Cambridge Assessment International Education

# Cambridge IGCSE™

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| CANDIDATE NAME | | | | | | | | | |
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*3613463103*

**PHYSICAL SCIENCE** **0652/41**

Paper 4 Theory (Extended) **October/November 2020**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Blank pages are indicated.

DC (RW/CB) 192666/5


[Turn over

**1** **(a)** Fig. 1.1 shows a go-kart travelling at constant speed along a straight horizontal road.

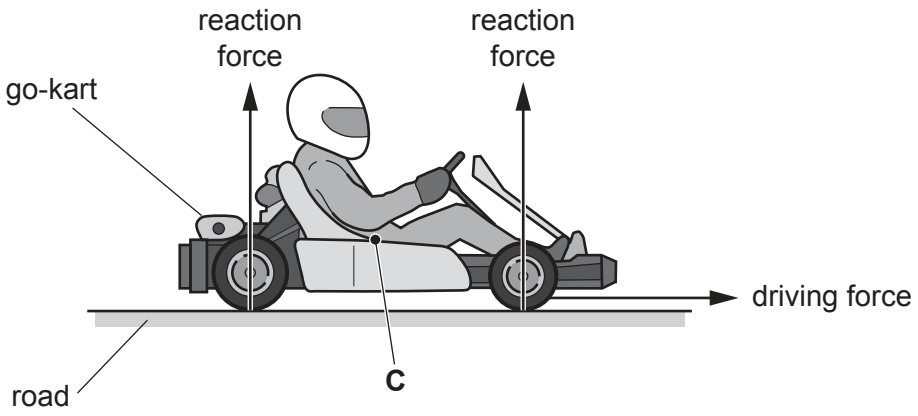


**Fig. 1.1**

**(i)** Point **C** is the centre of mass of the go-kart.

Explain what is meant by the term *centre of mass*.

.....

.....

..... [2]

**(ii)** State why it is an advantage to have the centre of mass of the go-kart as low as possible.

.....

..... [1]

**(iii)** The driving force and the reaction forces acting on the go-kart are shown on Fig. 1.1.

On Fig. 1.1, draw and label **two** more arrows to show two different forces acting on the go-kart. [2]

**(iv)** Deduce the resultant force on the go-kart travelling at constant speed.

resultant force = ..... [1]

**(b)** The go-kart and driver have a total mass of 850 kg and travel at a speed of 24 m / s.

Calculate the total kinetic energy of the go-kart and driver.

Give the unit.

kinetic energy = ..... unit ..... [3]

[Total: 9]

**2** Three states of matter are solid, liquid and gas.

**(a)** Complete Table 2.1 to compare the structure of a solid and a liquid in terms of particle separation, particle arrangement and particle motion.

**Table 2.1**

| | solid | liquid |
|---|---|---|
| particle separation | ..... ..... | ..... ..... |
| particle arrangement | regularly arranged | ..... ..... |
| particle motion | ..... ..... | ..... ..... |

[4]

