



# Cambridge IGCSE™

CANDIDATE  
NAME

CENTRE  
NUMBER

|  |  |  |  |  |  |
|--|--|--|--|--|--|
|  |  |  |  |  |  |
|--|--|--|--|--|--|

CANDIDATE  
NUMBER

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|



**CO-ORDINATED SCIENCES**

**0654/31**

Paper 3 Theory (Core)

**October/November 2022**

**2 hours**

You must answer on the question paper.

No additional materials are needed.

## INSTRUCTIONS

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

## INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **28** pages. Any blank pages are indicated.

- 1 (a) A person keeps a food diary for one day. They photograph everything that they eat and drink in the day.

Fig. 1.1 shows an extract from the diary.



Midday meal: chicken, rice, green beans, cucumber and onion salad  
Drink: Water

**Fig. 1.1**

- (i) Identify **one** food item from Fig. 1.1 that is a principal source of:
- carbohydrate .....
- protein .....
- vitamins .....
- [3]

- (ii) State why it is important to drink water as part of a balanced diet.
- .....
- ..... [1]

- (b) Rice is classified as a starch that provides a lot of fibre.

- (i) State the colour iodine solution turns when added to starch.
- ..... [1]

3

(ii) Circle the component from which starch is made.

amino acids

fatty acids

glucose

glycerol

glycogen

[1]

(iii) Describe the importance of fibre in the diet.

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

(c) Olive oil is a liquid fat used for cooking food.

Tick (✓) the boxes to show the **three** chemical elements present in all cooking oils.

|           |                          |
|-----------|--------------------------|
| calcium   | <input type="checkbox"/> |
| carbon    | <input type="checkbox"/> |
| hydrogen  | <input type="checkbox"/> |
| iron      | <input type="checkbox"/> |
| magnesium | <input type="checkbox"/> |
| oxygen    | <input type="checkbox"/> |

[1]

[Total: 8]

2 (a) The list below shows some chemical processes.

chlorination

chromatography

cracking

crystallisation

decomposition

electrolysis

fractional distillation

polymerisation

Identify the process from the list that is used:

(i) in the treatment of drinking water

..... [1]

(ii) to separate a mixture of dyes

..... [1]

(iii) to extract aluminium from bauxite

..... [1]

(iv) to produce long chain molecules from monomer units.

..... [1]

- (b) When dilute hydrochloric acid is added to aqueous sodium hydroxide, a neutralisation reaction occurs.

Fig. 2.1 shows apparatus used to investigate the change in pH as the acid is added.

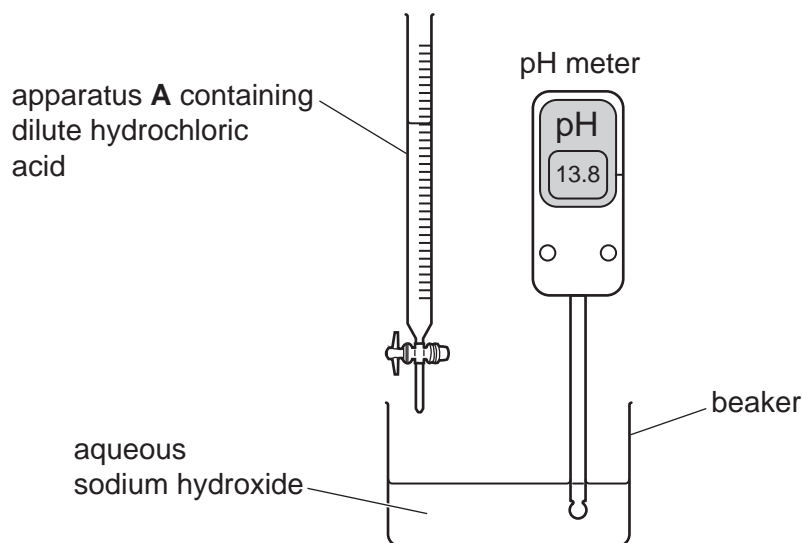


Fig. 2.1 (not to scale)

- (i) State the name of apparatus A.

..... [1]

- (ii) State the reading on the pH meter when the dilute hydrochloric acid exactly neutralises the aqueous sodium hydroxide.

..... [1]

- (iii) State the **two** products of the reaction shown in Fig. 2.1.

1 .....

2 .....

[2]

- (c) Describe what is observed when aqueous sodium hydroxide is added to blue copper(II) sulfate solution.

.....

