Cambridge Assessment International Education

# Cambridge IGCSE™

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| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | |

*4591423872*

**CHEMISTRY** **0620/33**

Paper 3 Theory (Core) **May/June 2024**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

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

**INFORMATION**

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.



**[Turn over**

**1** Fig. 1.1 shows the structures of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

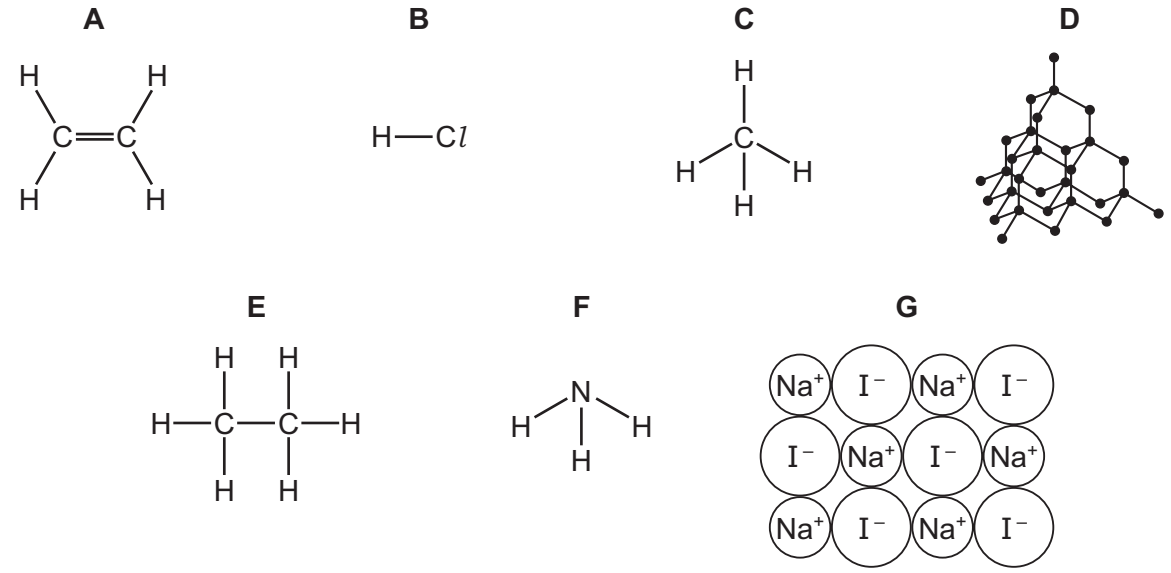



**Fig. 1.1**

**(a)** Answer the following questions using only the structures in Fig. 1.1.
Each structure may be used once, more than once or not at all.

State which structure represents:

**(i)** a compound that is the main constituent of natural gas

..... [1]

**(ii)** the monomer used to produce poly(ethene)

..... [1]

**(iii)** a giant covalent structure

..... [1]

**(iv)** a compound that has a high melting point

..... [1]

**(v)** a waste gas from digestion in animals

..... [1]

**(vi)** a solid at room temperature that conducts electricity when dissolved in water.

..... [1]

**(b)** Complete Fig. 1.2 to show the dot-and-cross diagram for structure **B**.
Show the outer electron shells only.

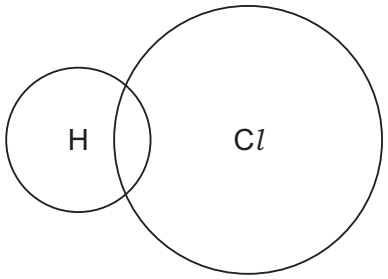



**Fig. 1.2**

[2]

[Total: 8]

**2** **(a)** Intracellular fluid is the solution between the cells in the human body.

Table 2.1 shows the masses, in mg, of some ions in 100 $cm^3$ of intracellular fluid.

