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EDEXCEL INTERNATIONAL GCSE PHYSICS: QUESTIONS BY TOPIC

Solids, Liquids and Gases (5)

IGCSE Physics Topic 5

39 questions · 369 marks · Mark schemes included

Pearson Edexcel International GCSE (9-1) Physics 4PH1, Papers 1P/1PR & 2P/2PR, 2019-2025

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 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

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

39 questions · 369 marks · 4 sub-topics



SUB-TOPIC 5.1

DENSITY

Sub-topic 5.1 · 9 questions · 79 marks · lowest tariff first



2 The photograph shows a brass mass.



© Dudaeva/Shutterstock

(a) State the formula linking density, mass and volume.

(1)

(b) The brass mass has a mass of 454 g.

The density of brass is 8.46 g/cm^3 .

Calculate the volume of the brass mass.

Give the unit.

(3)

volume = ... unit

(Total for Question 2 = 4 marks)

- 6 The photograph shows a small glass ball used to investigate density and pressure.



- (a) The mass of the ball is 19 g.

The density of the ball is 2.3 g/cm^3 .

- (i) State the formula linking density, mass and volume.

(1)

- (ii) Calculate the volume of the ball.

(2)

volume = ... cm^3

- (b) The ball is dropped into deep water and sinks to a depth of 560 cm.

- (i) State the formula linking pressure difference, height, density and gravitational field strength.

(1)

- (ii) Calculate the increase in pressure at this depth.

[density of water = 1000 kg/m^3]

(2)

increase in pressure = ... Pa

(Total for Question 6 = 6 marks)



6 A student needs to identify a sample of an unknown liquid.

She decides to do this by finding the density of the liquid.

(a) Describe how the student should measure the mass of the liquid.

(2)

(b) Describe how the student should use a measuring cylinder to obtain an accurate measurement of the liquid's volume.

(2)



(c) The table gives the values of the densities for some liquids.

Liquid	Density in g/cm ³
brine	1.23
glucose	1.44
olive oil	0.82
pure water	1.00
sodium hydroxide	1.25
sunflower oil	0.92

The student measures the mass of the sample of unknown liquid as 150 g and the volume as 163 cm³.

Deduce the name of the unknown liquid.

(3)

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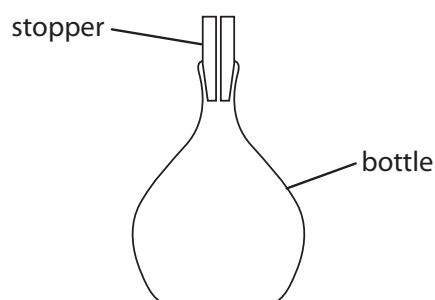
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(Total for Question 6 = 7 marks)



- 11** A student uses a bottle and a stopper to find the density of an unknown liquid.
The stopper fits tightly into the bottle and has a small diameter hole through it.



(a) This is the student's method.

- use a balance to find the mass of the bottle and stopper
- completely fill the bottle with water
- insert the stopper and dry the outside of the bottle
- use the balance to find the mass of the full bottle and stopper

These are the student's results.

mass of empty bottle and stopper = 63.4 g

mass of full bottle and stopper = 112.9 g

Use the student's results to determine the volume of the water in the bottle.

Give your answer to three significant figures.

[density of water = 0.998 g/cm³]

(4)

volume = ... cm³



(b) The student empties the bottle and then dries it.

He refills the bottle with the unknown liquid.

He measures the mass of the full bottle and stopper as 143.8 g.

Calculate the density of the unknown liquid.

(3)

density of unknown liquid = ... g/cm³

(c) Another student uses a measuring cylinder to find the volume of the unknown liquid.

Discuss the advantages and disadvantages of using each method to find the volume of the unknown liquid.

(3)

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(Total for Question 11 = 10 marks)



- 5 A student needs to determine the density of some small rocks that appear to all be made of the same material.



(Source: © Chake / Shutterstock)

- (a) The student decides to measure the mass and the volume of each rock.

Describe a method the student could use to accurately determine the mass and the volume of each rock.

You may draw a diagram to help your answer.

(5)

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8 A scientist investigates different samples of rock.

(a) The scientist wants to calculate the density of a rock sample.

She needs to measure the mass and the volume of the rock.

Describe how to obtain accurate measurements of the mass and the volume of the rock.

You may draw a diagram to support your answer.

(5)

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(b) The table shows the scientist's results for rocks made from different materials.

Material	Mass in g	Volume in cm ³	Density in g/cm ³
coal	54	41	1.3
marble	44	18	2.4
quartz	54	20	2.7
fluorite	32	10	3.2
hematite	64	12	5.3

(i) State the formula linking density, mass and volume.

(1)

(ii) Rock X has a mass of 32 g and a volume of 12 cm³.

Calculate the density of rock X.

Give your answer to 2 significant figures.

(3)

density = ... g/cm³

(iii) Rock X is made from the same material as one of the samples in the table.

Explain which material rock X is made from.

(2)

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(Total for Question 8 = 11 marks)

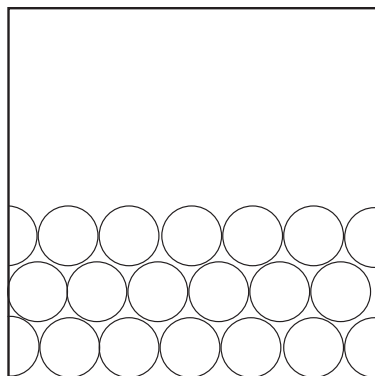


1 This question is about liquid nitrogen.

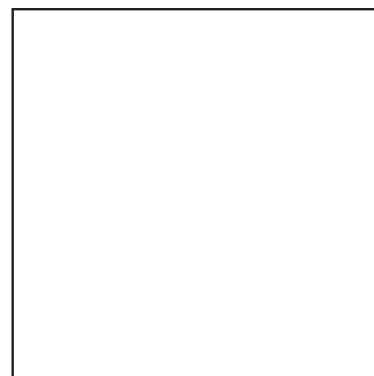
(a) (i) The diagram shows the arrangement of particles in solid nitrogen.

Draw the arrangement of particles in liquid nitrogen.

(2)



solid



liquid

(ii) Describe the motion of the particles in liquid nitrogen.

(1)

(b) A teacher uses this method to find the density of liquid nitrogen.

- measure the mass of a container
- pour liquid nitrogen into the container
- measure the total mass of the container and the liquid nitrogen
- read the volume of the liquid nitrogen from the scale on the side of the container

(i) Give a safety precaution the teacher should take when pouring the liquid nitrogen.

(1)

(ii) State the name of the apparatus that the teacher should use to measure the mass of the container.

(1)

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

mass of container in g	75
mass of container + liquid nitrogen in g	149
volume of liquid nitrogen in cm ³	88

Calculate the mass of liquid nitrogen in the container.

(1)

mass = ... g

(iv) State the formula linking density, mass and volume.

(1)

(v) Calculate the density of the liquid nitrogen.

Give a suitable unit.

(3)

density = ... unit = ...



(c) Over time, the liquid nitrogen warms up and changes state from a liquid into a gas.

Describe the changes to the arrangement and motion of particles when the liquid nitrogen changes state.

(3)

(Total for Question 1 = 13 marks)



10 The photograph shows a ring made of gold.



(Source: ©Michael Burrell / Alamy Stock Photo)

A student wants to determine the volume of the ring.

(a) The student measures the mass of the ring several times.

(i) Describe how the student should use laboratory equipment to accurately measure the mass of the ring.

(2)

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(ii) The table shows the student's measurements of the mass of the ring.

Mass in g
6.411
6.408
6.410
6.426
6.412

One of the student's measurements is an anomaly.

Draw a circle around the anomalous result in the table.

(1)

(iii) Calculate the mean mass of the gold ring.

(3)

mean mass = ... g

(iv) The student is given a value for the density of gold.

Which of these formulae should be used to calculate the volume of the gold ring?

(1)

- ☐ **A** volume = density $\div$ mass
- ☐ **B** volume = density $\div$ mass³
- ☐ **C** volume = mass $\div$ density
- ☐ **D** volume = mass $\div$ density³

(b) The student does not know if the ring is made of pure gold.

The student suggests that they could also measure the volume of the ring using a displacement method.

Discuss which method (calculation method or displacement method) will give the most accurate volume measurement.

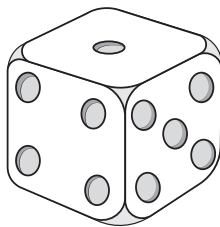
(4)

(Total for Question 10 = 11 marks)



- 1 A student plays a game using a single dice.

The student decides to determine the density of the dice by measuring its mass and volume.



- (a) Describe how the student could accurately measure the mass of the dice.

(2)

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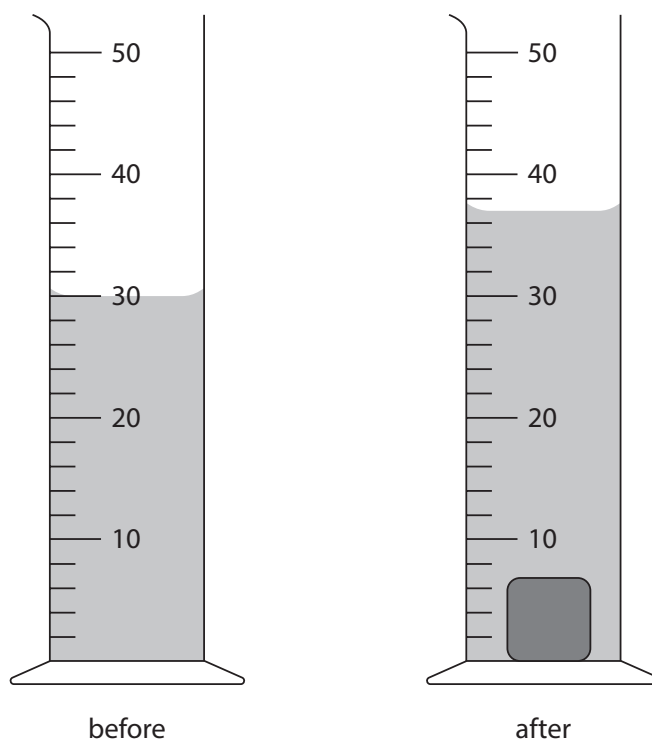
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- (b) The dice is not a regular shape.

The student decides to measure the volume of the dice using a displacement method.

The student places the dice into a measuring cylinder containing water.

The diagram shows the water in the measuring cylinder before and after the dice is fully submerged.



- (i) The measuring cylinder gives volume in units of cm^3 .

Using the diagram, determine the volume of the dice.

(2)

volume = ... cm^3

- (ii) The dice has a mass of 9.2 g.

Calculate the density of the dice using the formula

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

Give a suitable unit.

(3)

density = ... unit

(Total for Question 1 = 7 marks)

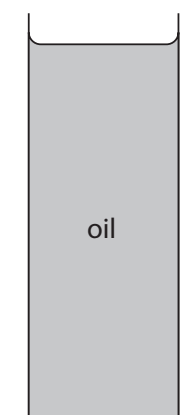
SUB-TOPIC 5.2

PRESSURE IN SOLIDS AND LIQUIDS

Sub-topic 5.2 · 10 questions · 101 marks · lowest tariff first



- 2 The diagram shows a can filled with oil.



- (a) The total pressure at the bottom of the can is 110 kPa.

Atmospheric pressure is 101 kPa.

Calculate the pressure difference due to the oil.

(1)

pressure difference = ... kPa

- (b) State the formula linking pressure difference, height, density and gravitational field strength.

(1)

- (c) Calculate the height of the oil in the can.

[density of oil = 960 kg/m^3]

(3)

height = ... m

(Total for Question 2 = 5 marks)

- 5 The drawing shows a camel and a person in a desert.



(Source: © Hennadii H/Shutterstock)

- (a) Describe a method you could use to find the pressure a person exerts on the ground when standing on two feet.

(4)

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(b) The total area of contact of the camel's feet with the ground is 1300 cm^2 .

The mass of the camel is 660 kg .

Calculate the pressure this camel exerts on the ground.

(3)

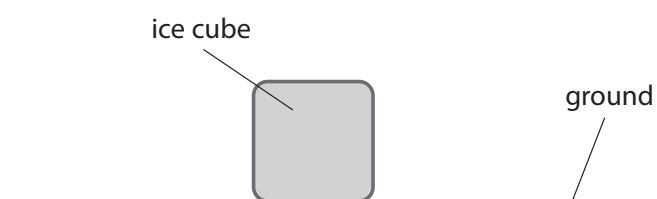
pressure = ... N/cm^2

(Total for Question 5 = 7 marks)



9 This is a question about a melting ice cube.

(a) The diagram shows an ice cube placed on the ground.



- (i) The mass of the ice cube is 3.7 g and its area of contact with the ground is $2.6 \times 10^{-4} \text{ m}^2$.

Calculate the pressure the ice cube exerts on the ground.

(4)

pressure = ...Pa

- (ii) The ice cube melts and becomes a puddle with a larger cross-sectional area.

Explain how the pressure of the ice cube on the ground changes when it melts.

(2)

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(b) Ice melts at a temperature of 0°C .

On the axes, sketch how the temperature of the ice cube changes as it rises from a temperature of -10°C to a temperature of 20°C .

(3)



(c) Explain the changes that occur when a solid melts.

Refer to particles in your answer.

(2)

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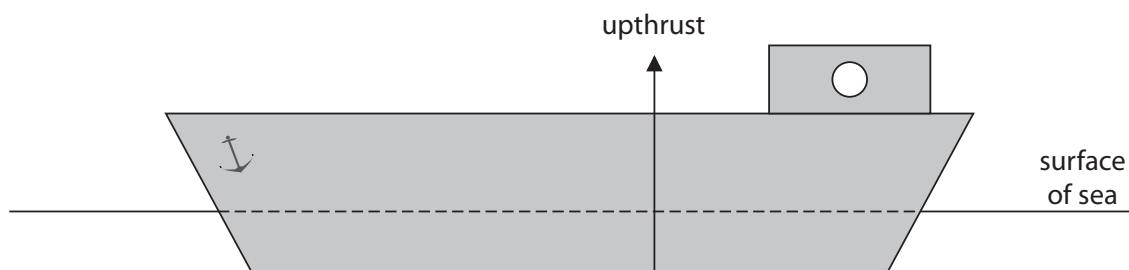
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(Total for Question 9 = 11 marks)

2 A ship floats on the sea.



(a) The ship floats because of the forces acting on it.

(i) The upward force acting on the ship is called upthrust.

This force is shown on the diagram.

Draw another labelled arrow on the diagram to show the other vertical force acting on the ship.

(2)

(ii) Forces are vector quantities.

State what is meant by the term **vector quantity**.

(2)

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(iii) Give another example of a vector quantity.

(1)

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- (b) The upthrust force acting on the ship is proportional to the pressure difference between the bottom of the ship and the surface of the sea.

The pressure acting on the ship at the surface of the sea is 100 kPa.

- (i) State the formula linking pressure difference, height, density and gravitational field strength (g).

(1)

- (ii) The bottom of the ship is 15.8 m below the surface of the sea.

Show that the pressure acting on the bottom of the ship is approximately 260 kPa.

[density of seawater = 1030 kg/m³]

(3)

- (iii) Explain why the bottom of the ship is deeper below the surface of the sea when the ship is fully loaded with cargo.

(2)

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(Total for Question 2 = 11 marks)



4 A student investigates how much pressure she exerts on the ground when she is standing up.

(a) The weight of the student is 520 N.

(i) State the formula linking weight, mass and gravitational field strength (g).

(1)

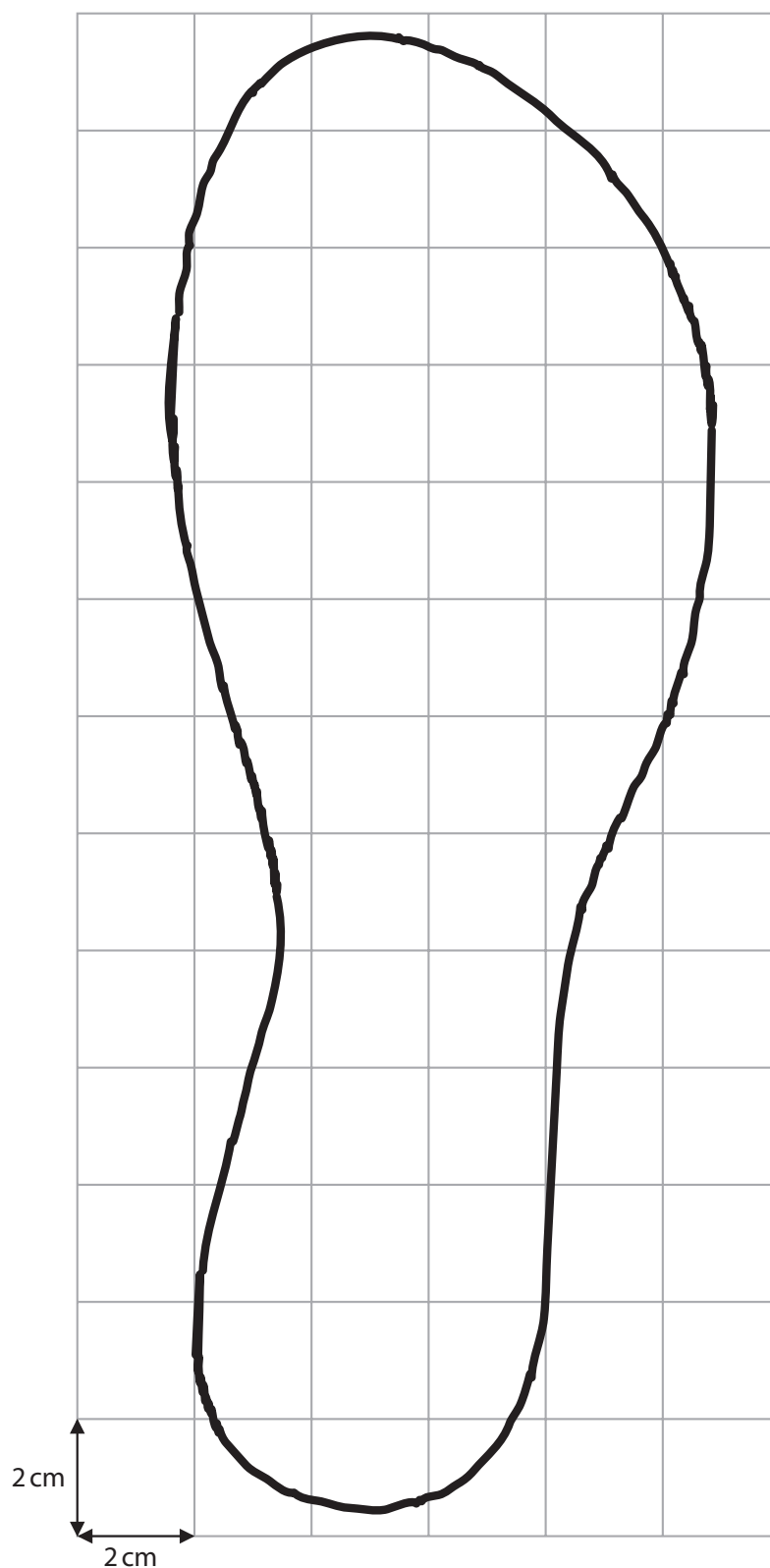
(ii) Calculate the mass of the student.