..... [1]

[Total: 9]

- 3 (a) The list below shows energy sources used by power stations, to generate electricity.

|      |         |                     |
|------|---------|---------------------|
| coal | gas     | hydroelectric (HEP) |
|      | nuclear | petroleum           |

- (i) State the **three** energy sources from the list that produce carbon dioxide when generating electricity.

1 .....

2 .....

3 .....

[2]

- (ii) Coal is described as a non-renewable energy source.

Explain what is meant by non-renewable when describing an energy source.

.....

..... [1]

- (iii) State one **disadvantage** of using nuclear fuel to generate electricity.

.....

..... [1]

- (b) (i) In a nuclear power station, fission of plutonium-239 nuclei takes place.

Describe what happens to the nucleus of a plutonium-239 atom during nuclear fission.

..... [1]

- (ii) State a safe way of storing a small sample of radioactive material.

.....

..... [1]

- (c) Technetium-99 is a radioactive material. The half-life of technetium-99 is 6 hours.

Calculate the percentage of technetium-99 remaining in a sample after 24 hours.

percentage = ..... [2]

[Total: 8]

4 (a) Complete the definition of the term hormone.

A hormone is a chemical substance, produced by a ..... and carried by the blood. It alters the activity of one or more specific target ..... [2]

(b) State the name of the component of blood that transports hormones.

..... [1]

(c) A person experiences a scary event whilst wearing a heart rate monitor.

Fig. 4.1 shows her heart rate before, during and after the event.

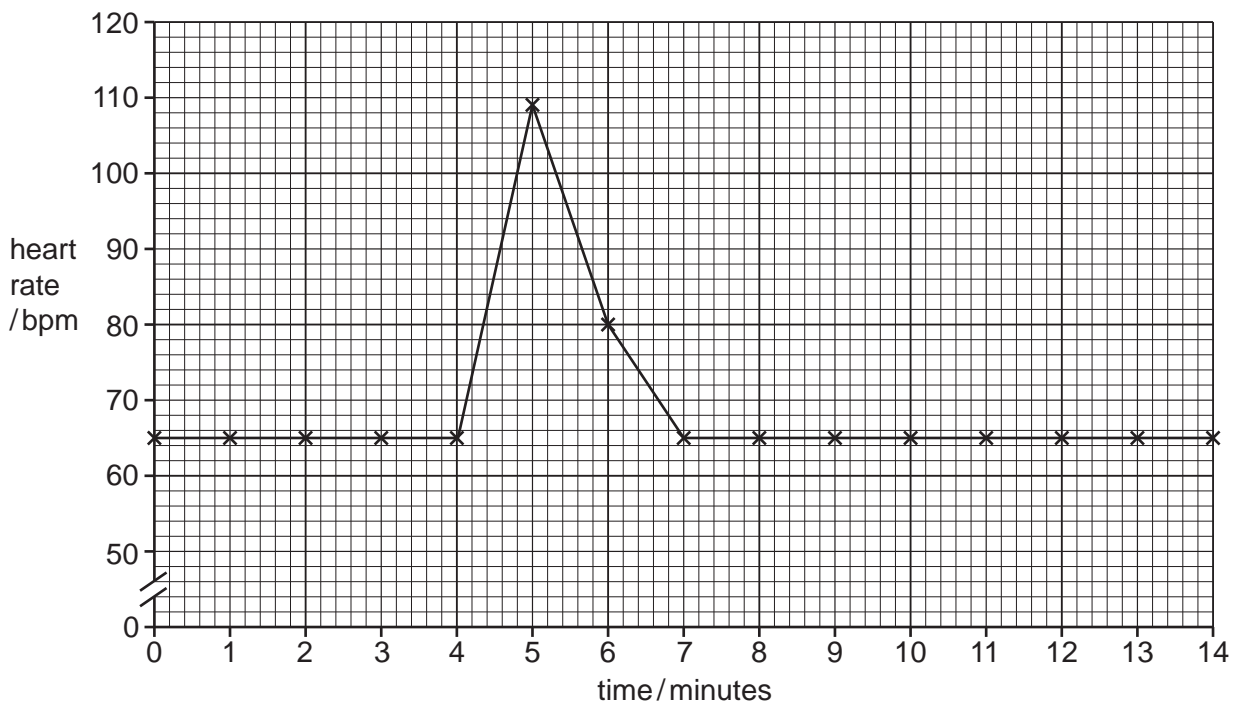


Fig. 4.1

(i) Use Fig. 4.1 to suggest the time that the scary event takes place.

time = ..... minutes [1]

(ii) Use Fig. 4.1 to identify the maximum heart rate of this person.

heart rate = ..... bpm [1]

(iii) State the name of the hormone that causes the increase in heart rate seen in Fig. 4.1.

