Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9649395153

CO-ORDINATED SCIENCES **0654/41**

Paper 4 (Extended) **October/November 2017**

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 an HB 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 32.

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 **32** printed pages.

DC (NF/JG) 139492/3

CAMBRIDGE
International Examinations

1 Fig. 1.1 shows a diagram of the male reproductive system.

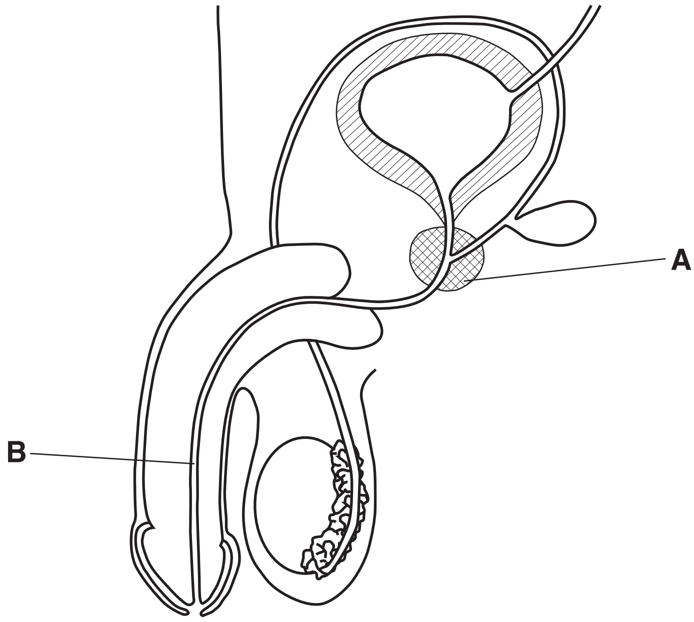

Fig. 1.1

(a) **(i)** Name the parts labelled **A** and **B** in Fig. 1.1.

A ....

B ....
[2]

(ii) Draw an **X** on Fig. 1.1 to show where sperm are made. [1]

(b) Meiosis is the process that produces gametes. A sperm is the male sex gamete.

(i) Define the term *meiosis*.

....

....

.... [2]

(ii) Describe **two** differences between a male gamete and a female gamete in humans.

1 ....

....

2 ....

....
[2]

(iii) Name the term used to describe the fusion of the male gamete and female gamete.

.... [1]

2 Fig. 2.1 shows part of the Periodic Table.

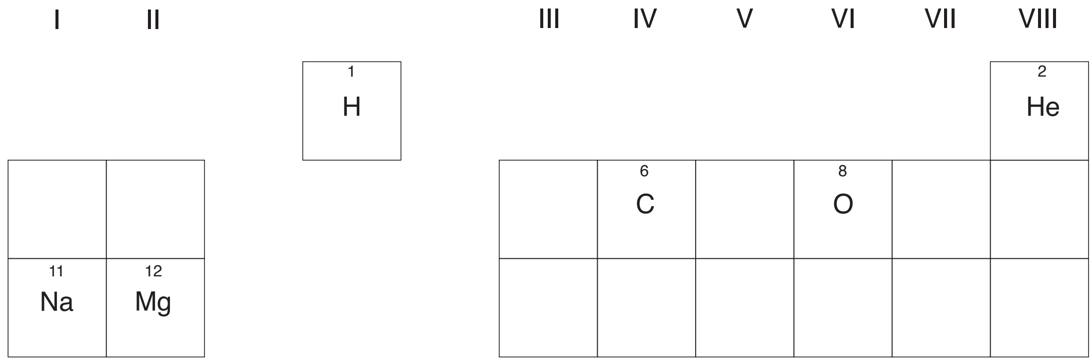

Fig. 2.1

(a) State the number of elements in the first period of the Periodic Table.

.... [1]

(b) The atomic number of magnesium is 12.

(i) Define the term *atomic (proton) number*.

....

....

.... [2]

(ii) A sodium atom is 23 times heavier than a hydrogen atom.

Explain this statement in terms of atomic structure.

....

....

.... [2]

(c) The electronic structure of a carbon atom is 2,4.

State the electronic structure of a magnesium atom.

.... [1]

(d) Sodium is produced industrially using electrolysis.

Fig. 2.2 shows a diagram of the process.

