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*5423893260*

**CHEMISTRY** **0620/43**

Paper 4 Theory (Extended) **May/June 2024**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

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

**INFORMATION**

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

This document has **16** pages. Any blank pages are indicated.


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**[Turn over**

**1** Name the process used to:

**(a)** produce ammonia from nitrogen

..... [1]

**(b)** produce lead from molten lead(II) bromide

..... [1]

**(c)** separate an insoluble solid from a mixture of an insoluble solid and a solution

..... [1]

**(d)** produce ethanol from ethene

..... [1]

**(e)** identify the components of a mixture of soluble coloured substances

..... [1]

**(f)** separate a mixture of several liquids with different boiling points

..... [1]

**(g)** determine the volume of an acid required to neutralise a given volume of an alkali.

..... [1]

[Total: 7]

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**2** Complete Table 2.1.

**Table 2.1**

| atom or ion | number of protons | number of electrons | number of neutrons |
|---|---|---|---|
| $^{63}_{29}Cu$ | 29 | | |
| $^{37}_{17}Cl^-$ | | | 20 |
| | 30 | 28 | 34 |

[5]

**3** This question is about elements and compounds.

**(a)** Some properties of graphite, oxygen and carbon monoxide are shown in Table 3.1.

**Table 3.1**

| | melting point / °C | boiling point / °C | conduction of electricity when solid |
|---|---|---|---|
| graphite | 3652 | 4827 | good |
| oxygen | –218 | –183 | poor |
| carbon monoxide | –199 | –191 | poor |

**(i)** Explain why graphite conducts electricity when solid.

.....

..... [1]

**(ii)** Complete the dot-and-cross diagram in Fig. 3.1 of a molecule of oxygen.

Show outer shell electrons only.

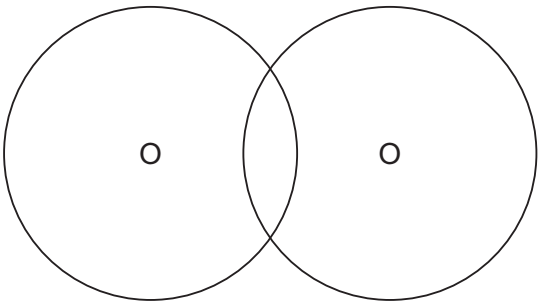



**Fig. 3.1**

[2]

**(iii)** Deduce the physical state of carbon monoxide at –195 °C. Use the data in Table 3.1 to explain your answer.

physical state .....

explanation .....

.....

[2]

**(iv)** Explain in terms of structure and bonding why graphite has a much higher melting point than carbon monoxide.

.....

.....

.....

..... [3]

**(b)** Potassium reacts with chlorine to form potassium chloride.

Write a symbol equation for this reaction.

..... [2]

**(c)** A dilute aqueous solution of potassium chloride undergoes electrolysis.

Oxygen is produced at the anode.

**(i)** State what is meant by the term electrolysis.

.....

.....

..... [2]

**(ii)** Write an ionic half-equation for the production of oxygen at the anode.

..... [2]

[Total: 14]

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**[Turn over**

**4** Dinitrogen tetroxide, $N_2O_4$, decomposes into nitrogen dioxide, $NO_2$.The reaction is reversible.

$$\underset{\text{colourless gas}}{N_2O_4(g)} \rightleftharpoons \underset{\text{brown gas}}{2NO_2(g)}$$

Fig. 4.1 shows a gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide. The gas syringe is sealed. The mixture reaches equilibrium and the colour of the mixture of gases is a pale brown.

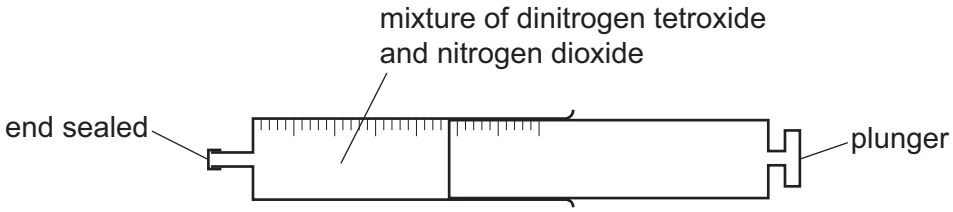



**Fig. 4.1**

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

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

.....

- the concentration of reactants and products.

.....

