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# Cambridge O Level

| CANDIDATE NAME | |
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| CENTRE NUMBER | | | CANDIDATE NUMBER | |
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**CHEMISTRY** **5070/22**

Paper 2 Theory **May/June 2025**

**1 hour 45 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.

**[Turn over**

**1** Choose from the following salts to answer the questions.

**aluminium sulfate**

**barium chloride**

**copper(II) nitrate**

**copper(II) sulfate**

**magnesium chloride**

**potassium iodide**

**potassium manganate(VII)**

**silver chloride**

**sodium bromide**

Each salt can be used once, more than once or not at all.

State which salt:

**(a)** is prepared using a precipitation reaction

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

**(b)** gives a yellow flame test colour

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

**(c)** dissolves to form a dark purple aqueous solution

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

**(d)** has an aqueous solution that reacts with dilute sulfuric acid to give a white precipitate

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

**(e)** has an aqueous solution that reacts with aqueous bromine.

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

[Total: 5]

**2** A dilute aqueous solution of magnesium chloride is electrolysed using graphite electrodes.

**(a)** Graphite has a high melting point and is inert.

    **(i)** Explain why graphite has a high melting point.

       Use ideas about structure and bonding.

       .............................................................................................................................

       .............................................................................................................................

       .............................................................................................................................

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

    **(ii)** State one **other** property of graphite that makes it suitable for use as an electrode during electrolysis.

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

**(b)** Predict the products of the electrolysis of dilute aqueous magnesium chloride with graphite electrodes.

    product at anode ...........................................................................................................

    product at cathode ........................................................................................................
                                                                         [2]

**(c)** Molten aluminium oxide is electrolysed using graphite electrodes to form oxygen and aluminium.

    Construct the ionic half-equation for the reaction at each electrode.

    reaction at anode .........................................................................................................

    reaction at cathode ......................................................................................................
                                                                           [2]

**(d)** A metal object is electroplated with copper.

    The metal object is the cathode during this electrolysis.

    State the name of the substance used for the anode and for the electrolyte.

    anode ...........................................................................................................................

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

[Total: 9]

**3** The equation for the reaction between ethene and bromine is shown in Fig. 3.1.
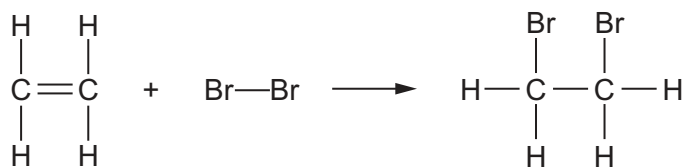


**Fig. 3.1**

**(a)** Describe the observation when ethene gas is bubbled through aqueous bromine.

.................................................................................................................................................

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

**(b)** Table 3.1 shows some bond energies.

**Table 3.1**

| bond | bond energy in kJ/mol |
|------|----------------------|
| C—H | 410 |
| C—C | 350 |
| C=C | 610 |
| Br—Br | 193 |
| C—Br | 280 |

Show by calculation that the enthalpy change of the reaction between ethene and bromine, $\Delta H$, is −107 kJ/mol.

[3]

**(c)** Complete the reaction pathway diagram in Fig. 3.2 for the reaction between ethene and bromine.

Label the:

- reactants
- product
- enthalpy change of the reaction, $\Delta H$
- activation energy, $E_a$.
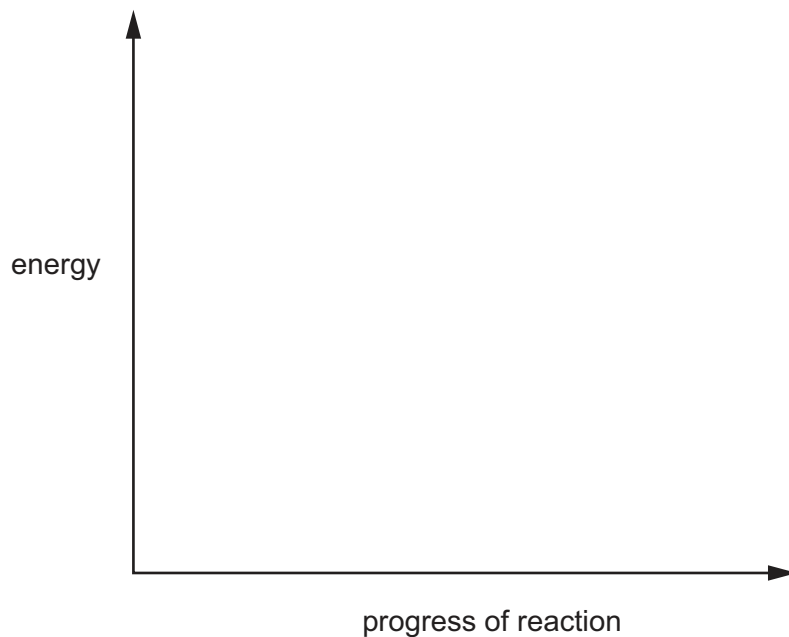
energy

progress of reaction

**Fig. 3.2**

[3]

**(d)** Draw a dot-and-cross diagram to show the electronic configuration in a molecule of ethene.

Show only the outer shell electrons.

[2]

[Total: 9]

**4** Ethanoic acid, $CH_3COOH$, is a member of the homologous series of carboxylic acids.

**(a)** Give the general formula of the homologous series of carboxylic acids.

...................................................................................................................................... [1]
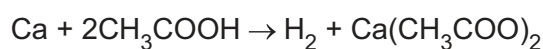
**(b)** One characteristic of a homologous series is that all the compounds share similar chemical properties.

Explain why the compounds share similar chemical properties.

..............................................................................................................................................

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

**(c)** The equation for the reaction between calcium and dilute ethanoic acid is shown.

$$Ca + 2CH_3COOH \rightarrow H_2 + Ca(CH_3COO)_2$$

**(i)** State the name of the compound $Ca(CH_3COO)_2$.

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

**(ii)** A sample of 1.35 g of calcium is added to excess dilute ethanoic acid.

Calculate the volume of hydrogen formed measured at room temperature and pressure.

Give your answer to **two** significant figures.

volume = ................................................. dm$^3$ [3]

**(d)** Dilute ethanoic acid is a component of vinegar.

Describe the manufacture of vinegar.

Include the reactants and conditions.

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

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

**(e)** Butanoic acid and propanoic acid are two other carboxylic acids.

**(i)** State the molecular formula of butanoic acid.

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

**(ii)** Draw the displayed formula of propanoic acid.

[1]

**(iii)** Solid sodium carbonate is added to dilute propanoic acid.

Predict an observation for this reaction.

...........................................................................................................................................

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

**(iv)** Aqueous sodium hydroxide is added to dilute butanoic acid.

State the names of the products of this reaction.

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

[Total: 13]

**5** The combustion of fossil fuels is used in some power stations.

**(a)** Some power stations use diesel oil as a fuel.

**(i)** One compound in diesel oil has the formula $C_{12}H_{26}$.

Construct the symbol equation to show the complete combustion of $C_{12}H_{26}$.

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

**(ii)** The complete combustion of $C_{12}H_{26}$ produces an air pollutant.

State **one** adverse effect of this pollutant.

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

**(iii)** Explain how diesel oil is separated from petroleum.

.............................................................................................................................

.............................................................................................................................

.............................................................................................................................

.............................................................................................................................

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

**(b)** Sulfur dioxide is removed from the emissions from a power station using calcium carbonate powder.

**(i)** State **one** adverse effect of sulfur dioxide as an air pollutant.

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

**(ii)** One mole of sulfur dioxide reacts with one mole of calcium carbonate to make one mole of carbon dioxide and only one other product.

Suggest the formula of this product.

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

**(iii)** State and explain the effect of increasing the temperature on the rate of this reaction.

.............................................................................................................................

