Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

8282841054

CO-ORDINATED SCIENCES **0654/43**

Paper 4 Theory (Extended) **October/November 2021**

2 hours

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 120.
- 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 **28** pages. Any blank pages are indicated.

[Turn over

1 A student investigates the effect of placing strips of potato in water and different concentrations of sugar solution.

Table 1.1 shows the results.

Table 1.1

concentration of sugar solution / mol dm^{-3}	length of potato strip at the start of the investigation / mm	length of the potato strip at the end of the investigation / mm	change in length of potato strip / mm
0.0 (water)	49.5	52.5	
0.2	50.0	52.0	+ 2.0
0.4	50.5	51.5	+ 1.0
0.6	50.0	50.5	+ 0.5
0.8	49.0	48.0	– 1.0
1.0	49.5	47.5	– 2.0

(a) Calculate the change in length of the potato strip in water.

..... mm [1]

(b) Use Table 1.1 to suggest the concentration of sugar solution inside the cells of the potato.

..... mol dm^{-3} [1]

(c) Explain why the potato strip immersed in a 0.2 mol dm^{-3} sugar solution increased in length by completing the sentences.

The potato strip has a ..... water potential than the sugar solution.

Water moves into the potato strip by .....,

from an area of ..... water potential to .....

water potential through the ..... membrane.

[4]

(d) Fig. 1.1 is a diagram of a cell placed in one of the concentrations of sugar solution.

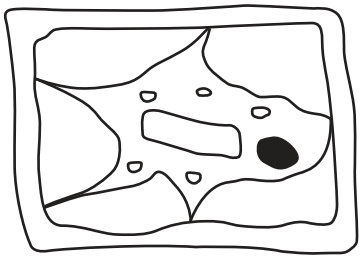


Fig. 1.1

(i) Describe and explain the appearance of the cell shown in Fig. 1.1.

.....

.....

..... [2]

(ii) Suggest which concentration of sugar solution in Table 1.1 this cell was immersed in.

concentration = ... $mol\,dm^{-3}$ [1]

(e) State **two** uses of water in a plant.

1 .....

2 ..... [2]

[Total: 11]

2 Chlorine and bromine are Group VII elements of the Periodic Table.

Chlorine is more reactive than bromine.

(a) State the names of the **two products** made when aqueous chlorine reacts with aqueous potassium bromide solution.

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

(b) Chlorine reacts with hydrogen to form hydrogen chloride.
Hydrogen chloride is a **covalent** compound.

(i) Explain why hydrogen chloride is a gas at room temperature.
Use ideas about structure and bonding.

.....

.....

..... [2]

(ii) Hydrogen chloride gas dissolves in water to form dilute hydrochloric acid.
Describe the effect of dilute hydrochloric acid on litmus paper.

..... [1]

(iii) State the formula of the ion present in all acids.
Choose from the list.

Cl^-

H^+

OH^-

O^{2-}

..... [1]

(c) A solution of dilute hydrochloric acid has a concentration of $73\,g/dm^3$.

Calculate the mass of hydrogen chloride in $250\,cm^3$ of the solution.

mass of hydrogen chloride = ... g [2]

(d) Bromine reacts with ethene.

Fig. 2.1 shows the structures of the reactants and products in this reaction.

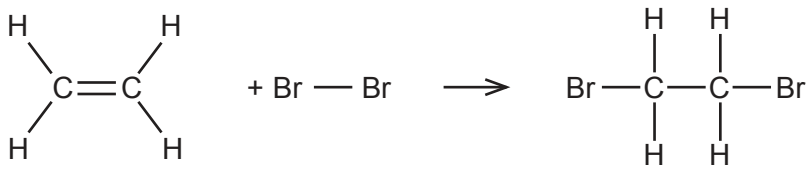


Fig. 2.1

(i) Put a circle around each of the bonds which are **made** when the reaction takes place.[1]

(ii) When ethene reacts with bromine the reaction is exothermic.

Explain why the reaction of ethene and bromine is exothermic.
Use ideas about bond breaking and bond making.

.....

.....

