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0653/31

October/November 2018

**1 hour 15 minutes**

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 20.

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 **18** printed pages and **2** blank pages.

- 1 (a) The list shows some processes that occur in living organisms.

breathing      digestion      excretion      growth      movement  
 reproduction      sensitivity

State **two** processes shown in the list which are **not** characteristics of all living things.

1. ....

2. ....

[2]

- (b) Fig. 1.1 shows a palisade cell which is found in the leaf of a plant.

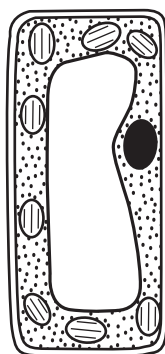


Fig. 1.1

- (i) On Fig. 1.1 use a label line and the correct name to show **one** structure that is present in **all** plant cells but is absent from animal cells. [2]

- (ii) Describe the pathway taken by water in the plant, from the soil to the palisade cells.

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

(c) Fig. 1.2 shows a plant growing in front of a large rock.



**Fig. 1.2**

- (i) The leaves of the plant in Fig. 1.2 turn towards the light.

Name the plant's response to light.

.....[1]

- (ii) The leaves of the plant in Fig. 1.2 are separated from each other as much as possible and do not overlap.

Suggest **and** explain why this is an advantage for the plant.

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

- 2 (a) Complete the following sentences using words from the list.

Each word may be used once, more than once or not at all.

atoms            compounds            covalent            elements  
ionic            ions            mixtures            molecules

- (i) The smallest parts of an element are ..... [1]
- (ii) All ..... contain atoms joined by sharing pairs of electrons  
in ..... bonds. [2]
- (iii) Atoms which lose or gain electrons form particles called  
..... [1]
- (iv) Elements in ..... cannot be separated by simple physical  
processes.  
Substances in ..... can be separated by simple physical  
processes. [2]
- (b) A student passes an electric current through aqueous copper chloride using the apparatus shown in Fig. 2.1.

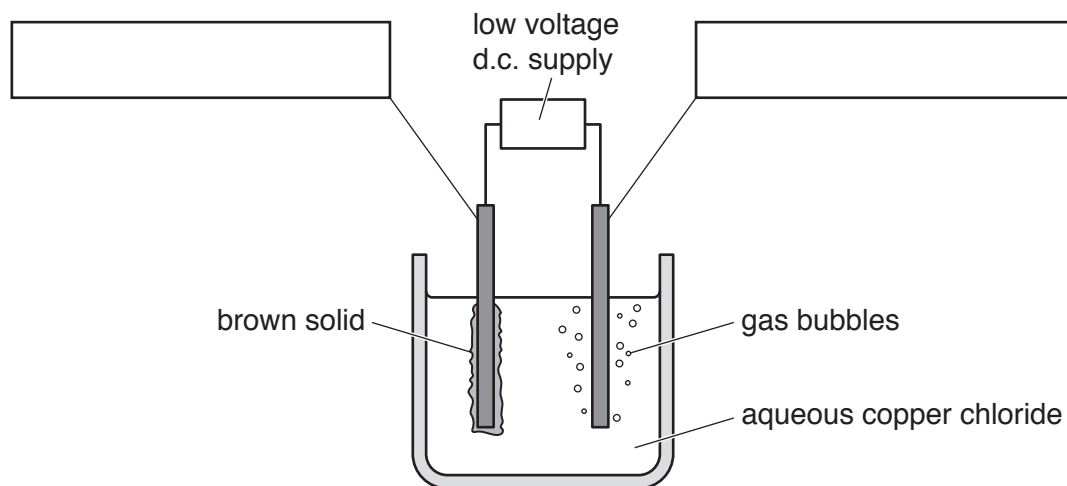


**Fig. 2.1**

- (i) Complete the labels in Fig. 2.1 by naming the two electrodes. [2]
- (ii) Name the solid and the gas formed in this process.
- solid .....
- gas ..... [2]

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- 3 Fig. 3.1 shows a train made up of a steam engine and a passenger coach.

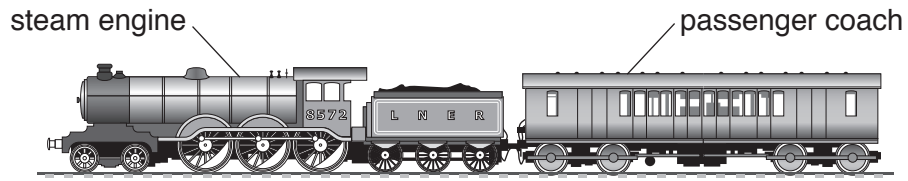


Fig. 3.1

- (a) The train is travelling at a constant speed along a level track. Fig. 3.2 shows the four forces **W**, **X**, **Y** and **Z** acting on the train.

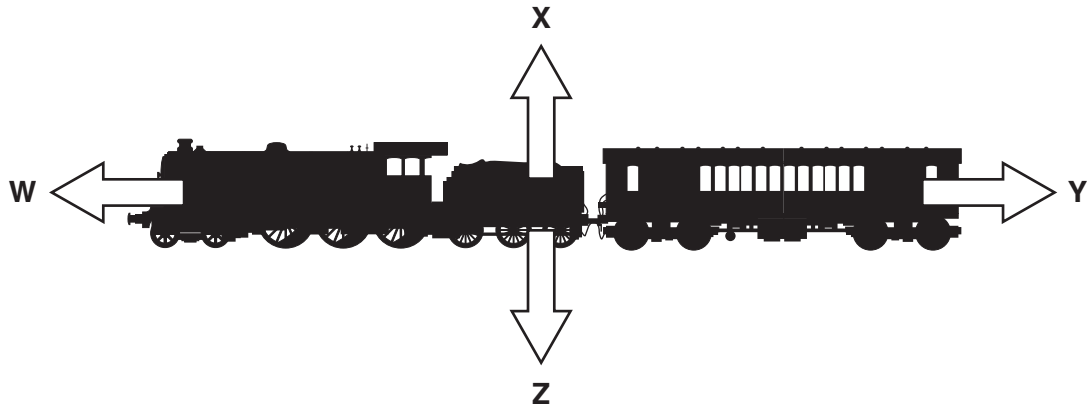


Fig. 3.2

- (i) Name force **Z**.

.....[1]

- (ii) The force arrows on Fig. 3.2 do not show the sizes of the forces.

State whether or not the driver has made force **W** equal in size to force **Y**.

Explain your answer.

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

(b) Fig. 3.3 shows a speed–time graph of the train as it travels between two stations.

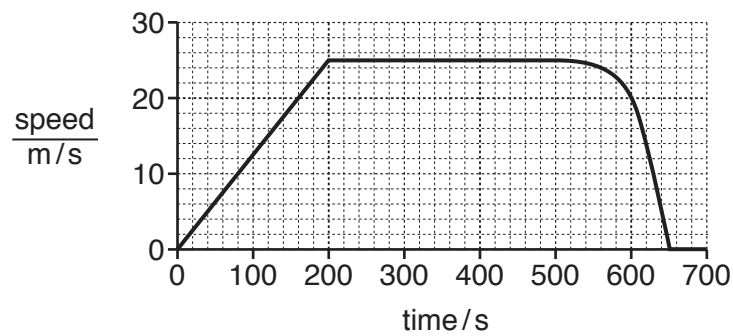


**Fig. 3.3**

(i) On Fig. 3.3, use the letter **P** to label **one** point in the journey when the train is travelling with changing speed. [1]

(ii) The distance between the two stations is 12.8 km.

State the distance between the stations in metres.

distance = ..... m [1]

(iii) Use your answer to (b)(ii) and information from the graph to calculate the average speed of the train on this journey in m/s.

Show your working.

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

(c) The steam engine is powered by burning coal to boil water. This makes steam that moves the engine.

Complete the energy transfer that moves the train.

..... energy in the coal

→ ..... energy of the train. [2]

(d) State the **original** source of the energy stored in coal.

..... [1]

4 Fig. 4.1 shows part of an aquatic food web.

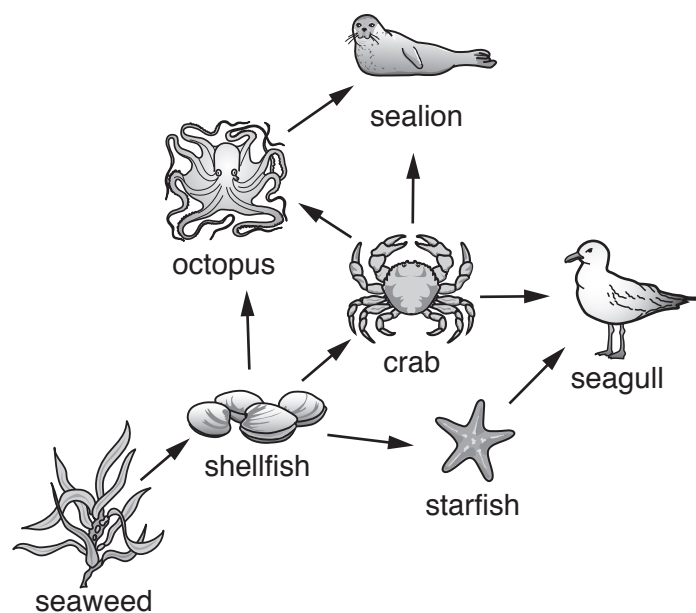


**Fig. 4.1**

**(a)** From Fig. 4.1 state the name of

a producer,

.....

a herbivore,

.....

a consumer.

.....

[3]

**(b)** The food web in Fig. 4.1 is made from interconnected food chains.

Write **two** complete food chains which contain the crab.

1. ....

2. ....

[3]

- (c) The population of crabs reduces suddenly.

Suggest **two** reasons why this causes the octopus population to decrease.

1. ....

.....

2. ....

.....

[2]

5 (a) A student makes magnesium sulfate by reacting magnesium with a dilute acid.

(i) Name the acid.

.....[1]

(ii) Describe the pH change of the mixture during the reaction.

.....[1]

(iii) Name **one other** substance that reacts with this acid to make magnesium sulfate.

.....[1]

(iv) The reaction between magnesium and this acid is exothermic.

State what is meant by the term *exothermic*.

.....