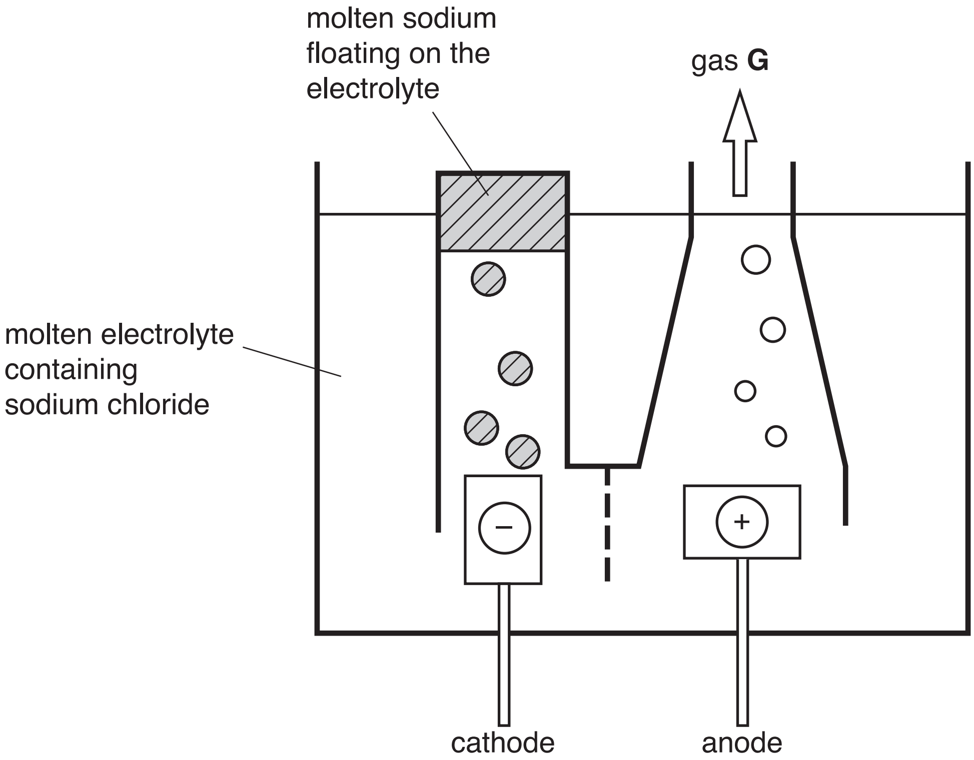

Fig. 2.2

State the name and chemical formula of gas **G**.

name ....

chemical formula ....

[2]

3 **(a)** Five different types of power station are listed.

A hydroelectric
B gas-fired
C nuclear
D oil-fired
E tidal

(i) State the letters of the **three** types of power station that use a boiler to turn water into steam.

.... [1]

(ii) State the letters of the **two** types of power station that use renewable energy sources.

.... [1]

(b) Overhead power transmission cables supply electrical energy to a town.

Energy losses in the transmission cables can be reduced if the voltage for transmission is increased.

(i) Name the device that steps up the voltage of the electricity before transmission.

.... [1]

(ii) It is suggested that less energy is lost during transmission if the resistance of the cable is changed.

The resistance of the cable is initially $8.0\,\Omega$.

It is suggested that the diameter of the cable should be doubled.

Use the relationship

- resistance is inversely proportional to $(\text{diameter})^2$

to calculate the resistance of a similar cable that has twice the diameter.

resistance = ... Ω [2]

(c) **(i)** In a nuclear power station, nuclear fission of uranium-235 atoms takes place.

Describe what happens to the atoms of uranium-235 during nuclear fission.

....

.... [1]

(ii) Another isotope of uranium, uranium-234, decays by alpha (α) emission to produce an isotope of thorium.

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

$$^{234}_{92}U \longrightarrow \,^{......}_{......}Th + \,^{......}_{......}He$$ [3]

