UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE
NAME

CENTRE
NUMBER

CANDIDATE
NUMBER

CO-ORDINATED SCIENCES **0654/31**

Paper 3 (Extended) **October/November 2013**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 36.

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.

This document consists of **35** printed pages and **1** blank page.

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

PAPA CAMBRIDGE

1 Sodium chloride (common salt) is obtained from underground deposits in the Earth's crust.

Low-sodium salt is a mixture containing both sodium chloride (melting point 801 °C) and potassium chloride (melting point 770 °C).

(a) (i) Explain why the Earth's crust contains the compound sodium chloride and not the uncombined elements sodium and chlorine.

....

.... [1]

(ii) State **one** difference between a compound, such as potassium chloride, and a mixture, such as low-sodium salt.

....

....

.... [2]

(iii) Suggest how a white solid could be tested to discover whether it was common salt or low-sodium salt.

....

....

.... [2]

(b) Table 1.1 contains the names and symbols of some positive and negative ions.

Table 1.1

positive ions			negative ions	
name	symbol		name	symbol
potassium	K^+		fluoride	F^-
ammonium	NH_4^+		oxide	O^{2-}
calcium	Ca^{2+}		nitride	N^{3-}
aluminium	Al^{3+}		sulfate	SO_4^{2-}

(i) Use the information shown in Table 1.1 and the Periodic Table on page 36 to determine the ions that have an electron configuration of 2, 8, 8.

.... [1]

(ii) Deduce the chemical formula of the compound calcium nitride.

Show how you obtained your answer.

.... [2]

(c) The element calcium is formed during the electrolysis of molten calcium chloride.

Describe what happens at the surface of the cathode to reduce calcium ions to calcium atoms, and state why calcium ions are said to be *reduced*.

....

....

....

.... [2]

2 Fig. 2.1 shows the inside of a refrigerator.

The temperature inside the freezing compartment is -20 °C and the temperature in the rest of the refrigerator is +5 °C.
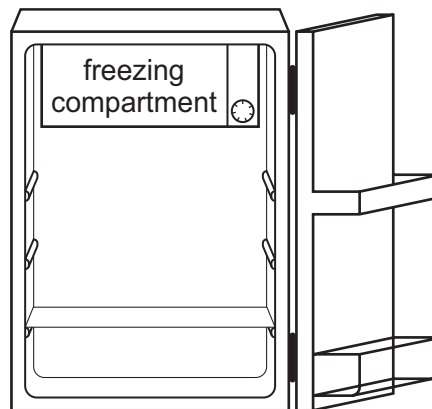

Fig. 2.1

(a) (i) The air in the refrigerator is cooled by convection.

Draw **one** arrow on Fig. 2.1 to show the movement of the air cooled by the freezing compartment. [1]

(ii) Explain this movement in terms of particles and density.

....

....

.... [2]

(b) The mass of air in the refrigerator is 0.19 kg.

The air in the refrigerator is cooled by 4 °C.

The specific heating capacity of air is 1.01 J / kg °C.

Calculate the heat energy removed from the air when it is cooled.

State the formula that you use, show your working and state the unit of your answer.

formula

working

................................ unit .... [2]

(c) (i) Some ice from the freezing compartment is allowed to melt at 0 °C.

Explain why energy is required to melt the ice even though the temperature remains at 0 °C.

....

....

.... [1]
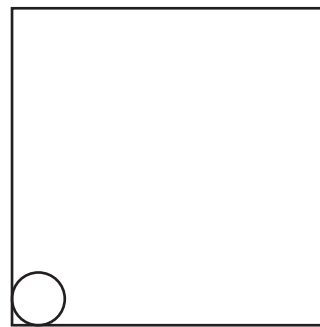
(ii) Complete the diagrams to show the arrangement of water molecules in solid ice and in liquid water.

One molecule has been drawn for you in each box. Each diagram should contain at least twelve water molecules.
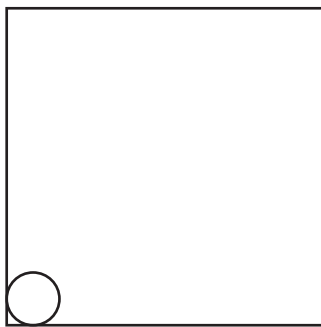
solid ice   liquid water

[2]

(d) A refrigerator can be warmed up by radiation energy absorbed by the outside surface of the refrigerator. Such absorption needs to be kept as low as possible.

The four refrigerators shown in Fig. 2.2 are identical except for the outside surface.

A　　　　　　**B**

Chillor　　　　　*Chillor*

black, shiny surface　　　　black, dull surface

C　　　　　　**D**

Chillor　　　　　*Chillor*

white, dull surface　　　　white, shiny surface
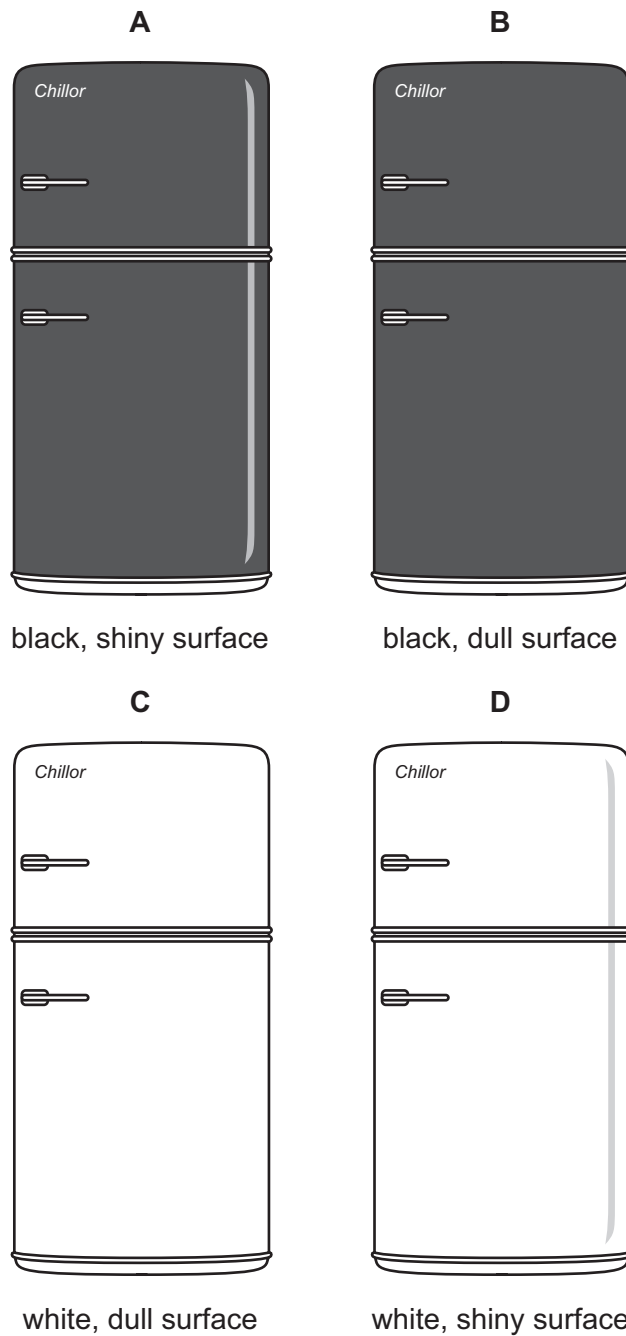
Fig. 2.2