.....[1]

(b) Another student reacts calcium with excess dilute acid in a beaker.

Calcium sulfate forms as a solid in the beaker.

Suggest the separation method that is used to separate the solid calcium sulfate from the excess acid.

Explain how this separation method removes the solid from the liquid.

method .....

explanation .....

.....

.....

[2]

(c) Calcium is in Group II of the Periodic Table.

(i) Complete the following sentences using words from the list.

Each word may be used once, more than once or not at all.

**good      high      low      poor**

Calcium is a ..... electrical conductor.

Calcium has a ..... melting point.

[1]

(ii) State the order of reactivity of calcium, magnesium and sodium.

..... most reactive  
.....  
.....  
..... least reactive

[1]

- 6 Fig. 6.1 shows a liquid-in-glass thermometer at room temperature.

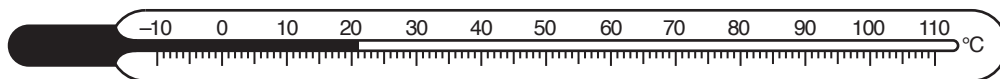


**Fig. 6.1**

- (a) State the property of a liquid that is used in a thermometer when measuring temperature.

.....[1]

- (b) Table 6.1 gives a list of the melting point and boiling point of five substances that are used in liquid-in-glass thermometers.

**Table 6.1**

| substance | melting point<br>/°C | boiling point<br>/°C |
|-----------|----------------------|----------------------|
| ethanol   | -114                 | 78                   |
| gallium   | 30                   | 2403                 |
| glycol    | -12                  | 198                  |
| mercury   | -39                  | 357                  |
| water     | 0                    | 100                  |

- (i) Ammonia has a melting point of  $-78^{\circ}\text{C}$  and a boiling point of  $-33^{\circ}\text{C}$ .

State which substance could be used in a liquid-in-glass thermometer to measure both the melting point and boiling point of ammonia. Explain your answer.

substance .....

explanation .....

[2]

- (ii) Explain why a thermometer that uses liquid gallium has to be kept in a warm container, well above room temperature.

.....

.....

.....[2]

- (c) An infra-red thermometer measures temperature in a different way. The wavelength of the infra-red radiation emitted by a hot body changes with temperature.

An infra-red thermometer measures the wavelengths of the infra-red radiation emitted and converts these to temperature readings.

- (i) Fig. 6.2 shows a wave motion with the waves moving from left to right.

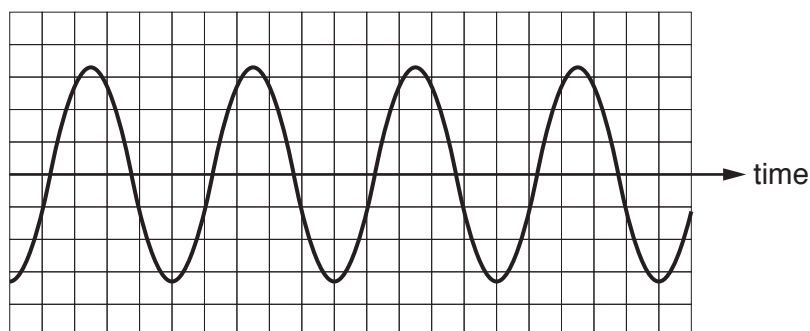


**Fig. 6.2**

State the number of complete wavelengths shown in Fig. 6.2.

.....[1]

- (ii) The wavelength of the infra-red radiation emitted decreases as the temperature of the hot body increases.

Predict what happens to the frequency of the infra-red radiation as the temperature of the hot body increases.

Explain your answer.

prediction .....

explanation .....

.....[2]

- (iii) In the infra-red thermometer, the radiation is focused onto the detector by a thin converging lens.

On Fig. 6.3 complete the ray diagram to show how this happens.

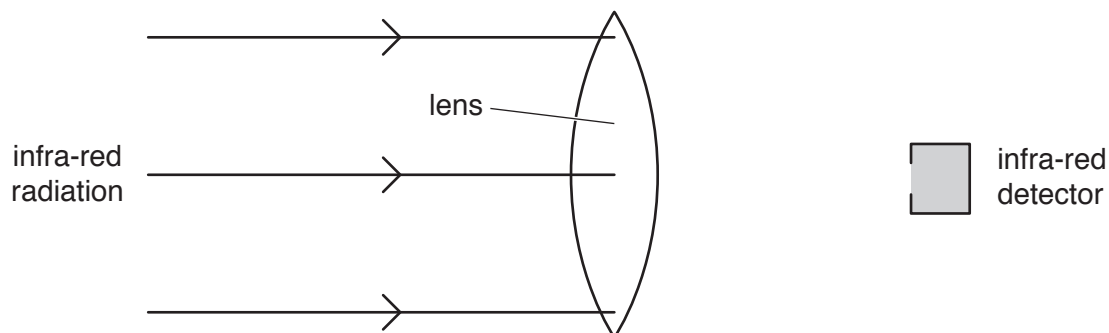


**Fig. 6.3**

- 7 (a) Table 7.1 shows some features of arteries, veins and capillaries.

Place a tick (✓) in the correct boxes in Table 7.1 to show the features of each blood vessel.

**Table 7.1**

| feature                           | blood vessel |      |           |
|-----------------------------------|--------------|------|-----------|
|                                   | artery       | vein | capillary |
| carries blood away from the heart |              |      |           |
| contains valves                   |              |      |           |
| walls are one cell thick          |              |      |           |
| exchange of materials occurs here |              |      |           |

[3]

- (b) A boy starts to play football. Immediately the concentration of the hormone adrenaline in his blood increases.

- (i) Describe **two** effects of adrenaline in the boy's body.

1. ....

2. ....

[2]

- (ii) The concentration of adrenaline in the boy's blood decreases after playing football.

Describe how the adrenaline is removed from his blood.

.....

.....[1]

- (c) The boy is 10 years old. It is important that he includes enough calcium and iron in his diet.

- (i) State **one** food which is a good source of calcium.

.....[1]

- (ii) Describe why calcium is important in the body.

.....[1]

- (iii) Describe the symptoms the boy may have if he does not have enough iron in his diet.

.....

.....[1]



- 8 Petroleum is separated into more useful substances using the process shown in Fig. 8.1.

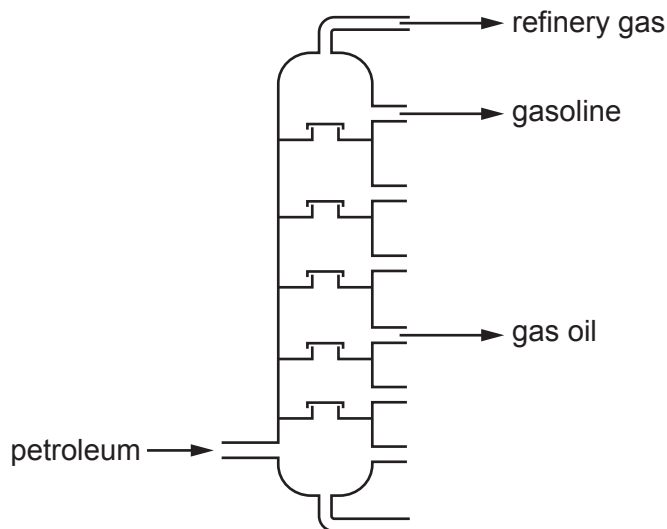


Fig. 8.1

- (a) (i) Name this process.

.....[1]

- (ii) State **one** use for gas oil.

.....[1]

- (b) During the complete combustion of gasoline, the amounts of some gases in the air change.

Name **two** of these gases and describe the change in the amount of each.

**gas 1**

name .....

change .....

**gas 2**

name .....

change .....

[4]

- (c) The formula of ethanol is  $\text{C}_2\text{H}_5\text{OH}$ .

Complete the structure of a molecule of ethanol.

Show all of the bonds between the atoms.



[2]

9 Fig. 9.1 shows a dishwasher (an electric dishwashing machine).

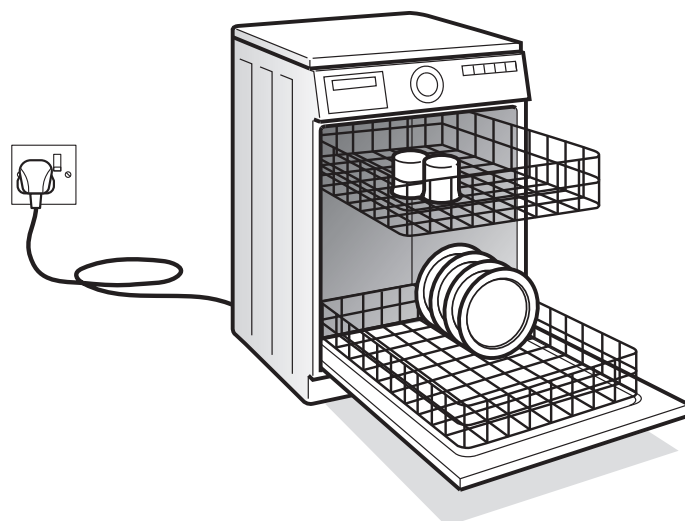


**Fig. 9.1**

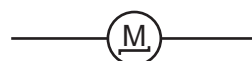
The dishwasher uses electrical energy to power

- a heater to heat the water used,
- a motor to pump the hot water through the machine.

The circuit symbols for a heater and a motor are:



heater



motor

Fig. 9.2 shows part of the circuit diagram for the dishwasher.

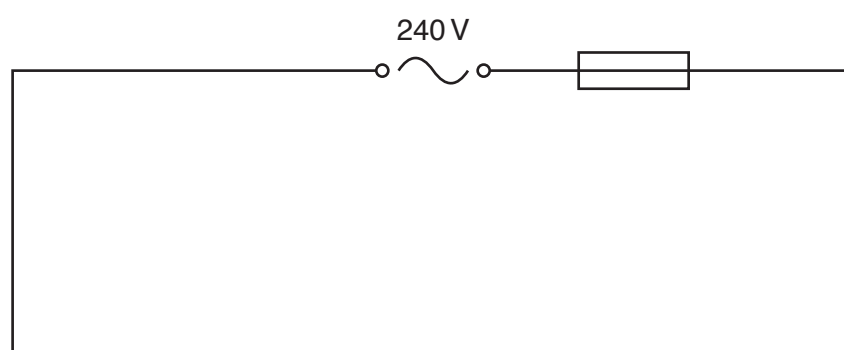
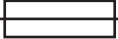


**Fig. 9.2**

- (a) (i) The heater and the motor are connected in parallel.