(2)

mass = ... kg



- (b) The student measures the area of one of her feet when it is in contact with the ground.
She draws around her foot on a piece of squared paper.



grid not
to scale

- (i) The squares on the paper have a side length of 2 cm.

Estimate the area of the student's foot in contact with the ground.

(4)

area = ... cm²

- (ii) State the formula linking pressure, force and area.

(1)

- (iii) The weight of the student is 520 N.

Calculate the pressure the student exerts on the ground when she is standing on **both** feet.

Give the unit.

(3)

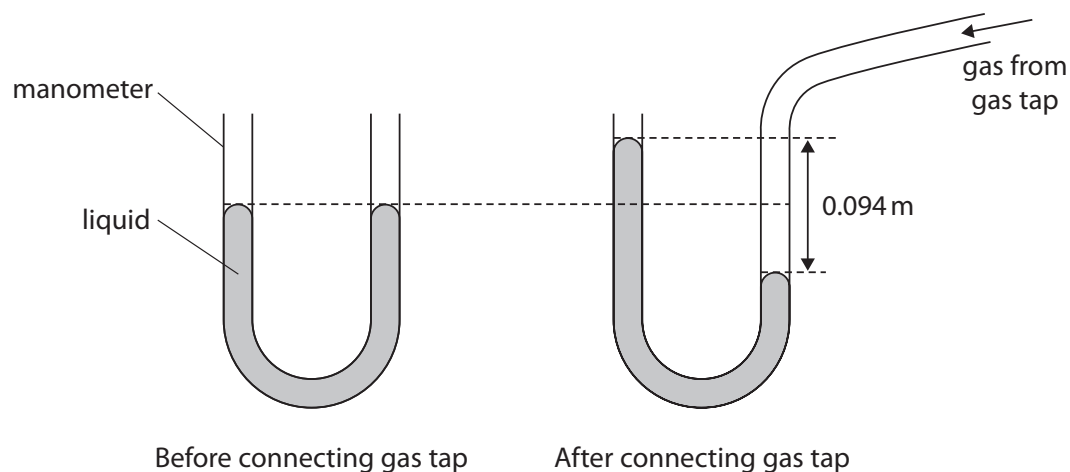
pressure = ... unit

(Total for Question 4 = 11 marks)



- 9 A manometer is a device that can be used to measure the pressure difference between gas from a gas tap and the atmosphere.

When a gas tap is connected to the manometer, the liquid in the manometer moves due to the additional pressure of the gas.



- (a) The pressure difference is linked to the difference in height of the two surfaces of the liquid by the formula

$$\text{pressure difference} = \text{density} \times g \times \text{height difference}$$

The height difference between the two surfaces is 0.094 m.

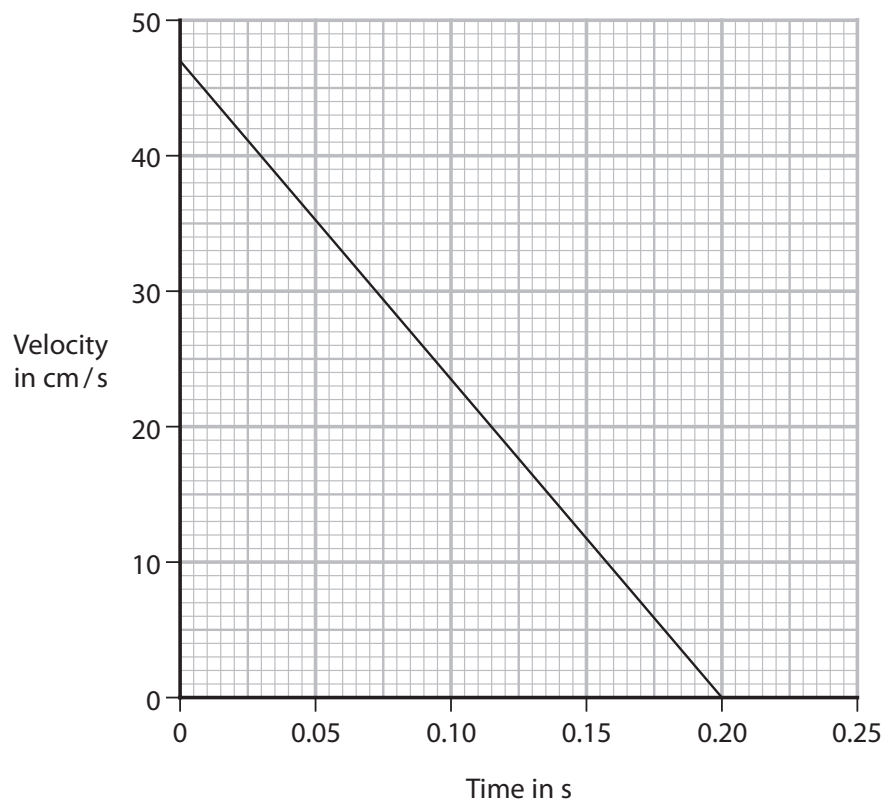
Calculate the pressure difference between the gas from the gas tap and the atmosphere.

[for liquid, density = $14\,000 \text{ kg/m}^3$]

(2)

pressure difference = ... Pa

- (b) The graph shows how the velocity of the surface of the liquid changes with time from when the gas tap is opened to when the water level stops moving.



- (i) Use the graph to show that the distance travelled by the surface of the liquid is 4.7 cm.

(3)

- (ii) Calculate the acceleration of the surface of the liquid.

(3)

acceleration = ... cm/s^2



(c) Explain how the gas pressure changes if the temperature of the gas increases.

You should use ideas about particles in your answer.

(3)

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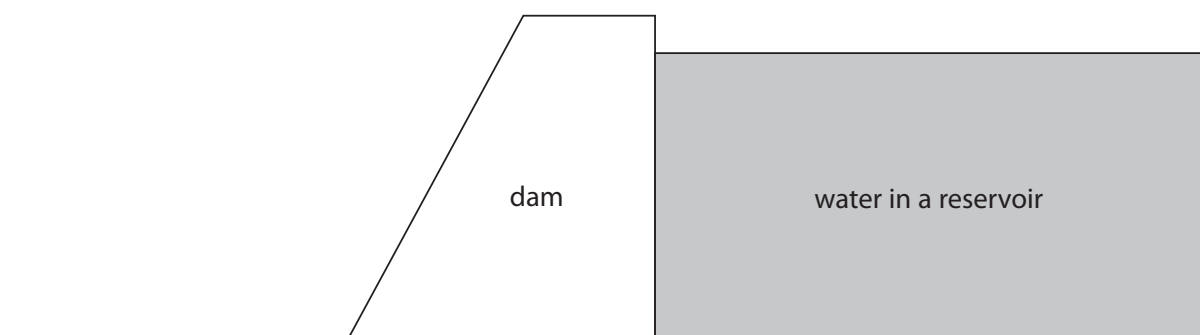
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(Total for Question 9 = 11 marks)



10 A dam is a structure designed to hold water in a reservoir.



(a) The water in the reservoir has a depth of 35 m.

(i) State the formula linking pressure difference, height, density and g .

(1)

(ii) Atmospheric pressure at the surface of the reservoir is 100 kPa.

Calculate the total pressure at the bottom of the reservoir.

[for water, density = 1000 kg/m^3]

(3)

pressure = ... kPa

(b) An underwater camera is used in the water reservoir.

The camera lens experiences a force of 430 N at a pressure of 260 kPa.

(i) State the formula linking pressure, force and area.

(1)

(ii) Calculate the area of the camera lens.

Give a suitable unit.

(4)

area = ... unit

(c) Sea water has a density of 1030 kg/m^3 .

Explain how the design of the dam would need to be changed to hold the same depth of sea water safely.

(2)

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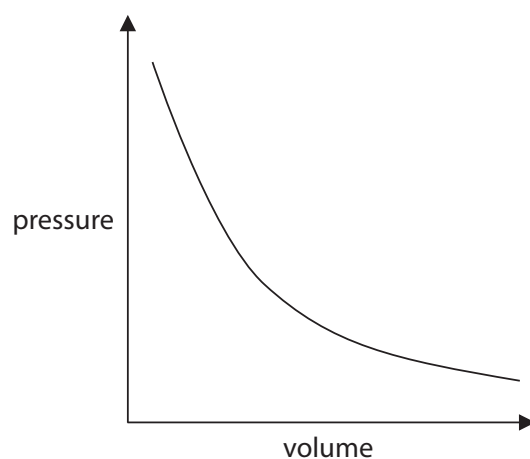
(Total for Question 10 = 11 marks)



7 A glass contains fizzy water.

Bubbles of carbon dioxide form at the bottom of the glass and rise to the surface.

- (a) The graph shows the relationship between the volume of a bubble and the pressure of the gas in the bubble.



- (i) Describe the relationship shown by the graph.

(2)

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- (ii) State the formula linking pressure difference, height, gravitational field strength and density.

(1)

(iii) The depth of the fizzy water in the glass is 22 cm.

The density of the fizzy water is 1080 kg/m^3 .

Calculate the pressure difference at the bottom of the glass due to the fizzy water.

(2)

pressure difference = ... Pa

(iv) Calculate the pressure of the gas in the bubble when the bubble is at the bottom of the glass.

[atmospheric pressure = $101\,000 \text{ Pa}$]

(1)

pressure = ... Pa

(v) When a bubble is at the top of the glass, the pressure of the gas in the bubble is equal to $101\,000 \text{ Pa}$ and the bubble has a volume of 0.084 cm^3 .

Calculate the volume of the gas in the bubble when the bubble is at the bottom of the glass.

Assume the temperature of the gas remains constant.

(3)

volume = ... cm^3

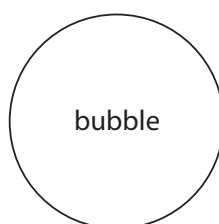


(b) A force called upthrust acts vertically upwards on the bubble.

When the bubble is released, it accelerates vertically upwards.

Draw two labelled arrows on the diagram to show the forces on the bubble as it is released.

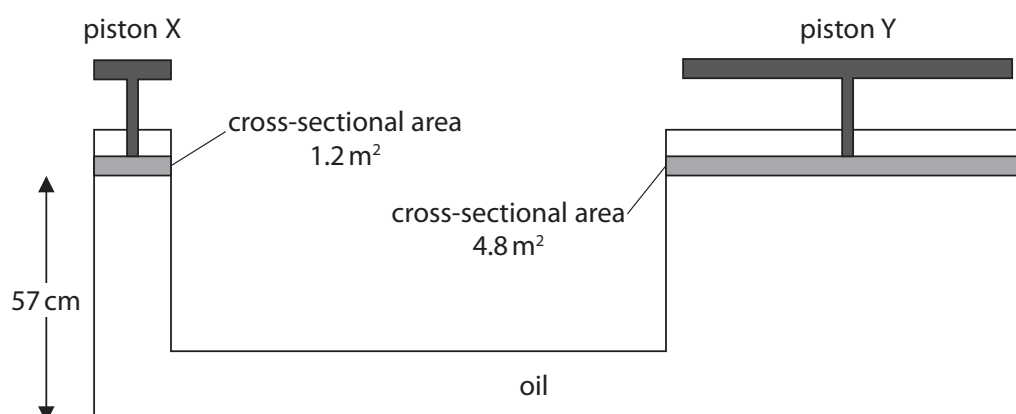
(3)



(Total for Question 7 = 12 marks)

10 The diagram shows a device called a hydraulic lift.

The hydraulic lift consists of a tube of oil with a piston at each end.



- (a) Calculate the pressure difference between the bottom of piston X and the bottom of the oil.

[density of oil = 820 kg/m^3]

(3)

pressure difference = ... Pa

- (b) A 24 kg mass is placed on piston X.

- (i) Calculate the weight of the 24 kg mass.

Give the unit.

(3)

weight = ... unit

(ii) Calculate the extra pressure on the oil due to the mass.

(2)

extra pressure = ... Pa

(iii) The oil transfers the same extra pressure to piston Y.

Calculate the force acting upwards on piston Y due to the extra pressure.

(3)

force = ... N

(c) Piston Y starts at rest, rises slowly and then comes to rest.

State how the following energy stores have changed from before the motion to after the motion is complete.

(4)

Energy store	Change
gravitational potential energy of piston X	
gravitational potential energy of piston Y	
chemical energy of piston Y	
kinetic energy of piston Y	

(Total for Question 10 = 15 marks)



7 This question is about pressure.

(a) Small air bubbles form in a container of water.

(i) The pressure of the water acts on these bubbles.

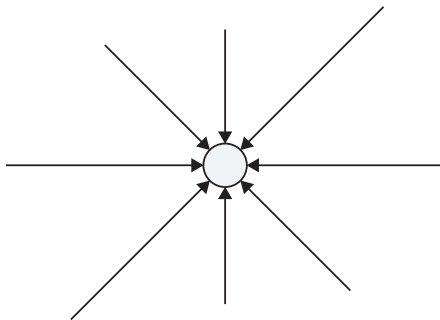
The diagrams show the forces that cause this pressure.

Which diagram correctly shows how the pressure of the water acts on a stationary air bubble?

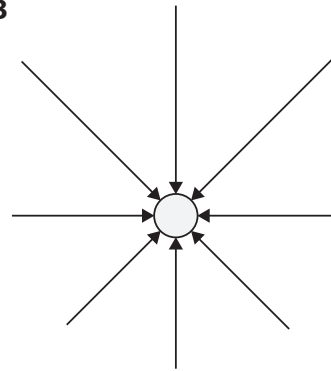
(1)



A



B



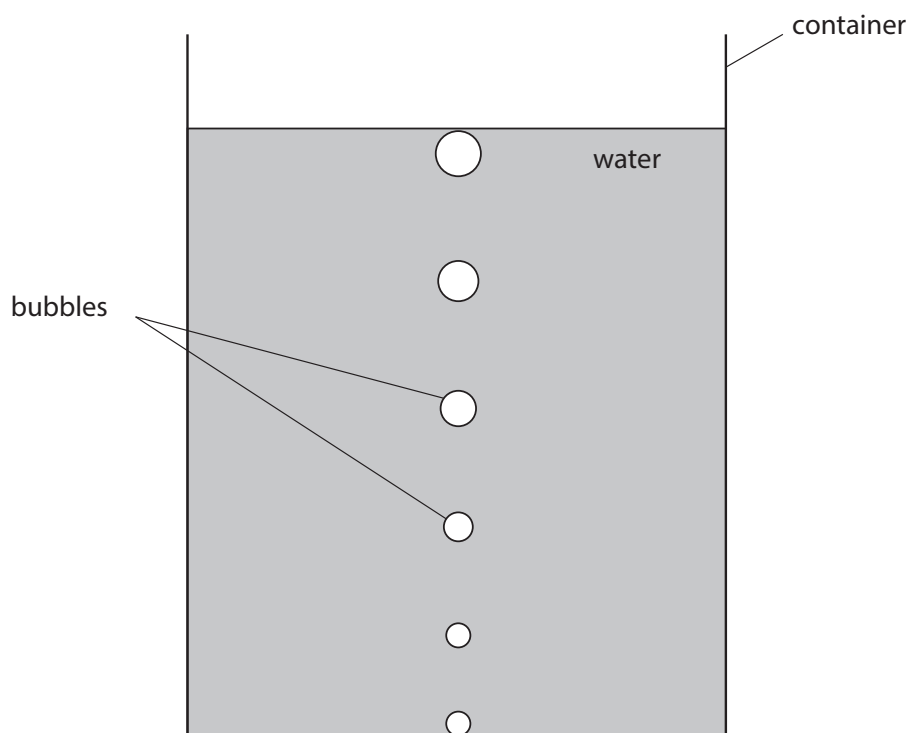
C



D



- (ii) The diagram shows the air bubbles rising to the surface of the water in a container.



Explain why the bubbles increase in volume as they get nearer to the surface of the water.

Assume that the temperature of the water is the same throughout the container.