..... [2]

[Total: 11]

3 Carbon-14 is an unstable isotope which decays to produce nitrogen-14.

(a) State what is meant by an *isotope*.

.....

..... [1]

(b) Use the correct nuclide notation to complete the symbol equation for this decay process.

$$^{14}_{6}C \longrightarrow {}^{\square}_{\square}N + {}^{\square}_{\square}\square$$

[2]

(c) Fig. 3.1 shows the percentage of carbon-14 in a sample.

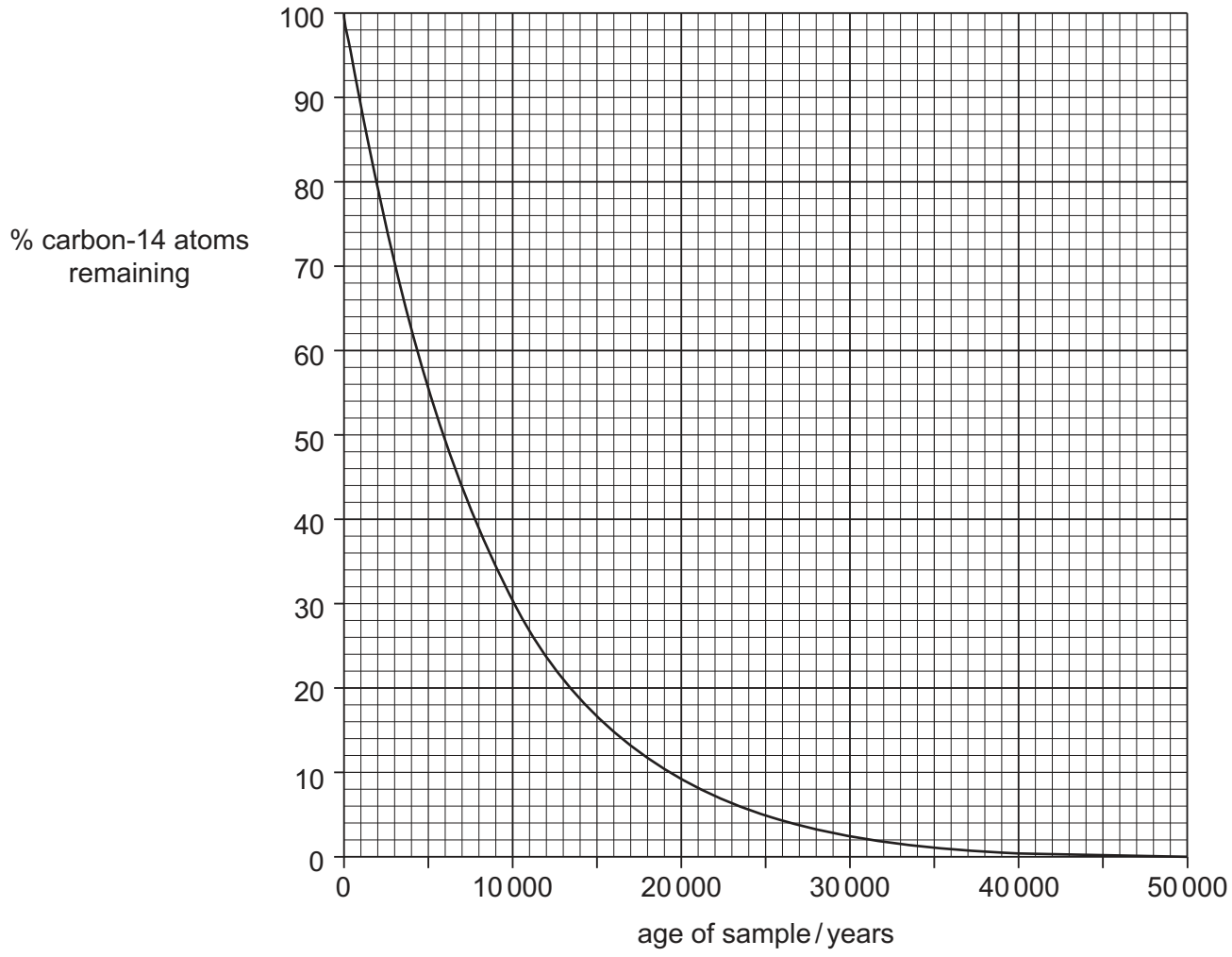


Fig. 3.1

Use Fig. 3.1 to determine the half-life of carbon-14.

half-life = ... years [2]

(d) The decay of unstable isotopes can also release gamma rays which are part of the electromagnetic spectrum.

