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EDEXCEL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Key Concepts in Chemistry (1)

GCSE Chemistry (Higher) Topic 1

32 questions · 316 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Chemistry 1CH0, Higher Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

32 questions · 316 marks · lowest tariff first



6-MARK QUESTIONS

2 questions in this booklet



- 1 (a) Figure 1 shows information about two isotopes of hydrogen, **A** and **B**.

Complete the table to show the number of subatomic particles in each isotope.

(2)

	isotope A	isotope B
atomic number	1	1
mass number	1	2
number of protons		
number of electrons		
number of neutrons		

Figure 1

- (b) Hydrogen gas and oxygen gas are used in a hydrogen–oxygen fuel cell.

Separate containers of hydrogen and oxygen are used to supply the gases.

A student tests the voltage supplied by the fuel cell every 15 minutes.

The results are shown in Figure 2.

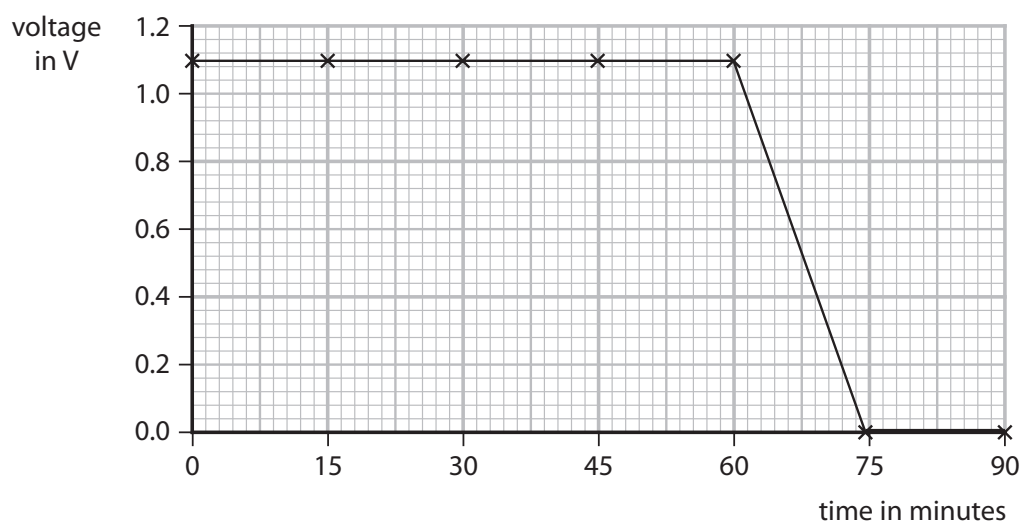


Figure 2

Describe what Figure 2 shows about how the voltage of this fuel cell varies with time.

(2)

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.....

.....

.....

(c) A chemical cell is made by placing two electrodes into an aqueous electrolyte.

Figure 3 shows a chemical cell.

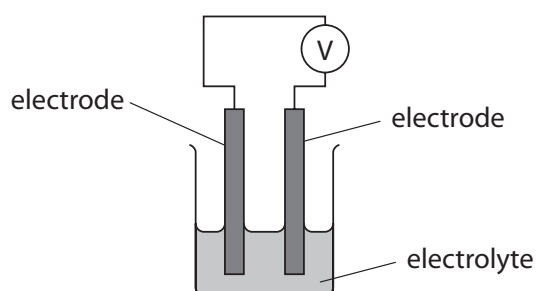


Figure 3

State why sodium and sulfur electrodes are **not** suitable for this experiment.

(2)

sodium

.....

.....

sulfur

.....

.....

(Total for Question 1 = 6 marks)

- 1 (a) A student carries out a flame test on a salt.
The student observes a yellow flame.

Which ion is in the salt?

(1)

- ☐ A Ca^{2+}
☐ B Cu^{2+}
☐ C Na^+
☐ D Li^+

- (b) A molecule of a yellow substance is shown in Figure 1.

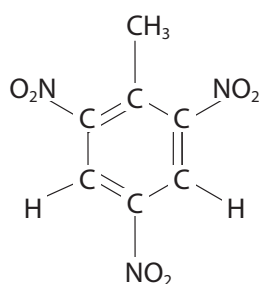


Figure 1

- (i) What is the formula of this molecule?

(1)

- ☐ A $\text{C}_6\text{H}_5(\text{NO}_2)_3$
☐ B $\text{C}_6\text{H}_2(\text{CH}_3)(3\text{NO}_2)$
☐ C $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$
☐ D $\text{C}_7\text{H}_6\text{N}_3\text{O}_6$

- (ii) A bottle of this substance is labelled with the hazard symbol in Figure 2.



Figure 2

State the danger associated with the contents of this bottle.

(1)

- (c) Yellow bananas emit ethene gas, C_2H_4 .

Draw one molecule of ethene, showing all covalent bonds.

(2)

- (d) Gold has a yellow colour.

A gold nanosphere has a surface area of 305 nm^2 .
The surface area to volume ratio is 1 : 4.60.

Calculate the volume, in nm^3 , of the gold nanosphere.

(1)

volume = ... nm^3

(Total for Question 1 = 6 marks)

7-MARK QUESTIONS

3 questions in this booklet



- 1 When heated, zinc carbonate decomposes to form zinc oxide and carbon dioxide gas.



- (a) A student investigated the decomposition of a sample of zinc carbonate.

The student used the following method.

- step 1** the mass of an empty crucible was determined
- step 2** a sample of zinc carbonate was placed into the crucible
- step 3** the mass of the crucible and the zinc carbonate was determined
- step 4** the crucible and zinc carbonate was heated for five minutes
- step 5** the mass of the crucible and contents was determined.

Figure 1 shows the apparatus used.

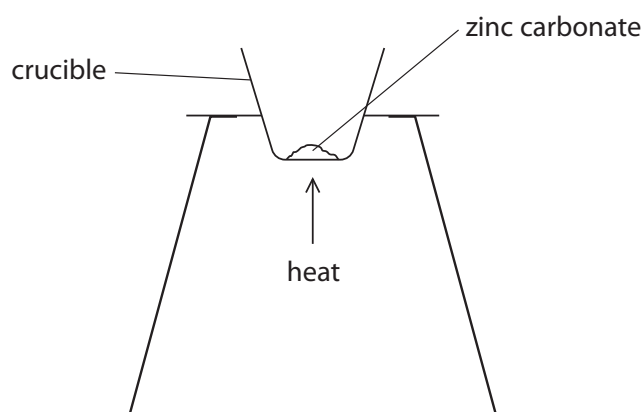


Figure 1

Suggest how the student could confirm that the decomposition was complete.

(3)

.....

.....

.....

(b) The theoretical maximum yield of zinc oxide was 1.86 g.

The actual yield was 1.63 g.

Calculate the percentage yield of zinc oxide.

(2)

percentage yield = ...

(c) Another student carried out the experiment using a similar method.

The student used a blue, roaring Bunsen burner flame and placed a lid on the crucible.

State why the student used a blue, roaring flame and a lid.

(2)

why a blue, roaring flame

why a lid

(Total for Question 1 = 7 marks)



3 Sodium carbonate has the formula Na_2CO_3 .

(a) Sodium carbonate contains Na^+ ions and CO_3^{2-} ions.

(i) The atomic number of sodium is 11.

What is the electronic configuration of the Na^+ ion?

(1)

- ☐ A 1
- ☐ B 2.8
- ☐ C 2.8.1
- ☐ D 2.8.2

(ii) Explain why solid sodium carbonate **cannot** conduct electricity but a solution of sodium carbonate **can** conduct electricity.

(3)

.....

.....

.....

.....

.....

.....

(b) Calculate the percentage by mass of sodium in sodium carbonate, Na_2CO_3 .

$$\text{percentage by mass of element} = \frac{\text{total relative atomic mass of element}}{\text{relative formula mass of compound}} \times 100$$

(relative atomic masses: C = 12, O = 16, Na = 23)

(3)

.....

.....

.....

.....

percentage by mass of sodium = ...

(Total for Question 3 = 7 marks)



3 Crude oil is a mixture of hydrocarbons.

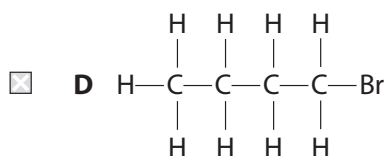
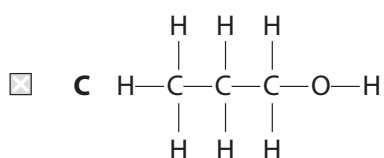
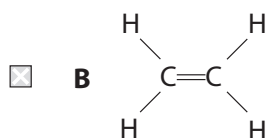
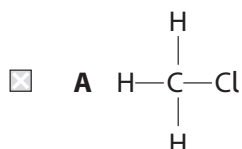
(a) (i) The majority of hydrocarbons in crude oil belong to one homologous series.

Give the name of this series.

(1)

(ii) Which structure represents a molecule of a hydrocarbon?

(1)



(b) When hydrocarbons undergo combustion, water is produced.

Draw a dot and cross diagram of a molecule of water.

(2)

(c) One compound in crude oil contains 0.96 g of carbon atoms combined with 0.32 g of hydrogen atoms.

Calculate the empirical formula of this compound.

(relative atomic masses: C = 12, H = 1.0)

(3)

.....

.....

.....

.....

.....

.....

.....

empirical formula of this compound = ...

(Total for Question 3 = 7 marks)



8-MARK QUESTIONS

1 question in this booklet



3 Magnesium carbonate has the formula MgCO_3 .

(a) Magnesium carbonate contains Mg^{2+} and CO_3^{2-} ions.

(i) The atomic number of magnesium is 12.

What is the electronic configuration of the Mg^{2+} ion?

(1)

- ☐ **A** 2
- ☐ **B** 2.8
- ☐ **C** 2.8.2
- ☐ **D** 2.8.4

(ii) Explain why solid magnesium carbonate cannot conduct electricity but solid magnesium can.

(3)

.....

.....

.....

.....

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.....

(b) Calculate the percentage by mass of magnesium in magnesium carbonate, MgCO_3 .

(relative atomic masses: C = 12.0, O = 16.0, Mg = 24.0)

(3)

.....

.....

.....

.....

percentage by mass of magnesium = ...



- (c) Magnesium carbonate reacts with dilute hydrochloric acid.
Water and carbon dioxide are two of the products of the reaction.

Complete the balanced equation for this reaction.

(1)



(Total for Question 3 = 8 marks)



9-MARK QUESTIONS

10 questions in this booklet



2 (a) A chlorine atom contains 17 electrons, 18 neutrons and 17 protons.

(i) State the mass number of this chlorine atom.

(1)

(ii) Give the electronic configuration of this chlorine atom.

(1)

(b) Describe what you would **see** if damp, blue litmus paper is placed into chlorine gas.

(2)

(c) Chlorine exists as diatomic molecules.

In a molecule, two chlorine atoms are joined by a covalent bond.

(i) Describe what is meant by a **covalent bond**.

(2)

(ii) Explain why chlorine is a gas, rather than a liquid, at room temperature.

(2)



- (d) When the gas hydrogen chloride, HCl , is dissolved in water, a solution forms. Blue litmus paper dipped in this solution turns red.

State why the litmus paper turns red.

(1)

(Total for Question 2 = 9 marks)



3 Lithium, sodium and potassium are reactive metals in group 1 of the periodic table.

- (a) Sodium metal tarnishes in air to form a layer of sodium oxide on its surface.
0.92 g of sodium combined with 0.32 g of oxygen in this oxide.

Calculate the empirical formula of this sodium oxide.

(relative atomic masses: O = 16, Na = 23)

You must show your working.

(3)

.....

.....

.....

.....

.....

.....

empirical formula of sodium oxide = ...

- (b) Sodium reacts with water to form sodium hydroxide solution and hydrogen.

Complete the balancing of the equation for this reaction and add the state symbols for each substance.

(3)



- (c) In an experiment equal-sized pieces of lithium, sodium and potassium are added to separate samples of water.

A flame is produced only with potassium because potassium

(1)

- ☐ **A** is the softest metal
- ☐ **B** has the lowest melting point
- ☐ **C** is the most reactive
- ☐ **D** is the only flammable metal

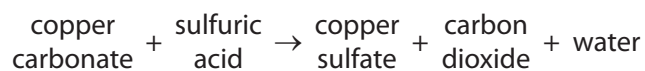
(d) Explain, in terms of electronic configurations, the increase in reactivity from lithium to sodium to potassium.

(2)

(Total for Question 3 = 9 marks)



3 The word equation for the reaction between copper carbonate and dilute sulfuric acid is



(a) (i) Complete the balanced equation for this reaction.

(2)



(ii) Calculate the relative formula mass of copper carbonate, CuCO_3 .
(relative atomic masses: C = 12.0, O = 16.0, Cu = 63.5)

(2)

.....

.....

.....

relative formula mass of CuCO_3 = ...

(iii) What is the chemical test to show that a gas is carbon dioxide?

(1)

- ☐ A bubble the gas through limewater, limewater turns cloudy
- ☐ B put damp blue litmus paper in the gas, litmus paper turns red
- ☐ C put a lighted splint into the gas, the splint is extinguished
- ☐ D measure the pH of the gas, pH = 4

- (b) Figure 4 shows a conical flask containing dilute sulfuric acid. Copper carbonate is added to the acid in the flask. The copper carbonate is added one spatula measure at a time until the reaction has finished.

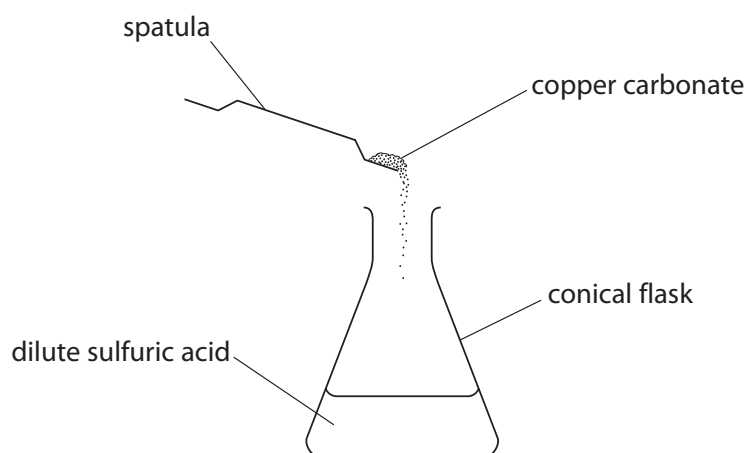


Figure 4

State **two** observations that would show the reaction has finished.

(2)

- 1
- 2

- (c) The electronic configuration of carbon is 2.4
The electronic configuration of oxygen is 2.6

Draw a dot and cross diagram for a molecule of carbon dioxide.

Show outer electrons only.

(2)

(Total for Question 3 = 9 marks)

2 (a) An atom of potassium has atomic number 19 and mass number 39.

(i) Give the electronic configuration of this potassium atom.

(1)

.....

(ii) This potassium atom forms the ion K^+ .

Which row shows the number of protons and the number of neutrons in this potassium ion, K^+ ?

(1)

	number of protons	number of neutrons
☐ A	19	19
☐ B	19	20
☐ C	20	19
☐ D	20	20

(b) Potassium and caesium are in the same group of the periodic table.

Explain, in terms of electrons, why potassium and caesium are in the same group.

(2)

.....

(c) Fluorine boils at -188°C .

There are forces between fluorine molecules.

Explain, in terms of these forces, why the boiling point of fluorine is low.

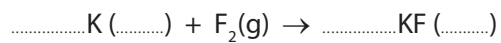
(2)

.....

- (d) Potassium reacts with fluorine to form potassium fluoride.
Potassium fluoride is a solid.

Complete the balanced equation for this reaction and add the state symbols.

(3)



(Total for Question 2 = 9 marks)



2 The scientist John Dalton lived over 200 years ago.

(a) John Dalton suggested an early model of atoms.

When Dalton first described atoms he said that

- all elements are made of atoms
- atoms are not formed of any smaller particles
- all atoms of the same element are identical.

Give two differences between Dalton's model of atoms and today's model of atoms.

(2)

1

.....

.....

2

.....

.....

(b) Dalton also investigated different gases.

One of the gases that Dalton investigated was ethene.

The structure of one molecule of ethene is shown in Figure 2.

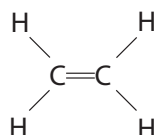


Figure 2

Give the molecular formula and the empirical formula of ethene.

(2)

molecular formula

empirical formula

(c) Another gas that Dalton investigated was chlorine.

Chlorine gas reacts with water.

The two products are a solution of hydrogen chloride and the substance HClO.

(i) Complete the balanced equation for this reaction, including the three missing state symbols.

(3)

..... (.....) + ... (.....) $\rightleftharpoons$ (.....) + HClO (aq)

(ii) Hydrogen chloride solution is acidic.

The formulae of four ions are shown in Figure 3.

H^+	H^-	Cl^+	Cl^-
--------------	--------------	---------------	---------------

Figure 3

Give the formula of the ion in Figure 3 that causes the hydrogen chloride solution to be acidic.

(1)

formula

(iii) An acid reacts with an alkali.

Give the name of this type of reaction.

(1)

.....

(Total for Question 2 = 9 marks)

- 2 (a) The concentration of a solution can be calculated using the equation

$$\text{concentration of solution} = \frac{\text{mass of solid}}{\text{volume of solution}}$$

A student dissolved 9.25 g of ammonium chloride in water and made up the solution to a volume of 200 cm³.

Use the equation to calculate the concentration of this solution in g dm⁻³.

(2)

concentration = ... g dm⁻³

- (b) Dissolving ammonium chloride in water is an endothermic process.

Figure 2 shows part of the reaction profile for this process.

