassium ion 	ALLOW any combination of dots and crosses	3
	M2 oxide ion 		
	M3 $(K)^+$ and $(O)^{2-}$		
		If only outer shells shows – max 2	

Question number	Answer	Notes	Marks
4 (c) (i)	hydroxide/OH^-	ALLOW HO^-	1
(ii)	$K_2O + H_2O \rightarrow 2KOH$	ALLOW multiples	1
(d)	M1 (when molten or in aqueous solution) ions can move M2 (in solid) ions cannot move		2
(e)	M1 X is chlorine / Cl_2 M2 Y is hydrogen / H_2 M3 $2Cl^- \rightarrow Cl_2 + 2e^{(-)}$ M4 $2H^+ + 2e^{(-)} \rightarrow H_2$	ALLOW oxygen / O_2 If both given but wrong way round or unclear which is which allow 1 mark from M1 and M2 $2H_2O \rightarrow O_2 + 4H^+ + 4e^{(-)}$ or $4OH^- \rightarrow O_2 + 2H_2O + 4e^{(-)}$	4

Total marks for Question 4 = 13

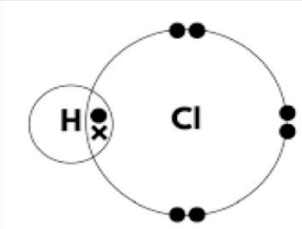
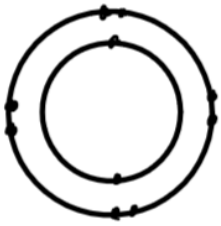
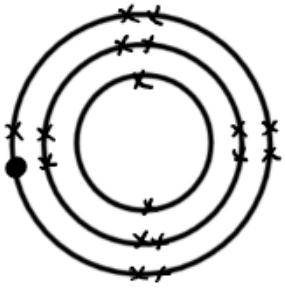
Question number	Answer	Notes	Marks
8 (a)	**M1** calcium loses electrons **M2** chlorine gains electrons **M3 two** atoms of chlorine each gain **one** electron **OR** **M3** calcium loses 2 electrons and chlorine gains 1 electron	**IGNORE** references to redox Allow 1 mark from **M1** and **M2** for electron transfer from chlorine to calcium If chlorine molecules are gaining electrons do not award **M3** Any reference to sharing electrons or covalent or metallic bonding scores 0	3
(b)	(test for Ca^{2+} ions) **M1** flame test (allow description of a flame test) **M2** orange-red flame colour (test for Cl^- ions) **M3** add silver nitrate **M4** white precipitate	 **ALLOW** brick-red **IGNORE** orange / red alone **M2** dep on **M1** **ALLOW M1** add sodium hydroxide **ALLOW M2** (slight) white precipitate (reject precipitate dissolves in excess sodium hydroxide) **IGNORE** reference to nitric acid **REJECT** hydrochloric acid or sulfuric acid **M4** dep on silver nitrate in **M3**	4

(c)(i)		**M1** and **M2** all points correct ± half a square **M3** 2 straight lines of best fit ignoring the anomalous point  	One plotting error scores **M1**	3
(c)	(ii)	the conductivity is (directly) proportional (to the number of spatulas of calcium chloride added) **OR** the conductivity increases (as the number of spatulas of calcium chloride increases)		1
	(iii)	Any **one** from: **M1** The student took the reading before adding the calcium chloride **M2** The student forgot to stir the mixture **OR** did not stir the mixture properly	**IGNORE** any references to human error	1
(d)		**M1** Heat (the calcium chloride) **M2** until molten / melts	**IGNORE** references to electrons / ions	2

Question number	Answer	Notes	Marks
5 (a)	(good) conductors of electricity / malleable	**ACCEPT** (good) conductors of heat/ductile/have basic oxides/hydroxides **ALLOW** high density/ high melting point/ sonorous/shiny/hard/ strong	1
5 (b)	**M1** (in mercury) particles can move/flow OWTTE **M2** (in solid metal) particles do not move /are in fixed positions	**IGNORE** references to spacing/gaps between particles / energy of particles **ACCEPT** particles vibrate (about fixed position)	2
5 (c) (i)	(bright) white flame	**ALLOW** white light **ACCEPT** white solid/ash/powder (formed)	1
5 (c) (ii)	(product/magnesium oxide is) basic / a base	**ALLOW** (product/magnesium oxide) neutralises acid / dissolves in/reacts with acid /(produces) alkali (when added to water) **REJECT** if incorrect product given	1
5 (d) (i)	magnesium/sulfur would react with/ burn in oxygen	**ACCEPT** magnesium oxide (not magnesium sulfide) would be formed **ALLOW** sulfur dioxide would be formed	1
5 (d) (ii)	**M1** magnesium (atom) loses two electrons **M2** sulfur (atom) gains two electrons (from magnesium) **M3** charge on magnesium (ion) $2^+/Mg^{2+}$ AND charge on sulfur/sulfide (ion) $2^-/ S^{2-}$	two electrons transferred from magnesium (atom) to sulfur (atom) scores **M1** and **M2**	3

Question number	Answer	Notes	Marks
5 (d) (iii)	**M1** strong (electrostatic) force of attraction **M2** between magnesium ions/Mg^{2+} and sulfide ions/S^{2-} ions **M3** large amount/lot of (heat/thermal) energy needed to overcome forces/attraction	**ALLOW** strong ionic bonds but No **M1** or **M2** if between atoms/molecules or any reference to intermolecular forces / covalent bonds **ACCEPT** between oppositely charged ions **ACCEPT** between positive and negative ions **ACCEPT** large amount/lot of (heat/thermal) energy needed to break the bonds **IGNORE** more energy No **M3** if reference to overcoming / breaking intermolecular forces / covalent bonds	3
5 (d) (iv)	$MgS + 2HCl \rightarrow MgCl_2 + H_2S$ **M1** all formulae correct **M2** correctly balanced	IGNORE **state symbols** **M2 DEP M1** **ACCEPT** multiples and fractions	2

Total for Question 5 = 14 marks

Question number	Answer	Notes	Marks
9 (a) (i)	M1 NaCl M2 ZnO M3 $(NH_4)_2SO_4$	ACCEPT Na^+Cl^- / ClNa ACCEPT $Zn^{2+}O^{2-}$ / OZn ACCEPT $(NH_4^+)_2SO_4^{2-}$ / $SO_4(NH_4)_2$ REJECT any incorrect charges Penalise once only for incorrect case or subscripts / superscripts	3
(ii)	zinc sulfate		1
(b) (i)	M1 2 bonding electrons M2 rest of the molecule correct 	ALLOW dots, crosses or any combination M2 dep on M1	2
(ii)	M1 magnesium ion  M2 chloride ion  M3 Mg^{2+} and Cl^-	ALLOW dots, crosses or any combination Only 1 mark max in M1 and M2 if they only show the outer electrons, as the question requires the electronic configurations	3

(iii)	An explanation that links any 5 of the following points M1 hydrogen chloride is simple molecular / simple covalent M2 magnesium chloride is giant ionic / ionic lattice M3 strong electrostatic attraction between (oppositely charged) ions M4 in hydrogen chloride there are weak intermolecular forces / weak forces between molecules M5 (much) more energy is required to break the (ionic) bonds in $MgCl_2$ than to overcome the (intermolecular) forces in HCl	 ALLOW molecular covalent ALLOW giant structure if ions are mentioned ALLOW strong ionic bonds No M3 if any mention of covalent bonds or intermolecular forces in magnesium chloride REJECT weak forces between bonds REJECT any reference to breaking covalent bonds in HCl or $MgCl_2$	5
			total for question = 14

