UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5739276938

PHYSICAL SCIENCE **8780/03**

Paper 3 Structured Questions **October/November 2012**

1 hour 30 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.

A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
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Total	

This document consists of **24** printed pages.

DC (SJF/CGW) 49995/5

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

Answer **all** the questions in the spaces provided.

Relevant Data, Formulae and the Periodic Table are provided in the Data Booklet.

1 A gas is contained in a cylinder by a piston.

(a) Explain, in terms of the kinetic theory, how the gas exerts a pressure on the walls of the cylinder.

....

....

....

....

....

.... [3]

(b) The piston is slowly pushed in to reduce the volume of the gas, with the temperature remaining constant.

Explain, in terms of the kinetic theory, why the pressure increases.

....

....

....

.... [1]

[Total: 4]

2 **(a)** Fig. 2.1 shows the distribution of molecular energies for an uncatalysed mix reactants. The activation energy for this reaction, E_a, is also shown.

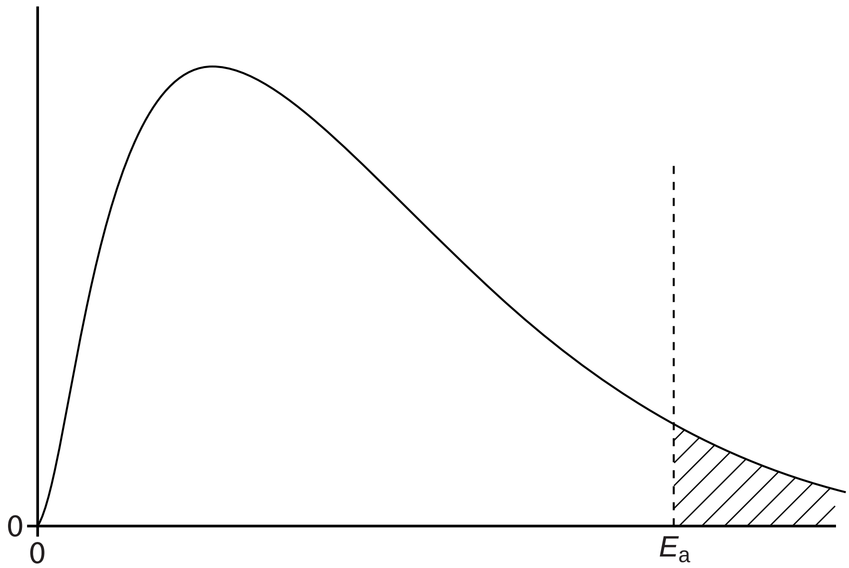


Fig. 2.1

(i) Label the axes. [1]

(ii) What does the shaded area on the sketch represent?

....

.... [1]

(iii) On Fig. 2.1, draw a second curve to show the distribution of molecular energies at a higher temperature. [1]

(b) Explain why a small increase in temperature would result in a large increase in reaction rate. In your answer you may wish to refer to Fig. 2.1.

....

....

....

.... [1]

[Total: 4]

3 A student uses a suitable measuring instrument to measure the diameter of a wire.

(a) In all measurements there are random uncertainties.

State and explain how, using the same measuring instrument, the random uncertainties in the measurement of the wire's diameter can be minimised.

....

....

....

....[2]

(b) The student measures the diameter of the wire as 0.14 mm.
He calculates the cross sectional area of the wire as 0.015 mm^2.
There is an uncertainty of ±0.01 mm in the measurement of the diameter.

Calculate the absolute uncertainty in the calculated area.

uncertainty = ± .... mm^2 [2]

[Total: 4]

4 An acid, H_2X, reacts with sodium hydroxide, NaOH, as shown in the equation below.

$$H_2X(aq) + 2NaOH(aq) \rightarrow Na_2X(aq) + 2H_2O(l)$$

A solution of this acid was prepared by dissolving 1.92 g of H_2X in water and making the volume up to 250 cm^3 in a volumetric flask.

25.0 cm^3 of this solution required 21.70 cm^3 of 0.150 mol dm^{-3} aqueous sodium hydroxide for complete reaction.