4 Fig. 4.1 shows the atmospheric carbon dioxide concentration measured in Hawaii from 1958 to 2005.

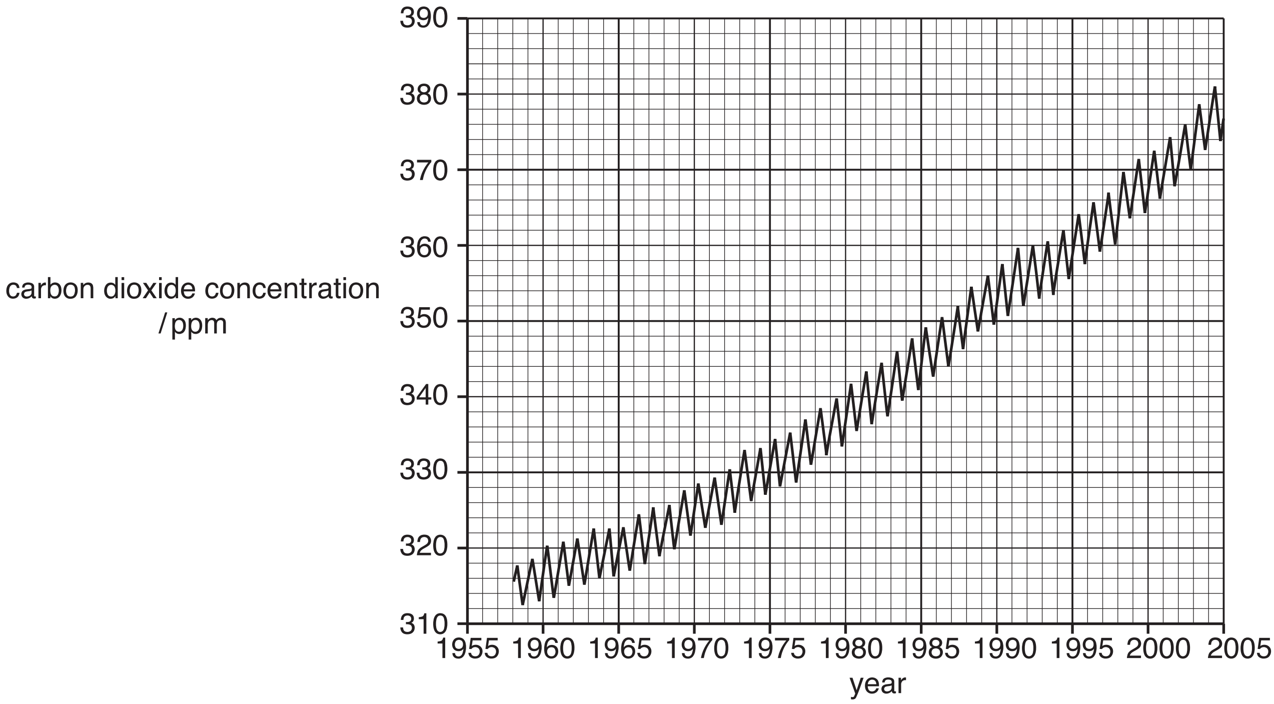

Fig. 4.1

(a) Carbon dioxide emissions have increased between 1958 and 2005.

Suggest **one** reason for the regular fluctuations of carbon dioxide emissions shown in Fig. 4.1.

....

.... [1]

(b) Carbon dioxide is a greenhouse gas.

Name **one other** greenhouse gas.

.... [1]

(c) **(i)** Explain how an increase in carbon dioxide concentration leads to global warming.

....

....

....

....

.... [3]

(ii) Describe **two** effects of global warming on the environment.

1 ....

....

2 ....

....
[2]

(iii) Suggest **two** ways governments could encourage industries to reduce carbon dioxide emissions.

1 ....

....

2 ....

....
[2]

5 **(a)** **(i)** State the percentage of nitrogen in clean air.

.............................% [1]

(ii) Name **two other** uncombined gaseous elements in clean air.

.... and .... [1]

(b) Air bags protect passengers if a car is involved in a collision.

When a collision occurs, sodium azide, NaN_3, decomposes releasing nitrogen gas to inflate the air bag.

Fig. 5.1 shows an air bag protecting a passenger.

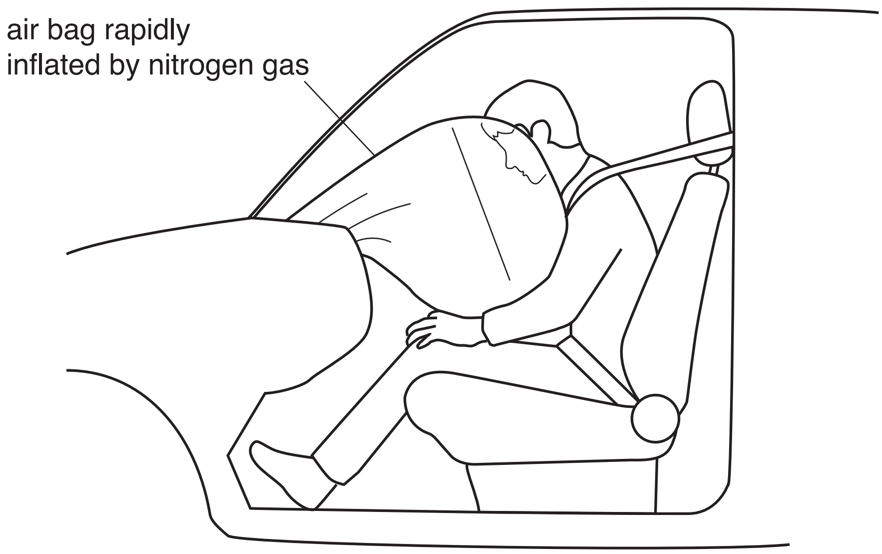

Fig. 5.1

(i) Sodium azide, NaN_3, is an ionic compound.

Sodium ions have the formula Na^+.

Deduce

the charge of an azide ion, ...

the formula of an azide ion ....

[2]

(ii) The balanced equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

Complete the steps in the calculation to find the volume of nitrogen gas that is released when 130 g of sodium azide decomposes completely.

Show your working.

Step 1
Calculate the relative formula mass of sodium azide.
[A_r: Na = 23, N = 14]

relative formula mass = ...

Step 2
Calculate the number of moles in 130 g of sodium azide.

number of moles = ...

Step 3
Deduce the number of moles of nitrogen gas released by 130 g of sodium azide.

number of moles = ...

Step 4
Calculate the volume of nitrogen gas released.
[molar gas volume = 24 dm^3]

volume of nitrogen gas = ... dm^3
[4]

(c) In industry, nitrogen is used in the Haber process to make ammonia.

(i) Describe how nitrogen for the Haber process is obtained from air.

....

....

.... [2]

(ii) State the **word** equation for the reaction that forms ammonia in the Haber process.

.... [1]

[Turn over

6 **(a)** A house has an electric doorbell.

(i) Draw a circuit diagram to show a doorbell connected in series with a switch and a battery.

Use the circuit symbol, , for an electric bell.

[2]

(ii) The bell produces a sound when a metal hammer strikes it.

Describe how this action produces a sound.

....

.... [1]

(b) The house has a heater filled with water at 20 °C.

Fig. 6.1 shows the heater.