Question number	Answer	Notes	Marks
3 (a) (i)	**M1** same number of protons **M2** different number of neutrons	**IGNORE** same number of electrons **REJECT** the different number of electrons for **M2**	2
(ii)	**M1** $\frac{76.5 \times 24 + 10.5 \times 25 + 13.0 \times 26}{100}$ **M2** 24.365 **M3** 24.4	correct answer without working scores 3 24 no working scores 0	3
(b)	**B (calcium sulfate)** A is incorrect as calcium nitrate is soluble C is incorrect as magnesium nitrate is soluble D is incorrect as magnesium sulfate is soluble		1
(c)	**M1** diagram of magnesium ion with electron configuration 2,8 **M2** diagram of oxide ion with electron configuration 2,8 **M3** correct charges on the ions, e.g. Mg^{2+} and O^{2-}	**ALLOW** any combination of dots and crosses If the two inner circles of the electrons are missing **M1** and **M2** allow 1 mark **M3 is** an independent mark **ALLOW** Mg^{+2} and O^{-2}	3
(d)	An explanation that links the following five points **M1** water is covalent /water is a molecule **M2** water has not enough charged particles /not enough ions /no (delocalised) electrons **AND** so not free to move /cannot conduct electricity /cannot carry a current	 **ALLOW** no charged particles/ no ions /no (delocalised) electrons **IGNORE** cannot carry a	5

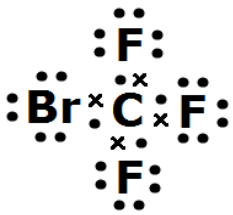
		charge **M3** magnesium chloride is an ionic (compound/substance/solid/lattice) **M4** ions in solid magnesium chloride do not move /ions in fixed positions (do not move) **M5** ions in aqueous / solution magnesium chloride are free to move	No **M5** if any mention of electrons moving or delocalised electrons lose 1 mark if there is any mention of intermolecular forces in magnesium chloride	
(e)	(i)	$2Cl^- \rightarrow Cl_2 + 2e^{(-)}$		1
	(ii)	chloride (ions)/Cl^- (ions) lose electron(s)	**ALLOW** electron(s) are lost **REJECT** chlorine / Cl / Cl_2 loses electrons	1 **Total 16**

Question number	Answer	Notes	Marks
2 (a) (i)	B A, C and D are not the correct answers as metals conduct electricity when solid		1
(ii)	D A is not the correct answer because diamond will not conduct electricity when molten B is not the correct answer because diamond will not conduct electricity when solid or molten C is not the correct answer because diamond has a much higher melting and boiling point		1
(iii)	C A is not the correct answer as A is a solid at 600°C B is not the correct answer as B is a liquid at 600°C D is not the correct answer as D is a solid at 600°C		1
(b) (i)	5/five		1
(ii)	32/thirty two		1
			Total for question = 5

Question number	Answer	Notes	Marks
8 (a)	M1 graphite has delocalised electrons M2 that are able to flow throughout the structure	IGNORE sea of electrons /free electrons ACCEPT are able to move / are mobile IGNORE references to carrying charge/ current M2 dep on mention of electrons Any mention of ions in graphite scores 0 out of 2	2
(b)	M1 (diamond is hard because) it has a 3D lattice/rigid lattice /tetrahedral lattice /every carbon is bonded to four other carbons M2 (graphite is soft because) the layers can slide over one another	ALLOW 3D/ rigid/ tetrahedral structure REJECT mention of intermolecular forces in diamond IGNORE mention of intermolecular forces between layers in graphite	2
(c)	Any one from: (the C_{60} molecule/it) will not react with the blood/medicine (the C_{60} molecule/it) is non-toxic the medicine can fit inside (the C_{60} molecule)	ALLOW any acceptable answer ALLOW it is inert /unreactive	1
			Total for question = 5

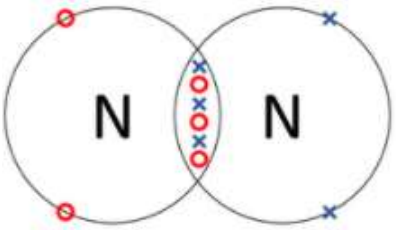
Question number	Answer	Notes	Marks
7 a	An explanation that links together the following two points: **M1** (silicon dioxide has) many/strong (covalent) bonds **M2** (therefore) a large amount of (heat/thermal) energy is required to break the bonds/ overcome the forces	**ACCEPT** strong (electrostatic) forces of attraction between the nuclei of atoms and the bonding electrons **IGNORE** more energy Any mention of intermolecular forces/forces between molecules or ions/ionic bonding /metallic bonding scores 0 out of 2	**2**
b	An explanation that links together the following two points: **M1** (graphite has) delocalised electron(s) **M2** that are able to flow (through the structure)	**IGNORE** sea of electrons **IGNORE** free electrons **ACCEPT** are able to move / are mobile **IGNORE** references to carrying charge/ current **M2** dep on mention of electrons Any mention of ions in graphite scores 0 out of 2	**2**

c	**M1** (diamond is hard because) it has a 3D lattice/rigid lattice /tetrahedral lattice /every carbon is bonded to four other carbons **M2** (graphite is soft because) the layers can slide over one another	**ALLOW** 3D/ rigid/ tetrahedral structure **REJECT** mention of intermolecular forces in diamond **IGNORE** mention of intermolecular forces between layers in graphite	**2**
		Total	**6**

Question number	Answer	Notes	Marks
9 a	**M1** C 8.05 ÷ 12 **OR** 0.671 **and** Br 53.69 ÷ 80 **OR** 0.671 **and** F 38.26 ÷ 19 **OR** 2.01 **M2** divide all numbers by 0.671 (to obtain ratio 1 : 1 : 3)	**ALLOW** ECF from **M1** If division by atomic numbers or numerators and denominators reversed 0 marks **Alternative method** **M1** M_r (of $CBrF_3$) = 149 **M2** $\frac{12}{149} \times 100 = 8.05$ (%) **and** $\frac{80}{149} \times 100 = 53.69$ (%) **and** $\frac{57}{149} \times 100 = 38.26$ (%)	**2**
b	 **M1** all four bonding pairs correct **M2** rest of electrons correct	**ACCEPT** any combination of dots and crosses **IGNORE** inner shell electrons even if incorrect **M2** DEP on **M1**	**2**

Question number	Answer	Notes	Marks
9 c	An explanation that links together the following two points: **M1** the intermolecular forces (of attraction) are weak **M2** therefore little energy is required to overcome the forces	**ACCEPT** London forces/dispersion forces/dipole-dipole forces **ALLOW** intermolecular bonds **ALLOW** little energy is required to separate the molecules **ALLOW** little energy is required to break the bonds as long as it is clear that the bonds are between molecules **IGNORE** less energy Any mention of covalent bonds/ionic bonds/metallic bonds breaking scores 0 out of 2	**2**
		Total	**6**

Question number	Answer	Notes	Marks
3 (a)	**Type of bonding** **Type of structure** (X) covalent simple molecular (Y) **M1** covalent **M2** giant (covalent)	**ALLOW** giant molecular /giant covalent lattice **ACCEPT** macromolecular	4
	(Z) **M3** ionic **M4** giant (ionic) <u>lattice</u>	**ALLOW** (ionic) lattice **IGNORE** 'giant' alone	
(b)	An explanation that links the following points **M1** (X has) weak intermolecular forces / weak forces between molecules	**ALLOW** weak intermolecular bonds / weak bonds between molecules **IGNORE** less energy	2
	M2 (so) little energy needed to overcome the forces/separate the molecules / the forces require little energy to break	**REJECT** any reference to weak covalent bonds or covalent bonds being broken or ionic bonds for both marks. **REJECT** intermolecular forces between atoms/bonds for both marks	
			Total 6