(3)

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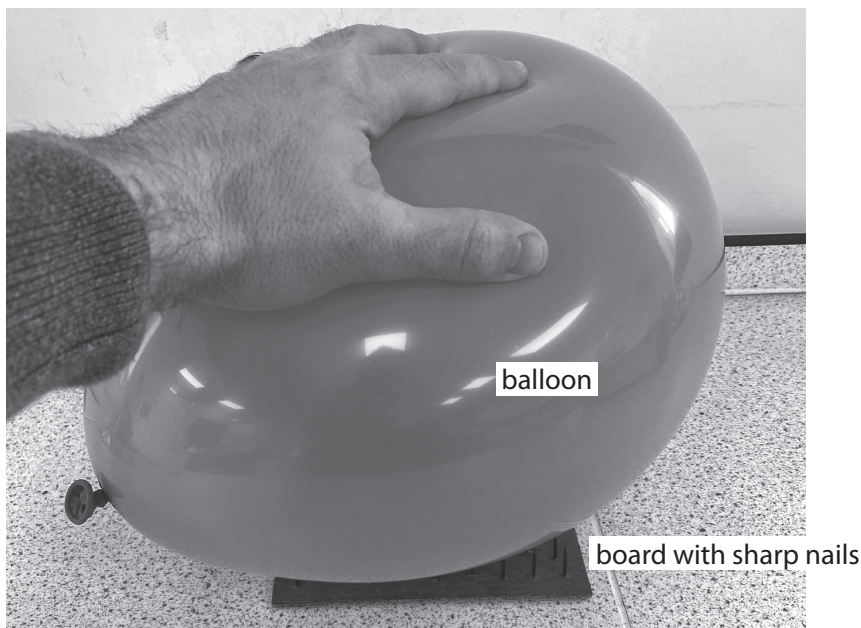
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- (b) A teacher does a demonstration using an inflated balloon and a board with many sharp nails.



The teacher pushes the balloon onto the board of nails. The balloon does not pop.

The teacher then pops the balloon using a single nail.

Explain why the balloon does not pop when pushed onto the board of nails.

(3)

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(Total for Question 7 = 7 marks)

SUB-TOPIC 5.3

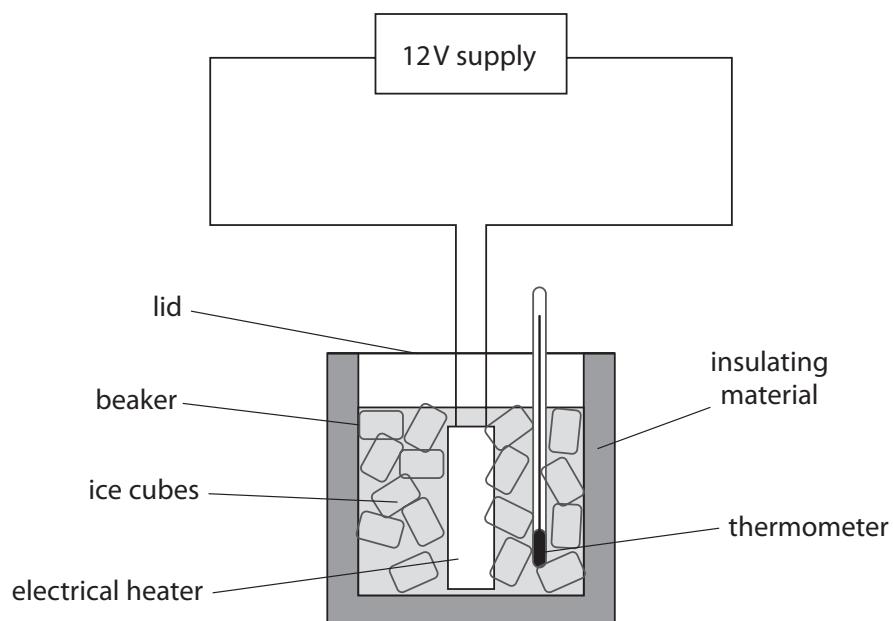
PARTICLES, CHANGES OF STATE AND SPECIFIC HEAT CAPACITY

Sub-topic 5.3 · 8 questions · 73 marks · lowest tariff first



- 5 A student does an investigation to determine the temperature-time graph for water as it changes state from ice to liquid water.

The diagram shows the student's apparatus.



The ice has an initial temperature of -17°C .

After 5 minutes, the ice begins to melt.

After a further 6 minutes, all the ice has melted.

The investigation continues for a total time of 20 minutes.

- (a) (i) Sketch a graph on the axes to show how the temperature changes with time.

Assume that the rate of energy transfer from the heater to the ice cubes is constant.

(3)



(ii) Suggest a precaution the student should take to obtain high quality data.

(1)

.....

.....

.....

(b) During the experiment the heater transfers 2500 J of energy to the beaker.

The beaker has a specific heat capacity of $880 \text{ J/kg } ^\circ\text{C}$ and a mass of 48 g.

Calculate the increase in the temperature of the beaker.

(3)

temperature increase = ... $^\circ\text{C}$

(Total for Question 5 = 7 marks)



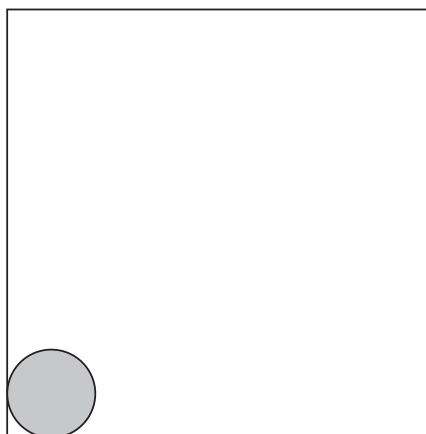
3 A sample of liquid gallium is allowed to cool in a laboratory.

The liquid gallium freezes to become a solid.

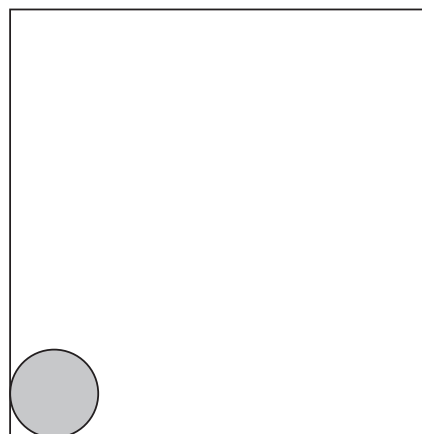
- (a) Complete the diagram by drawing the arrangement of particles in a liquid and the arrangement of particles in a solid.

The first particle in each box has been drawn for you.

(4)



Liquid



Solid

(b) The initial temperature of the sample of liquid gallium is 80°C .

The freezing temperature of gallium is 30°C .

The final temperature of the solid gallium is 20°C .

Complete the graph to show how the temperature of the gallium changes during the time that it cools to 20°C .

Add appropriate values to the temperature axis.

(3)

Temperature
in $^{\circ}\text{C}$

Time

(Total for Question 3 = 7 marks)

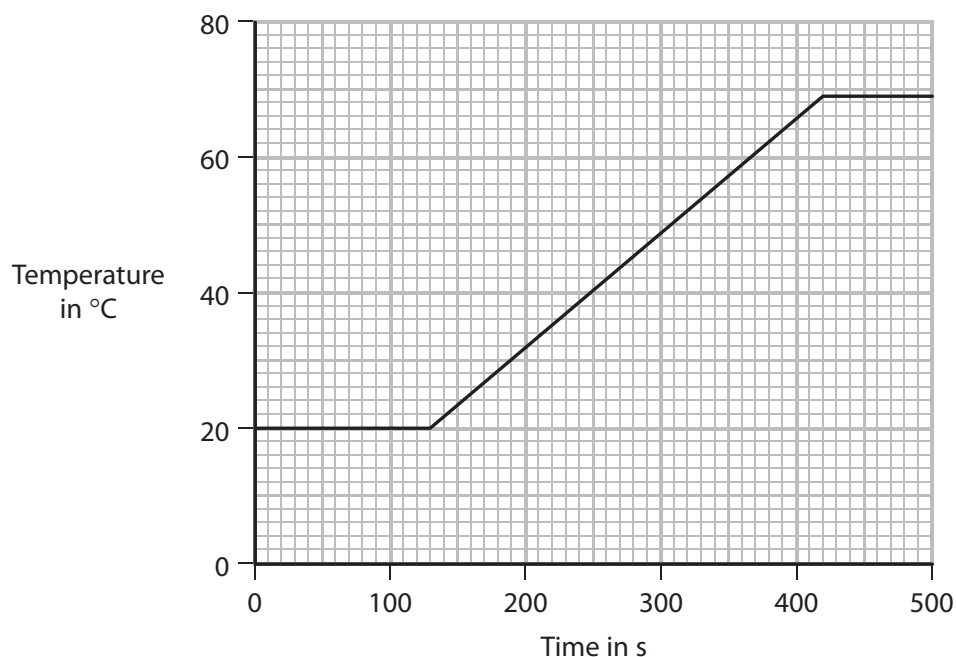


- 5 Stearic acid is a solid at room temperature and melts at a temperature of 69°C .

A student investigates the specific heat capacity of solid stearic acid.

He heats a sample of stearic acid from room temperature using an electrical heater and measures its temperature using a data logger and temperature sensor.

The graph shows his results.



- (a) The student starts heating the stearic acid at 130 seconds.

- (i) Determine the time it takes to heat the stearic acid until it reaches its melting point.

(1)

time = ... s

- (ii) The stearic acid gains 39 kJ of energy during the time it is heated to its melting point.

Calculate the mean (average) power of the heater.

Give a unit with your answer.

[assume no energy lost to surroundings]

(3)

mean power = ... unit



(b) The mass of stearic acid used in the investigation is 0.45 kg.

The stearic acid gains 39 kJ of energy when it is heated to its melting point.

Calculate the specific heat capacity of stearic acid.

You should use data from the graph in your calculation.

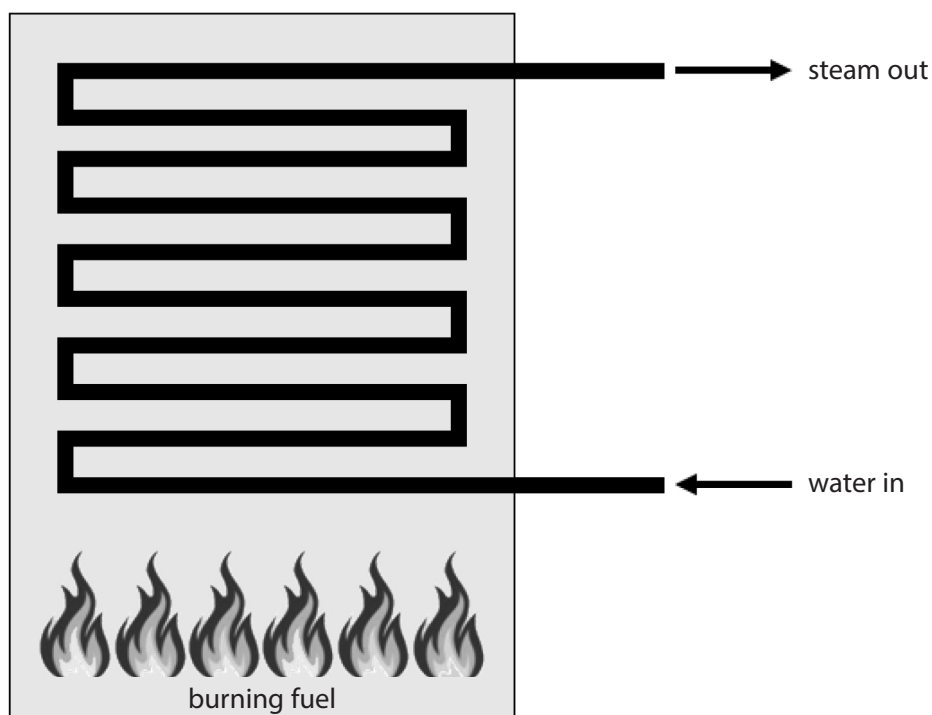
(4)

specific heat capacity = ... J/kg °C

(Total for Question 5 = 8 marks)



6 Conventional power stations burn fuel in a furnace.



(a) The fuel can be a solid, a liquid or a gas.

Describe the motion of particles in a solid, a liquid and a gas.

(3)

solid

.....

.....

liquid

.....

.....

gas

.....

.....

(b) When the fuel is burned, energy is transferred from the fuel to the water.

The water boils and turns into steam.

(i) Describe how energy stored in the fuel is transferred to the water.

Refer to energy stores and transfers in your answer.

(3)

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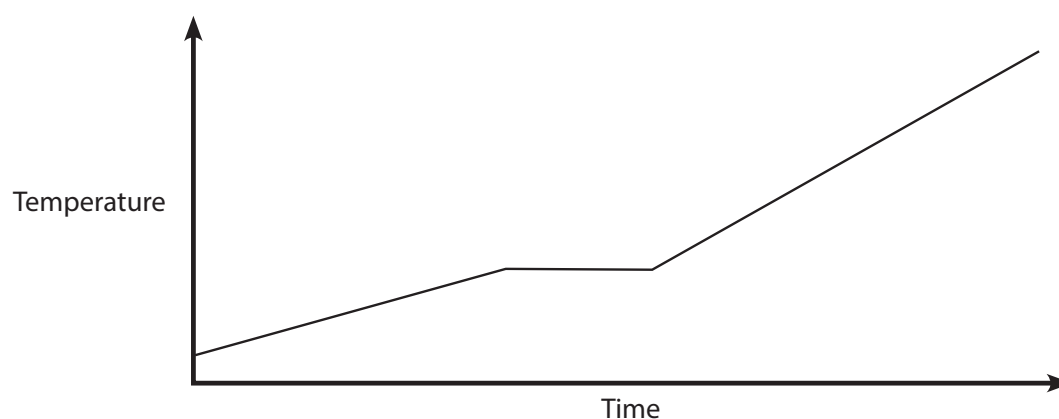
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(ii) The temperature-time graph shows how the temperature of the water changes as it is heated in the furnace at a constant rate.



Explain how the graph shows that the water changes state as it is heated.

(2)

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(Total for Question 6 = 8 marks)

- 2 A solid bar of chocolate is taken from a refrigerator.



(Source: © MarySan/Shutterstock)

- (a) The temperature of the chocolate bar is 5°C .

Describe the arrangement and motion of the particles inside the chocolate bar.

(2)

- (b) The chocolate is heated at a constant rate until the temperature reaches 45°C .

The chocolate has a melting point of 32°C and a boiling point of 55°C .

- (i) Describe the motion of the particles in the chocolate when the chocolate is at a temperature of 45°C .

(2)

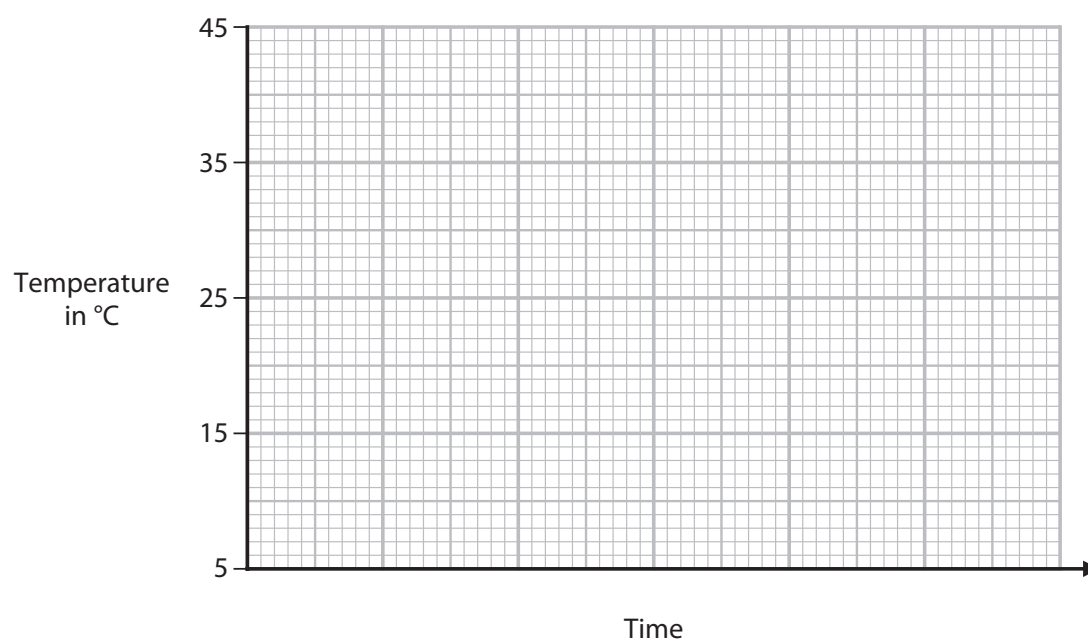
- (ii) Which of these is used to measure the temperature of the chocolate?

(1)

- ☐ A balance
- ☐ B ruler
- ☐ C stopwatch
- ☐ D thermometer

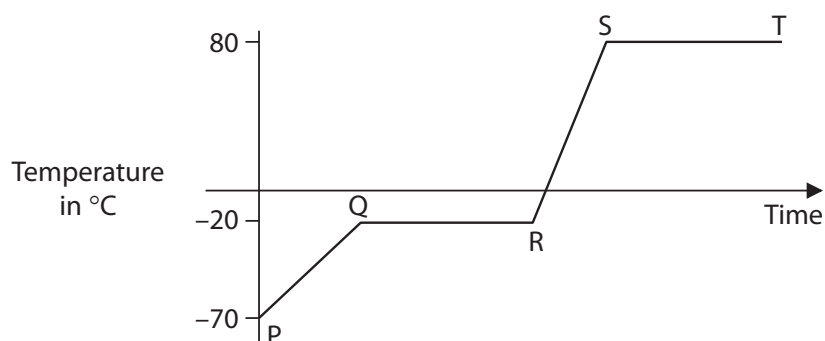
- (iii) Use the axes to sketch a graph of how the temperature of the chocolate changes with time when it is heated from 5 °C to 45 °C.

