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

Paper 4 Theory (Extended)

February/March 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.

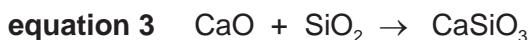
INFORMATION

- 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 **12** pages.

- 1 Iron ore contains iron(III) oxide, Fe_2O_3 . A blast furnace is used to extract iron from Fe_2O_3 .

Equations for some of the reactions in the blast furnace are shown.



- (a) **Equation 1** shows the combustion of carbon in the blast furnace.

- (i) Name the substance which provides the carbon for this reaction.

..... [1]

- (ii) State the purpose of the combustion of carbon in the blast furnace.

..... [1]

- (b) Iron(III) oxide, Fe_2O_3 , in iron ore is converted to iron when it reacts with carbon monoxide, CO , in the blast furnace.

- (i) Calculate the percentage by mass of iron in iron(III) oxide, Fe_2O_3 .

percentage =% [2]

- (ii) State the name of the iron ore which consists mainly of iron(III) oxide.

..... [1]

- (iii) Describe how carbon monoxide is formed in the blast furnace.

..... [1]

- (iv) Write the symbol equation to show the reaction that occurs when iron(III) oxide is converted to iron in the blast furnace.

..... [2]

- (v) Name the chemical process which happens to iron when iron(III) oxide is converted to iron in the blast furnace.

..... [1]

- (c) State the type of reaction shown by **equation 2**.

..... [1]

- (d) (i) Explain why the reaction in **equation 3** can be described as an acid–base reaction.

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

[2]

- (ii) State:

- the chemical name of SiO_2

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

[2]

- (e) Aluminium **cannot** be extracted from its ore using a blast furnace.

- (i) State why aluminium is **not** extracted from its ore using a blast furnace.

.....

[1]

- (ii) Name the process used to extract aluminium from its ore.

.....

[1]

- (f) Both iron(III) oxide and aluminium oxide contain metal ions with a 3+ charge.

- (i) Write the electronic configuration of an Al^{3+} ion.

.....

[1]

- (ii) Deduce the number of protons and electrons in an Fe^{3+} ion.

| protons | electrons |
|---------|-----------|
| | |

[2]

[Total: 19]

2 The elements in Group VII of the Periodic Table are known as the halogens. Halogens can form halide ions.

(a) Identify the halogen with the lowest density at r.t.p. (room temperature and pressure).

..... [1]

(b) State the appearance of bromine at r.t.p.

..... [1]

(c) Use the Periodic Table to:

- give the symbol of the halogen with the highest atomic number

.....

- deduce the number of occupied electron shells in an atom of this element.

.....

[2]

(d) Bromine molecules have covalent bonding.

(i) State what is meant by the term covalent bond.

.....

[2]

(ii) Name **one** halide ion which bromine molecules can displace.

..... [1]

(iii) Explain why bromine can displace the halide ion in (d)(ii).

..... [1]

(e) Name a halide compound which can be used to detect the presence of water.

..... [2]

- (f) Calcium chloride is an ionic compound.

Complete the dot-and-cross diagram in Fig. 2.1 for the ions in calcium chloride.

Give the charges on each of the ions.

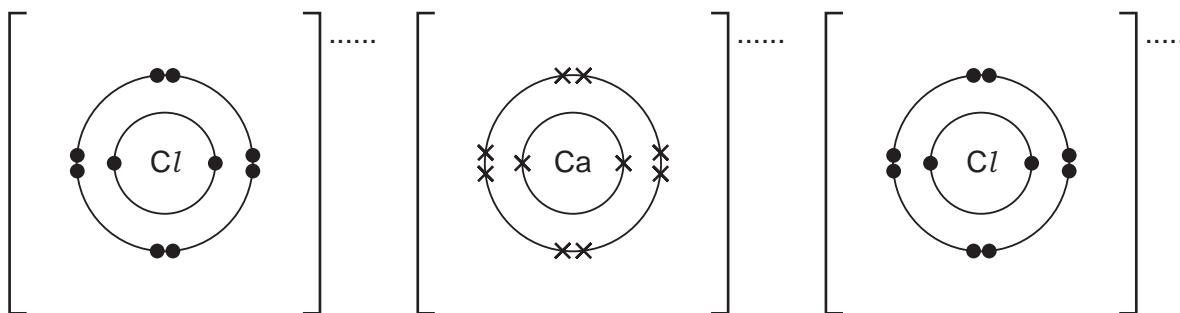


Fig. 2.1

[3]

- (g) Aqueous lead(II) ions are added to aqueous chloride ions. A white precipitate of insoluble lead(II) chloride, PbCl_2 , is formed.

- (i) Name a lead(II) compound which can be used in this reaction.

..... [1]

- (ii) Write the ionic equation for this reaction. Include state symbols.

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

- (iii) Name one **other** insoluble chloride.

..... [1]

[Total: 18]

- 3 This question is about acids, bases and alkalis.

Table 3.1 shows the pH values of some substances.

Table 3.1

| substance | pH |
|--------------------------|----|
| NaOH(aq) | 14 |
| Ca(OH) ₂ (aq) | 10 |
| H ₂ O(l) | 7 |
| CH ₃ COOH(aq) | 4 |
| HNO ₃ (aq) | 1 |

- (a) Define the term base.

..... [1]

- (b) State what is meant by the term alkali.

..... [1]

- (c) Thymolphthalein is an indicator.

State the colour of thymolphthalein in:

- NaOH(aq)
- CH₃COOH(aq).

