



## Cambridge IGCSE™

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## CHEMISTRY

0620/43

Paper 4 Theory (Extended)

October/November 2025

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 **16** pages. Any blank pages are indicated.

- 1 Atoms and ions are made from particles called electrons, neutrons and protons.

(a) Complete Table 1.1.

Table 1.1

| particle | relative charge | relative mass    |
|----------|-----------------|------------------|
| electron | -1              | $\frac{1}{1840}$ |
| neutron  |                 |                  |
| proton   |                 |                  |

[2]

- (b) Table 1.2 shows information about some atoms or ions.

Complete Table 1.2.

Table 1.2

| atom or ion                  | number of electrons | number of neutrons | number of protons |
|------------------------------|---------------------|--------------------|-------------------|
| ${}^{40}_{20}\text{Ca}^{2+}$ |                     | 20                 | 20                |
| ${}^{19}_9\text{F}$          | 9                   |                    | 9                 |
|                              | 10                  | 9                  | 8                 |

[5]

- (c) (i) The relative atomic mass,  $A_r$ , of an element is the average mass of its isotopes compared to one atom of isotope X.

Identify isotope X.

..... [1]

- (ii) A sample of magnesium consists of two isotopes with mass numbers 24 and 26. [ $A_r$ : Mg, 24.3]

Calculate the percentage abundance of the isotope of magnesium with mass number 24.

percentage abundance = ..... [1]

[Total: 9]



- 2 Table 2.1 shows the melting points, boiling points and electrical conductivities of seven substances, **A, B, C, D, E, F** and **G**.

Table 2.1

| substance | melting point /°C | boiling point /°C | electrical conductivity when solid | electrical conductivity when molten |
|-----------|-------------------|-------------------|------------------------------------|-------------------------------------|
| <b>A</b>  | 1600              | 2230              | poor                               | poor                                |
| <b>B</b>  | -219              | -183              | poor                               | poor                                |
| <b>C</b>  | 770               | 1420              | poor                               | good                                |
| <b>D</b>  | -39               | 357               | good                               | good                                |
| <b>E</b>  | -7                | 58                | poor                               | poor                                |
| <b>F</b>  | 44                | 280               | poor                               | poor                                |
| <b>G</b>  | 1085              | 2562              | good                               | good                                |

- (a) Identify which substance, **A, B, C, D, E, F** or **G**, is:

- (i) a gas at 25 °C

..... [1]

- (ii) a solid consisting of simple molecules at 25 °C

..... [1]

- (iii) a metal which is liquid at 25 °C.

..... [1]

- (b) (i) Identify which substance, **A, B, C, D, E, F** or **G**, has a giant covalent structure.

Use the information in Table 2.1 to give **two** reasons for your choice.

substance .....

reason 1 .....

reason 2 ..... [3]

- (ii) Identify which substance, **A, B, C, D, E, F** or **G**, is an ionic compound.

Use the information in Table 2.1 to give **one** reason for your choice.

substance .....

reason ..... [2]

[Total: 8]



3 This question is about aluminium and other metallic elements.

- (a) Aluminium is extracted from purified bauxite by electrolysis. Fig. 3.1 shows a diagram of the electrolytic cell used.

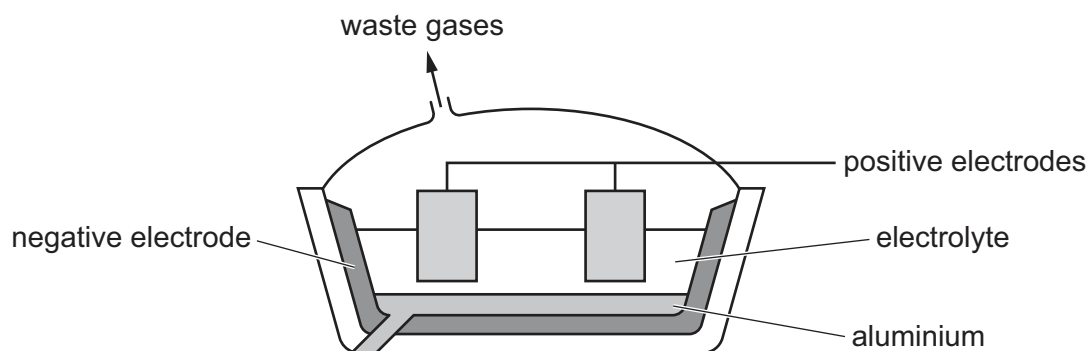


Fig. 3.1

- (i) State the name of the aluminium compound present in bauxite.