**Table 2.1**

| name of ion | formula of ion | mass of ion in 100 $cm^3$ of intracellular fluid / mg |
|---|---|---|
| calcium | $Ca^{2+}$ | 6 |
| chloride | $Cl^-$ | 7 |
| hydrogencarbonate | $HCO_3^-$ | 49 |
| phosphate | $PO_4^{3-}$ | 547 |
| magnesium | $Mg^{2+}$ | 31 |
| potassium | $K^+$ | 624 |
| sodium | $Na^+$ | 23 |
| sulfate | $SO_4^{2-}$ | 96 |

Answer these questions using information from Table 2.1.

**(i)** Name the positive ion that is present in the lowest concentration.

..... [1]

**(ii)** Name the ion that contains an element in Group IV of the Periodic Table.

..... [1]

**(b)** Describe a test for sulfate ions.

test .....

.....

observations .....

.....

[2]

**(c)** Small amounts of ammonium ions and chloride ions are formed in some cells of the body.

State the formula of the compound formed from ammonium ions and chloride ions.

..... [1]

**(d)** Choose from the list the salt that is insoluble in water.

Tick (✓) **one** box.

| | |
|---|---|
| copper(II) nitrate | ☐ |
| lead(II) chloride | ☐ |
| potassium nitrate | ☐ |
| sodium chloride | ☐ |

[1]

**(e)** Table 2.2 shows some properties of the Group I metals.

**Table 2.2**

| metal | hardness / MPa | observations on reaction with water |
|---|---|---|
| lithium | 5.0 | bubbles form very slowly and no flame |
| sodium | 0.69 | bubbles form very slowly and no flame |
| potassium | | bubbles form very rapidly and flame |
| rubidium | 0.22 | |

Use the information in Table 2.2 to:

- predict the hardness of potassium

.....

- describe the observations when rubidium reacts with water.

.....

[2]

**(f)** Sodium reacts with hydrogen to produce sodium hydride, NaH.

Complete the symbol equation for this reaction.

$$2Na + \text{.....} \rightarrow \text{.....}NaH$$

[2]

[Total: 10]

**3** **(a)** Molten calcium bromide is electrolysed.

**(i)** Define the term electrolysis.

.....

..... [2]

**(ii)** Name an inert metal that can be used for the electrodes.

..... [1]

**(iii)** Name the product formed at each electrode.

positive electrode .....

negative electrode .....
[2]

**(b)** Calcium reacts with water. An alkaline solution is produced.

**(i)** Name the ion which causes a solution to be alkaline.

..... [1]

**(ii)** Choose the pH value of an alkaline solution.

Draw a circle around your chosen answer.

**pH 1** **pH 5** **pH 7** **pH 9** [1]

**(iii)** Dilute hydrochloric acid is added to a solution of litmus in alkaline solution until the acid is in excess.

State the colour change of the litmus.

from ..... to ..... [2]

**(c)** Calcium carbonate is added to the blast furnace in the production of iron.
Calcium carbonate breaks down when heated to produce calcium oxide and a gas that turns limewater milky.

**(i)** Name the gas that turns limewater milky.

..... [1]

**(ii)** Name the type of chemical reaction that takes place when calcium carbonate is heated.

..... [1]

[Total: 11]

**4** **(a)** Chlorophyll is a coloured compound found in plants. Chlorophyll is needed for photosynthesis.

**(i)** Complete the word equation for photosynthesis.

| | | | | | | |
|---|---|---|---|---|---|---|
| carbon dioxide | + | water | → | ..... | + | ..... |

[2]

**(ii)** State one **other** condition that is essential for photosynthesis.

..... [1]

**(b)** Several other coloured compounds are found in plant leaves.

A student extracts a mixture of coloured compounds from a plant leaf.

Fig. 4.1 shows the apparatus used to separate the coloured compounds.

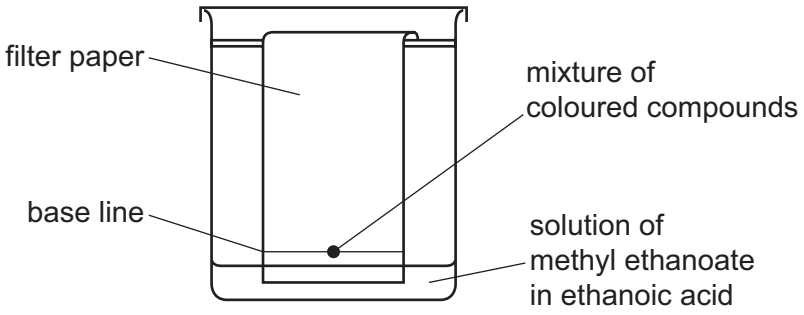



**Fig. 4.1**

**(i)** Name this method of separation.

..... [1]

**(ii)** Suggest why the base line is drawn in pencil and **not** in ink.

..... [1]

**(iii)** The liquid used to separate the coloured compounds is a solution of methyl ethanoate in ethanoic acid.

State the meaning of the term solution.

