



## Cambridge IGCSE™

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

Paper 3 Theory (Core)

**October/November 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.



1 Fig. 1.1 shows part of the Periodic Table.

| I II |    | III IV V VI VII VIII |  |    |    |  |  |    |    |
|------|----|----------------------|--|----|----|--|--|----|----|
|      |    |                      |  |    |    |  |  | H  | He |
| Li   |    |                      |  |    |    |  |  |    | Ne |
|      |    |                      |  |    |    |  |  | Al |    |
| K    | Ca |                      |  | Cr | Fe |  |  | Zn |    |
| Rb   |    |                      |  |    |    |  |  | Ag | I  |
|      |    |                      |  |    |    |  |  | Au |    |

Fig. 1.1

- (a) Answer the following questions using only the elements in Fig. 1.1.  
Each symbol of the element may be used once, more than once or not at all.

Give the symbol of the element that:

- (i) is in brass

..... [1]

- (ii) produces an orange-red colour in a flame test

..... [1]

- (iii) is a reactant in a fuel cell

..... [1]

- (iv) has an atom with only three occupied electron shells

..... [1]

- (v) forms an ion that gives a red-brown precipitate on addition of aqueous ammonia

..... [1]

- (vi) forms an ion with a charge of 1–.

..... [1]

- (b) Explain why Li, K and Rb have similar chemical properties.

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

[Total: 8]



2 Oxygen, water and ethene have simple molecular structures.

(a) (i) State the percentage of oxygen in clean, dry air.

..... [1]

(ii) Complete Fig. 2.1 to show the dot-and-cross diagram for a molecule of water.  
Show outer shell electrons only.

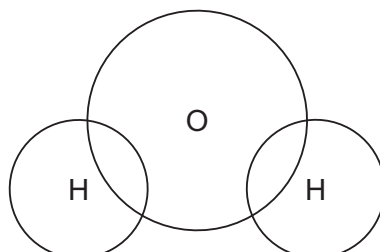


Fig. 2.1

[2]

(iii) Ethene is a small molecule used to make polymers.

State the name of the polymer formed from ethene.

..... [1]

(iv) Complete this sentence about polymers.

Polymers are large molecules built up from many smaller molecules called

..... [1]

(b) Potassium chloride is an ionic compound.

(i) State **two** physical properties of ionic compounds.

1 .....

2 ..... [2]

(ii) Choose the correct statement that describes ionic bonding.

Tick (✓) **one** box.

It is a weak electrostatic attraction between anions and cations.

☐

It is a weak electrostatic attraction between cations.

☐

It is a strong electrostatic attraction between anions.

☐

It is a strong electrostatic attraction between cations and anions.

☐

[1]

[Total: 8]





3 (a) The list shows some gases in a sample of water.

Choose from the list the gas that is essential for aquatic life.

Draw a circle around your chosen answer.

argon      hydrogen      nitrogen      oxygen

[1]

(b) Polluted water contains harmful substances.

Link each harmful substance on the left to the correct effect on the right.  
One has been done for you.

| harmful substance                            |  | effect                                        |
|----------------------------------------------|--|-----------------------------------------------|
| plastics                                     |  | are toxic to aquatic organisms                |
| metal compounds such as mercury(II) chloride |  | contains harmful microbes which cause disease |
| sewage                                       |  | harm aquatic life when eaten                  |
| nitrates                                     |  | lead to deoxygenation of water                |

[1]





**Question 3 continues on the next page.**





(c) Table 3.1 shows the masses of ions, in mg, present in a  $1000\text{ cm}^3$  sample of polluted water.

