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9534637521

CHEMISTRY **0620/43**

Paper 4 Theory (Extended) **May/June 2023**

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.

1 Some symbol equations and word equations, **A** to **J**, are shown.

A $H^+ + OH^- \rightarrow H_2O$

B $Cr^{3+} + 3OH^- \rightarrow Cr(OH)_3$

C methane + chlorine → chloromethane + hydrogen chloride

D propene + bromine → 1,2-dibromopropane

E $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

F chlorine + aqueous potassium bromide → bromine + aqueous potassium chloride

G methane + oxygen → carbon monoxide + water

H $C_2H_5COOH + CH_3OH \rightarrow C_2H_5COOCH_3 + H_2O$

I hydrogen + oxygen → water

J $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Use the equations to answer the questions that follow.
Each equation may be used once, more than once, or not at all.

Give the letter, **A** to **J**, for the equation which represents:

(a) photosynthesis ..... [1]

(b) an addition reaction ..... [1]

(c) a precipitation reaction ..... [1]

(d) incomplete combustion ..... [1]

(e) a displacement reaction ..... [1]

(f) a substitution reaction. ..... [1]

[Total: 6]

Question 2 starts on the next page.

2 **(a)** The symbols of the elements in Period 3 of the Periodic Table are shown.

Na Mg A*l* Si P S C*l* Ar

Use the symbols of the elements in Period 3 to answer the questions that follow.
Each symbol may be used once, more than once, or not at all.

Give the symbol of the element that:

(i) is present in purified bauxite ..... [1]

(ii) contains atoms with a full outer shell of electrons ..... [1]

(iii) is used to kill microbes in water treatment ..... [1]

(iv) forms an amphoteric oxide ..... [1]

(v) forms an oxide which causes acid rain ..... [1]

(vi) has an oxidation number of –1 when it forms a compound with hydrogen.

..... [1]

(b) The relative atomic masses of elements can be calculated from the relative masses of isotopes and their percentage abundances.

(i) Identify the isotope to which all relative masses are compared.

..... [1]

(ii) Table 2.1 shows the relative masses and the percentage abundances of the two isotopes in a sample of magnesium.

Table 2.1

relative mass of isotope	percentage abundance of isotope
24	85
26	15

Calculate the relative atomic mass of magnesium to **one** decimal place.

relative atomic mass = ... [2]

(c) An ion contains 10 electrons, 13 protons and 14 neutrons.

(i) State the nucleon number of the ion.

..... [1]

(ii) Identify the element that forms this ion.

..... [1]

[Total: 11]

3 Magnesium forms ionic compounds.

(a) Magnesium reacts with fluorine to form the ionic compound magnesium fluoride.
The electronic configurations of an atom of magnesium and an atom of fluorine are shown in Fig. 3.1.

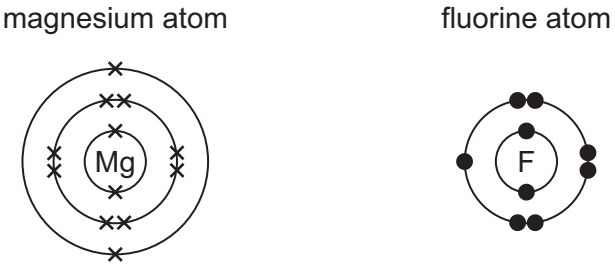

Fig. 3.1

(i) Ions are formed by the transfer of electrons from magnesium atoms to fluorine atoms.

Complete the dot-and-cross diagrams in Fig. 3.2 to show the electronic configurations of **one** magnesium ion and **one** fluoride ion. Show the charges on the ions.

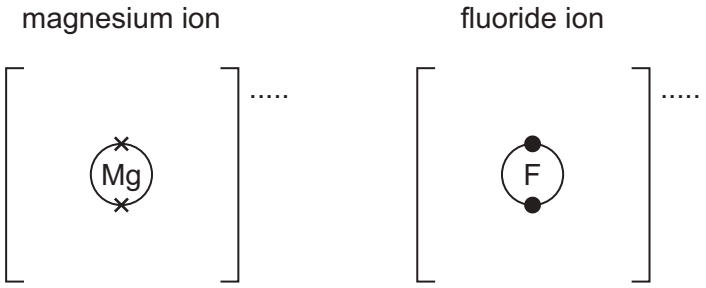

Fig. 3.2

[3]

(ii) Deduce the formula of magnesium fluoride.

..... [1]

(iii) When solid magnesium fluoride is dissolved in water it forms a solution that conducts electricity.