Question number	Answer	Notes	Marks
10 (a) (i)		ALLOW dots, crosses or any combination.	2
	M1 6 bonding electrons		
	M2 2 non-bonding electrons on each atom	M2 dep on M1	
(ii)	M1 shared pair(s) of electrons		2
	M2 attracted to (two) nuclei	REJECT nucleus. Must be plural for M2. M2 dep on mention of electrons in M1	
(b) (i)	diamond		1
(ii)	Any four from:		4
	M1 graphite is giant covalent	ALLOW giant structure if M2 is scored REJECT molecules of graphite	
	M2 (in melting graphite) covalent bonds are broken	ALLOW description of covalent bonds	
	M3 (C_{60}) (simple) molecular structure	ALLOW molecules of C_{60}	
	M4 (in melting C_{60}) intermolecular forces (of attraction) are overcome	ALLOW breaking bonds in C_{60} if intermolecular forces clearly mentioned M4 subsumes M3	
	M5 more energy is needed to break covalent bonds (in graphite) than intermolecular forces (in C_{60})	Mention of intermolecular forces in graphite no M2 or M5	

		Mention of breaking covalent bonds in C_{60} no M4 or M5	
			Total for question = 9 marks

Question number	Answer	Notes	Marks
6 (a)	**M1** shared pair(s) of electrons **M2** attracted to (two) nuclei	 **REJECT** nucleus. Must be plural for **M2** **M2** dep on mention of electrons in **M1**	2
(b)	a pair of electrons in each bond and no non-bonding electrons.	**ALLOW** dots, crosses or any combination	1
(c) (i)	Any one from M1 oxygen is a smaller atom/particle than silicon M2 each (atom of) oxygen forms two bonds (to silicon atoms)		1
(ii)	M1 silicon dioxide has a giant (covalent) structure M2 (in melting silicon dioxide) strong/many covalent bonds (need to be broken) M3 (in melting silicon hydride) weak intermolecular forces (of attraction need to be overcome/broken) M4 more (thermal/heat) energy is needed to break the (covalent) bonds (in SiO_2) than break/overcome the intermolecular forces (in SiH_4)	 **ALLOW** description of covalent bonds as long as strong/many mentioned **ALLOW** weak intermolecular bonds Max 2 if contradictions/references to incorrect forces/particles	4
(d)	$SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$ all formula correct and equation correctly balanced	 **IGNORE** state symbols **ALLOW** multiples and fractions	1

Total for question 6 = 9 marks

Question number	Answer	Notes	Marks
8 (a)	**M1** (electrostatic) attraction between (two) nuclei **M2** and shared/bonding pair(s) of electrons **OR** **M1** (electrostatic) attraction between shared/bonding pair(s) of electrons **M2** and (two) nuclei	nuclei must be plural ALLOW nucleus of both/two atoms nuclei must be plural	2
(b)	An explanation that links the following three points **M1** diamond is a giant covalent structure/giant lattice structure **M2** there are (many) strong covalent bonds (which need to be broken) **M3** large amount of (heat/thermal) energy needed to break the covalent bonds	 IGNORE giant molecule **IGNORE** more energy no **M2** or **M3** if reference to intermolecular forces/ions in diamond	3
(c)	An explanation that links the following two points **M1** (graphite has) delocalised electrons **M2** (electrons) are mobile/move/flow	 Ignore free electrons **M2** dep on mention of electrons Ignore carry charge 0 marks if reference to ions in graphite or atoms moving	2
(d)	**M1** (number of atoms =) $60 \times 6.0 \times 10^{23}$ **M2** 3.6×10^{25}	correct answer without working scores 2 answer must be in correct standard form to 1 decimal place	2
			Total 9

Question number	Answer	Notes	Marks
8 (a)	An explanation that links the following three points **M1** covalent bonds are strong **M2** many (covalent) bonds (need to be broken) **M3** a large amount of (heat/thermal) energy is needed to break the bonds	 **ACCEPT** strong (electrostatic) forces between the shared pair of electrons and nuclei **IGNORE** more energy NOT just heat Any mention of intermolecular forces/forces between molecules or ions/ionic bonding/metallic bonding scores 0 out of 3	3
(b)	An explanation that links six of the following points but must include **M3** and **M7** for full marks **M1** carbon atoms are joined together by covalent bonds **M2** (structure is) in layers /in a 2D structure **M3** (layers) can slide over each other (therefore it is soft) **M4** (because there are) weak forces between layers **M5** each carbon atom is bonded to three others (carbons) **M6** there are delocalised electrons (between the layers) **M7** electrons are free to move (therefore they can conduct electricity)	 ACCEPT sheets If reference to weak intermolecular forces or layers of molecules then no **M4** **IGNORE** free/spare electron/unbonded **IGNORE** reference to can carrying a charge/current	6 **Total 9**

Question number	Answer	Notes	Marks
8 (a)	**M1** diamond has a tetrahedral (structure) **OR** in diamond each (carbon) atom is (covalently) bonded to 4 other (carbon) atoms **M2** graphite has a hexagonal (structure) / has layers **OR** in graphite each (carbon) atom is (covalently) bonded to 3 other (carbon) atoms **M3** diamond does not conduct electricity **OR** graphite conducts electricity **M4** diamond has no delocalised electrons **OR** graphite has delocalised electrons **M5** diamond is hard **OR** graphite is soft **M6** in diamond the strong (C-C) bonds need to be broken **OR** in graphite the layers can slide over each other **OR** graphite has weak forces between layers	**REJECT** ions / metallic once in **M1** or **M2** **REJECT** diamond is soft / graphite is hard **REJECT** reference to intermolecular	6
(b)	An explanation that links the following four points: **M1** C_{60} fullerene has weak forces between the molecules /weak intermolecular forces **M2** little / less energy needed to break / overcome the forces /separate the molecules **M3** diamond and graphite have many / strong (covalent) bonds (between atoms) **M4** large amount of /more energy needed to break /overcome the (covalent) bonds	no **M1** or **M2** if reference to breaking bonds in fullerene no **M3** or **M4** if reference to intermolecular forces in diamond and graphite If **M1** and **M3** are not scored allow 1 mark for covalent bonds (in diamond and graphite) need to be broken / overcome **AND** intermolecular forces need to be broken / overcome in fullerene	4 **Total 10**

Question number	Answer	Notes	Marks
9 (a)	M1 (electrostatic) attraction between nuclei M2 and shared pair(s) of electrons OR M1 (electrostatic) attraction between shared pair(s) of electrons M2 and nuclei	must be plural must be plural	2
(b)	An explanation that links any 3 from M1 the boiling points increase (down the group/from F to Br) M2 because the intermolecular forces get stronger M3 as (molecular) mass / size / number of electrons /(electron) shells increases M4 so more energy needed to separate the molecules/break the intermolecular forces	 No M2, M3 or M4 if any mention of breaking covalent/ionic bonds	3
(c)	An explanation that links any five from M1 the structure is in layers M2 there are weak forces between the layers (of atoms) M3 which can slide (over one another making it soft) M4 each carbon / atom makes three covalent bonds M5 (one) delocalised electron (per carbon / atom) M6 (delocalised) electrons flow / move / are mobile (to conduct electricity)	 ALLOW sheets /rows REJECT intermolecular forces/molecules/ions REJECT ionic bonds REJECT molecules/ions	5
			Total for question = 10