**(b)** Fig. 2.1 shows how the temperature of a substance varies when it is heated steadily for a period of time.

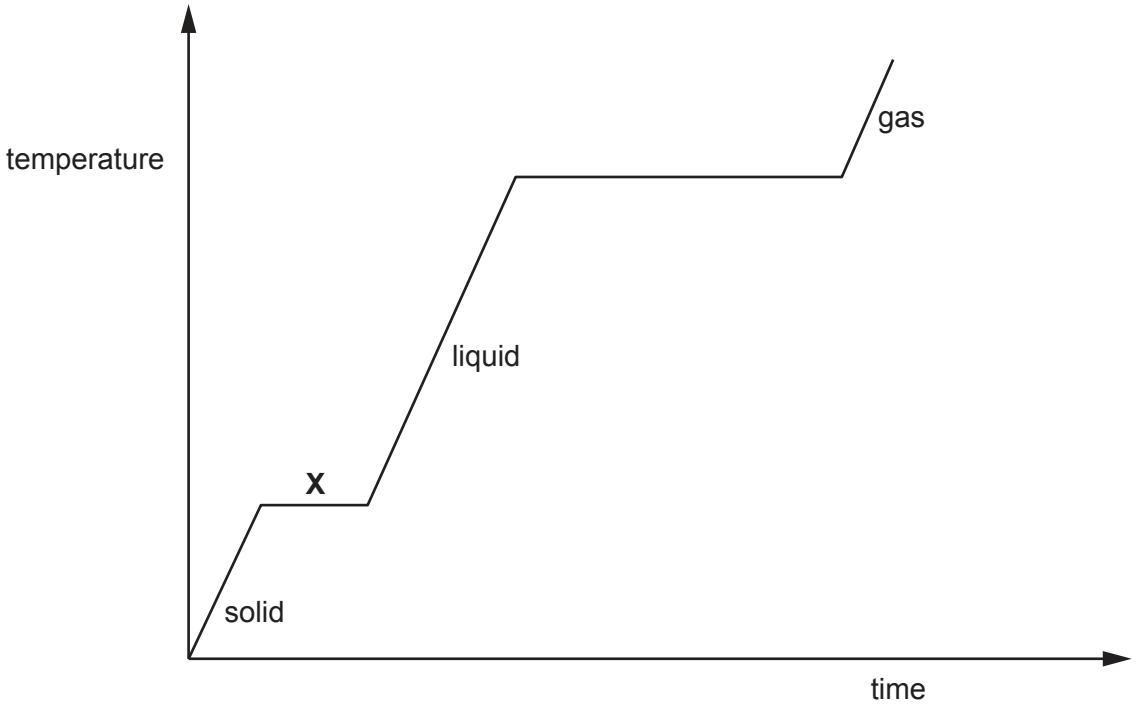


**Fig. 2.1**

Explain why the temperature stays constant for some time at **X**.

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

**3** Fig. 3.1 shows a refrigerator.

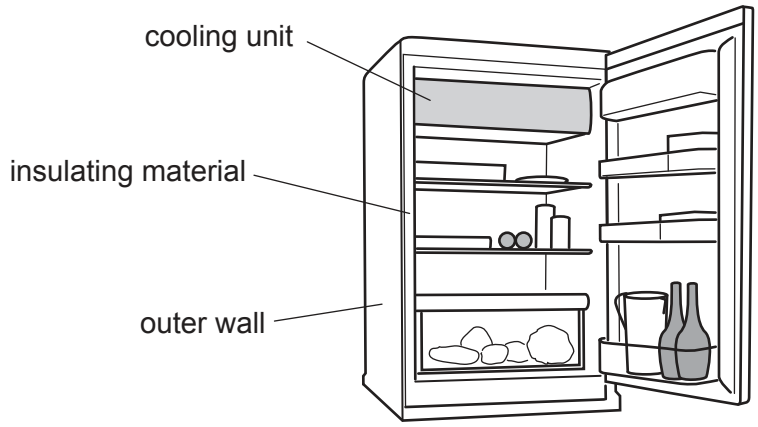


**Fig. 3.1**

**(a)** The cooling unit is placed at the top of the refrigerator.

Explain why this causes convection currents in the refrigerator.

.....

.....

.....

..... [3]

**(b)** **(i)** Explain why the insulating material is required.

.....

..... [1]

**(ii)** The outer wall is made from metal.

Explain why metals are good thermal conductors.

.....

.....

..... [2]

**(c)** The metal outer wall is usually painted shiny white.

Explain the effect this has when bright sunlight falls on the refrigerator.

.....

.....

..... [2]

[Total: 8]

**4** Sound is transmitted by longitudinal waves. Water waves are mainly transverse waves.

**(a)** Explain the difference between *longitudinal* and *transverse* waves.

.....

.....

.....

..... [2]

**(b)** A sound wave consists of a series of compressions and rarefactions.

Explain what is meant by a *rarefaction*.

.....

.....

..... [2]

**(c)** A musical note has a frequency of 256 Hz.

The speed of sound in air is 320 m / s.

Calculate the wavelength of the musical note.

wavelength = ..... m [2]

**(d)** A sound wave enters a person's ear.

State how the sound wave affects the person's ear to cause them to detect the sound.

.....

..... [1]

[Total: 7]

**5** A student investigates the melting point of a sample of a medicinal drug.

The result is shown in Table 5.1.

**Table 5.1**

| melting point data / °C |
|---|
| 70–75 |

The student thinks the sample is a drug called ibuprofen.

The melting point of ibuprofen is 76 °C.

**(a)** Explain how the data indicates that the sample is **not** pure.

.....

..... [1]

**(b)** The molecular formula for ibuprofen is $C_{13}H_{18}O_2$.

Determine the relative molecular mass, $M_r$, of ibuprofen.