(3)



(Total for Question 2 = 8 marks)

- 1 The diagram shows the temperature-time graph for a substance which is heated at a constant rate.



- (a) (i) Which section of the graph shows when the substance is melting?

(1)

- ☐ A PQ
☐ B QR
☐ C RS
☐ D ST

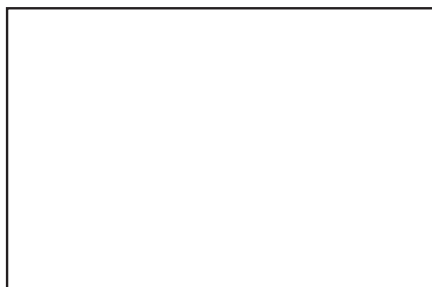
- (ii) Which section of the graph shows when all the substance is a solid?

(1)

- ☐ A PQ
☐ B QR
☐ C RS
☐ D ST

- (iii) Draw particles in the box to show the arrangement of particles when the substance is a gas.

(1)



(iv) Which of these statements best describes the motion of particles in a gas?

(1)

- ☐ **A** they vibrate about fixed points
- ☐ **B** they are stationary
- ☐ **C** they slide past each other
- ☐ **D** they move quickly and randomly

(b) (i) Name a piece of apparatus that could be used to measure the temperature of the substance.

(1)

(ii) Determine the boiling point of this substance.

(1)

boiling point = ... °C

(c) The substance has a mass of 1.2 kg.

Calculate the energy required to raise the temperature of the substance from 10 °C to 37 °C.

[assume specific heat capacity of substance = 840 J/kg °C]

(3)

energy = ... J

(Total for Question 1 = 9 marks)



2 This question is about sound waves.

(a) Sound is an example of a type of wave.

State the name of this type of wave.

(1)

(b) The speed of sound in liquids is greater than the speed of sound in gases.

(i) Describe the arrangement of particles in liquids and in gases.

You may use diagrams to help your answer.

(2)

(ii) Suggest why the speed of sound in liquids is greater than the speed of sound in gases.

(2)



(c) A buzzer is an electrical device that produces sound.

The frequency of sound produced by the buzzer is 1400Hz.

(i) State the formula linking speed, frequency and wavelength of a wave.

(1)

(ii) Sound travels at a speed of 340 m/s in air.

Calculate the wavelength of the sound wave from the buzzer.

(2)

wavelength = ... m



- 8 The photograph shows a water bath that a technician uses to heat some water.



- (a) The water bath is filled with water at an initial temperature of 15°C .

Calculate the initial temperature of the water in kelvin.

(1)

initial temperature = ... K

(b) The technician heats the water to a final temperature of 60 °C.

- (i) Describe how the energy of the water molecules changes as the temperature of the water increases. (2)

- (ii) The table shows some information about the heating element in the water bath and the heating process.

Initial temperature of water	15 °C
Final temperature of water	60 °C
Voltage of heating element	230V
Current in heating element	1.5 A
Time taken to heat water	45 minutes

Calculate the energy transferred by the heating element in the water bath during the heating process. (3)

energy transferred = ... J

- (iii) Calculate the mass of water being heated.

Assume that all the energy is transferred to the thermal store of the water.
[for water, specific heat capacity = 4200 J / kg °C] (3)

mass of water = ... kg

QUESTION CONTINUES ON THE NEXT PAGE

(c) Some water evaporates as a gas from the water bath.

(i) Describe the arrangement of particles in a gas.

(2)

(ii) Describe **two** differences between evaporation and boiling.

(2)

(Total for Question 8 = 13 marks)



SUB-TOPIC 5.4

GAS PRESSURE, TEMPERATURE AND KINETIC THEORY

Sub-topic 5.4 · 12 questions · 116 marks · lowest tariff first



9 This question is about air pressure.

(a) During an aeroplane flight, a passenger drinks some water from a plastic bottle.

The passenger then replaces the top to seal the bottle, as shown in diagram 1.

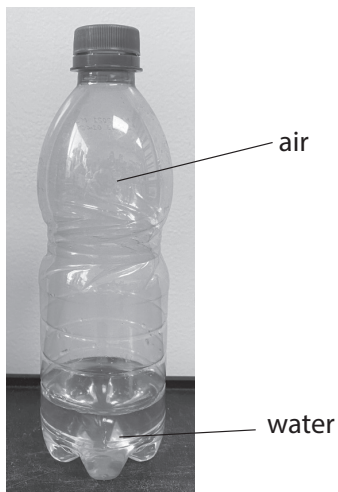


Diagram 1

The air pressure outside the bottle is 80 kPa.

State the air pressure inside the bottle just after the bottle has been sealed.

(1)

air pressure = ... kPa

(b) As the aeroplane descends, the air pressure inside the aeroplane changes.

When the aeroplane lands, the passenger notices that the plastic bottle has collapsed, as shown in diagram 2.

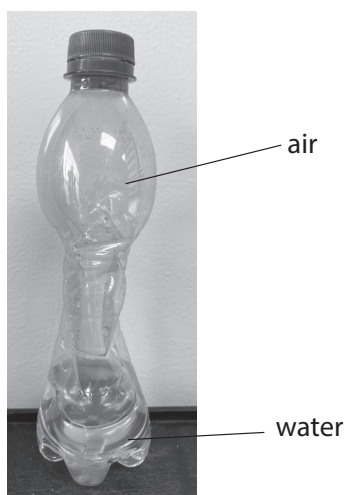


Diagram 2

Explain why the bottle has collapsed.

(2)

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(c) Explain how gas molecules in the air exert a pressure on the surface of the bottle.

(3)

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(Total for Question 9 = 6 marks)

11 This question is about gas pressure.

(a) Diagram 1 shows some of the molecules of a gas in a sealed container.

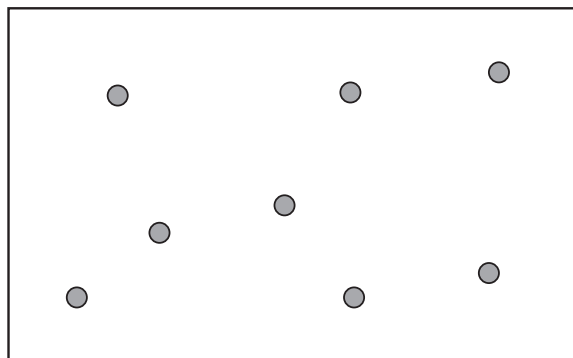


Diagram 1

The molecules collide with all the surfaces of the container. This exerts an outward force on the container and causes pressure.

Describe how the motion of the gas molecules causes an equal pressure on all the walls of the container.

You may add to diagram 1 to help your answer.

(2)

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- (b) The width of the container is slowly decreased so that the volume of the container is smaller than before.

Diagram 2 shows the width of the container before and after this change. All other dimensions of the container remain the same.

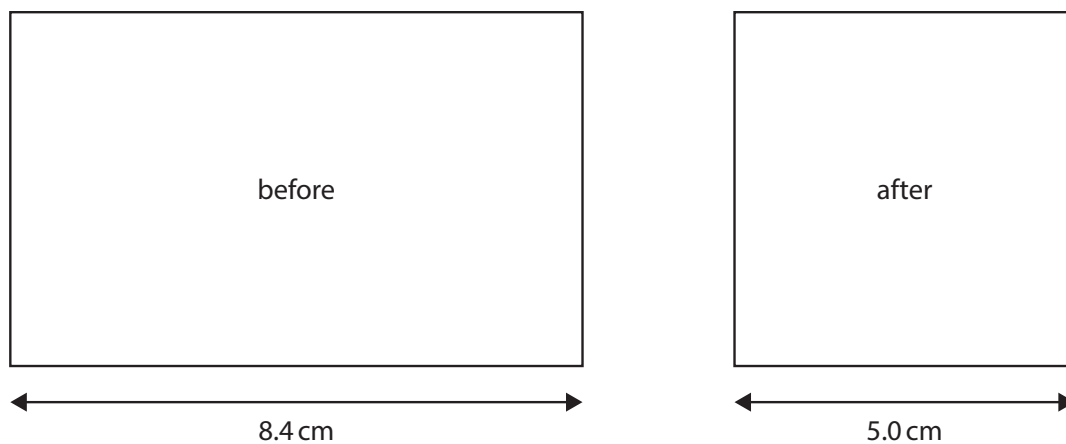


Diagram 2

The initial volume of the gas is 130 cm^3 .

The initial pressure of the gas is 100 kPa .

Calculate the pressure of the gas after the width of the container is decreased.

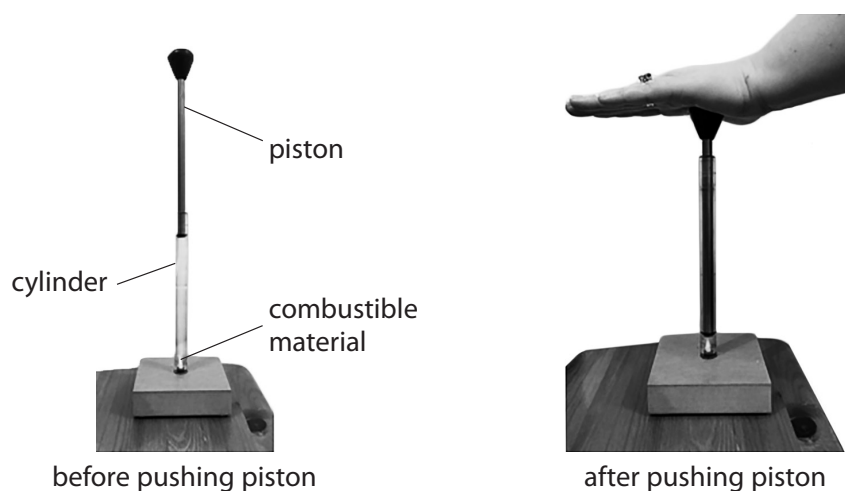
Assume the temperature of the gas remains constant.

(4)

pressure = ... kPa

(Total for Question 11 = 6 marks)

- 8 The photograph shows a device that can be used to ignite small pieces of combustible material. The device consists of a cylinder containing trapped air and a piston.



A small piece of combustible material is placed at the bottom of the cylinder.

When the piston is pushed quickly into the cylinder, the trapped air is compressed and heats up.

This increase in temperature is enough to ignite the combustible material.

- (a) The piston is quickly pushed down a distance of 145 mm.

The average force exerted on the piston is 4.2 N.

- (i) State the formula linking work done, force and distance moved in the direction of the force. (1)

- (ii) Calculate the work done on the trapped air when the piston is quickly pushed down. (2)

work done = ... J

(iii) State the maximum amount of energy that could be transferred to the trapped air.

(1)

energy transferred = ... J

(iv) Using ideas about molecules, explain why the trapped air heats up.

(2)

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(b) Suggest why the trapped air does not reach a high enough temperature to ignite the combustible material if the piston is slowly pushed into the cylinder.

(1)

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(Total for Question 8 = 7 marks)

7 A student uses a syringe containing trapped air to investigate pressure.

Diagram 1 shows the apparatus he uses.

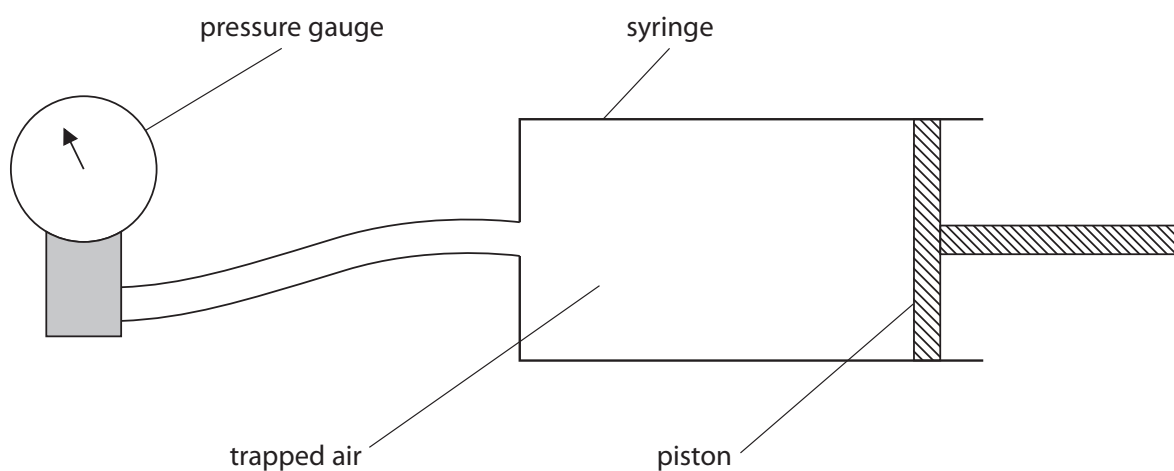
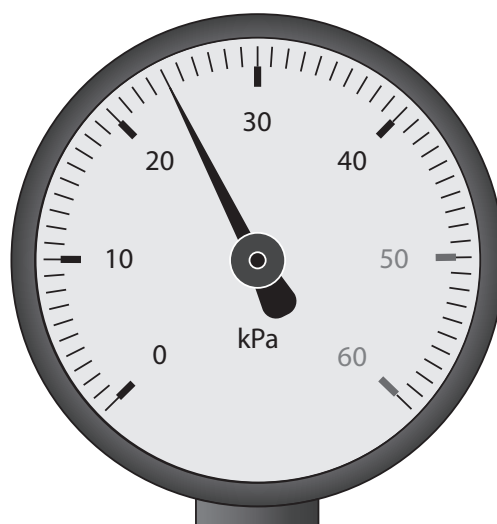


Diagram 1

(a) Diagram 2 shows the pressure gauge when the piston is at its initial position.



© Lubos Chlubny/Shutterstock

Diagram 2

Determine the reading on the pressure gauge.

(1)

pressure = ... kPa

- (b) The piston is pushed in so that the volume of trapped air in the syringe is halved. The temperature of the trapped air remains constant.

Explain how the reading on the pressure gauge will change when the piston is pushed in.

(3)

- (c) The position of the piston is then fixed so that the volume of trapped air in the syringe is now constant.

The air in the syringe is then cooled.

- (i) State how the motion of air particles inside the syringe changes when the air is cooled.

(1)

- (ii) Explain how the pressure of the trapped air inside the syringe changes when the air is cooled.

Refer to particles in your answer.

(3)

(Total for Question 7 = 8 marks)



13 This question is about pressure in gases.

(a) Photograph 1 shows an open conical flask containing air.



Photograph 1

The air in the flask is heated to a temperature of 85°C .

(i) Calculate the temperature of the air in the flask in kelvin.

(1)

temperature = ... K

(ii) Describe how the motion of the molecules in the flask changes when the temperature of the air inside the flask increases.

(2)

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(iii) The pressure of the air in the flask does not change when the temperature of the air increases.

State what happens to the number of air molecules in the flask when the temperature of the air inside the flask increases.

(1)

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.....

- (b) Photograph 2 shows a boiled egg, without its shell, placed in the top of the conical flask containing hot air.

The flask is no longer being heated.

The egg seals the flask so that no air escapes.

Photograph 3 shows the egg and the flask a short time later.



Photograph 2



Photograph 3

Explain why the egg moves down into the flask and then stops moving.

Refer to ideas about pressure in your answer.

(4)

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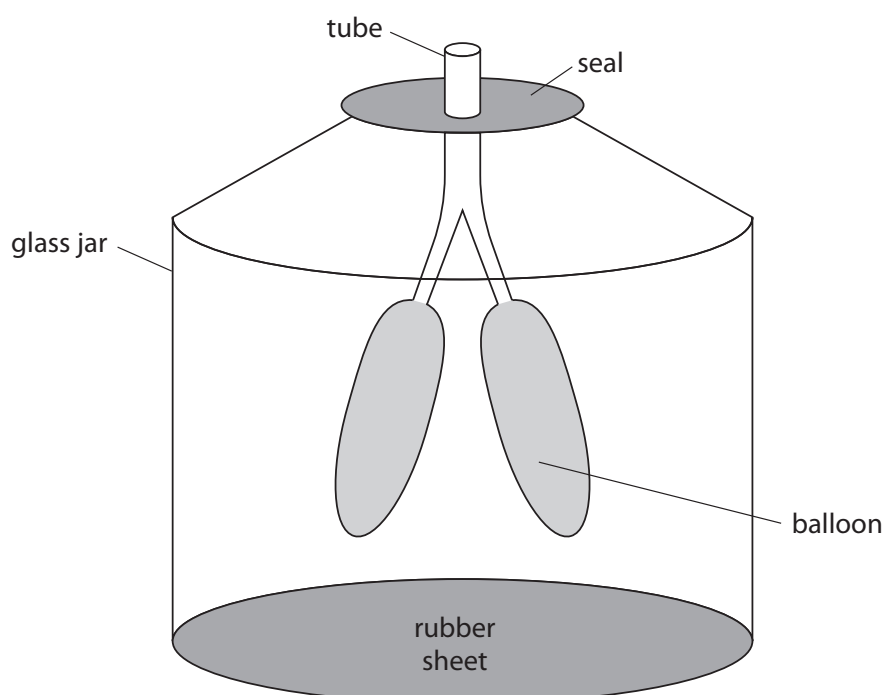
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(Total for Question 13 = 8 marks)

11 The diagram shows a model of the human breathing system.



The rubber sheet is pulled downwards so that the air inside the glass jar occupies a larger volume.