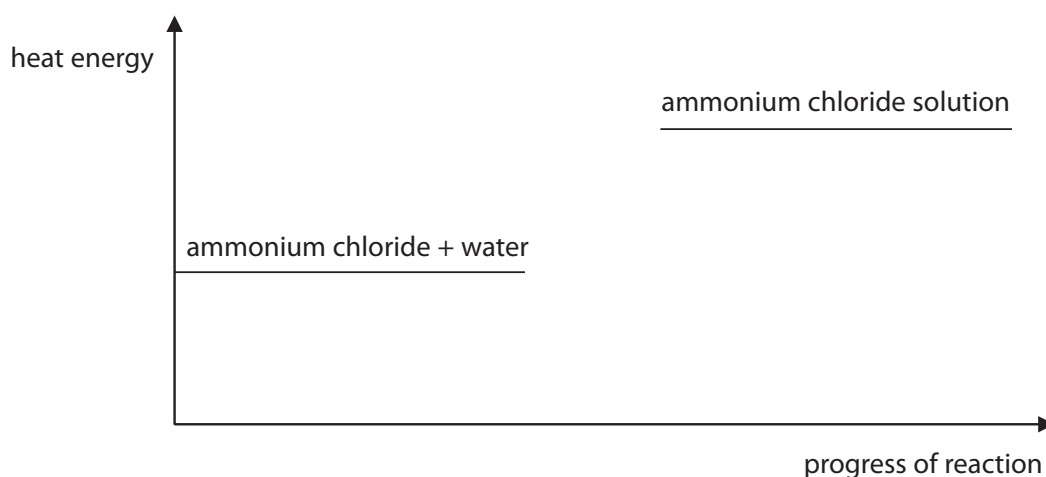


Figure 2

- (i) Explain how Figure 2 shows that dissolving ammonium chloride in water is an endothermic process.

(2)

(ii) Complete the reaction profile in Figure 2 and label the activation energy.

(2)

(c) A student used the equipment in Figure 3 to investigate whether electricity can pass through solid ammonium chloride and through ammonium chloride solution.

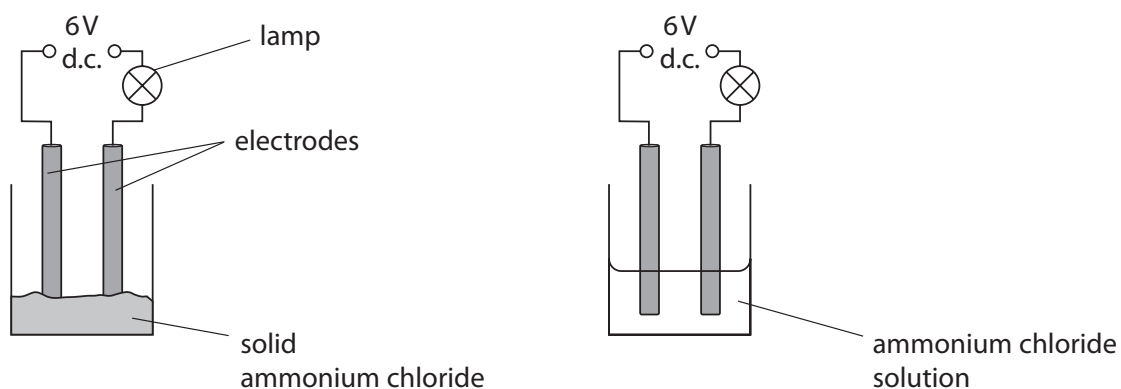


Figure 3

If an electrical current flows in the circuit, the lamp will light up.

Figure 4 shows the results of the investigation.

substance	lamp
solid ammonium chloride	did not light up
ammonium chloride solution	lit up brightly

Figure 4

Explain the results of the investigation.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 2 = 9 marks)

3 This question is about gases.

(a) When sodium is added to water, hydrogen gas is produced.

Which observation shows that a gas has been produced?

(1)

- ☐ A a white precipitate forms
- ☐ B effervescence is seen
- ☐ C the sodium sinks in the water
- ☐ D the water changes to a pink colour

(b) Some damp litmus paper is placed in a gas.
The litmus paper is bleached.

Which gas bleaches damp litmus paper?

(1)

- ☐ A carbon dioxide
- ☐ B chlorine
- ☐ C hydrogen
- ☐ D oxygen

(c) When calcium carbonate is heated it decomposes.



When 5.000 g of calcium carbonate is heated, the mass of solid remaining is 2.800 g.

Calculate the mass of carbon dioxide that has been released.

Give your answer to three significant figures.

(2)

.....

.....

mass of carbon dioxide = ... g



(d) A diagram of an atom of helium is shown in Figure 5.

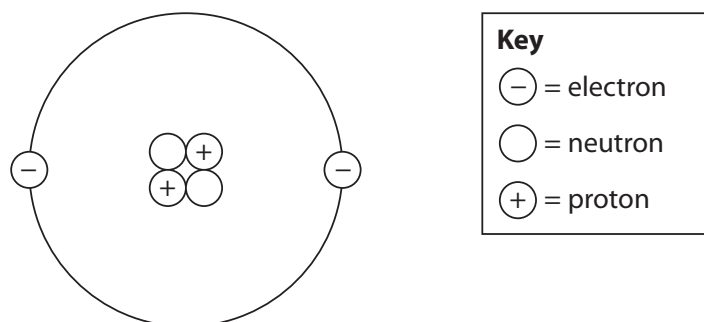


Figure 5

(i) Explain, using Figure 5, why helium is inert.

(2)

.....

.....

.....

(ii) Helium is used to fill balloons.

State one property of helium, apart from it being inert, that makes it suitable for filling balloons.

(1)

.....

(e) Oxygen gas has the formula O_2 .

Calculate the number of oxygen **atoms** in 3.50 mol of oxygen gas.

(Avogadro constant = 6.02×10^{23})

(2)

.....

.....

.....

number of oxygen atoms = ...

(Total for Question 3 = 9 marks)



2 (a) Atoms of neon are made up of subatomic particles.

(i) Figure 2 shows some information about the subatomic particles in neon atoms.

Complete Figure 2 with the missing information.

(3)

subatomic particle	relative charge	relative mass
proton		1
neutron	0	
electron		negligible

Figure 2

(ii) All atoms of neon have an atomic number of 10.

Describe what information about the number of subatomic particles can be obtained from the atomic number of neon.

(2)

.....

.....

.....

.....

(iii) Explain why atoms of neon are electrically neutral.

(2)

.....

.....

.....

.....



(b) A sample of neon contains three isotopes

90.48% of neon-20

0.27% of neon-21

9.25% of neon-22

Using this information, calculate the relative atomic mass of this sample of neon.

(2)

.....

.....

.....

.....

relative atomic mass = ...

(Total for Question 2 = 9 marks)



5 Nitrogen, N_2 , oxygen, O_2 and fluorine F_2 are all gases.

(a) Nitrogen, oxygen and fluorine are in the same period of the periodic table.

Explain, in terms of electronic configuration, in which period of the periodic table nitrogen, oxygen and fluorine are located.

(2)

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.....

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.....

(b) Fluorine has a boiling point of -188°C .

(i) Explain why fluorine has a low boiling point.

(3)

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.....

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.....

(ii) A mixture of nitrogen and oxygen becomes a liquid when cooled to -200°C .

Which row shows the changes in energy and movement of the molecules as they are cooled from room temperature to -200°C ?

(1)

		movement of molecules	energy of molecules
☐	A	less	more
☐	B	more	less
☐	C	less	less
☐	D	more	more



(iii) The mixture of liquid nitrogen and liquid oxygen can be separated.

Which process could be used to separate a mixture of liquid nitrogen and liquid oxygen?

(1)

- ☐ A paper chromatography
- ☐ B fractional distillation
- ☐ C filtration
- ☐ D crystallisation

(c) At high temperatures, nitrogen, N_2 , can react with oxygen, O_2 , to form nitrogen dioxide only.

Write the balanced equation for this reaction.

(2)

(Total for Question 5 = 9 marks)

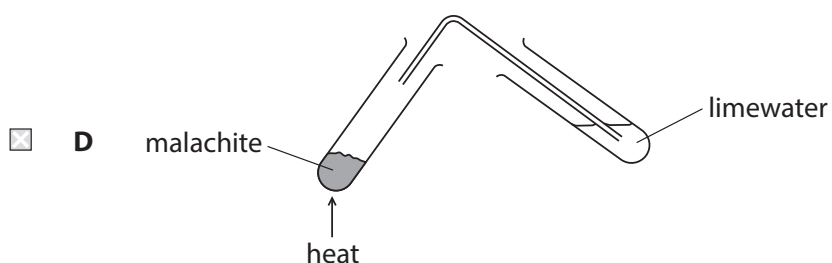
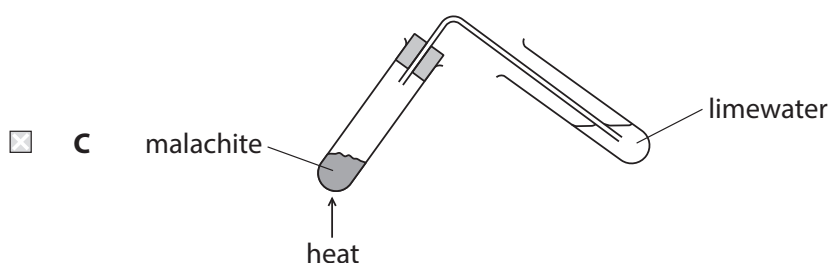
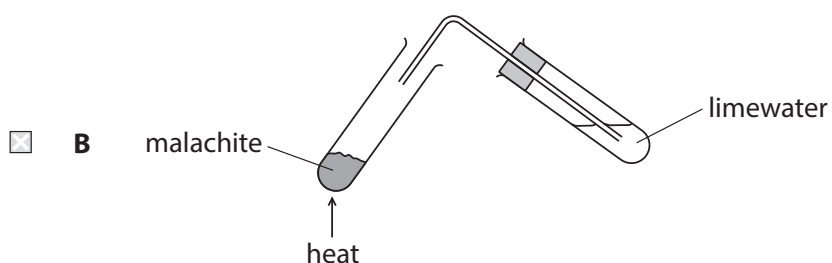
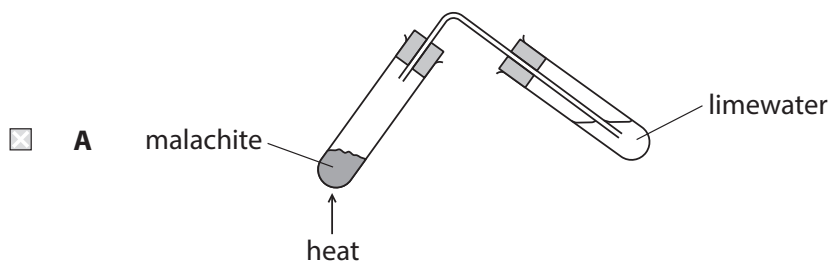


6 Malachite, $\text{Cu}_2\text{CO}_3(\text{OH})_2$, is a mineral containing copper.

(a) When heated, malachite decomposes to form copper oxide, carbon dioxide and water.

(i) Which apparatus should be used to heat the malachite and test for carbon dioxide?

(1)



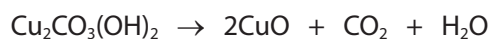
- (ii) When carbon dioxide is bubbled through limewater, a precipitate forms. This precipitate solid makes the limewater cloudy.

Name the precipitate that makes the limewater cloudy.

(1)

.....

- (iii) The equation for the decomposition of malachite when it is heated is



Calculate the maximum mass of copper oxide that can be formed when 22.1 g of malachite is decomposed completely.

(relative atomic masses: Cu = 63.5, O = 16.0, C = 12.0, H = 1.0)

(4)

.....

.....

.....

.....

.....

maximum mass of CuO = ... g



- (b) Copper can be extracted from copper oxide by heating the copper oxide with carbon.

A student investigated two methods to extract the maximum mass of copper from copper oxide.

Figure 3 shows the two methods.

method 1	method 2
step 1 place one spatula measure of copper oxide into a beaker	step 1 place one spatula measure of copper oxide into a glass test tube
step 2 mix the copper oxide thoroughly with carbon powder	step 2 carefully add carbon powder on top of the copper oxide
step 3 place the mixture into a metal crucible and heat the mixture with a roaring Bunsen flame	step 3 heat the two layers with a roaring Bunsen flame

Figure 3

Comment on the strengths and weaknesses of these two methods.

(3)

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(Total for Question 6 = 9 marks)



11-MARK QUESTIONS

9 questions in this booklet



8 Covalent substances can be simple molecular covalent or giant covalent.

(a) (i) Ammonia is a simple molecular, covalent substance.

Which is the most likely set of properties for ammonia?

(1)

	melting point in °C	boiling point in °C	ability to conduct electricity in liquid state
☐ A	1713	2950	does not conduct
☐ B	−78	−33	does not conduct
☐ C	−39	357	conducts
☐ D	801	1413	conducts

(ii) Ammonia, NH_3 , is made by reacting nitrogen with hydrogen.

Write the balanced equation for this reaction.

(2)

(b) Oxygen, O_2 , is also a simple molecular, covalent substance.

Draw a dot and cross diagram for the molecule of oxygen.

(2)



*(c) Figure 8 shows the arrangement of carbon atoms in diamond, graphene and a fullerene (C_{60}).

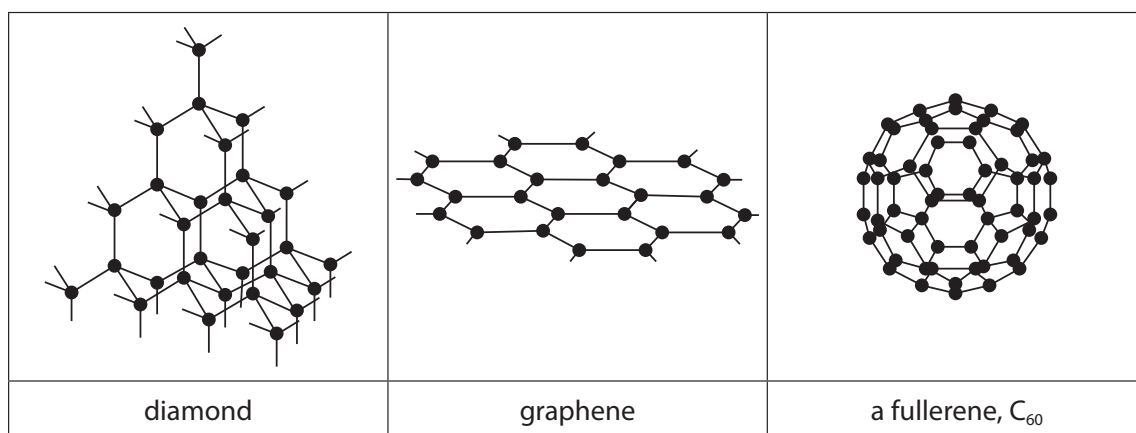


Figure 8

Consider these three substances.

Explain, in terms of their structures and bonding, their relative melting points, strengths and abilities to conduct electricity.

(6)

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(Total for Question 8 = 11 marks)



6 Titanium and iron are examples of transition metals.

(a) Figure 6 shows the percentage abundance of each isotope in a sample of titanium.

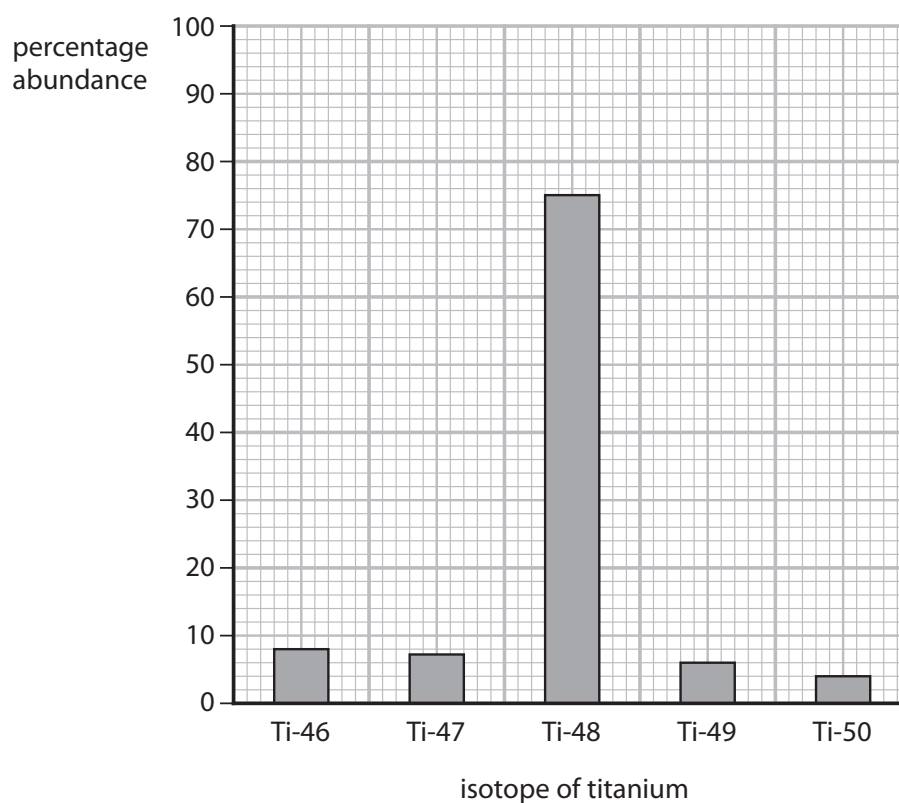


Figure 6

Calculate the relative atomic mass of titanium in this sample.

(3)

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relative atomic mass = ...