**Table 3.1**

| name of ion       | formula of ion      | mass of ion in $1000\text{ cm}^3$ of polluted water / mg |
|-------------------|---------------------|----------------------------------------------------------|
| bromide           | $\text{Br}^-$       | 0.1                                                      |
| calcium           | $\text{Ca}^{2+}$    | 2.0                                                      |
| chloride          | $\text{Cl}^-$       | 3.5                                                      |
| hydrogencarbonate | $\text{HCO}_3^-$    | 12.0                                                     |
| magnesium         | $\text{Mg}^{2+}$    | 0.8                                                      |
| mercury           | $\text{Hg}^{2+}$    | 0.3                                                      |
| nitrate           | $\text{NO}_3^-$     | 0.4                                                      |
| phosphate         | $\text{PO}_4^{3-}$  | 2.0                                                      |
| potassium         | $\text{K}^+$        | 6.4                                                      |
| silicate          | $\text{SiO}_3^{2-}$ | 4.0                                                      |
| sodium            | $\text{Na}^+$       | 10.2                                                     |
|                   | $\text{SO}_4^{2-}$  | 0.5                                                      |
| tin               | $\text{Sn}^{2+}$    | 0.2                                                      |

Answer these questions using the information from Table 3.1.

(i) Name the positive ion that has the lowest concentration.

..... [1]

(ii) State the name of the  $\text{SO}_4^{2-}$  ion.

..... [1]

(iii) Calculate the mass of potassium ions in  $125\text{ cm}^3$  of polluted water.

mass = ..... mg [1]





- (d) Name **two** substances used in the treatment of the domestic water supply.  
For each substance give a reason for its use.

substance 1 .....

reason .....

substance 2 .....

reason .....

[4]

- (e) Complete the symbol equation for the reaction of silicon(IV) chloride,  $\text{SiCl}_4$ , with water.



[Total: 11]





4 (a) Fig. 4.1 shows the displayed formula of compound **A**.

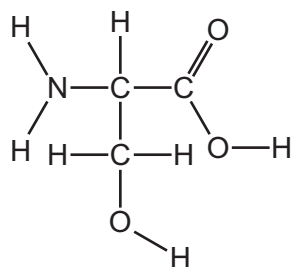


Fig. 4.1

(i) On Fig 4.1 draw a circle around the carboxylic acid functional group. [1]

(ii) Deduce the molecular formula of compound **A**.

..... [1]

(b) Compound **A** reacts with ethanol to produce a compound with the molecular formula  $C_5H_{11}NO_3$ .

Complete Table 4.1 to calculate the relative molecular mass of  $C_5H_{11}NO_3$ .

Table 4.1

| type of atom | number of atoms | relative atomic mass |                    |
|--------------|-----------------|----------------------|--------------------|
| carbon       | 5               | 12                   | $5 \times 12 = 60$ |
| hydrogen     |                 | 1                    |                    |
| nitrogen     |                 | 14                   |                    |
| oxygen       |                 | 16                   |                    |

relative molecular mass = ..... [2]





**Question 4 continues on the next page.**





- (c) Table 4.2 shows the names, formulae and boiling points of methanol, ethanol, propanol and butanol.

Table 4.2

| name     | formula                          | boiling point<br>/ °C |
|----------|----------------------------------|-----------------------|
| methanol | CH <sub>3</sub> OH               | 65                    |
| ethanol  | C <sub>2</sub> H <sub>5</sub> OH | 79                    |
| propanol | C <sub>3</sub> H <sub>7</sub> OH | 98                    |
| butanol  | C <sub>4</sub> H <sub>9</sub> OH | 117                   |

Use the information in Table 4.2 to answer these questions.

- (i) Name the homologous series that includes methanol, ethanol, propanol and butanol.

..... [1]

- (ii) Deduce the general formula of this homologous series.

..... [1]

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

..... [1]

- (d) Ethanol can be manufactured by an addition reaction.

- (i) Name **two** substances and state **two** conditions required.

substance 1 .....

substance 2 .....

condition 1 .....

condition 2 .....

[4]





(ii) Draw the displayed formula of ethanol.

[1]

(iii) Name the toxic gas produced when ethanol undergoes incomplete combustion.