..... [1]

(iv) State **two** other effects of this hormone.

1 .....

2 .....

[2]

8

(d) Complete these sentences about the human nervous system.

The nervous system consists of the central nervous system and the

..... nervous system.

The central nervous system has two parts: the .....

and the .....

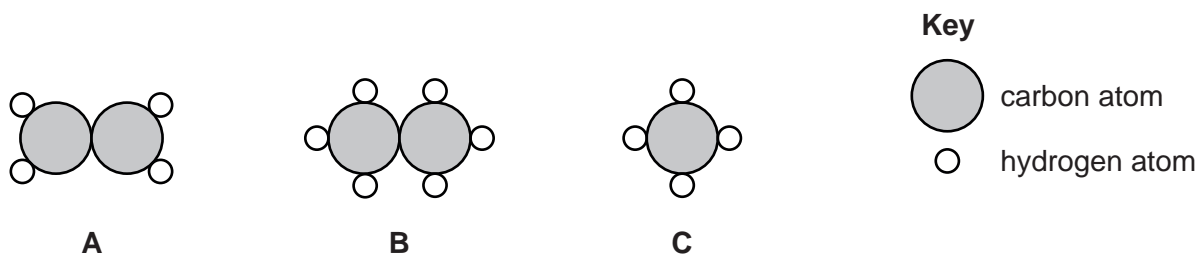
[3]

[Total: 11]



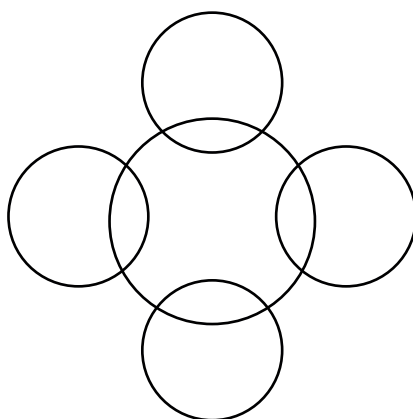
**BLANK PAGE**

5 Fig. 5.1 shows three hydrocarbon molecules, **A**, **B** and **C**.



**Fig. 5.1**

(a) (i) Complete the dot-and-cross diagram of molecule **C**. Show the outer shell electrons only.



[2]

(ii) Molecule **C** is a greenhouse gas.

State the name of **one** other greenhouse gas.

..... [1]

(b) The reaction between molecule **A** and oxygen is exothermic.  
Describe what is meant by an exothermic reaction.

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

(c) State and explain which molecule **A**, **B** or **C** represents a molecule of ethane.

molecule .....

explanation .....

..... [1]

(d) (i) State and explain which molecule **A**, **B** or **C** is unsaturated.

molecule .....

explanation .....

..... [1]

(ii) An orange solution is used to test if a hydrocarbon molecule is unsaturated or saturated.

State the name of this orange solution.

..... [1]

(iii) Describe what is observed when the solution in (ii) is reacted with an unsaturated hydrocarbon molecule.

.....

..... [1]

[Total: 8]



6 (a) Water vapour in the air over the sea comes from liquid water in the sea.

(i) State the name of the process by which liquid water in the sea forms water vapour in the air.

..... [1]

(ii) Describe how the process named in (i) occurs. Use ideas about water molecules in your answer.

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

(b) Fig. 6.1 shows a boat moving at constant speed.

Four forces **A**, **B**, **C** and **D** act on the boat.