A switch turns both the heater and the motor on and off.

On Fig. 9.2 complete the circuit diagram for the dishwasher. [3]

- (ii) Name the component in Fig. 9.2 represented by the symbol  and state the reason for including it in the circuit.

component .....

reason .....

..... [2]

- (b) When switched on, the resistance of the heater is  $24\ \Omega$  and the resistance of the motor is  $4\ \Omega$ .

- (i) Use the formula  $R = \frac{V}{I}$  to calculate the current through the heater.

Show your working and give the unit of your answer.

working

current = ..... unit ..... [3]

- (ii) Put a circle around the likely value of the combined resistance of the heater and motor in this circuit. Give a reason for your choice.

3.4  $\Omega$       28  $\Omega$

reason .....

..... [1]

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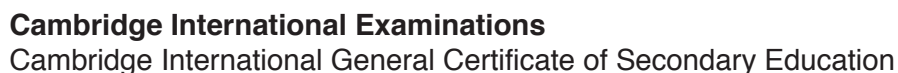
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The Periodic Table of Elements

| Group                      |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                                                                                             |                             |                               |                              |                              |                            |                              |
|----------------------------|-----------------------------|----------------------------|-----------------------------|---------------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|--------------------------------|-------------------------------|---------------------------------------------------------------------------------------------|-----------------------------|-------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|
| I                          | II                          |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | III                                                                                         | IV                          | V                             | VI                           | VII                          | VIII                       |                              |
|                            |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | 1<br>H<br>hydrogen<br>1                                                                     |                             |                               |                              |                              |                            |                              |
|                            |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | <div>Key</div> <div>atomic number<br/>atomic symbol<br/>name<br/>relative atomic mass</div> |                             |                               |                              |                              |                            |                              |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | 5<br>B<br>boron<br>11                                                                       | 6<br>C<br>carbon<br>12      | 7<br>N<br>nitrogen<br>14      | 8<br>O<br>oxygen<br>16       | 9<br>F<br>fluorine<br>19     | 10<br>Ne<br>neon<br>20     |                              |
| 11<br>Na<br>sodium<br>23   | 12<br>Mg<br>magnesium<br>24 |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | 13<br>Al<br>aluminium<br>27                                                                 | 14<br>Si<br>silicon<br>28   | 15<br>P<br>phosphorus<br>31   | 16<br>S<br>sulfur<br>32      | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40    |                              |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45 | 22<br>Ti<br>titanium<br>48  | 23<br>V<br>vanadium<br>51       | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55  | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59   | 28<br>Ni<br>nickel<br>59     | 29<br>Cu<br>copper<br>64       | 30<br>Zn<br>zinc<br>65        | 31<br>Ga<br>gallium<br>70                                                                   | 32<br>Ge<br>germanium<br>73 | 33<br>As<br>arsenic<br>75     | 34<br>Se<br>selenium<br>79   | 35<br>Br<br>bromine<br>80    | 36<br>Kr<br>krypton<br>84  |                              |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89   | 40<br>Zr<br>zirconium<br>91 | 41<br>Nb<br>niobium<br>93       | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>—  | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103 | 46<br>Pd<br>palladium<br>106 | 47<br>Ag<br>silver<br>108      | 48<br>Cd<br>cadmium<br>112    | 49<br>In<br>indium<br>115                                                                   | 50<br>Sn<br>tin<br>119      | 51<br>Sb<br>antimony<br>122   | 52<br>Te<br>tellurium<br>128 | 53<br>I<br>iodine<br>127     | 54<br>Xe<br>xenon<br>131   |                              |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137   | 57–71<br>lanthanoids       |                             | 72<br>Hf<br>hafnium<br>178      | 73<br>Ta<br>tantalum<br>181  | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186   | 76<br>Os<br>osmium<br>190  | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201                                                                  | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207       | 83<br>Bi<br>bismuth<br>209   | 84<br>Po<br>polonium<br>—    | 85<br>At<br>astatine<br>—  | 86<br>Rn<br>radon<br>—       |
| 87<br>Fr<br>francium<br>—  | 88<br>Ra<br>radium<br>—     | 89–103<br>actinoids        |                             | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>—    | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>—    | 108<br>Hs<br>hassium<br>—  | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>—                                                               | 114<br>Fl<br>flerovium<br>— | 116<br>Lv<br>livermorium<br>— | 118<br>Ts<br>tennessine<br>— | 119<br>Og<br>oganeson<br>—   | 120<br>Nh<br>nihonium<br>— | 121<br>Lr<br>lawrencium<br>— |

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

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



\_\_\_\_\_

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0653/32

October/November 2018

**1 hour 15 minutes**

No Additional Materials are required.

## READ THESE INSTRUCTIONS FIRST

DO **NOT** WRITE IN ANY BARCODES.

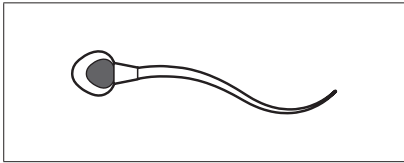
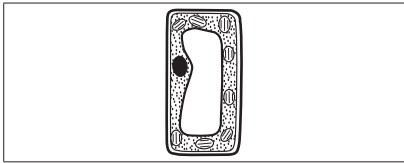
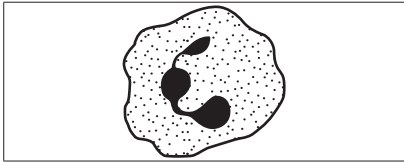
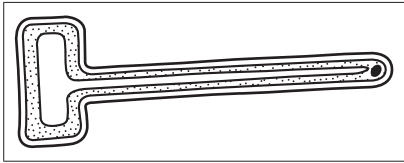
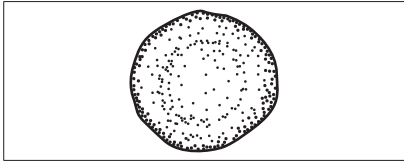
A copy of the Periodic Table is printed on page 20.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **19** printed pages and **1** blank page.

- 1 (a) The boxes in Fig. 1.1 contain the names of cells, diagrams of these cells, and their functions.

Draw straight lines to connect each named cell with its correct diagram and function.  
One is done for you.

| diagram (not to scale)                                                              | name of cell     | function                   |
|-------------------------------------------------------------------------------------|------------------|----------------------------|
|    | palisade cell    | carries out photosynthesis |
|    | red blood cell   | defends against disease    |
|   | root hair cell   | male gamete                |
|  | sperm cell       | transports oxygen          |
|  | white blood cell | water uptake               |

Connections shown in the image:  
 - A line connects the sperm cell diagram to the 'sperm cell' name box.  
 - A line connects the 'sperm cell' name box to the 'male gamete' function box.

Fig. 1.1

[4]

- (b) One of the cells is shown in Fig. 1.2.

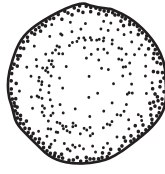


**Fig. 1.2**

The actual diameter of the cell is 0.0070 mm.

Calculate the magnification shown by the diagram.

magnification = ..... [2]

- (c) The list shows some substances that are found in living organisms.

**amino acids      bile      carbon dioxide      enamel**  
**glycogen      platelets      starch**

Draw a circle around **three** substances which are transported by the blood plasma. [2]

- (d) (i) Describe the importance of chemical digestion in the body.

.....

.....

.....

.....

..... [3]

- (ii) State **one** organ of the body which produces digestive enzymes.

..... [1]

- 2 (a) A student makes a salt using the apparatus shown in Fig. 2.1.

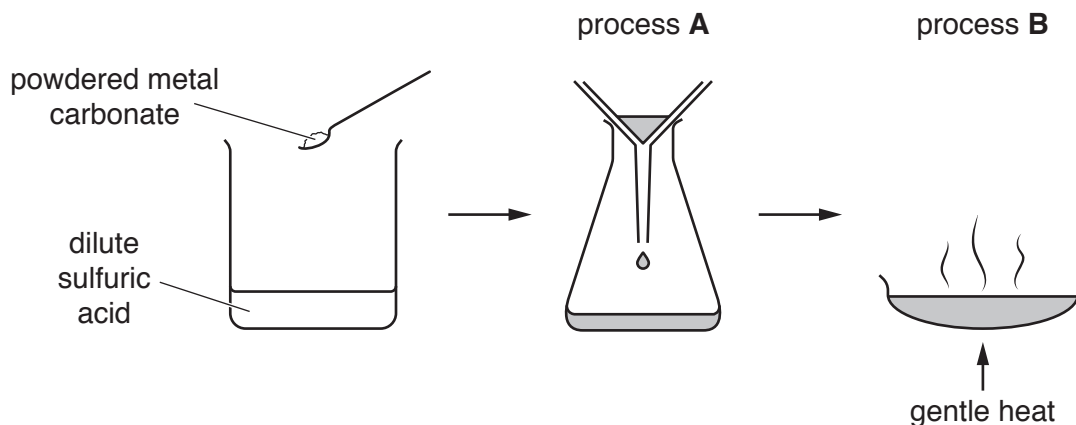


Fig. 2.1

- (i) Name process **A** and process **B**.

process **A** .....

process **B** .....

[2]

- (ii) The student uses 1 g of the powdered metal carbonate.

Describe the effect of using a single 1 g piece of the metal carbonate on the rate of this reaction.

.....[1]

- (iii) Describe the effect of using the same volume of a more concentrated sulfuric acid on the rate of this reaction.