(a) Calculate the amount, in moles, of sodium hydroxide in 21.70 cm^3 of 0.150 mol dm^{-3} aqueous sodium hydroxide.

NaOH in 21.70 cm^3 of solution = ... mol [1]

(b) **(i)** Calculate the amount, in moles, of H_2X which reacted with this amount of sodium hydroxide.

H_2X in 25.0 cm^3 of solution = ... mol

(ii) Hence deduce the amount, in moles, of H_2X in the original solid sample.

H_2X in original sample = ... mol
[2]

(c) Calculate the relative molecular mass, M_r, of H_2X.

M_r of H_2X = ... [1]

[Total: 4]

5 Fig. 5.1 shows a signal generator connected to a cathode ray oscilloscope (c.r.o.).

The time base on the c.r.o. is set at 500 μs div^{-1}, and the *y*-gain is set to 2.5 V div^{-1}.

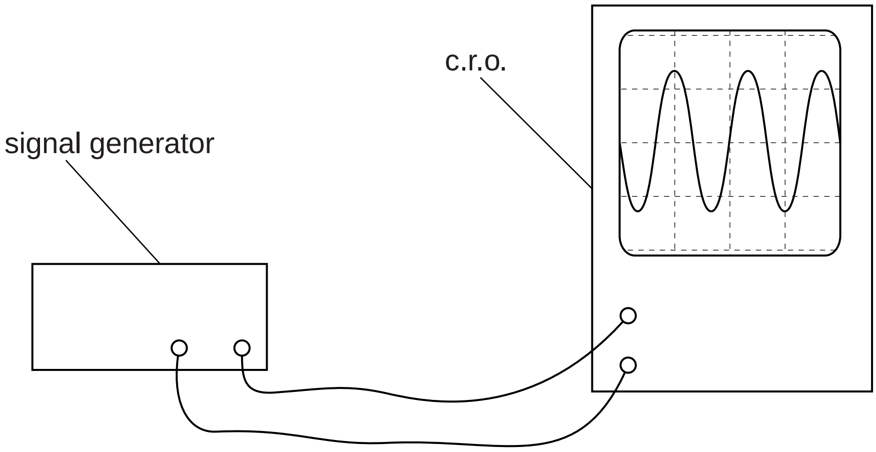


Fig. 5.1

(a) Determine

(i) the amplitude of the signal,

amplitude = ... V [1]

(ii) the frequency of the signal.

frequency = ... Hz [1]

(b) A second signal generator is connected to the same input of the c.r.o. The first signal generator remains connected.

The signal from the second signal generator has same amplitude and frequency as the signal from the first signal generator.

State and explain how the trace on the oscilloscope compares with the trace in Fig. 5.1 when

(i) the two signals are exactly in phase,

....

....

....

(ii) the two signals are 180° out of phase.

....

....

....

[3]

[Total: 5]

6 A student determines a value for the enthalpy change of combustion of propan-1-ol, $CH_3CH_2CH_2OH$, using the apparatus shown in Fig. 6.1.

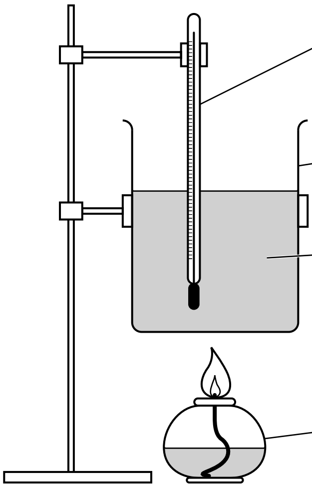


Fig. 6.1

She obtains the following results.

mass of water in the calorimeter	=	100 g
initial temperature of the water	=	21.5 °C
final temperature of the water	=	34.0 °C
loss in mass of burner containing propan-1-ol	=	0.341 g

(a) (i) Calculate the thermal (heat) energy, Q, required to raise the temperature of the water from 21.5 °C to 34.0 °C.

The specific heat capacity of water can be found in the Data Booklet.