(b) Iron, when heated in air, reacts with oxygen to form iron oxide.

(i) This reaction is an example of

(1)

- ☐ A crystallisation
- ☐ B distillation
- ☐ C neutralisation
- ☐ D oxidation

(ii) The equipment shown in Figure 7 can be used to find the mass of oxygen that combines with iron.

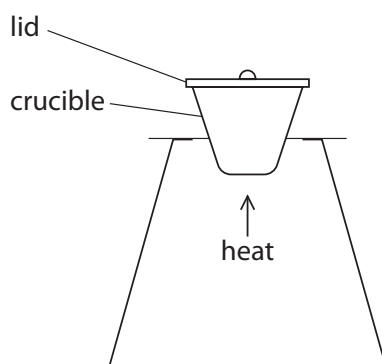


Figure 7

Describe how the equipment shown in Figure 7 could be used to find the mass of oxygen that combines with 0.500 g of iron wool in a crucible and lid of known mass.

(3)

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(c) 2.24 g of iron combines with 0.96 g of oxygen to form an oxide of iron.

Determine the formula of this oxide of iron and use it to complete the balanced equation.

(relative atomic masses: Fe = 56.0, O = 16.0)

You must show your working.

(4)

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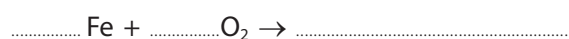
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balanced equation for the reaction is



(Total for Question 6 = 11 marks)



- 8 (a) Calcium has an atomic number of 20.
A calcium atom has a mass number of 40.

- (i) Which row of the table shows the number of protons and number of neutrons in this atom of calcium?

(1)

	number of protons	number of neutrons
☐ A	20	20
☐ B	40	20
☐ C	20	60
☐ D	60	20

- (ii) Figure 8 shows the arrangement of electrons in an atom of calcium.

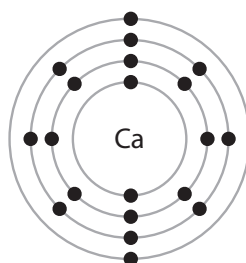


Figure 8

Explain, using the information in Figure 8, in which period of the periodic table calcium can be found.

(2)

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(b) Calcium and potassium react with water in similar ways.

- (i) One similarity in the reactions is that hydrogen gas is produced.

State **one** other similarity in the products of the reactions of calcium and potassium with water.

(1)

- (ii) Potassium is higher in the reactivity series than calcium and reacts more vigorously with water than calcium reacts with water.

State why potassium is higher in the reactivity series and reacts more vigorously with water than calcium.

(1)



(Total for Question 8 = 11 marks)



7 (a) Air contains several gaseous elements.

Which of these shows the three most common gaseous elements in air, listed in order from the most common to the least common?

(1)

- ☐ A oxygen, chlorine, nitrogen
- ☐ B nitrogen, oxygen, hydrogen
- ☐ C oxygen, nitrogen, helium
- ☐ D nitrogen, oxygen, argon

(b) The density of a gas can be found using the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

A student carried out an experiment to find the density of argon.

The mass of a stopper and flask, containing no gas, was known.
The flask was completely filled with argon and its mass measured.

Figure 4 shows the results the student wrote down.

mass of stopper and flask in g	78.639
mass of stopper and flask full of argon in g	79.120
volume of flask in cm ³	250.0

Figure 4

(i) Use the results to calculate the density of argon in g cm⁻³.

(2)

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.....

density of argon = ... g cm⁻³



- (ii) The flask used for the experiment is shown in Figure 5.
The flask holds 250.0 cm^3 when filled up to the line.

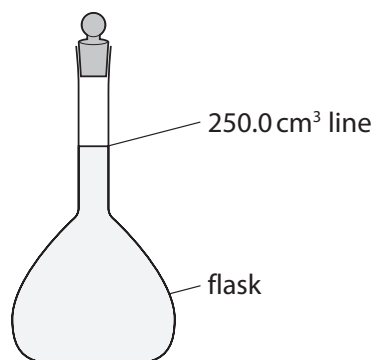


Figure 5

There is an error in the volume the student has used in the calculation.
This would give an incorrect value for the density of argon.

Identify this error and state what should be done to correct it.

(2)

error

what should be done to correct it

- (c) Four of the noble gases are argon, helium, krypton and neon.

Give these gases in order of increasing density.

(2)

- (d) Much of the carbon dioxide present in the Earth's early atmosphere dissolved into the oceans.

This led to the formation of compounds including calcium carbonate, CaCO_3 .

Some of the calcium carbonate reacted with magnesium ions to form dolomite, $\text{CaMg}(\text{CO}_3)_2$.

Complete the **ionic** equation for the reaction of calcium carbonate with magnesium ions.

(2)



- (e) **P** and **Q** are both mixtures of gases.

One has the same composition as the early atmosphere and the other has the same composition as the current atmosphere.

Tests are carried out on gas mixtures **P** and **Q**.

The test for carbon dioxide is to bubble the gas into limewater; if carbon dioxide is present calcium carbonate is formed.

The results of the tests are shown in Figure 6.

test	result with gas mixture P	result with gas mixture Q
bubble gas into limewater	white precipitate forms after 4 minutes	white precipitate forms after 10 seconds
place burning splint into gas mixture	splint continues to burn	splint immediately goes out

Figure 6

Explain, using the data in Figure 6, which gas mixture represents the early atmosphere.

(2)

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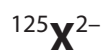
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(Total for Question 7 = 11 marks)



- 9 (a) An ion of element **X** can be represented as



This ion of element **X** has 54 electrons.

Calculate the number of protons and the number of neutrons in this ion.

(2)

number of protons

number of neutrons

- (b) A sample of silicon contains isotopes.

- (i) State, in terms of subatomic particles, how atoms of these isotopes are the same.

(1)

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.....

- (ii) This sample of silicon contains three isotopes.

92% of the atoms are silicon-28

5% of the atoms are silicon-29

3% of the atoms are silicon-30

Calculate the relative atomic mass of silicon in this sample.

(2)

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relative atomic mass = ...



(Total for Question 9 = 11 marks)



8 Ammonia can be produced from the reaction of hydrogen with nitrogen.

(a) What is the percentage by mass of nitrogen in ammonia, NH_3 ?

(relative atomic masses: $\text{H} = 1.0$, $\text{N} = 14$)

(1)

- ☐ A 18%
- ☐ B 42%
- ☐ C 51%
- ☐ D 82%

(b) The reaction between hydrogen and nitrogen is exothermic.

Figure 13 shows the reaction profile of this exothermic reaction.

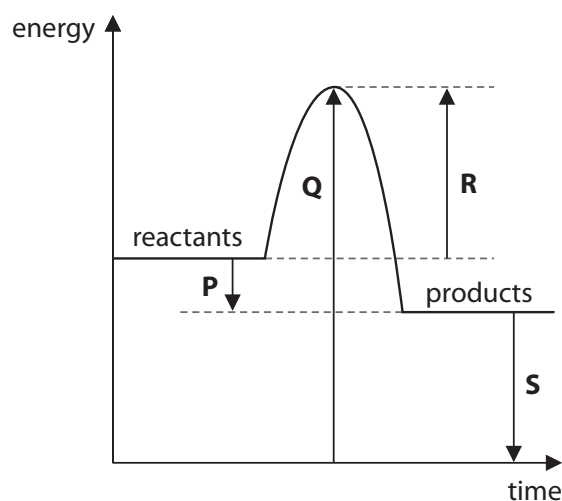


Figure 13

(i) Which arrow represents the activation energy for the reaction?

(1)

- ☐ A arrow P
- ☐ B arrow Q
- ☐ C arrow R
- ☐ D arrow S

- (ii) Describe what the reaction profile shows about the energy involved in bond breaking and bond making in this reaction.

(2)

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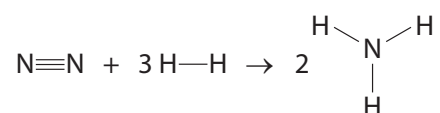
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- (iii) Figure 14 shows the energies of some bonds.

bond	bond energy in kJ mol^{-1}
$\text{N}\equiv\text{N}$	944
$\text{H}-\text{H}$	436
$\text{H}-\text{N}$	388

Figure 14

The equation for the reaction between nitrogen and hydrogen to form ammonia is



Calculate the energy change, in kJ mol^{-1} , for this reaction.

(4)

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energy change = ... kJ mol^{-1}



- (c) Ammonia, NH_3 , and silicon dioxide, SiO_2 , are both compounds that are made of two non-metallic elements.

Ammonia has a boiling point of -33°C .

Silicon dioxide has a boiling point of 2230°C .

Explain why the boiling points of ammonia and silicon dioxide are so different.

(3)

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(Total for Question 8 = 11 marks)



8 This question is about the properties of different substances.

(a) Silicon tetrachloride is a simple molecular covalent compound.

(i) A molecule of silicon tetrachloride is composed of a silicon atom and four chlorine atoms.

- a silicon atom has 4 outer electrons
- a chlorine atom has 7 outer electrons

Draw a dot and cross diagram of a molecule of silicon tetrachloride, SiCl_4 .

Show outer electrons only.

(2)

(ii) Explain why simple molecular covalent compounds such as silicon tetrachloride have low melting and boiling points.

(2)

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(b) Part of the structure of rubidium bromide is shown in Figure 7.

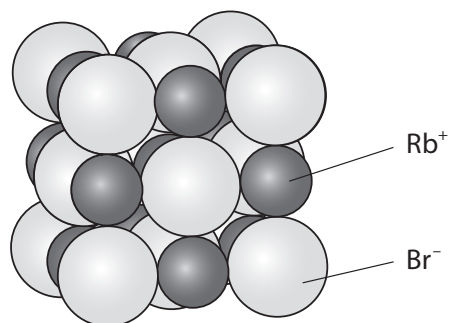


Figure 7

Which row shows the most likely melting point and boiling point of rubidium bromide?

(1)

	melting point in °C	boiling point in °C
☐ A	6.93	134.0
☐ B	69.3	134.0
☐ C	69.3	1340
☐ D	693	1340

*(c) Diamond and graphite are two forms of carbon.

Figure 8 shows how the carbon atoms are arranged in a part of the structure of each of these forms of carbon.

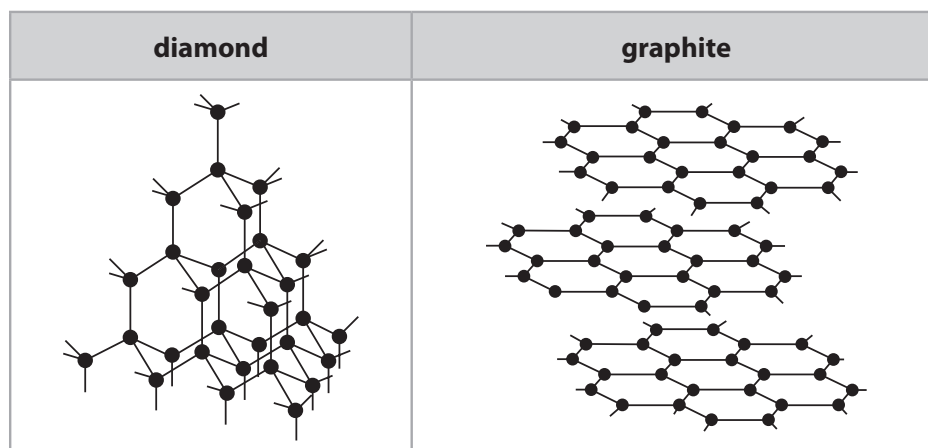


Figure 8

- diamond is one of the hardest known substances on Earth and is used in cutting tools.
- graphite is soft and flaky.
- diamond is a poor electrical conductor, but graphite is a good electrical conductor.

Explain, in terms of structure and bonding, these properties of diamond and graphite.

(6)

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(Total for Question 8 = 11 marks)



- 7 (a) The relative atomic mass of argon is 40 and the relative atomic mass of potassium is 39 but potassium appears after argon in the periodic table.

State why potassium appears after argon in the periodic table.

(1)

- (b) Potassium reacts with water to form two products.

- (i) Give the formulae of both products.

(1)

..... and

- (ii) The reaction of potassium with water is exothermic.

On Figure 9, draw and label the reaction profile diagram for this reaction, labelling the activation energy.

(2)



Figure 9

(c) Some reactions are endothermic.

Explain, in terms of bond breaking and bond forming, why some reactions are endothermic.

(3)



(d) Ethene reacts with hydrogen chloride.

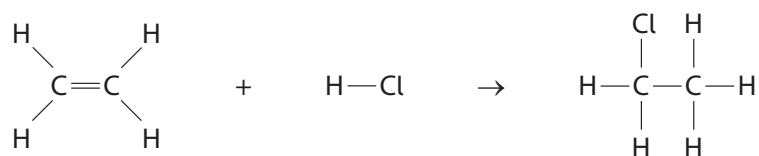


Figure 10 shows the bond energies for the different bonds in the three molecules in the reaction.

bond	bond energy in kJ mol^{-1}
$\text{C}-\text{H}$	412
$\text{C}=\text{C}$	612
$\text{C}-\text{C}$	348
$\text{H}-\text{Cl}$	431
$\text{C}-\text{Cl}$	338

Figure 10

Calculate the energy change for this reaction.

(4)

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energy change = ... kJ mol^{-1}

(Total for Question 7 = 11 marks)

9 This question is about ammonia.

(a) Ammonia is a gas.

Suggest why the litmus paper used to test for ammonia gas has to be damp.

(2)

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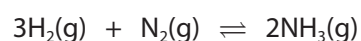
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(b) Ammonia can be made on an industrial scale using the Haber process.

The equation for the reaction is



The reaction can reach a dynamic equilibrium.

(i) Explain what happens when the reaction reaches dynamic equilibrium

(2)

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- (ii) Figure 8 shows the changes in percentage yield of ammonia at equilibrium as temperature increases, at a pressure of 300 atmospheres and at a pressure of 1000 atmospheres.

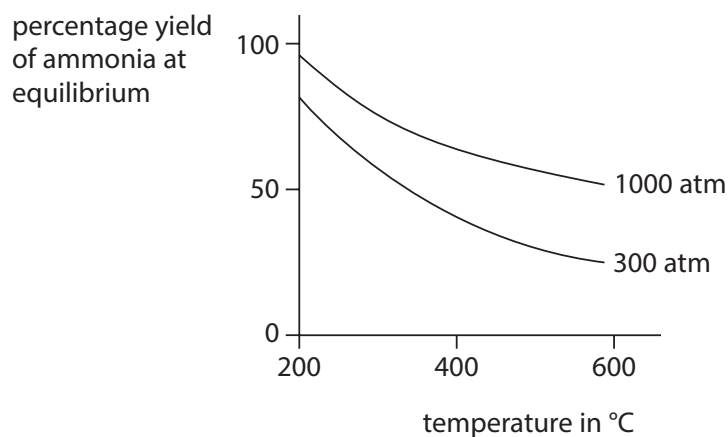


Figure 8

Which row of the table will give the highest percentage yield of ammonia at equilibrium?

(1)

	temperature in °C	pressure in atm
☐ A	200	1000
☐ B	300	1000
☐ C	600	300
☐ D	600	1000

- (iii) In industry, a pressure of 200 atmospheres is used for the Haber process.

Using Figure 8, explain what happens to the position of dynamic equilibrium if the process is carried out at 100 atmospheres.

(2)

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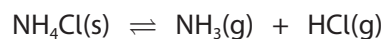
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(c) Ammonia can also be made by heating ammonium chloride.



A sample of solid ammonium chloride is heated in a boiling tube.

After a few minutes ammonium chloride, a white solid, is also seen at the top of the boiling tube, as shown in Figure 9.

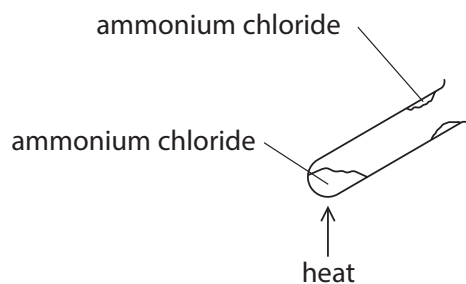


Figure 9

Explain how ammonium chloride is formed at the top of the boiling tube.

(4)

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(Total for Question 9 = 11 marks)

12-MARK QUESTIONS

5 questions in this booklet



8 This question is about some of the elements in group 7 of the periodic table.

- (a) Which row in the table correctly shows the colours and physical states of the elements at room temperature?

(1)

☐ A	iodine: purple gas	bromine: yellow liquid
☐ B	chlorine: pale green gas	iodine: brown solid
☐ C	bromine: red-brown liquid	chlorine: yellow liquid
☐ D	iodine: dark grey solid	bromine: red-brown liquid

- (b) The compound phosphorus oxychloride has the formula POCl_3 .

Calculate the percentage by mass of chlorine in phosphorus oxychloride.

(relative atomic masses: O = 16.0, P = 31.0, Cl = 35.5)

(2)

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percentage by mass of chlorine = ...

- (c) When iron reacts with chlorine, iron chloride is formed.

Two possible equations for this reaction are



In an experiment, 8.40 g iron reacts with chlorine to form 19.05 g iron chloride.

Show, using a calculation, which reaction, **A** or **B**, is taking place.

You must show your working.

(relative atomic masses: Cl = 35.5, Fe = 56.0)

(3)

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(Total for Question 8 = 12 marks)



- 8 (a) Bromine is a liquid at room temperature and vaporises readily. Bromine has a simple molecular structure.

Which row of the table shows the most likely melting and boiling points of bromine?

(1)

	melting point in °C	boiling point in °C
☐ A	−70	−6.3
☐ B	−17	6.3
☐ C	−7	63
☐ D	17	630

- (b) Part of the structure of graphene is shown in Figure 5.