(i) On Fig. 3.2 write gamma in the correct position.

			visible	infrared	microwaves	

Fig. 3.2

[1]

(ii) State the speed of the gamma rays produced by radioactive decay.

..... [1]

(iii) A gamma ray has a wavelength of 2.0×10^{-11} m.
Use your answer to **(d)(ii)** to calculate the frequency of this gamma ray.
State the unit for your answer.

frequency = ... unit ..... [3]

(iv) Draw lines to match each form of electromagnetic radiation to its use.

form of electromagnetic radiation	**uses**
infrared	medicine and security
microwaves	radio and TV communications
radiowaves	remote controls and intruder alarms
X-rays	satellite television and telephones

[2]

(e) All electromagnetic waves are transverse waves.
Sound is an example of a longitudinal wave.
Give **one** difference between transverse and longitudinal waves.

.....

..... [1]

[Total: 13]

4 **(a)** Complete the definition of the term *ecosystem*.

An ecosystem is defined as a unit containing all of the

..... and their environment, ...

together, in a given area. [2]

(b) Fig. 4.1 is part of a food web.

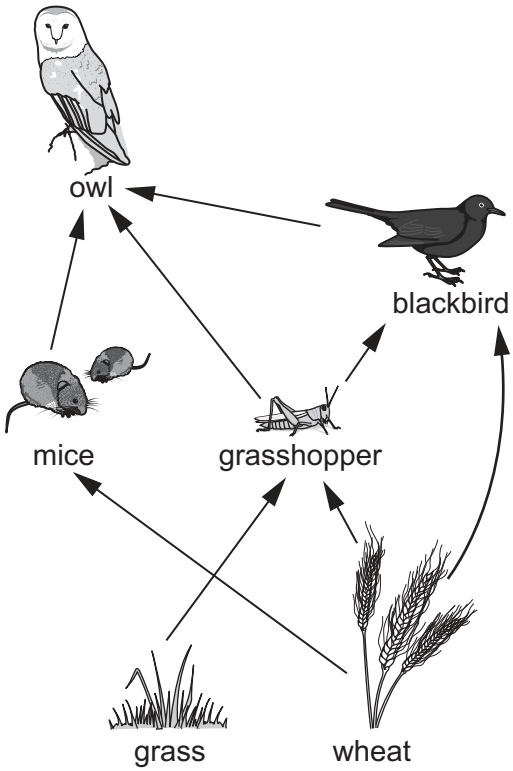


Fig. 4.1

Use Fig. 4.1 to answer the following questions.

(i) State the number of trophic levels in this food web.

..... [1]

(ii) Name the general term given to the type of organisms that occupy the first trophic level.

..... [1]

(iii) Name the organism that feeds at the 2nd and 3rd trophic level.

..... [1]

(iv) Explain why there are fewer numbers of organisms in the 3rd trophic level than in the 2nd trophic level.

.....

.....

.....

.....

.....

..... [3]

(c) Wheat is a type of crop plant.

The statements outline how artificial selection is used to improve yield of crop plants such as wheat. The yield is the amount of wheat crop produced in a given area.

They are **not** in the correct order.

Write numbers next to the statements to show the correct order.

The first one has been done for you.

This process is repeated over many generations.	
The offspring are observed and those that produce the highest yield are chosen and bred again.	
Eventually the entire population of wheat plants will produce high yields.	
Wheat plants are observed to see which produce the highest yield.	**1**
These wheat plants are crossed to produce offspring.	

[1]

(d) State **two** ways that artificial selection is different from natural selection.

1 .....