.............................................................................................................................

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

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**(iv)** Lumps of calcium carbonate are used instead of calcium carbonate powder.

State and explain the effect of this change on the rate of this reaction.

.......................................................................................................................................

.......................................................................................................................................

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

[Total: 11]

**6** Bromine, $Br_2$, is in Group VII of the Periodic Table.

**(a)** The melting point of bromine is –7 °C and the boiling point is 59 °C.

**(i)** Explain why bromine is a solid at –50 °C.

.......................................................................................................................................

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

**(ii)** Describe the arrangement and motion of bromine molecules at –50 °C.

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

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

**(b)** A sample of bromine liquid contains $2.408 \times 10^{25}$ molecules.

One mole of bromine liquid contains $6.02 \times 10^{23}$ molecules.

Calculate the mass of this sample of bromine liquid.

mass of sample = ....................................................g [2]

**(c)** The ionic equation shows the reaction of bromine with warm concentrated aqueous sodium hydroxide.

$$3Br_2 + 6OH^- \rightarrow BrO_3^- + 5Br^- + 3H_2O$$

**(i)** State the oxidation number of bromine in $Br_2$ and in $Br^-$.

$Br_2$ ............................................................

$Br^-$ ............................................................

[2]

**(ii)** During the reaction bromine is reduced.

Explain why, using ideas about electrons.

.......................................................................................................................................

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

**(d)** Bromine reacts with hydrogen in a closed system to form an equilibrium mixture. The forward reaction releases thermal energy into the surroundings.

$$Br_2(g) + H_2(g) \rightleftharpoons 2HBr(g)$$
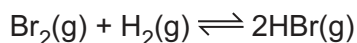
**(i)** The temperature of the equilibrium mixture is increased. The pressure remains constant.

State and explain what happens to the position of equilibrium.

statement ......................................................................................................................

explanation ...................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

[2]

**(ii)** The pressure of the equilibrium mixture is increased. The temperature remains constant.

State and explain what happens to the position of equilibrium.

statement ......................................................................................................................

explanation ...................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

[2]

**(e)** A bromide of phosphorus contains 7.2% phosphorus by mass.

Calculate the empirical formula of this bromide.

Show your working.

empirical formula ....................................................... [3]

[Total: 16]

https://xtremepape.rs/

**7** Iron is used to make stainless steel.

Stainless steel is used to make cutlery because it is resistant to rusting.

**(a)** Give one **other** reason why stainless steel is used to make cutlery.

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

**(b)** Stainless steel is an alloy.

Give the meaning of the term alloy.

..............................................................................................................................................

..............................................................................................................................................

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

**(c)** Iron nails are galvanised with zinc to prevent rusting.

Explain **two** ways in which galvanising iron nails with zinc prevents rusting.

..............................................................................................................................................

..............................................................................................................................................

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..............................................................................................................................................

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

**(d)** Iron reacts with hot dilute sulfuric acid to form hydrogen and aqueous iron(III) sulfate as the only products.

Construct a symbol equation for this reaction.

Include state symbols.

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

[Total: 7]

**8** Fig. 8.1 shows the displayed formula of compound **A**.



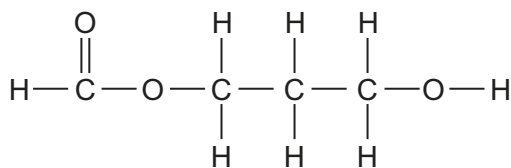**Fig. 8.1**

**(a)** Compound **A** is both a saturated alcohol and a saturated ester.

   **(i)** Explain why compound **A** is saturated.

   ...................................................................................................................................

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

   **(ii)** Explain why compound **A** is an alcohol.

   ...................................................................................................................................

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

   **(iii)** Explain why compound **A** is an ester.

   ...................................................................................................................................

