



# Cambridge IGCSE™

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**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.

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

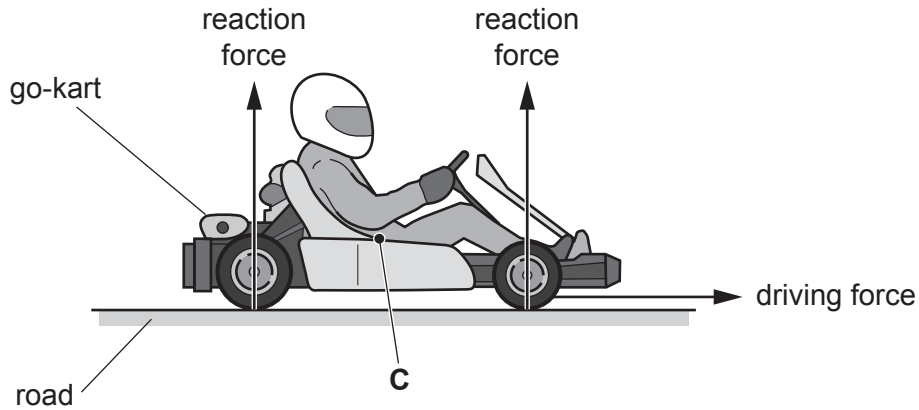


Fig. 1.1

(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.