2 ..... [2]

[Total: 11]

5 Iron is a transition metal.

(a) State **two** properties of transition metals that are **not** properties of all metals.

1. .....

2. ..... [2]

(b) Iron is extracted from iron(III) oxide, Fe_2O_3, in an industrial process.

Two of the stages in the process are:

1 $C + CO_2 \rightarrow 2CO$

2 $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(i) Suggest **one** hazard associated with stage **1**.

..... [1]

(ii) In stage **2**, iron(III) ions are reduced to iron atoms.

Explain, in terms of electrons, why this is a **reduction** reaction.

.....

..... [1]

(iii) Complete and balance the half equation for the reaction in **5(b)(ii)**.

..... + ... → Fe

[2]

(iv) In stage **2**, 32 kg of iron(III) oxide, Fe_2O_3, is added to 17.5 kg of carbon monoxide, CO.

The balanced symbol equation is shown.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Calculate the moles of iron(III) oxide and the number of moles of carbon monoxide.

Use your answers to explain why iron(III) oxide is the **limiting reactant**.

Show your working.

[A_r: C, 12; Fe, 56; O, 16]

moles of iron(III) oxide = ...

moles of carbon monoxide = ...

Iron(III) oxide is the limiting reactant because .....

.....

..... [4]

[Total: 10]

6 Different energy sources can be used to generate electricity.

(a) Draw a circle around each energy source which is non-renewable.

coal **hydroelectric** **natural gas** **solar** **tidal** **wind**

[2]

(b) Fig. 6.1 shows a diagram of a geothermal power station.
Cold water is heated by hot rocks to produce steam which drives a turbine that turns a generator.

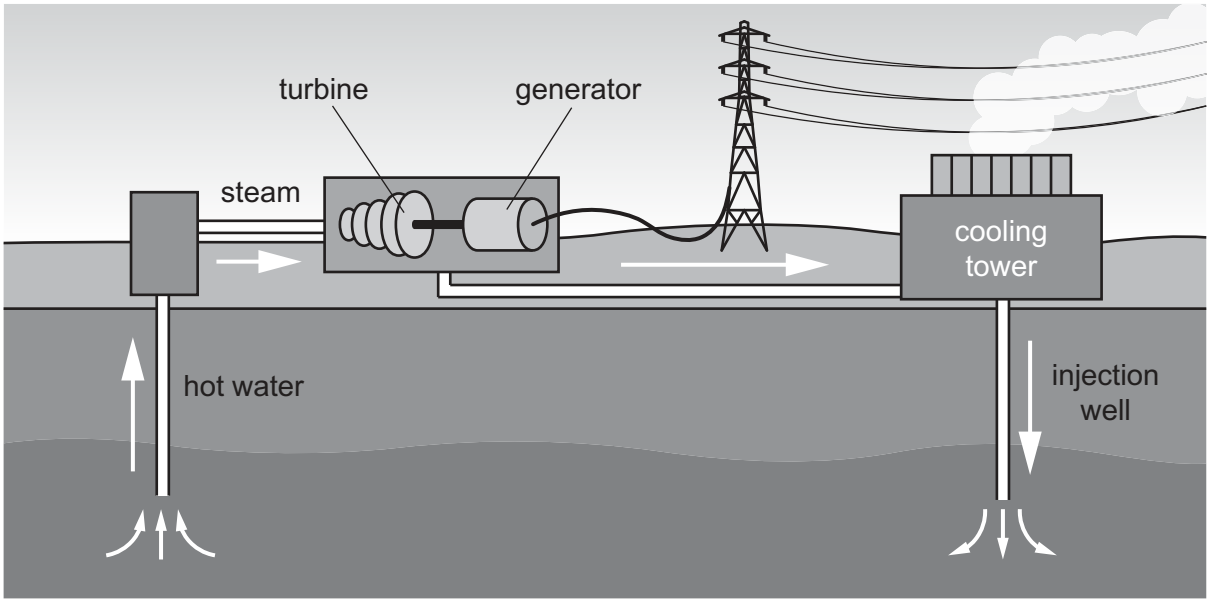


Fig. 6.1

The geothermal power station can generate 0.72 kJ of electrical energy from 6.0 kJ of thermal energy.