..... [1]

- (ii) Name the substance that purified bauxite is dissolved in before electrolysis is carried out.

..... [1]

- (iii) Name the substance that is used for the positive electrodes.

..... [1]

- (iv) Write the ionic half-equation for the production of aluminium at the negative electrode.

..... [2]

- (b) Aluminium is above zinc in the reactivity series.

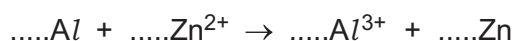
- (i) When a piece of aluminium foil is added to aqueous zinc sulfate, a reaction is **not** immediately observed even though aluminium is above zinc in the reactivity series.

Explain why a reaction is **not** immediately observed.

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

- (ii) After a few minutes, a displacement reaction occurs between aluminium and aqueous zinc ions.

Complete the ionic equation for this reaction.



[1]



(iii) State the oxidation number of zinc in:

$\text{Zn}^{2+}$  .....

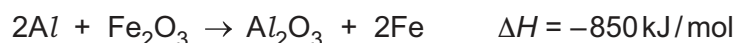
$\text{Zn}$  .....

[2]

(iv) Define the term reduction in terms of oxidation number.

..... [1]

(c) Aluminium reacts with iron(III) oxide. The equation is shown.



(i) State the meaning of the symbol  $\Delta H$ .

..... [1]

(ii) State what can be deduced about the reaction from the negative sign in  $\Delta H = -850 \text{ kJ/mol}$ .

..... [1]

(d) Gallium has many similarities to aluminium. Gallium(III) oxide is an amphoteric oxide.

State what is meant by the term amphoteric.

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

(e) The reaction of gallium(III) oxide,  $\text{Ga}_2\text{O}_3$ , with aqueous sodium hydroxide forms a salt which contains the negative ion  $\text{GaO}_2^-$ . The only other product is water.

Write a symbol equation for this reaction.

..... [2]

(f) Deduce the formula of:

• gallium(III) bromide .....

• gallium(III) sulfate. ....

[2]

[Total: 17]

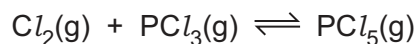




4 This question is about chlorine and compounds of chlorine.

- (a) Gaseous chlorine reacts with gaseous phosphorus(III) chloride to form gaseous phosphorus(V) chloride. The reaction is a reversible reaction.

When the three gases are in a closed container the system reaches equilibrium.



- (i) Describe a reversible reaction at equilibrium in terms of:

- the rate of the forward reaction and the rate of the reverse reaction

.....

- the concentrations of reactants and products.

.....

[2]

- (ii) Complete Table 4.1 using only the words **increases**, **decreases** or **no change**.

Table 4.1

| change to condition       | effect on the rate of the forward reaction | effect on the equilibrium concentration of $\text{PCl}_5$ |
|---------------------------|--------------------------------------------|-----------------------------------------------------------|
| the pressure is decreased |                                            |                                                           |
| a catalyst is added       | increases                                  |                                                           |

[3]

- (iii) When the temperature of the equilibrium mixture is increased, the equilibrium concentration of  $\text{PCl}_5$  decreases.

State what conclusion about the forward reaction can be made from this information.

..... [1]



(b) Ethene,  $C_2H_4$ , reacts with chlorine,  $Cl_2$ , to form 1,2-dichloroethane,  $CH_2ClCH_2Cl$ .

The equation for this reaction can be represented as shown.

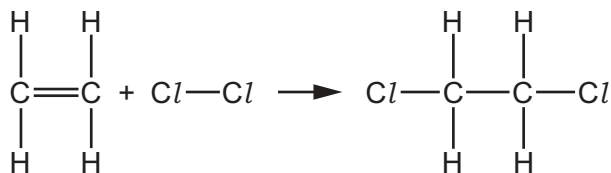


Table 4.2 shows some bond energies.