State which refrigerator is most effective at keeping the contents cool.

Explain your answer.

....

....

.... [2]

Please turn over for Question 3.

3   The concentration of glucose in the blood does not normally vary much. High levels of glucose in the blood are harmful to health.

   (a) Suggest the effect of a high blood glucose concentration on the cells of the body.

   ....

   ....

   ....

   .... [2]

   (b) Researchers investigated how adding fibre to foods affected the concentration of glucose in the blood after eating.

   Fig. 3.1 shows the results that they obtained for two different types of cornflakes. Cornflakes contain a lot of starch.
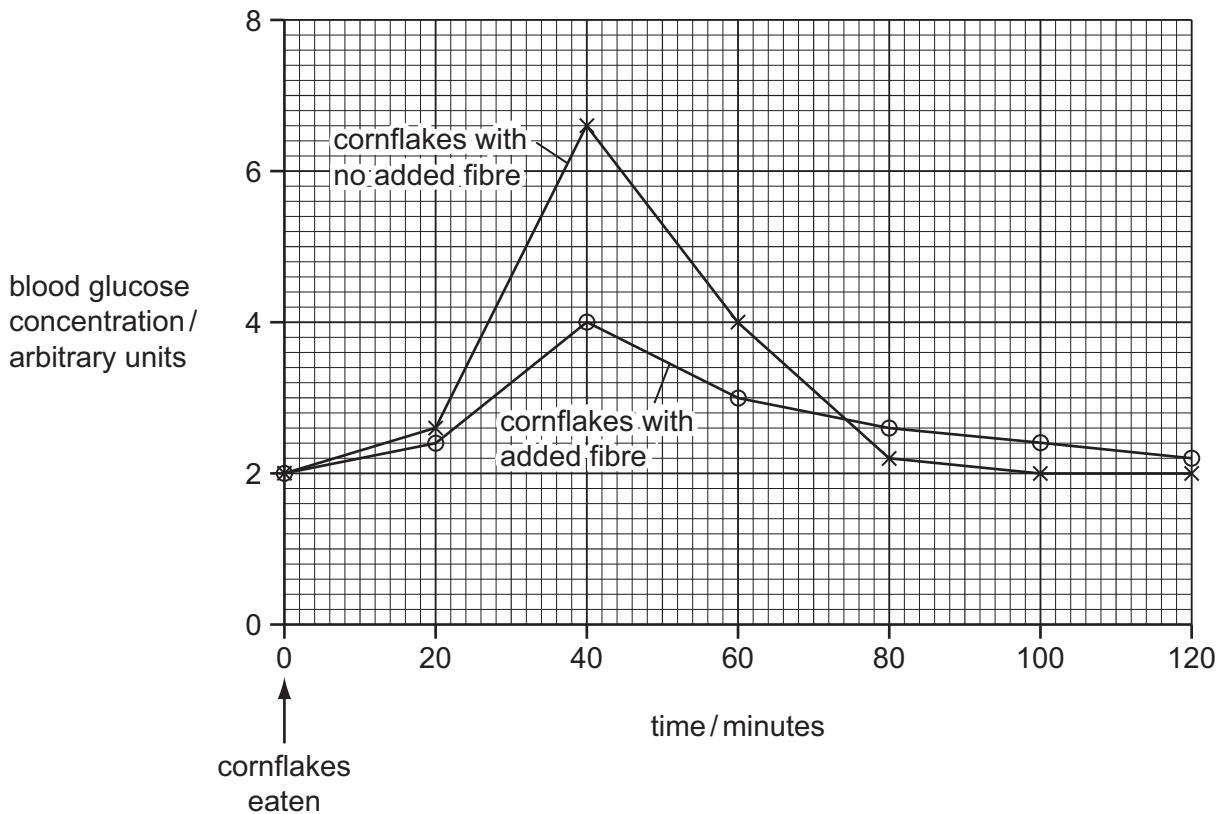

Fig. 3.1

Use the information in Fig. 3.1 to help you to answer the following questions.

(i) Describe how the blood glucose concentration changed after eating cornflakes with no added fibre.

....

....

....

....

[3]

(ii) Explain why these changes in blood glucose concentration occurred.

....

....

....

....

....

....

[4]

(iii) With reference to Fig. 3.1, as well as your own knowledge, suggest and explain the advantages of adding fibre to foods such as cornflakes.

....

....

....

[2]

4 Fig. 4.1 shows the nucleus and **outer** electron shell of an atom of an element from the **third** period of the Periodic Table .
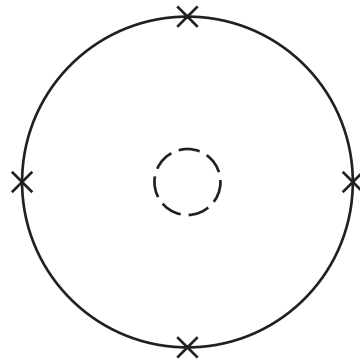
Fig. 4.1

(a) Deduce the name of the element and explain your answer briefly.

name of element ....

explanation ....