.....

..... [1]



**[Turn over**

**(c)** Fig. 4.2 shows the displayed formula of a compound found in plant cells.

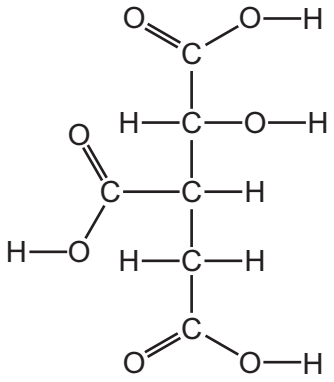


**Fig. 4.2**

On Fig. 4.2, draw a circle around the alcohol functional group. [1]

[Total: 7]

**5** **(a)** An atom of phosphorus is represented by the symbol shown.

$$^{31}_{15}P$$

Describe this atom of phosphorus in terms of:

- the position of the electrons, neutrons and protons in the atom

.....

.....

- the number of neutrons and the number of protons

.....

.....

- the electronic configuration.

.....

[5]

**(b)** Complete the symbol equation for the reaction of phosphorus with oxygen.

$$.....P + .....O_2 \rightarrow P_4O_{10}$$ [2]

**(c)** Fig. 5.1 shows the displayed formula of a compound of phosphorus.

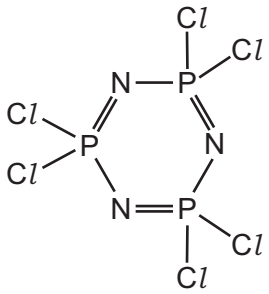



**Fig. 5.1**

Deduce the molecular formula of this compound.

..... [1]

**(d)** Another compound of phosphorus has the formula $Na_3PO_4$.

Complete Table 5.1 to calculate the relative formula mass of $Na_3PO_4$.

**Table 5.1**

| type of atom | number of atoms | relative atomic mass | |
|---|---|---|---|
| sodium | 3 | 23 | $3 \times 23 = 69$ |
| phosphorus | | 31 | |
| oxygen | | 16 | |

relative formula mass = ..... [2]

**(e)** Phosphates in rivers can cause deoxygenation of water.

State **one** source of phosphates in river water.

..... [1]

[Total: 11]

**6** Dilute hydrochloric acid reacts with small pieces of calcium carbonate.

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

**(a)** State the meaning of the state symbol (aq).

..... [1]

**(b)** Fig. 6.1 shows how the mass of small pieces of calcium carbonate changes as the reaction proceeds. The calcium carbonate is in excess.