Table 4.2

| bond  | bond energy<br>in kJ/mol |
|-------|--------------------------|
| C–C   | 350                      |
| C=C   | 610                      |
| C–H   | 410                      |
| Cl–Cl | 240                      |
| C–Cl  | 340                      |

Use the bond energies in Table 4.2 to calculate the enthalpy change, in kJ/mol, of the reaction.

Use the following steps.

- Calculate the total energy needed to break the bonds in  $C_2H_4$  and  $Cl_2$ .

.....kJ

- Calculate the total energy released when the bonds form in  $CH_2ClCH_2Cl$ .

.....kJ



- Calculate the enthalpy change of the reaction.  
Your answer should include a sign.

..... kJ/mol  
[3]

- (c) Chlorine reacts with nitrogen to form nitrogen trichloride,  $\text{NCl}_3$ .

Complete the dot-and-cross diagram in Fig. 4.1 of a molecule of  $\text{NCl}_3$ .

Show outer shell electrons only.

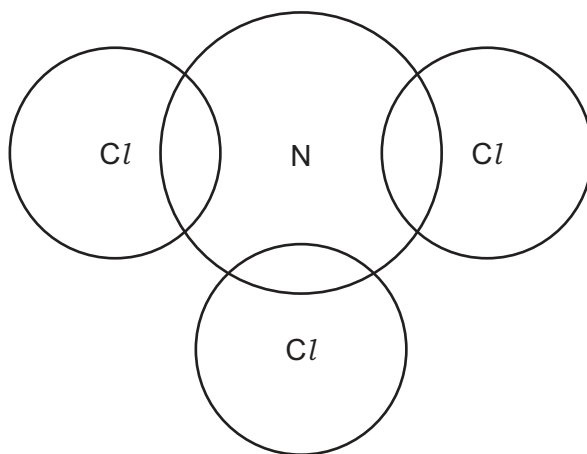


Fig. 4.1

[3]



- (d) When solid magnesium carbonate,  $\text{MgCO}_3$ , is added to dilute hydrochloric acid,  $\text{HCl}$ , a chemical reaction occurs. The equation for the reaction is shown.



- (i) Give **two** observations when solid magnesium carbonate is added to dilute hydrochloric acid.

1 .....

2 ..... [2]

- (ii) Calculate the volume, in  $\text{cm}^3$ , of  $\text{CO}_2(\text{g})$  that is produced at room temperature and pressure (r.t.p.) when  $50.0\text{ cm}^3$  of  $0.100\text{ mol/dm}^3$   $\text{HCl}$  reacts with excess  $\text{MgCO}_3$ .

The volume of 1 mol of any gas is  $24\,000\text{ cm}^3$  at r.t.p.

Use the following steps.

- Calculate the number of moles of  $\text{HCl}$  in  $50.0\text{ cm}^3$  of  $0.100\text{ mol/dm}^3$   $\text{HCl}$ .

..... mol

- Deduce the number of moles of  $\text{CO}_2(\text{g})$  produced.

..... mol

- Calculate the volume, in  $\text{cm}^3$ , of  $\text{CO}_2(\text{g})$  produced at r.t.p.

.....  $\text{cm}^3$   
[3]

[Total: 17]



5 This question is about metallic compounds.

(a) Insoluble metal salts, such as lead(II) sulfate, are made by precipitation.

When aqueous lead(II) ions react with aqueous sulfate ions, a precipitate of lead(II) sulfate forms.

A sample of pure lead(II) sulfate can be obtained from the precipitate formed.

(i) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(ii) State the name of an aqueous solution containing lead(II) ions.

..... [1]

(iii) State the name of an aqueous solution containing sulfate ions.

..... [1]

(iv) The lead(II) sulfate precipitate is separated from the rest of the reaction mixture by filtration. The impure lead(II) sulfate remains on the filter paper.

State the general term given to an insoluble substance that remains on the filter paper during filtration.