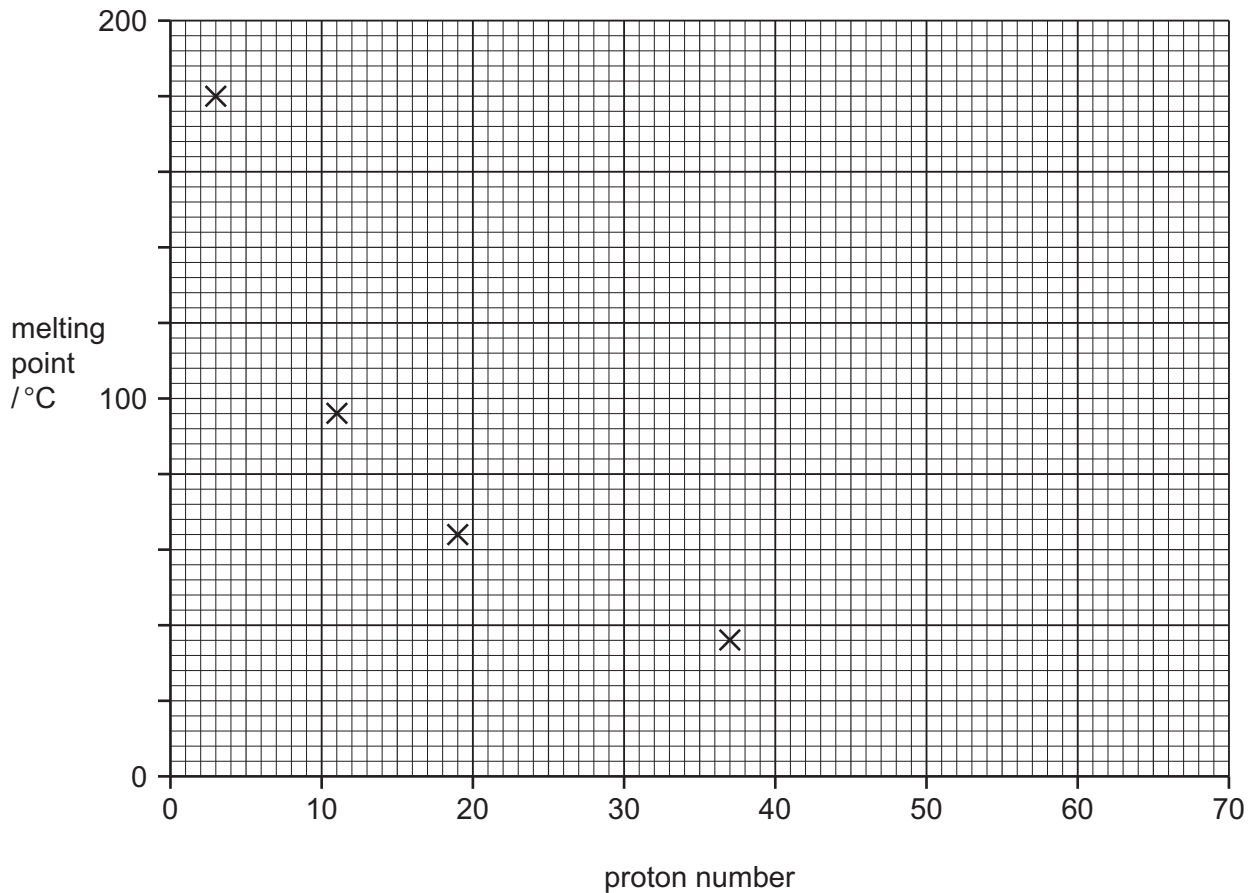.. [2]

(b) Fig. 4.2 shows the melting points of four metallic elements from the same group of the Periodic Table.

melting point / °C

proton number

Fig. 4.2

(i) State the number of the group that contains the elements whose melting points are shown in Fig. 4.2.

Explain your answer briefly.

group number ....

explanation ....

.... [1]
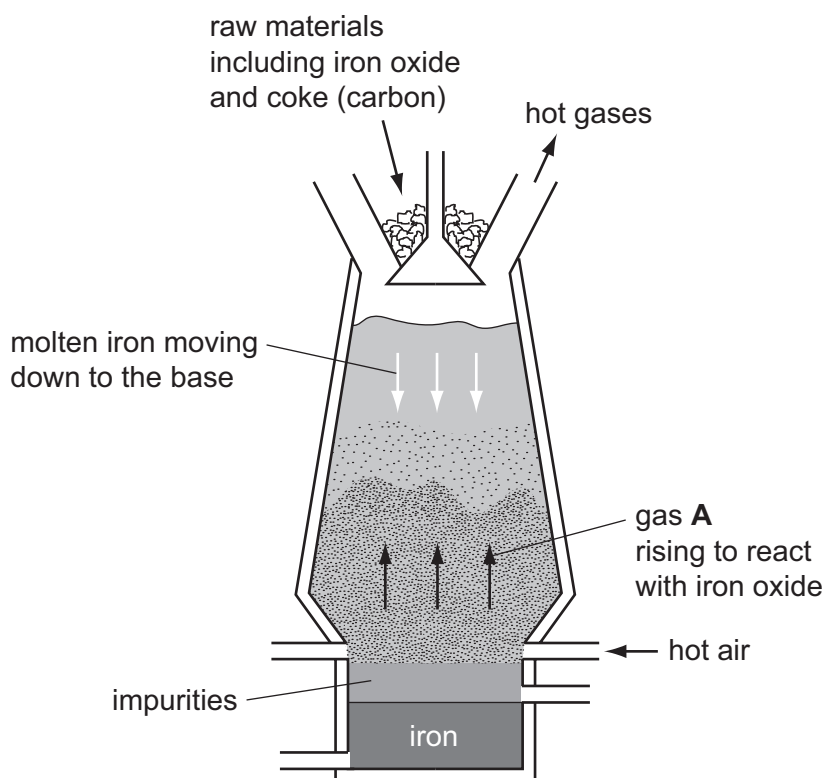
(ii) Estimate the melting point of the next element in the same group of the Periodic Table.

Use the symbol **X** to mark your estimate on the grid in Fig. 4.2. [2]

 [Turn over

(c) Fig. 4.3 shows a cross section through a blast furnace which is used to extract iron from iron oxide.

raw materials
including iron oxide
and coke (carbon)

hot gases

molten iron moving
down to the base

gas **A**
rising to react
with iron oxide

hot air

impurities

iron

Fig. 4.3

  (i) Name gas **A** which reacts with iron oxide to produce iron.

  .... [1]

 (ii) The mixture of hot gases which is released from the top of the furnace contains carbon dioxide.

  State **word** chemical equations for **two** different reactions that produce carbon dioxide inside the blast furnace.

  1 ....

  2 .... [2]

(iii) Explain how gas **A** in Fig. 4.3 is formed inside the blast furnace.

  ....

  .... [1]

Please turn over for Question 5.