The temperature of the air does not change.

(a) Explain, in terms of particles, why the pressure of the air inside the glass jar decreases. (3)

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(b) Before the rubber sheet is pulled down, the air inside the jar is at atmospheric pressure.

The volume of gas inside the jar increases from 110 cm^3 to 140 cm^3 .

Calculate the pressure inside the jar after the rubber sheet is pulled down.

[atmospheric pressure = 101 kPa]

(3)

pressure = ... Pa

(c) The jar is sealed, but the balloons are open to the atmosphere.

Before the rubber sheet is pulled down, the air inside the balloons is at atmospheric pressure.

Explain why the balloons start to expand when the rubber sheet is pulled down.

(3)

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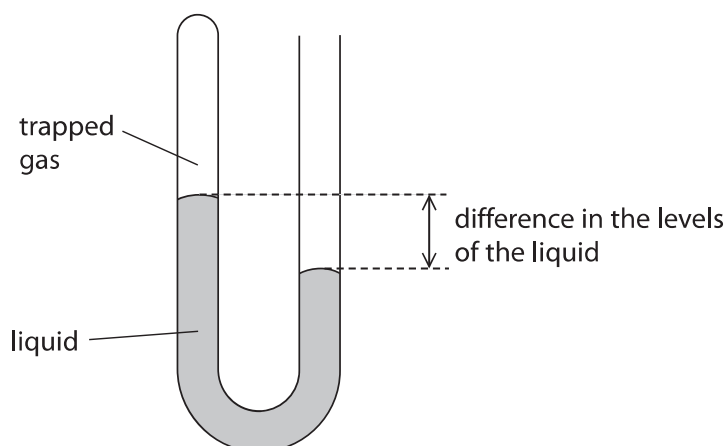
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(Total for Question 11 = 9 marks)



11 The diagram shows a manometer, a device used for measuring differences in pressure.



- (a) One side of the manometer has some trapped gas. The other side is left open to the atmosphere.

The difference in pressure can be calculated using this formula.

[difference in pressure = height $\times$ density $\times$ 10]

The density of the liquid is $1.3 \times 10^4 \text{ kg/m}^3$.

The difference in the levels of the liquid is 3.8 cm.

Calculate the difference in pressure between the atmosphere and the trapped gas.

(3)

difference in pressure = ... Pa

(b) The temperature and pressure of the trapped gas increase when it is warmed.

(i) Explain, in terms of particles, why the pressure of the trapped gas increases.

(3)

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(ii) The pressure of the trapped gas in the manometer is $9.95 \times 10^4 \text{ Pa}$ and the temperature is 16°C .

Calculate the new pressure of the trapped gas if the temperature increases to 32°C .

[assume volume of the trapped gas remains constant]

(4)

new pressure = ... Pa

(Total for Question 11 = 10 marks)



3 This question is about solids, liquids and gases.

(a) Melting is the process that occurs when a solid changes into a liquid.

Using ideas about particles, describe the process of melting.

(2)

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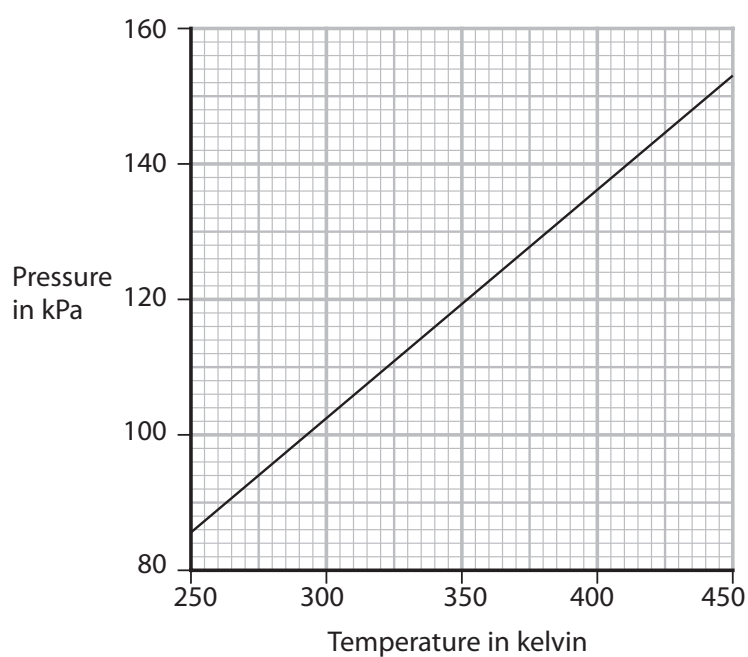
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(b) A sealed metal flask contains air at room temperature.

The flask is then heated.

The graph shows how the pressure of the air increases as its temperature increases.



(i) Explain how heating the flask increases the temperature of the air inside the flask.

(2)

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(ii) Explain why the pressure of the air increases as its temperature increases.

(2)

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(iii) Using the graph, determine the pressure of the air when its temperature is 400 K.

(1)

pressure = ... kPa

(iv) The air in the flask is now cooled to a temperature of 230 K.

Calculate the new pressure of the air.

(3)

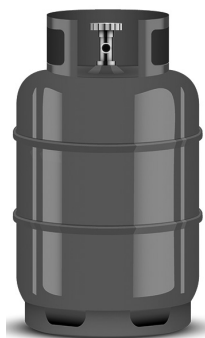
pressure = ... kPa

(Total for Question 3 = 10 marks)



9 This question is about gas pressure.

(a) The diagram shows a cylinder containing propane gas.



(Source: © VitaminCo/Shutterstock)

The propane gas is stored in the cylinder at a pressure of $1.03 \times 10^6 \text{ Pa}$.

(i) State the formula linking pressure, force and area.

(1)

(ii) The cylinder has an internal surface area of 1.13 m^2 .

Calculate the force exerted on the walls of the cylinder by the propane gas.

(3)

force = ... N

(iii) Explain why the pressure exerted by the propane gas acts equally in all directions.

(2)

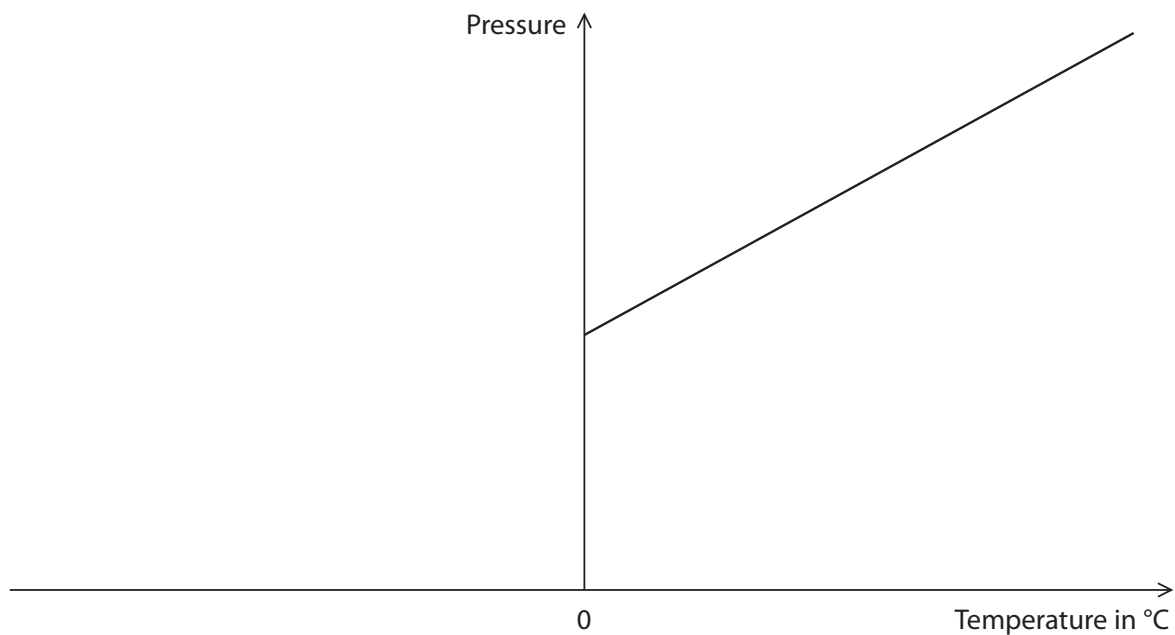
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(b) The graph shows how the pressure of a gas varies with its temperature.



- (i) Describe how the graph can be used to show that there is a minimum value of temperature, known as absolute zero.

(2)

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- (ii) Give the value of absolute zero in °C.

(1)

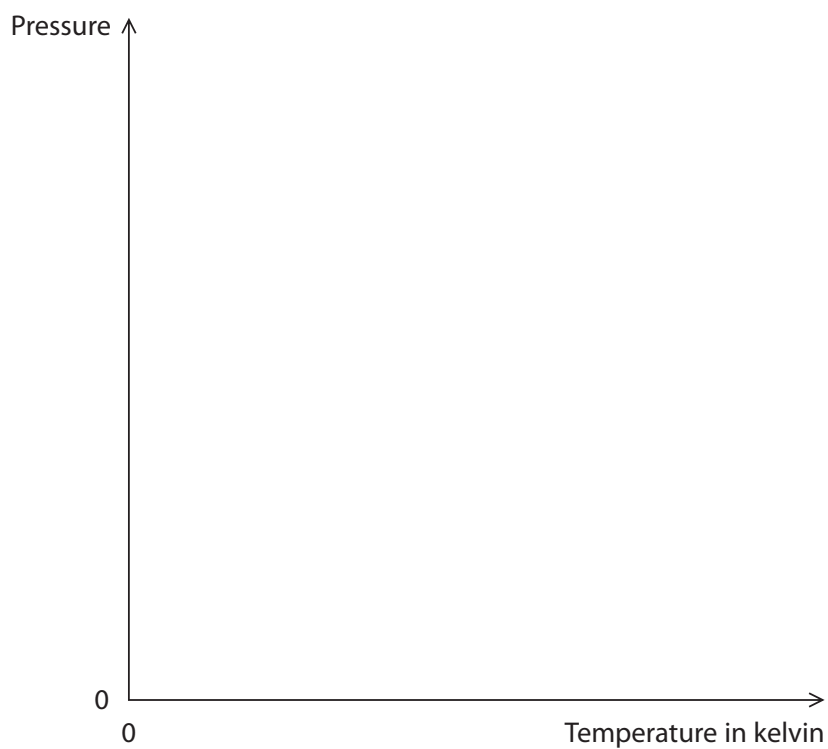
absolute zero = ... °C



(iii) Temperature can also be measured in kelvin.

On the axes below, sketch a graph to show how the pressure of a gas varies with its kelvin temperature.

(2)



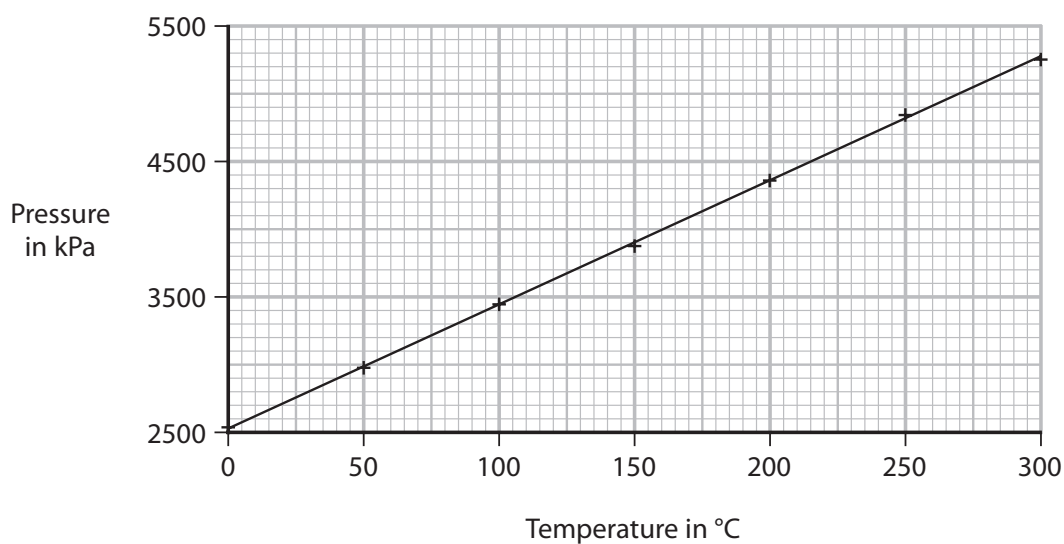
(Total for Question 9 = 11 marks)



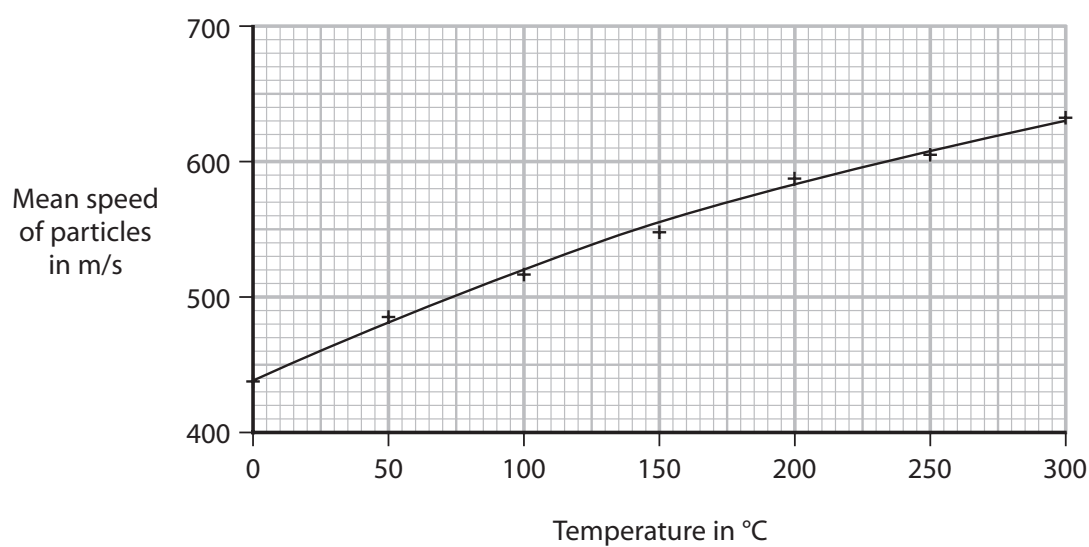
8 A student uses a computer simulation to investigate the motion of particles in a gas.

He records the pressure of the gas and the mean speed of the particles in the gas at different temperatures.

The graphs show his results.



Graph 1



Graph 2

- (a) Give a reason why the student does not start the y-axis scale from zero on either of his graphs.

(1)

- (b) Describe the relationships shown by the graphs.

(3)

- (c) Explain why the value of temperature chosen in the simulation should not decrease below -273°C .

(2)



(d) The student then calculates the kinetic energy of a single gas particle at each temperature.

- (i) Using the curve of best fit on graph 2, determine the mean speed of a gas particle when the gas temperature is 100°C .

(1)

mean speed = ... m/s

- (ii) The mass of a single gas particle is 5.3×10^{-26} kg.

Calculate the average kinetic energy of a gas particle when the temperature of the gas is 100°C .

(3)

kinetic energy = ... J

- (iii) Calculate the temperature of the gas in kelvin when its temperature is 100°C .

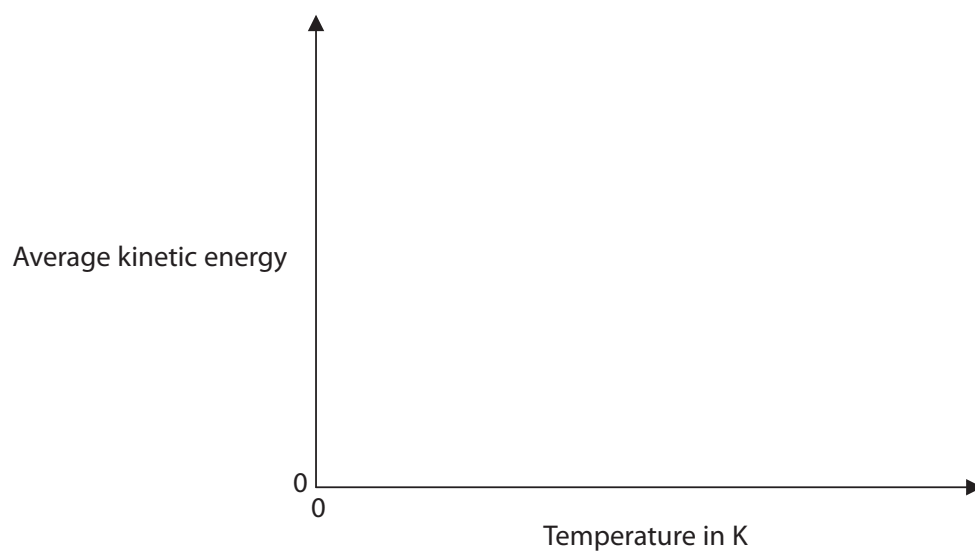
(1)

temperature = ... K



(iv) On the axes, sketch a graph of the average kinetic energy of the gas particles against temperature in kelvin.