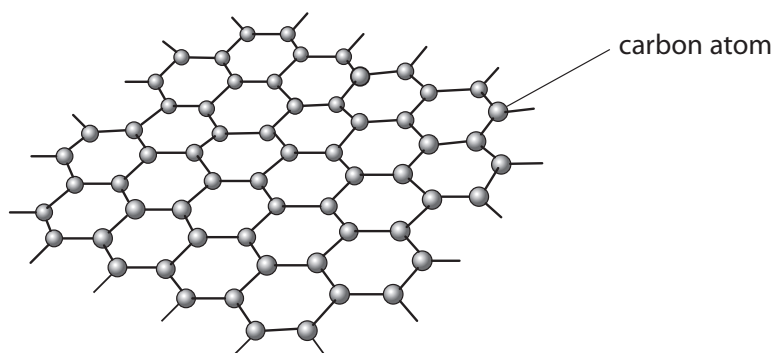


Figure 5

Explain why graphene will be a good conductor of an electric current.

(3)

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(c) Part of the structure of potassium chloride is shown in Figure 6.

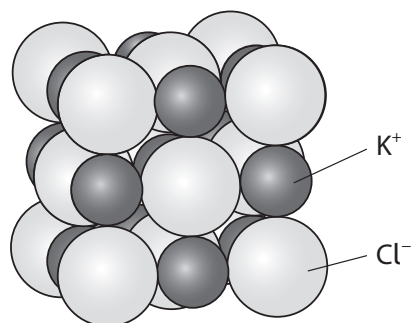


Figure 6

Potassium chloride has a melting point of 770°C .

Explain why potassium chloride has a high melting point.

(2)

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(Total for Question 8 = 12 marks)



- 9 (a) Figure 11 shows the structure of a molecule of compound **S**.

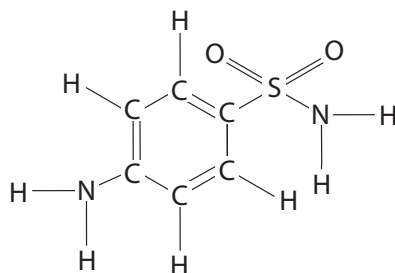


Figure 11

- (i) Use Figure 11 to deduce the empirical formula of compound **S**.

(1)

- (ii) The melting points of three samples of **S** are shown in Figure 12.

sample	melting point in °C
A	160–164
B	166
C	163–165

Figure 12

State whether each of these samples, **A**, **B** and **C**, is pure or impure and justify your answers using the information in Figure 12.

(3)

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(b) A scientist uses chromatography in an investigation of compound **S**.

In the conditions used, compound **S** has an R_f value of 0.22.

Calculate the distance the spot of compound **S** moves if the solvent front has moved by 2.4 cm.

(2)

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distance = ... cm



(Total for Question 9 = 12 marks)



10 (a) Figure 13 shows the apparatus used to burn different alcohols.

The mass of each alcohol required to raise the temperature of the water by 40°C is found.

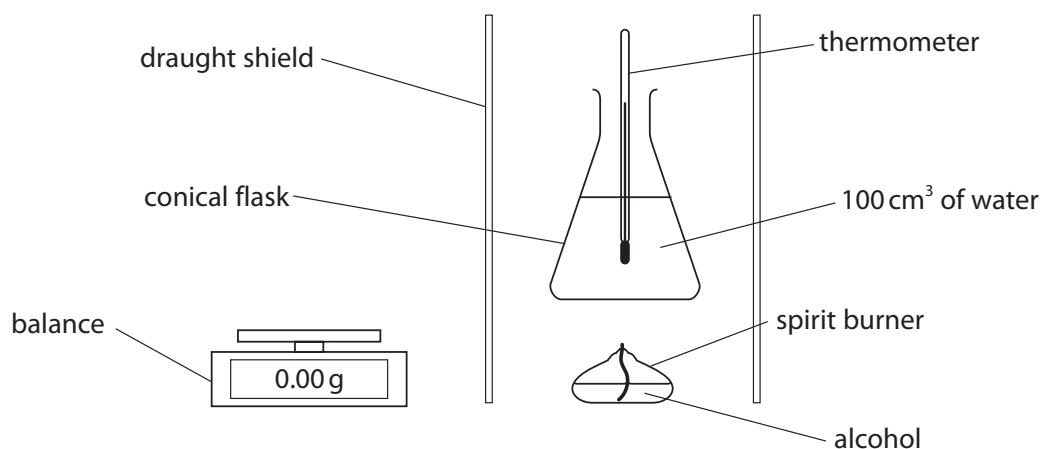


Figure 13

- (i) State **one** variable, apart from the volume of water, that should be kept the same when each alcohol is burned.

(1)

- (ii) It is found that 1.6 g of ethanol is used to raise the temperature of water by 40°C .

Calculate the number of moles of ethanol used.
Give your answer to two significant figures.
(relative formula mass: ethanol = 46)

(2)

number of moles = ...

- (iii) The mass of ethanol used to raise the temperature of the water by 40 °C is higher than the theoretical value.

The experiment is repeated and the same result obtained.

Give a reason why the mass of ethanol used is higher than expected.

(1)

- (b) Poly(phenylethene) is an addition polymer.

Figure 14 shows part of the poly(phenylethene) molecule formed in the addition reaction between three phenylethene monomer molecules.

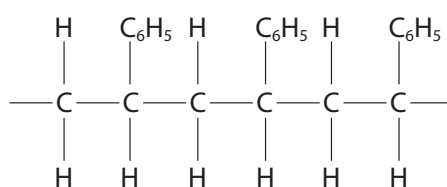


Figure 14

- (i) Draw the structure of **one** phenylethene monomer molecule.

(2)

- (ii) Explain what is **seen** when a few drops of bromine water are shaken with phenylethene.

(3)

(c) Poly(phenylethene) is an addition polymer.

Polyesters are condensation polymers.

Describe the differences between the type of monomer molecules used to form addition polymers and the type of monomer molecules used to form condensation polymers.

(3)

(Total for Question 10 = 12 marks)



8 This question is about molecules containing two atoms.

(a) In an experiment, hydrochloric acid is reacted with zinc.

The volume of gas produced is measured by collecting the gas in an upturned measuring cylinder over water.

Give a method of collecting and measuring the gas that would give a more accurate volume of gas.

(1)

(b) Iodine has an atomic number of 53 and a mass number of 127.

How many electrons are there in an iodine molecule, I_2 ?

(1)

- ☐ **A** 53
- ☐ **B** 106
- ☐ **C** 127
- ☐ **D** 180

(c) Iodine reacts with hydrogen to form hydrogen iodide, HI.

Explain whether or not a solution of hydrogen iodide in water conducts electricity.

(2)

(d) Chlorine gas is bubbled through a colourless solution of potassium bromide, KBr. The mixture turns orange.

(i) Give the name of the substance that causes the orange colour.

(1)

(ii) Write the balanced equation for this reaction.

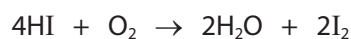
(3)

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(e) Hydrogen iodide reacts with oxygen to form water and iodine.

The equation for this reaction is



Calculate the energy change for this reaction using the bond energies in Figure 11.

bond	bond energy in kJ mol^{-1}
H—I	299
O=O	495
H—O	464
I—I	151

Figure 11

Include a sign and unit in your answer.

(4)

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energy change = ...

(Total for Question 8 = 12 marks)



13-MARK QUESTIONS

2 questions in this booklet



8 Magnesium sulfate is an ionic compound.

(a) A student adds magnesium sulfate to water to form a solution.

Which of these will also form a solution when added to water?

(1)

- ☐ **A** barium sulfate
- ☐ **B** calcium sulfate
- ☐ **C** lead sulfate
- ☐ **D** sodium sulfate

(b) (i) Calculate the percentage by mass of oxygen in magnesium sulfate, MgSO_4 .

(relative atomic mass: $\text{O} = 16.0$)

(relative formula mass: $\text{MgSO}_4 = 120$)

Give your answer to 3 significant figures.

(3)

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percentage by mass = ...

(ii) Calculate the number of oxygen atoms in 7.20 g of MgSO_4 .

(relative formula mass: $\text{MgSO}_4 = 120$)

Avogadro constant = 6.02×10^{23})

(3)

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number of oxygen atoms = ...



(Total for Question 8 = 13 marks)



7 This question is about carbon and some carbon compounds.

(a) Two forms of pure carbon are graphite and Buckminsterfullerene.

(i) Explain why graphite is used as a lubricant.

(2)

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(ii) Calculate the mass, in kg, of five moles of Buckminsterfullerene, C_{60} .

(relative atomic mass: $C = 12$)

(2)

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mass = ... kg

(b) A molecule in an homologous series has the formula $C_9H_{21}N$.

What is the formula of the next molecule in this homologous series?

(1)

☐ **A** $C_{10}H_{21}N$

☐ **B** $C_{10}H_{23}N$

☐ **C** $C_{10}H_{21}N_2$

☐ **D** $C_{10}H_{23}N_2$



(c) A Bunsen burner burns methane gas, CH_4 .

A student investigates the time taken to heat up a beaker of water using this Bunsen burner.

Figure 9 shows the apparatus used.

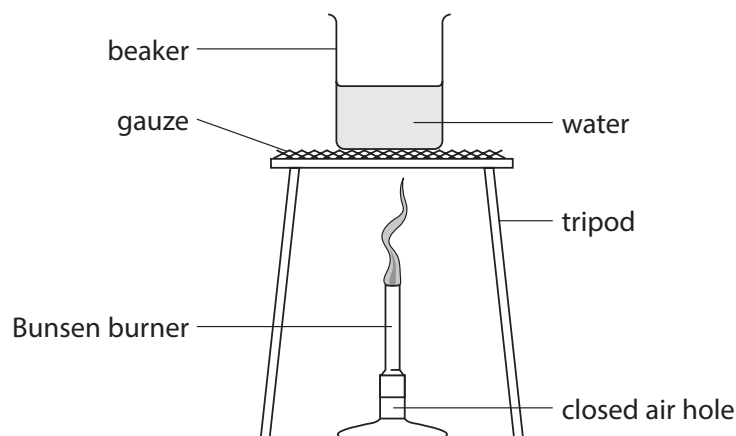


Figure 9

The student sees that a large amount of carbon forms as a black solid on the underside of the gauze.

The teacher said that the investigation would be improved if no carbon forms.

Explain what the student should do to stop carbon forming on the underside of the gauze.

(2)

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- *(d) Natural processes and human activities change the amount of carbon dioxide in the atmosphere.

Figure 10 shows the concentration of carbon dioxide in the atmosphere measured in one location and the mean global temperature from 1960 to 2000.

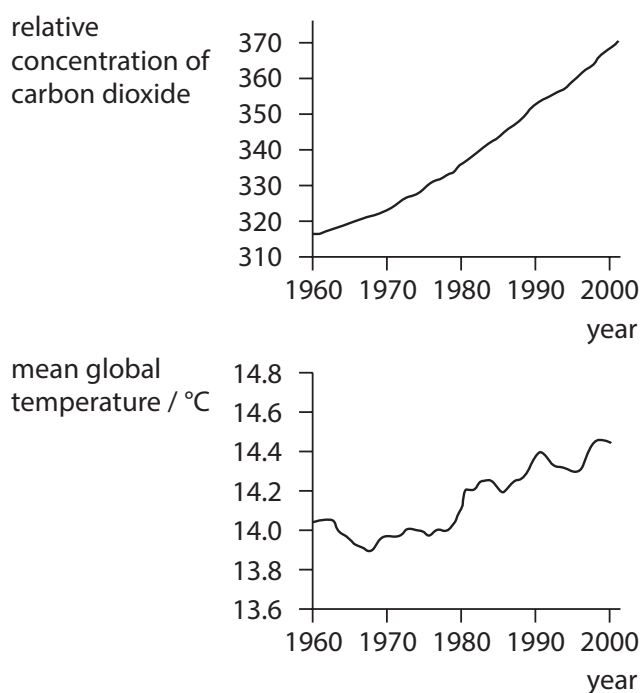


Figure 10

Evaluate whether the data in Figure 10 shows that the change in the amount of carbon dioxide is leading to climate change.

Your answer should include

- the natural processes that change the amount of carbon dioxide in the atmosphere
- the human activities that change the amount of carbon dioxide in the atmosphere
- how carbon dioxide contributes to the greenhouse effect and climate change.

(6)

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(Total for Question 7 = 13 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



Question number	Answer			Mark
1(a)		isotope A	isotope B	all 6 correct (2) 4 or 5 correct (1) 0-3 correct scores 0
	atomic number	1	1	
	mass number	1	2	
	number of protons	1	1	
	number of electrons	1	1	
	number of neutrons	0	1	

Question number	Answer	Additional guidance	Mark
1(b)	An description including - voltage {stays same/ constant/ steady/ stable/ at 1.1(V)} <u>for 60 minutes/ 1hr</u> (1) - and then falls <u>to 0(V)</u> (during the time 60-75 mins) (1)	for MP1 units of voltage not essential (but time span required) allow 1.08-1.12(V) allow power for voltage for MP2 units of voltage not required must specify that V decreases to zero/ nothing (but time span not required) ignore phrases such as 'voltage stops', 'no voltage', 'voltage runs out'	A03 1 (2)

Question number	Answer	Additional guidance	Mark
1(c)	- sodium would react with the {electrolyte / water/ solution} (1) - sulfur does not conduct (electricity) (1)	allow sodium is not inert/ is (very) reactive / reacts with the liquid ignore 'sodium will dissolve'/ will react with air/ loses electrons allow poor conductor/ sulfur is a non-metal/ electrons cannot pass through	A02 2 (2)

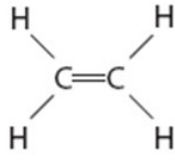
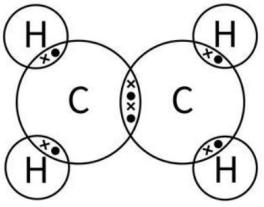


Question number	Answer	Mark
1(a)	C Na^+ is the only correct answer. A (brick red), B (green blue) and D (red) are not correct as these ions do not give a yellow flame.	(1) A01 2 MCQ

Question number	Answer	Mark
1(b)(i)	C $\text{C}_7\text{H}_5\text{N}_3\text{O}_6$ is the only correct answer. A and B are incorrect as they have too few carbons; D is incorrect because it has too many hydrogens	(1) A02 1

Question number	Answer	Additional Guidance	Mark
1(b)(ii)	(they are) explosive / can explode	allow 'blows up' ignore other hazards such as toxic	(1) A03-3



Question number	Answer	Additional Guidance	Mark
1(c)	 (2) or $>C=C<$ (1) then rest of molecule correct (1)	allow 'h' allow dot and cross diagram:  (2) 4 electrons between 2 carbon atoms (1) rest of molecule correct (1) in both cases, MP2 depends on MP1 ignore bond angles	(2) A03-2
Question number	Answer	Additional Guidance	Mark
1(d)	1403 nm ³	allow 1400	(1) A02-1

Total for Question 1 = 6 marks



Question number	Answer	Additional guidance	Mark
1(a)	- heat remaining solid/ heat it for longer / heat it again (1) - and determine mass (1) - repeat until mass after heating stays the same (1)	allow heat to a constant mass (3) allow remove sample (1) add acid (1) no fizz (1)	(3) AO3

Question number	Answer	Additional guidance	Mark
1(b)	$\frac{1.63}{1.86}$ (1) (= 0.876) 0.876×100 (1) (= 87.6 (%))	award full marks for correct final answer without working allow 2 or more sig figs MP2 depends on MP1	(2) AO2

Question number	Answer	Additional guidance	Mark
1(c)	blue flame: hot(test) / very hot (1) lid: to stop {zinc oxide/ product} escaping (1)		(2) AO2

(Total for question 1 = 7 marks)



Question number	Answer	Mark
3(a)(i)	B 2.8 A is incorrect as there are too few electrons C and D are incorrect as there are too many electrons	(1) AO1-1

Question number	Answer	Additional guidance	Mark
3(a)(ii)	an explanation linking SOLID - has an {(ionic) lattice / ions held by strong (electrostatic) attractions} (1) - so the ions {cannot move / are fixed / just vibrate} (1) SOLUTION - in solution the ions {can move / are free} (1)	allow giant structure / regular arrangement / regular structure for lattice allow atoms / (charged) particles in MP1 only ignore electrons for MP1 reject molecules / elements reject electrons allow liquid for solution reject electrons reject intermolecular forces	(3) AO2-1

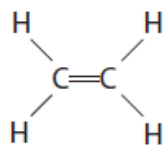


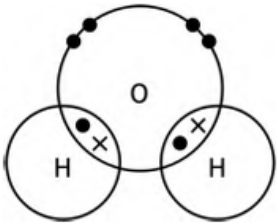
Question number	Answer	Additional guidance	Mark
3(b)	43(.4) with or without working scores 3 $2 \times 23 + 12 + 3 \times 16 = 106$ (1) $\frac{46}{106} = 0.4339622642$ (1) $0.4339622642 \times 100 = 43.4$ (1)	43.39622642 rounded correctly to 2 or more sig. fig. scores 3 if M_r incorrect, must show working to allow ECF on MP2 and MP3 $\frac{46}{106}$ attempt of $M_r \text{ Na}_2\text{CO}_3$ $\frac{23 \text{ or } 46}{106} \times 100$ attempt of $M_r \text{ Na}_2\text{CO}_3$ the following common answers with working are awarded 21.69811321 rounded correctly to 2 or more sig. fig. scores 2 76.6666667 rounded correctly to 2 or more sig. fig. scores 2 48.11320755 rounded correctly to 2 or more sig. fig. scores 1	(3) AO2-1