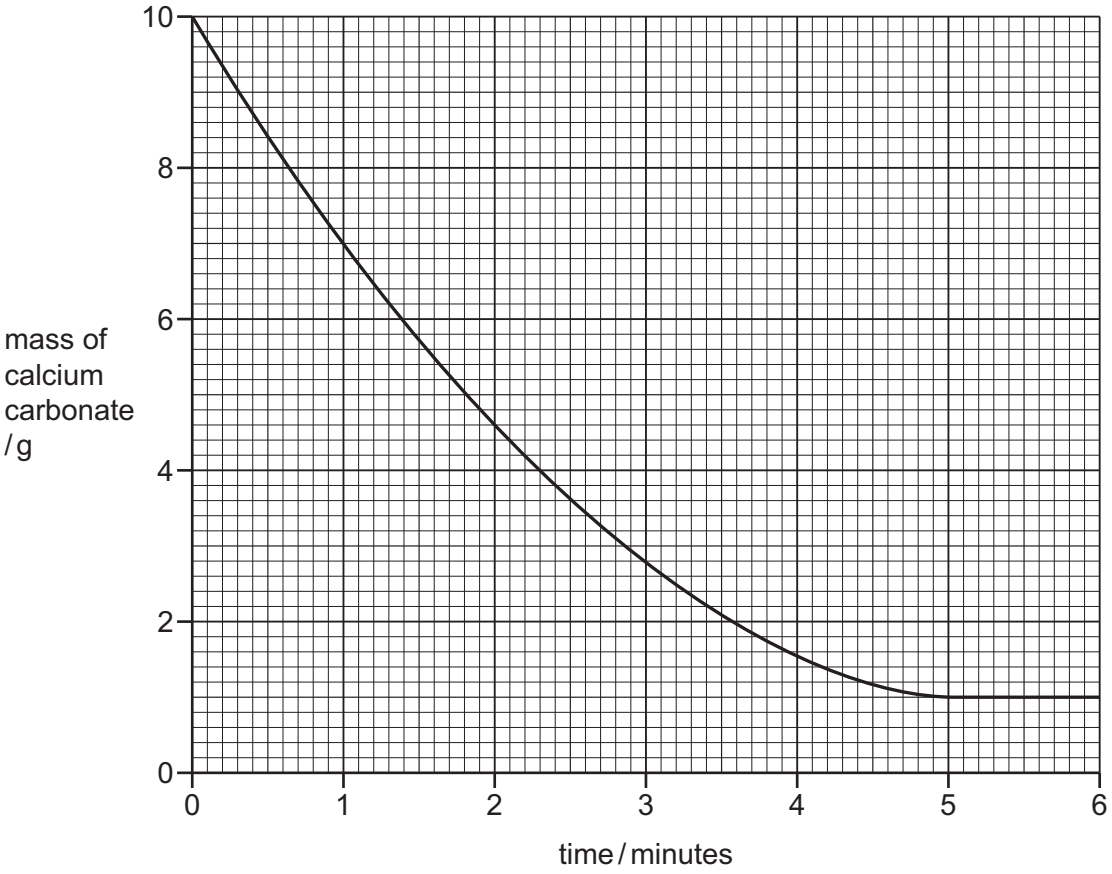



**Fig. 6.1**

**(i)** Deduce the mass of calcium carbonate two minutes from the start of the reaction.

..... [1]

**(ii)** Explain how the graph shows that the calcium carbonate is in excess.

..... [1]

**(iii)** The experiment is repeated at a higher temperature.

All other conditions stay the same.

Draw a line on Fig. 6.1 to show how the mass of calcium carbonate changes at a higher temperature as the time increases. [2]

**(c) (i)** Describe the effect, if any, on the rate of reaction when large pieces of calcium carbonate are used instead of small pieces of calcium carbonate.

All other conditions stay the same.

..... [1]

**(ii)** Increasing the concentration of dilute hydrochloric acid increases the rate of reaction of dilute hydrochloric acid with calcium carbonate.

Choose the correct unit of concentration from the list.

Draw a circle around your chosen answer.

**$dm^3/g$** **$g/dm^2$** **$mol/dm$** **$mol/dm^3$** [1]

**(d)** Concentrated hydrochloric acid gives off hydrogen chloride gas.
Hydrogen chloride is an acidic gas that turns damp universal indicator paper red.

A long glass tube is set up as shown in Fig. 6.2.

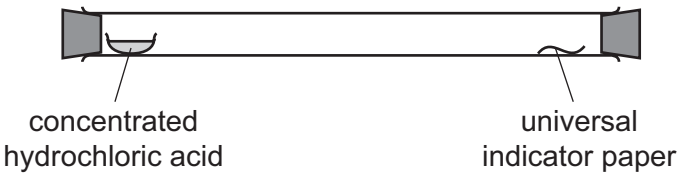



**Fig. 6.2**

At first, the universal indicator paper does not change colour.
The universal indicator paper turns red after a short time.

Explain these results in terms of kinetic particle theory.

.....

.....

.....

..... [3]

**(e)** Hydrogen chloride breaks down to form hydrogen and chlorine at 1500 °C.
The reaction in endothermic.

State the meaning of the term endothermic.