.....[1]

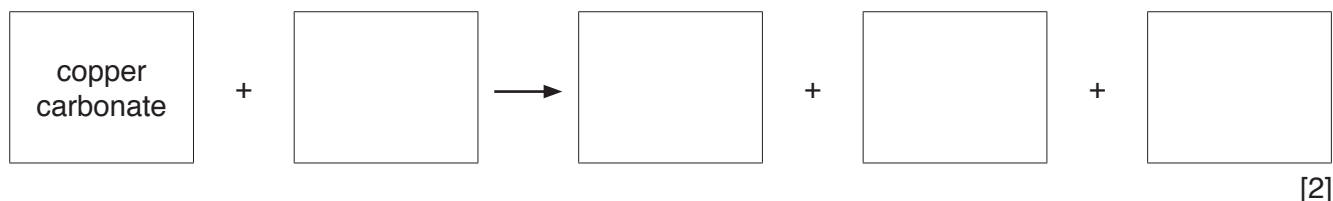
- (iv) When the metal carbonate is mixed with dilute sulfuric acid, the temperature increases.

State the name given to chemical reactions that cause the temperature to increase.

.....[1]

- (b) The student mixes copper carbonate with dilute sulfuric acid. Copper(II) sulfate and a colourless gas and a colourless liquid are formed.

(i) Complete the word equation for this reaction.



(ii) Describe a test for aqueous copper(II) ions.

State the observations that show copper(II) ions are present.

test .....

observations .....

.....

[2]

(iii) Copper is a transition metal. It forms coloured compounds.

Describe **one other** property of a **transition** metal.

.....[1]

3 Fig. 3.1 shows a farm tractor pulling a trailer.

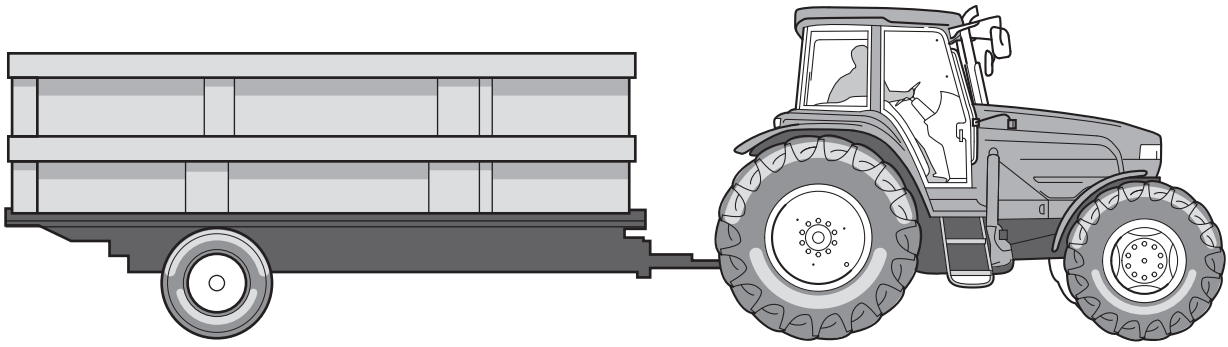


Fig. 3.1

(a) The tractor and trailer are moving across a level field. Fig. 3.2 shows the four forces **W**, **X**, **Y** and **Z** acting on the trailer.

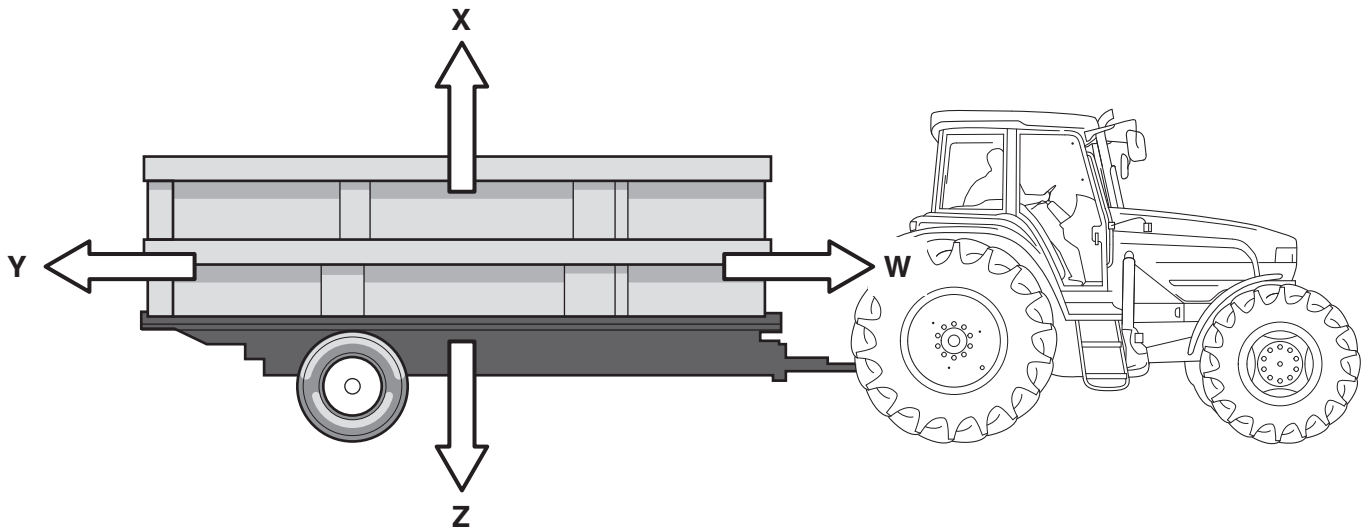


Fig. 3.2

(i) State the letter corresponding to the gravitational force acting on the trailer.

.....

[1]

(ii) The tractor and trailer are moving at a constant speed.

Force **W** has a value of 2000 N.

State the value of force **Y**. Explain your answer.

value of force **Y** = ..... N

explanation .....

.....

[2]

- (b) The tractor leaves the trailer in the field and drives to the farmyard.

Fig. 3.3 shows a speed–time graph of the tractor as it travels from the field to the farmyard.

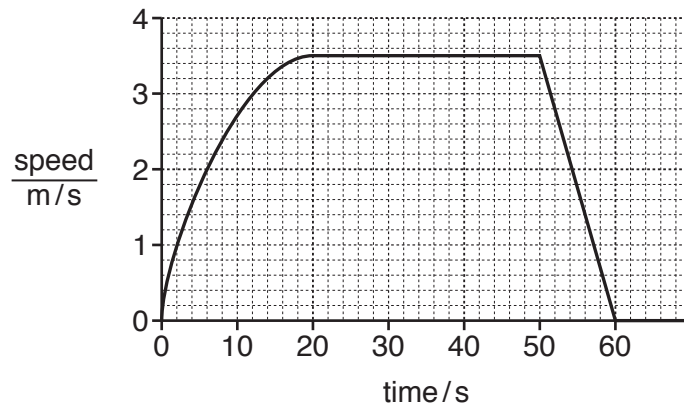


**Fig. 3.3**

- (i) On Fig 3.3, label with a letter **C** a point in the journey when the tractor is travelling with changing speed. [1]
- (ii) The tractor travels 200 m from the field to the farmyard.

Use information from the graph to calculate the average speed of the tractor on this journey in m/s.

Show your working.

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

- (c) (i) The tractor is powered by a diesel engine, which burns diesel oil.

Complete the energy transfer that occurs to move the tractor.

..... energy in the diesel oil

→ ..... energy of the tractor. [2]

- (ii) State the **original** source of the energy stored in diesel oil.

..... [1]

- (iii) To keep the tractor moving at constant speed for 30 s, an energy input of 300 000 J from diesel fuel is needed. Only 60 000 J is required to do the work against forces resisting the motion.

Describe what happens to most of the wasted energy.

..... [1]

- 4 (a) Fig. 4.1 shows a piece of potato in a solution of hydrogen peroxide. A reaction occurs and oxygen gas is produced.

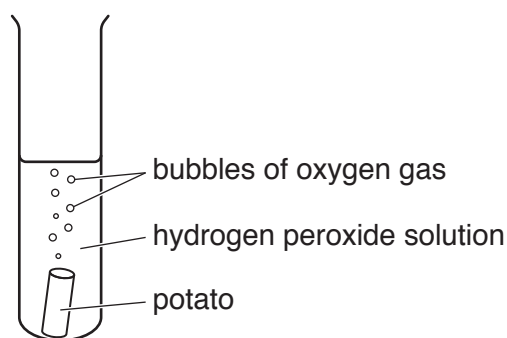


**Fig. 4.1**

The student thinks the reaction is caused by an enzyme in the potato. She repeats the experiment with potato that has been boiled first, and then allowed to cool.

Predict what the student sees if an enzyme in the potato is responsible for the reaction. Explain your prediction.

prediction .....

explanation .....

.....[2]

- (b) A farmer has a field of potato plants near a river.

Some untreated human sewage is spilled into the river. The river overflows and deposits some of the sewage onto the potato field.

- (i) Explain why the potatoes in the field are now unsafe to eat.

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

- (ii) The concentration of oxygen in the river decreases after the sewage is spilled into the river.

Suggest how this affects the animals living in the river. Explain your answer.

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

5 (a) Natural gas and coal are fossil fuels.

(i) Name **one other** fossil fuel.

.....[1]

(ii) Name the main constituent of natural gas.

.....[1]

(b) Ethane,  $C_2H_6$ , is an alkane.

(i) Describe the chemical properties of alkanes.

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

(ii) Complete the structure of a molecule of ethane.



[2]

(c) The atomic numbers and mass numbers of carbon and of hydrogen are shown in Table 5.1.

**Table 5.1**

|          | atomic number | mass number |
|----------|---------------|-------------|
| carbon   | 6             | 12          |
| hydrogen | 1             | 1           |

(i) Define *atomic number*.

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

(ii) Complete Table 5.2 to describe the particles in an atom.

**Table 5.2**

| particle | position in atom | relative charge | relative mass |
|----------|------------------|-----------------|---------------|
| electron |                  | -1              |               |
| neutron  | in nucleus       |                 |               |
| proton   |                  |                 | 1             |

[3]



- 6 (a) (i) State **one** property that distinguishes a liquid from a solid.

.....[1]

- (ii) Describe how this property is the result of the arrangement of molecules.

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

- (b) When a liquid is heated, it expands.

Name a measuring instrument that makes use of this property of liquids.

.....[1]

- (c) Fig. 6.1 shows a hot drink in a cup left to cool down.



**Fig. 6.1**

The statements below describe ways in which the drink loses thermal energy as it cools.