Q = ... J [2]

(ii) Calculate the amount, in moles, of propan-1-ol lost from the burner.

amount of propan-1-ol = ... mol [1]

(iii) Calculate a value for the enthalpy change of combustion of propan-1-ol.

enthalpy change of combustion = ... $kJ\,mol^{-1}$ [1]

(b) Your answer in part **(a)(iii)** is very different from the literature value for the enthalpy change of combustion of propan-1-ol.

(i) Suggest **one** feature of the experimental design that would account for this large difference.

....

....

....

(ii) State and explain whether the experimental value obtained for the enthalpy change will be too large or too small as a result of the feature suggested in **(i)**.

....

....

....
[2]

[Total: 6]

7 Selenium is an element in Group VI. It forms the hydride H_2Se.

(a) Balance the equation for the reaction in which H_2Se is formed from Al_2Se_3.

$$Al_2Se_3 \ + \ \ldots\ldots H_2O \rightarrow \ldots\ldots Al(OH)_3 \ + \ \ldots\ldots H_2Se$$ [1]

(b) **(i)** Draw the shape of an H_2Se molecule and the shape of an NH_3 molecule.

Show any lone pairs of electrons.

H_2Se NH_3

[2]

(ii) The H-N-H bond angle in an NH_3 molecule is less than 109.5°.

Explain why the H-Se-H bond angle in an H_2Se molecule is even smaller than the H-N-H bond angle.

....

....

....

.... [2]

[Total: 5]

8 Carbon has several isotopes.

(a) Explain, in terms of atomic structure, what is meant by *isotopes*.

....

....

....

....[2]

(b) The isotope carbon-14 is formed in the upper atmosphere.

A nucleus of nitrogen-14 absorbs a neutron and emits another particle to form a carbon-14 nucleus.

Write an equation for this process.

....[2]

(c) The carbon-14 nucleus is unstable and decays by emission of a β-particle.

On the grid in Fig. 8.1, mark, with crosses, the position of

- the nuclide carbon-14,
- the daughter nuclide formed in this decay.

Label each nuclide with its full nuclide notation.

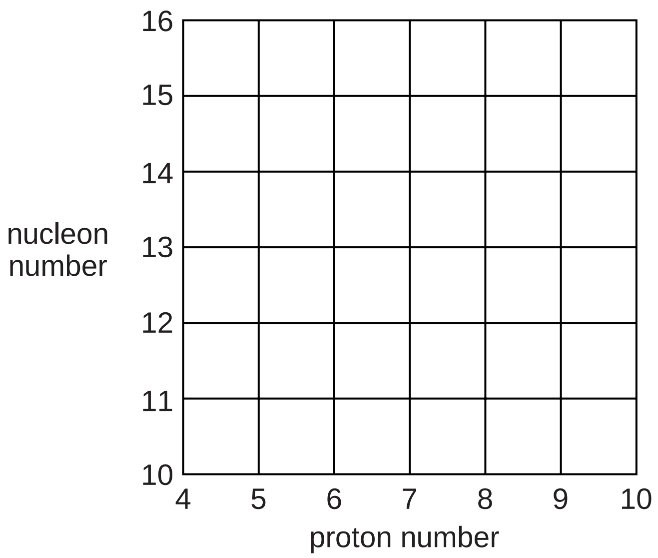


Fig. 8.1

[2]

[Total: 6]

9 In the gas phase, hydrogen reacts with nitrogen to form ammonia.

$$\tfrac{1}{2}N_2(g) + \tfrac{3}{2}H_2(g) \rightleftharpoons NH_3(g) \qquad \Delta H = -46.2\ \text{kJ mol}^{-1}$$

Four experiments are carried out. In each experiment a starting mixture containing 1 mol of nitrogen, N_2, and 3 mol of hydrogen, H_2, is used.

Fig. 9.1 shows, for each experiment, how the amount of ammonia present in the reaction mixture changes with time.

Experiment **1** was carried out at a constant temperature of 600 K and constant pressure of 20 MPa.

In each of the experiments **2**, **3** and **4**, **one** change is made to these reaction conditions.

A different change is made in each of these experiments.

- In one experiment the temperature is raised above 600 K.
- In another the pressure is raised above 20 MPa.
- In the remaining experiment a catalyst is used.