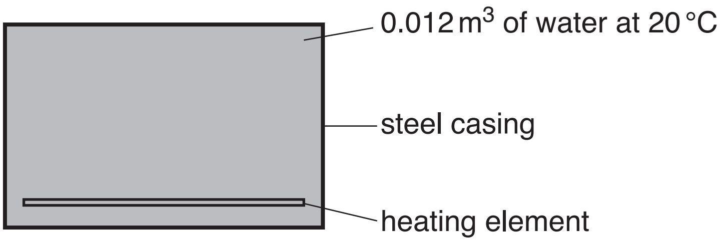

Fig. 6.1

The heating element supplies 2 000 000 J of energy to the 0.012 m^3 of water.

The density of water at 20 °C is 1000 kg / m^3.

The specific heat capacity of water is 4200 J / (kg °C).

(i) Show that the **maximum** temperature that the water will reach is approximately 60 °C.

State any formula you use and show your working.

formula

working

[4]

(ii) Suggest why the water will **not** reach the temperature you calculated in **(b)(i)**.

....

.... [1]

7 **(a)** **(i)** Describe how water is lost from a leaf.

....

....

.... [2]

(ii) Explain how the water lost from leaves causes water to move up the plant.

....

....

....

....

.... [3]

(b) A student does an investigation on water loss in leaves.

- The student removes four similar-sized leaves, **A**, **B**, **C** and **D**, from a plant and covers different surfaces of three of these leaves with petroleum jelly, a waterproof substance.
- The mass of each leaf is measured and the leaves are left in the same place.
- The mass of each leaf is measured again after 5 days.

The mass lost from the leaves is an indication of the water loss.

Table 7.1 shows the student's results.

Table 7.1

leaf	petroleum treatment	mass at start / g	mass at end / g	difference in mass / g
A	no covering	4.1	3.3	....
B	upper surface covered only	4.1	3.5	0.6
C	lower surface covered only	4.5	4.2	0.3
D	both surfaces covered	4.2	4.2	0.0

(i) Complete Table 7.1 by calculating the mass of water lost in leaf **A**. [1]

(ii) Suggest why a smaller mass of water is lost in leaf **C** than in leaf **B**.

....

.... [1]

(iii) The same investigation is done at a higher temperature.

Predict how this would affect the results.

....

....

.... [2]

8 Fig. 8.1 shows apparatus a student uses to collect the gas that is made when a solid reacts with a liquid.

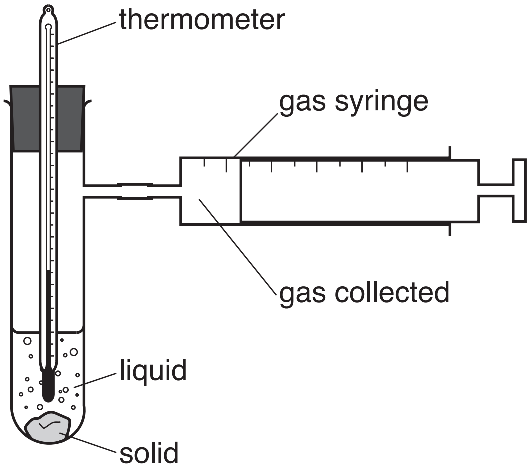

Fig. 8.1

Table 8.1 shows information about five experiments, **P**, **Q**, **R**, **S** and **T**, the student does.

The temperature of the contents of the test-tube at the start of each experiment is 20 °C.

Table 8.1

experiment	liquid	solid	temperature / °C		gas made
			at start	after 2 mins	
P	dilute hydrochloric acid	sodium hydrogencarbonate	20	17	carbon dioxide
Q	dilute hydrochloric acid	magnesium	20	29	
R	dilute sulfuric acid	copper	20	20	
S	water	calcium	20	32	
T	dilute hydrochloric acid	calcium carbonate	20	22	

(a) **(i)** Complete Table 8.1 to show the gas made, if any, in experiments **Q**, **R**, **S** and **T**.

If no gas is made, state *none*. [3]

(ii) Describe the pH changes, if any, in experiment **R** and in experiment **S**.

Explain your answers.

pH change in **R** ....

explanation ....

....

pH change in **S** ....

explanation ....

....
[2]

(iii) Using Table 8.1, deduce the change in the kinetic energy of the particles in experiment **P** during the reaction.

Explain your answer.

change ....

explanation ....

....
[1]

(b) The student repeats experiment **T** several times, changing the concentration of the dilute hydrochloric acid each time.

She keeps all of the other variables the same.

Her results are shown as a sketch graph in Fig. 8.2.