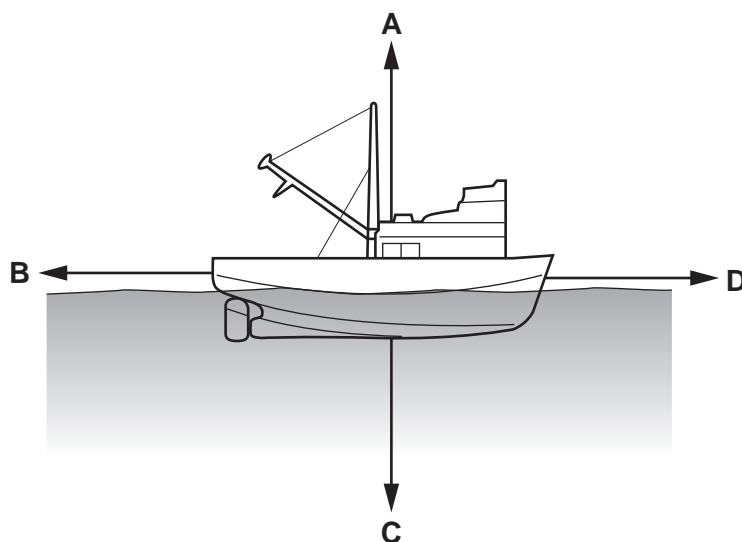
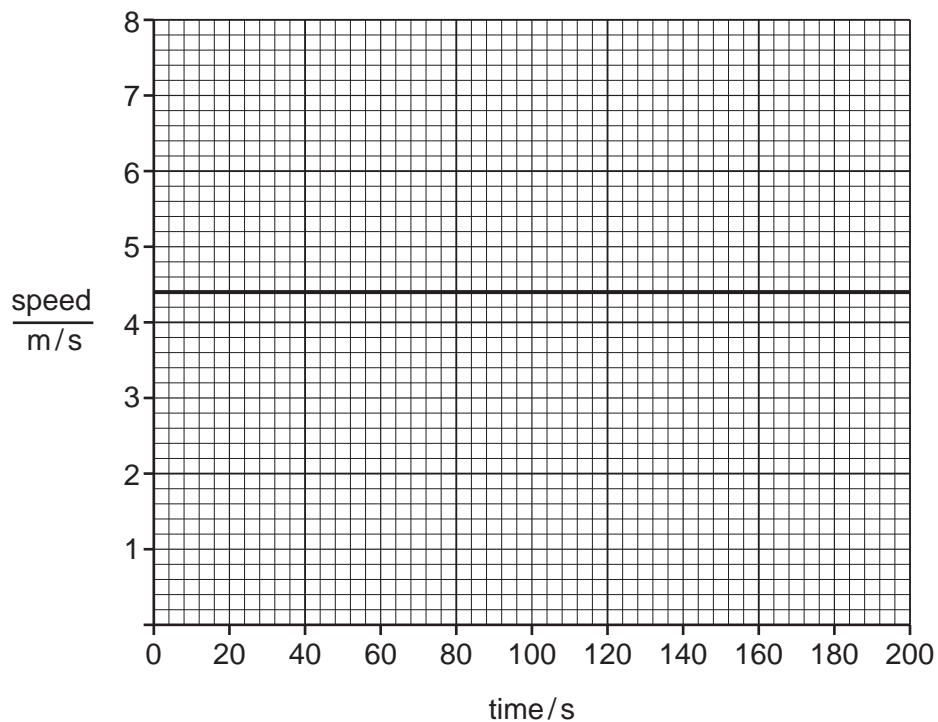


Fig. 6.1

State the name of force **C**.

..... [1]

(c) Fig. 6.2 shows a speed-time graph for the boat.



**Fig. 6.2**

(i) Determine the speed of the boat.

speed = ..... m/s [1]

(ii) Calculate the distance travelled by the boat in 200 s.

distance = ..... m [2]

(d) Fig. 6.3 shows a wave similar to a water wave on the surface of the sea.