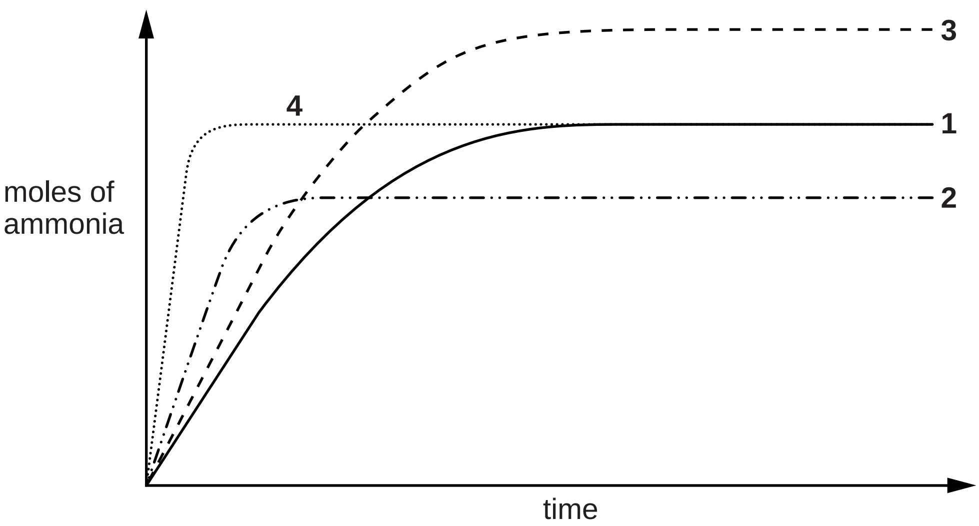


Fig. 9.1

(a) On the line for experiment **1** in Fig. 9.1, mark with a cross the point at which equilibrium is first reached.

Explain your answer.

....

....

.... [1]

(b) **(i)** Use Fig. 9.1 to complete the following statements.

The pressure is increased in experiment number ....

The temperature is increased in experiment number ....

(ii) Explain, in terms of Le Chatelier's principle, the difference between the line for experiment **1** and the line for the experiment at a higher pressure.

....

....

....

....

(iii) Explain the difference between the line for experiment **1** and the line for the experiment in which a catalyst is present.

....

....

....

....

[4]

[Total: 5]

10 Fig. 10.1 shows a tennis player serving. He throws the ball vertically upwards and stri the moment when it is stationary.

Fig. 10.1

The ball has a mass of 142 g.
It is in contact with the racquet for 0.0451 s.
It leaves the racquet with a speed of 53.0 m s^{-1}.

(a) (i) Calculate the momentum of the ball as it leaves the racquet.

momentum = ... [2]

(ii) Calculate the average force on the ball when it is in contact with the racquet.

force = ... N [1]

(b) Calculate the kinetic energy of the ball when it leaves the racquet.

kinetic energy = ... J [1]

(c) As the ball passes over the net, it is travelling at $49\,m\,s^{-1}$.

(i) Explain the process by which the ball loses kinetic energy as it travels.

....

....

....

....[2]

(ii) State what happens to the kinetic energy lost by the ball.

....

....

....[1]

[Total: 7]

11 Fig. 11.1 shows a pair of parallel metal plates 5.0 cm apart in an evacuated tube. The are connected to a 400 V supply.