(i) Calculate the efficiency of the geothermal power station.

efficiency = ... % [2]

(ii) Suggest an environmental advantage of using geothermal energy instead of coal to generate electricity.

.....

..... [1]

(c) The powerstation uses a large a.c. generator.
Fig. 6.2 shows a simple a.c. generator.

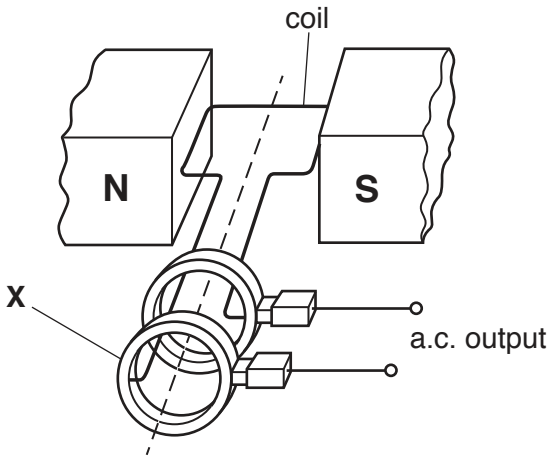


Fig. 6.2

(i) Define the term *electromotive force (e.m.f.)*.

.....

..... [1]

(ii) Describe how turning the coil produces an a.c. output from the coil.

.....

.....

.....

..... [2]

(iii) Name the component labelled **X** in Fig. 6.2.
Describe **two** functions of component **X** in this generator.

component name .....

1. .....

.....

2. .....

.....
[3]

[Total: 11]

7 **(a)** Fig. 7.1 is a drawing of a sperm cell.

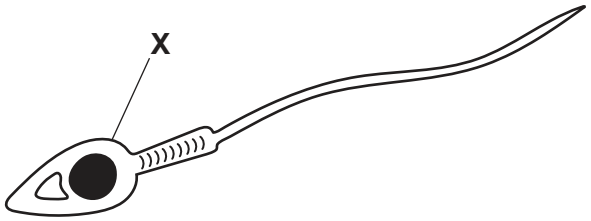


Fig. 7.1

(i) Identify the part labelled **X** in Fig. 7.1.

..... [1]

(ii) Table 7.1 compares some of the features of sperm and egg cells.
Complete Table 7.1.

Table 7.1

feature	sperm cell	egg cell
relative size		
motility		
relative number released		

[3]

(iii) State **one** adaptive feature of egg cells.

..... [1]

(b) The box on the left contains the beginning of a sentence about human sperm nuclei.

The boxes on the right contain some sentence endings.

Draw **three** lines from the box on the left to **three** boxes on the right to make three correct sentences.

Sperm nuclei	are diploid.
	are haploid.
	are produced by mitosis.
	contain unpaired chromosomes.
	contain 23 chromosomes.
	contain 2 sets of chromosomes.
	contain 23 pairs of chromosomes.

[3]

(c) State the name of the cell produced when fertilisation occurs.

..... [1]

[Total: 9]

8 **(a)** Propene is an alkene.

Put a tick (✓) in the box next to the statement which describes alkenes.

Alkenes are saturated polymers.	☐
Alkenes are saturated hydrocarbons.	☐
Alkenes are unsaturated polymers.	☐
Alkenes are unsaturated hydrocarbons.	☐

[1]

(b) Propane is an alkane.

Propane and propene are both gases.

Describe a test to show which gas is propane.

test .....

result with propane .....

result with propene .....

[3]

(c) Propene is used to make poly(propene).

Draw the **bonds** to complete the structures of propene and poly(propene) in Fig. 8.1.

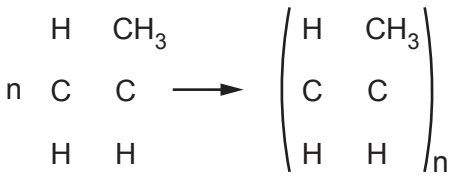


Fig. 8.1

[3]

(d) Poly(propene) is made by **addition** polymerisation.