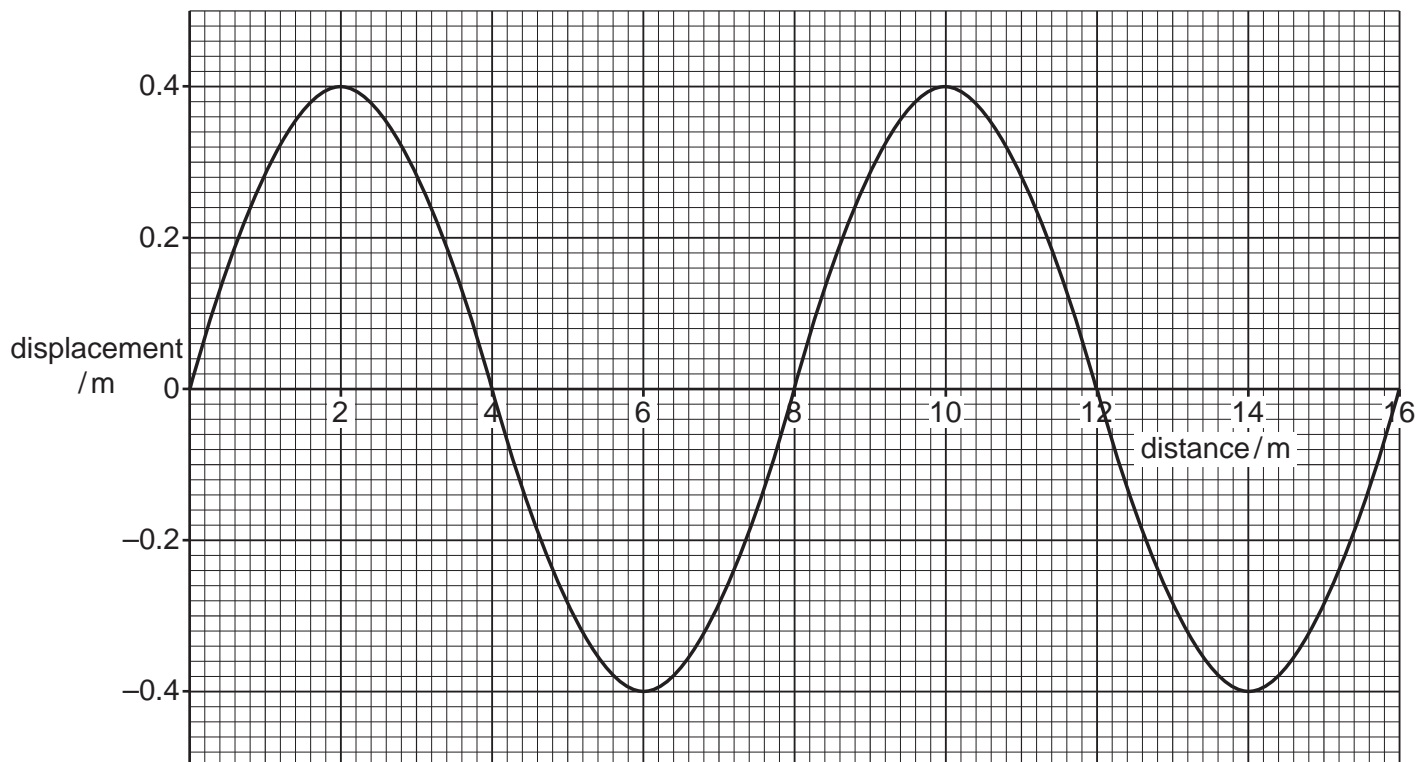


Fig. 6.3

(i) Determine the wavelength of the wave.

wavelength = ..... m [1]

(ii) On Fig. 6.3, indicate with a double headed arrow ( $\updownarrow$  or  $\leftrightarrow$ ) the amplitude of the wave. [1]

(iii) The frequency of the wave is 0.08 Hz.

Calculate how many wavefronts pass a fixed point in 25 seconds.

number of waves = ..... [1]

[Total: 10]

- 7 (a) A student investigates photosynthesis.

The student places four plants **A**, **B**, **C** and **D** in different conditions and records whether they photosynthesise.

Table 7.1 shows her results.

**Table 7.1**

| plant    | conditions    |                     | did the plant photosynthesise? |
|----------|---------------|---------------------|--------------------------------|
|          | light present | chlorophyll present |                                |
| <b>A</b> | ✓             | ✓                   | ✓                              |
| <b>B</b> | ✓             | x                   | x                              |
| <b>C</b> | x             | ✓                   | x                              |
| <b>D</b> | x             | x                   | x                              |

- (i) Use Table 7.1 to state the conditions needed for photosynthesis.

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

- (ii) Each plant is provided with an excess of carbon dioxide.

Explain why.

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

- (iii) State the word equation for photosynthesis.

..... [2]

- (b) State the name of the cell structure where photosynthesis occurs.

..... [1]



(c) Magnesium is an essential mineral needed by plants.

Draw **three** lines to link the boxes and make **three** correct sentences about magnesium ions in plants.

Magnesium ions

are a component of starch in a plant.

are absorbed by the root hairs.

are transported in the xylem.

are required for synthesis of chlorophyll.

enter a plant through the stomata.

provide the energy for photosynthesis.

[3]

(d) State the name of the principal ion required to make amino acids in a plant.

..... [1]

[Total: 10]

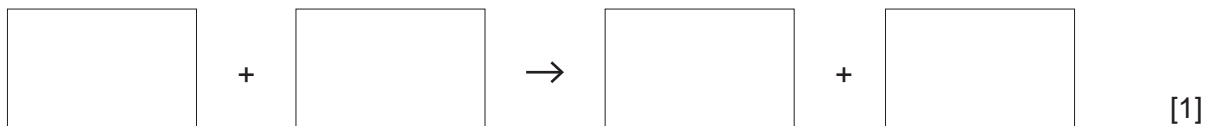
8 (a) An atom of copper has a proton number of 29 and a nucleon number of 63.

(i) State the number of electrons in this copper atom. .... [1]

(ii) State the number of neutrons in this copper atom. .... [1]

(b) Copper oxide is heated with carbon. Copper and carbon dioxide are made.

(i) Write the word equation for this reaction.



(ii) In this reaction, reduction of copper in the copper oxide occurs.

Describe what is meant by the term reduction.

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

(iii) Explain why copper oxide is described as a basic oxide.