..... [1]

[Total: 13]





5 (a) Table 5.1 shows some properties of five halogens.

Table 5.1

| halogen  | melting point<br>in °C | boiling point<br>in °C | atomic volume<br>in cm <sup>3</sup> /mol |
|----------|------------------------|------------------------|------------------------------------------|
| fluorine | −220                   | −188                   |                                          |
| chlorine | −101                   | −35                    | 22.7                                     |
| bromine  | −7                     | +59                    | 25.6                                     |
| iodine   | +114                   | +184                   | 25.8                                     |
| astatine |                        | +337                   | 32.8                                     |

Use the information in Table 5.1 to predict:

- (i) the melting point of astatine ..... [1]
- (ii) the atomic volume of fluorine ..... [1]
- (iii) the physical state of fluorine at −240 °C. Give a reason for your answer.

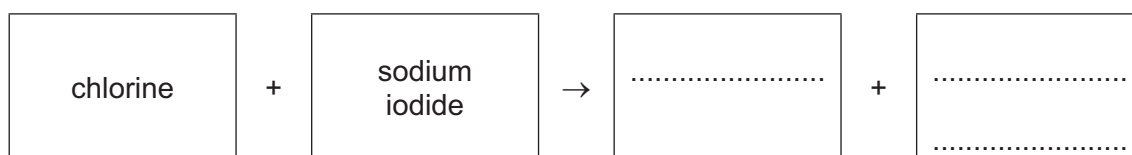
physical state .....

reason .....

..... [2]

(b) Aqueous chlorine reacts with aqueous sodium iodide.

- (i) Complete the word equation for this reaction.



[2]

- (ii) Explain why aqueous bromine does **not** react with aqueous sodium chloride.

..... [1]





- (c) Fluorine reacts with water to produce hydrogen fluoride and oxygen.

Complete the symbol equation for this reaction.



- (d) Name an anhydrous compound used to test for water.  
State the colour of the compound after water is added.

name of compound .....

colour after water is added ..... [2]

[Total: 11]





6 This question is about metals.

(a) Metals are malleable and ductile.

State three **other** typical physical properties of metals.

1 .....

2 .....

3 .....

[3]

(b) (i) Complete Table 6.1 to show the number of electrons, neutrons and protons in the calcium atom and copper ion shown.

Table 6.1

|                            | number of<br>electrons | number of<br>neutrons | number of<br>protons |
|----------------------------|------------------------|-----------------------|----------------------|
| $^{48}_{20}\text{Ca}$      | 20                     |                       |                      |
| $^{65}_{29}\text{Cu}^{2+}$ |                        | 36                    |                      |

[3]

(ii) Write the electronic configuration of the calcium atom.

..... [1]

(c) Copper is a transition element.

Choose the correct statement about transition elements.

Tick (✓) **one** box.

They have low densities.

☐

They often act as catalysts.

☐

They have low melting points.

☐

All their compounds are white.

☐

[1]



(d) Table 6.2 shows the observations when four different metals react with concentrated nitric acid.

**Table 6.2**

| metal     | observations with concentrated nitric acid |
|-----------|--------------------------------------------|
| calcium   | brown gas produced very rapidly            |
| copper    | brown gas produced slowly                  |
| manganese | brown gas produced rapidly                 |
| niobium   | no brown gas seen                          |

Put the four metals in order of their reactivity.  
Put the least reactive metal first.

least reactive  $\longrightarrow$  most reactive

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

[2]

(e) Manganese(IV) oxide is reduced by aluminium.



Explain how this equation shows that manganese(IV) oxide is reduced.

..... [1]

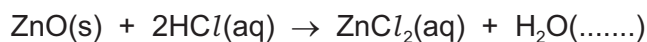
[Total: 11]





7 This question is about acids, bases and salts.

- (a) Crystals of zinc chloride can be made by warming excess solid zinc oxide with dilute hydrochloric acid.