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

**(b)** Fig. 8.2 shows compound **B**.
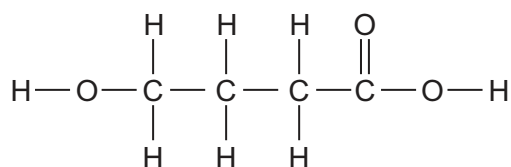


**Fig. 8.2**

Explain why compound **A** and compound **B** are a pair of structural isomers.

...................................................................................................................................

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

**(c)** The displayed formula of compound **C** is shown in Fig. 8.3.

$$\begin{array}{ccccccc} & H & & H & & H & & & O \\ & | & & | & & | & & & \| \\ H- & C & - & C & - & C & -O- & C & -H \\ & | & & | & & | & & & \\ & H & & H & & H & & & \end{array}$$
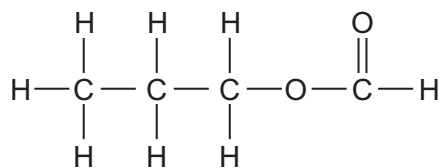
**Fig. 8.3**

Compound **C** is an ester.

Compound **C** is made by the reaction of an alcohol and a carboxylic acid in the presence of a catalyst.

**(i)** State the name of the type of catalyst used in this reaction.

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

**(ii)** State the name and draw the displayed formula of the alcohol used in this reaction.

name ...............................................................................................................................

displayed formula

[2]

**(d)** Fig. 8.4 shows two monomers that react to make a condensation polymer.
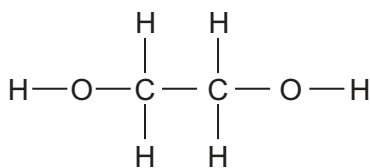


monomer **D**
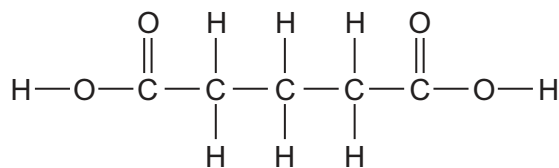
monomer **E**

**Fig. 8.4**

**(i)** Draw the structure of **one** repeat unit of this condensation polymer.

[2]

**(ii)** An equal number of moles of the monomers **D** and **E** are reacted to make the condensation polymer.

The total mass of the monomers **D** and **E** is 80 g. There is a 100% yield.

Explain why the mass of the condensation polymer made is less than 80 g.

...................................................................................................................................................

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

[Total: 10]

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# The Periodic Table of Elements