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

(c) Copper is a transition element.

Transition elements have high densities, high melting points and high boiling points. They are all metals.

State **one other** property of a transition element.

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

(d) (i) Brass is a mixture of copper and zinc.

State the term used to describe a mixture of metals.

..... [1]

(ii) Brass is more malleable than either copper or zinc.

State the meaning of the term malleable.

..... [1]

(iii) State the symbols of both copper and zinc.

copper symbol .....

zinc symbol .....

[1]

(e) A metal key is covered with a layer of copper by electroplating.

(i) The key is an electrode.

State which electrode is the key.

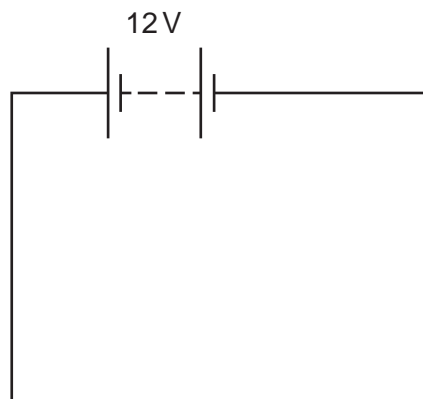
..... [1]

(ii) Suggest a suitable electrolyte for electroplating the key.

..... [1]

[Total: 11]

- 9 (a) A car has two headlamps, connected in parallel, across a 12 V battery. There is one switch in the circuit which controls both lamps.
- (i) Complete the circuit diagram in Fig. 9.1 to show how the two lamps and the switch are connected to the battery.



**Fig. 9.1**

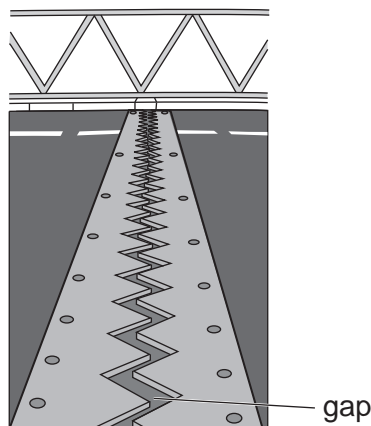
[3]

- (ii) The current passing through each lamp is 4.0 A.  
The potential difference across each lamp is 12 V.  
Calculate the resistance of each lamp.  
State the unit of your answer.

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

(b) The car is crossing a long bridge.

Fig. 9.2 shows a gap in the road surface in the middle of the bridge.



**Fig. 9.2**

On a hot day the temperature of the road surface increases.

(i) State what happens to the gap as the temperature increases.

..... [1]

(ii) Explain why the gap is needed.

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

(c) The driver of the car notices that the sound from the engine is louder and has a higher pitch when the car accelerates up a hill.

(i) State how the amplitude of the sound wave changes when the car accelerates up the hill.

..... [1]

(ii) State how the frequency of the sound wave changes when the car accelerates up the hill.

..... [1]

(iii) The car gains thermal energy as it accelerates up the hill.

State **two other** forms of energy gained by the car as it accelerates up the hill.

1 .....

2 .....

[2]

[Total: 12]

- 10 (a) A researcher collects some information about organisms that live in a desert environment.

Fig. 10.1 is a summary of the information.

Snakes eat desert rats.  
 Desert foxes eat snakes.  
 Desert rats eat cactus.

**Fig. 10.1**

- (i) Construct a food chain from the information given in Fig. 10.1.

..... [2]

- (ii) Table 10.1 contains the names of the organisms from Fig. 10.1 and some of the terms that can be used to describe them.

Complete Table 10.1 by placing ticks (✓) in the boxes to show all the terms that describe each organism. Use only the information given in Fig. 10.1.

One row has been done for you.

**Table 10.1**

| organism   | carnivore | herbivore | producer | secondary consumer |
|------------|-----------|-----------|----------|--------------------|
| cactus     |           |           | ✓        |                    |
| desert fox |           |           |          |                    |
| desert rat |           |           |          |                    |
| snake      |           |           |          |                    |

[3]

- (b) State the name of the type of organisms that get their energy from dead and waste organic matter.

..... [1]

- (c) State the name of the principal source of energy for all food chains.

..... [1]

(d) Nutrition is one of the characteristics of living things.

State the name of **three** other characteristics.

1 .....

2 .....

3 .....

[3]

(e) State the name of the basic building blocks of which all living organisms are made.

..... [1]

[Total: 11]

- 11 (a) Sodium and chlorine are elements.

Sodium chloride is a compound.

Describe what is meant by an element and a compound.

element .....