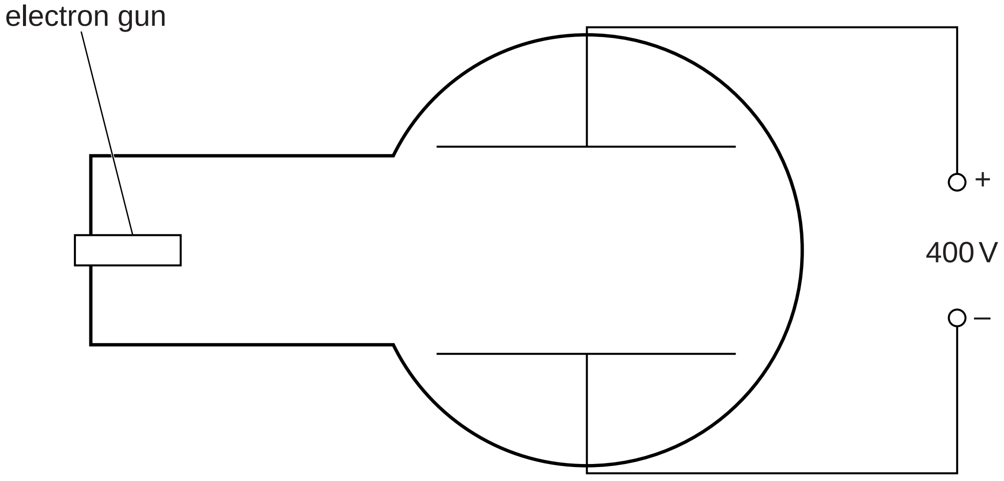


Fig. 11.1

(a) **(i)** On Fig. 11.1, draw the field lines to represent the electric field between the plates. [1]

(ii) Calculate the electric field strength *E* between the plates.

E = ... [2]

(b) Fig. 11.2 shows the path of an electron after it leaves the electron gun.

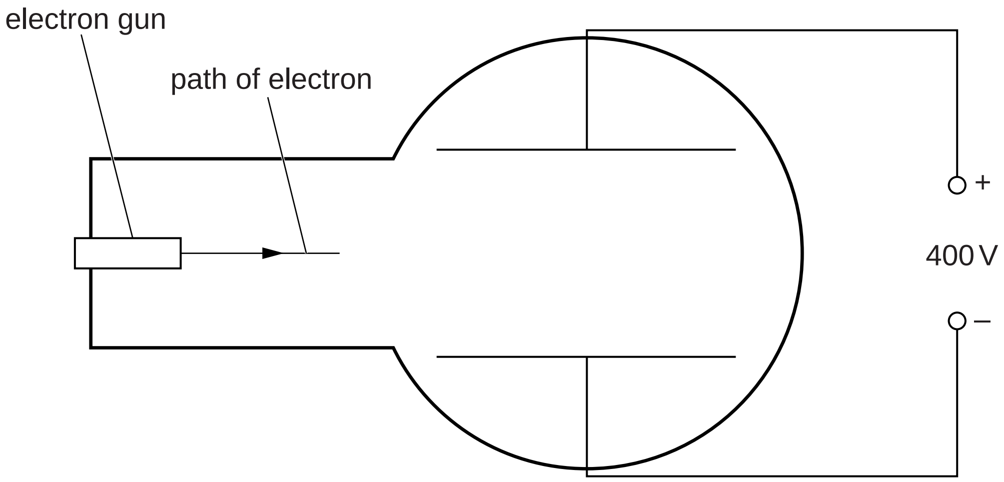


Fig. 11.2

On Fig. 11.2, continue the path of the electron as it travels through the electric field. [1]

(c) The electron travels through the electric field.

Describe the change, if any, in

(i) the component of the electron's velocity perpendicular to the plates,

....

....

....

(ii) the component of the electron's velocity parallel to the plates.

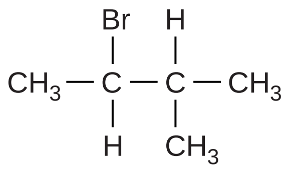
....

....

....
[2]

[Total: 6]

12 Compound **A** undergoes a reaction to form two isomeric alkenes, **B** and **C**.



compound **A**

(a) (i) Name compound **A**.

....[1]

(ii) Give the name of the type of reaction involved in the formation of alkenes from compound **A**.

....[1]

(iii) Identify a suitable reagent and suitable conditions for this reaction.

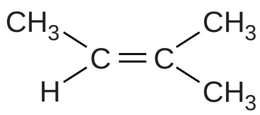
reagent ....

conditions ....

[1]

(iv) The structural formula of one of the isomers formed in this reaction, alkene **B**, is shown below.

Draw the structural formula of the isomer, alkene **C**.



alkene **B** alkene **C** [1]

(v) Explain whether alkene **B** can exist as cis-trans isomers.

....

....

....[1]

(b) When compound **A** is treated with potassium cyanide, a nitrile is formed.