[$A_r$: C, 12; H, 1; O, 16]

$M_r$ of ibuprofen = ..... [1]

**(c)** The structure of ibuprofen is shown in Fig. 5.1.

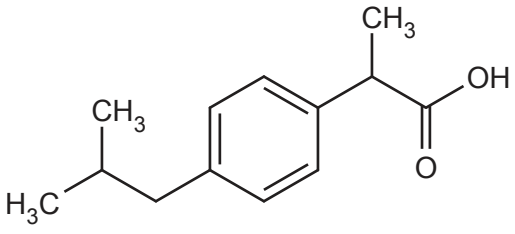


**Fig. 5.1**

Explain why ibuprofen is **not** a hydrocarbon.

.....

..... [1]

**(d)** Ibuprofen is a weak acid.

State what is meant by the term *acid*, in terms of proton transfer.

.....

..... [1]

**(e)** Ibuprofen reacts with sodium.

**(i)** Table 5.2 shows the charges on an ibuprofen ion and a sodium ion.

**Table 5.2**

| name | formula of ion | charge of ion |
|---|---|---|
| ibuprofen ion | $C_{13}H_{17}O_2^-$ | –1 |
| sodium ion | $Na^+$ | +1 |

Determine the formula of the ionic compound formed when the ibuprofen ion and sodium ion combine.

..... [1]

**(ii)** The other product formed is a gas that gives a pop sound when tested with a lighted splint.

State the name of the gas.

..... [1]

**(f)** Ibuprofen is soluble in ethanol.

Explain how a chemist can separate the ibuprofen from the ethanol.

.....

.....

.....

..... [2]

[Total: 8]

**6** **(a)** Carbon and oxygen react to form carbon dioxide.

The equation for the reaction is shown.

$$C + O_2 \rightarrow CO_2$$

Calculate the mass of carbon dioxide produced when 4 g of carbon reacts with oxygen.

[$A_r$: C, 12; O, 16]

mass of $CO_2$ = ..... g [3]

**(b)** State why incomplete combustion of carbon is a problem.

.....

..... [1]

**(c)** Carbon dioxide, $CO_2$, is a covalent compound.

Draw a dot-and-cross diagram to represent the bonding in a molecule of carbon dioxide.

You only need to show the outer electrons of each atom.

[3]

**(d)** Table 6.1 gives the melting points of some compounds.

**Table 6.1**

| compound | melting point / °C |
|---|---|
| **V** | 0 |
| **W** | 801 |
| **Y** | –210 |
| **Z** | –57 |

Circle the letters of **all** the compounds that are covalent.

Give a reason for your choices.

**V** **W** **Y** **Z**

.....

.....

[2]

[Total: 9]

**7** Fig. 7.1 shows a circuit with a battery of electromotive force (e.m.f.) 9.0 V, connected to two resistors in series.

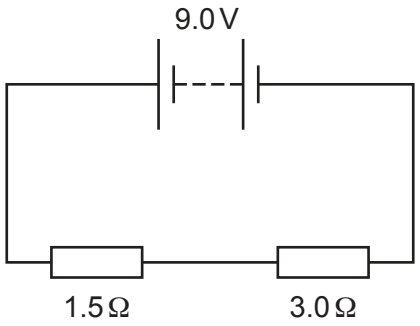


**Fig. 7.1**

**(a) (i)** Calculate the total resistance in the circuit.

resistance = ..... Ω [1]

**(ii)** Calculate the current in the circuit.

current = ..... A [2]

**(iii)** Calculate the power produced by the battery.

power = ..... W [2]

**(b)** A student connects a 6.0 Ω resistor in parallel with the two resistors, as shown in Fig. 7.2.

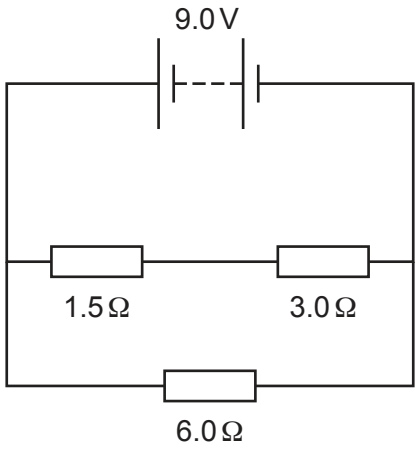


**Fig. 7.2**

Calculate the resistance of this combination of the three resistors.

resistance = ..... Ω [2]

[Total: 7]

**8** Fig. 8.1 shows the structure of an organic compound, 3-cyclopentene-1-ol.

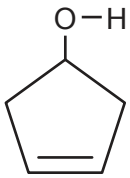


**Fig. 8.1**

- The *cyclo* part of the name of this compound is because there is a ring shape,  .
- The *pent* part is because there are five carbon atoms.
- The *-ol* part is because there is an OH group, which is present in all alcohols.

