Cambridge Assessment International Education

# Cambridge IGCSE™

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**CHEMISTRY** **0620/42**

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.

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**1** The three states of matter are solid, liquid and gas.

**(a)** Complete Table 1.1 to describe the structures of solids, liquids and gases in terms of particle separation, particle arrangement and particle motion.

View solution

**Table 1.1**

| state of matter | particle separation | particle arrangement | particle motion |
|---|---|---|---|
| solid | touching | | |
| liquid | | | |
| gas | | random | random |

[3]

**(b)** Substances can physically change.

View solution

Name each physical change:

- solid to liquid .....
- gas to liquid .....
- solid to aqueous. .....

[3]

**(c)** Gases diffuse.

View solution

**(i)** Describe, in terms of particles, why gases diffuse.

..... [1]

**(ii)** State what determines the relative rate of diffusion of gases at constant temperature.

..... [1]

**(d)** Gaseous oxides of nitrogen are atmospheric pollutants. One adverse effect of oxides of nitrogen is the formation of acid rain.

View solution

State **two other** adverse effects of oxides of nitrogen.

1.....

2.....

[2]

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**(e)** In a catalytic converter, oxides of nitrogen are removed by reaction with the toxic gaseous product of the incomplete combustion of hydrocarbon fuels. Two non-toxic gases are formed in this reaction.

View solution

**(i)** Name the toxic gaseous product of the incomplete combustion of hydrocarbon fuels.

..... [1]

View solution

**(ii)** Name the **two** non-toxic gases formed in the catalytic converter.

1 .....

2 .....

[2]

[Total: 13]

**2** Iron is extracted from iron ore in a blast furnace.

View solution

**(a)** The iron compound in the main iron ore used in the blast furnace is iron(III) oxide.

**(i)** State the name of the main iron ore used in the blast furnace.

..... [1]

**(ii)** State how the main source of heat is provided in the blast furnace.

..... [1]

**(iii)** Name the gaseous reducing agent in the blast furnace.

..... [1]

**(iv)** Write a symbol equation for the reduction of iron(III) oxide by the gaseous reducing agent in **(a)(iii)**.

..... [2]

**(v)** The main impurity in iron ore is silicon(IV) oxide.

Write **two** symbol equations to show the role of limestone in removing silicon(IV) oxide from iron ore.

1 .....

2 .....

[2]

View solution

**(b)** Table 2.1 shows four different isotopes of iron, **A**, **B**, **C** and **D**.

**Table 2.1**

| A | B | C | D |
|---|---|---|---|
| $^{54}Fe$ | $^{56}Fe$ | $^{57}Fe$ | $^{58}Fe$ |

Explain why **A**, **B**, **C** and **D** are isotopes of iron.

.....

..... [2]

**(c)** Iron can form two different ions, $Fe^{2+}$ and $Fe^{3+}$.

**(i)** Complete Table 2.2 to show the number of protons, neutrons and electrons in the two iron ions shown.

View solution

**Table 2.2**

| | $^{54}Fe^{2+}$ | $^{58}Fe^{3+}$ |
|---|---|---|
| protons | | |
| neutrons | | |
| electrons | | |

[3]

**(ii)** Describe a test for aqueous $Fe^{2+}$ ions.

View solution

test .....

observations .....

.....

[2]

**(d)** An oxidising agent converts $Fe^{2+}$ ions to $Fe^{3+}$ ions.

View solution

**(i)** Define the term oxidising agent.

.....

..... [2]

**(ii)** Explain why the conversion of $Fe^{2+}$ ions to $Fe^{3+}$ ions is described as oxidation. View solution

..... [1]

**(iii)** The oxidising agent for the conversion of $Fe^{2+}$ ions to $Fe^{3+}$ ions is aqueous potassium manganate(VII).

State **one** condition needed for the oxidation to take place.

View solution

..... [1]

**(e)** Iodide ions, $I^-$, reduce $Fe^{3+}$ ions to $Fe^{2+}$ ions in aqueous solution.

View solution

Suggest the identity of the other product formed in this reaction.

..... [1]

[Total: 19]

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**3** A student prepares a sample of the insoluble salt barium sulfate, $BaSO_4$.
The student adds aqueous sodium sulfate, $Na_2SO_4(aq)$, to aqueous barium chloride, $BaCl_2(aq)$.

The student carries out the following steps.

**step 1** Dissolve 0.100 moles of solid $BaCl_2$ in 100 $cm^3$ of distilled water in a beaker to form $BaCl_2(aq)$.

**step 2** Add an aqueous solution which contains 0.100 moles of $Na_2SO_4(aq)$ to the beaker containing the $BaCl_2(aq)$ from **step 1**.

**step 3** Stir the mixture and then filter it.

**step 4** Dry the solid left in the filter paper.

**(a)** Complete the symbol equation for the reaction. Include state symbols.

View solution

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(.....) + .....(.....)$$

[2]

**(b)** Calculate the mass of solid $BaCl_2$ dissolved in **step 1**.

View solution

mass = ..... g [2]

**(c)** The concentration of $Na_2SO_4(aq)$ in **step 2** is 1.25 $mol/dm^3$.

Calculate the volume, in $cm^3$, of 1.25 $mol/dm^3$ $Na_2SO_4(aq)$ added in **step 2** which contains 0.100 moles of $Na_2SO_4$.

View solution

volume = ..... $cm^3$ [1]

**(d)** State the colour of the solid formed in **step 2**.

View solution

..... [1]

**(e)** The mixture is filtered in **step 3**.

View solution

State the general term given to a solid left in the filter paper after filtration.