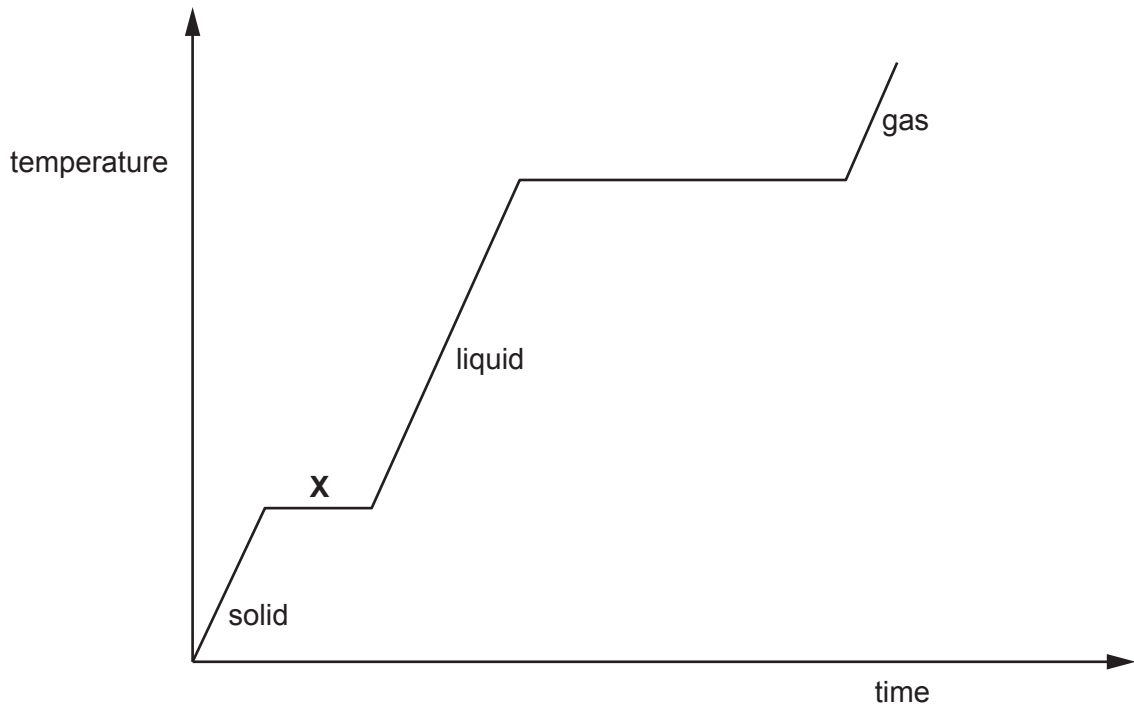


Fig. 2.1

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

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

3 Fig. 3.1 shows a refrigerator.

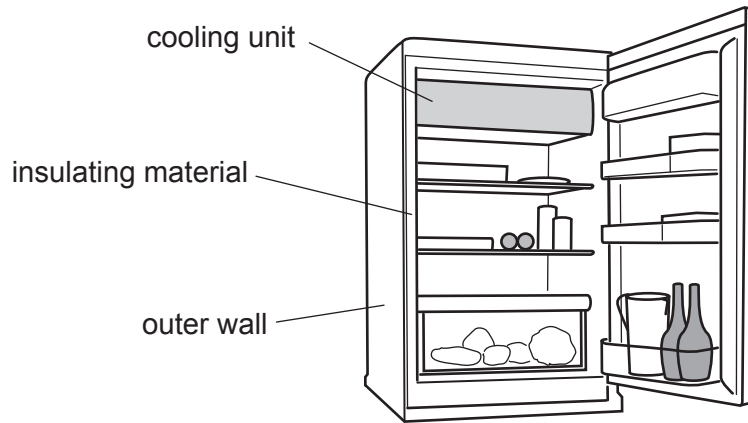


Fig. 3.1

(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]

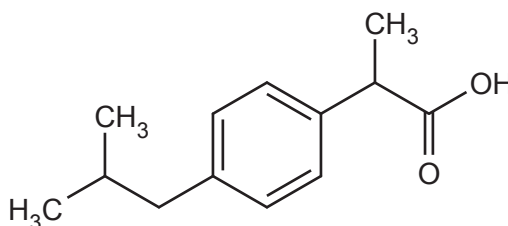
- (b) The molecular formula for ibuprofen is  $C_{13}H_{18}O_2$ .

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.

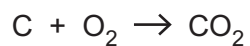
Explain how a chemist can separate the ibuprofen from the ethanol.

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

[Total: 8]

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

The equation for the reaction is shown.



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

[A<sub>r</sub>: C, 12; O, 16]

mass of CO<sub>2</sub> = ..... g [3]

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

.....

..... [1]

(c) Carbon dioxide,  $\text{CO}_2$ , 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/ $^{\circ}\text{C}$
<b>V</b>	0
<b>W</b>	801
<b>Y</b>	-210
<b>Z</b>	-57

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

Give a reason for your choices.

**V**

**W**

**Y**

**Z**

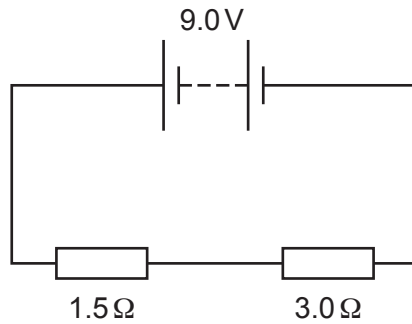
.....

.....

[2]

[Total: 9]

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



**Fig. 7.1**

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

resistance = .....  $\Omega$  [1]

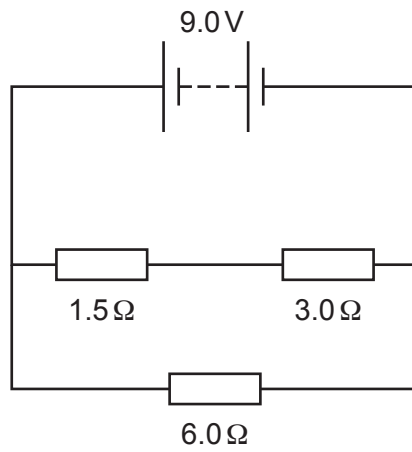
- (ii) Calculate the current in the circuit.

current = ..... A [2]

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

power = ..... W [2]

(b) A student connects a  $6.0\ \Omega$  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 = .....  $\Omega$  [2]

[Total: 7]

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

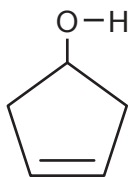



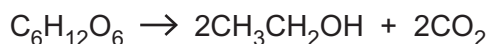
Fig. 8.1

- 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<sub>3</sub>CH<sub>2</sub>OH.



(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.

.....

.....

.....