.....

compound .....

.....

[2]

- (b) Sodium reacts with chlorine to make sodium chloride.

Balance the symbol equation for this reaction.



[1]

- (c) When sodium reacts with chlorine, sodium atoms become sodium ions and chlorine atoms become chloride ions.

The electron configuration of a sodium atom is 2.8.1.

The electron configuration of a chlorine atom is 2.8.7.

State the electron configuration of a sodium ion and a chloride ion.

sodium ion .....

chloride ion .....

[2]

- (d) Describe the difference in the solubility in water of an ionic compound compared with a covalent compound.

.....

.....

[1]

- (e) Sodium chloride contains chloride ions.

Describe the test for chloride ions and state the observation for a positive result.

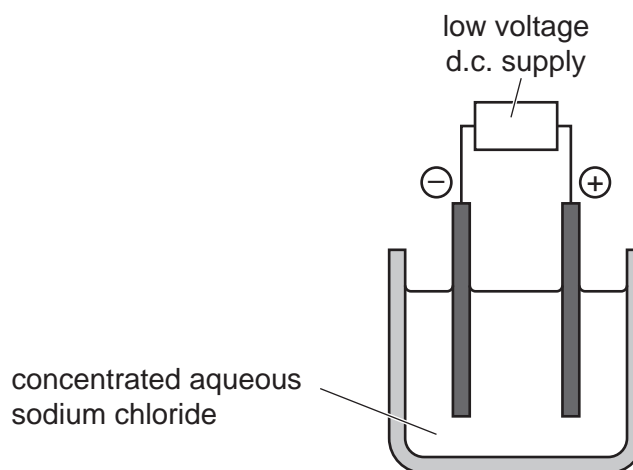
test .....

observation .....

[2]



(f) Fig. 11.1 shows the electrolysis of concentrated aqueous sodium chloride.



**Fig. 11.1**

Complete the sentences about the electrolysis of concentrated aqueous sodium chloride.

Electrolysis is defined as the breakdown of an ionic compound when

..... or in aqueous solution by the passage of .....

The gas released at the negative electrode is ..... and the gas

released at the positive electrode is .....

[4]

[Total: 12]

- 12 (a) A person standing on a warm, sunny beach is exposed to several forms of electromagnetic radiation.

Fig. 12.1 shows part of the electromagnetic spectrum.

Complete Fig. 12.1 by writing the names of the **other two** forms of electromagnetic radiation in the correct places.

|                 |  |             |               |          |  |             |
|-----------------|--|-------------|---------------|----------|--|-------------|
| gamma-radiation |  | ultraviolet | visible light | infrared |  | radio waves |
|-----------------|--|-------------|---------------|----------|--|-------------|

Fig. 12.1

[2]

- (b) The person stands with both feet on some very soft sand on the beach.

When one foot is lifted off the sand, the other foot sinks deeper into the sand.

Explain why this happens.

.....

.....

..... [2]

- (c) A sample of sand has a mass of 8000 kg.

This sand has a density of  $1600 \text{ kg/m}^3$ .

- (i) Calculate the volume of this sample of sand.

volume = .....  $\text{m}^3$  [2]

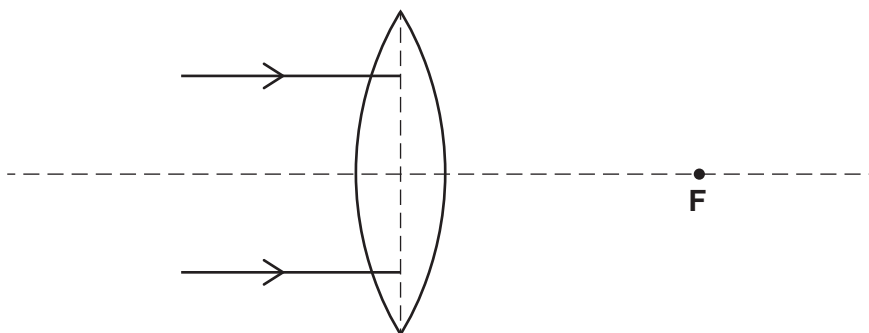
- (ii) Show that the weight of this sample of sand is 80 000 N.

The gravitational field strength,  $g$ , is  $10 \text{ N/kg}$ .

[1]

- (d) A piece of glass has been left on the beach. The glass acts like a convex lens focusing the Sun's rays.

Fig. 12.2 shows two rays of light passing through a convex lens.