 [Turn over

5 Fig. 5.1 shows a solar-powered vehicle.
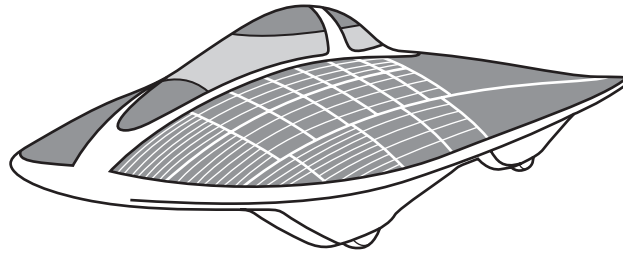
Fig. 5.1

(a) Fig. 5.2 shows a speed/time graph for the vehicle for the first hour of a journey.

Fig. 5.2

(i) Calculate the distance travelled during the first hour.

Show your working and state the unit of your answer.
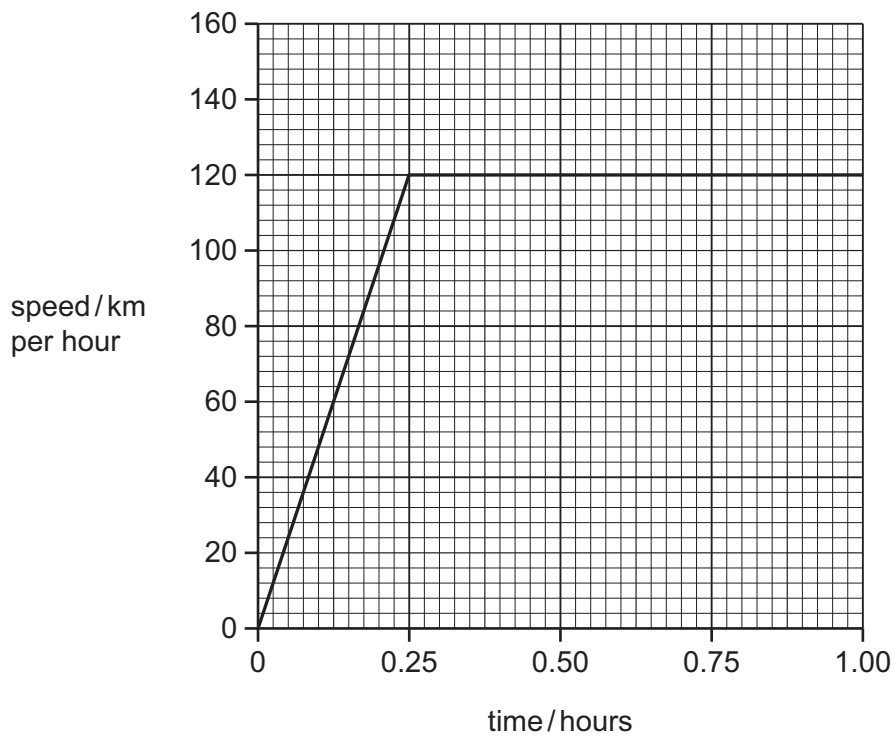
.... unit .... [2]

(ii) Calculate the acceleration of the vehicle during the first quarter of an hour.

State your answer in m/s^2.

Show your working.

.... m/s^2 [3]

(b) Fig. 5.3 shows the energy flow diagram for the solar-powered vehicle.
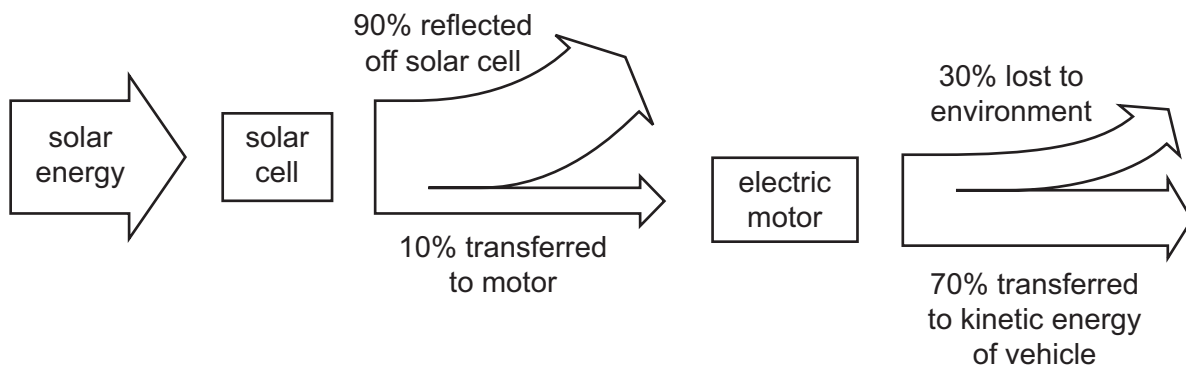
Fig. 5.3

(i) State the efficiency of the **solar cell**.

.... %   [1]

(ii) During part of the journey, the solar cell receives 1 000 000 joules of solar energy.

Calculate the number of joules transferred as kinetic energy to the **vehicle**.

Show your working.

.... J   [2]

(c) The driver needs to see a vehicle following behind.

Fig. 5.4 shows a ray of light from the vehicle behind reflected into the driver's eye from a rear-view mirror.

eye
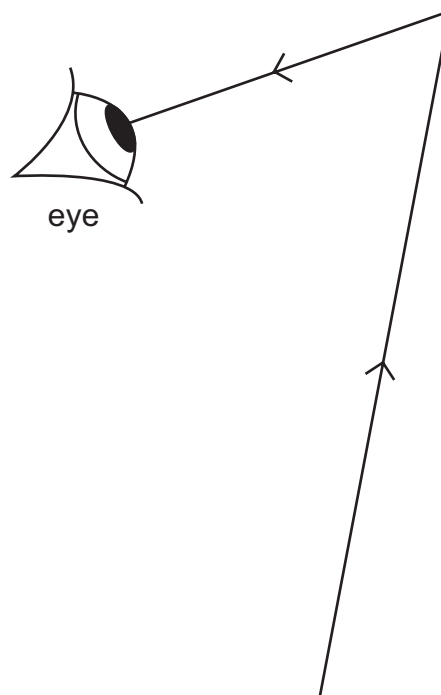
Fig. 5.4

(i) Complete the diagram to show the rear view mirror in its correct position. [2]

(ii) On the diagram, show and mark the angle of incidence with its value. [2]

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(d) Sunlight can be focused onto smaller areas of a solar panel to improve efficiency.

Fig. 5.5 shows two parallel rays of sunlight being focused by a lens. The lens has a focal length of 5 cm.

Complete the diagram to show the rays of sunlight being focused by the lens.