[2]

- (d) (i) Use the information in Table 3.1 to identify the substance with the highest concentration of H⁺(aq) ions.

Explain your answer.

substance

explanation

[2]

- (ii) Name an indicator which can be used to identify the substance with the highest concentration of H⁺(aq) ions.

..... [1]

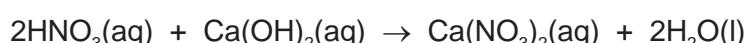
- (e) Complete the equation to show the dissociation of ethanoic acid, CH_3COOH , in aqueous solution.

$\text{CH}_3\text{COOH(aq)}$ [3]

- (f) Write the **ionic** equation which represents a neutralisation reaction between any acid and any alkali.

..... [11]

- (g) Dilute nitric acid, $\text{HNO}_3\text{(aq)}$, reacts with aqueous calcium hydroxide, $\text{Ca}(\text{OH})_2\text{(aq)}$, as shown.



20.0 cm³ of 0.0150 mol/dm³ Ca(OH)₂(aq) reacts with 25.0 cm³ of HNO₃(aq).

Calculate the concentration of $\text{HNO}_3(\text{aq})$ in g/dm³.

Use the following steps.

- Calculate the number of moles of $\text{Ca}(\text{OH})_2(\text{aq})$ used.

..... mol

- Determine the number of moles of $\text{HNO}_3(\text{aq})$ which react with the $\text{Ca}(\text{OH})_2(\text{aq})$.

..... mol

- Calculate the concentration of HNO_3 (aq) in mol/dm³.

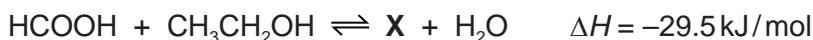
..... mol/dm³

- Calculate the concentration of HNO_3 (aq) in g/dm³.

..... g/dm³
[5]

[Total: 16]

- 4 The equation for the reaction between methanoic acid and ethanol in the presence of a catalyst can be represented as shown.



X represents the ester formed.

- (a) (i) In the equation, methanoic acid is represented by the formula HCOOH.

Name this type of formula.

..... [1]

- (ii) Write the empirical formula of methanoic acid.

..... [1]

- (b) Name and draw the displayed formula of ester X.

name

displayed formula

[3]

- (c) The reaction is reversible and reaches an equilibrium within a closed system.

- (i) State what is meant by the term closed system.

..... [1]

- (ii) State **two** characteristics of an equilibrium.

1

.....

2

.....

[2]

- (iii) Complete Table 4.1 to show the effect, if any, on the concentration of **X** at equilibrium for each change of condition.

Table 4.1

| change of condition | effect on the concentration of X at equilibrium |
|--|--|
| temperature is decreased | |
| concentration of HCOOH is decreased | |
| concentrations of both HCOOH and $\text{CH}_3\text{CH}_2\text{OH}$ are decreased | |
| the catalyst is removed | |

[4]

[Total: 12]

10

5 Butane and but-1-ene are colourless gases at room temperature and pressure.

(a) Suggest why but-1-ene diffuses quicker than butane.

..... [1]

(b) Identify the products formed when butane undergoes complete combustion.

..... [1]

(c) One molecule of butane reacts with one molecule of chlorine in the presence of ultraviolet light. During the reaction, one hydrogen atom in butane is replaced by one chlorine atom.

(i) Name the type of reaction which needs ultraviolet light.

..... [1]

(ii) State the purpose of ultraviolet light during this reaction.

..... [1]

(iii) Name the type of reaction which takes place when one atom of chlorine replaces one atom of hydrogen.

..... [1]

(iv) Determine how many different structural isomers can form during this reaction.

..... [1]

(d) When but-1-ene reacts with steam, **two** possible products form.

(i) Identify the type of catalyst which is used in this reaction.

..... [1]

- (ii) Name and draw the displayed formulae of the **two** possible products.

| product 1 | product 2 |
|-------------------|-------------------|
| name | name |
| displayed formula | displayed formula |

[4]

- (e) But-1-ene undergoes polymerisation.

- (i) State the type of polymerisation but-1-ene undergoes.

..... [1]

- (ii) Draw part of the polymer molecule to show **three** repeat units.

[3]

[Total: 15]

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The Periodic Table of Elements

| I | | II | | Group | | | | | | | | | | | | | | | |
|-----------------------------------|------------------------------------|-----------------------------------|--|---|-------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|------------------------------------|----------------------------------|----------------------------------|
| | | | | I | | | | | | II | | | | | | | | | |
| | | | | Key | | | | | | | | | | | | | | | |
| 3 Li lithium 7 | 4 Be beryllium 9 | | | atomic number name relative atomic mass | atomic symbol | | | | | | | | | | | | | | |
| 11 Na sodium 23 | 12 Mg magnesium 24 | 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 damarium – | 111 Rg roentgenium – | 112 Cn copernicium – | 113 Nh nihonium – | 114 Fl ferrovium – | 115 Mc moscovium – | 116 Lv livmorium – | 117 Ts tennessine – | 118 Og oganesson – | | |

| | | | | | | | | | | | | | | | | |
|-------------------------------------|-----------------------------------|--|-------------------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|-----------------------------------|--------------------------------------|-----------------------------------|--------------------------------------|-----------------------------------|-------------------------------------|-------------------------------------|--|--|
| 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 | | |
| 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 Fm fermium – | 100 Md mendelevium – | 101 No nobelium – | 102 Og oganesson – | 103 Lf lawrencium – | | |

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