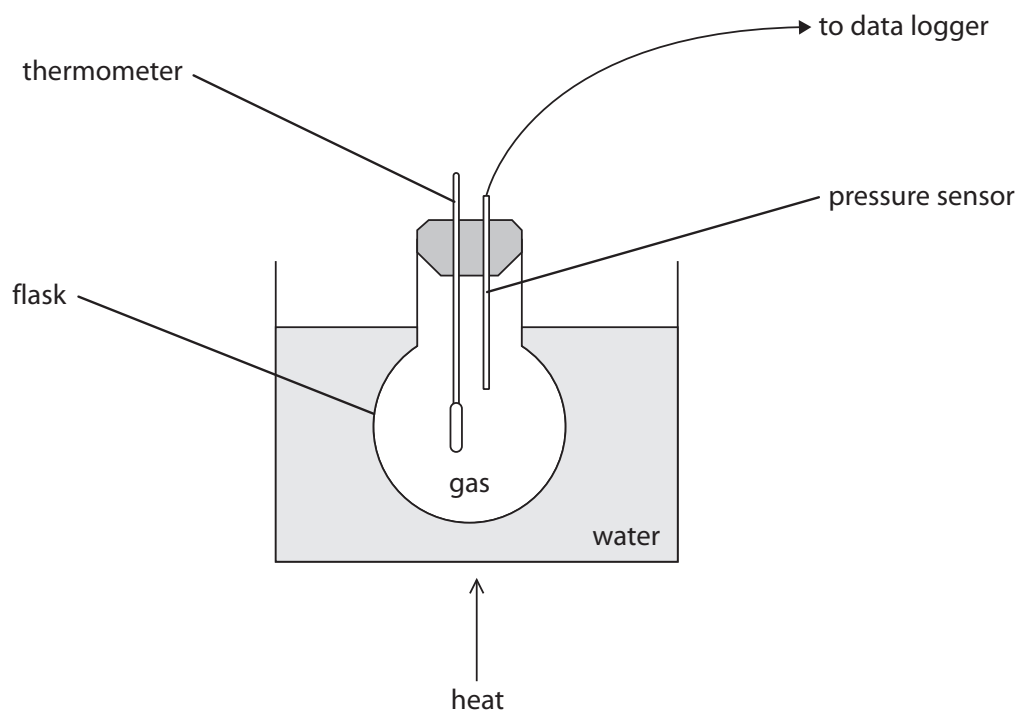
(2)



(Total for Question 8 = 13 marks)



- 4 The diagram shows apparatus used to investigate how the pressure of a gas varies with temperature.



- (a) The volume of the gas is kept constant by the flask.

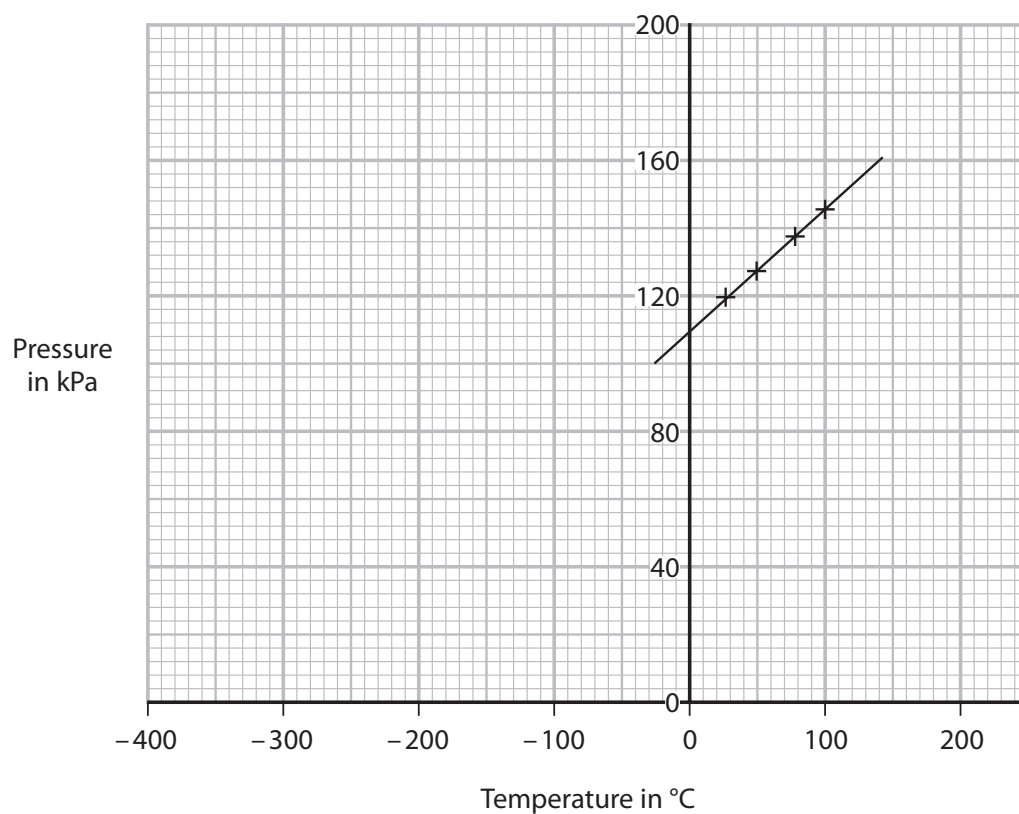
The volume of the gas is a control variable.

State why it is important to keep a control variable constant throughout the investigation.

(1)

(b) The pressure of the gas changes as its temperature increases.

The graph shows the results.



(i) Explain how these results show that there is a linear, but not proportional, relationship between the pressure of the gas and its temperature in °C.

(2)

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(ii) Use the graph to determine the value for absolute zero.

(2)

temperature = ... °C

(iii) Explain how the pressure of the gas changes as its temperature increases.

Include ideas about particles in your answer.

(3)

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(c) The pressure of the gas is 112 kPa when its temperature is 35 °C.

The gas is heated to 340 °C using some different apparatus.

(i) Calculate the pressure of the gas when its temperature is 340 °C.

Assume the gas has a constant volume.

(4)

pressure = ... kPa

(ii) The volume of the gas is constant in the investigation.

Give the name of the other quantity that must be constant for the calculation to be correct.

(1)

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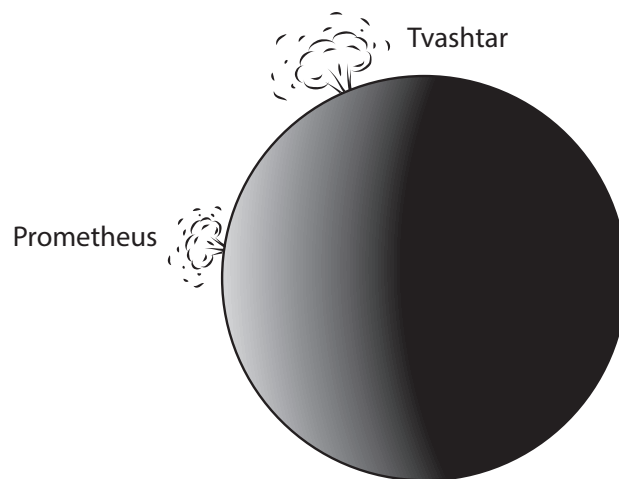
(Total for Question 4 = 13 marks)



7 This is a question about Io, a moon of Jupiter.

The diagram shows two jets of gas from volcanoes on Io.

One jet of gas is from the volcano Prometheus and the other is from the volcano Tvashtar.



(a) Gas particles in the Prometheus jet leave the surface of Io and move vertically upwards.

The particles reach their maximum height when their speed is zero.

Some particles in the Prometheus jet reach a maximum height of 92 km.

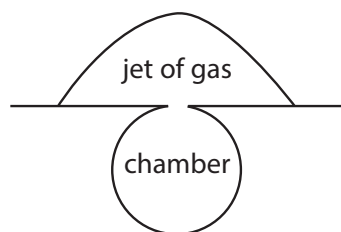
Calculate the initial speed of these particles as they leave the surface of Io.

[acceleration due to gravity on Io = 1.8 m/s^2]

(3)

initial speed = ... m/s

(b) Before the gas particles leave the surface of Io, they are trapped in a chamber.



(i) Explain how the gas particles exert a pressure on the walls of the chamber.

(3)

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(ii) The Tvashtar chamber has the same volume as the Prometheus chamber and contains the same number of molecules of the same type of gas.

The temperature of the gas in the Prometheus chamber is 1200 K.

The temperature of the gas in the Tvashtar chamber is 1600 K.

The pressure of the gas in the Prometheus chamber is 8.2 kPa.

Calculate the pressure of the gas in the Tvashtar chamber.

(3)

pressure = ... kPa



(iii) Explain why the pressure inside the chambers increases when the temperature increases.

Use ideas about particles in your answer.

(3)

(iv) Explain why the particles from the Tvashtar chamber reach a greater maximum height than the particles from the Prometheus chamber.

(3)

(Total for Question 7 = 15 marks)



MARK SCHEMES

official mark schemes



Question number	Answer	Notes	Marks
2 (a)	density = mass / volume;	allow standard symbols and rearrangements e.g. $\rho = m / V$ condone use of d for density	1
(b)	substitution OR rearrangement; evaluation; unit; e.g. $8.46 = 454 / V$ OR $V = m / \rho$ $(V =) 53.7$ cm^3	equation must be correct -1 for POT error allow m^3 only if consistent with data used 53.664... $5.37 \times 10^{-5} \text{ m}^3$ gains 3 marks	3

Total for Question 2 = 4 marks



Question number	Answer	Notes	Marks
6 (a)	(i) density = mass / volume;	allow rearrangements and use of symbols e.g. $V = m / \rho$ or $D = M/V$	1
	(ii) substitution OR rearrangement; evaluation; e.g. $V = m / \rho$ OR $2.3 = 19 / V$ ($V =$) 8.3 (cm ³)	allow 8.26...	2
(b)	(i) pressure difference = height x density x g;	allow use of standard symbols e.g. $p = h \times \rho \times g$ reject 'gravity'	1
	(ii) substitution; evaluation; e.g. ($p =$) $5.6 \times 1000 \times 10$ ($p =$) 56 000 (Pa)	accept use of $g = 9.8(1)$ m/s ² -1 if POT error in substitution Use of 9.8 gives 54 880 Use of 9.81 gives 54 936 Both round to 55 000	2

Total for Question 6 = 6 marks

Question number	Answer	Notes	Marks
6 (a)	using a balance; suitable method to subtract mass of container;	ignore weighing scales / scales e.g. - measure mass of similar empty container and subtract - place another container on balance and press zero then pour liquid into this container	2
(b)	any two from: MP1. measuring cylinder placed on horizontal surface; MP2. reading taken from bottom of meniscus/eq; MP3. reading taken at eye level (to avoid parallax); MP4. wait for all liquid to run down the sides of the measuring cylinder; MP5. ensure measuring cylinder is empty before use;	ignore idea of 'repeat and average' condone 'flat surface'	2
(c)	use of density formula; evaluation of density of liquid; liquid is sunflower oil; e.g. density = $150 / 163$ density = $0.92 \text{ (g/cm}^3\text{)}$ closest to sunflower oil => liquid is sunflower oil	unsupported correct conclusion scores 1 mark only	3

Total for Question 6 = 7 marks

Question number	Answer	Notes	Marks
11 (a)	determination of mass of water; substitution into / rearrangement of density formula; evaluation; rounding to 3 s.f.; e.g. mass = 49.5 (g) $0.998 = 49.5/\text{volume}$ OR $\text{volume} = \text{mass}/\text{density}$ volume = 49.599 49.6 (cm ³)	allow ECF from incorrect mass mark independently	4
(b)	determination of mass of liquid; use of volume from (a); evaluation; e.g. $143.8 - 63.4 = 80.4$ (g) density = $80.4 / 49.6$ density = 1.62 (g/cm ³)	allow ECF from (a) allow ECF from incorrect mass	3
(c)	any three from: MP1. with measuring cylinder can read volume to nearest cm ³ ; MP2. measuring cylinder is easier/quicker to use; MP3. measuring cylinder does not need to be dried; MP4. idea that measuring cylinder value could be incorrect due to parallax errors/meniscus etc; MP5. 'bottle' gives volume to nearest 1 dp; MP6. 'bottle' allows density to be more precisely determined;	allow RA throughout	3

Total for Question 11 = 10 marks

Question number	Answer	Notes	Marks
5 (a)	MP1. use balance to measure mass; MP2. use of measuring cylinder to measure volume; PLUS Any three from: MP3. ensure balance reads zero before placing rock; MP4. ensure balance is on a level surface; MP5. ensure rock is dry when measuring its mass MP6. recording volume before rock added to water MP7. finding difference in volume of water after rock added MP8. ensure rock is fully submerged; MP9. ensure no water is spilt / all water collected by measuring cylinder; MP10. read measuring cylinder at eye level / on a level surface; MP11. read to bottom of water meniscus;	marks can be awarded from candidate's diagram allow (weighing) scales reject scale allow measure mass before volume fill displacement can to 'top' or 'spout'/eq catch displaced volume when rock added ignore unqualified reference to 'avoid parallax'	5
(b) (i)	density = mass / volume;	allow standard symbols and rearrangements e.g. $\rho = m / V$ allow d for density	1
(b) (ii)	idea that different materials have different densities; correct evaluation of density for at least one rock; correct evaluation of density for all rocks; conclusion from density values that rock A is made from a different material (so student is correct);	A = 2.38 or 2.4 (g/cm³) B = 2.1(3) (g/cm³) C = 2.1(3) (g/cm³) ecf incorrect densities if candidate's conclusion is consistent	4

Total for Question 5 = 10 marks



Question number	Answer	Notes	Marks
8 (a)	any FIVE from: MP1 use a balance (to measure the mass); MP2 mention a displacement method; MP3 measure the mass first; MP4 (because) a wet rock weighs more; MP5 use of eureka/displacement can or measuring cylinder; MP6 mention of eye-level or parallax avoidance; MP7 make sure rock completely submerged; MP8 make sure no water splashes out/put rock in gently;	ignore • geometry equations • use of a ruler to measure rock • density = mass / volume Can be implied from order of response. explicit mention only	5
(b) (i)	density = mass / volume;	accept correct rearrangements accept symbols i.e. rho, m/M, v/V	1
(ii)	substitution; evaluation; answer to 2 sf; e.g. density = 32/12 density = 2.66... g/cm³ density = 2.7 g/cm³ to 2 sf	2 sf marked independently	3
(iii)	quartz; as the density of rock X is the same as the density of quartz;		2

Total for Question 8 = 11 marks



Question number	Answer	Notes	Marks
1 (a) (i)	particles with larger spaces between them;	max space in body or surface one of particles from diagram on left.	2
	particles in less regular structure;		
(ii)	particles {slide/move/flow} past each other;	ignore 'more freely'	1
(b) (i)	safety goggles/gauntlets/gloves/not splashing/eq;		1
(ii)	balance;	condone 'scales' ignore 'meter(s)'	1
(iii)	74 (g);		1
(iv)	density = mass/volume;	allow any accepted letters for density, mass or volume allow d, ρ for density	1
(v)	substitution; evaluation; matching unit; correct answer: 0.84 g/cm^3 e.g. density = mass / volume density = $74/88$ density = 0.84 g/cm^3 to 2 sf	ECF for incorrect mass allow 0.8409090...	3
(c)	(particles) far apart / much further apart; particles move with (much) higher speed / have higher <u>kinetic</u> energy; move (more) randomly;	allow KE for kinetic energy	3

Total for Question 1 = 13 marks

Question number	Answer	Notes	Marks
10 (a) (i)	use of a balance; PLUS idea that balance should be zeroed / idea that balance should be level / idea that there should be no draughts	ignore scale allow weighing scale condone scales allow idea that balance is placed on a flat/level surface	2
(ii)	6.426 circled;		1
(iii)	evidence of correct method of calculating mean; evidence of ignoring anomaly in calculation; answer rounded to 3 decimal places; e.g. mean mass = $(6.411 + 6.408 + 6.410 + 6.412) / 4$ mean mass = 6.410 (g)	e.g. adding all five values together and dividing by five = 6.4134 allow ecf from (ii) expect 6.41025	3
(iv)	C (volume = mass ÷ density); A is incorrect because this is the incorrect rearrangement B is incorrect because this is the incorrect rearrangement D is incorrect because it has density cubed		1

(b)	any four from: MP1. idea that density will depend on purity of gold; MP2. idea that calculating volume will be affected by purity; MP3. reference to mass measurement being four significant figures; MP4. source of error in displacement method described; MP5. idea that small volume of ring will be difficult to measure using displacement method; MP6. calculating volume is likely to be more accurate than measuring for a valid reason e.g. if gold is pure or if there's splashing in a displacement method	e.g. • possible splashing • ring not fully submerged • meniscus • parallax e.g. due to gradations being not small enough accept RA i.e. if gold is not pure then measurement could be more accurate	4
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Total for Question 10 = 11 marks

Question number	Answer	Notes	Marks
1 (a)	use of a balance; PLUS any ONE from - idea that balance should be zeroed; - idea that there should be no draughts; - idea that balance should be level;	ignore scale allow weighing scale condone scales allow 'tare' for 'zero' allow idea that balance is placed on a flat/level surface ignore idea of 'repeat and average' ignore references to sig figs or decimal places	2
(b) (i)	either reading correctly measured; both readings correctly measured and subtracted;	allow 30 or 37 seen in working final answer of 7 (cm³) scores both marks	2
(ii)	substitution; evaluation; any dimensionally correct unit that matches candidate's evaluation; e.g. density = $9.2 \div 7$ (density =) 1.3 g/cm³	allow ecf from (i) allow any value which would round to 1.3×10^n e.g. the following would score full marks: 1300 kg/m³ 1.3 g/cm³ 1300 g / litre 1.3×10^{-3} kg/cm³ allow 1.31...	3