Question number	Answer	Notes	Marks
9 (a)	An explanation linking the following three points		3
	M1 covalent bonds are strong	**ACCEPT** strong (electrostatic) forces of attraction between the nuclei of atoms and the bonding electrons	
	M2 many (covalent) bonds (need to be broken)		
	M3 a large amount of (thermal/heat) energy is needed to break the bonds	**IGNORE** more energy **NOT** just heat Any mention of intermolecular forces/forces between molecules or ions/ionic bonding /metallic bonding scores 0 out of 3	

(b)	(i)	An explanation linking the following two points **M1** the intermolecular forces (of attraction) are weak **M2** therefore little/less (thermal/heat) energy needed to overcome the forces (of attraction)	 **ACCEPT** London forces/dispersion forces/dipole-dipole forces/Van der Waals forces **ALLOW** the attractions between the molecules are weak **ALLOW** weak intermolecular bonds **NOT** just heat **ALLOW** little/less energy needed to separate the (fullerene) molecules **ALLOW** little/less energy is required to break the bonds as long as it is clear that the bonds are between molecules Any mention of (breaking of) covalent/ionic/metallic bonds scores 0 out of 2	2
	(ii)	Any one from the medicine can fit inside (the C_{60} molecule/it) (C_{60} molecule/it) will not react with the blood/medicine (C_{60} molecule/it) is non-toxic	 **ALLOW** any other sensible suggestion eg C_{60} molecule/it is inert/unreactive	1

(c)	An explanation linking any **five** of the following six points but must include **M3** and **M6** for full marks (graphite is soft because) **M1** the structure is in layers **M2** there are weak forces/attractions between the layers (of atoms) **M3** layers can slide/slip over each other (graphite conducts electricity because) **M4** each carbon atom is (covalently) bonded to three other carbon atoms **M5** one delocalised electron per carbon atom **M6** delocalised electrons flow/move (through the structure)	If reference to weak intermolecular forces or layers of molecules/ions no **M2** **ALLOW** air /water (molecules) trapped between the layers **ALLOW** layers can easily flake off **M2 / M3** can subsume **M1** **ALLOW** one unbonded/free/spare electron per carbon atom **ALLOW** (only) three (of the carbon) electrons involved in (covalent) bonding **ALLOW** not all (of the carbon) electrons involved in (covalent) bonding **ALLOW** are mobile **IGNORE** free electrons **IGNORE** sea of electrons **IGNORE** references to carrying charge/current To score M6 the term delocalised electrons must be seen somewhere If reference to ions for conduction of electricity no **M4 M5 M6**	5 **Total 11**

Question number	Answer	Notes	Marks
8 (a) (i)	sublimation / subliming		1
(ii)	**M1** (add to/bubble into) limewater		2
	M2 (limewater) turns cloudy/milky	**ACCEPT** forms white precipitate M2 DEP M1	
(b)	An explanation that links the following two points		
	M1 weak forces (of attraction) between molecules / weak intermolecular forces (of attraction)	**ALLOW** weak intermolecular bonds **ALLOW** weak intermolecular attractions	
	M2 little energy needed to overcome the (intermolecular) forces	**IGNORE** less energy **ALLOW** little energy needed to separate the molecules **M2** DEP **M1** correct or missing	2

(c)	Any explanation that links any **three** of the following points for diamond		6
	M1 each (carbon) atom is (covalently) bonded to four other (carbon) atoms	**ALLOW** each carbon has four bonds	
	M2 in a (giant) tetrahedral lattice /network / structure	**ALLOW** 3D/rigid in place of tetrahedral	
	M3 the (covalent) bonds are (very) strong	**ALLOW** reference to lot of energy needed to break the (covalent) bonds **ALLOW** there are lots of/many (covalent) bonds	
	M4 (therefore) diamond is (very) hard (and so good for cutting tools)	**ALLOW** diamond is (very) strong If mention of intermolecular forces in diamond MAX 2 for diamond If mention of ions in diamond only M4 can be scored	
	Any explanation that links any **three** of the following points for graphite		
	M5 each (carbon) atom is (covalently) bonded to three other (carbon) atoms		
	M6 (the structure is) in layers	**ALLOW** sheets	
	M7 weak forces (between layers)		
	M8 (the layers can) slide over each other/ rub off		
	M9 this makes graphite soft (so it can make marks on paper)	**ALLOW** slippery If mention of intermolecular forces in graphite MAX 2 for graphite If mention of ions in graphite only M9 can be scored	
			Total 11

Question number	Answer	Notes	Marks
10 (a) (i)	**M1** four electrons between the carbon and each oxygen **M2** rest of molecule correct	 **M2** dep on **M1**	2
(ii)	**M1** shared pair(s) of electrons **M2** attracted to (two) nuclei	 **REJECT** nucleus. Must be plural for **M2.** **M2** dep on mention of electrons in **M1**	2
(b) (i)	**M1** Graphite has delocalised electrons **M2** (delocalised electron(s)) can move or flow (throughout the structure)	**IGNORE** sea of electrons **IGNORE** free electrons **IGNORE** number of electrons **IGNORE** references to carrying a charge or current **IGNORE** references to layers **M2** dep on mentioning electrons in **M1** Any mention of ions scores 0	2
(ii)	**M1** (diamond) giant covalent **M2** (in melting diamond) covalent bonds are broken **M3** (C_{60}) (simple) molecular structure **M4** (in melting C_{60}) intermolecular forces (of attraction) are overcome **M5** more energy is needed to break covalent bonds (in diamond) than intermolecular forces (in C_{60})	**ALLOW** macromolecular **ALLOW** giant structure if M2 is scored **IGNORE** tetrahedral structure **REJECT** molecules of diamond **ALLOW** description of covalent bonds **ALLOW** molecules of C_{60} **ALLOW** strong covalent bonds and weak intermolecular forces (or attraction)	5

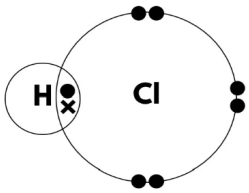
			ACCEPT breaking bonds in C_{60} if intermolecular forces clearly mentioned Mention of intermolecular forces in diamond no **M2** or **M5** Mention of breaking covalent bonds in C_{60} no **M4** or **M5**		

Question number	Answer	Notes	Marks
5 (a) (i)	6/six		1
(ii)	One of the following two points methanol/it) does not contain only carbon and hydrogen OR (methanol/it) contains (an atom of) oxygen		1
(b) (i)	**M1** two/ pair of electrons **M2** shared between two atoms	**ACCEPT (electrons)** attracted to the nuclei (of the two atoms in the bond) **ACCEPT** **M1** (electrostatic) attraction between two nuclei **M2** (and the) shared pair(s) of electrons (between them)	2
(ii)	**M1** 4 pairs of electrons around central carbon atom, with one pair to O and 3 pairs to H **M2** rest of molecule fully correct	**ALLOW** any combination of dots and crosses **M2** DEP on **M1**	2

Question number	Answer	Notes	Marks
5 (c) (i)	• Divide percentages by relative atomic masses • Divide results by smallest value to obtain ratio • Write empirical formula Example calculation **M1** C: $\frac{38.7}{12}$ H: $\frac{9.7}{1}$ O: $\frac{51.6}{16}$ **M2** $\frac{3.225}{(3.225)}$ $\frac{9.7}{(3.225)}$ $\frac{3.225}{(3.225)}$ **OR** 1 3 1 **M3** CH_3O	0 marks if division by atomic numbers or upside-down calculation **M2** subsumes **M1** **ACCEPT** symbols in any order	3
(ii)	• Divide relative molecular mass by empirical formula mass • Write molecular formula Example calculation **M1** $\frac{62}{12 + 3 + 16}$ **OR** $\frac{62}{31}$ (= 2) **M2** $C_2H_6O_2$	**ACCEPT** symbols in any order Correct answer without working scores 2 marks	2
			Total 11