**(a)** Describe what the *-ene* part of the name refers to.

.....

..... [1]

**(b)** Ethanol is an alcohol. The equation shows the formation of ethanol, $CH_3CH_2OH$.

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$$

**(i)** State the name of the process this equation represents.

..... [1]

**(ii)** State **one** use for ethanol.

..... [1]

**(c)** A catalyst is involved during the formation of the organic compound shown in Fig. 8.1.

**(i)** Catalysts increase the rate of a reaction by affecting the activation energy of the reaction.

Explain what is meant by the term *activation energy*.

.....

..... [1]

**(ii)** Concentration of the reactants affects the rate of a reaction.

Describe and explain the effect of increasing the concentration of a reactant on the rate of a reaction.

.....

.....

.....

.....

.....

..... [3]

**(d)** Fig. 8.2 shows an energy level diagram for an exothermic reaction.

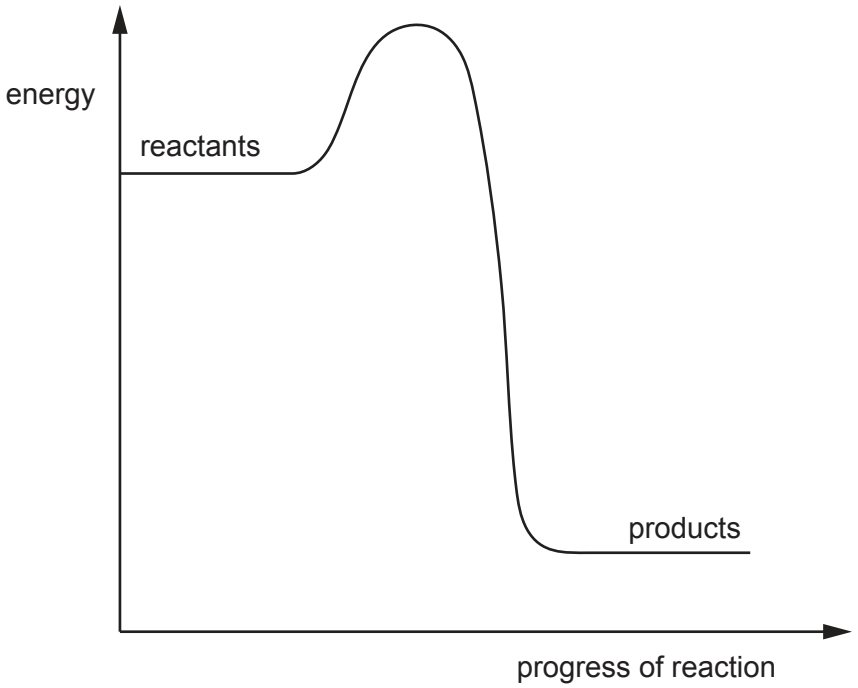


**Fig. 8.2**

On Fig. 8.2, use labelled arrows to show:

- the activation energy
- the overall change in energy.

[2]

[Total: 9]

**9** Fig. 9.1 shows a conductor in the magnetic field formed by two electromagnets.

The conductor is connected to a sensitive voltmeter.

