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CANDIDATE NAME	

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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.

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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.

equation 1 $C + O_2 \rightarrow CO_2$

equation 2 $CaCO_3 \rightarrow CaO + CO_2$

equation 3 $CaO + SiO_2 \rightarrow CaSiO_3$

(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]

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(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

.....

- the common name given to $CaSiO_3$ when it is formed in the blast furnace.

.....
[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]

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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]

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(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.

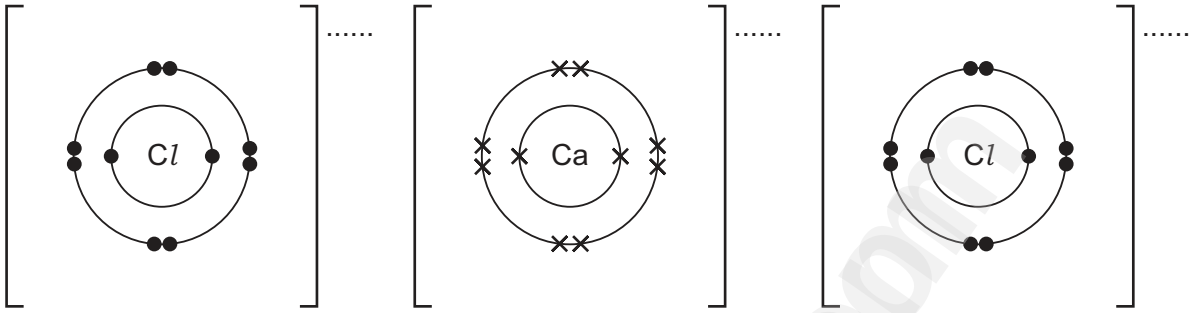

Fig. 2.1

[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]

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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_2O(l)	7
CH_3COOH(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) .....
- CH_3COOH(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]

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

$CH_3COOH(aq)$ ..... [3]

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

..... [1]

(g) Dilute nitric acid, $HNO_3(aq)$, reacts with aqueous calcium hydroxide, $Ca(OH)_2(aq)$, as shown.

$$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$$

$20.0\,cm^3$ of $0.0150\,mol/dm^3$ $Ca(OH)_2(aq)$ reacts with $25.0\,cm^3$ of $HNO_3(aq)$.

Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

Use the following steps.

- Calculate the number of moles of $Ca(OH)_2(aq)$ used.

..... mol

- Determine the number of moles of $HNO_3(aq)$ which react with the $Ca(OH)_2(aq)$.

..... mol

- Calculate the concentration of $HNO_3(aq)$ in mol/dm^3.

..... mol/dm^3

- Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

..... g/dm^3
[5]

[Total: 16]

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

$$HCOOH + CH_3CH_2OH \rightleftharpoons \mathbf{X} + H_2O \qquad \Delta H = -29.5\,kJ/mol$$

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]

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(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 CH_3CH_2OH are decreased	
the catalyst is removed	

[4]

[Total: 12]

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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]

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(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

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.).

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