Put a tick (✓) in the box alongside any **correct** statement.

Put a cross (X) in the box alongside any **incorrect** statement.

conduction through the sides and base of the cup

☐

convection as air above the cup is heated and the warm air moves upwards

☐

ultraviolet radiation in all directions

☐

evaporation as the faster molecules escape from the surface of the liquid

☐

[2]

(d) Astronomers use telescopes to study stars. Stars are extremely hot bodies that lose energy by emitting electromagnetic radiation into space.

(i) Explain why stars can only lose energy by radiation, and not by conduction or convection.

.....

.....

.....[1]

(ii) Some stars can emit gamma radiation.

Fig. 6.2 shows an incomplete electromagnetic spectrum.

On Fig. 6.2 place gamma radiation in the correct box.

|  |  |              |  |           |            |  |
|--|--|--------------|--|-----------|------------|--|
|  |  | ultra-violet |  | infra-red | microwaves |  |
|--|--|--------------|--|-----------|------------|--|

Fig. 6.2

[1]

(iii) Some telescopes use converging lenses. Light from a distant star arrives at a telescope as a beam of parallel rays.

On Fig. 6.3 complete the ray diagram to show how a clear image of the star is formed on the screen by a converging lens.

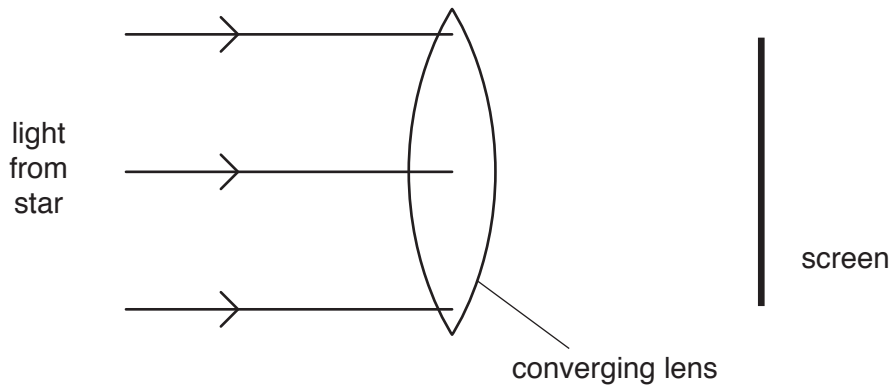


Fig. 6.3

[1]

(iv) On your ray diagram in Fig. 6.3, mark and label the focal length of the lens.

[1]

- 7 (a) Fig. 7.1 shows cross-sections through a root and a stem of a flowering plant.

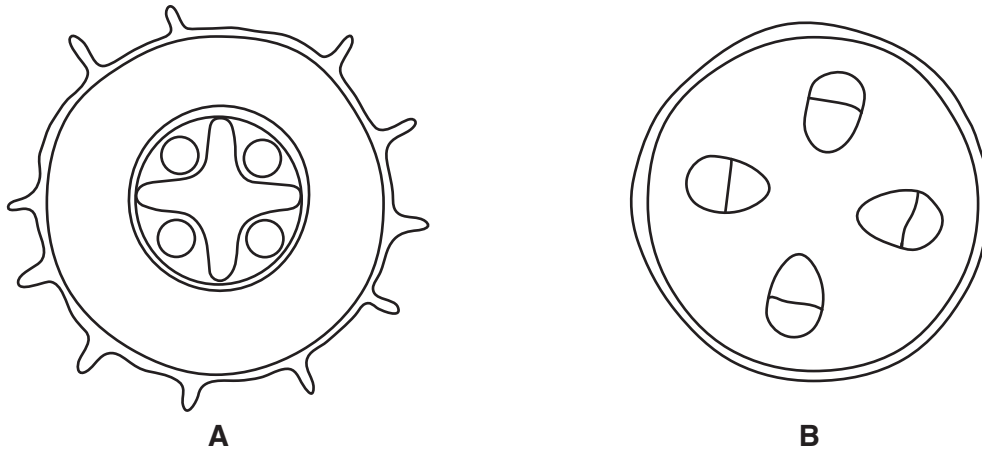


Fig. 7.1

- (i) State which diagram, **A** or **B**, represents the root.

Give **two** reasons for your answer.

The root is diagram .....

reason 1 .....

.....

reason 2 .....

.....

[2]

- (ii) On diagram **B**, in Fig. 7.1, shade in **one** area where the xylem is found.

[1]

- (b) Use the words or phrases to complete the sentences about transpiration.

Each word may be used once, more than once or not at all.

**cuticle**      **diffuses**      **dissolves**      **guard cells**      **higher**      **lower**  
**mesophyll cells**      **stomata**      **similar**      **xylem**

Water evaporates from the surfaces of ..... inside the leaf.

This gives the air inside the leaf a ..... concentration of water vapour

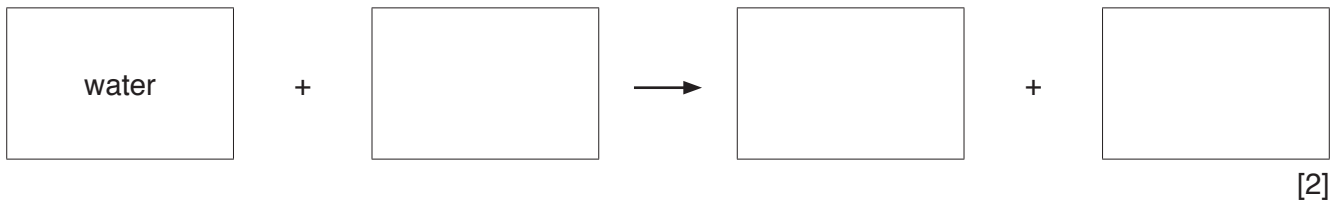
than the atmosphere. As a result the water vapour ..... out of the

leaves through tiny holes called the .....

[4]

(c) Water is one of the raw materials for photosynthesis.

Complete the word equation for photosynthesis.



- 8 (a) A teacher uses the apparatus shown in Fig. 8.1 to demonstrate the electrolysis of lead(II) bromide.

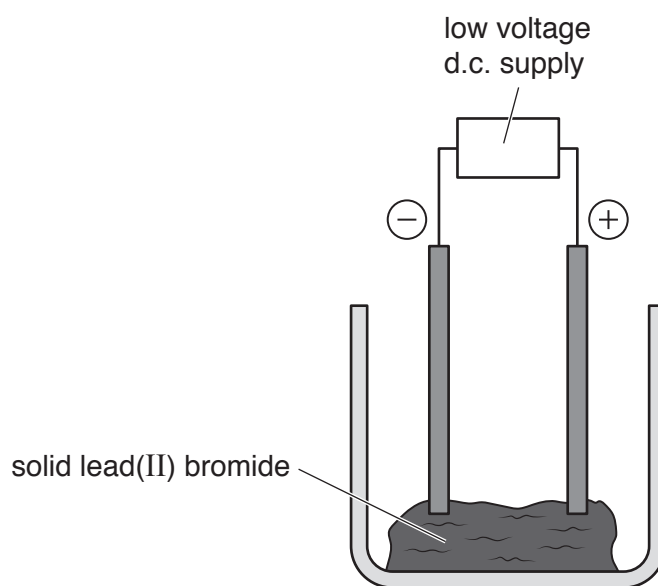


Fig. 8.1

Predict whether this electrolysis works.

Explain your answer.

prediction .....

explanation .....

.....

.....

[1]

- (b) A student electrolyses aqueous copper chloride using the apparatus shown in Fig. 8.2.

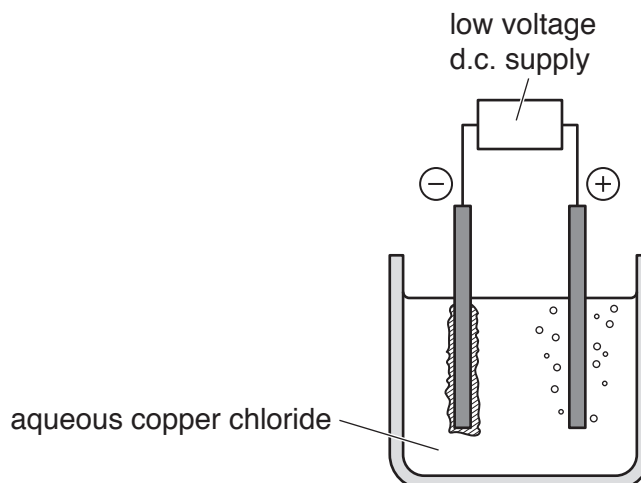


Fig. 8.2

Copper forms on the negative electrode.

A gas forms at the positive electrode. The student tests this gas with damp litmus paper.

Name the gas and predict its effect on the colour of the litmus paper.

name .....

effect .....

[2]

- (c) Copper can be extracted by heating copper oxide with carbon.

The equation for this reaction is:



Identify one substance which is oxidised and one substance which is reduced during this reaction.

oxidised .....

reduced .....

[2]

- (d) Carbon dioxide is present in clean air in small quantities.

- (i) Name **one other** gas which is present in clean air in small quantities.

.....[1]

- (ii) Name **two** substances present in clean air which cause rusting.

1. ....

2. ....

[1]

- 9 Fig. 9.1 shows a circuit diagram for an investigation of how the resistance of a lamp changes with the current in the lamp.