- (i) Complete the symbol equation by adding the state symbol for water at room temperature. [1]

- (ii) State the method used to separate the excess solid zinc oxide from the reaction mixture. [1]

.....

- (iii) Describe how to make dry crystals of zinc chloride from an aqueous solution of zinc chloride. [2]

.....

.....

.....

.....

- (b) Choose from the list the ion that is present in all acids.

Draw a circle around your chosen answer.

$\text{Cl}^-$        $\text{H}^+$        $\text{O}^{2-}$        $\text{OH}^-$  [1]



(c) The reaction of zinc oxide with hydrochloric acid is exothermic.

(i) Define the term exothermic.

..... [1]

(ii) Fig. 7.1 shows the incomplete reaction pathway diagram for the reaction of zinc oxide with hydrochloric acid.

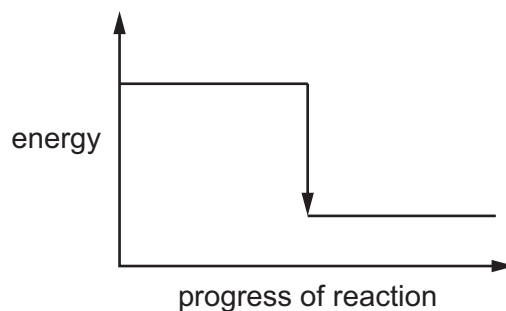


Fig. 7.1

Complete Fig. 7.1 by writing these formulae on the diagram:

- $\text{ZnO} + 2\text{HCl}$
- $\text{ZnCl}_2 + \text{H}_2\text{O}$ .

[1]

(iii) Explain how Fig. 7.1 shows that the reaction is exothermic.

..... [1]

(d) Litmus is an acid–base indicator.

State the colour of litmus at pH 2 and at pH 12.

colour at pH 2 .....

colour at pH 12 .....

[2]

[Total: 10]





- 8 (a) A student investigates the reaction of small pieces of magnesium oxide with excess dilute hydrochloric acid of three different concentrations.  
The time taken for each reaction to finish is recorded.

The three concentrations of the acid are:

- $0.4 \text{ mol/dm}^3$
- $0.8 \text{ mol/dm}^3$
- $1.6 \text{ mol/dm}^3$ .

All other conditions stay the same.

Table 8.1 shows the time taken for each reaction to finish.

**Table 8.1**

| concentration of<br>dilute hydrochloric acid<br>in $\text{mol/dm}^3$ | time taken for the<br>reaction to finish<br>in s |
|----------------------------------------------------------------------|--------------------------------------------------|
|                                                                      | 160                                              |
|                                                                      | 80                                               |
|                                                                      | 320                                              |

- (i) Complete Table 8.1 by writing the concentrations in the first column. [1]
- (ii) Describe the effect on the time taken for the reaction to finish when the reaction is carried out at a lower temperature.

All other conditions stay the same.

..... [1]

- (iii) Describe the effect on the time taken for the reaction to finish when large pieces of magnesium oxide are used instead of small pieces of magnesium oxide.

All other conditions stay the same.

..... [1]





(b) Molten magnesium chloride is electrolysed using inert electrodes.

(i) Name the products at the positive and negative electrodes.

product at the positive electrode .....

product at the negative electrode .....

[2]

(ii) Describe the arrangement, motion and separation of the particles in liquid magnesium chloride.

arrangement .....

.....

motion .....

.....

separation .....

.....

[3]

[Total: 8]

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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       | 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>— | 113<br>Nh<br>nihonium<br>—  | 114<br>Fl<br>flerovium<br>— | 115<br>Mc<br>moscovium<br>—  | 116<br>Lv<br>livermorium<br>— | 117<br>Ts<br>tennessine<br>— | 118<br>Og<br>oganesson<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 dm³ at room temperature and pressure (r.t.p.).