[2]

**(b)** The pressure of the mixture is increased. All other conditions stay the same.

The mixture immediately turns darker brown before the position of equilibrium changes.

Explain in terms of particles why the mixture immediately turns darker brown.

..... [1]

**(c)** The temperature of the mixture is increased. All other conditions stay the same.

The mixture turns darker brown.

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

..... [1]

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**(d)** Sulfur is converted into sulfuric acid, $H_2SO_4$, by a series of reactions.

Sulfur dioxide, $SO_2$, and oxygen, $O_2$, react to form sulfur trioxide, $SO_3$. The reversible reaction reaches equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

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

**Table 4.1**

| | effect on the rate of the forward reaction | effect on the equilibrium yield of $SO_3(g)$ |
|---|---|---|
| add a catalyst | | |
| increase the pressure | | |

[4]

**(ii)** Deduce the oxidation number of sulfur in:

S .....

$SO_3$ .....

[2]

[Total: 10]

**5** **(a)** Barium sulfate, $BaSO_4$, is an insoluble salt and is made by precipitation.

**(i)** Name **two** aqueous solutions that produce a precipitate of barium sulfate when they are mixed.

1 .....

2 .....
[2]

**(ii)** Describe how to produce a pure sample of barium sulfate from the mixture of aqueous solutions in **(a)(i)**.

.....

..... [2]

**(iii)** Write an ionic equation for the precipitation reaction which produces barium sulfate. Include state symbols.

..... [3]

**(b)** Soluble salts are made from dilute acids.

Name the dilute acid and one other substance that react together to make copper(II) sulfate.

dilute acid .....

other substance .....
[2]

**(c)** Nitrates decompose when they are heated.

When hydrated copper(II) nitrate is heated, oxygen gas is produced.

**(i)** Describe a test for oxygen.

test .....

observations .....
[1]

**(ii)** Complete the equation for the decomposition of hydrated copper(II) nitrate.

$$2Cu(NO_3)_2 \bullet 3H_2O \rightarrow .....CuO + .....NO_2 + O_2 + .....H_2O$$ [2]

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**(d)** Hydrated zinc sulfate gives off water when it is heated.

$$ZnSO_4 \bullet \mathbf{x}H_2O(s) \rightarrow ZnSO_4(s) + \mathbf{x}H_2O(g)$$

A student does an experiment to determine the value of **x** in $ZnSO_4 \bullet \mathbf{x}H_2O$.

**step 1** The student weighs a sample of hydrated zinc sulfate.

**step 2** The student heats the sample of hydrated zinc sulfate.

**step 3** The student weighs the solid after heating.

**step 4** The student repeats **step 2** and **step 3** until the mass of solid after heating is constant.

**(i)** State why the student does **step 4**.

..... [1]

**(ii)** In an experiment, 0.574 g of $ZnSO_4 \bullet \mathbf{x}H_2O$ is heated until the mass is constant.

The mass of $ZnSO_4$ that remains is 0.322 g.

[$M_r$: $ZnSO_4$, 161; $H_2O$, 18]

Determine the value of **x** using the following steps.

- Calculate the number of moles of $ZnSO_4$ remaining.

..... mol

- Calculate the mass of $H_2O$ given off.

..... g

- Calculate the number of moles of $H_2O$ given off.

..... mol

- Determine the value of **x**.

**x** = .....
[4]

[Total: 17]

**6** This question is about iron.

**(a)** Fig. 6.1 shows a blast furnace used to extract iron from its ore.

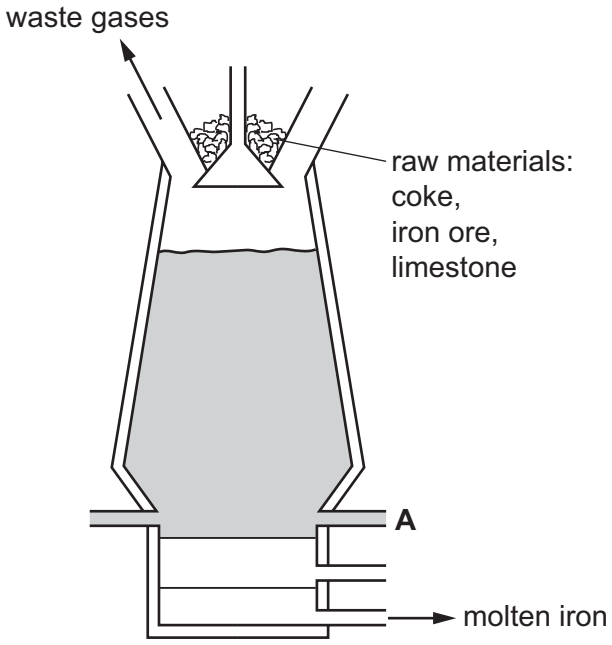



**Fig. 6.1**

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

..... [1]