Fig. 5.5

[2]
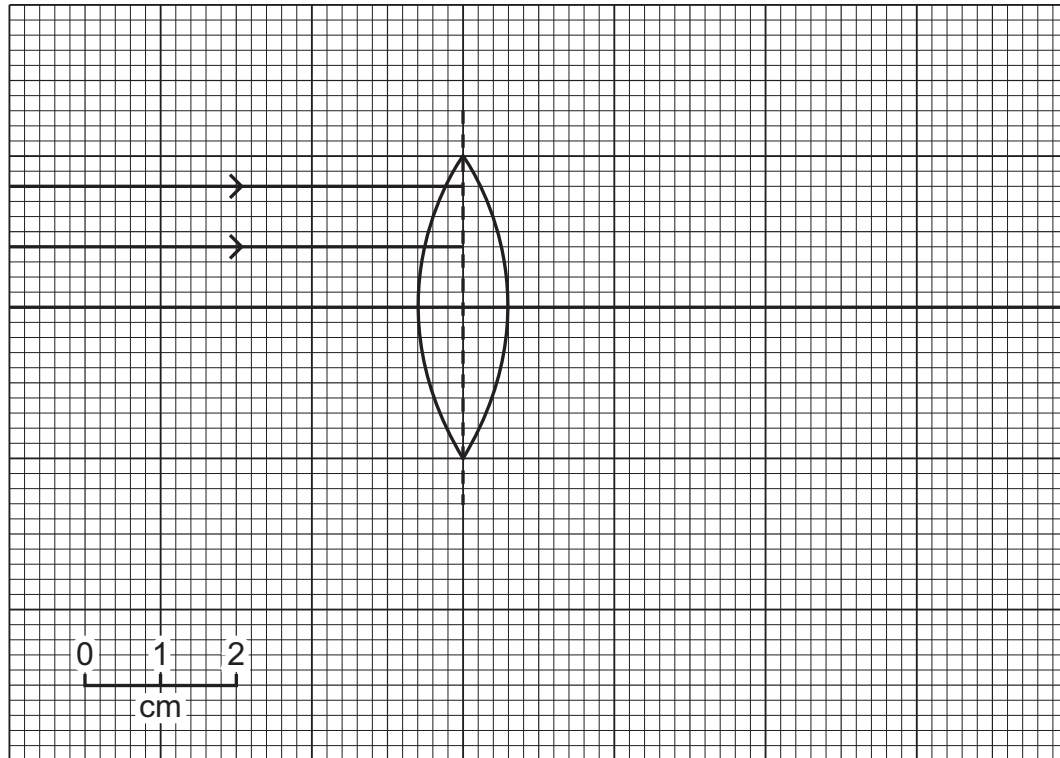
6   Fig. 6.1 shows an external view of the heart and the blood vessels that are connected to it.
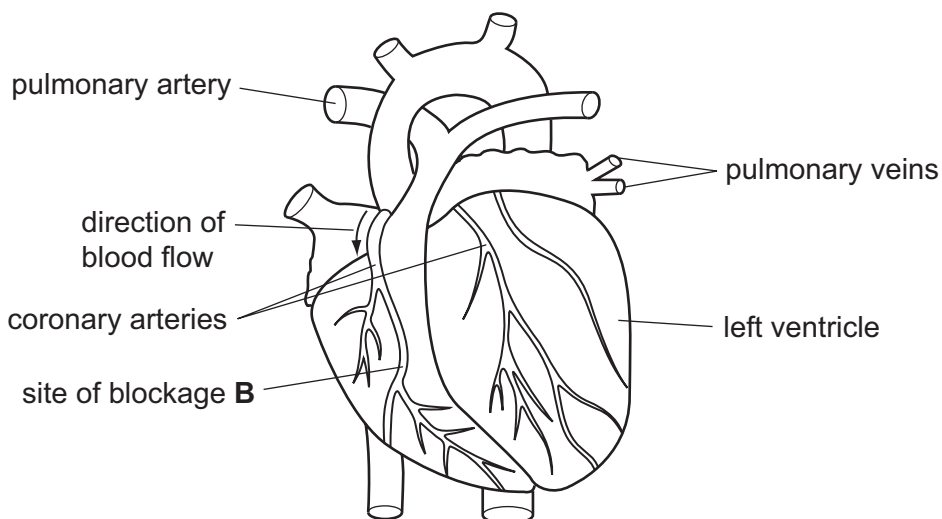
Fig. 6.1

(a) The muscles in the walls of the ventricles contract and relax rhythmically.

   (i) Describe how contraction of the muscles in the wall of the left ventricle affects the blood inside the ventricle.

   ....

   ....

   .... [2]

   (ii) Describe how contraction of the muscles in the wall of the left ventricle affects the valve between the left atrium and the left ventricle.

   .... [1]

(b) The coronary arteries supply the muscles of the heart with oxygen and nutrients.

   (i) Explain why these muscles require a constant supply of oxygen.

   ....

   ....

   .... [2]

   (ii) A blockage occurs in the coronary artery at site **B**.

   On Fig. 6.1, shade the area of the heart wall that will be affected by this blockage.
   [1]

(iii) List **three** lifestyle factors that **increase** the chance that a blockage will develop in a coronary artery.

1 ....

2 ....

3 .... [3]

(c) (i) Describe **two** differences between the contents of a pulmonary artery and a pulmonary vein.

1 ....

....

2 ....

.... [2]

(ii) Describe **two** differences between the structure of the wall of a pulmonary artery and the wall of a pulmonary vein.

1 ....

....

2 ....

.... [2]

7 Zirconium, Zr, is a metallic element found in Period 5 of the Periodic Table.

(a) Fig. 7.1 shows information about isotopes of zirconium.

relative
abundance
of isotope
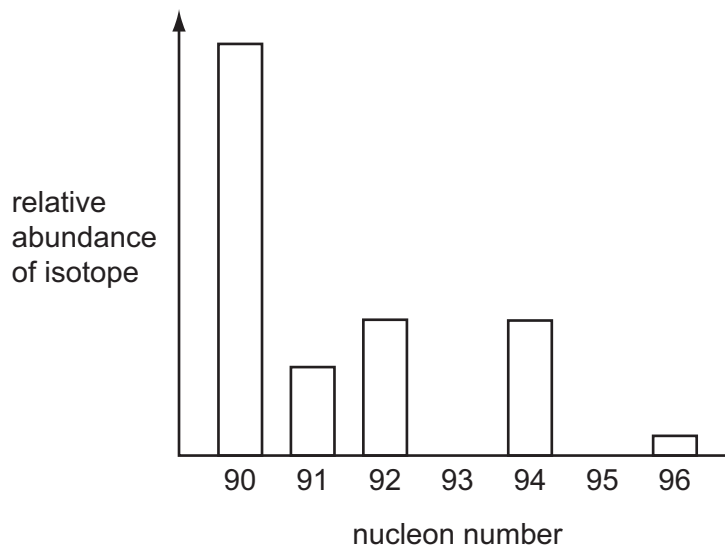
nucleon number

Fig. 7.1

(i) Complete Table 7.1 to show the numbers of nucleons and electrons in two of the zirconium isotopes.