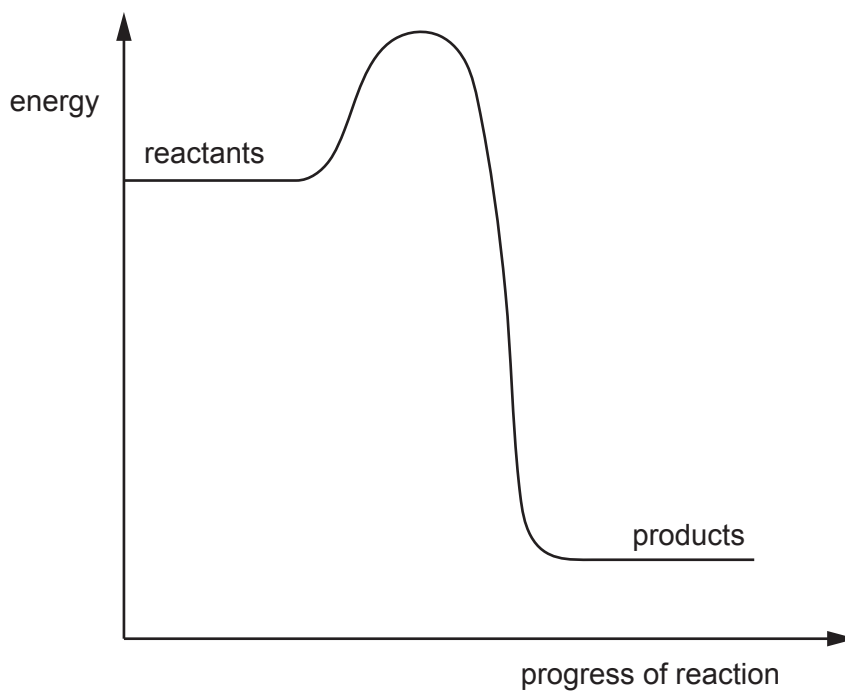
.....

.....

.....

..... [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.

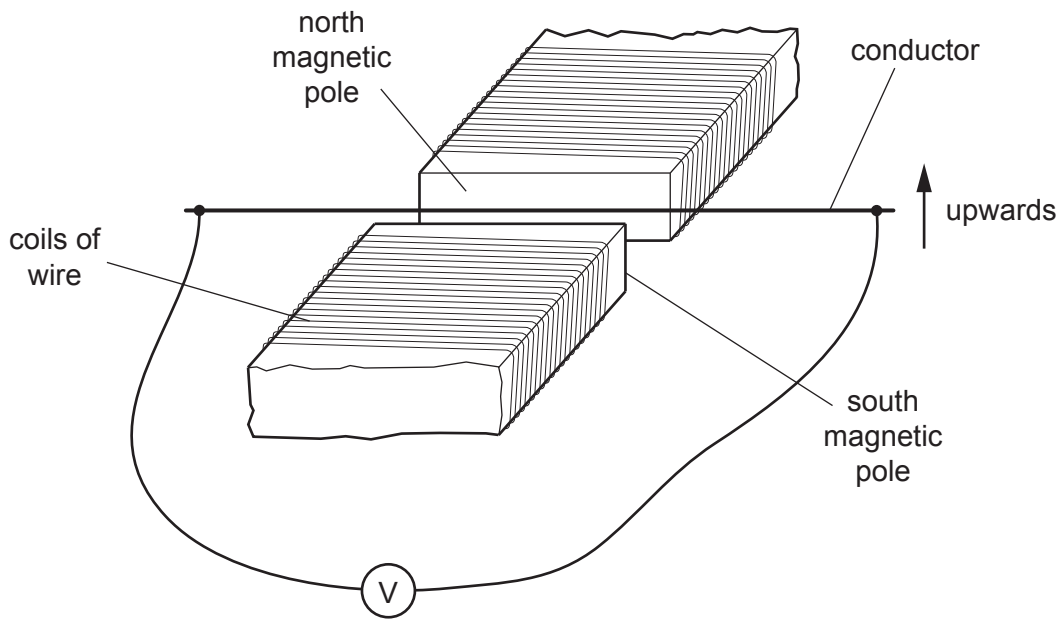


Fig. 9.1

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.

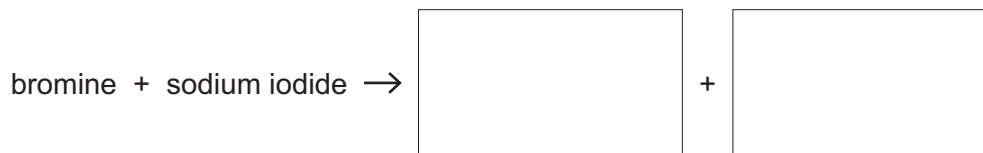
(i) Explain the meaning of the term *oxidising agent*.