**Key**

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

Group

| I | II | | | | | | | | | | | | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1<br>**H**<br>hydrogen<br>1 | | | | | | | | | | | 2<br>**He**<br>helium<br>4 |
| 3<br>**Li**<br>lithium<br>7 | 4<br>**Be**<br>beryllium<br>9 | | | | | | | | | | | | 5<br>**B**<br>boron<br>11 | 6<br>**C**<br>carbon<br>12 | 7<br>**N**<br>nitrogen<br>14 | 8<br>**O**<br>oxygen<br>16 | 9<br>**F**<br>fluorine<br>19 | 10<br>**Ne**<br>neon<br>20 |
| 11<br>**Na**<br>sodium<br>23 | 12<br>**Mg**<br>magnesium<br>24 | | | | | | | | | | | | 13<br>**Al**<br>aluminium<br>27 | 14<br>**Si**<br>silicon<br>28 | 15<br>**P**<br>phosphorus<br>31 | 16<br>**S**<br>sulfur<br>32 | 17<br>**Cl**<br>chlorine<br>35.5 | 18<br>**Ar**<br>argon<br>40 |
| 19<br>**K**<br>potassium<br>39 | 20<br>**Ca**<br>calcium<br>40 | 21<br>**Sc**<br>scandium<br>45 | 22<br>**Ti**<br>titanium<br>48 | 23<br>**V**<br>vanadium<br>51 | 24<br>**Cr**<br>chromium<br>52 | 25<br>**Mn**<br>manganese<br>55 | 26<br>**Fe**<br>iron<br>56 | 27<br>**Co**<br>cobalt<br>59 | 28<br>**Ni**<br>nickel<br>59 | 29<br>**Cu**<br>copper<br>64 | 30<br>**Zn**<br>zinc<br>65 | | 31<br>**Ga**<br>gallium<br>70 | 32<br>**Ge**<br>germanium<br>73 | 33<br>**As**<br>arsenic<br>75 | 34<br>**Se**<br>selenium<br>79 | 35<br>**Br**<br>bromine<br>80 | 36<br>**Kr**<br>krypton<br>84 |
| 37<br>**Rb**<br>rubidium<br>85 | 38<br>**Sr**<br>strontium<br>88 | 39<br>**Y**<br>yttrium<br>89 | 40<br>**Zr**<br>zirconium<br>91 | 41<br>**Nb**<br>niobium<br>93 | 42<br>**Mo**<br>molybdenum<br>96 | 43<br>**Tc**<br>technetium<br>– | 44<br>**Ru**<br>ruthenium<br>101 | 45<br>**Rh**<br>rhodium<br>103 | 46<br>**Pd**<br>palladium<br>106 | 47<br>**Ag**<br>silver<br>108 | 48<br>**Cd**<br>cadmium<br>112 | | 49<br>**In**<br>indium<br>115 | 50<br>**Sn**<br>tin<br>119 | 51<br>**Sb**<br>antimony<br>122 | 52<br>**Te**<br>tellurium<br>128 | 53<br>**I**<br>iodine<br>127 | 54<br>**Xe**<br>xenon<br>131 |
| 55<br>**Cs**<br>caesium<br>133 | 56<br>**Ba**<br>barium<br>137 | 57–71<br>lanthanoids | 72<br>**Hf**<br>hafnium<br>178 | 73<br>**Ta**<br>tantalum<br>181 | 74<br>**W**<br>tungsten<br>184 | 75<br>**Re**<br>rhenium<br>186 | 76<br>**Os**<br>osmium<br>190 | 77<br>**Ir**<br>iridium<br>192 | 78<br>**Pt**<br>platinum<br>195 | 79<br>**Au**<br>gold<br>197 | 80<br>**Hg**<br>mercury<br>201 | | 81<br>**Tl**<br>thallium<br>204 | 82<br>**Pb**<br>lead<br>207 | 83<br>**Bi**<br>bismuth<br>209 | 84<br>**Po**<br>polonium<br>– | 85<br>**At**<br>astatine<br>– | 86<br>**Rn**<br>radon<br>– |
| 87<br>**Fr**<br>francium<br>– | 88<br>**Ra**<br>radium<br>– | 89–103<br>actinoids | 104<br>**Rf**<br>rutherfordium<br>– | 105<br>**Db**<br>dubnium<br>– | 106<br>**Sg**<br>seaborgium<br>– | 107<br>**Bh**<br>bohrium<br>– | 108<br>**Hs**<br>hassium<br>– | 109<br>**Mt**<br>meitnerium<br>– | 110<br>**Ds**<br>darmstadtium<br>– | 111<br>**Rg**<br>roentgenium<br>– | 112<br>**Cn**<br>copernicium<br>– | | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| actinoids | 89<br>**Ac**<br>actinium<br>– | 90<br>**Th**<br>thorium<br>232 | 91<br>**Pa**<br>protactinium<br>231 | 92<br>**U**<br>uranium<br>238 | 93<br>**Np**<br>neptunium<br>– | 94<br>**Pu**<br>plutonium<br>– | 95<br>**Am**<br>americium<br>– | 96<br>**Cm**<br>curium<br>– | 97<br>**Bk**<br>berkelium<br>– | 98<br>**Cf**<br>californium<br>– | 99<br>**Es**<br>einsteinium<br>– | 100<br>**Fm**<br>fermium<br>– | 101<br>**Md**<br>mendelevium<br>– | 102<br>**No**<br>nobelium<br>– | 103<br>**Lr**<br>lawrencium<br>– |

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