Table 7.1

isotope	number of protons	number of neutrons	number of electrons
Zr-90			
Zr-96			

[2]

(ii) The relative atomic mass of zirconium is 91 (to the nearest whole number).

State the meaning of the term *relative atomic mass*.

....

....

.... [2]

(b) Zirconium is produced in a reaction between zirconium chloride and magnesium.

The balanced equation for the reaction is

$$ZrCl_4 \ + \ 2Mg \longrightarrow Zr \ + \ 2MgCl_2$$

(i) A chemical company makes 182 kg of zirconium.

Calculate the number of moles in 182 kg of zirconium.

Show your working.

.... [2]

(ii) Calculate the mass of magnesium chloride that will be made when 182 kg of zirconium are made.

Show your working.

.... [2]

(c) A large piece of zirconium does not burn in air but zirconium powder burns rapidly, forming zirconium oxide.

(i) Suggest why zirconium powder burns rapidly but a large piece of zirconium does not.

....

....

.... [2]

(ii) The word equation for the combustion of zirconium is

zirconium + oxygen ⟶ zirconium oxide.
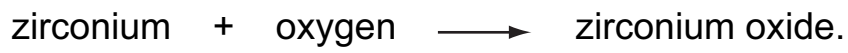
State and explain whether the reactants or the product of this reaction contains the greater amount of chemical potential energy.

....

....

.... [2]

Please turn over for Question 8.

8 (a) Fig. 8.1 shows a circuit which could be used for the lights on a car. When each headlight bulb is fully lit, 6 A passes through it. When each sidelight is fully lit, 0.5 A passes through it.
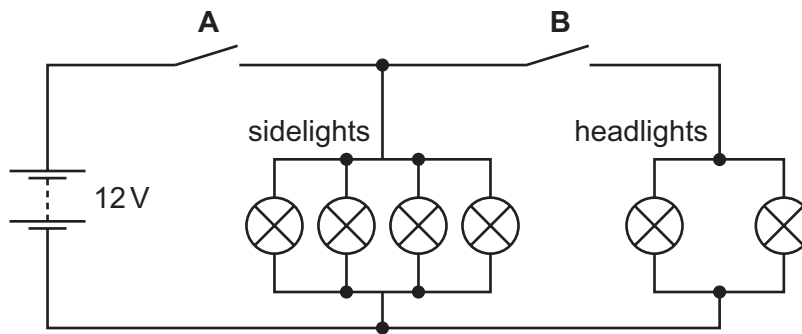
Fig. 8.1

Calculate the total current flowing from the battery when

switch **A** is closed and switch **B** is open,

....

switches **A** and **B** are both closed.

.... [1]

(b) Fig. 8.2 is a graph showing how the resistance of a thermistor changes with temperature.
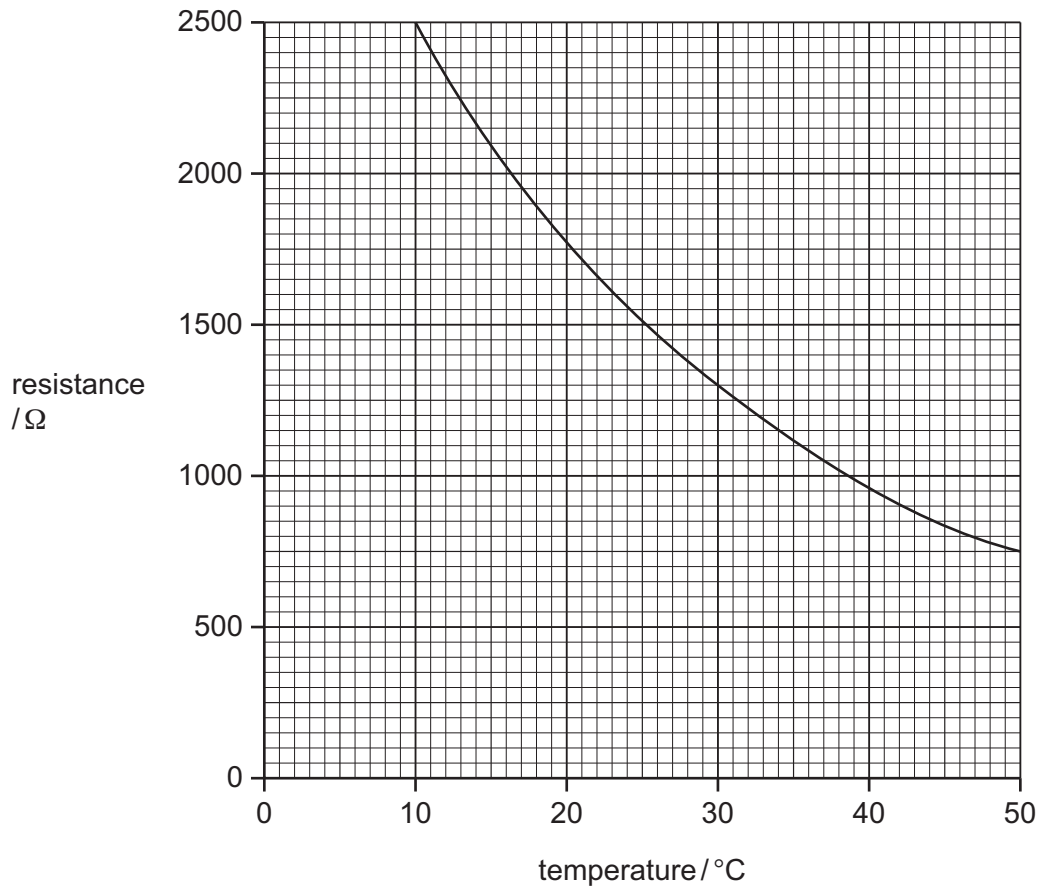
Fig. 8.2

Calculate the current that passes through the thermistor at 30 °C when it is connected to a 12 V power supply.