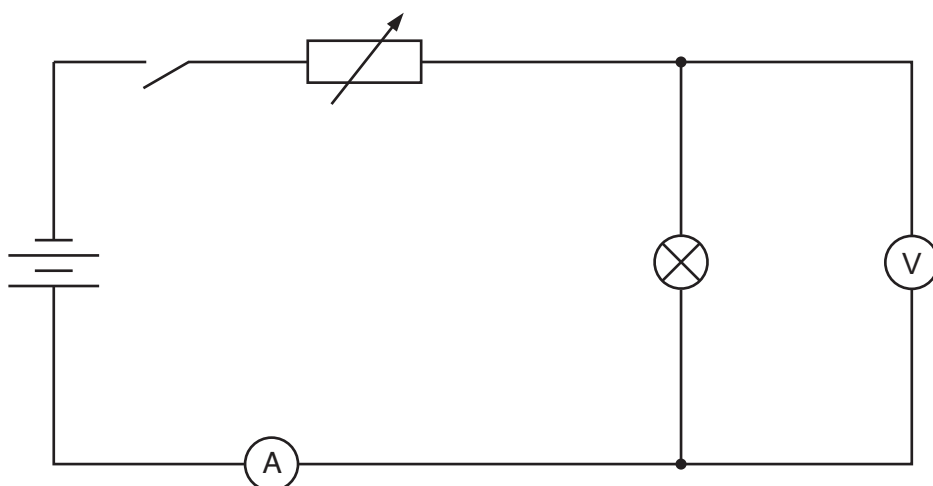
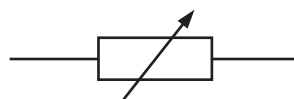


Fig. 9.1

- (a) Name the circuit component with the symbol



.....[1]

- (b) Table 9.1 shows some results from the investigation.

Table 9.1

| experiment number | voltmeter reading / V | ammeter reading / A | resistance of lamp / $\Omega$ |
|-------------------|-----------------------|---------------------|-------------------------------|
| 1                 | 6.0                   | 0.54                | 11                            |
| 2                 | 4.0                   | 0.46                | 8.7                           |
| 3                 | 3.0                   | 0.40                |                               |
| 4                 | 2.0                   | 0.32                | 6.3                           |

- (i) Complete Table 9.1 by calculating the missing resistance value.

State the formula you use and show your working.

formula

working

[2]

- (ii) Suggest what happens to the lamp as the experiments are carried out in turn from experiment 1 to experiment 4.

.....[1]

- (c) (i) On Fig. 9.1 add a second identical lamp in parallel with the first lamp. [1]

- (ii) Experiment 1 is now repeated with the second lamp in the circuit in parallel with the first lamp.

Suggest how the ammeter reading will compare with the reading in the original experiment 1.

Give a reason for your answer.

effect on ammeter reading .....

reason .....

.....[2]

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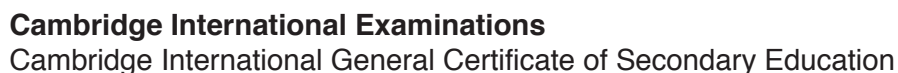
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The Periodic Table of Elements

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

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

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



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0653/33

October/November 2018

**1 hour 15 minutes**

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 20.

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 **20** printed pages.

- 1 (a) Fig. 1.1 shows a flowering plant and some functions carried out by the plant.

Draw **one** straight line from each box to a part of the plant where the function is carried out. [4]

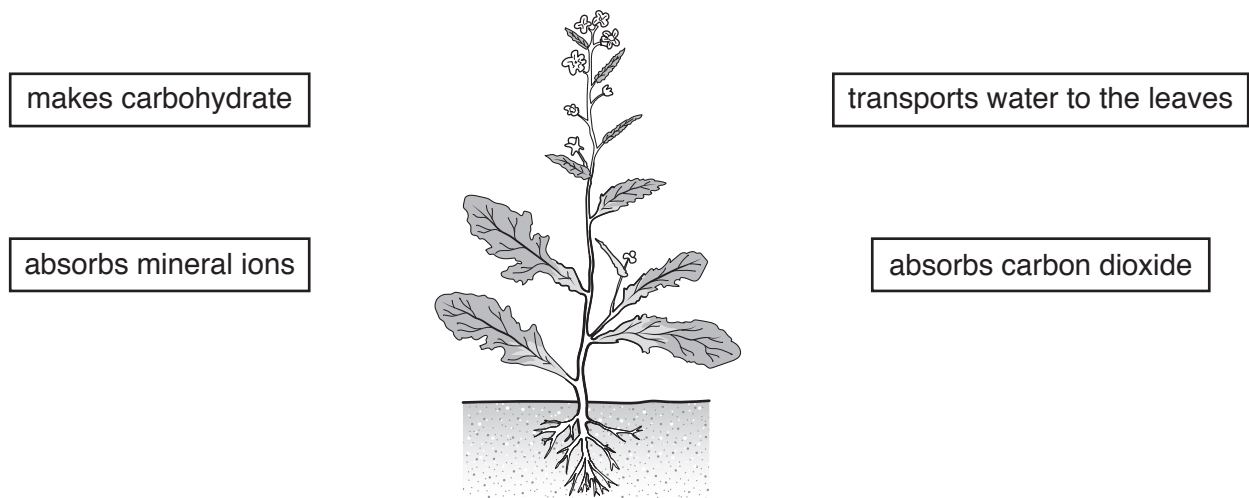


Fig. 1.1

- (b) Fig. 1.2 shows a drawing of a vertical section through a flower.

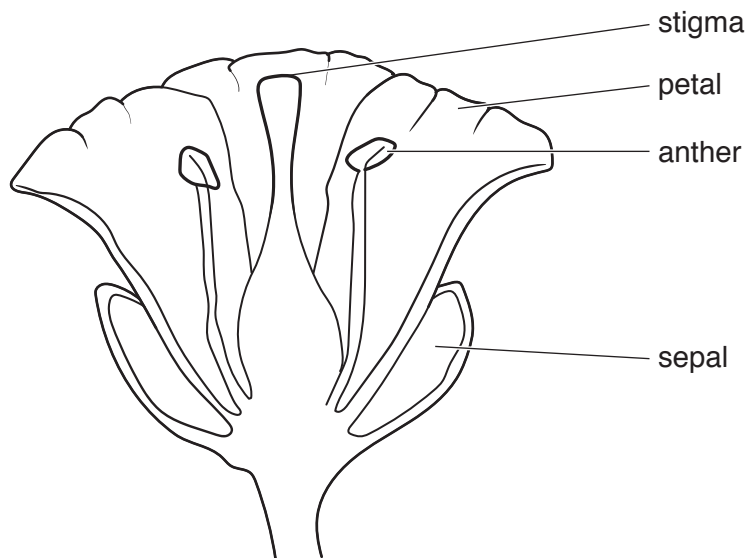


Fig. 1.2

Suggest **one** piece of evidence shown in Fig. 1.2 that the flower is insect pollinated.

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

- (c) Fig. 1.3 shows a drawing of a pollen grain from an insect-pollinated flower, viewed using a microscope.

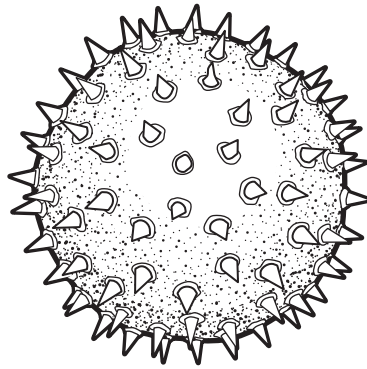


**Fig. 1.3**

Suggest **and** explain how the structure of the pollen grain makes it suitable for insect pollination.

.....

.....

.....[2]

- (d) (i) Oxygen is required for the germination of seeds.

Explain in detail why germination requires a supply of oxygen.

.....

.....

.....[2]

- (ii) State **one other** environmental condition that is needed for germination.

.....[1]

- 2 (a) The Periodic Table contains the symbols of all of the elements.

Complete the sentences about the Periodic Table.

The Periodic Table lists the elements in order of their ..... number.

The unreactive gases in Group VIII, which include helium, neon and argon, are known as the ..... gases.

The collection of metals in the middle of the Periodic Table have high densities and form coloured compounds. They are known as the ..... elements. [3]

- (b) Carbon dioxide is a compound of carbon and oxygen, two non-metallic elements.

- (i) State the name of the type of bonding between a carbon atom and an oxygen atom.

.....[1]

- (ii) Describe, in terms of electrons, the bonding between a carbon atom and an oxygen atom.

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

- (c) The compound sodium chloride contains sodium ions and chloride ions.

Describe, in terms of electrons, the formation of ions from atoms.

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

- (d) A mixture contains aqueous sodium chloride and insoluble powdered charcoal (carbon).

- (i) Suggest how the powdered charcoal can be separated from the mixture.

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

- (ii) Suggest how water can be removed from aqueous sodium chloride.

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

- (iii) State whether the separation of this mixture into charcoal, water and sodium chloride is a physical change or a chemical change.

Explain your answer.

change .....

explanation .....

.....

[1]

3 Fig. 3.1 shows a man pushing a shopping trolley.



Fig. 3.1

(a) The man and the trolley are moving. Fig. 3.2 shows the four forces **W**, **X**, **Y** and **Z** acting on the trolley.

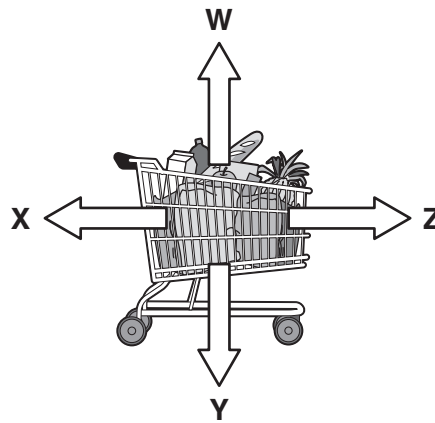


Fig. 3.2

State the letter corresponding to the gravitational force acting on the trolley.

.....

[1]

(b) Fig. 3.3 shows a speed–time graph of the trolley as the man pushes it to the checkout.

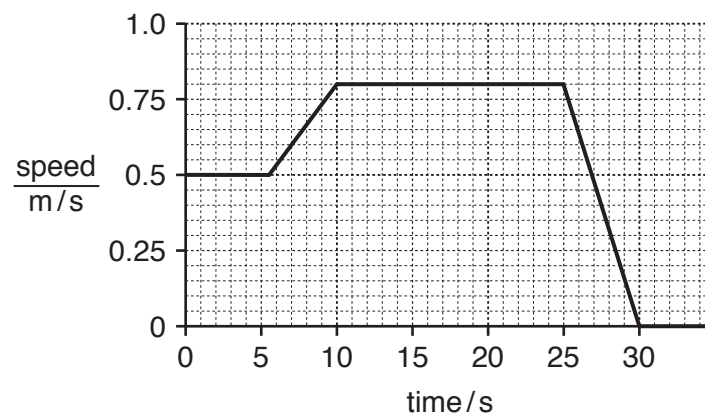


Fig. 3.3

- (i) On Fig. 3.3, label with a letter **C** a point in the journey when the trolley is travelling with changing speed. [1]

- (ii) The trolley travels 20 m to the checkout.