..... [1]

(v) Describe how the lead(II) sulfate is purified after filtration.

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





(b) Copper is a transition element.

A list of properties of copper is shown.

- It has good electrical conductivity.
- It has variable oxidation states.
- It forms soluble salts.
- It forms coloured compounds.
- It forms basic oxides.
- It acts as a catalyst.

(i) Give **two** properties from the list that show how copper is similar to metals in Group I of the Periodic Table.

1 .....

2 ..... [2]

(ii) Give **two** properties from the list that show how copper is different from metals in Group I of the Periodic Table.

1 .....

2 ..... [2]

[Total: 12]



6 This question is about organic compounds.

(a) Organic compound **Q** has the following composition by mass.

C, 50.00%; H, 5.56%; O, 44.44%

Calculate the empirical formula of compound **Q**.

empirical formula = ..... [3]

(b) Organic compound **R** has the empirical formula CHO and a relative molecular mass of 116.

Determine the molecular formula of compound **R**.

molecular formula = ..... [1]

(c) Carboxylic acids react with alcohols to form esters.

(i) Name the other product that is formed when a carboxylic acid reacts with an alcohol.

..... [1]

(ii) Name the **type** of catalyst that is used when a carboxylic acid reacts with an alcohol.

..... [1]

(iii) Ester **S** has the structural formula  $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ .

Name the carboxylic acid and the alcohol which react together to form ester **S**.

carboxylic acid .....

alcohol .....

[2]





(d) Fig. 6.1 shows part of a polymer structure.

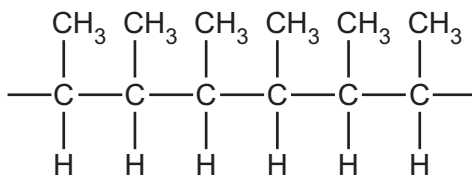


Fig. 6.1

- (i) Name the type of polymerisation that is used to produce this polymer.  
 ..... [1]
- (ii) Suggest why it is **not** possible to write the molecular formula of this polymer.  
 ..... [1]
- (iii) State the number of monomer units that are needed to make the part of the polymer structure shown in Fig. 6.1.  
 ..... [1]
- (iv) Draw the displayed formula of the monomer used to make this polymer.

[2]



(e) Fig. 6.2 shows part of the general structure of an amino acid.

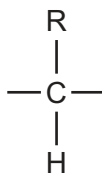


Fig. 6.2

(i) Complete Fig. 6.2 to show all the atoms and all the bonds in the two functional groups of the amino acid. [2]

(ii) Part of a natural polyamide structure is shown in Fig. 6.3.

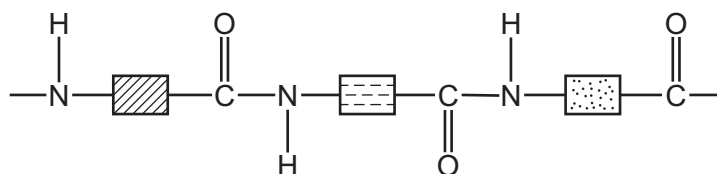


Fig. 6.3

On Fig. 6.3, draw a circle around **one** amide linkage. [1]

(iii) State the name given to natural polyamides made from amino acids.

..... [1]

[Total: 17]

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The Periodic Table of Elements

| Group                      |                             |                                                                |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                               |                             |                             |                              |                               |                              |                             |
|----------------------------|-----------------------------|----------------------------------------------------------------|-----------------------------|---------------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|------------------------------|-------------------------------|------------------------------|-----------------------------|
| I                          | II                          | Key                                                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | III                           | IV                          | V                           | VI                           | VII                           | VIII                         |                             |
|                            |                             | atomic number<br>atomic symbol<br>name<br>relative atomic mass |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                               |                             |                             |                              |                               |                              |                             |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   |                                                                |                             |                                 |                              |                              |                              |                            |                              |                                |                               | 1<br>H<br>hydrogen<br>1       |                             |                             |                              |                               |                              |                             |
| 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>— | 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>— |

actinoids

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