State the formula that you use, show your working and state the unit of your answer.

formula

working

.... unit .... [3]

[Turn over

(c) Fig. 8.3 shows a simple a.c. generator. It consists of a coil of wire rotating between the poles of a permanent magnet.

The output is fed to an external circuit through carbon contacts pressing against two slip rings.
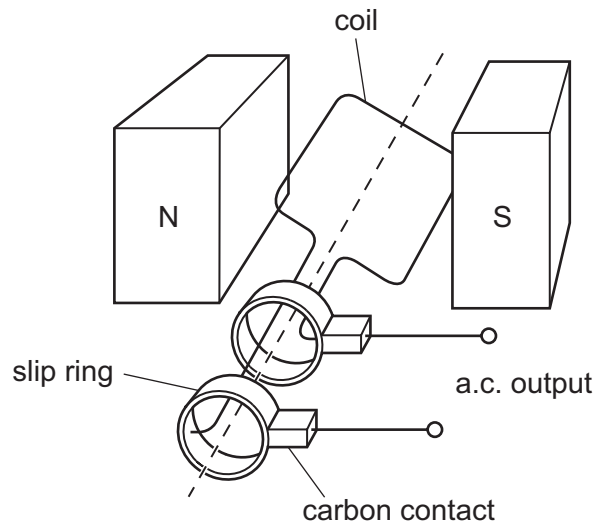
Fig. 8.3

(i) On the grid below, sketch a graph of voltage output against time for the generator.
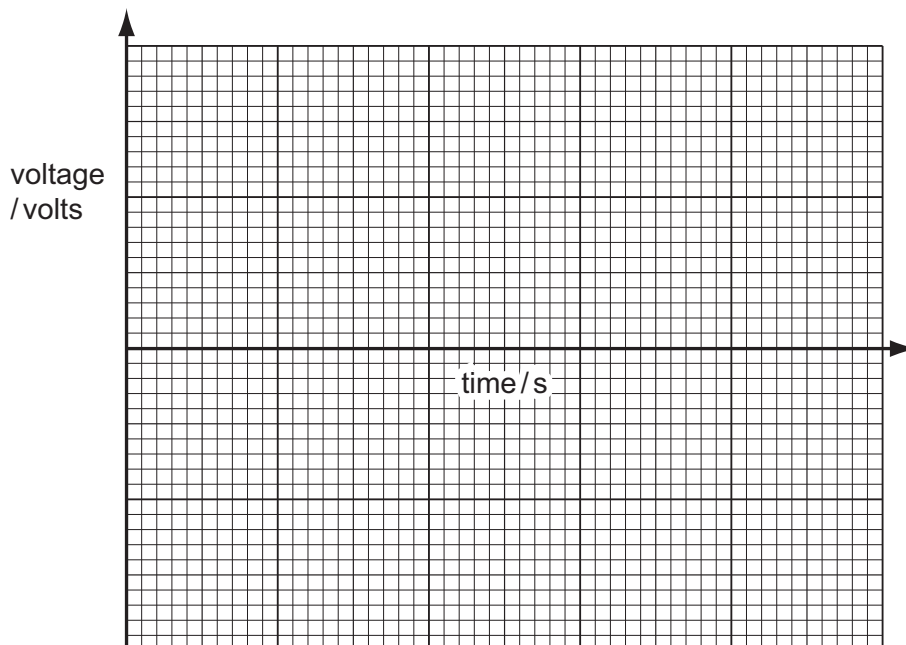
[2]

(ii) State **two** factors on which the magnitude of the output voltage depends.

1 ....

2 .... [2]

Please turn over for Question 9.

9 Chinchillas are mammals with thick grey fur. Chinchillas are often kept as pets.

People try to breed chinchillas with unusual fur. A mutation occurred in 1995 which produced a new allele affecting the colour of the fur.

(a) (i) Define the term *mutation*.

[1]

(ii) State **one** factor that can increase the chance of a mutation occurring.

[1]

(b) The new allele, **A**, is dominant to the normal allele, **a**. Table 9.1 shows the possible fur colours arising from these two alleles.

Table 9.1

genotype	colour
AA	zygote does not develop
Aa	white
aa	normal grey

(i) State the biological term for the observed effect produced by the genotype.

[1]

(ii) A breeder has two white chinchillas.

Draw a genetic diagram to show the genotypes of the offspring that would be produced when these two chinchillas are bred together.

[3]

(iii) State the ratio of fur colour that you would expect in the offspring resulting from this cross.

Explain your answer.

....

....

.... [2]

(c) Wild chinchillas live high in the Andes mountains where it is often very cold.

Suggest how the chinchilla's fur can help it to maintain a constant body temperature.

....

....

.... [2]

10 (a) A gaseous hydrocarbon **X** contains 4 carbon atoms in each of its molecules.

A sample of **X** was bubbled through some bromine solution.

hydrocarbon **X** ⟶

bromine solution
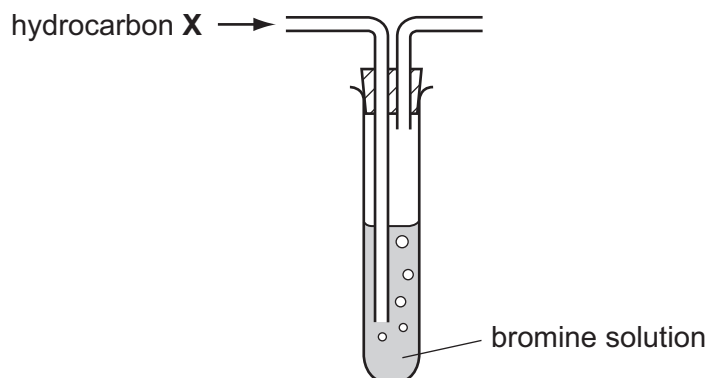
Bromine did **not** react quickly with **X** at room temperature.

Name hydrocarbon **X** and the homologous series to which **X** belongs.

name of **X** ....

name of homologous series .... [2]

(b) Ethene, C_2H_4, is an unsaturated hydrocarbon.

Fig. 10.1 shows structures of the molecules involved when ethene reacts with bromine.
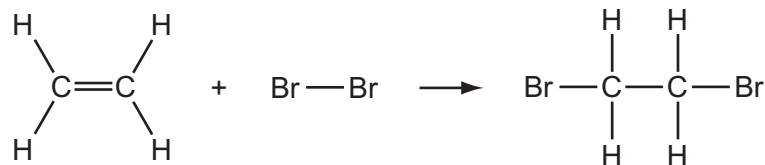
Fig. 10.1

(i) Describe the colour change that is observed when ethene reacts with bromine.

from .... to .... [1]

(ii) Name the type of chemical reaction shown in Fig. 10.1.