Use information from the graph to calculate the average speed of the trolley on this journey.

Show your working.

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

- (c) The man provides the energy to push the trolley to the checkout. The original source of the energy in the man is the Sun.

- (i) Use words from the list to complete the sentences that describe how energy is transferred from the Sun to move the trolley.

Each word may be used once, more than once, or not at all.

**chemical      electrical      gravitational      kinetic      nuclear**

Light energy from the Sun is converted to ..... energy in food.

When the man eats the food, he gains ..... energy.

When he pushes the trolley, some of this energy is transferred to the

..... energy of the trolley. [3]

- (ii) To keep the trolley moving at constant speed for 15 s, an energy input of 20 000 J to the man is needed. Only 2400 J is required to do the work against forces resisting the motion.

Describe what happens to most of the wasted energy.

.....

.....[1]

- 4 (a) Fig. 4.1 shows a diagram of part of the alimentary canal and its associated organs.

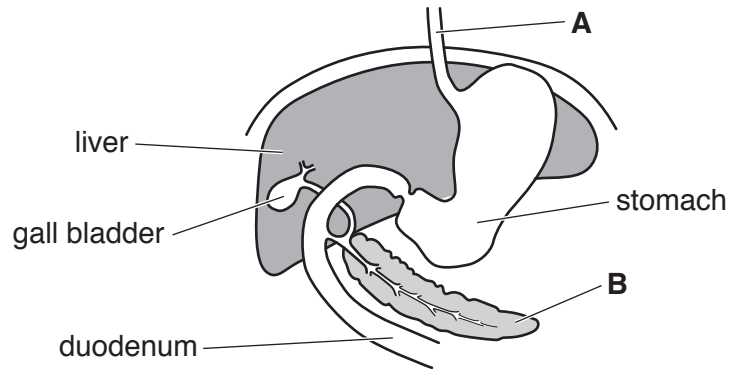


Fig. 4.1

- (i) Name structures **A** and **B** shown on Fig. 4.1.

**A** .....

**B** ..... [2]

- (ii) During digestion food passes through the duodenum.

State where the food goes to immediately after passing through the duodenum.

..... [1]

- (iii) Describe the function of the gall bladder.

..... [1]

- (b) Table 4.1 shows the approximate pH values in some areas of the alimentary canal.

Table 4.1

| area of alimentary canal | approximate pH in area |
|--------------------------|------------------------|
| mouth cavity             | 7                      |
| stomach                  | 2                      |
| duodenum                 | 8                      |

Enzymes in the mouth begin the digestion of starch in food.

Suggest why more enzymes must be secreted into the small intestine to complete the digestion of starch.

.....

.....

..... [2]

(c) Glucose is transported to the body cells in the blood plasma.

List **two** other soluble substances which are transported by the plasma.

1. ....

2. ....

[2]

(d) Describe how oxygen is transported in the blood around the body.

.....

.....

..... [2]

- 5 (a) A student investigates the rate of reaction of four metals, calcium, iron, magnesium and zinc, with dilute hydrochloric acid.

She uses pieces of metal which are all of the same size.

A gas is produced when the metals react.

She uses the apparatus shown in Fig. 5.1.

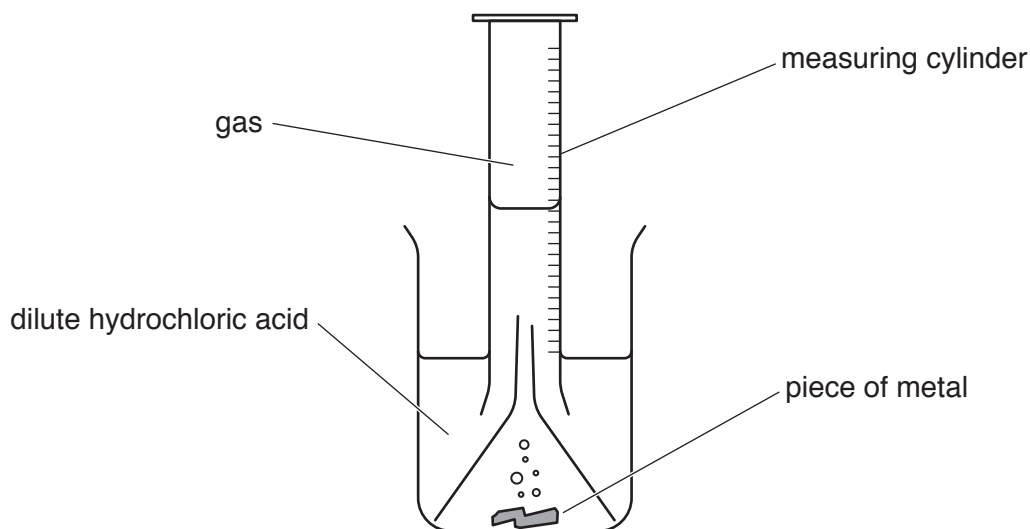


Fig. 5.1

The student determines the rate of the reaction between each metal and the dilute acid.

- (i) Describe the **two** measurements that the student records for each reaction.

1. ....

2. ....

[2]

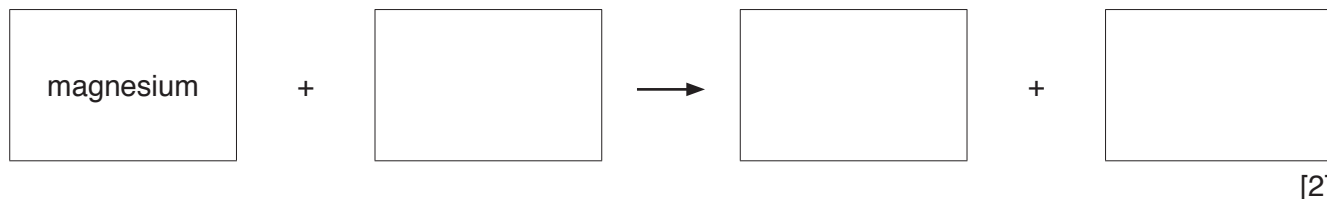
- (ii) Place calcium, iron, magnesium and zinc, in order of rate of reaction, from highest to lowest.

..... highest  
.....  
.....  
..... lowest

[1]

- (iii) During the reaction between magnesium and dilute hydrochloric acid, hydrogen gas and a salt are produced.

Complete the word equation for this reaction.



- (iv) Describe a test for hydrogen gas.

State the test result.

test .....

result .....

.....

[2]

- (b) Copper is a metal which is extracted by heating copper oxide with carbon.

The equation for this reaction is:



Name the substance that is oxidised during this reaction.

Explain your answer.

substance .....

explanation .....

.....

[1]

- 6 (a) (i) State **one** property that distinguishes a liquid from a gas.

.....[1]

- (ii) Describe how this property is the result of a difference in the arrangement of molecules.

.....

.....[2]

- (b) When gases are heated, they expand.

Describe **one** example of a use of this property of gases.

.....

.....[1]

- (c) Fig. 6.1 shows a pan of boiling water left to cool on a balance.

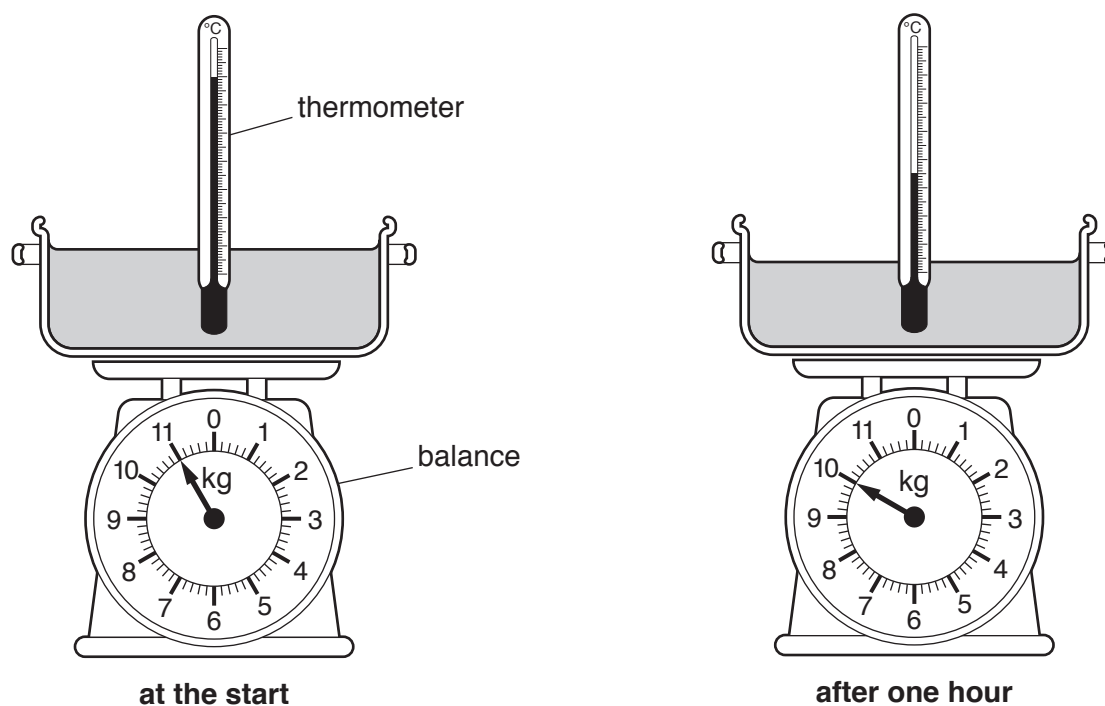


Fig. 6.1

After one hour, the reading on the scale of the balance has changed.

- (i) Name the process that has caused the change in the mass of water in the pan.

.....[1]

- (ii) The thermometer in Fig. 6.1 shows that the temperature of the water and the pan is less after one hour.

State the main method of heat loss

1. from the inside to the outside of the pan,

.....

2. from the outside of the pan to the room.