Nylon is made by condensation polymerisation.

Describe **two** differences between addition and condensation polymerisation.

1. .....

.....

2. .....

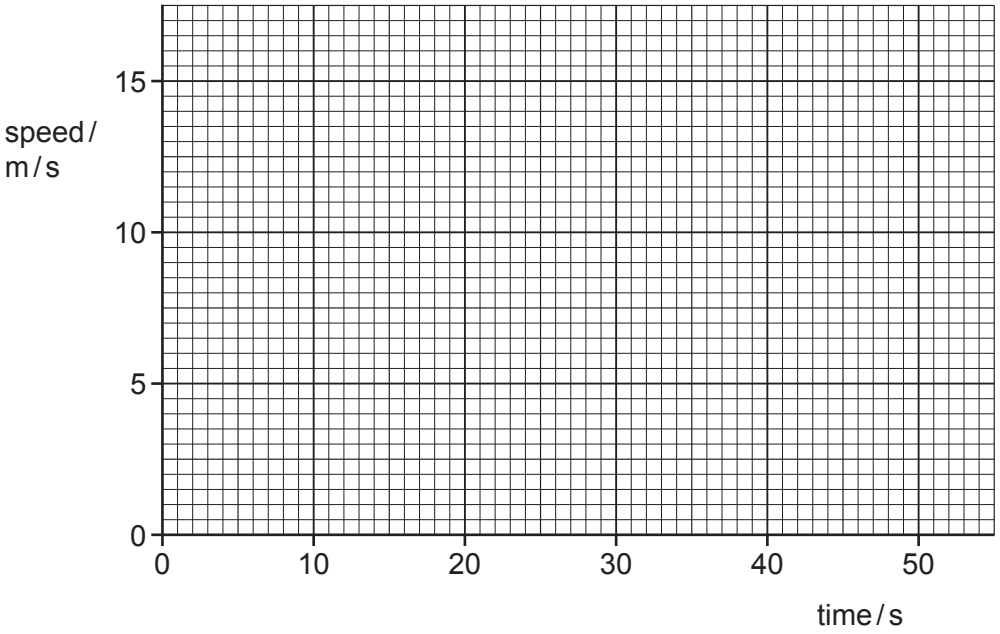
.....

[2]

[Total: 9]

9 **(a)** A car travels at 12 m/s for 15 seconds. The driver applies the brakes which brings the car to rest after 25 seconds of braking. The deceleration is constant.

(i) On the grid, draw a speed/time graph for this car's journey.



[2]

Fig. 9.1

(ii) Show that the deceleration of the car during the braking period is 0.48 m/s^2.

[1]

(iii) The mass of the car is 1200 kg.
Calculate the size of the braking force.

force = ... N [2]

(iv) The braking distance of the car is 150 m.
Using your answer from **9(a)(iii)** calculate the work done by the brakes.

work done = ... J [2]

(b) Describe the main energy transfer that happens when the car brakes.

from ..... energy to ..... energy

[2]

[Total: 9]

10 (a) An athlete monitors their pulse rate at rest and during exercise.

Fig. 10.1 shows the results.