..... [1]

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**(f)** The actual mass of dry $BaSO_4$ collected in **step 4** is greater than the expected mass. This is because the student should do an additional step between **step 3** and **step 4**.

Suggest what the student should do in this additional step, and explain why the actual mass collected is greater than the expected mass.

.....

.....

.....

..... [2]

**(g)** State the name of this method of salt preparation. View solution

..... [1]

**(h)** State the name of a different: View solution

- barium salt that can be used in place of $BaCl_2$ .....
- sulfate salt that can be used in place of $Na_2SO_4$ .....
- barium salt that can be made by this method. .....

[3]

[Total: 13]

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**4** Nitric acid, $HNO_3$, and sulfuric acid, $H_2SO_4$, are strong acids. Ethanoic acid, $CH_3COOH$, is a weak acid.

**(a)** One mole of each acid is added separately to 1000 $cm^3$ of distilled water to form a dilute solution. All three acids dissociate in distilled water.

**(i)** State the formula of the common cation produced when each of the three acids dissociates in water.

..... [1]

**(ii)** Explain, in terms of dissociation, why:

View solution

- nitric acid is described as a strong acid

.....

- ethanoic acid is described as a weak acid.

.....
[2]

**(iii)** State which of the three dilute acids will have the highest pH value.

..... [1]

**(iv)** State the colour of thymolphthalein in all three dilute acids.

..... [1]

**(v)** Give the formula of the anion formed when:

- sulfuric acid dissociates in water

.....

- ethanoic acid dissociates in water.

.....
[2]

**(vi)** Name the **two** gaseous products formed during the electrolysis of dilute sulfuric acid using inert electrodes.

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

**(vii)** Name the salt formed when calcium reacts with ethanoic acid.

..... [1]

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**(b)** Aluminium nitrate, $Al(NO_3)_3$, is made when dilute nitric acid reacts with aluminium hydroxide, $Al(OH)_3$.

View solution

**(i)** $Al(OH)_3$ acts as a base in this reaction.

Define the term base.

..... [1]

**(ii)** $Al(OH)_3$ is **not** an alkali.

State what this tells you about the solubility of $Al(OH)_3$.

..... [1]

**(iii)** Name **one other** compound which forms aluminium nitrate when added to dilute nitric acid.

..... [1]

**(iv)** The oxidation number of the O atoms in $Al(NO_3)_3$ is –2.
The formula of the aluminium ion in $Al(NO_3)_3$ is $Al^{3+}$.

Determine the oxidation number of the N atoms in $Al(NO_3)_3$.
Show your working.

oxidation number of N = ..... [2]

[Total: 15]

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**5** This question is about the homologous series of alkanes.

Three general characteristics of alkanes are:

- they are generally unreactive because they do **not** have a functional group
- they show trends in their physical properties, such as melting points and boiling points
- they have similar chemical properties.

**(a)** Describe **two other** general characteristics of the homologous series of alkanes.

View solution

1 .....

2 .....

[2]

**(b)** **(i)** State the trend in the boiling points of the alkanes as the carbon chain length increases.

..... [1]

**(ii)** Name **one other** physical property of alkanes that shows a trend, other than melting points and boiling points.

Describe this trend as the carbon chain length of alkanes increases.

View solution

name .....

description .....

[2]

**(c)** State why alkanes are described as saturated.

..... [1]

View solution

**(d)** Propane has the structural formula $CH_3CH_2CH_3$.

When propane undergoes a monosubstitution reaction with chlorine at room temperature, **two** organic products can be formed.

View solution

**(i)** State **one** condition needed for this substitution reaction to take place.

..... [1]

View solution

**(ii)** Give the structural formula and state the name of each organic product formed.

- structural formula of product 1

name of product 1 .....

- structural formula of product 2

name of product 2 .....

[4]

View solution

**(iii)** The two products formed are structural isomers of each other.

Define the term structural isomers.

.....

..... [1]

[Total: 12]

**6** Compound **E** shown in Fig. 6.1 is an ester.

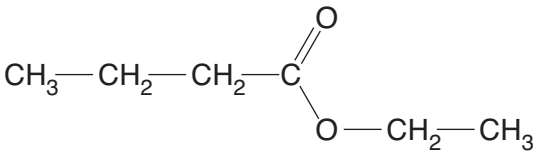

**Fig. 6.1**

View solution

**(a)** **On Fig. 6.1**, draw a circle around all the atoms which make up the ester linkage. [1]

View solution

**(b)** Name compound **E**.

..... [1]

View solution

**(c)** Deduce the empirical formula of compound **E**.

..... [1]

**(d)** Compound **E** is produced when two different compounds react together in the presence of a catalyst.

View solution

**(i)** Name the **two** compounds that react together to produce compound **E**.

1 .....

2 .....

[2]

View solution

**(ii)** Suggest a suitable catalyst for this reaction.

..... [1]

**(e)** Determine the number of unbranched esters which have the molecular formula $C_5H_{10}O_2$.

..... [1]

**(f)** All unbranched esters with the molecular formula $C_5H_{10}O_2$ combust completely to form carbon dioxide and water only.

Write the symbol equation for the complete combustion of $C_5H_{10}O_2$.

View solution

..... [1]

[Total: 8]

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## The Periodic Table of Elements

| Group I | Group II | | | | | | | | | | | Group III | Group IV | Group V | Group VI | Group VII | Group 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.).