..... [1]

[Total: 11]

**7** Chromium and iron are transition elements. They are ductile and have high melting and boiling points.

**(a)** State three **other** physical properties of chromium.

1 .....

2 .....

3 .....

[3]

**(b)** The formula for rust is $Fe_2O_3 \cdot xH_2O$.

**(i)** State the chemical name of rust.

..... [2]

**(ii)** An iron object is coated with plastic.

Explain how this prevents the iron from rusting.

.....

..... [2]

**(c)** Chromium behaves as a typical metal when it reacts with sulfuric acid.

Complete the word equation for this reaction.

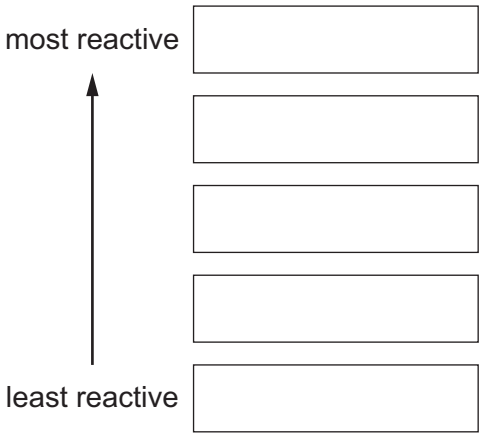
| | | | | | | |
|---|---|---|---|---|---|---|
| chromium | + | sulfuric acid | → | ..... ..... | + | ..... |

[2]

**(d)** The list shows five metals.

**aluminium calcium copper iron zinc**

Put these metals in order of their reactivity.
Put the most reactive metal at the top.




[2]

**(e)** Zinc can be produced by heating zinc oxide with carbon.

$$ZnO + C \rightarrow Zn + CO$$

Describe how this equation shows that zinc oxide is reduced.

.....

..... [1]

[Total: 12]

**8** This question is about hydrocarbons.

**(a)** Table 8.1 shows the names, formulae and boiling points of methane, ethane, propane and butane.

**Table 8.1**

| name | formula | boiling point / °C |
|---|---|---|
| methane | $CH_4$ | –164 |
| ethane | $C_2H_6$ | –88 |
| propane | $C_3H_8$ | –42 |
| butane | $C_4H_{10}$ | 0 |

Use the information in Table 8.1 to answer these questions.

**(i)** Name the homologous series that includes methane, ethane, propane and butane.

..... [1]

**(ii)** State the trend in the boiling point of this homologous series as the number of carbon atoms increases.

..... [1]

**(iii)** Deduce the general formula of this homologous series.

..... [1]

**(b)** Complete the word equation for the complete combustion of ethane.

| | | | | | | |
|---|---|---|---|---|---|---|
| ethane | + | oxygen | → | ..... | + | .....<br>..... |

[2]

**(c)** Long-chain hydrocarbons can be cracked to produce alkenes and hydrogen.

**(i)** State **two** conditions for cracking.

1 .....

2 .....
[2]

**(ii)** The diesel oil fraction from the fractional distillation of petroleum can be used for cracking.

Give one **other** use of the diesel oil fraction.

..... [1]

**(d)** Alkene molecules can react together to produce polymers.

Define the term polymer.

.....

..... [2]

[Total: 10]

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## The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | | | | | | | | | | | III | IV | V | VI | VII | VIII |
| | | | | | | | 1 H hydrogen 1 | | | | | | | | | | 2 He helium 4 |
| 3 Li lithium 7 | 4 Be beryllium 9 | | | | | | | | | | | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 |
| 11 Na sodium 23 | 12 Mg magnesium 24 | | | | | | | | | | | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 |
| 19 K potassium 39 | 20 Ca calcium 40 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium – | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 |
| 55 Cs caesium 133 | 56 Ba barium 137 | 57–71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89–103 actinoids | 104 Rf rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | 113 Nh nihonium – | 114 Fl flerovium – | 115 Mc moscovium – | 116 Lv livermorium – | 117 Ts tennessine – | 118 Og oganesson – |

**Key**

atomic number
atomic symbol
name
relative atomic mass

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

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).