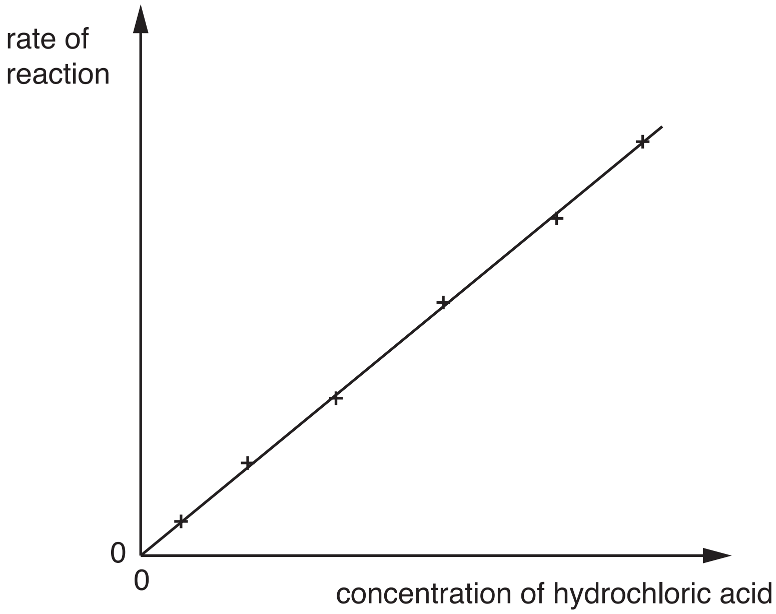

Fig. 8.2

(i) Describe the relationship between the concentration of the hydrochloric acid and the rate of the reaction.

....

....

.... [2]

(ii) Explain the results shown in Fig. 8.2 in terms of collisions involving particles of acid.

....

....

....

.... [2]

Please turn over for Question 9.

9 Fig. 9.1 shows a snowboarder moving down a ski slope.

Fig. 9.1

(a) Fig. 9.2 shows a speed-time graph for the snowboarder.

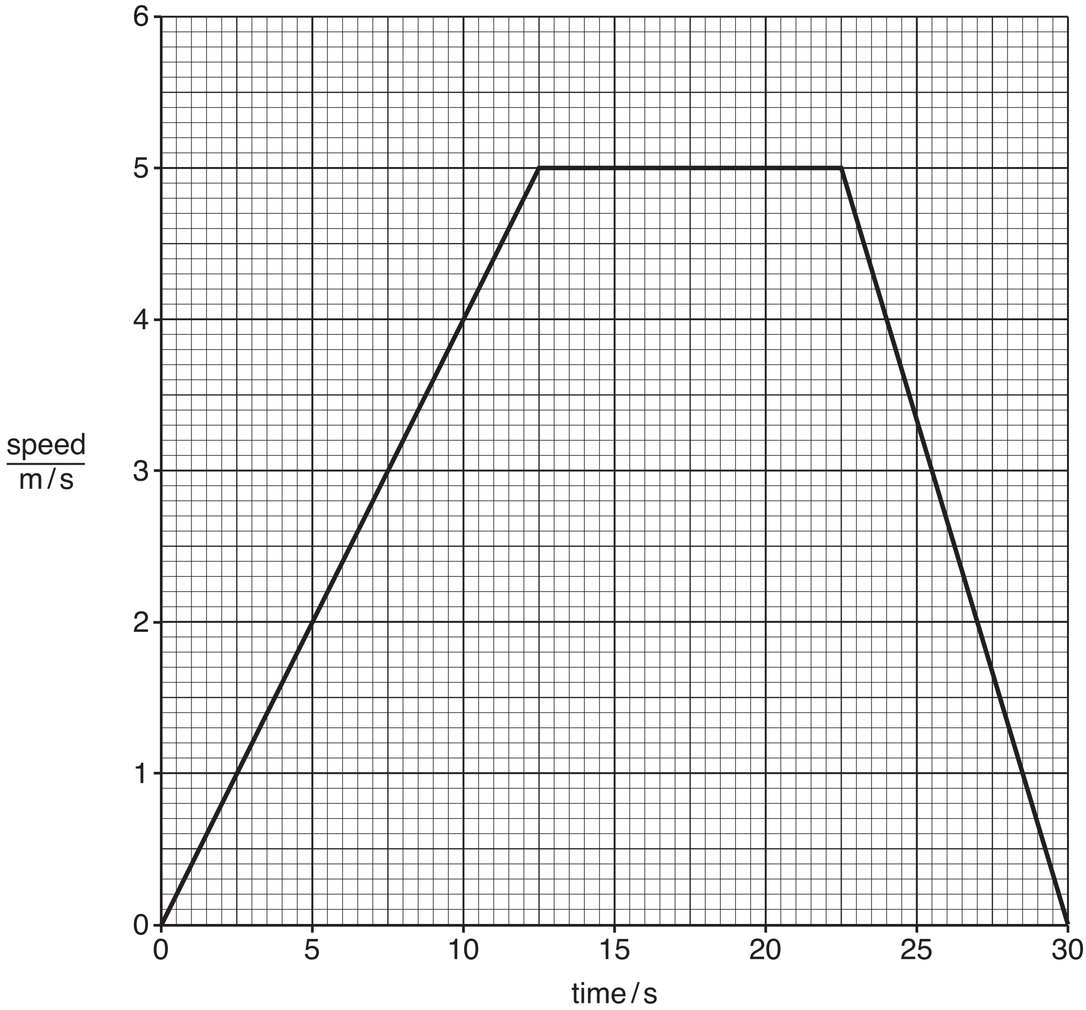

Fig. 9.2

The mass of the snowboarder is 75 kg.

(i) Calculate the maximum kinetic energy of the snowboarder.

State the formula you use and show your working.

formula

working

kinetic energy = ... J [3]

(ii) Calculate the acceleration of the snowboarder in the first 10 seconds.

Show your working. State the unit of your answer.

acceleration = ... unit .... [3]

(iii) Calculate the force required to produce the acceleration of the snowboarder you calculated in **(a)(ii)**.