**(ii)** Name the substance that enters the blast furnace at **A**.

..... [1]

**(iii)** Name the reducing agent in the extraction of iron in the blast furnace.

..... [1]

**(iv)** Explain why limestone is added to the blast furnace. Give details of the chemical reactions that are involved.

.....

.....

.....

..... [3]

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**(b)** The list shows the properties of some elements.

- act as catalysts
- have low densities
- have low melting points
- form acidic or basic oxides
- form coloured compounds
- form positive or negative ions

Iron is a transition metal. Sodium is a Group I metal.

State which property from the list:

**(i)** is true for sodium but **not** iron

..... [1]

**(ii)** is true for iron but **not** sodium

..... [1]

**(iii)** is true for both sodium and iron

..... [1]

**(iv)** is **not** true for sodium and **not** true for iron.

..... [1]

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**[Turn over**

**(c)** Steel consists mainly of iron.

Iron rusts when it reacts with water and oxygen.

Fig. 6.2 shows magnesium blocks attached to the bottom of a steel boat. The magnesium does **not** completely cover the steel.

The magnesium blocks provide sacrificial protection for the steel.

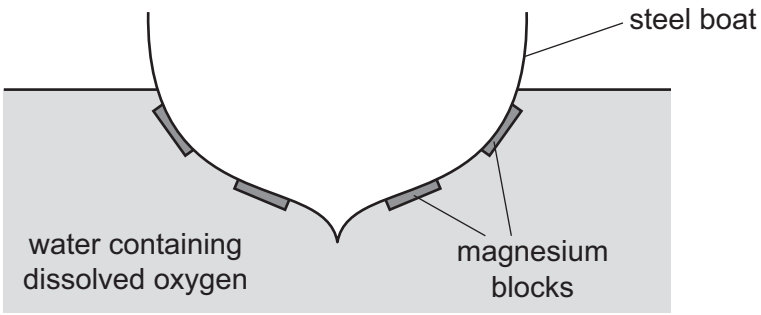



**Fig. 6.2**

**(i)** Explain, in terms of electrons, why magnesium is used for sacrificial protection.

.....

..... [2]

**(ii)** Name a metal that cannot provide sacrificial protection for steel.

..... [1]

[Total: 13]

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**7** Many organic compounds contain carbon and hydrogen only.

**(a) (i)** An organic compound **A** has the following composition by mass.

C, 83.33%; H, 16.67%

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

empirical formula = ..... [3]

**(ii)** Compound **B** has the empirical formula $C_2H_5$ and a relative molecular mass of 58.

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

molecular formula = ..... [2]

**(b)** Fig. 7.1 shows a section of a polymer formed from an alkene.

**(i)** Identify the functional group in alkenes that reacts when alkenes form polymers.

..... [1]

**(ii)** A section of a polymer is shown in Fig. 7.1.

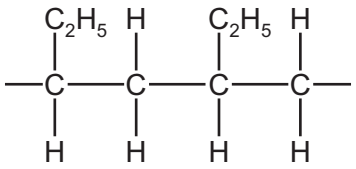



**Fig. 7.1**

- Draw the displayed formula of the monomer that forms this polymer.

- Name the monomer used to form this polymer.

.....
[3]

**(c)** Alkenes are produced by cracking alkanes.

When $C_{12}H_{26}$ is cracked, the products are ethene and an alkane which form in a 2 : 1 mole ratio.

Write a symbol equation for this reaction.

$C_{12}H_{26} \rightarrow$ ..... + ..... [2]

**(d) (i)** State the general formula for alcohols.

..... [1]

**(ii)** Draw the displayed formula of **one** alcohol with the molecular formula $C_3H_8O$. Name the alcohol you have drawn.

name of alcohol .....
[2]

[Total: 14]

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## The Periodic Table of Elements

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

**Key**

atomic number
atomic symbol
name
relative atomic mass

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

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