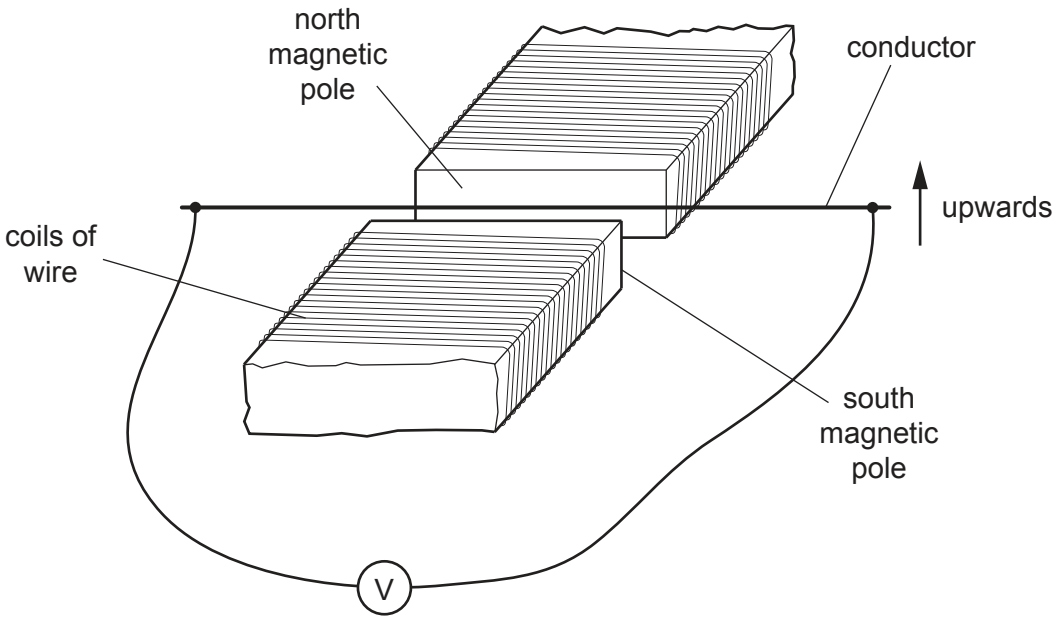


**Fig. 9.1**

State what is observed on the voltmeter when:

- the conductor is moved vertically upwards out of the magnetic field .....

  .....

- the conductor is then moved back to its original position in the magnetic field .....

  .....

- the current in the coils of the electromagnet is then switched off. .....

  .....

[4]

**10** The halogens are in Group VII of the Periodic Table.

**(a)** Chlorine is an oxidising agent.

**(i)** Explain the meaning of the term *oxidising agent*.

.....

..... [1]

**(ii)** Predict whether iodine is a more or less powerful oxidising agent than chlorine. Give a reason for your answer.

.....

.....

..... [1]

**(b)** Complete the word equation for the reaction of bromine with aqueous sodium iodide.

bromine + sodium iodide → [ ] + [ ]

[1]

**(c)** Data about Group VII elements are shown in Table 10.1.

**Table 10.1**

| element | symbol | melting point / °C | boiling point / °C | state at room temperature | colour |
|---|---|---|---|---|---|
| fluorine | F | –219 | –188 | gas | pale yellow |
| chlorine | ..... | –101 | –34 | gas | yellow-green |
| bromine | Br | ..... | 59 | liquid | red-brown |
| iodine | I | 114 | 184 | ..... | purple |
| astatine | At | 300 | 350 | solid | ..... |

Complete the table. [4]

[Total: 7]

**11** **(a)** The isotope thallium-208 ($^{208}_{81}Tl$) decays into a stable isotope of lead by emission of a β-particle.

Complete the equation showing this decay.

$$^{208}_{81}Tl \rightarrow \ ^{.....}_{.....}Pb \ + \ ^{.....}_{.....}\beta$$ [2]

**(b)** The half-life of the isotope thallium-208 ($^{208}_{81}Tl$) is investigated.

Fig. 11.1 shows a graph of the counter reading against time.

The background count is 8 counts per minute.