Total for question 03 = 7 marks



Question number	Answer	Additional guidance	Mark
3(a)(i)	alkane(s)	ignore saturated hydrocarbons reject alkenes	(1) A01-1

Question number	Answer	Mark
3(a)(ii)	B  is the only correct answer A, C and D are not correct because they are not hydrocarbons	(1) A02-1

Question number	Answer	Additional guidance	Mark
3(b)	 a shared pair of electrons (1) rest of molecule correct including correct atomic symbols, if given (1)	allow all dots / all crosses allow unlabelled atoms ignore inner electrons even if incorrect if no circles present, atomic symbols must be present ignore double / triple bonds MP2 depends on MP1	(2) A01-1

Question number	Answer	Additional guidance	Mark
3(c)	CH₄ without working (0) carbon $\frac{0.96}{12}$ (= 0.08) and hydrogen $\frac{0.32}{1}$ (= 0.32) (1) simplest whole number ratio 1 : 4 (1) empirical formula CH₄ (1)	marks awarded for working using the masses from the question MP1 for mass/A_r calculated MP2 for MP1 converted to simplest whole number ratio MP3 for whole number ratio from MP2 correctly converted to formula allow C₁H₄ / CH₄ (3 with working) allow C₄H / C₄H₁ (2 – with working, scores MP2 and 3 only)	(3) A02-1

Total for Question 3 = 7 marks



Question number	Answer	Mark
3(a)(i)	B 2.8 is the only correct answer A is incorrect as there are too few electrons C and D are incorrect as there are too many electrons	(1) AO1-1

Question number	Answer	Additional guidance	Mark
3(a)(ii)	An explanation linking ions (in magnesium carbonate) {cannot move / in a fixed position / <u>held</u> in a lattice / <u>held</u> together by strong electrostatic forces} (1) - magnesium contains {delocalised/free} electrons (1) - electrons (in magnesium) can {flow / move} / are mobile (1)	ignore charged particles throughout allow magnesium carbonate does not have {delocalised / free} electrons reject references to covalent bonding in magnesium carbonate for MP1 allow sea of electrons ignore ions in magnesium ignore carry a {charge / current}	(3) AO2-1

Question number	Answer	Additional guidance	Mark
3(b)	MP1 – relative formula mass MgCO_3 $24.0 + 12.0 + 3 \times 16.0$ (1) (= 84.0) MP2 – division $\frac{24(.0)}{84(.0)}$ (1) (= 0.28571429) MP3 – conversion to percentage $(0.28571429) \times 100$ (= 28.57 / 28.6 / 29) (1)	28.57 / 28.6 / 29 with or without working gains 3 marks. allow ECF for MP2 and MP3 must have 2 or more sig figs for MP2 e.g $M_r = 52$ (0) $\frac{24}{52} = 0.4615$ (1) $\times 100 = 46.2$ (1) MP3 - $\times 100$ mark only if using all 3 pieces of data in calculation allow any number of sig figs except 1 correctly rounded allow $\frac{84(.0)}{24(.0)} \times 100 = 350$ (2)	(3) AO2-1
Question number	Answer	Additional guidance	Mark
3(c)	$\text{MgCO}_3 + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ (1)	reject any number in front of MgCl_2 reject upper case {G / L} / lower case m allow non-subscript 2 but reject superscript 2. ignore correct charges	(1) AO2-1

Total for Question 03 = 8 marks



Question Number	Answer	Additional guidance	Mark
2(a)(i)	35	reject 35.5	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
2(a)(ii)	2.8.7	allow any separator including gaps e.g. 2 8 7	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
2(b)	A description to include • (blue litmus) (first turns) red (1) • (then) bleaches / turns white (1)	allow shades of red and pink but not other colours e.g. red-purple allow colour disappears/goes colourless ignore yellow/colour fades/discolours white then red = 0; just 'goes white' = 1	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
2(c)(i)	A description to include • shared electron(s) (1) • {a pair of / two} (electrons) (1)	allow a diagram for both mark points reference to ionic bonding/ions scores 0 e.g. gains two electrons = 0	(2) AO 1 1



Question Number	Answer	Additional guidance	Mark
2(c)(ii)	An explanation linking any two from - intermolecular forces / forces between molecules (1) (intermolecular) forces {weak / take little energy to break} / little energy to separate molecules (1) - boiling point is below room temperature / has a low boiling point (1)	if answer relates to the breaking of any type of bond first two marking points cannot be scored (but 3rd could) allow 'attractions' instead of 'forces'	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
2(d)	(the solution is) acid(ic) / contains {hydrogen ions/ H ⁺ }	allow pH < 7 allow hydrogen chloride is acidic if incorrect identity of acidic solution then 0 marks (e.g. chlorine is acidic = 0)	(1) AO 2 1

(Total for Question 2 = 9 marks)



Question Number	Answer	Additional guidance	Mark
3(a)	Na : O $\frac{0.92}{23} : \frac{0.32}{16}$ (1) 0.04 : 0.02 OR 2 : 1 (1) (empirical formula from ratio) Na₂O (1)	formula alone scores 0 2nd MP is either for working out correct number of moles OR for finding the correct ratio by dividing by the smaller number from an incorrect first step 3rd MP is for correctly converting a ratio to a formula with whole numbers only example $\frac{23}{0.92} : \frac{16}{0.32}$ 25 : 50 (0) 1 : 2 (1) NaO₂ (1)	(3) AO 2 1

Question Number	Answer	Additional guidance	Mark
3(b)	2Na(s) + 2H₂O(l) → 2NaOH(aq) + H₂(g) 2 Na (1) 2 NaOH (1) s, l, aq, g (1)	allow S, L, AQ, G ignore words	(3) AO 2 1

Question Number	Answer	Mark
3(c)	C is the most reactive The only correct answer is C <i>A is not correct because this is irrelevant</i> <i>B is not correct because this is irrelevant</i> <i>D is not correct because this is irrelevant</i>	(1) AO 2 1

Question Number	Answer	Additional guidance	Mark
3(d)	An explanation linking - atoms become larger/outer electron becomes further from the nucleus / ORA (1) - so outer electron more easily lost / less energy needed to lose outer electron / ORA (1)	allow atomic radius increases / increased shielding effect (by inner complete(electron) shells)/ more (inner) shells/ decreased force of attraction between outer shell electron and nucleus / correct electronic configurations (at least two) reject 'more outer shells' / incorrect forces such as intermolecular	(2) AO 1 1

(Total for Question 3 = 9 marks)

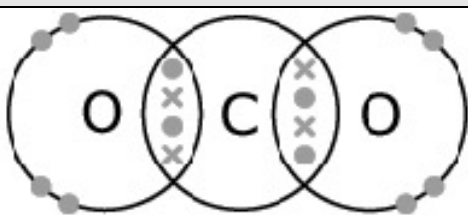


Question number	Answer	Additional guidance	Mark
3(a)(i)	Left : H_2SO_4 (1) Right : CuSO_4 (1)	reject superscript numbers reject superscript numbers incorrect balancing max 1	(2)

Question number	Answer	Mark
3(a)(ii)	$63.5 + 12 + 3 \times 16$ (1) $= 123.5$ (1)	(2)

Question number	Answer	Mark
3(a)(iii)	A bubble the gas through limewater, limewater turns cloudy The only correct answer is A B is not correct because test shows only an acidic gas C is not correct because test shows only that the gas does not support combustion D is not correct because test shows only an acidic gas	(1)

Question number	Answer	Additional guidance	Mark
3(b)	Any TWO from - no more bubbles / fizzing (1) - no further change in colour (1) {solid / copper carbonate} remains at bottom of flask / no more {solid / copper carbonate} dissolves (1)	ignore references to pH allow cloudy/opaque liquid ignore no more copper carbonate will react	(2)

Question number	Answer	Additional guidance	Mark
3(c)	 (2) or • CO₂ with one correct double bond (1) • rest of structure correct (1)	ignore any inner electrons shown remaining electrons on oxygen either singly or paired allow all dots or all crosses 2nd mark dependent on 1st	(2)

Question number	Answer	Additional guidance	Mark
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Question number	Answer	Additional guidance	Mark
2(a)(i)	2.8.8.1	allow any separator including gaps e.g. 2 8 8 1 send to review any diagrams	(1)

Question number	Answer	Mark
2(a)(ii)	B 19 (protons) 20 (neutrons) is the only correct answer. A is incorrect because there are 20 neutrons in the ion C is incorrect because there are 19 protons and 20 neutrons D is incorrect because there are 19 protons in the ion	(1)

Question number	Answer	Additional guidance	Mark
2(b)	An explanation linking - outer (electron) shell (1) (both have) {same number / 1} electron(s) (1)	allow both lose 1 electron (to form ion / to form noble gas configuration) reject same number of outer shells / same number of electrons MP2 depends on MP1	(2)



Question number	Answer	Additional guidance	Mark
2(c)	An explanation linking (intermolecular) forces are weak (1) - little energy needed (to overcome forces) (1)	allow intermolecular bonds / weak bonds between molecules ignore needs a low temperature to break	(2)

Question number	Answer	Additional guidance	Mark
2(d)	2K (s) + F₂ (g) → 2KF (s) 2 K (1) 2 KF (1) s, s (1)	ignore words	(3)



Question number	Answer	Additional guidance	Mark
2(a)	Any two from (in modern model) - atoms are formed of sub-atomic particles (1) - atoms have a nucleus (1) - atoms contain protons (1) - atoms contain neutrons (1) - atoms contain (shells of) electrons (1) - atoms of same element can have different numbers of neutrons / isotopes exist (1)	allow (for Dalton's model) atoms are indivisible ignore statements that are simply the negative of those in the question reject each comparison with 'plum pudding model'	(2) AO1

Question number	Answer	Additional guidance	Mark
2(b)	molecular formula: C ₂ H ₄ (1) empirical formula: CH ₂ (1)	allow H ₄ C ₂ allow H ₂ C allow use of small letter / superscripts / non-subscripts	(2) AO2

Question number	Answer	Additional guidance	Mark
2(c)(i)	Cl ₂ (g) + H ₂ O(l) ⇌ HCl(aq) + HClO(aq) (3)	all three formulae (only) on correct sides of equation with no incorrect balancing (2) two formulae correct regardless of any other error (1) all three state symbols (1) Do not allow incorrect symbols or non subscripts eg CL ²	(3) AO2

Question number	Answer	Additional guidance	Mark
2(c)(ii)	H ⁺	if any other ions included 0 marks	(1) AO1

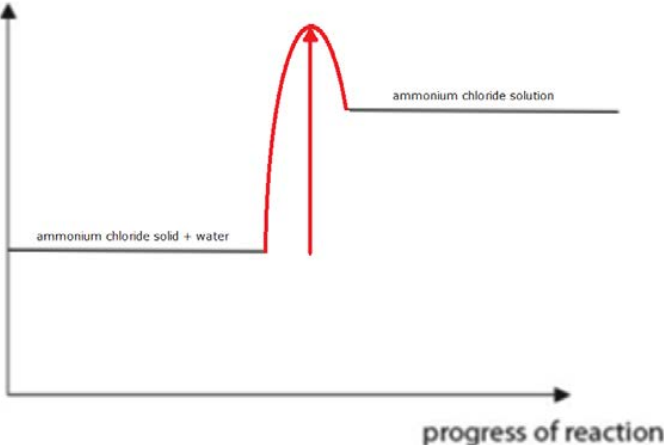
Question number	Answer	Additional guidance	Mark
2(c)(iii)	neutralisation	allow exothermic reject endothermic	(1) AO1

(Total for question 2 = 9 marks)



Question number	Answer	Additional guidance	Mark
2(a)	46.25 / 46 with or without working scores 2 marks $\frac{200}{1000} (1) = 0.200 \text{ (dm}^3\text{)}$ $\frac{9.25}{0.200} (1) = 46.25 / 46$ OR $\frac{9.25}{200} = (0.04625) (1)$ $0.04625 \times 1000 = 46.25 (1)$	answer to 2 or more sig fig	(2) AO2

Question number	Answer	Additional guidance	Mark
2(b)(i)	an explanation linking two of: {ammonium chloride solution/product} has more energy than {ammonium chloride solid and water/reactant} / ora (1) - heat (energy) has increased / energy change is positive (1) (therefore) heat energy has been {absorbed/taken in} (1)	ignore arguments about bond making / bond breaking	(2) AO3

Question number	Answer	Additional guidance	Mark
2(b)(ii)	 (2)	curve from reactants to products with peak higher than product energy (1) arrow labelled activation energy on correct curve (1)	(2) AO2

Question number	Answer	Additional guidance	Mark
2(c)	An explanation linking - ammonium chloride solution conducts electricity and solid ammonium chloride does not conduct electricity (1) - ammonium chloride contains ions (1) - in solution ions can move / in solid ions cannot move (1)	Answer must refer to both solid and solution for full marks	(3) AO3

Total for Question 2 = 9 marks



Question number	Answer	Mark
3(a)	B effervescence is seen is the only correct answer. A, C and D are incorrect as they are not linked to gas production	(1) AO1 2

Question number	Answer	Mark
3(b)	B chlorine is the only correct answer. A, C and D are incorrect because only chlorine bleaches litmus.	(1) AO1 1

Question number	Answer	Additional guidance	Mark
3(c)	2.20 with or without working scores (2) 5(.000) – 2.8(00) = 2.2(00) (1) = 2.20 (1)	reject additional processing for MP1 (e.g 5 – 2.8 = 2.2 then $\frac{2.2}{100} = 0.0220$) does not score MP1 – additional process of dividing by 100 does not score MP2 - using a number not in the question for MP2 final answer must be to 3sf, correct evaluation of expression using only numbers from the question 2.2 / 2.200 scores 1 mark $\frac{5.000}{2.800} = 1.79$ scores 1 mark $\frac{2.800}{5.000} = 0.560$ scores 1 mark [0.56 = 0] 5.000 5.000 × 2.800 = 14.0 scores 1 mark [14 = 0] 5.000 + 2.800 = 7.80 scores 1 mark [7.8 = 0]	(2) AO2 1



Question number	Answer	Additional guidance	Mark
3(d)(i)	An explanation linking: - it has two electrons in outer shell/ it has a full outer shell / OWTTE (1) - so does not {gain/ lose/ transfer/ share} electrons (1)	MP1 – reject if number of electrons in outer shell is stated and not 2 ignore references to protons and neutrons allow helium has two electrons in its (only) shell / helium's (only) shell is full ignore helium does not need to react	(2) AO1 1

Question number	Answer	Additional guidance	Mark
3(d)(ii)	less dense than air	allow less dense than nitrogen allow low density / not (very) dense allow diffuses slowly out of balloon ignore less dense than oxygen ignore it is a gas / light / lightweight / inert/ unreactive/ non-flammable / lighter than air / makes balloon float / it rises/ it floats ignore non-toxic / not poisonous	(1) AO2 1

Question number	Answer	Additional guidance	Mark
3(e)	4.214×10^{24} with or without working scores (2) 2×3.5 (1) (= 7(.0)) $7(.0) \times 6.02 \times 10^{23}$ (1) (= 4.214×10^{24}) OR $3.5 \times 6.02 \times 10^{23}$ (1) (= 2.107×10^{24}) $2 \times 2.107 \times 10^{24}$ (1) (= 4.214×10^{24})	allow any number of sig figs except 1 for full marks allow answer not in standard form	(2) AO2 1

(Total for question 3 = 9 marks)



Question number	Answer	Additional guidance	Mark									
2(a)(i)	<table><tr><td>proton</td><td>+1 (1)</td><td>1</td></tr><tr><td>neutron</td><td>0</td><td>1 (1)</td></tr><tr><td>electron</td><td>-1 (1)</td><td>negligible</td></tr></table>	proton	+1 (1)	1	neutron	0	1 (1)	electron	-1 (1)	negligible	allow 1(+) / +, reject -1 reject +1, -1 allow (1)-, reject +1 / 1	(3) AO1 1
proton	+1 (1)	1										
neutron	0	1 (1)										
electron	-1 (1)	negligible										

Question number	Answer	Additional guidance	Mark
2(a)(ii)	A description including 10 protons (1) 10 electrons (1)	allow {'how many' / 'number of'} protons allow {'how many' / 'number of'} electrons / (electronic configuration) 2.8 allow 'number of protons and (number of) electrons' (2) ignore any reference to location of subatomic particles ignore neutrons	(2) AO1 1

Question number	Answer	Additional guidance	Mark
2(a)(iii)	An explanation linking <u>same number of</u> protons and electrons (1) (so) the (+ and -) <u>charges</u> cancel (1)	ignore reference to neutrons allow <u>charge</u> (on neon atom) = 0 +10 plus -10 = 0 (2)	(2) AO2 1

Question number	Answer	Additional guidance	Mark
2(b)	$90.48 \times 20 + 0.27 \times 21 + 9.25 \times 22 = 2018.77 \text{ (1)}$ $\frac{2018.77}{100} = 20.1877 \text{ (1)}$	20.2 / 20.19 with or without working scores 2 marks 20.18 / 20.187 with or without working scores 1 mark 2018.77 with or without working (1) allow 90.48x20 + 0.27x21 + 9.25x22 unevaluated (1) or 90.48x0.20 + 0.27x0.21 + 9.25x 0.22 unevaluated (1) incorrect / early rounding loses MP2 allow 3 or more sf	(2) AO2 1

Total for Question 2 = 9 marks



Question number	Answer	Additional guidance	Mark
5(a)	An explanation linking - period 2 (1) (because) 2 (electron) shells (1)	accept 'row', <u>horizontal</u> line allow electron configurations for each element ignore same number of shells reject 2 outer shells if no other mark awarded period = number of electron shells (1)	(2) AO1 1