Question number	Answer	Notes	Marks
5 (a) (i)	5/five		1
(ii)	46		1
(iii)	**M1** hydrocarbons contain only carbon and hydrogen (atoms) **M2** methanoic acid/it contains oxygen (as well as hydrogen and carbon)	REJECT molecules	2
(b) (i)	**M1** (electrostatic) attraction between nuclei **M2** (and the) shared pair of electrons OR M1 (electrostatic) attraction between shared pair(s) of electrons M2 and nuclei	Must be plural Must be plural	2
(ii)	**M1** 3 pairs of electrons for 3 single bonds **M2** 2 shared pairs for one C=O double bond **M3** rest of molecule fully correct (lone pairs on oxygen atoms must be shown)	**ALLOW** any combination of dots and crosses **M3** dep on **M1** and **M2** correct	3
(c)	• divide percentages by relative atomic masses • divide results by smallest value to obtain ratio • write empirical formula Example calculation **M1** C: $\frac{52.2}{12}$ H: $\frac{13.0}{1}$ O: $\frac{34.8}{16}$ **M2** $\frac{4.35}{2.175}$ $\frac{13.0}{2.175}$ $\frac{2.175}{2.175}$ **OR** 2 6 1 **M3** C_2H_6O	0 marks if division by atomic numbers or upside-down calculation **ACCEPT** symbols in any order	3
			Total 12

Question number	Answer	Notes	Marks
11 (a)	has only one type of atom	ACCEPT only made up of carbon atoms	1
(b)	M1 (attraction between) a shared pair of electrons M2 and nuclei OR M1 a shared pair of electrons M2 and (attraction between) nuclei	 do not accept nucleus nuclei must be plural do not accept nucleus nuclei must be plural	2
(c) (i)	M1 delocalised electrons M2 (electrons) can move / flow (throughout the structure)	No marks if mention of ions / molecules in graphite	2
(ii)	M1 (diamond is hard because) it has a 3D lattice/rigid lattice /tetrahedral lattice /every carbon is bonded to four other carbons M2 in diamond, the bonds need a lot of energy to break M3 (graphite is soft because) it has layers M4 which can slide over one another	ALLOW 3D/ rigid/ tetrahedral structure REJECT mention of intermolecular forces in diamond for M1 and M2 ALLOW sheets IGNORE intermolecular forces in graphite M4 dep on M3	4
(d)	M1 calculation M_r of C_x M2 $M_r \div 12$ M3 answer given as an integer exemplar M1 $1.40 \times 10^{-21} \times 6.02 \times 10^{23}$ OR 842.8 M2 842.8 ÷ 12 (= 70.23) M3 70	 ALLOW any number of significant figures from 2 ALLOW ECF if division by atomic number 6 Answer of 70 without working scores 3	3
			total for question = 12

Question number	Answer	Notes	Marks
8 (a)	M1 attraction between nuclei M2 and shared pair(s) of electrons OR M1 attraction between shared pair(s) of electrons M2 and nuclei	nucleus must be plural nucleus must be plural REJECT intermolecular forces for both marks	2
(b) (i)	 M1 one shared pair of electrons M2 rest of the molecule correct	ALLOW any combination of dots and crosses ALLOW any inner shells of chlorine as long as they are correct	2
(ii)	M1 intermolecular forces of attraction are weak M2 which require little energy to overcome	ALLOW weak forces between molecules M2 dep on M1 do not allow **less** energy	2
(c) (i)	any one from: oxygen/it is a smaller atom than silicon oxygen/it has two shells, silicon has three shells each silicon atom is bonded to four oxygen atoms each oxygen atom is bonded to two silicon atoms		1
(ii)	silicon dioxide/SiO_2 is acidic and calcium oxide/CaO is basic	ALLOW an acid base reaction ALLOW one is an acid, one is a base REJECT calcium oxide is an alkali	1

			5
(iii)	an explanation linking any 5 of the following points: NB do not credit high melting point as in the question M1 giant (covalent) structure / lattice M2 covalent bonds are **strong** M3 which requires a lot of energy to break the (covalent) bonds M4 3D / tetrahedral structure M5 every silicon atom makes 4 bonds / 4 pairs of electrons shared M6 no layers / atoms cannot slide over each other	ALLOW **strong** attraction between shared pairs of electrons and nuclei M3 being dep on covalent do not allow **more** energy Lose 1 mark if they mention intermolecular forces or ionic bonding	
			Total = 13

Question number	Answer	Additional guidance	Marks
4 (a)	**C** (electrostatic attraction between positively charged particles and delocalised electrons) is correct as it describes metallic bonding A is incorrect since it describes ionic bonding not metallic bonding B is incorrect since it describes covalent bonding not metallic bonding D is incorrect since it describes interatomic or intermolecular forces not metallic bonding		1
(b)	Any two from the following: **M1** good conductor of heat/thermal energy **M2** does not react with food/affect flavour of food **M3** resistant to corrosion **M4** high melting point **M5** low density/lightweight/strong	 **IGNORE** non-toxic **ALLOW** does not corrode/rust **IGNORE** unreactive/inert **IGNORE** references to recycling **IGNORE** light	2

Question number	Answer	Additional guidance	Marks
4 (c) (i)	a mixture of (two or more) elements, one of which is a metal	**ACCEPT** a mixture of (two or more) metals **ALLOW** combination for mixture **REJECT** compound or references to chemical bonding	1
(ii)	An explanation that links together the following three points:		
	M1 the regular arrangement of atoms is distorted/disrupted OWTTE	**ALLOW** lattice/layers/rows of atoms are disrupted/distorted **ALLOW** lattice/layers/rows of atoms less regular	3
	M2 because magnesium atoms are larger than aluminium atoms	**ALLOW** magnesium and aluminium atoms are of different sizes	
	M3 and therefore it is more difficult for the layers to slide over one another	**ALLOW** layers cannot (as easily) slide over one another **IGNORE** references to strength of metallic bonds	
		Total	**7**

Question number	Answer	Notes	Marks
5 (a)	M1 electrolysis M2 as sodium is more reactive than carbon	REJECT electrolysis of an aqueous solution ALLOW it is above carbon in the reactivity series ALLOW carbon cannot displace sodium M2 dependent on M1	2
(b)	M1 layers / rows (of atoms, ions or particles) M2 can slide over one another	REJECT if mention of molecules or intermolecular forces for M1 REJECT electrons sliding for M2	2
(c)	M1 sodium loses electrons and oxygen gains electrons M2 two atoms of sodium lose one electron and oxygen gains 2 electrons	ACCEPT correctly labelled diagrams Mention of sharing electrons scores 0	2
(d)	Sodium: M1 (giant) metallic structure/lattice M2 (electrostatic) attraction between positive ions and delocalised electrons Sodium oxide: M3 giant ionic structure OR (giant) ionic lattice M4 (electrostatic) attraction between oppositely charged ions Comparison: M5 more energy is required to overcome the bonds in sodium oxide than sodium ORA	 REJECT Intermolecular forces for M1 and M2 REJECT Intermolecular forces/covalent/metallic for M3 and M4 M5 is comparative mark that is independent of M1-M4	5
			Total = 11