State one other change that can be made to solid magnesium fluoride to allow it to conduct electricity.

..... [1]

(b) Silicon tetrachloride, $SiCl_4$, and silicon(IV) oxide, SiO_2, are covalent compounds.

Complete the dot-and-cross diagram in Fig. 3.3 to show the electronic configuration in a molecule of silicon tetrachloride. Show outer shell electrons only.

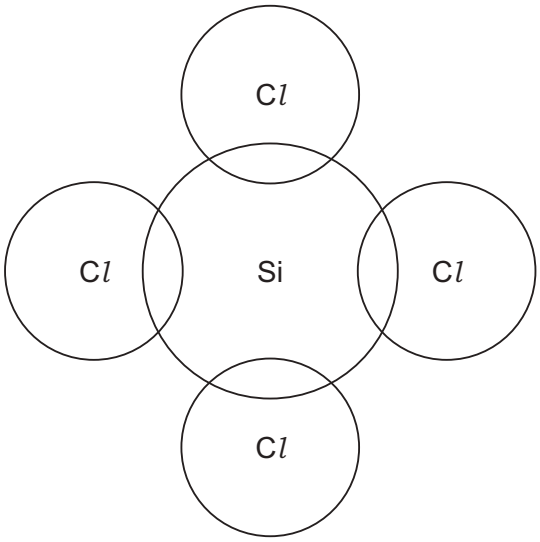

Fig. 3.3

[2]

(c) The melting points of silicon tetrachloride and silicon(IV) oxide are shown in Table 3.1.

Table 3.1

	melting point / °C
silicon tetrachloride	–69
silicon(IV) oxide	1710

(i) Silicon tetrachloride has a low melting point because it has weak forces of attraction between particles.

Name the type of particles that are held together by these weak forces of attraction.

..... [1]

(ii) Explain, in terms of structure and bonding, why silicon(IV) oxide has a high melting point.

.....

.....

.....

..... [2]

[Total: 10]

4 Hydrogen is produced by the reaction between zinc and dilute sulfuric acid, H_2SO_4.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

(a) A student carries out an experiment using excess zinc and dilute sulfuric acid.

The student measures the volume of hydrogen produced at regular time intervals using the apparatus shown in Fig. 4.1.

Lumps of zinc are used.

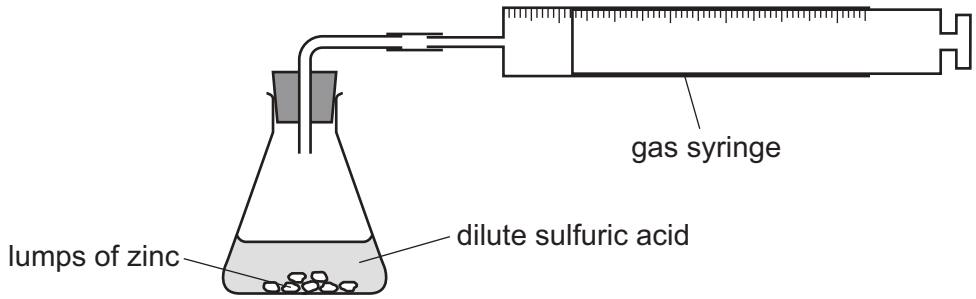

Fig. 4.1

The rate of reaction decreases as the reaction progresses. The rate eventually becomes zero.

(i) Explain why the rate of reaction decreases as the reaction progresses.

.....

..... [1]

(ii) Explain why the rate of reaction eventually becomes zero.

.....

..... [1]

(b) The experiment is repeated using powdered zinc instead of lumps of zinc.
All other conditions remain the same.

Explain, in terms of collision theory, why the rate of reaction increases if powdered zinc is used.

.....

.....

..... [2]

(c) The equation for the reaction is shown.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

25.0 cm^3 of 2.00 mol/dm^3 $H_2SO_4(aq)$ is added to excess zinc.

Calculate the volume of H_2 formed at room temperature and pressure (r.t.p.). The volume of one mole of any gas is 24 dm^3 at r.t.p.
Use the following steps.

- Calculate the number of moles of H_2SO_4 used.

..... mol

- Deduce the number of moles of H_2 produced.

..... mol

- Calculate the volume of H_2 formed at r.t.p.

..... dm^3
[3]

(d) Hydrogen can also be produced by the reaction of zinc with dilute hydrochloric acid.

(i) Write a symbol equation for this reaction.