.....  
 ..... [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.



[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 ( ${}^{208}_{81}\text{Tl}$ ) decays into a stable isotope of lead by emission of a  $\beta$ -particle.

Complete the equation showing this decay.



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

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

The background count is 8 counts per minute.

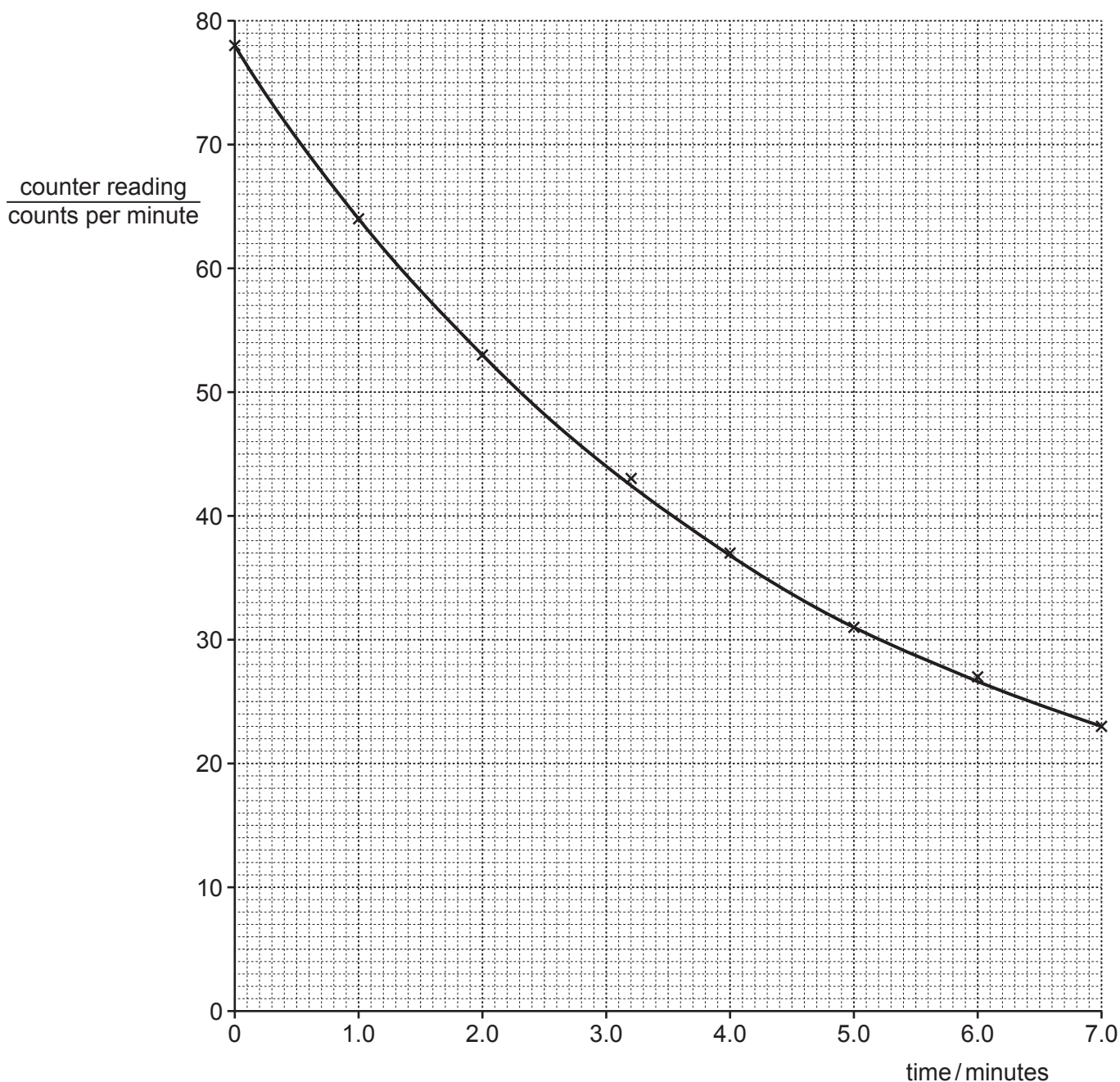


Fig. 11.1

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]

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## The Periodic Table of Elements

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

## Key

atomic number  
atomic symbol  
name  
relative atomic mass

lanthanoids

actinoids

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

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