State the formula you use and show your working.

formula

working

force = ... N [2]

(b) The snowboarder is exposed to infra-red and ultraviolet radiation from the Sun.

Infra-red and ultraviolet radiation are both parts of the electromagnetic spectrum.

(i) Place the radiations infra-red and ultraviolet in their correct positions in the incomplete electromagnetic spectrum in Fig. 9.3.

γ-rays			visible light			radio waves

Fig. 9.3

[1]

(ii) State the speed at which ultraviolet waves travel from the Sun to the Earth in km/s.

Give a reason for your answer.

speed .... km/s

reason ....

.... [2]

(c) Some snow is steadily heated in a beaker.

The temperature of the snow is measured as it is heated.

Fig. 9.4 shows a graph of the results.

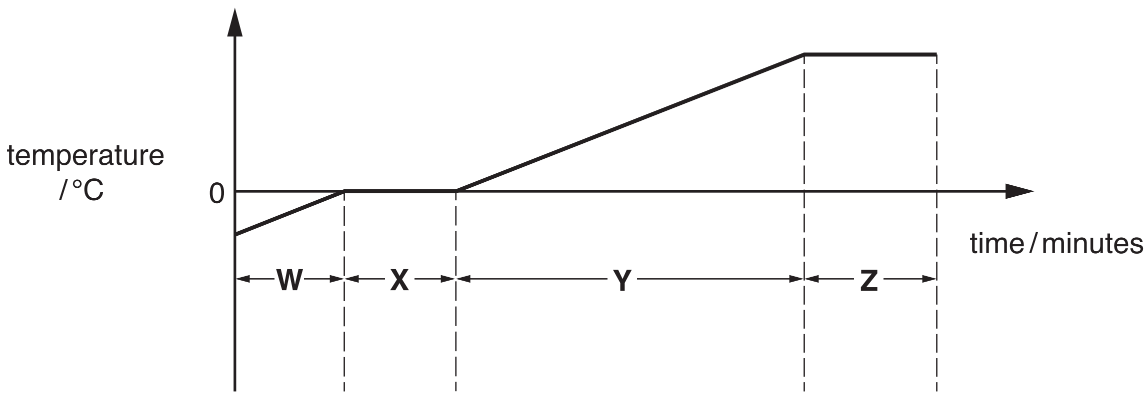

Fig. 9.4

Explain why the temperature of the snow does not increase in section **X**. Use the term *latent heat of fusion* in your answer.

....

....

....

.... [2]

10 Fig. 10.1 is a graph to show the blood glucose concentration of a person's blood measured every hour over a period of 15 hours.