Use drawings to show the mechanism for this reaction.

In your mechanism, use curly arrows to show the movement of electrons. Include the structural formula of the product in your answer.

[2]

[Total: 7]

13 (a) Explain what is meant by a *vector* quantity.

....

....[1]

(b) Fig. 13.1 shows a frictionless block on a slope.

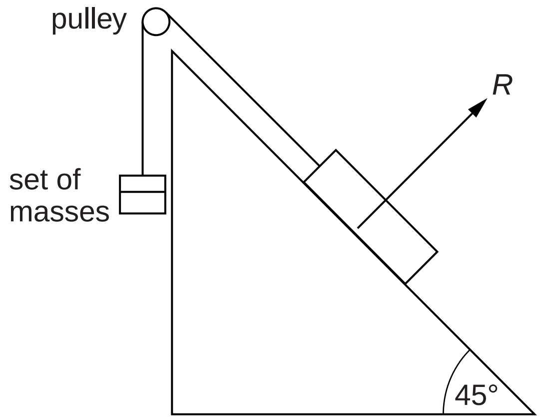


Fig. 13.1

The block has a mass of 510 g.
It is held at rest by a string which passes over a frictionless pulley to a set of hanging masses.

(i) The slope pushes on the frictionless block with a reaction force *R*.

On Fig. 13.1, draw arrows to represent the other forces acting on the block when it is in equilibrium. [1]

(ii) Calculate the weight of the block.

weight = ... N [1]

(iii) Use a triangle of vectors to find the tension in the string.
Draw your triangle on Fig. 13.2.
Use an appropriate scale.