.... [1]

(iii) The reaction between ethene and hydrogen chloride, HCl(g), is similar to the reaction shown in Fig. 10.1.

Complete the equation below to suggest the structure of the molecule that is produced.

$$
\begin{array}{c}
H \\ \backslash \\ \\ / \\ H
\end{array}
C = C
\begin{array}{c}
H \\ / \\ \\ \backslash \\ H
\end{array}
\quad + \quad H - Cl \quad \longrightarrow
$$
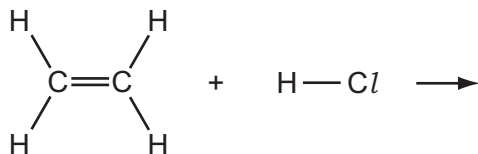
[2]

(iv) Name the compound that is made when ethene reacts with steam.

.... [1]

(c) Methane, CH_4, reacts with steam in the presence of a catalyst to produce carbon monoxide, CO, and hydrogen gas.

Construct a balanced symbol chemical equation for this reaction.

.... [3]

11 X-rays and γ(gamma)–rays are both forms of electromagnetic radiation. They are also both forms of ionising radiation and are used in the treatment of cancer.

(a) State the meaning of the term *ionising radiation*.

....

.... [1]

(b) Name the radiation that comes between X-rays and visible light in the electromagnetic spectrum. Give **one** use for this radiation.

radiation ....

use ....

.... [2]

(c) State the speed at which both X-rays and γ-rays travel through a vacuum.

.... [1]

(d) (i) State the meaning of the term *half-life*.

....

.... [1]

(ii) Fig. 11.1 shows the decay of a sample of the isotope Cs-137.

Cs-137 has a half-life of 30 years.
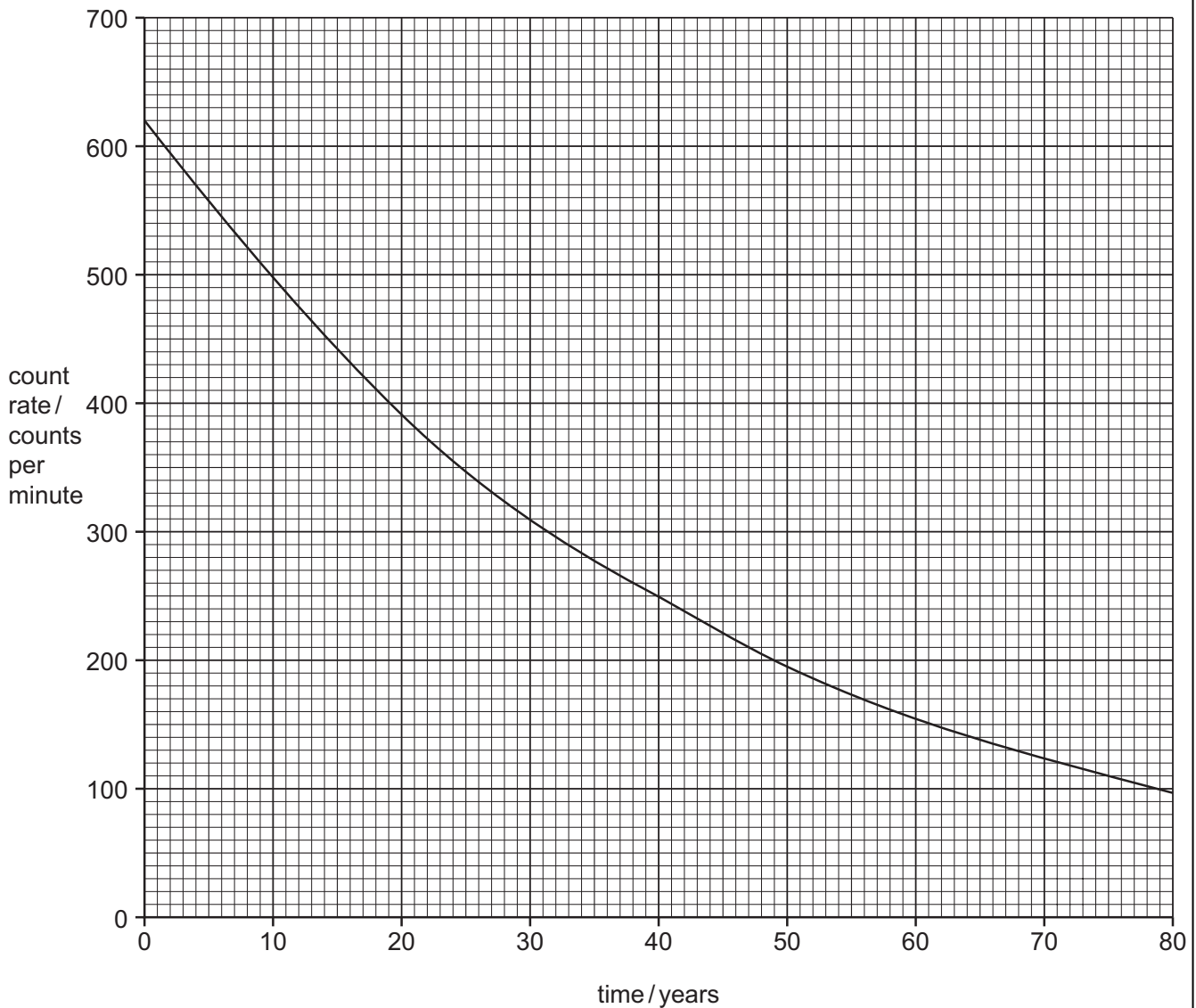
Fig. 11.1

(ii) Use Fig. 11.1 to show that the half-life of Cs-137 is 30 years.

Show your working on the graph.

[2]

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34

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12 About one tenth of the Earth's surface is covered by forests in which much photosynthesis takes place.

(a) Describe how photosynthesis transforms energy from sunlight to chemical energy.

....

....

....

....

....

.... [3]

(b) Explain how extensive deforestation could lead to an increase in the rate of global warming.

....

....

....

....

....

.... [3]

DATA SHEET
The Periodic Table of the Elements

Group

I	II										III	IV	V	VI	VII	0
			1 **H** Hydrogen 1													4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4										11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12										27 **A*l*** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **C*l*** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **T*l*** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †														

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	**Pa** Protactinium 91	238 **U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

*58–71 Lanthanoid series
†90–103 Actinoid series

Key

a	
X	
b	

a = relative atomic mass
X = atomic symbol
b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).