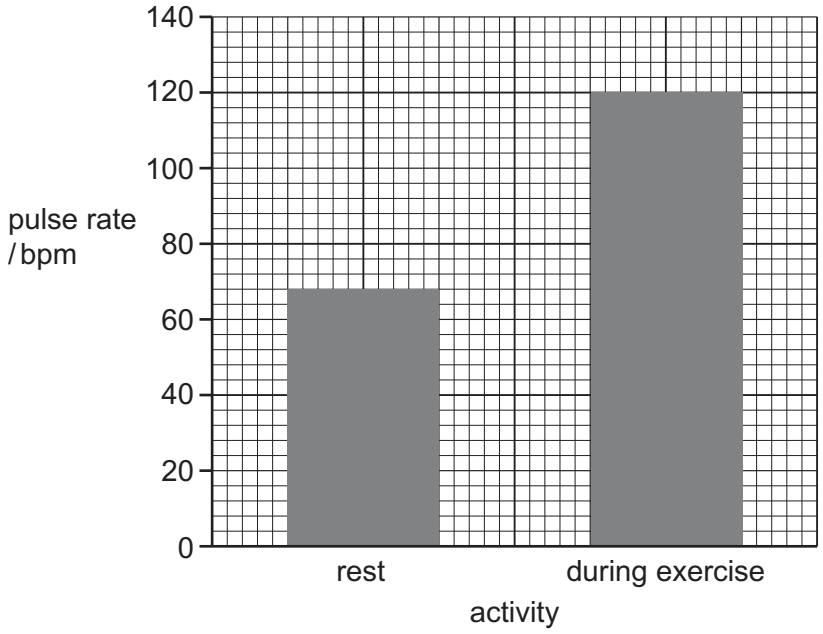


Fig. 10.1

(i) Explain the results shown in Fig. 10.1.

.....

.....

.....

.....

.....

..... [3]

(ii) Describe the action of the different parts of the heart that make the heart pump blood.

.....

.....

..... [2]

(iii) State the name of the structures in the heart that ensure the blood only flows one way.

..... [1]

(b) Fig. 10.2 shows a blood vessel.

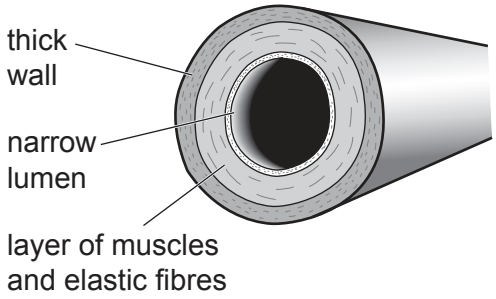


Fig. 10.2

(i) State the name of the type of blood vessel shown in Fig. 10.2.

..... [1]

(ii) Explain how each of the features adapt the blood vessel for its function.

thick wall .....

.....

narrow lumen .....

.....
[2]

[Total: 9]

11 A student investigates the reaction between zinc, Zn, and dilute hydrochloric acid, HC*l*.

Zinc chloride, ZnCl_2, and hydrogen gas are made.

(a) Write the balanced symbol equation for this reaction.

..... [2]

(b) The student does the experiment three times.
The student uses dilute hydrochloric acid with the **same concentration** each time.

Fig. 11.1 shows the student's results.

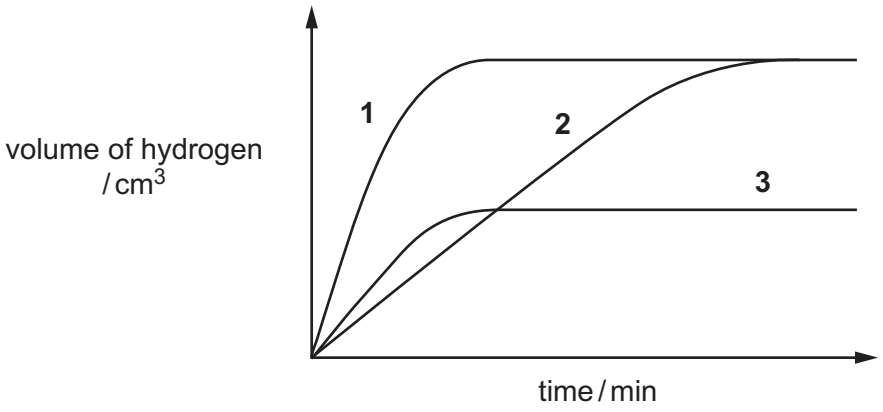


Fig. 11.1

(i) State which reaction took the **longest** to finish.
Choose from experiments **1**, **2** or **3**.

..... [1]

(ii) In all three experiments the student keeps the **same**:
- volume of dilute hydrochloric acid
- concentration of dilute hydrochloric acid
- size pieces of zinc.

State **one** variable that could have been changed from experiment **1** to produce the results in experiment **2**.

Explain your answer.

variable changed.....

explanation.....

.....