Total for Question 1 = 7 marks

Question number	Answer	Notes	Marks
2 (a)	9 (kPa);		1
(b)	(liquid) pressure = depth (of liquid) $\times$ density $\times$ g;	accept d, h, height for depth rho, ρ for density g.f.s or gravitational field strength for g reject gravity for g	1
(c)	substitution; rearrangement; evaluation; e.g. pressure difference = 9 kPa $9\,000 = d \times 960 \times 10$ $d = 9000 / (9600)$ $d = 0.94$ (m)	allow ecf from (a) allow use of $g = 9.8(1) \text{ m/s}^2$ giving 0.96 m allow 0.937(5) POT error penalty of 1 mark, except if formula is incorrect i.e. no 'g'	3

Total for Question 2 = 5 marks

Question number	Answer	Notes	Marks
5 (a)	any four from: MP1. measurement of area of foot/feet; MP2. idea of drawing round foot/feet on squared/grid/graph paper (to measure area); MP3. measurement of weight / use of $W = mg$; MP4. use of a balance / scale(s) (to measure weight/mass); MP5. use of $p = F \div A$;	allow if weight referred to in a calculation allow newtonmeter expressed in words or symbols	4
(b)	weight = 6600 (N); substitution into $p = F / A$; correct evaluation; e.g. weight = $660 \times 10 = 6600$ (N) pressure = $6600 / 1300$ (pressure =) 5.1 (N/cm ²)	allow use of $g = 9.8, 9.81$ (N/kg) to get weight = 6468, 6474.6 (N) -1 for POT error allow 5 (N/cm ²) if supported by working using mass instead of weight to get 0.51 (N/cm ²) scores 2 marks max. allow 5.076... (N/cm ²) condone 5.0 (N/cm ²) allow 4.975..., 4.980... (N/cm ²) from use of different values of g	3

Total for Question 5 = 7 marks

Question number	Answer	Notes	Marks
9 (a) (i)	Selection of $P=F/A$; Conversion of g to kg; Evaluation of weight; Evaluation of pressure; Correct answer: 140 (Pa) i.e. $W = 3.7 \times 10^{-3} \times 10 = 3.7 \times 10^{-2} \text{ N}$; $P = 3.7 \times 10^{-2} / (2.6 \times 10^{-4})$; $P = 140 \text{ (Pa)}$;	0.0037 seen anywhere Accept any value that rounds to 140. i.e 142, 142.3, Accept use of 9.8(1) for 'g', giving 139(.46)	4
(ii)	Same weight (and larger cross-sectional area); $P=F/A$ so smaller pressure;	Allow 'force' for weight	2
(b)	Increases continuously from -10°C to 0°C; Remains constant at 0°C; Increases continuously from 0°C to 20°C;	Responses with no period of time at 0°C score max 1 mark. Accept - Any gradient - Straight lines or curves for the increasing temperature parts - Any non-zero amount of time at 0°C by eye Ignore any numbers on the time axis.	3
(c)	Any TWO from: Bonds between particles are weakened or broken; Particles go from regular to irregularly packed/EQ; Particles go from vibrating (about a fixed position) to sliding past each other/EQ;	Allow particles get (slightly) further apart/EQ; ignore references to KE	2

Question number	Answer	Notes	Marks
2 (a) (i)	downward arrow labelled weight;	ignore starting point of arrow allow 'gravitational force', 'force due to gravity' reject 'gravity' judge by eye	2
	downward arrow is equal in length to upthrust arrow;		
	(ii) (a quantity with) magnitude; and direction;	allow size, amount ignore quantity, measurement	2
(iii)	any correct vector; e.g. velocity, displacement, acceleration, momentum etc.	ignore force, any named force e.g. weight, upthrust etc	1
(b) (i)	pressure (difference) = height $\times$ density $\times$ g;	allow standard symbols and rearrangements e.g. $p = h \times \rho \times g$ allow d for density ignore "gravity" for g	1
	(ii) substitution; evaluation of pressure difference in Pa OR kPa to at least 3s.f.; addition of surface pressure (100 kPa) to give answer; e.g. $p = 15.8 \times 1030 \times 10$ $p = 162740 \text{ Pa}$ OR 162.74 kPa $p = 162.74 + 100 (= 260 \text{ kPa})$	allow $g = 9.8, 9.81$ -1 for POT error unless due to physics error reject this mark if inconsistent units used allow final answer in Pa or kPa allow 262 740 (Pa)	3
	(iii) any two from: MP1. idea that {weight of ship / downwards force} is greater; MP2. larger pressure difference (when deeper in water); MP3. larger upthrust force (needed to keep forces balanced);	allow ship is heavier, ship has more mass allow larger pressure (on bottom of ship)	2

Total for Question 2 = 11 marks

Question number	Answer	Notes	Marks
4 (a)	(i) weight = mass $\times$ gravitational field strength;	allow rearrangements and standard symbols e.g. $W = m \times g$ ignore 'gravity' for g	1
	(ii) substitution or rearrangement; evaluation; e.g. $520 = \text{mass} \times 10$ OR $\text{mass} = W / g$ (mass =) 52 (kg)	allow $g = 9.8, 9.81$ allow 53.1, 53.0, 53	2
(b)	(i) evidence of counting squares to find area; number of squares in range 37-42; evaluation of area of one square; evaluation of total area; e.g. dots seen in each square in diagram number of squares = 39 area of one square = $(2 \times 2) = 4 \text{ cm}^2$ total area = $(4 \times 39) = 156 \text{ cm}^2$	allow attempt to find area by splitting into rectangles / triangles allow if 2×2 seen in working allow ecf from incorrect number of squares allow 148-168	4
	(ii) pressure = force / area;	allow standard symbols and rearrangements e.g. $p = F / A$	1
	(iii) dimensionally correct substitution; evidence of doubling area or halving pressure to account for both feet; evaluation with matching unit; e.g. (pressure =) $520 / 156$ area = 156×2 OR pressure = $3.2 \div 2$ (pressure =) 1.7 N/cm^2	allow ecf from (b)(i) allow N/cm^2 , N/m^2 or Pa if no marks awarded for calculation allow 1 mark if valid unit for pressure given allow $1.5\text{-}1.8 \text{ N/cm}^2$ allow $15\,000\text{-}18\,000 \text{ N/m}^2$	3

Total for Question 4 = 11 marks



Question number	Answer	Notes	Marks
9 (a)	substitution into given formula; evaluation; e.g. pressure difference = $14\,000 \times 10 \times 0.094$ pressure difference = 13 000 (Pa)	allow use of $g = 9.8$, 9.81 N/kg -1 for POT error but only if not due to omitting g allow answers rounding to 13 000 (Pa) allow 13 200, 13 160 (Pa)	2
(b) (i)	idea that distance is area under graph; correct values read from graph; working arriving at 4.7 (cm);	expressed explicitly or implied from working allow alternative method that distance = average speed $\times$ time expect 47 and 0.20 to be seen in working DOP	3
(ii)	any viable attempt at a gradient; correct use of 47 and 0.20 in gradient calculation; acceleration in range $(-230 \text{ to } -240 \text{ cm/s}^2)$;	allow use of $v^2 = u^2 + 2as$ allow other suitable values for gradient e.g. 35 (cm/s) in 0.15 (s)	3
(c)	idea of (gas) particles speeding up; idea of more frequent collisions between particles and liquid/walls/container; idea of harder collisions between particles and liquid/walls/container;	allow KE of particles increases allow force (on container) increases	3

Total for Question 9 = 11 marks

Question number	Answer	Notes	Marks
10 (a) (i)	pressure difference = height $\times$ density $\times$ g;	allow in words or standard symbols e.g. $p = h \times \rho \times g$ condone d for density	1
(ii)	substitution; evaluation of pressure difference in kPa; evaluation of total pressure by adding 100 (kPa); e.g. (pressure difference =) $35 \times 1000 \times 10$ (pressure difference =) 350 (kPa) (pressure = $350 + 100$ =) 450 (kPa)	allow 343 (kPa) for use of $g=9.8$ N/kg ECF candidate's water pressure allow 443 (kPa) for use of $g=9.8(1)$ N/kg allow 450 000 Pa with clear intent from candidate i.e. removal of 'k' from unit on answer line. -1 for POT error but not if due to physics error such as missing g, substitution of 100 (kPa) for g 350 kPa gets 2 marks 350 100 kPa gets 2 marks unqualified 350 000 (kPa) gets 1 mark	3
(b) (i)	pressure = force $\div$ area;	allow in words or standard symbols e.g. $p = F / A$	1
(ii)	substitution; rearrangement; evaluation; corresponding unit of area; e.g. $260\,000 = 430 / \text{area}$ (area =) $430 / 260\,000$ (area =) 0.0017 m^2	condone pressure in Pa or kPa accept standard form i.e. $1.7 \times 10^{-3} (\text{m}^2)$ allow 0.0016538... m^2 etc allow 17, 16.5... (cm^2) etc allow 1.65... m^2 scores 3 allow 1.65... cm^2 scores 2	4
(c)	pressure (at bottom) is greater than before / eq; wider base /eq;	allow stronger material/eq ignore taller	2

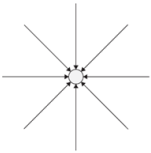
Total for Question 10 = 11 marks

Question number	Answer	Notes	Marks
7 (a)	(i) as pressure increases, volume decreases; pattern statement relating to gradient; e.g. 'at a decreasing rate'	ORA	2
	(ii) pressure = depth × gravitational field strength × density;	'inversely proportional' scores 2 marks. allow recognised symbols e.g. P or p for pressure d or h for depth ρ for density reject d for density, reject gravity for g	1
	(iii) substitution; evaluation; e.g. pressure = $0.22 \times 10 \times 1080$ pressure = 2 400 (Pa)		2
	(iv) 103 000 (Pa)	Accept use of g=9.8(1) (N/kg) 2376 (Pa) -1 for POT error provided g is used accept 103 400 (Pa) allow ECF	1
	(v) substitution into given formula; rearrangement; evaluation; e.g. $p_1 \times V_1 = p_2 \times V_2$ $101\,000 \times 0.084 = 103\,000 \times V_2$ $V_2 = 0.082 \text{ (cm}^3\text{)}$	allow ECF from (iv) e.g. 98624 gives 0.086 (cm ³) 0.082368932 -1 for POT error	3
	(b) vertical arrow upwards labelled upthrust; vertical arrow downwards labelled weight; upthrust > weight;	ignore drag reject this mark if there are more than two arrows	3

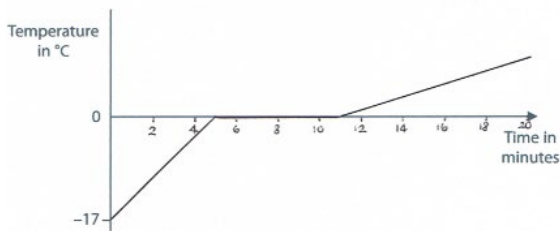
(Total for Question 7 = 12 marks)

Question number	Answer	Notes	Marks
10 (a)	use of $p = h \times \text{density} \times g$; conversion of 57 cm into 0.57 m; evaluation; e.g. $\text{pressure difference} = 57 \times 820 \times 10$ $\text{pressure difference} = 0.57 \times 820 \times 10$ $(\text{pressure difference} =) 4700 \text{ (Pa)}$	allow mark if formula on its own is seen in working allow use of $g = 9.8, 9.81$ 470 000, 467 000, 467 400, 458 052, 458 519.4 etc. score 2 marks allow 4670, 4674, 4580.52, 4585.194 etc.	3
(b) (i)	substitution into $W = m \times g$; evaluation; correct unit; e.g. $W = 24 \times 10$ $(W =) 240$ newtons / N	no mark for formula on its own allow use of $g = 9.8, 9.81$ -1 for POT error e.g. incorrectly changing kg to g mark independently allow 235.2, 235.44	3
(ii)	substitution into $p = F/A$; evaluation; e.g. $p = 240 / 1.2$ $(p =) 200 \text{ (Pa)}$	no mark for formula on its own allow ecf from (i)	2
(iii)	substitution into $p = F/A$; rearrangement; evaluation; e.g. $200 = F / 4.8$ $F = 200 \times 4.8$ $(F =) 960 \text{ (N)}$	no mark for formula on its own allow ecf from (ii)	3
(c)	GPE of piston X = decrease; GPE of piston Y = increase; chemical energy of piston Y = no change; kinetic energy of piston Y = no change;	allow marks if the meaning is clear e.g. allow +, ↑ for increase etc.	4

Total for Question 10 = 15 marks

Question number	Answer	Notes	Marks
7 (a) (i)	D; () <i>A is incorrect because the pressure is not equal around the bubble</i> <i>B is incorrect because the pressure above the bubble is greater than below the bubble</i> <i>C is incorrect because the pressure to the right of the bubble is greater than to the left of the bubble</i>		1
(ii)	pressure decreases as bubbles get nearer to the surface; (because) less (weight of) water above the bubble; with one from: volume is inversely proportional to pressure; OR forces outside bubble decrease (as pressure decreases), which leads to bubble expanding;	allow RA allow less pressure at smaller depth allow RA allow use of $p = \rho gh$ to justify why pressure decreases as height decreases allow pressure $\times$ volume = constant OR $p_1 V_1 = p_2 V_2$ condone as pressure decreases volume increases	3
(b)	idea that board of nails increases the area that force is being applied; pressure is less with board; (for a given force) pressure is inversely proportional to area; OR idea that force on each nail is less when using board of nails; pressure is less with board; (for a given area) pressure is proportional to force;	allow $p = F/A$ allow $p = F/A$	3

Total for Question 7 = 7 marks

Question number	Answer	Notes	Marks
5 (a) (i)	line starts at (0,-17) and rises to steady temperature of 0 °C (after 5 minutes); 6 minutes along time axis at temperature of 0 °C; line drawn showing increase in temperature from 0 °C until 20 minutes on time axis; 	allow candidate's time axis scale or clearly marked times line can be curved or straight ignore start and end times as long as duration is 6 minutes line can be curved or straight and can end at any temperature	3
(ii)	any one from: • keep heater submerged; • (check) voltage remains constant; • idea of not removing lid; • stirring (once some ice has melted); • repeat and average;	ignore using more insulation, digital thermometer allow idea that lid is well sealed allow repeat and remove anomalies	1
(b)	dimensionally correct substitution into $\Delta Q = m \times c \times \Delta T$; rearrangement; evaluation; e.g. $2500 = 0.048 \times 880 \times \Delta T$ $\Delta T = 2500 / (0.048 \times 880)$ $(\Delta T =) 59 \text{ (}^\circ\text{C)}$	allow mass in kg or g for this mark seen or implied from working -1 for POT error final answer of 42 = 2 marks allow 59.2, 59.18... (°C) condone 59.1 (°C)	3

Total for Question 5 = 7 marks

Question number	Answer	Notes	Marks
3 (a)	liquid arrangement: attempt to draw most particles in contact with each other; random arrangement; solid arrangement: attempt to draw particles in contact with each other; regular arrangement;	ignore if particles don't fill entire box reject if gap large enough to draw another particle ignore if particles don't fill entire box reject if gap large enough to draw another particle	4
(b)	line drawn decreasing from any high temperature to any low temperature; single constant temperature stage drawn in the middle of the cooling (to show freezing); temperature axis labelled with suitable values e.g. line starts at 80, flat stage at 30 and line ends at 20;	allow straight lines and curves DOP ignore constant temperature at the end of the process all three temperatures required ignore scale	3

Total for Question 3 = 7 marks

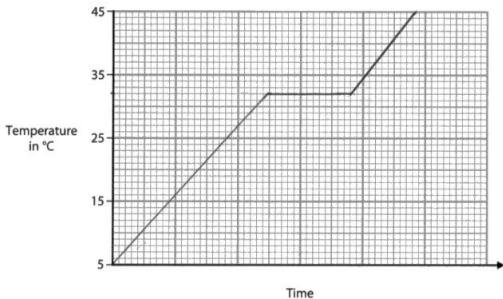
Question number	Answer	Notes	Marks
5 (a) (i)	290 (s);		1
(ii)	substitution into $P = E/t$; evaluation; a matching unit for power; e.g. $(P =) 39000/290$ $(P =) 130$ watts / W	allow ecf from (a)(i) a correct unit for power may score 1 if no other mark scored allow 134.48... allow J/s answers of 0.13 kW, 0.13 kJ/s gain 3 marks answers of 0.13 W, 0.13 J/s gain 2 marks	3
(b)	correct evaluation of temperature change; substitution into $\Delta Q = m \times c \times \Delta\theta$; rearrangement; evaluation; e.g. temperature change = 49 (°C) $39\,000 = 0.45 \times c \times 49$ $(c =) 39\,000 / (0.45 \times 49)$ $(c =) 1800 \text{ (J/kg}^\circ\text{C)}$	allow 49 seen anywhere in working allow ecf from incorrect temperature change value of 50, 69 or 70 only -1 for POT error allow 1770, 1769, 1768.7... answer of 1.7687... gains 3 marks answer of 1733, 1256, 1238 gains 3 marks answer of 1.256..., 1.733..., 1.238... gains 2 marks	4

Total for Question 5 = 8 marks



Question number	Answer	Notes	Marks
6 (a) (i)	(in solids) particles vibrate only; (in liquids) particles slide over each other; (in gases) particles move freely / randomly;		3
(b) (i)	energy starts in a chemical store (in the fuel); energy is transferred by heating; to a thermal store (in the water);	allow transfer by convection / radiation allow kinetic store of water allow heat energy for thermal energy	3
(ii)	horizontal line shows the change of state; (because) temperature remains constant during change of state;	can be shown on graph	2