Question number	Answer	Additional guidance	Mark
5(b)(i)	An explanation linking - simple covalent / simple molecular (1) (because) <u>weak</u> intermolecular forces (of attraction) (1) (so) only a small / low amount of {energy/heat} is needed (to break these forces) (1)	reject ionic / ions for MP1 & MP2 only ignore covalent alone allow weak intermolecular bonds reject weak covalent bonds reject hydrogen bonds reject weak (intermolecular) forces between bonds ignore less {energy / heat} reject breaking {covalent / ionic} bonds	(3) AO1 1

Question number	Answer	Mark
5(b)(ii)	C less less is the only correct answer A is incorrect as the particles will have less energy B is incorrect as the particles will move less D is incorrect as the particles will have less energy and move less	(1) AO1 1

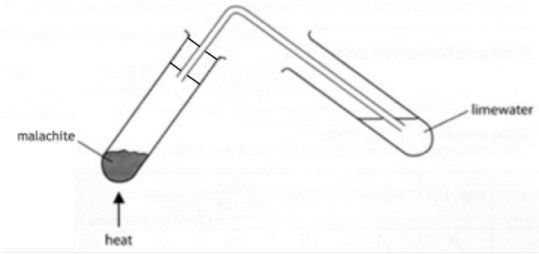


Question number	Answer	Mark
5(b)(iii)	B Fractional distillation A, C and D are not correct as they would not separate oxygen and nitrogen	(1) AO2 2

Question number	Answer	Additional guidance	Mark
5(c)	$\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$ (2) all formulae correct (1) balancing of <u>correct formulae</u> for the reaction (1)	do not penalise incorrect cases accept = / $\rightleftharpoons$ ignore state symbols reject superscripts allow multiples	(2) AO2 1

Total for Question 5 = 9 marks



Question number	Answer	Mark
6(a)(i)	C  B and D are not correct as the carbon dioxide would escape A is not correct as the bung would pop out and the carbon dioxide would escape	(1) AO3 3b

Question number	Answer	Additional guidance	Mark
6(a)(ii)	calcium carbonate	allow CaCO_3	(1) AO2 2

Question number	Answer	Additional guidance	Mark
6(a)(iii)	formula mass of $\text{Cu}_2\text{CO}_3(\text{OH})_2$: $(63.5 \times 2) + 12 + (16 \times 3) + ((16+1) \times 2) = 221$ (1) $\frac{22.1}{221} = 0.1$ (1) $0.1 \times 2 = 0.2$ (1) $0.2 \times 79.5 = 15.9$ (1)	15.9 gains 4 marks with or without working allow ECF throughout alternative method: $(63.5 \times 2) + 12 + (16 \times 3) + ((16+1) \times 2) = 221$ (1) mole ratio 1 mole: 2 moles CuO (1) 221g malachite : $2 \times 79.5 = 159\text{g CuO}$ (1) 22.1 malachite : $159 \times 22.1/221 = 15.9\text{g}$ (1) 31.8 (g) scores 3 7.95 (g) scores 3	(4) AO2 1



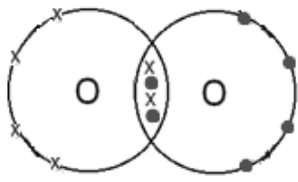
Question number	Answer	Additional guidance	Mark
6(b)	comments to include three from: method 1 - mixing - strength - means more will react OR method 2 - not mixing - weakness - less will react (1) method 1 and / or method 2 - quantity of carbon not given – weakness - may not be in excess (1) method 1 - use of a metal crucible - strength - conducts more heat (1) method 1 - use of a metal crucible – weakness – metal crucible might react (1) method 1 – transfers reactants between containers – weakness – loss of reactants (1) method 1 and / or method 2 - roaring flame - strength - gives enough energy for reaction to occur (1) method 1 and / or method 2 – separation of copper – weakness - no method given (1)	Note: implication of strength/weakness and method can be obtained from the way in which the candidate gives the answer eg using the metal crucible is better as it conducts more heat Only Method 1 is using the metal crucible so the method has been identified. 'is better' would be another way of saying that it is a strength	(3) A03 1

Total for Question 6= 9 marks



Question Number	Answer	Mark
8(a)(i)	B -78 -33 does not conduct The only correct answer is B A is not correct because simple molecular, covalent substances do not have high mpt and bpt C is not correct because ammonia is a gas at room temperature and does not conduct D is not correct because simple molecular, covalent substances do not have these properties	(1) AO 2 1

Question Number	Answer	Additional guidance	Mark
8(a)(ii)	$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$ (2) left hand side formulae (1) balancing of correct formulae (1)	accept multiples allow = or $\rightleftharpoons$ in place of $\rightarrow$ ignore state symbols even if incorrect do not allow N2, n2, etc	(2) AO 2 1

Question Number	Answer	Additional guidance	Mark
8(b)	 (2)	double bond (1) rest of molecule (1) (dependent on correct double bond) ignore atomic symbol allow all x or ● ignore inner shells of electrons even if incorrect	(2) AO 1 1

Question Number	Indicative content	Mark
8(c) *	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. - in all structures the carbon atoms bonded by single covalent bonds - shared pair of electrons - strong bonds - in diamond each carbon atom joined to four others - diamond has a giant covalent {structure/lattice} - graphene has a giant covalent {structure/lattice} - fullerene has a molecular structure - in graphene and fullerene each carbon atom joined to three others - in diamond and graphene many bonds need to be broken to melt - need lots of energy - therefore very high melting / sublimation points - in fullerene weak forces between molecules - less energy needed to separate molecules - fullerene has the lowest melting / sublimation point - because diamond and graphene have lots of strong covalent bonds so both are very strong materials - because weak forces between fullerene molecules so its strength is very low - in diamond there are no free electrons - so diamond does not conduct - in graphene and fullerene each carbon atom has one free electron - hence delocalised electrons - graphene conducts electricity - fullerene only conducts electricity across the surface of the molecule - no/little movement of electrons between molecules - so fullerene is poor conductor of electricity (/ semi conductor)	(6) AO 1 1
Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas, enquiry, techniques and procedures lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and

		fully devolved. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully devolved. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Total for question 8 = 11 marks



Question number	Answer	Additional guidance	Mark
6(a)	final answer of 47.91 / 47.9 with or without working (3) All percentages given as: Ti-46 = 8 Ti-47 = 7 Ti-48 = 75 Ti-49 = 6 Ti-50 = 4 (1) 46 x 8 = (368) 47 x 7 = (329) 48 x 75 = (3600) 49 x 6 = (294) 50 x 4 = (200) (= 4791) (1) $\frac{4791}{100} = 47.91$ (1)	48 without working = 0 allow 7-7.5 for Ti-47 (7.5 gives 48.145) allow ECF for MP2 [Note: answer of 48 can score MP3 but must have correct working] Allow ECF but answer for MP3 must be between 46 and 50	(3)

Question number	Answer	Additional guidance	Mark
6(b)(i)	D oxidation Answers A and B are physical processes rather than chemical reactions. C is wrong because it is not neutralisation.		(1)

Question number	Answer	Additional guidance	Mark
6(b)(ii)	A description linking any three from: - lift lid from time to time/ leave small gap between crucible and lid (1) - find mass (of crucible, lid and product) (1) {repeat / heat} to constant mass (1) - final mass – start mass = mass of oxygen (1)	allow 'weigh' allow find the change in mass	(3)

Question number	Answer	Additional guidance	Mark
6 (c)	$\frac{2.24}{56.0} = 0.04$ and $\frac{0.96}{16.0} = 0.06$ (1) $1 : 1.5 / 2 : 3$ (1) Fe_2O_3 (1) $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$ (1)	allow ECF for MP2 and MP3 only. allow $\frac{2.24}{56.0} = 0.04$ and $\frac{0.96}{32.0} = 0.03$ (1) $1.33 : 1 / 4 : 3$ (1) Fe_2O_3 (1) $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$ (1) NOTE: equation alone gains no marks.	(4)

Question number	Answer	Additional guidance	Mark
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Question number	Answer	Additional guidance	Mark
8(a)(i)	A 20 20 is the only correct answer B, C and D are incorrect because calcium does not have 40 protons; calcium does not have 60 neutrons; calcium does not have 60 protons		(1)

Question number	Answer	Additional guidance	Mark
8(a)(ii)	an explanation linking - period 4 (1) - four shells of electrons (1)	reject four <u>outer</u> shells	(2)

Question number	Answer	Additional guidance	Mark
8(b)(i)	both form a hydroxide	allow formulae ignore observations	(1)

Question number	Answer	Additional guidance	Mark
8(b)(ii)	potassium {forms cations / loses (outer) electron} more easily ORA	ignore speed of electron loss / sizes of atoms / number of shells / distance of electrons from nucleus / number of electrons in outer shell	(1)



Question number	Indicative content	Mark
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 (3 marks) and A02 (3 marks) STRUCTURE - calcium chloride is an ionic compound with lattice of positive and negative ions - calcium is a metal and so has a metallic structure of delocalised electrons and {calcium/Ca^{2+} ions} - chlorine is a simple molecular covalent compound MELTING POINT - there are strong electrostatic forces of attraction/ionic bonds between the ions in calcium chloride - a large amount of heat energy is required to break the electrostatic forces (so calcium chloride has a high melting point) - strong electrostatic forces between ions and delocalised electrons in calcium - a large amount of heat energy is required to break the electrostatic forces (so calcium has a high melting point) - chlorine has weak forces of attraction between its molecules and these weak forces only take a small amount of energy to break down (so chlorine has a low melting point) CONDUCTIVITY WHEN SOLID - ions are fixed in a lattice and so cannot move (therefore calcium chloride cannot conduct a current) - delocalised electrons in metallic structure can move to carry a current (so calcium can conduct a current) - there are no delocalised electrons/ions/charged particles/overall charges in chlorine molecules and (so chlorine cannot conduct a current) CONDUCTIVITY WHEN MOLTEN - however, when molten ions are free to move (and therefore molten calcium chloride can conduct a current) - delocalised electrons in metallic structure can move to carry a current (so calcium can conduct a current) - there are no delocalised electrons/ions/charged particles/overall charges in chlorine molecules and (so chlorine cannot conduct a current) all incorrect information/explanations should be ignored reject contradictory explanations	(6)



Level	Mark	Additional Guidance	General additional guidance Eg - At each level, as well as content, the scientific coherency of what is stated backed up by planning detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Three structures named OR one structure described OR one property explained for one substance	<u>Possible candidate responses</u> - calcium is metallic, chlorine is a molecule (1) - calcium chloride is ionic with positive calcium ions and negative chloride ions (2) - calcium is metallic, chlorine is covalent, calcium chloride is ionic (2) - calcium is metallic it conducts when solid as it has mobile electrons (2)
Level 2	3–4	<u>Additional guidance</u> Three structures described or three properties explained.	<u>Possible candidate responses</u> - calcium has a metallic lattice of cations and delocalised electrons. Chlorine is made of simple molecules with weak intermolecular forces between them (3) - calcium has a metallic lattice of cations and delocalised electrons. Chlorine is made of simple molecules with weak intermolecular forces between them, this means that chlorine has a low melting point because little energy is needed to overcome these forces. (4)
Level 3	5–6	<u>Additional guidance</u> Six properties explained.	<u>Possible candidate responses</u> - calcium chloride has strong electrostatic forces between the ions so a high melting point and these ions are fixed in a lattice so the solid does not conduct. When melted, the ions are free to move and so the liquid does conduct. There are weak intermolecular forces between chlorine molecules so the melting point is low.(5) - calcium chloride has strong electrostatic forces between the ions so a high melting point and these ions are fixed in a lattice so the solid does not conduct. When melted, the ions are free to move and so the liquid does conduct. There are weak intermolecular forces between chlorine molecules so the melting point is low and molecules are uncharged so chlorine does not conduct electricity when solid or liquid (6)



Question number	Answer	Mark
7(a)	D nitrogen, oxygen, argon is the only correct answer A is not correct because nitrogen is the most common gas B is not correct because hydrogen is not the third most common gas C is not correct because nitrogen is the most common gas	(1)

Question number	Answer	Additional guidance	Mark
7(b)(i)	mass argon = $79.120 - 78.639 (= 0.481 \text{ (g)})$ (1) density = $0.481/250 = 0.001924 \text{ (gcm}^{-3}\text{)}$ (1)	allow ECF allow 0.002, 0.0019, 0.00192, 0.001924..... for (2)	(2)

Question number	Answer	Additional guidance	Mark
7(b)(ii)	An explanation including - the volume of the flask is more than 250 cm^3 / more argon is in the flask than up to the line (1) - measure the whole volume of the flask (e.g. fill with water and measure volume of water) (1)	allow use a flask/ container of known volume	(2)

Question number	Answer	Additional guidance	Mark
7(c)	helium, neon, argon, krypton (2)	krypton, argon, neon, helium (1) if order correct except that two adjacent elements transposed allow 1 allow formulae	(2)



Question number	Indicative content	Mark
7(d)	$2 \text{CaCO}_3 + \text{Mg}^{2+} \rightarrow \text{CaMg}(\text{CO}_3)_2 + \text{Ca}^{2+}$ 2 (1) Mg²⁺ (1)	(2)

Question number	Indicative content	Additional guidance	Mark
7(e)	An explanation to include Q is early atmosphere (0) because - limewater ppt faster so contains { more/ large amount of } carbon dioxide (1) - splint goes out so { little/no oxygen } (1)	If P given then (0) If neither P nor Q stated they must be clearly referring to Q to score.	(2)



Question number	Answer	Mark
9(a)	number of protons = 52 (1) number of neutrons = 125 - number of protons (1) (= 73)	(2) AO2

Question number	Answer	Additional guidance	Mark
9(b)(i)	(isotopes of same element) have the same number of protons	allow same number of electrons reject same number of neutrons	(1) AO1

Question number	Answer	Additional guidance	Mark
9(b)(ii)	total mass of 100 atoms = $(28 \times 92) + (29 \times 5) + (30 \times 3)$ (1) (= 2811) relative atomic mass = $\frac{2811}{100}$ (= 28.11) (1)	correct final answer without working (2) final answer must contain at least one decimal place	(2) AO2



Question number	Indicative content	Mark
*9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. Substance A • giant ionic structure • (high melting point) strong electrostatic attractions between ions • due to a lot of energy required to overcome strong forces • (electrical conductivity) in solid ions strongly attracted in lattice ions cannot move, so poor conductor when solid • when molten ions free to move, so good conductor when molten Substance B • metallic structure • (high melting point) strong attraction between metal ions and delocalised electrons • due to a lot of energy required to overcome strong forces between particles in solid • (electrical conductivity) in solid delocalised electrons • free to move throughout metallic lattice, so good conductor when solid • delocalised electrons and ions free to move when molten, so good conductor when molten Substance C • covalent simple molecular • (low melting point) weak intermolecular forces/ attractions between molecules • little energy needed to separate molecules, so low melting point • (electrical conductivity) in solid and when molten no delocalised electrons or ions to carry charge, so poor conductor	(6) AO1 / AO3



Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated backed up by detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> Identifies correct structure types OR explains a property of one substance	<u>Possible candidate responses</u> • A – giant ionic, B – metallic, C – simple molecular • High mp (for A or B) due to strong bonds (between atoms / ions) • Low mp for C due to weak intermolecular forces • A conducts when molten – ions can move • B conducts when solid / molten – electrons can move • C does not conduct – no free ions or electrons can't move
Level 2	3–4	<u>Additional guidance</u> Identifies correct structure type for one substance AND explains at least one property of that substance OR explains at least two properties	<u>Possible candidate responses</u> • A – giant ionic AND high mp due to strong bonds between ions AND poor conductor when solid – ions not free to move; good conductor when molten – ions free to move • B – metallic AND high mp due to strong bonds between {atoms / metal ions and delocalised electrons} AND good conductor when solid and molten – electrons free to move • C – simple molecular AND low mp due to weak intermolecular forces AND poor conductor when solid and molten – no ions and electrons not free to move
Level 3	5–6	<u>Additional guidance</u> Identifies correct structure types and explains properties for least two substances	<u>Possible candidate responses</u> • A – giant ionic AND high mp due to strong bonds between ions AND poor conductor when solid – ions not free to move; good conductor when molten – ions free to move AND / OR • B – metallic AND high mp due to strong bonds between {atoms / metal ions and delocalised electrons} AND good conductor when solid and molten – electrons free to move AND / OR • C – simple molecular AND low mp due to weak intermolecular forces AND poor conductor when solid and molten – no ions and electrons not free to move



Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Deconstructs scientific information but understanding and connections are flawed. An unbalanced or incomplete argument that provides limited synthesis of understanding. (AO3)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Deconstructs scientific information and provides some logical connections between scientific concepts. An imbalanced argument that synthesises mostly relevant understanding, but not entirely coherently (AO3)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Deconstructs scientific information and provide logical connections between scientific concepts throughout. A balanced, well-developed argument that synthesises relevant understanding coherently. (AO3)

(Total for question 9 = 11 marks)



Question number	Answer	Mark
8 (a)	D 82% is the only correct answer A is not correct as this is percentage of hydrogen in ammonia B is not correct as this is the mass of hydrogen multiplied by the mass of nitrogen C is not correct as this is the mass of hydrogen multiplied by the mass of ammonia	(1) AO2-1

Question number	Answer	Mark
8 (b)(i)	C arrow R is the only correct answer A, B and D are incorrect because they do not show the activation energy	(1) AO2-1



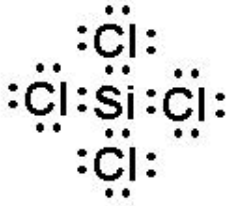
Question number	Answer	Additional guidance	Mark
8 (b)(ii)	A description to include: any two for 1 mark all three for 2 marks - energy is taken in breaking bonds (in the reactants) - energy is given out making bonds (in the products) - more energy is given out than taken in	allow breaking bonds is endothermic allow forming bonds is exothermic allow less energy taken in than given out ignore products have less energy than reactants ignore reaction is exothermic / gives out energy alone for energy taken in allow : absorbed / needed / used /required for energy given out allow: released	(2) AO1-1