Question number	Answer	Notes	Marks
3 (a) (i)	M1 (positive) ion/cation M2 (delocalised) electron	ALLOW atom REJECT proton for M1	2
(ii)	M1 layers (of atoms / ions) M2 (atoms/ions) can slide over one another	ALLOW particles REJECT references to intermolecular forces	2
(b) (i)	$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ M1 balancing M2 state symbols	 ALLOW multiples or fractions – O_2 must also be changed to score.	2
(ii)	magnesium gains oxygen	ALLOW magnesium loses electrons IGNORE magnesium reacts with oxygen	1
(c) (i)	to increase the rate of reaction OWTTE		1
(ii)	to ensure all the acid has reacted/neutralise the acid OWTTE		1
(iii)	M1 amount of HCl = (25 × 2) ÷ 1000 OR 0.050 (mol) M2 amount of magnesium = 0.050 ÷ 2 OR 0.025 (mol) M3 0.025 × 24 = 0.60 g/0.6 g	 ALLOW ecf M1 ÷ 2 ALLOW ecf M2 × 24 Answer of 0.60 g without working scores 3 Answer of 1.20 g with working scores 2	3
			Total marks for question 3 = 12

Question number	Answer	Notes	Marks
4 (a)	**M1** layers of atoms/positive ions **M2** can slide over one another	**IGNORE** layers unqualified **REJECT** layers of molecules **M2** DEP on mention of layers/atoms/ions in **M1**	2
4 (b) (i)	ions cannot move	**ALLOW** ions are in fixed positions/in a lattice **IGNORE** no free ions **REJECT** any reference to electrons	1
(ii)	$2Br^- \rightarrow Br_2 + 2e^-$		1
(iii)	**M1** lead ions (are positive and) are attracted to the negative electrode / Pb^{2+} (ions) are attracted to the negative electrode **M2** lead ions gain electrons / Pb^{2+} (ions) gain electrons (to form lead)	**ALLOW** cathode for negative electrode **ALLOW** a correct half equation for M2 **IGNORE** references to redox ALLOW lead ions get discharged (to form lead)	2
(iv)	metal or lead connects the electrodes or completes the circuit OWTTE	**ALLOW** metal or lead conducts electricity ALLOW metal or lead allows electrons to flow	1

Question number	Answer	Notes	Marks
5 (a)	**M1** add sodium hydroxide (to the copper(II) sulfate solution) **M2** blue precipitate (forms) **OR** **M1** flame test **M2** blue-green (flame)	**ALLOW** potassium hydroxide or aqueous ammonia No **M1** if any incorrect reagent added **IGNORE** qualifiers e.g. pale / dark etc. **M2** dep on addition of a correct alkali **ACCEPT** description of flame test **ALLOW** green **M2** dep on flame	2
(b)	An description that refers to any three from **M1** copper ions are positively charged / cations / Cu^{2+} (ions) **M2** and are attracted to / travel to the negative electrode / cathode **M3** where they accept electrons **M4** and become (copper) <u>atoms</u>	 **ALLOW M1** and **M3** for a fully correct half equation i.e. $Cu^{2+} + 2e \rightarrow Cu$	3
(c)	pink solid / deposit / coating / metal	**ACCEPT** pink-brown / orange-brown / brown / orange / red-brown **REJECT** red **REJECT** precipitate	1
(d) (i)	relights a glowing splint		1
(ii)	$2H_2O \rightarrow 4H^+ + O_2 + 4e^{(-)}$ **M1** $O_2 + e^{(-)}$ **M2** equation fully correct	$4OH^- \rightarrow 2H_2O + O_2 + 4e^{(-)}$ scores 1 **IGNORE** state symbols even if incorrect **IGNORE** any numbers in front of $O_2 + e^{(-)}$ and any other species	2
(iii)	electrons are lost	**ALLOW** H_2O / water loses electrons	1
			Total 10

Question number	Answer	Notes	Marks
3 (a)	An explanation that links the following two points **M1 e**lectrons are delocalised **M2** (electrons) can move/can flow/are mobile	 **IGNORE** sea of electrons /free electrons **REJECT** cations/atoms move for both marks **M2** dep on **M1** or mention of electrons i.e. 'electrons move' scores 1 mark	2
(b) (i)	**M1** brown/pink/pink-brown solid formed **M2** bubbles/fizzing/effervescence	**ACCEPT** brown/pink coating/deposit on the electrode **ALLOW** red-brown **REJECT** orange **REJECT** precipitate **ALLOW** 1 mark if both observations correct but at incorrect electrodes **IGNORE** gas produced /evolved/released **IGNORE** name of gas	2
(ii)	copper **ion(s)**/Cu^{2+} gains electrons	**ACCEPT** oxidation state of copper goes down / goes from +2 to 0 **IGNORE** references to loss of oxygen **ALLOW** electrons are gained **REJECT** copper/Cu gains electrons	1
(iii)	An explanation that links the following two points **M1** the (blue) colour is caused by copper **ions**/Cu^{2+} **M2** copper ions/Cu^{2+} are being discharged/ removed from the solution	 **ACCEPT** concentration of copper ions/Cu^{2+} decreases **ALLOW** copper ions/Cu^{2+} form copper	2

Question number	Answer	Notes	Marks
3 (c)	• calculate the mass of water removed • calculate the amount, in moles, of $CuSO_4$ • calculate the amount, in moles, of water • divide amount of H_2O by amount of $CuSO_4$ Example calculation **M1** (12.5 – 8.0) = 4.5 (g) **M2** $n(CuSO_4)$ = 8.0 ÷ 159.5 = 0.05(0) (mol) **M3** $n(H_2O)$ = 4.5 ÷ 18 = 0.25 (mol) **M4** 0.25 ÷ 0.05(0) (= 5)	**ACCEPT** alternative methods which show that the answer is 5	4 **Total 11**

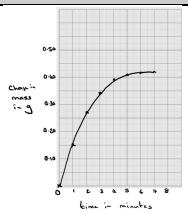
Question number	Answer	Notes	Marks
4 (a)	**M1** bright/white light **OR** bright/white flame **M2** white powder/solid/ash	 **ALLOW** white smoke **ALLOW** grey powder /solid/ash **REJECT** white precipitate	2
(b)	A description that refers to the following two points **M1** magnesium/Mg loses two electrons/becomes 2.8 **M2** oxygen/O gains two electrons/becomes 2.8	 **ACCEPT** magnesium gives two electrons to oxygen for **M1** and **M2** Both marks can be scored from diagrams showing correct electronic configurations of the ions.	2
(c) (i)	magnesium is more reactive/higher in the reactivity series (than carbon)/magnesium is a better reducing agent (than carbon) ORA	**ALLOW** carbon cannot displace magnesium	1
(ii)	An explanation that links the following four points **M1** (magnesium) has delocalised electrons **M2** electrons can move **M3** (magnesium chloride) can only conduct when molten/in solution **OR** (magnesium chloride) cannot conduct when solid **M4** ions are free to move	 **REJECT** reference to ions or atoms moving for **M2** ions are free to move when (magnesium chloride) is molten/in solution scores **M3** and **M4** **REJECT** reference to electrons moving for **M4**	4
(d) (i)	magnesium ions/ Mg^{2+} gains electrons	**ALLOW** electrons are gained **REJECT** magnesium /Mg gains electrons **REJECT** reference to loss or gain of oxygen	1
(ii)	$2Cl^- \rightarrow Cl_2 + 2e^{(-)}$	**ALLOW** $2Cl^- - 2e^{(-)} \rightarrow Cl_2$ **ALLOW** multiples or fractions **IGNORE** state symbols even if incorrect	1
			Total 11