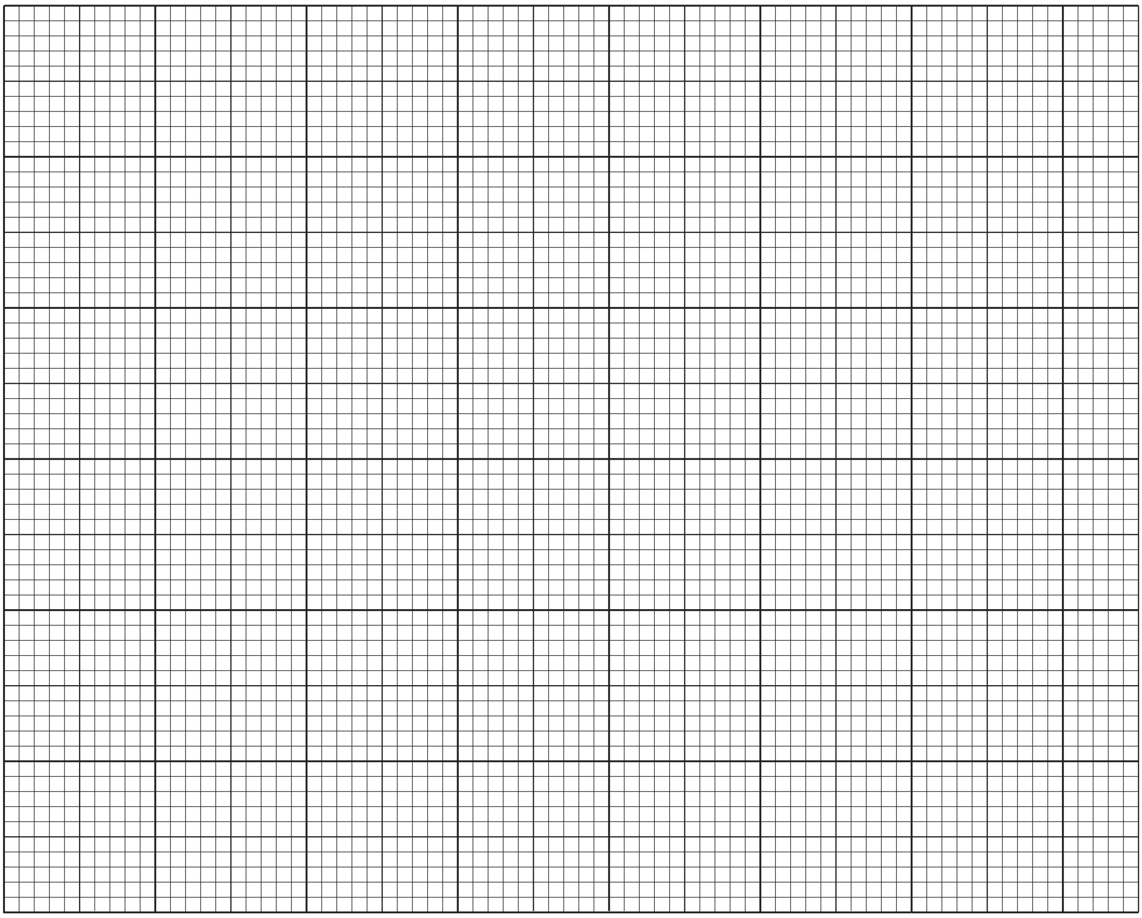


Fig. 13.2

tension = ... N [3]

(c) In a separate experiment, the same frictionless block, of mass 510 g, is held at re different slope.

The tension in the string is 2.4 N. The string is cut.

On Fig. 13.3, draw a velocity–time graph to show the motion of the block as it moves down the slope.

Use the space in the box below Fig. 13.3 to show your working.

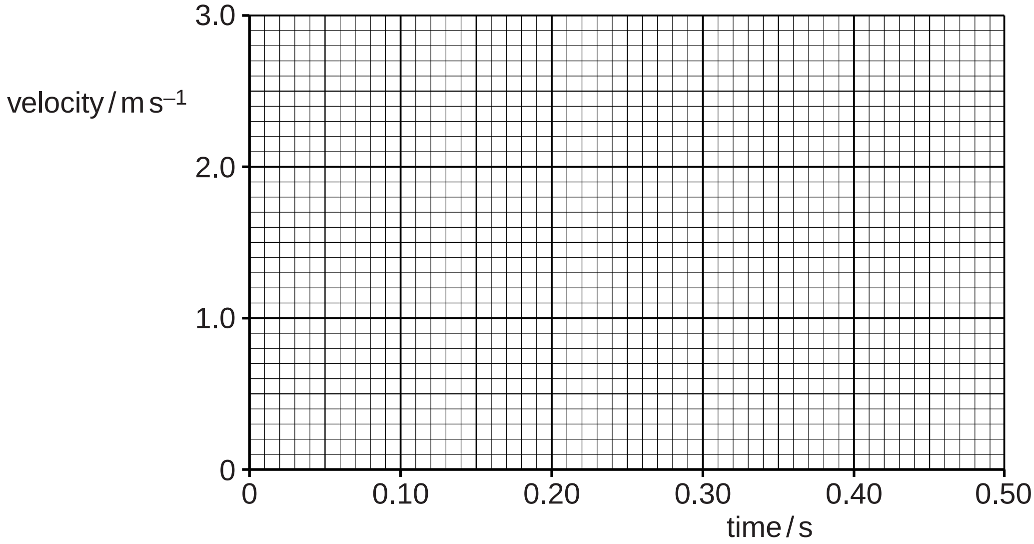


Fig. 13.3

[2]

[Total: 8]

14 Compound **X** is a metal salt.

When heated strongly, compound **X** decomposes to produce a gaseous mixture which is brown in colour and relights a glowing splint.

The residue left after heating dissolves readily in water to produce a highly alkaline solution.

(a) Explain these observations.

....

....

....

....[2]

(b) **(i)** Suggest an identity for compound **X**.

....

(ii) Write an equation for the thermal decomposition of compound **X**.

....

[2]

[Total: 4]

Question 15 is on the next page.

15 Aluminium is the most abundant metal in the Earth's crust. Despite this, aluminium is more expensive than iron and steel. For this reason, the recycling of aluminium is becom much more common.

(a) Describe, with the aid of appropriate equations, how aluminium is extracted from purified bauxite.

Include in your answer an explanation of why aluminium is, relatively, so expensive.

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....

....

....

....[4]

(b) Briefly explain **one** major environmental advantage arising from the recycling of metals.

....

....[1]

[Total: 5]