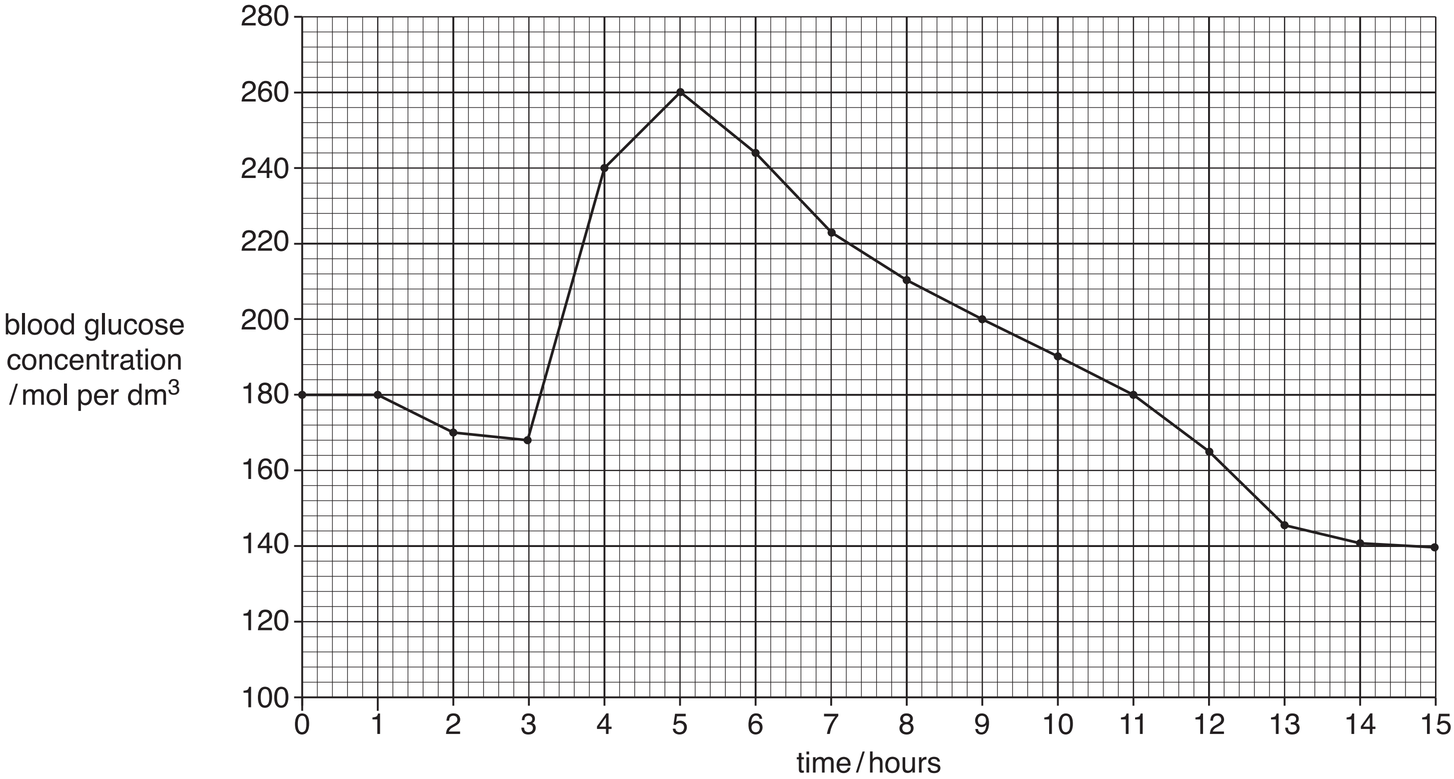

Fig. 10.1

(a) **(i)** Suggest a reason for the change in the blood glucose concentration immediately after 3 hours.

.... [1]

(ii) State how many hours it takes for the blood glucose concentration to return to its starting concentration after its peak at 260 mol per dm^3.

.... hours [1]

(iii) Explain why the blood glucose concentration decreases after its peak at 5 hours.

....

....

.... [2]

(b) Suggest **one** situation when the blood glucose concentration falls dramatically below normal.

....

.... [1]

(c) **(i)** Control of blood glucose concentration is an example of negative feedback.

Explain the term *negative feedback*.

....

....

.... [2]

(ii) Name **one other** example of negative feedback in the human body.

.... [1]

Please turn over for Question 11.

11 Petroleum is a liquid fossil fuel that is a mixture containing many different hydrocarbons.

Petroleum is extracted from the Earth and is then processed into useful products.

(a) Suggest why petroleum is described as a *fossil* fuel, but wood is not a *fossil* fuel.

....

.... [1]

(b) Fractional distillation is used to separate petroleum into simpler, more useful mixtures called fractions.

Fig. 11.1 shows this process and two of the useful fractions obtained.

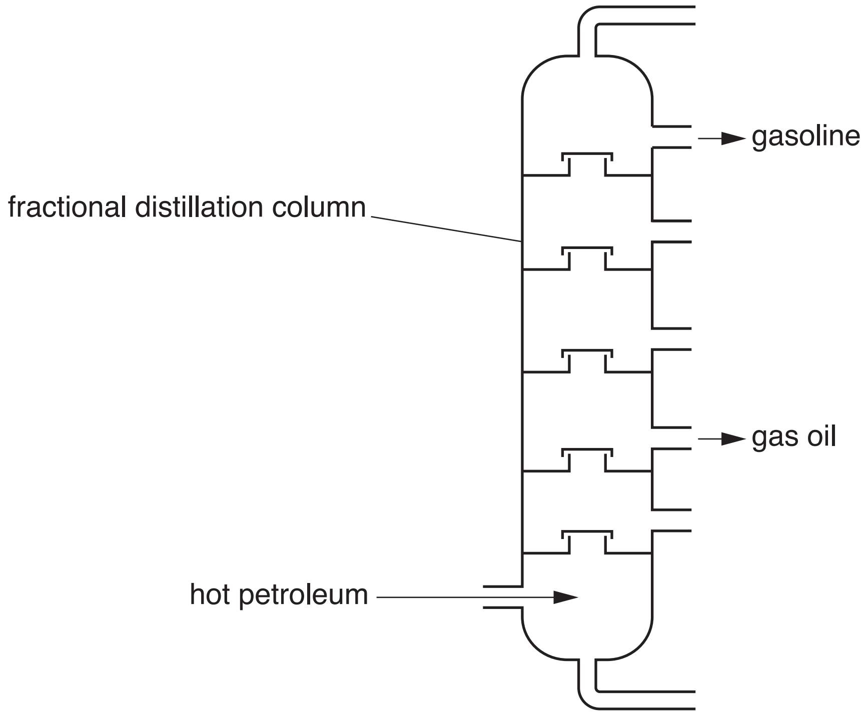

Fig. 11.1

(i) State the **two** physical changes involved in forming each fraction.

.... followed by .... [1]

(ii) The gasoline fraction has a lower average boiling point than gas oil.

Explain this in terms of molecular sizes and intermolecular forces.

....

....

....

.... [3]

(c) Cracking breaks down large, saturated hydrocarbon molecules into smaller ones. This process also produces some unsaturated hydrocarbons.

The equation shows a chemical reaction that occurs during cracking.

$$C_{16}H_{34} \longrightarrow C_xH_y + 3C_2H_4 + C_3H_6$$

Determine the values of x and y.

x = ...

y = ...

[1]

(d) **(i)** Compound **W** has the formula C_3H_6.

State the name of compound **W**.

.... [1]

(ii) Compound **W** is added to aqueous bromine and shaken.

Describe the changes observed, if any.

Explain your answer.

change ....

explanation ....

....

[2]

(iii) Compound **W** reacts with hydrogen gas, H_2, in an addition reaction to produce compound **X**.