Question number	Answer	Notes	Marks
4 (a)	An explanation of properties that includes five of the following points **M1** conducts electricity **M2** (because the) delocalised electrons can move/flow (through structure) **M3** malleable/ductile **M4** (because) layers of cations/atoms **M5** layers/cations/atoms can slide/slip/move over each other **M6** high melting point **M7** (because) strong (electrostatic) attraction between cations and delocalised electrons	reason must be linked to correct property IGNORE references to cost/reactivity/hardness/ strength/shiny If any mention of ions/atoms moving cannot score M2 ALLOW explanations of malleable/ductile ALLOW sheets/rows IGNORE high boiling point ALLOW giant metallic lattice/strong bonds between cations and delocalised electrons /strong metallic bonds **Max 4** if any mention of intermolecular forces/covalent/ionic bonding	5
(b) (i)	copper ion Cu^{2+} sulfate ion SO_4^{2-}	ALLOW Cu^{+2} SO_4^{-2}	1
(ii)	effervescence/bubbles/fizzing	IGNORE oxygen/gas	1
(iii)	relights a glowing splint		1
(iv)	$2H_2O \rightarrow O_2 + 4H^+ + 4e^{(-)}$ OR $4OH^- \rightarrow O_2 + 2H_2O + 4e^{(-)}$ **M1** all formulae correct **M2** balancing of correct formulae		2

(v)	(OH^- ions/they) are present in/come from water OWTTE	ACCEPT (some) water molecules dissociate to give OH^- ions OWTTE ALLOW because copper sulfate solution/it contains water/is aqueous REJECT because copper sulfate/solution is alkaline	**Total 11**

Question number	Answer	Notes	Marks
5 (a)	M1 <u>layers / rows</u> of atoms / (positive) ions M2 can slide over one another	REJECT molecules IGNORE refs to electrons	2
(b) (i)	M1 ions M2 can move	REJECT electrons M2 dep on ions in M1	2
(ii)	M1 positive sodium **ions** / cations / Na^+ (ions) are attracted (to the negative electrode) M2 where they gain electrons OR where they are reduced	ALLOW move REJECT atoms / metal ALLOW balanced ionic equation ($Na^+ + e \rightarrow Na$)	2
(iii)	$2Cl^- \rightarrow Cl_2 + 2e^-$	ALLOW $2Cl^- - 2e^- \rightarrow Cl_2$	1
(iv)	sodium is more reactive (than hydrogen) / higher in the reactivity series (than hydrogen)	ALLOW (in aqueous solution) hydrogen ions are discharged / hydrogen is produced	1
(c)	M1 mass of copper = 3.81g and mass of oxygen = 0.96g M2 moles of copper = 0.06 and moles of oxygen = 0.06 M3 ratio = 1:1	 M2 allow ECF from M1 but only if A_r for copper and oxygen are used M3 dep on M1 and M2 but must be 1:1 ratio IF A_r is divided by mass, then M1 only scores	3
			Total for question = 11

Question number	Answer	Notes	Marks
6 (a) (i)	platinum	ALLOW silver / gold / graphite	1
(ii)	glowing splint relights		1
(iii)	lit splint (with a squeaky) pop		1
(iv)	$2H^+ + 2e^- \rightarrow H_2$		1
(v)	0.0237 g	correct answer (to 3 sig figs) without working scores 3	3
	M1 (moles of oxygen) 17.80 ÷ 24 000 OR 0.000742		
	M2 M_r of oxygen = 32		
	M3 0.0237 g	ALLOW ecf from M1 and M2 answer must be to 3 sig figs for M3	
(b) (i)	ions can move/are mobile OWTTE		1
(ii)	Hydrogen/it is less reactive than sodium ORA	ALLOW H^+ ions are more easily reduced / accept electrons more easily than Na^+ ions ALLOW hydrogen is below sodium in the reactivity series	1
(iii)	M1 the universal indicator turns blue / purple		2
	M2 OH^- / hydroxide ions are present in solution	ALLOW solution is sodium hydroxide ALLOW the solution is alkaline	
			Total marks for question 6 = 11

Question number	Answer	Notes	Marks
6 (a) (i)	all points plotted ± half a square		1
(ii)	curved line of best fit		1
(iii)	An explanation that links the following two points M1 curve shows increasing mass (of negative electrode) because (more) copper deposits/forms M2 line becomes horizontal because there are no more copper(II) ions left in the solution/ all the copper has been deposited/formed OWTTE	 ALLOW line becomes horizontal as there is no copper sulfate solution left	2
(b) (i)	A description that refers to two of the following points M1 fill a test tube/measuring cylinder with copper sulfate solution M2 place the tube over the positive electrode M3 collect gas/oxygen by displacement of solution/water	 ALLOW fill a test tube/ measuring cylinder with water	2
(ii)	$2H_2O \rightarrow O_2 + 4H^+ + 4e^{(-)}$ M1 all formulae correct M2 correct balancing of correct formulae **OR** $4OH^- \rightarrow O_2 + 2H_2O + 4e^{(-)}$ M1 all formulae correct M2 correct balancing of correct formulae	 M2 dep on M1 M2 dep on M1	2
(c) (i)	M1 layers (of atoms or ions) M2 can slide over one another	ALLOW sheets/rows M2 dep on M1 ALLOW atoms/ions slide over each other for M2	2
(ii)	M1 delocalised electrons M2 are free to move (throughout the structure)	IGNORE sea of electrons /free electrons M2 dep on mention of electrons in M1 0 marks if reference to ions moving	2
			Total for question = 12

Question number	$_3$Answer	Notes	Marks
6 (a)	A description that refers to the following three points **M1** filter **M2** wash the precipitate/solid/lead(II) bromide /residue (with distilled water) **M3** dry with filter paper/in a (warm) oven	 **ALLOW** leave to dry or any other suitable method **REJECT** direct heating e.g. with a Bunsen burner If description relates to preparation of a soluble salt allow 1 mark only for **M3** for a suitable method of drying the solid	3
(b)	**M1** solid lead(II) bromide does not conduct electricity **M2** because ions cannot move/are in fixed positions	**ALLOW** lead(II) bromide only conducts when molten **ALLOW** when lead(II) bromide is solid no electricity/current flow(s) through the circuit/lamp **REJECT** reference to (delocalised) electrons /atoms cannot move in solid	2

Question number	Answer	Notes	Marks
6 (c) (i)	brown vapour/gas/fumes (of bromine)	**ALLOW** orange/orange-brown	1
(ii)	An explanation that links the following four points	Penalise incorrect use of ide/ine once only	4
	M1 bromide ions are negatively charged / Br^-	**ALLOW** bromide ions are anions	
	M2 (so bromide ions/they) are attracted to the positive electrode	**ALLOW** anode	
	M3 (at the positive electrode) bromide ions/they lose/give up electron(s) (to form bromine atoms)	**ALLOW** bromide ions are oxidised **ALLOW** $Br^- \rightarrow Br + e^{(-)}$	
	M4 (bromine atoms) join in pairs to form bromine molecules/Br_2 OWTTE	**ALLOW** $Br + Br \rightarrow Br_2$ $2Br^- \rightarrow Br_2 + 2e^{(-)}$ scores **M1 M3** and **M4**	
(d)	$Pb^{2+}(l) + 2e^{(-)} \rightarrow Pb(s)$ **M1** formulae and balancing correct **M2** both state symbols correct	**ALLOW** Pb(l) **ALLOW** multiples and fractions **ALLOW M2** ECF if charge on lead ion and/or balancing are incorrect	2
			Total 12