Total for Question 6 = 8 marks

Question number	Answer	Notes	Marks
2 (a)	arrangement: fixed (position) / eq; motion: vibrating / eq ;	condone ideas of “regular” or “uniform”	2
(b) (i)	(movement now) random; idea that particles are no longer in fixed position;	ignore references to bonds, spacing or arrangement allow flowing past each other, reference to non-zero speed, non-zero KE condone ‘free to move’	2
(ii)	D - thermometer; A cannot be the answer as a balance measures mass B cannot be the answer as a ruler measures length C cannot be the answer as a stopwatch measures time		1
(iii)	temperature increases from 5 °C to 45 °C; temperature remains constant at some stage below 45 degrees; single constant temperature section at 32 °C; 	ignore first constant section at 5 degrees ignore second constant section at 45 degrees	3

Total for question 2: 8 marks

Question number	Answer	Notes	Marks
1 (a) (i)	B – QR; A is not correct as the substance is a solid C is not correct as the substance is a liquid D is not correct as the substance is boiling		1
(ii)	A – PQ; B is not correct as the substance is part solid, part liquid C is not correct as the substance is a liquid D is not correct as the substance is boiling		1
(iii)	any irregular , spaced out collection of particles;		1
(iv)	D – they move quickly and randomly; A is not correct as this is how particles in a solid move B is not correct as only particles at 0 K can theoretically be stationary C is not correct as this is how particles in a liquid move		1
(b) (i)	thermometer;	allow temperature sensor, temperature probe	1
(ii)	80 (°C);		1
(c)	temperature difference = 27 (°C); substitution; evaluation; e.g. $\Delta T = 37 - 10 = 27$ (°C) energy = $1.2 \times 840 \times 27$ (energy =) 27 000 (J)	allow ECF from incorrect temperature difference 37296, 10080 = 2 marks allow 27216, 27220, 27200	3

(Total for Question 1 = 8 marks)

Question number	Answer	Notes	Marks
2 (a)	longitudinal;		1
(b) (i)	particles arranged randomly; particles further apart in gas than in liquid;	allow either mark if clear from diagrams allow irregularly for randomly mark can be given for description of liquid, gas, or both allow RA ignore diagram for this mark if gaps in liquid bigger than one particle	2
(ii)	(sound travels by) vibrations; idea that {vibrations / sound / waves / energy} are passed on more effectively because particles are closer together;	allow alternatives for vibrations e.g. oscillations allow "sound vibrates particles" allow equivalents for effectively e.g. faster, easily, efficiently etc.	2

(c)	(i)	(wave) speed = frequency $\times$ wavelength;	allow correct use of symbols and rearrangements e.g. $v = f \times \lambda$ condone s as symbol for speed	1
	(ii)	substitution OR rearrangement; evaluation; e.g. $340 = 1400 \times \lambda$ OR $\lambda = v / f$ $(\lambda =) 0.24 \text{ (m)}$	allow 0.243, 0.242857... etc. condone 0.242	2
	(iii)	any five from: MP1. sound heard by student A is louder; MP2. sound heard by student A is constant pitch; MP3. no change in sound heard by student A when speed of rotation is varied; MP4. sound heard by student B varies in pitch; MP5. sound heard by student B is high pitch when buzzer is moving towards them AND low pitch when moving away from them; MP6. change of pitch for student B is greater when speed of rotation is greater; MP7. sound varies in loudness for student B;	allow use of frequency instead of pitch throughout allow RA allow RA i.e. constant loudness for student A	5

Total for Question 2 = 13 marks

Question number	Answer	Notes	Marks
8 (a)	288 (K);	allow 288.15 (K) allow 288.16 (K)	1
(b) (i)	(energy of molecules) increases; kinetic energy increases;	scores both marks allow KE for kinetic energy	2
(ii)	substitution into $E = V \times I \times t$; conversion of minutes to seconds; evaluation; e.g. time = $45 \times 60 = 2700$ (s) energy = $230 \times 1.5 \times 2700$ energy = 9.3×10^5 (J)	independent mark i.e. allow $\times 60$ seen anywhere allow in either order allow 931 500 (J) however rounded 15 525 (J) scores 2 marks however rounded 258.75 (J) scores 2 however rounded	3
(iii)	substitution into $Q = m \times c \times \Delta T$; rearrangement; evaluation; e.g. $9.3 \times 10^5 = \text{mass} \times 4200 \times (60-15)$ mass = $9.3 \times 10^5 / 4200 \times 45$ (mass =) 4.9 (kg)	allow ecf from (ii) allow in either order answer that rounds to 0.082 (kg) scores 3 ecf from 15 525 divided by (4200 $\times$ 45) answer that rounds to 0.0014 (kg) scores 3 ecf from 258.75 divided by (4200 $\times$ 45)	3

(c)	(i)	particles are arranged randomly; idea that particles are spread out or are widely spaced;	condone moving randomly condone irregular for random idea of 'large gaps'	2
	(ii)	boiling happens at a specific or fixed temperature or 100 °C but evaporation happens at any temperature; boiling happens throughout a liquid but evaporation only happens at the surface /eq ;	needs comparison condone idea of a lower temperature (compared to boiling point) ignore reference to bubbles	2

Total for Question 8 = 13 marks



Question number	Answer	Notes	Marks
9 (a)	80 (kPa);		1
(b)	any two from: MP1. pressure (in aeroplane) increases; MP2. (resultant) force (inwards) on bottle; MP3. idea that decreasing volume (in bottle) increases pressure (in bottle);	allow idea that pressure outside bottle is greater than inside bottle	2
(c)	any three from: MP1. (direction of) movement of molecules is random; MP2. molecules collide with the (bottle) surface; MP3. exert a force (on the surface); MP4. pressure is force on an area;	allow particles / atoms for molecules allow equivalent words for collide e.g. bounce, hit etc. ignore 'molecules collide' (with each other) allow if given in formula format	3

Total for Question 9 = 6 marks

Question number	Answer	Notes	Marks
11 (a)	idea that (large number of) molecules moving randomly; idea of equal rate of collisions in each direction;	allow atoms or particles for 'molecules' can be acquired from diagram by showing arrows of different lengths (by eye) or different directions (by eye) condone idea of equal number in each direction	2
(b)	evaluation of new volume; substitution into $p_1V_1 = p_2V_2$; rearrangement; evaluation of new pressure; e.g. $V_2 = (130 \times 5.0/8.4 =) 77 \text{ (cm}^3\text{)}$ $100 \times 130 = p_2 \times 77$ $(p_2 =) 100 \times 130/77$ $(p_2 =) 170 \text{ (kPa)}$	ecf different yet incorrect volume -1 POT error allow 77.38... allow any value that rounds to 170 (kPa)	4

Total for Question 11 = 6 marks

Question number	Answer	Notes	Marks
8 (a) (i)	work (done) = force $\times$ distance (moved in direction of force);	accept correct symbols and rearrangements e.g. $W = F \times s$ allow d for distance	1
(ii)	substitution; evaluation; e.g. (W =) 4.2×0.145 (W =) 0.61 (J)	-1 for POT error allow 0.609 (J) 609 (J) gains 1 mark	2
(iii)	same answer as (ii);		1
(iv)	kinetic energy (store) of molecules increases; (temperature increases) because temperature is proportional to (mean) KE (of molecules);	allow molecules move faster / eq	2
(b)	any one from: MP1. idea that (more) energy would be transferred / lost to the surroundings (for slow compressions); MP2. piston would have less KE (to transfer); MP3. less force on piston (so less work done on gas);	allow less work done on air	1

Total for Question 8 = 7 marks

Question number	Answer	Notes	Marks
7 (a)	24 (kPa);		1
(b)	any three from: MP1. reading increases / pressure increases; MP2. reading doubles / pressure doubles/ reading is 48 kPa; MP3. (because) air particles collide with walls more often ; MP4. (because) pressure $\times$ volume is constant;	scores first 2 marks allow quoted formula allow (because) pressure is inversely proportional to volume	3
(c) (i)	{speed / velocity / KE} of particles decreases;	allow less frequent collisions ignore 'motion / movement decreases'	1
(ii)	pressure decreases; particles collide with walls less often; particles collide with less force;	allow particles colliding less hard	3

Total for Question 7 = 8 marks



Question number	Answer	Notes	Marks
13 (a) (i)	358 (K);		1
(ii)	idea that speed / KE increases; mean speed / mean KE increases;	allow average for mean	2
(iii)	number of molecules decreases;	however expressed	1
(b)	any four from: MP1. air in flask cools; MP2. molecules in flask slow down/ <u>kinetic</u> energy of molecules reduces; MP3. pressure inside flask decreases (as temperature decreases); MP4. pressure outside flask greater than inside/eq; MP5. resultant force (from air) pushes egg down the neck of the flask; MP6. volume of air in flask decreases as the egg moves down; MP7. (so) pressure inside flask increases (as volume decreases); MP8. (eventually) pressure inside and outside balance; MP9. (so) resultant force is now zero (so egg stops moving down);	allow 'stretches egg' allow higher level arguments including weight of egg, friction with neck, etc	4

Total for Question 13 = 8 marks

Question number	Answer	Notes	Marks
11 (a)	any THREE from: MP1 walls further apart; MP2 fewer collisions between particles and walls per second/lower frequency of collisions; MP3 means (average) force on walls lower; MP4 lower force means lower pressure for same wall surface area;	reject unqualified 'fewer collisions' accept idea that force per collision is the same ignore references to particles colliding with each other accept	3
(b)	substitution into given equation " $p_1 \times V_1 = p_2 \times V_2$ "; rearrangement to give p_2 ; evaluation of p_2 ; e.g. $101 \times 110 = p_2 \times 140$ $p_2 = 101 \times 110 / 140$ $p_2 = 79\,000 \text{ (Pa)}$	allow 79357.1... (Pa), 79(.4) kPa , standard form	3
(c)	any THREE from: MP1 pressure outside balloon is lower than inside balloon; MP2 pressure difference causes a force; MP3 force is outwards on balloon; MP4 force causes extension of balloon;	accept 'stretching'	3

Total for Question 11 = 9 marks

Question number	Answer	Notes	Marks
11 (a)	conversion of cm to m; substitution into given formula; evaluation; e.g. $3.8\text{cm} = 0.038$ $\text{pressure difference} = 0.038 \times 1.3 \times 10^4 \times 10$ $(\text{pressure difference} =) 4900 \text{ (Pa)}$	seen anywhere in working -1 for POT error 494 000 gains 2 marks allow 4940 (Pa) allow 4800, 4840, 4846, 4841 (Pa) for use of $g=9.8/9.81$	3
(b) (i)	any three from: MP1. particles have more energy in their kinetic store / particles speed up; MP2. {more frequent collisions / more collisions per second} with the walls of the tube; MP3. each collision with the wall is harder; MP4. increasing the force (on the walls of the container);	allow particles have more KE allow particles collide more often with walls ignore collisions with each other allow 'greater momentum change'	3
(ii)	conversion of temperatures to kelvin; substitution; rearrangement; evaluation; e.g. $T_1 = 289\text{K}$, $T_2 = 305\text{K}$ $9.95 \times 10^4 / 289 = p_2 = 305$ $p_2 = 9.95 \times 10^4 \times 305 / 289$ $(p_2 =) 1.1 \times 10^5 \text{ (Pa)}$	not converting to kelvin giving 199 000 (Pa) gains 2 marks max. allow $1.05 \times 10^5 \text{ (Pa)}$, 105008.65... (Pa)	4

Total for Question 11 = 10 marks



Question number	Answer	Notes	Marks
3 (a)	(some) bonds (between particles) are broken or weakened; particles begin to move around or slide over each other;	award either or both marks if clear from diagram accept idea of reduction in intermolecular forces reject MP2 if there is a reference to the speed of particles or KE changing during melting	2
(b) (i)	any two from: MP1. energy is transferred to air/particles (by heating); MP2. idea that particles move faster; MP3. temperature (in K) is (directly) proportional to KE of particles;	accept molecules for particles accept particles gain KE	2
(ii)	particles hit (flask) walls more frequently ; particles hit (flask) walls with more force / harder;		2
(iii)	136 (kPa);	allow answers in the range 135-137 (kPa)	1
(iv)	substitution; rearrangement; evaluation; e.g. $136 / 400 = p_2 / 230$ $(p_2 =) (136 \times 230) / 400$ $(p_2 =) 78 \text{ (kPa)}$	allow ecf from (b)(iii) e.g. 86 (kPa) for (iii) gives 79 (kPa) for (iv) substitution and rearrangement in either order allow 78.2... accept extrapolation back to $T = 230$ for 2 marks accept value between 79 and 77 by this method accept calculation using graph (i.e. extrapolation numerically/algebraically) back to 230 for 2 marks accept value between 79 and 77 by this method	3

Total for question 3 = 10 marks

Question number	Answer	Notes	Marks
9	(a) (i)	pressure = force / area;	1
	(ii)	substitution; rearrangement; evaluation; e.g. $1.03 \times 10^6 = \text{force} / 1.13$ (force =) $1.03 \times 10^6 \times 1.13$ (force =) 1.16×10^6 (N)	3 -1 for POT error allow 1.2×10^6 , 1163900 etc.
	(iii)	any two from: MP1. idea that gas particles move randomly; MP2. idea that gas particles collide with all walls of container; MP3. idea that force per unit area is the same on all sides of cylinder;	2 allow move in all directions
	(b) (i)	idea of extrapolating line backwards; absolute zero is the temperature when the pressure is zero;	2 allow if seen on graph allow temperature when line cuts x-axis/temperature axis (may be indicated on graph)
	(ii)	-273 (°C);	1 allow -273.15
	(iii)	straight line with positive gradient drawn; line passes through the origin;	2 judge by eye

Total for Question 9 = 11 marks

Question number	Answer	Notes	Marks
8 (a)	any one from: - idea that there is no data at the value of 0; - idea that {pressure of gas / speed of particles} cannot be zero; - idea that all data would be bunched together at the top of the axis / eq;		1
(b)	for either graph: MP1. as temperature increases, pressure/speed increases; for graph 1: MP2. relationship is linear; for graph 2: MP3. relationship is non-linear; MP4. idea of decreasing gradient of curve;	ignore positive correlation accept proportional only if there is a clear link to the temperature being measured in kelvin	3
(c)	any two from: MP1. this temperature is <u>absolute zero</u> ; MP2. pressure/speed/kinetic energy of gas particles would be 0 at this temperature; MP3. idea that it is impossible to have a temperature lower than this;	allow idea that negative pressure/speed/KE is impossible	2
(d) (i)	answer in range 520-525 (m/s);	ignore 515	1
(ii)	recall of KE formula; substitution; evaluation; e.g. $KE = \frac{1}{2} \times \text{mass} \times \text{speed}^2$ (KE =) $0.5 \times 5.3 \times 10^{-26} \times 520^2$ (KE =) 7.2×10^{-21} (J)	can be implied from working ECF from (i) -1 for POT error allow 7.16×10^{-21} - 7.31×10^{-21}	3
(iii)	373 (K);		1
(iv)	straight line with positive gradient; line passes through origin;	judge straightness by eye	2

Total for Question 8 = 13 marks



Question number	Answer	Notes	Marks
4 (a)	idea that not doing so means impossible to tell what change caused the change in the dependent;	allow idea of a 'fair test' ignore references to accuracy, reliability	1
(b) (i)	straight line; (line) does not go through origin;	condone linear	2
(ii)	given line extrapolated to x-axis; -300 °C;	accept in range -320 to -280 degrees C	2
(iii)	any THREE from: MP1 (increase in temperature) increases speed/KE; MP2 collisions between walls and particles more frequent/eq; MP3 idea collisions between walls and particles are harder; MP4 idea that force (between wall and particle) is increased; MP5 $P=F/A$ so increased force means increased pressure for same area.		3
(c) (i)	conversion of both temperatures to kelvin scale; substitution; rearrangement; evaluation; e.g. 35°C and $340^{\circ}\text{C} \rightarrow 308$ and 613 K $112\text{ (kPa)}/308 = P / 613$ $P = 613 \times 112 / 308$ $P = 220\text{ (kPa)}$	-1 for POT error accept 222.909... accept 1088 (kPa) for 2 marks (no conversion of temperature) accept type of gas	4
(ii)	number of {particles/moles/mass/molecules} of gas		1

(Total for Question 4 = 13 marks)



Question number	Answer	Notes	Marks
7 (a)	substitution into $v^2 = u^2 + 2as$; rearrangement; evaluation; e.g. $0^2 = u^2 + (2 \times -1.8 \times 92\,000)$ $u = \sqrt{3.6 \times 92\,000}$ (initial speed =) 580 (m/s)	allow answers in terms of conservation of energy for full marks ignore units condone poor handling of minus signs allow 575.(499...) (m/s) answer of 331 200 gains 2 marks POT error on distance will give 18.2 (m/s) for 2 marks	3
(b) (i)	particles collide with walls; (collisions result in) force on walls; force over area gives pressure;	ignore collisions between particles allow momentum arguments allow $p = F / A$	3
(ii)	substitution into $p_1/T_1 = p_2/T_2$; rearrangement; evaluation; e.g. $8.2/1200 = p_2/1600$ $p_2 = (1600 \times 8.2/1200)$ $(p_2 =) 11$ (kPa)	allow pressure in kPa or Pa allow 10.9... (kPa)	3
(iii)	any three from: particles have more kinetic energy; particles collide with walls more frequently ; idea that particles collide with walls with more force / 'harder'; (average) force increases;	allow particles move faster/eq.	3
(iv)	any three from: MP1. idea that higher pressure means higher speed; MP2. Tvashtar particles have more (initial) KE; MP3. particles from both chambers experience the same deceleration; MP4. (higher speed with same deceleration) takes longer to reach 0 m/s; MP5. relevant quantitative argument based on motion formulae; MP6. Tvashtar particles have more GPE (at max. height);	allow Tvashtar particles have higher speed / RA allow Tvashtar particles take longer to reach max. height / RA	3

Total for Question 7 = 15 marks