.....
[3]

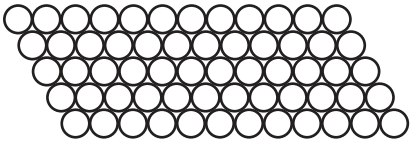
(iii) The student uses 1 g of zinc in experiment **1**.
Suggest the mass of zinc used in experiment **3**.

mass of zinc = ... g [1]

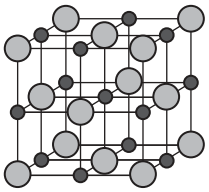
(c) Brass is an **alloy** made when zinc is mixed with copper.
State which diagram shows the structure of brass.

Choose from **A**, **B**, **C** or **D**.

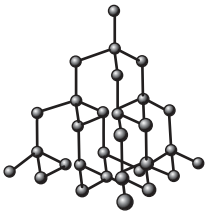
A



B



C



D

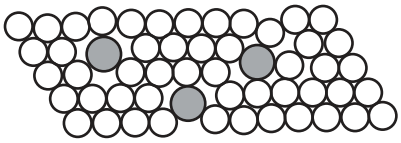


diagram ..... [1]

(d) Copper metal is a good conductor of electricity.

Explain why copper is a good conductor of electricity.

.....

.....

..... [2]

[Total: 10]

12 (a) Fig. 12.1 shows a sealed glass jar filled with pure oxygen gas. Each oxygen molecule has a mass of 5.34×10^{-26} kg.

Fig. 12.1

(i) Describe how the motion of the oxygen molecules causes pressure inside the glass jar.

.....

.....

.....

..... [2]

(ii) The average kinetic energy of a molecule of oxygen is 2.67×10^{-22} J.
Calculate the average speed of a molecule of oxygen.

average speed = ... m/s [2]

(b) Fig. 12.2 shows a sample of gas in a sealed container attached to a pressure gauge.

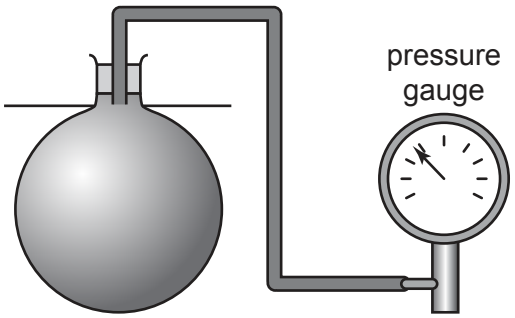


Fig. 12.2

The temperature of the gas is increased and the pressure is measured. Fig. 12.3 shows how the pressure changes with temperature.

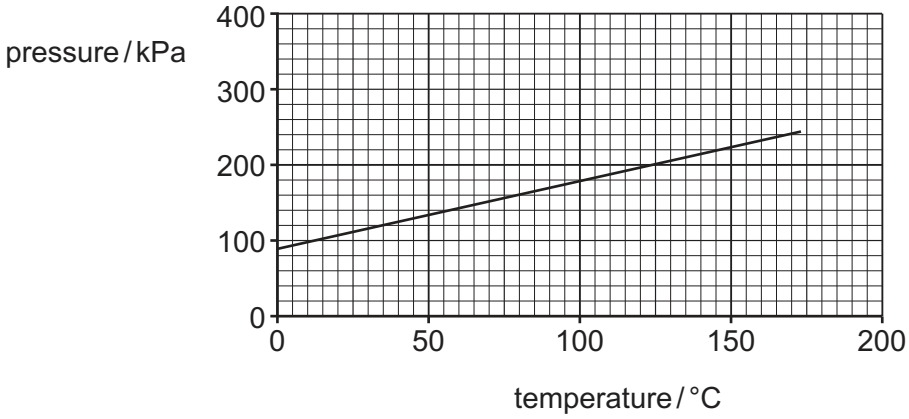


Fig. 12.3

(i) Describe the results shown in Fig. 12.3.

.....

.....

.....

..... [2]

(ii) A student suggests repeating the experiment with a non-flammable balloon filled with gas rather than a sealed container.
Explain why this method would **not** produce the graph shown in Fig. 12.3.

.....

..... [1]

[Total: 7]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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.).