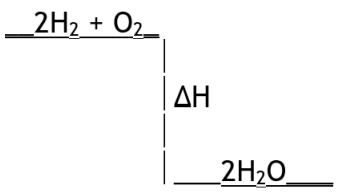
Question number			Answer	Notes	Marks
3	(a)		Explanation including the following points: (metals) M1 contain delocalised electrons M2 (which) move/flow/are mobile/are free to move (through the metal structure) and two from (covalent compounds) M3 contain neutral molecules / molecules with no overall charge M4 electrons held (tightly) in covalent bonds (so) M5 no electrons free to move (so do not conduct)	IGNORE free electrons/sea of electrons M2 dependent on mention of electrons If any mention of ions/atoms moving cannot score M1 M2 ALLOW do not contain ions ALLOW there are no delocalised electrons If state ions present cannot score M3 M4 M5	4
	(b)		ion(s)	ALLOW hydrogen ion/H^+ ALLOW chloride ion/Cl^-	1
	(c)	(i)	all points plotted correctly (within half a small square)		1
		(ii)	point at (0.4, 25) circled		1
		(iii)	straight line of best fit through origin drawn with ruler		1
		(iv)	explanation linking M1 the volume/reading is less than expected M2 because the current was less than 0.4A / some gas escaped/ there was a leak	ALLOW reading taken before 5 minutes	2
		(v)	the greater the current the greater the volume (of gas)	ACCEPT directly proportional ACCEPT positive correlation	1

Question number	Answer	Notes	Marks
3 (d) (i)	(transfer of two/same number of electrons produces) one mole of chlorine/Cl_2 and one mole of hydrogen/H_2	ALLOW same number of moles of chlorine/Cl_2 and hydrogen/H_2 ALLOW molecules for moles	1
(ii)	chlorine dissolves/soluble in acid/solution	ALLOW dissolves/soluble in water	1
			(Total for Question 3 = 13)

Question number	Answer	Notes	Marks
6 (a) (i)	(squeaky) pop with lighted splint		1
(ii)	**M1** (damp) litmus paper/ universal indicator **M2** bleached	 **ACCEPT** turns white OR decolourised **ACCEPT** (damp) blue litmus turns red and is bleached scores **M1** and **M2**	2
(b) (i)	chloride ions/Cl^- lose electrons /electrons are lost	**ALLOW** oxidation state of chlorine increases /changes from -1 to 0 **REJECT** chlorine loses electrons **REJECT** reference to gain of oxygen	1
(ii)	$2H^+ + 2e^{(-)} \rightarrow H_2$		1
(iii)	chlorine is toxic/poisonous		1
(iv)	(some) chlorine dissolves (in the solution)	**ALLOW** chlorine dissolves in water	1

Question number	Answer	Notes	Marks
6 (c) (i)	An explanation that links two of the following points **M1** in solid sodium chloride the ions are not free to move/are in fixed positions **M2** in molten sodium chloride the ions are mobile **M3** ions/charged particles need to move for current (to flow) / to conduct electricity	No **marks** if reference to mobile electrons	2
(ii)	• calculate the amount, in moles, of NaCl • determine the amount, in moles, of Cl_2 • calculate the volume of Cl_2 • give the final answer in standard form Example calculation **M1** $\frac{23\,400\,000}{58.5}$ **OR** 400 000 **M2** $\frac{400\,000}{2}$ **OR** 200 000 **M3** 200 000 x 24 **OR** 4 800 000 (dm^3) **M4** 4.8×10^6 (dm^3)	**OR** $\frac{\text{answer to } \mathbf{M1}}{2}$ **OR** answer to **M2** x 24 **OR** answer to **M3** in standard form correct answer in standard form without working scores 4 4 800 000 without working scores 3 9.6×10^6 and 1.92×10^7 score 3 9 600 000 and 19 200 000 score 2 **M4** can be awarded for an answer in standard form as long as some working is shown	4 **Total 13**

Question number	Answer	Notes	Marks
7 (a)	An explanation that links the two points **M1** in solid sodium chloride ions are in a fixed position/in a lattice/cannot move **M2** when molten or in solution ions are free to move/flow	No marks if reference to electrons moving	2
(b) (i)	$2H_2O \rightarrow 4H^+ + (1)O_2 + 4e^-$	**ALLOW** multiples and fractions **IGNORE** state symbols even if incorrect	1
(ii)	chloride (ions)/(2)Cl^-/it lose electrons	**ALLOW** electrons are lost **REJECT** chlorine loses electrons	1
(c) (i)	(squeaky) pop with lighted splint	**REJECT** glowing splint	1
(ii)	An explanation that links any three of the following four points **M1** solution/water contains hydrogen ions/H^+ **M2** hydrogen ions/H^+ are attracted to the negative electrode/cathode **M3** hydrogen ions/H^+ gain electrons **M4** and (combine in pairs to) form hydrogen molecules/H_2	**IGNORE** sodium ions Can score M3 and M4 for fully correct half equation. i.e. $2H^+ + 2e \rightarrow H_2$	3
(d) (i)	**M1** $\sum$ bond energies on LHS = 2 × 436 + 498 **OR** 1370 (kJ) **M2** $\sum$ bond energies on RHS = 4 × 463 **OR** 1852 (kJ) **M3** (1370 − 1852) = −482 (kJ)	Correct answer without working scores 3 **ALLOW** ecf on **M1** and **M2** **ALLOW** −241 (kJ) (for 1 mole of water) for all 3 marks sign required to score **M3**	3

Question number	Answer	Notes	Marks
7 (d) (ii)	**M1** two horizontal lines in correct positions with products line to the right of reactants line **M2** horizontal lines labelled correctly with formulae of reactants and products **M3** vertical line in correct position and labelled Δ*H*  	**ALLOW** ecf on incorrect positive value for **M3** **ACCEPT** double headed arrow or arrow pointing from reactants level to products level **REJECT** arrow pointing from products level to reactants level **IGNORE** activation energy hump	3
			Total 14

Question number	Answer	Notes	Marks
6 (a)	A description that refers to the following three points **M1** filter (the mixture) **M2** wash (the precipitate/solid/lead(II) bromide with distilled water) **M3** suitable drying method	 e.g. dry with filter paper /leave to dry/dry in a desiccator/dry in an oven **REJECT M3** if they attempt to crystallise the filtrate If any attempt to evaporate the solution allow MAX 1	3
(b) (i)	2(.0) x 0.025 = 0.05(0) (mol) **OR** $\frac{2(.0) \times 25}{1000}$ = 0.05(0) (mol)	**ACCEPT** 25 ÷ 1000 = 0.025 0.05 ÷ 0.025 = 2 All working must be shown to gain full marks	1
(ii)	**M1** (n $PbBr_2$) = 0.05(0) ÷ 2 = 0.025 **M2** 0.025 x 367 = 9.175 (g) **OR** **M1** 0.05 x 367 = 18.35 (g) **M2** 18.35 ÷ 2 = 9.175 (g)	**ALLOW** 2:1 = 0.05:0.025 **ACCEPT** 9.18/9.2/9 (g) **ACCEPT** 9.18/9.2/9 (g) All working must be shown to gain full marks	2
(c) (i)	An explanation that links the following three points **M1** when solid the ions are in fixed positions/in a lattice **M2** so there are no ions/electrons/charged particles free to move **M3** (when molten) the ions are free to move so can conduct electricity/carry a current	 **IGNORE** carry charge **REJECT** solution for **M3** **REJECT** electrons moving /delocalised electrons for **M3**	3

	(ii)	An explanation that links the following two points **M1** graphite **M2** resistance to high temperature /has a high melting point	 **IGNORE** carbon **ALLOW** platinum **ALLOW** conducts electricity / doesn't react with product /is inert **M2** dependent on graphite /carbon /a transition metal	2
	(iii)	$Pb^{2+} + 2e^{(-)} \rightarrow Pb$	**ACCEPT** multiples **IGNORE** state symbols even if incorrect	1
(d)	(i)	brown vapour/gas/fumes	**ALLOW** red-brown vapour/gas/fumes **REJECT** orange/orange-brown/red alone	1
	(ii)	bromide (ions)/Br^- loses electrons	**ALLOW** electrons are lost **REJECT** bromine loses electrons	1
				Total 14