**Fig. 12.2**

- (i) Complete the light rays in Fig. 12.2 to show how the light rays are focused by the lens. [1]
- (ii) State the name of point **F**.  
 ..... [1]
- (iii) On Fig. 12.2, draw a double headed arrow ( $\leftrightarrow$ ) to indicate the focal length of the lens. [1]

[Total: 10]

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at [www.cambridgeinternational.org](http://www.cambridgeinternational.org) after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

The Periodic Table of Elements

| Group                             |                                    |                                    |  |                                    |                                     |                                     |                                      |                                      |                                       |
|-----------------------------------|------------------------------------|------------------------------------|--|------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|
| I                                 | II                                 | III                                | IV                                     | V                                  | VI                                  | VII                                 | VIII                                 |                                      |                                       |
| 3<br><b>Li</b><br>lithium<br>7    | 4<br><b>Be</b><br>beryllium<br>9   | 5<br><b>B</b><br>boron<br>11       | 6<br><b>C</b><br>carbon<br>12          | 7<br><b>N</b><br>nitrogen<br>14    | 8<br><b>O</b><br>oxygen<br>16       | 9<br><b>F</b><br>fluorine<br>19     | 10<br><b>Ne</b><br>neon<br>20        |                                      |                                       |
| 11<br><b>Na</b><br>sodium<br>23   | 12<br><b>Mg</b><br>magnesium<br>24 | 13<br><b>Al</b><br>aluminium<br>27 | 14<br><b>Si</b><br>silicon<br>28       | 15<br><b>P</b><br>phosphorus<br>31 | 16<br><b>S</b><br>sulfur<br>32      | 17<br><b>Cl</b><br>chlorine<br>35.5 | 18<br><b>Ar</b><br>argon<br>40       |                                      |                                       |
| 19<br><b>K</b><br>potassium<br>39 | 20<br><b>Ca</b><br>calcium<br>40   | 21<br><b>Sc</b><br>scandium<br>45  | 22<br><b>Ti</b><br>titanium<br>48      | 23<br><b>V</b><br>vanadium<br>51   | 24<br><b>Cr</b><br>chromium<br>52   | 25<br><b>Mn</b><br>manganese<br>55  | 26<br><b>Fe</b><br>iron<br>56        | 27<br><b>Co</b><br>cobalt<br>59      | 28<br><b>Ni</b><br>nickel<br>59       |
| 37<br><b>Rb</b><br>rubidium<br>85 | 38<br><b>Sr</b><br>strontium<br>88 | 39<br><b>Y</b><br>yttrium<br>89    | 40<br><b>Zr</b><br>zirconium<br>91     | 41<br><b>Nb</b><br>niobium<br>93   | 42<br><b>Mo</b><br>molybdenum<br>96 | 43<br><b>Tc</b><br>technetium<br>—  | 44<br><b>Ru</b><br>ruthenium<br>101  | 45<br><b>Rh</b><br>rhodium<br>103    | 46<br><b>Pd</b><br>palladium<br>106   |
| 55<br><b>Cs</b><br>caesium<br>133 | 56<br><b>Ba</b><br>barium<br>137   | 57-71<br>lanthanoids               | 72<br><b>Hf</b><br>hafnium<br>178      | 73<br><b>Ta</b><br>tantalum<br>181 | 74<br><b>W</b><br>tungsten<br>184   | 75<br><b>Re</b><br>rhenium<br>186   | 76<br><b>Os</b><br>osmium<br>190     | 77<br><b>Ir</b><br>iridium<br>192    | 78<br><b>Pt</b><br>platinum<br>195    |
| 87<br><b>Fr</b><br>francium<br>—  | 88<br><b>Ra</b><br>radium<br>—     | 89-103<br>actinoids                | 104<br><b>Rf</b><br>rutherfordium<br>— | 105<br><b>Db</b><br>dubnium<br>—   | 106<br><b>Sg</b><br>seaborgium<br>— | 107<br><b>Bh</b><br>bohrium<br>—    | 108<br><b>Hs</b><br>hassium<br>—     | 109<br><b>Mt</b><br>meitnerium<br>—  | 110<br><b>Ds</b><br>darmstadtium<br>— |
|                                   |                                    |                                    |  |                                    |                                     |                                     | 111<br><b>Rg</b><br>roentgenium<br>— | 112<br><b>Cn</b><br>copernicium<br>— | 114<br><b>Fl</b><br>flerovium<br>—    |
|                                   |                                    |                                    |  |                                    |                                     |                                     | 116<br><b>Lv</b><br>livermorium<br>— | 118<br><b>Og</b><br>oganeson<br>—    |                                       |

1  
**H**  
hydrogen  
1

**Key**  
atomic number  
atomic symbol  
name  
relative atomic mass

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

lanthanoids

actinoids

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