.....

[2]

- (d) An observer is measuring the temperature of the water in the pan in (c).

He says the thermometer looks bent where it goes into the water. He says the thermometer bulb is at **X** on Fig. 6.2.

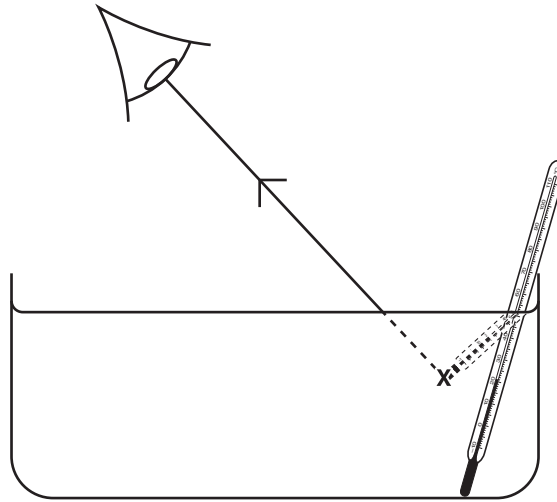


Fig. 6.2

- (i) Rays of light change direction when they pass through the surface of the water.

Name this effect.

.....[1]

- (ii) Fig. 6.2 shows where the observer thinks the ray is coming from.

On Fig. 6.2 complete the ray diagram to show where the ray is actually coming from. [1]

- 7 Rainforest is often cleared for agriculture. Trees are cut down and burned to prepare the land for planting crops. This practice is called 'slash and burn'.

The burning of the trees produces carbon dioxide gas and a smoky haze made from very small carbon particles suspended in the air.

Fig. 7.1 is a picture of clearing land by slash and burn.

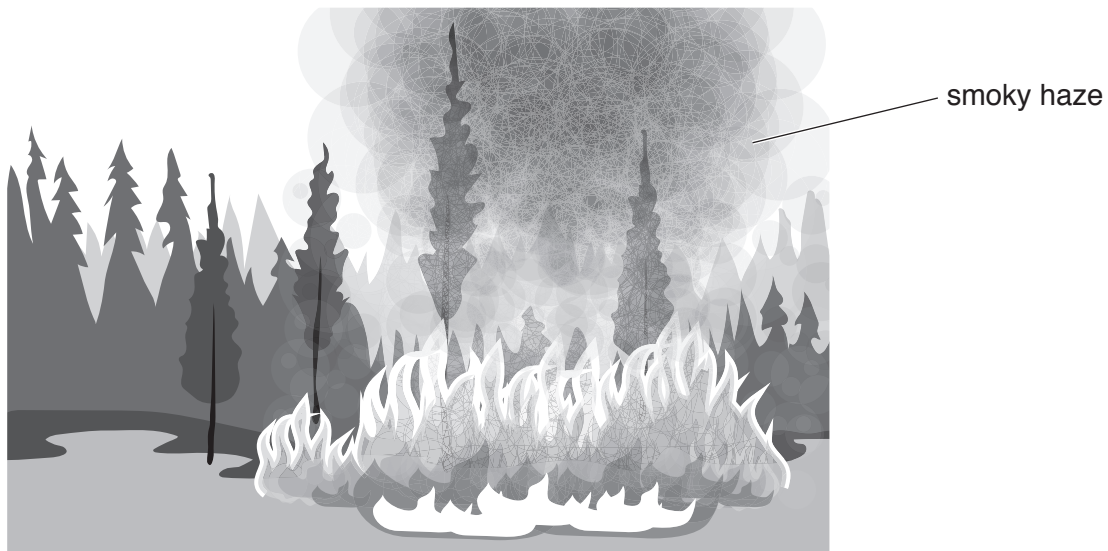


**Fig. 7.1**

- (a) The wind carries the smoky haze to neighbouring countries.

Suggest **and** explain how the smoky haze affects the rate of photosynthesis in plants in these countries.

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

- (b) After slash and burn there is an increased risk of loss of soil from the area.

Suggest a reason for this loss of soil from the area.

Explain your answer.

reason .....  
 .....  
 explanation .....  
 .....

[2]

(c) State **two** effects of slash and burn on the animals living in the trees.

1. ....

2. ....

[2]

(d) The practice of slash and burn causes the concentration of carbon dioxide in the atmosphere to increase.

Explain why this is undesirable for the environment.

.....

.....

.....[2]

- 8 (a) Petroleum is separated into useful fractions, as shown in Fig. 8.1.

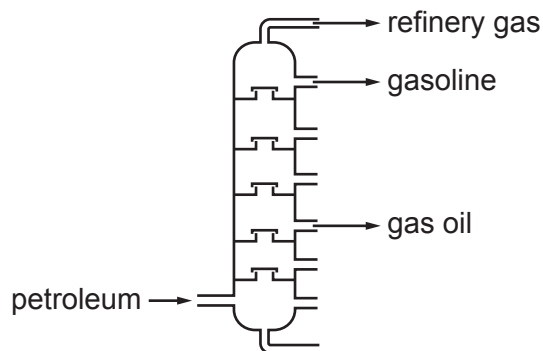


Fig. 8.1

- (i) Petroleum is a fossil fuel.

Name two other fossil fuels.

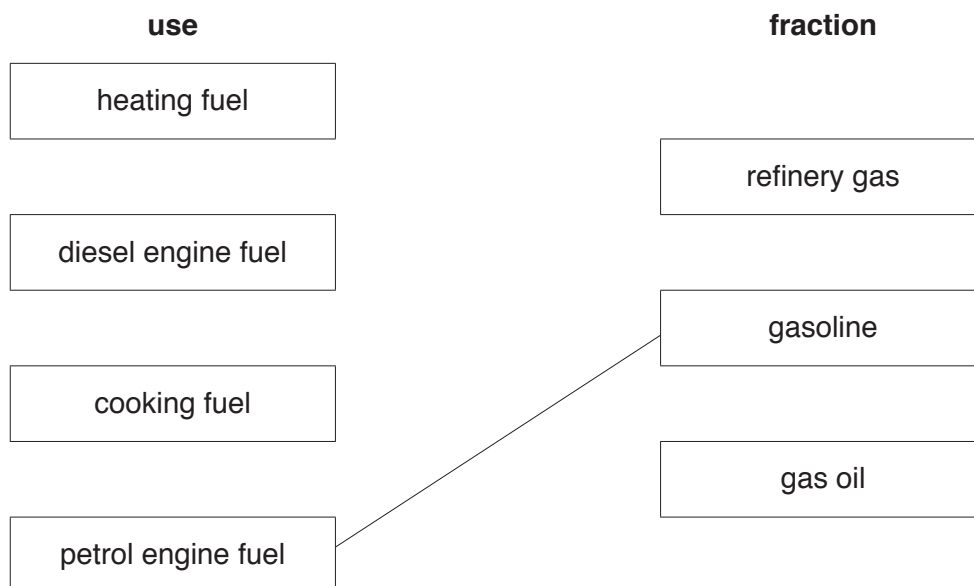
1. ....
2. ....

[1]

- (ii) The fractions obtained from petroleum have different uses as fuels.

Draw **one** line from each use to the fraction from which the fuel is obtained.

One line has been drawn for you.



[2]

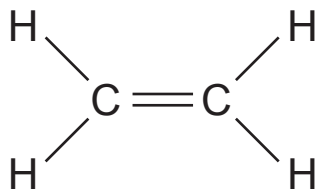
- (iii) When fuels burn, the reaction produces a temperature increase.

State the name given to reactions that always cause a temperature increase.

.....[1]

- (b) (i) The structure of a molecule of a compound is shown below.

Name this compound.



.....[1]

- (ii) The formula of ethanol is  $C_2H_5OH$ .

Complete the structure of a molecule of ethanol.



[2]

- (c) Petroleum is a mixture of different compounds.

Methane,  $CH_4$ , is a compound.

- (i) State what is meant by a *compound*.

Use ideas about atoms in your answer.

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

- (ii) Explain what is meant by a *mixture*.

You may use ideas about separation methods in your answer.

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

- 9 Fig. 9.1 shows a display refrigerator for storing cold drinks.

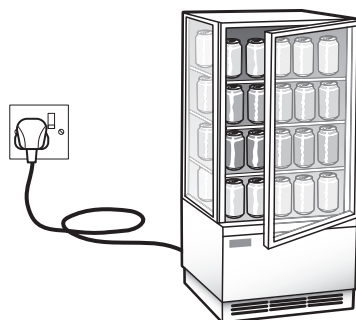


**Fig. 9.1**

The refrigerator uses electrical energy

- for a lamp to light up the inside of the refrigerator
- to power an electric motor to run the cooler in the refrigerator.

The circuit symbol for an electric motor is:



Fig. 9.2 shows part of the circuit diagram for the refrigerator.

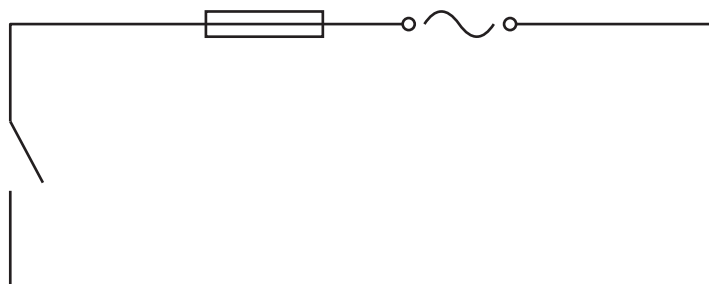


**Fig. 9.2**

- (a) (i) The electric motor and lamp are connected in parallel.

The lamp has a switch in series so it can be switched off while the motor is switched on.

On Fig. 9.2 complete the circuit diagram for the refrigerator.

[4]

- (ii) Suggest why it is an advantage to have the electric motor and lamp connected in parallel.

.....[1]

- (iii) Name the circuit component with the symbol 

.....[1]

- (iv) State why a fuse has been included in the circuit.

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

- (b) The potential difference across the electric motor is 240 V. When the electric motor is working, a current of 1.25 A flows through it.

Calculate the resistance of the electric motor.

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

formula

working

resistance = ..... unit ..... [3]

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The Periodic Table of Elements

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

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

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