Deduce the formula of compound **X** and complete the diagram in Fig. 11.2 of a molecule of **X**.

formula ....

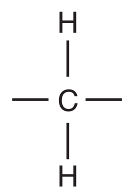

Fig. 11.2

[2]

12 **(a)** Fig. 12.1 shows two forces acting on a swimmer as he swims in a swimming pool.

Fig. 12.1

(i) State the size **and** direction of the resultant force.

size ....

direction ....
[2]

(ii) State how the speed of the swimmer is changing.

Explain your answer.

....

....

.... [2]

(b) The swimmer starts a race when he hears the starting sound from a loudspeaker.

(i) The sound waves travel through the air.

Fig. 12.2 represents a sound wave travelling through the air.

The sound wave travels by a series of compressions **(C)** and rarefactions **(R)**.

Fig. 12.2

Use Fig. 12.2 to describe **one** difference between a region of compression and a region of rarefaction.

....

....

.... [1]

(ii) Water waves are transverse waves. Sound waves are longitudinal waves.

Describe the difference between a transverse wave and a longitudinal wave.

You may draw a labelled diagram if it helps your answer.

....

....

....

.... [2]

(c) There are submerged lamps in the pool. Fig. 12.3 shows two light rays from one of these lamps.

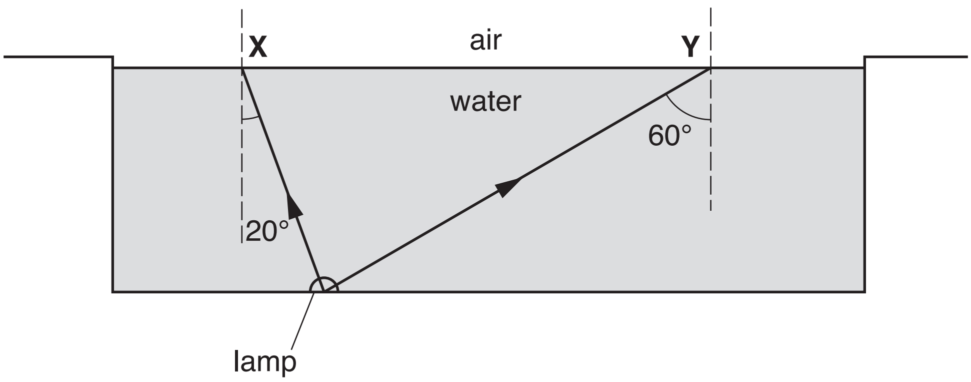

Fig. 12.3

The critical angle for the boundary between water and air is 48°.

On Fig. 12.3, complete the paths of the two rays after they reach the surface at **X** and **Y**. Explain your answer.

....

....

.... [3]

13 Yeast is used in the brewing industry to make beer. The yeast for this process is grown in fermenters. Fig. 13.1 shows a diagram of a fermenter.

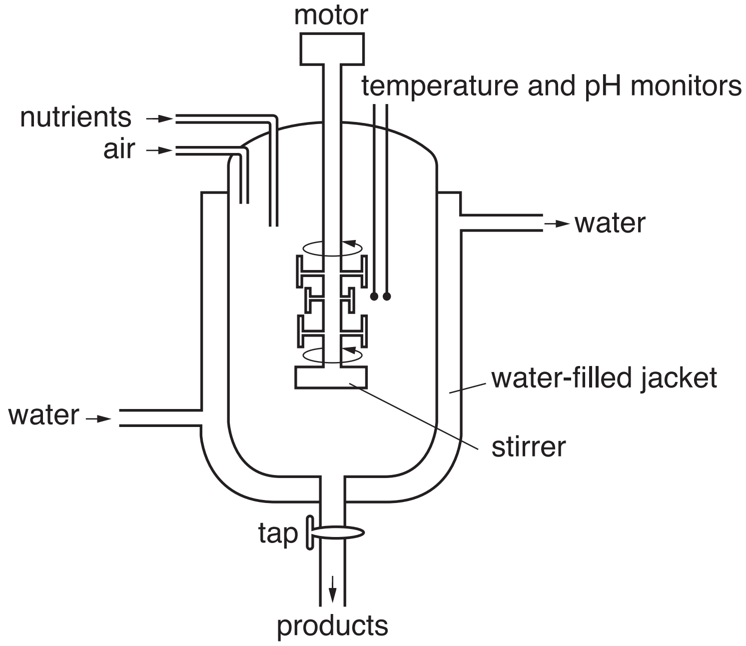

Fig. 13.1

(a) **(i)** Suggest **and** explain why the fermenter is surrounded by a water-filled jacket.

....

....

.... [2]

(ii) Suggest why the contents of the fermenter are stirred.

....

.... [1]

(b) Anaerobic respiration of yeast is used to make beer in a separate fermenter.

(i) State the **word** equation for anaerobic respiration in yeast.

.... [1]

(ii) State **one** difference between anaerobic respiration in yeast and anaerobic respiration in animals.

....

.... [1]

(c) State **one other** use of anaerobic respiration in yeast.

.... [1]

The Periodic Table of Elements

Key: atomic number / atomic symbol / name / relative atomic mass

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 –		

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.).