Question number	Answer	Additional guidance	Mark
8 (b)(iii)	-76 with or without working scores 4 BROKEN $944 + (3 \times 436) = 2252$ (1) MADE $2 \times (3 \times 388) = 2328$ (1) DIFFERENCE (broken) 2252 – (made) 2328 (1) ANSWER = - 76 (1)	allow ecf ignore sign ignore sign MP3 for difference between their 2 values MP4 for correct evaluation, including correct sign, of <u>bonds broken – bonds made</u> using their values (+)76 scores 3 (+)1088 scores 3 (+)604 scores 3 (+)1476 scores 3 -1088 scores 2 -604 scores 2	(4) A02-1



Question number	Answer	Additional guidance	Mark
8 (c)	an explanation linking AMMONIA ammonia {is simple molecular / has weak intermolecular forces} SILICON DIOXIDE silicon dioxide is {giant covalent / has strong covalent bonds} (1) DIFFERENCE more {heat / energy} to break bonds in silicon dioxide than intermolecular forces in ammonia	Mark independently allow weak {forces / bonds} <u>between molecules</u> allow <u>intermolecular</u> bonds reject anything ionic for MP1 allow macromolecular reject anything ionic / simple molecular for MP2 in MP3 mark is for saying more energy/ heat needed to break the 'attractions' <u>in silicon dioxide</u> than in ammonia. The 'attractions' do not have to be correct. allow the energy required to break the attractions in ammonia is small and the energy required to break the attractions in silicon dioxide is large	(3) AO1-1



Question number	Answer	Additional guidance	Mark
8(a)(i)	 (2) all four bond pairs (1) rest of molecule correct (1)	MP2 dependent on MP1 electrons may be shown as dots or crosses or any combination electrons can be shown in any overlapping part of intersecting shells allow atoms unlabelled ignore inner shells, whether correct or otherwise	(2) AO2-1
8(a)(ii)	An explanation linking - weak forces between molecules/ intermolecular forces (1) - little {heat / energy} needed (1)	MP2 can score even if MP1 not scored allow intermolecular bonds / bonds between molecules reject forces between {atoms / bonds / ions} for MP1 only ignore less energy needed / 'easy' to break ignore low temperature	(2) AO1-1

Question number	Answer	Mark
8(b)	D 693 1340 is the only correct answer A has a boiling point showing a liquid at room temperature B and C although solids at room temperature would melt very easily	(1) AO2-1

Question number	Indicative content	Mark
*8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (6 marks) electrical conductivity • diamond – all 4 outer shell electrons of carbon form (covalent) bonds • each carbon joined to four other carbon atoms • no free electrons available for electrical conductivity • graphite – 3 outer shell electrons of carbon form (covalent) bonds • each carbon joined to three other carbon atoms • 1 free electron for each carbon atom • delocalised electrons • are between the layers • delocalised electrons move to carry current hardness • diamond - strong (covalent) bonds • between all carbon atoms • in 3D lattice / giant (covalent) lattice / tetrahedral structure • requires a very high amount of energy to overcome • graphite – giant (covalent) lattice • strong (covalent) bonds between all carbon atoms within each layer • weak forces between layers / allow weak intermolecular forces • layers can slide	(6) AO1-1



Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	- Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	- Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)



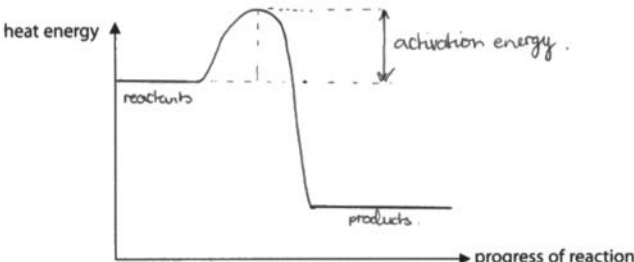
Level	Mark	Descriptor	Possible candidate response
Read whole answer. Ignore all incorrect / irrelevant material and reject any contradictory material.			
	0	No rewardable material.	
Level 1	1–2	<u>Additional Guidance</u> explains fully one property OR describes structure of diamond or graphite	<u>Possible candidate response</u> - Diamond has strong bonds (1) - Diamond is hard because the strong covalent bonds need a lot of energy to break (2) - Graphite has layers of carbon atoms with delocalised electrons between layers (2)
Level 2	3–4	<u>Additional Guidance</u> explains fully two properties OR describes fully structure of diamond and graphite	<u>Possible candidate response</u> - Graphite conducts electricity because the delocalised electrons can move but diamond does not because it does not have free electrons (3) - Graphite conducts electricity because the free electrons can move between layers and graphite is soft because the layers of atoms can slide because of weak forces between the layers (4) - Graphite has layers of carbon atoms with delocalised electrons between layers and diamond has a giant lattice with each carbon atom bonded to four others (4)
Level 3	5–6	<u>Additional Guidance</u> explains fully three properties using the structure and bonding of diamond and graphite	<u>Possible candidate response</u> - Graphite has layers of carbon atoms so it is flaky because the layers slide; and diamond has a giant lattice with each carbon atom bonded to four others with strong bonds, so it is hard because the carbon atoms need energy to separate and does not conduct because there are no free electrons (5) - Graphite has layers of carbon atoms held with weak intermolecular forces with delocalised electrons between layers so it is flaky because the layers easily slide off and conducts electricity because the free electrons move; and diamond has a giant lattice with each carbon atoms bonded to four others, so it is hard because the covalent bonds between the carbon atoms need a lot of energy to break (6)

Total for question 08 = 11 marks



Question number	Answer	Additional guidance	Mark
7(a)	periodic table is in atomic number order/ argon has atomic number 18 and potassium 19/ argon has 18 protons and potassium has 19 / (potassium has) higher atomic number	allow potassium (atoms) have more protons ignore electrons and neutrons allow proton number for atomic number ignore potassium is in group 1 and argon is in group 0	(1) AO2 1

Question number	Answer		Mark
7b(i)	KOH AND H ₂	allow formulae in either order allow KHO ignore HOK / OHK / HKO / OKH allow incorrect case and subscript reject 2H	(1) AO1 1

Question number	Answer	Additional guidance	Mark
7(b)(ii)	 products line (ends to) right of reactants line AND lower (1)	allow labels of names of reactants and products allow unlabelled reactants and products but reject if labels reversed allow energy at start/ end as labels	(2) AO2 1

Question number	Answer	Additional guidance	Mark
7(c)	an explanation linking • bond breaking {endothermic/ requires energy} (1) • bond forming {exothermic/ releases energy} (1) • less energy is released (forming bonds) than is required (to break bonds) (1)	allow heat for energy ignore number of bonds/ more bond breaking etc. MP3 dependant on scoring MP1 AND MP2 energy needed to break bonds is more than energy released forming bonds (3)	(3) AO1 1

Question number	Answer		Mark
7(d)	-55 with or without working scores 4 BROKEN: $612 + 4(412) + 431 = 2691$ (1) MADE: $412 + 348 + 338 + 4(412) = 2746$ (1) DIFFERENCE: $2691 - 2746$ (1) ANSWER: = - 55 (1)	allow positive or negative allow positive or negative allow ecf for +broken -made allow ecf for addition or subtraction of 2 <u>calculated</u> values (working required) using bond energies	(4) AO2 1



	OR BROKEN: $612 + 431 = 1043$ (1) MADE: $412 + 348 + 338 = 1098$ (1) DIFFERENCE: $1043 - 1098$ (1) ANSWER: = - 55 (1)	allow positive or negative allow positive or negative allow ecf for +broken -made allow ecf for addition or subtraction of 2 <u>calculated</u> values (working must be seen) using bond energies with or without working, final answers of: -55 scores 4 (+) 55 scores 3 (+)293 scores 3 (+)705 scores 3 -486 scores 3 (+)486 scores 2	
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Total for question 7 = 11 marks



Question number	Answer	Additional guidance	Mark
9(a)	An answer linking any two from - so that the ammonia can {react with / dissolve in} the water (1) (so) colour change seen (1) - hydroxide ions form (1)	allow 'dampness' for water allow ammonia is absorbed by water ignore ammonia condenses on / sticks to paper ignore any colour even if incorrect but reject bleach for MP2 allow alkaline / basic solution formed	(2) AO2 2

Question number	Answer	Additional guidance	Mark
9(b)(i)	An explanation linking - both reactions happen at the same rate (1) (because) there is no overall change in the system (1)	ignore both reactions happen at the same time allow total amount/concentration of products and reactants are <u>constant</u> ignore reference to amounts/concentration of products and reactants being <u>equal</u> ignore closed system	(2) AO1 1

Question number	Answer	Mark
9(b)(ii)	A 200 1000 B , C and D are incorrect as a temperature of 200°C and a pressure of 1000 would give the highest percentage yield of ammonia.	(1) AO3 1



Question number	Answer	Additional guidance	Mark
9(b)(iii)	An explanation linking: - equilibrium would move {backwards / to left} (1) (because) there are more moles on {left hand side / reactants} (1)	allow references to lower yield / less product formed / more reactant formed. allow particles / molecules for moles allow RA throughout if no other mark scored, 'equilibrium shifts to the side with more moles / molecules' scores 1 mark. ignore all references to temperature / heat / exothermic / endothermic. ignore all references to rate.	(2) AO1 1

Question number	Answer	Additional guidance	Mark
9(c)	An explanation linking: - ammonia and hydrogen chloride / gases form (in the forward reaction) (1) - the gas / gases rise to the top of the container (1) - where it is cooler / the gas(es) cool (1) - the reverse reaction takes place / reaction forms {white solid/ammonium chloride} (at the top of tube) (1)	allow formula throughout allow endothermic reaction takes place reject ammonium chloride gas / hydrochloric acid forms for MP1 only allow exothermic reaction takes place allow hydrogen chloride and ammonia react (at the top of the tube)	(4) AO3 2

Total for Question 9 = 11 marks



Question number	Answer	Mark
8(a)	D iodine: dark-grey solid bromine: red-brown liquid Is the only correct answer A, B and C all contain at least one incorrect piece of information	(1) AO1

Question number	Answer	Additional guidance	Mark
8(b)	Formula mass $\text{POCl}_3 = (31 + 16 + 3 \times 35.5)$ (1) (= 153.5) % Cl = $\frac{3 \times 35.5}{153.5} \times 100$ (1) (= 69.4%)	allow answers to 2 or more sig figs allow ecf on formula mass allow % Cl = $\frac{35.5}{82.5} \times 100 = 43\%$ (1)	(2) AO2



Question number	Answer	Additional guidance	Mark
8(c)	mass of chlorine = $19.05 - 8.40$ (1) (= 10.65 g) EITHER moles iron = $\frac{8.40}{56}$ and moles chlorine = $\frac{10.65}{35.5 \times 2}$ (1) (= 0.15) (= 0.15) ratio 1:1 so equation A represents reaction (1) OR moles iron = $\frac{8.40}{56}$ and moles chlorine atoms = $\frac{10.65}{35.5}$ (1) (=0.15) (=0.30) Ratio 1:2 for formula of product FeCl_2 so equation A (1) OR formula mass $\text{FeCl}_2 = 56 + 2 \times 35.5$ (=127) (1) moles Fe = $\frac{8.4}{56}$ and moles $\text{FeCl}_2 = \frac{19.05}{127}$ (1) (=0.15) (=0.15) ratio 1:1 so equation A represents reaction (1)	allow not finding mass of chlorine initially: moles iron = $\frac{8.40}{56}$ (=0.15) <u>and</u> moles chlorine atoms = $\frac{19.05}{35.5}$ (=0.537) (1) simplest ratio: $\frac{0.15}{0.15} : \frac{0.537}{0.15}$ or 1 : 3.58 allow: mass of chlorine = $19.05 - 8.40$ (1) (= 10.65 g) for reaction A, mass of chlorine needed $\frac{2 \times 35.5}{56} \times 8.4 = 10.65$ (g) (1) mass of chlorine needed = mass of chlorine reacted, so equation A represents reaction (1) accept calculations based on expected mass of FeCl_2 or mass of FeCl_3 to show which reaction is taking place	(3) AO3



Question number	Indicative content	Mark
8(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. • group 1 metals form positive ions • outer electron lost • further down the group outer electron more easily lost • due to electron shell further from nucleus OR greater electron shielding • so lower nuclear attraction • group 1 metal becomes more reactive • order of reactivity $\text{Li} < \text{K} < \text{Rb}$ • group 7 elements form negative ions • gains electron to complete outer shell • further down the group electron is less easily gained • due to outer electron shell further from nucleus OR greater electron shielding • so lower nuclear attraction • group 7 element becomes less reactive • order of reactivity $\text{F} > \text{Br} > \text{I}$ • most reactive pair likely to be potassium + fluorine with suitable justification (K low in group 1 and F is at the top of group 7) • allow rubidium + iodine with justification (Rb lower in group 1 than K and so more reactive)	(6) AO1 AO2



Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated backed up by detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> States some simple facts about group 1 OR group 7 elements OR Correctly identifies most violent reaction(s) with simple reasoning	<u>Possible candidate responses</u> - Group 1 elements lose 1 electron from outer shell. - Group 7 elements are more reactive up the group. - The most violent reaction could be potassium with fluorine as fluorine is the most reactive group 7 element (2)
Level 2	3–4	<u>Additional guidance</u> Correctly identifies most violent reaction(s) with a simple justification OR A simple explanation of the reactivity of group 1 AND group 7 elements. OR A detailed explanation of the reactivity of group 1 OR group 7 elements.	<u>Possible candidate responses</u> - The most violent reaction could be rubidium with iodine as rubidium is the most reactive of the group 1 elements given. Rubidium is so reactive because it loses its outer electron easily. - Group 1 elements are more reactive down the group as the distance between the nucleus and the outer electron is further, so the force of attraction between them is weaker and the electron is more easily lost. - Fluorine is the most reactive halogen because its outer electron shell is closer to the nucleus. Group 1 elements are more reactive down the group as their outer shell gets further from the nucleus.
Level 3	5–6	<u>Additional guidance</u> Correctly identifies the most violent reaction with a detailed justification. OR A detailed explanation of the reactivity of group 1 AND group 7 elements.	<u>Possible candidate responses</u> - The most violent reaction is potassium and fluorine as fluorine is the most reactive element in group 7. Potassium loses its outer electron easily as there is a weak nuclear attraction, and fluorine gains this electron easily as it has a strong nuclear attraction. - Group 1 elements become more reactive down the group. They lose 1 electron to form cations and the larger the distance between the nucleus and the outer shell, the more easily the electron is lost. Group 7 elements gain 1 electron to form anions and the smaller elements gain this electron more easily. This is because the force between the nucleus and the outer shell is stronger.



Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3–4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5–6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

Total for Question 8 = 12 marks



Question number	Answer	Mark
8(a)	C -7 63 is the only correct answer A and B have boiling points showing a gas at room temperature D has a boiling point that of a giant structure	(1) AO2-1

Question number	Answer	Additional guidance	Mark
8(b)	An explanation linking - carbon has 4 outer shell electrons (1) 3 electrons used in bond with other carbon atoms / each carbon forms 3 bonds (1) (one) electron free to move / delocalised (1)	allow each carbon atom has 1 electron not involved in bonding (1) allow delocalised electrons reject reference to movement of ions	(3) AO1-1

Question number	Answer	Additional guidance	Mark
8(c)	An explanation linking EITHER {ionic / giant / lattice} structure (1) OR - strong forces of attraction (between ions of opposite charge) / strong (ionic) bonds (1) AND (so) needs large amount of energy to overcome ionic forces (1)	reject covalent / molecular / intermolecular / atoms in the wrong context allow 'more energy' instead of 'large amount of energy' ignore temperature / heat	(2) AO2-1



Question number	Indicative content	Mark
*8(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (3 marks) and AO2 (3 marks) • they show methane contains carbon and hydrogen • structure A only shows the ratio of C:H (as 1:4) • structure A gives no information about bonding in molecule • structure A gives no information about shape of molecule • dot & cross diagram, B, shows the covalent bonding between the C and H atoms • single bonds, show in structures B, C and D • inner shell not involved in bonding • structure B does not show the 3-D positions of atoms • single lines used to show single covalent bonds in structure C • only a 2-D representation and not positions in space • ball & stick model, D, shows position in space / 3-D arrangement • atoms not actually connected by the sticks • space-filling, structure E, model shows 3-D arrangement of atoms • E shows approximate relative sizes occupied by separate atoms • no information about type of bond between atoms in structure E	(6) AO1-1 AO2-1



Level	Mark	Additional Guidance	General additional guidance - the decision between levels
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1-2	<u>Additional Guidance</u> Makes simple statements about the models that are not explained or linked. OR Gives a description of at least one model OR Identifies limitations of at least one model	<u>Possible Candidate Responses</u> - the models show that methane contains 1 carbon and 4 hydrogen atoms - model A gives no information about the structure of the molecule - model B is a dot and cross diagram showing shared pairs of electrons between carbon and hydrogen - a detailed description of one model scores the upper part of the level
Level 2	3-4	<u>Additional Guidance</u> Gives different descriptions of at least three models OR Gives a description of at least two models and links at least one model to its limitations OR Identifies different limitations of at least three models	<u>Possible Candidate Responses</u> - model B is a dot and cross diagram showing the covalent bonds. Model D is a ball and stick model showing a 3D model. All models show that methane contains one carbon and four hydrogen atoms. - model E shows the relative sizes of carbon and hydrogen atoms but gives no detail about the bonding between the atoms. Model C shows single covalent bonds. - model A gives no information about how the atoms are arranged in methane, and models B and C give no information about how the atoms are arranged in space and model E gives no information about the bonds. - detailed descriptions in all cases score the upper part of the level
Level 3	5-6	<u>Additional Guidance</u> Gives a description of at least three models AND three limitations OR Gives a description of all five models AND at least one limitation for one of the models	<u>Possible Candidate Responses</u> model C shows the displayed formula and single bonds in methane but is only a 2D model and does not show the position of the atoms in space. Model A is the molecular formula and tells us how many carbon and hydrogen atoms are in the molecule but gives no information about how these are arranged. Model D shows the 3D arrangement of atoms, but model E does not show how the atoms are bonded.



Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	- Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	- Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Total for Question 08 = 12 marks



Question number	Answer	Additional guidance	Mark
9(a)(i)	$C_6H_8N_2SO_2$	Letters can be in any order e.g. $C_6N_2H_8O_2S$ (1) must be written as a formula numbers do not have to be subscripts ignore any formula with brackets	A02 1 (1)

Question number	Answer	Additional Guidance	Mark
9(a)(ii)	A description including: - B is pure and A is impure and C is impure (1) - B has a sharp/ single melting point (1) - A and C have melting points {over a range / lower than (the sharp melting point of) B} (1)	ignore repeats the stem e.g. melting point is 160-164 ignore suggestions about composition e.g B is an element mark independently (can score MP2 and MP3 even if MP1 incorrect) allow fixed / specific / definite/ one/ exact/ no range ignore accurate/ precise melting point allow the melting points vary /gradual change/ not sharp/ not exact ignore these have two melting points/ different melting points (i.e idea that melts at 160 and at 164) reject boiling point only once in MP2 or MP3	A03 1 (3)

Question number	Answer	Additional Guidance	Mark
9(b)	0.528/ 0.53 with or without working scores 2 - distance = $R_f \times \text{solvent front distance} / 0.22 \times 2.4$ (1) = 0.528/ 0.53 (cm) (1)	MP1 for rearranged equation or values note : any unambiguous wording accepted in formula If additional calculation steps used, score 0 for whole question. 0.5 scores 2 only with working No ecf for MP2	A02 1 (2)



Question number	Indicative content	Mark
*9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Do not credit separation techniques other than distillation (e.g. crystallisation/ simply evaporating off the water) or additional steps to distillation that would not work. Allow distil off (some) water and then crystallise the remaining (concentrated) sodium chloride solution. Allow fractional distillation. AO1 (6 marks) SODIUM CHLORIDE • ionic compound • giant lattice • positive (sodium) ions and negative (chloride) ions • strong electrostatic attraction between ions • lots of energy to overcome attraction/ bonds WATER • simple covalent/ molecular • strong covalent bonds between atoms in a molecule • weak forces between molecules • little energy needed to overcome the intermolecular forces SEPARATION • use distillation – with condenser or simple apparatus: delivery tube into test tube in ice water • water has much <u>lower</u> boiling point • water will distil but sodium chloride will not • water collected after being condensed • sodium chloride remains in flask	(6) AO1 1 AO1 2



Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3–4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> a basic description of one of the types of bonding or the separation technique	<u>Possible candidate response</u> sodium chloride is ionic (1) use distillation (1) sodium chloride has ionic bonding and water has covalent bonding (2) sodium chloride has strong ionic bonds which take a lot of energy to break (2) heat the mixture and condense the water (2)
Level 2	3–4	<u>Additional Guidance</u> a description of two of the aspects: bonding in NaCl/ intermolecular forces in water/ distillation	Possible candidate response water is a simple molecular covalent compound, there are weak intermolecular forces which take little energy to break but sodium chloride is ionic (3) sodium chloride has ionic bonding, there are strong electrostatic forces of attraction between oppositely charged ions, which take a lot of energy to break and the solution is separated by distillation (3) use distillation because water has a lower boiling point than sodium chloride so water will distil but sodium chloride will not, water can be collected after it has been condensed and the sodium chloride will remain in the flask. This is because sodium chloride is ionic with strong bonds. (4)
Level 3	5–6	<u>Additional Guidance</u> An explanation of both of the types of bonding and of the separation technique	sodium chloride has strong ionic bonds which take a lot of energy to break whereas water has intermolecular forces which does not take a lot of energy to break. Heat the mixture and condense the water, sodium chloride is left in the flask (5) Sodium chloride is ionic, the electrostatic attractions between ions take a lot of energy to break. Water is covalent, not a lot of energy is used to overcome the intermolecular forces. Use distillation because water has a lower boiling point than sodium chloride so water will distil but sodium chloride will not, water can be collected after it has been condensed and the sodium chloride will remain in the flask. (6)

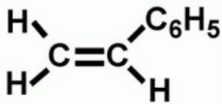
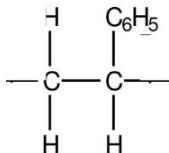


Question number	Answer	Mark
10(a)(i)	distance between {burner/ flame} and flask / height of flask / {length/ size} of wick	(1) AO1 2

Question number	Answer	Additional guidance	Mark
10(a)(ii)	0.035 with or without working scores 2 $\frac{1.6}{46}$ (1) = 0.035 (1)	29 scores 1 MP1 for showing the fraction (whatever number shown) or if no fraction shown 0.03478260869565 CORRECTLY ROUNDED to any no. of sig figs NO ECF for MP2 except allow 1 mark for 29	(2) AO2 1

Question number	Answer	Additional guidance	Mark
10(a)(iii)	{heat/ energy} lost / incomplete combustion / ethanol evaporates	ignore generic statements such as side reactions or incomplete reactions or not a closed system	(1) AO1 2



Question number	Answer	Additional guidance	Mark
10(b)(i)	 one C=C only in any molecule with <u>8 carbons</u> (1) monomer fully correct (2)	For MP1 all that is required is one, and only one, C=C bond and any other 6 C atoms in any structure [but ignore any C=C in attempted structure of the phenyl group], even if molecule does not exist. no continuation bonds allowed in fully correct molecule allow 1 mark for correct repeating unit (with or without brackets or continuation bonds but reject if includes n) 	(2) AO3 1
Question number	Answer	Additional guidance	Mark
10(b)(ii)	an explanation to include: (bromine water is) {orange/ yellow} (1) - turns colourless/ decolourises (1)	mark independently reject red or brown ignore clear	(3) AO2 1

Question number	Answer	Additional guidance	Mark
10(c)	a description to include ADDITION MONOMER – Max 2 • only one monomer (1) • monomer is {an alkene / unsaturated / has C=C} (1) CONDENSATION MONOMER – Max 2 • two/different monomers (1) • one monomer is (di)alcohol (1) • one monomer is (di)carboxylic acid (1) • each monomer molecule has (two) functional groups (at each end) (1)	allow monomers are identical allow (2x) -OH allow (2x) -COOH	(3) AO1 1

Total for question 10 = 12 marks



Question number	Answer	Additional guidance	Mark
8(a)	gas syringe	upturned burette over water	(1) A01-2

Question number	Answer	Mark
8(b)	B 106 is the only correct answer A, C and D are incorrect because $2 \times 53 = 106$	(1) A03-2

Question number	Answer	Additional guidance	Mark
8(c)	An explanation linking - the solution forms ions (1) (so) (ions) can move (1)	mention of covalent = 0 score 0 if answer suggests non-conductor reject delocalised electrons (because) (solutions containing ions) conduct electricity (1) mp2 depends on mp1	(2) A01-1

Question number	Answer	Mark
8(d)(i)	bromine	(1) A02-2

Question number	Answer	Additional guidance	Mark
8(d)(ii)	$\text{Cl}_2 + 2 \text{KBr} \rightarrow 2 \text{KCl} + \text{Br}_2$ (3) reactant formulae: $\text{Cl}_2 + \text{KBr} \rightarrow$ (1) product formulae: $\rightarrow \text{KCl} + \text{Br}_2$ (1) balancing correct formulae (1)	allow correct balanced ionic equation (3) allow ClK ignore correct charges on KCl & KBr ignore state symbols even if incorrect	(3) A02-1

Question number	Answer	Additional guidance	Mark
8(e)	-467 kJ mol ⁻¹ with or without working scores 4 - bonds broken = (4 x 299) + 495 = 1691 (1) - bonds made = (4 x 464) + (2 x 151) = 2158 (1) - energy change = 1691 - 2158 (1) = -467 kJ mol⁻¹ (1)	-467 without correct unit scores 3, +467 without correct unit scores 2 allow ecf throughout ignore sign / unit ignore sign / unit allow answers without positive sign where appropriate ecf, answer including sign and unit needed if no sign, assume it is positive	(4) A02-1

Total for Question 8 = 12 marks



Question number	Answer	Mark
8(a)	D sodium sulfate A, B and C are incorrect as they are not soluble in water	(1) A01 2

Question number	Answer	Additional guidance	Mark
8(b)(i)	$\frac{64.0}{120} = 0.533333$ (1) $0.533333 \times 100 = 53.333$ (1) (%) 53.3 (1)	53.3 with or without working gains 3 marks 53(.33)% with or without working gains 2 marks allow ecf for MP3 only if appropriate Ar values have been used and answer <100% ignore any dot above the 3 13.3 scores 2 marks $\frac{16.0}{120} \times 100$ unevaluated scores 1	(3) A02 1

Question number	Answer	Additional guidance	Mark
8(b)(ii)	$\frac{7.20}{120} = 0.06$ (1) $0.06 \times 4 = 0.24$ (1) $0.24 \times 6.02 \times 10^{23} = 1.444(8) \times 10^{23}$ (1)	$1.444(8) \times 10^{23}$ with or without working gains 3 marks Allow any number of sig figs except 1 allow ECF throughout MP3 only awarded ECF if numbers from the question are multiplied by L $120/7.2 = 16.67$ (0) $16.67 \times 4 = 66.67$ (1) $66.67 \times L = 4.01 \times 10^{25}$ (1) ie scores 2 (missed mp1) $0.06 \times L = 3.612 \times 10^{22}$ scores 2 (missed mp2)	(3) A02 1



Question number	Indicative content	Mark
8(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (6 marks) • Mg^{2+} and SO_4^{2-} ions are present in magnesium sulfate solution • water splits to form H^+ and OH^- ions • negative ions / anions move positive electrode / anode • sulfate ions / SO_4^{2-} and hydroxide / OH^- ions move to anode • can credit ions shown on diagram • hydroxide ions / OH^- lose electrons • loss of electrons is oxidation • hydroxide ions are oxidised • $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$ • positive ions / cations move to negative electrode / cathode • magnesium ions / Mg^{2+} and hydrogen ions / H^+ move to cathode • hydrogen forms as it's less reactive than magnesium • hydrogen ions / H^+ gain electrons • gain of electrons is reduction • hydrogen ions are reduced • $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	(6) AO1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Total for Question 8 = 13 marks



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material and any references to other metals / discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> Identifies ions from magnesium sulfate Identifies ions from water Identifies correct movement of ions Oxidation & reduction	<u>Possible candidate response</u> (all examples, not a definitive list) Mg^{2+} / SO_4^{2-} / H^+ / OH^- ions (any one ion) present (1) Identifies at least two ions present (2) Negative ions move to anode (1) Negative ions move to {anode/positive electrode} and positive ions move to {cathode/negative electrode} (2) Oxidation at anode and reduction at cathode (2)
Level 2	3–4	<u>Additional Guidance</u> Identifies one ion and states where it moves to during electrolysis Identifies at least 2 ions present and their movement during electrolysis Identifies H^+ or OH^- , states direction of movement and product formed Describes oxidation and reduction	<u>Possible candidate response</u> Mg^{2+} present and moves to cathode (3) Mg^{2+} and SO_4^{2-} ions are present, Mg^{2+} moves to negative electrode, SO_4^{2-} moves to the positive electrode (4) Hydrogen ions present, move to negative electrode / cathode and form hydrogen (4) Oxidation is loss of electrons at anode; reduction is gain of electrons at cathode (4)
Level 3	5–6	<u>Additional Guidance</u> Identifies both H^+ and OH^- , states direction of movement and products formed Identifies all ions present and gives the direction of movement to correct electrodes Identifies at least one cation and at least one anion, states direction of movement of ions, what happens at electrode (loss/gain of electrons) for one ion and identifies product Identifies at least one cation and at least one anion, states direction of movement of both ions, what happens at electrode (loss/gain of electrons or reduction/oxidation) for both ions and identifies products; MAY attempt half equations, but not essential Correctly write both half equations	<u>Possible candidate response</u> Hydrogen ions and hydroxide ions present, H^+ move to negative electrode form hydrogen, OH^- move to anode and form oxygen (5) Magnesium, sulfate, hydrogen and hydroxide ions are present, the magnesium and hydrogen ions move towards the negative electrode, sulfate and hydroxide move towards the positive electrode (5) Mg^{2+} ions are present; H^+ move to cathode, the H^+ gain electrons OR are reduced to form H_2 . (5) Mg^{2+} and SO_4^{2-} are present from the magnesium sulfate, H^+ and OH^- are present from the water. Mg^{2+} and H^+ move to cathode, the H^+ gains electrons and is reduced to form H_2 . (6) Mg^{2+} and SO_4^{2-} are present from the sodium sulfate, H^+ and OH^- are present from the water. Na^+ and H^+ move to cathode, the hydrogen is reduced to form H_2 . OH^- and SO_4^{2-} move to anode and oxygen is produced; $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$ (6) $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ and $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$ (6)



Question number	Answer	Additional guidance	Mark
7(a)(i)	An explanation linking: - graphite has layers (1) (because) (layers) slide over each other (1)	allow sheets of atoms / carbon / graphene ignore weak (intermolecular) forces (between layers)	(2) A01-1

Question number	Answer	Additional guidance	Mark
7(a)(ii)	$12 \times 60 \times 5 = 3600$ (1) $3600/1000 = 3.6$ (kg) (1)	3.6 (kg) with or without working scores 2 allow ecf throughout allow with working: $12 \times 60 / 1000 = 0.72$ (1) $60 \times 5 / 1000 = 0.30$ (1) $5 \times 12 / 1000 = 0.06$ (1) each error loses a mark in the calculation	(2) A02-1

Question number	Answer	Mark
7(b)	B C ₁₀ H ₂₃ N is the only correct answer A, C and D are incorrect because C ₁₀ H ₂₃ N is the only correct answer	(1) A02-1



Question number	Answer	Additional guidance	Mark
7(c)	An explanation linking: • open the air hole (slightly) of the Bunsen / use a roaring / blue flame (1) • (because) to ensure complete combustion (1)	allow more oxygen in / can mix with {methane / gas} allow to release carbon dioxide instead of carbon allow to prevent incomplete combustion	(2) A03-3



Question number	Indicative content	Mark
*7(d)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (3 marks) AO3 (3 marks) - carbon dioxide molecules absorb heat energy - likely carbon dioxide increase has caused temperature increase NATURAL PROCESSES - photosynthesis removes carbon dioxide - carbon dioxide dissolves into oceans - forming carbonate rocks - volcanoes release carbon dioxide HUMAN ACTIVITIES - burning fossil fuels releases carbon dioxide - deforestation means less carbon dioxide removed by trees - respiration DATA EVALUATION - from 1960-2000 steady increase in amount of carbon dioxide - from 1960-2000 general increase in mean temperature - correlation between carbon dioxide amount and temperature - increased mean temperature leads to a change in climate	(6) A01-1 A03-1



Level	Mark	Descriptor	Additional Guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1–2	<u>Additional Guidance</u> Identifies processes that change atmospheric carbon dioxide OR Simple description of processes / global warming OR Simple statement about the data	<u>Possible candidate response</u> - Plants remove carbon dioxide from the atmosphere (1) - Plants, volcanoes and burning fossil fuels all change levels of carbon dioxide in the atmosphere (2) - As carbon dioxide levels have increased so has the temperature of the Earth (2) - Carbon dioxide levels have increased between 1960 and 2000 (1) - Carbon dioxide is emitted from volcanoes when they erupt (2)
Level 2	3–4	<u>Additional Guidance</u> Describes at least two processes that change levels of carbon dioxide OR Describes at least one process that change levels of carbon dioxide AND describes global warming OR uses the data in the graph to provide an evaluation	<u>Possible candidate response</u> - Burning fossil fuels and respiration of living things both release carbon dioxide into the atmosphere (3) - Photosynthesis removes carbon dioxide from the atmosphere and carbon dioxide dissolved in the oceans (3) - Plants remove carbon dioxide from the atmosphere during photosynthesis. Combustion of fossil fuels releases carbon dioxide into the atmosphere (4) - Deforestation means more carbon dioxide because less is absorbed by photosynthesis. As carbon dioxide levels have increased so has the temperature of the Earth (4) - Carbon dioxide absorbs IR, traps heat and reradiates it which links with the graphs showing increase of CO₂ and an increase in temperature (4)
Level 3	5–6	<u>Additional Guidance</u> Describes at least two processes that change levels of carbon dioxide AND uses the data in the graph to provide an evaluation OR Describes at least one process that change levels of carbon dioxide AND describes global warming AND uses the data in the graph to provide an evaluation	<u>Possible candidate response</u> - Increase in population has led to an increase in carbon dioxide levels through respiration, and the increase in population has also resulted in the increased burning of fossil fuels in cars. This has resulted in an increase in carbon dioxide levels from 1960 to 2000 (5) - Deforestation means more carbon dioxide because less is absorbed by photosynthesis, but carbon dioxide is removed when it dissolves in the oceans and forms carbonate rocks. The graphs show that carbon dioxide has increased over time AND so has the temperature which is a correlation (6)



Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3)
Level 2	3–4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3)
Level 3	5–6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3)

Total for Question 7 = 13 marks