..... [2]

(ii) State the test for hydrogen gas.

test .....

positive result .....
[1]

[Total: 10]

5 This question is about electricity and chemical reactions.

(a) Aqueous copper(II) sulfate is an electrolyte.
The electrolysis of aqueous copper(II) sulfate using inert electrodes forms:
- copper at the cathode
- oxygen at the anode.

(i) State what is meant by the term electrolyte.

.....

..... [2]

(ii) State the term given to the Roman numeral, (II), in the name copper(II) sulfate.

..... [1]

(iii) State what happens to the colour of the aqueous copper(II) sulfate as this electrolysis progresses.

..... [1]

(iv) Write an ionic half-equation for the formation of copper at the cathode.

..... [2]

(v) Give the formula of the ion that forms oxygen at the anode.

..... [1]

(b) The electrolysis of aqueous copper(II) sulfate is repeated using **copper** electrodes.

State what happens to the anode.

..... [1]

(c) Spoons can be electroplated with silver.

(i) Name the substances used as:

the anode (positive electrode) .....

the cathode (negative electrode) .....

the electrolyte. .....
[3]

(ii) State **two** reasons why spoons are electroplated.

1 .....

2 .....
[2]

(d) Hydrogen–oxygen fuel cells can be used to produce electricity to power cars.
Petrol produces carbon dioxide and carbon monoxide when it powers cars.

(i) State **one** adverse effect of carbon dioxide and carbon monoxide.

carbon dioxide .....

carbon monoxide .....
[2]

(ii) State **one** disadvantage, other than cost, of using hydrogen–oxygen fuel cells to power cars compared to using petrol.

..... [1]

[Total: 16]

6 This question is about nitrogen and compounds of nitrogen.

(a) Ammonia is manufactured by the reaction between nitrogen and hydrogen in the Haber process.
The equation is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State the source of nitrogen for the Haber process.

..... [1]

(ii) State the source of hydrogen for the Haber process.

..... [1]

(iii) State the typical conditions used in the Haber process.

temperature ..... °C

pressure ..... atm

[2]

(iv) Name the catalyst used in the Haber process.

..... [1]

(v) State what is meant by the term catalyst.

.....

..... [2]

(b) Ammonia is converted into nitric acid.

(i) The first stage is the conversion of ammonia into nitrogen monoxide, NO.
The equation is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The reaction is carried out at a temperature of 900 °C and a pressure of 7 atm.
The forward reaction is exothermic.

Using explanations that do **not** involve cost:

- explain why a temperature less than 900 °C is **not** used

.....

- explain why a pressure greater than 7 atm is **not** used.

.....
[2]

(ii) In the second stage, nitrogen monoxide reacts with water and oxygen to produce nitric acid.

Balance the symbol equation for the reaction.

$$.....NO + ...O_2 + ...H_2O \rightarrow .....HNO_3$$ [1]

(c) A student makes aqueous copper(II) nitrate by adding an excess of solid copper(II) carbonate to dilute nitric acid.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) State **two** observations that indicate the copper(II) carbonate is in excess.

1 .....

2 .....
[2]

(iii) Name **one** compound, other than copper(II) carbonate, that can be added to dilute nitric acid to produce aqueous copper(II) nitrate.

..... [1]

[Total: 15]

7 This question is about organic compounds.

(a) Propane and chlorine react at room temperature. An equation for the reaction is shown.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

(i) State the condition required for this reaction.

..... [1]

(ii) Draw the displayed formulae of **two** structural isomers with the formula C_3H_7Cl.

[2]

(b) Alkenes are a homologous series of hydrocarbons.

(i) State **two** characteristics that all members of the same homologous series have in common.

1 .....

2 .....
[2]

(ii) Addition polymers are made from alkenes.

Complete Fig. 7.1 to show one repeat unit of the addition polymer formed from but-2-ene.

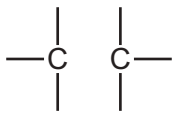

Fig. 7.1

[2]

(c) A repeat unit of a condensation polymer is shown in Fig. 7.2.
The polymer is made from two monomers.

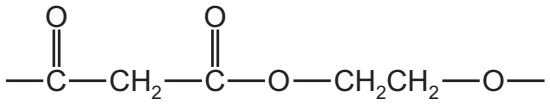

Fig. 7.2

(i) Draw the structures of the monomers used to produce the polymer in Fig. 7.2.

[2]

(ii) Name the **type** of condensation polymer in Fig. 7.2.

..... [1]

(iii) Name the **two** homologous series to which the monomers in **(i)** belong.

1 .....

2 .....
[2]

[Total: 12]

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.).