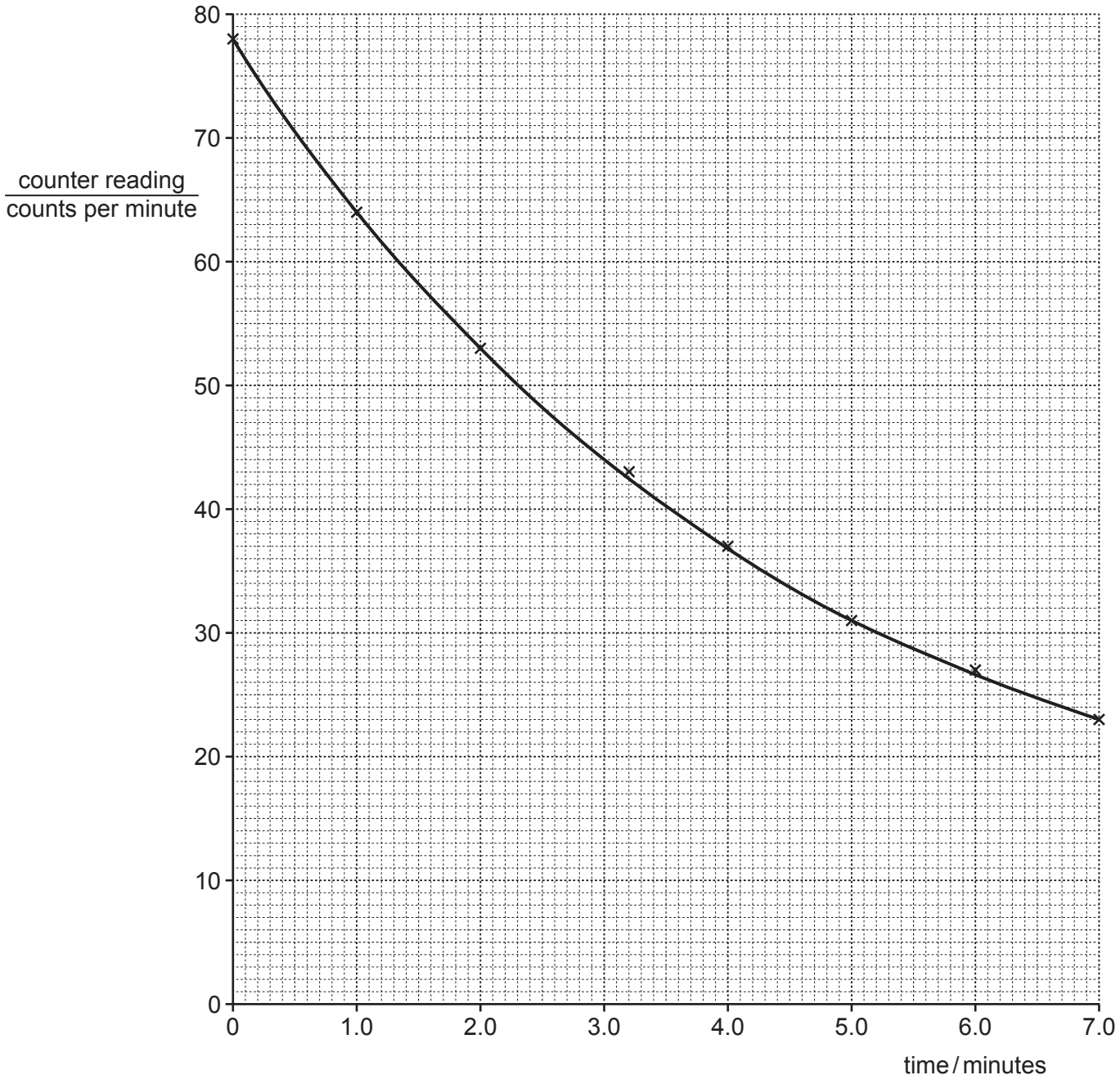


**Fig. 11.1**

Use the graph in Fig. 11.1 to determine the half-life of the isotope, thallium-208.

You must clearly show how you used the graph in Fig. 11.1.

half-life = ..... minutes [3]

[Total: 5]

## The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
| | | | | | | | 1 H hydrogen 1 | | | | | | | | | | 2 He helium 4 |
| 3 Li lithium 7 | 4 Be beryllium 9 | | | | | | | | | | | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | | | | | | | | | | | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 |
| 19 K potassium 39 | 20 Ca calcium 40 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium – | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89–103 actinoids | 104 Rf rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | | 114 Fl flerovium – | | 116 Lv livermorium – | | |

**Key**

atomic number
atomic symbol
name
relative atomic mass

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lanthanoids | 57 La lanthanum 139 | 58 Ce cerium 140 | 59 Pr praseodymium 141 | 60 Nd neodymium 144 | 61 Pm promethium – | 62 Sm samarium 150 | 63 Eu europium 152 | 64 Gd gadolinium 157 | 65 Tb terbium 159 | 66 Dy dysprosium 163 | 67 Ho holmium 165 | 68 Er erbium 167 | 69 Tm thulium 169 | 70 Yb ytterbium 173 | 71 Lu lutetium 175 |
| actinoids | 89 Ac actinium – | 90 Th thorium 232 | 91 Pa protactinium 231 | 92 U uranium 238 | 93 Np neptunium – | 94 Pu plutonium – | 95 Am americium – | 96 Cm curium – | 97 Bk berkelium – | 98 Cf californium – | 99 Es einsteinium – | 100 Fm fermium – | 101 Md mendelevium – | 102 No nobelium – | 103 Lr lawrencium – |

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