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CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **October/November 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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1 The formulae of the molecules **A** to **I** are shown in Table 1.1.

Table 1.1

molecule	formula
A	C_2H_4
B	C_2H_5OH
C	CO
D	CO_2
E	Cl_2
F	NO_2
G	N_2
H	O_2
I	SO_2

Answer the following questions about the molecules, **A** to **I**.
Each letter may be used once, more than once or not at all.

State which of the molecules **A** to **I**:

(a) is an element with a triple bond ..... [1]

(b) is a product of photosynthesis ..... [1]

(c) is used as a fuel ..... [1]

(d) turns limewater milky ..... [1]

(e) undergoes a substitution reaction with alkanes ..... [1]

(f) is a colourless liquid at r.t.p. ..... [1]

(g) is unsaturated ..... [1]

(h) is 21% of clean, dry air ..... [1]

(i) is a reactant in the Haber process. ..... [1]

[Total: 9]

2 Aluminium is manufactured by the electrolysis of aluminium oxide.

(a) State the name of the main ore of aluminium.

..... [1]

(b) Name the substance mixed with aluminium oxide to reduce the operating temperature of the process.

..... [1]

(c) Explain why the molten mixture in **(b)** conducts electricity.

..... [1]

(d) Table 2.1 contains some information about the processes which take place at the anode and the cathode.

Table 2.1

anode	cathode
$2O^{2-} \rightarrow O_2 + ...e^-$	……

(i) Complete Table 2.1:

- Write the number of electrons needed to balance the ionic half-equation for the reaction at the anode.
- Write the ionic half-equation for the reaction at the cathode.

[3]

(ii) State why the process at the anode is an oxidation.

..... [1]

(iii) Oxygen is formed at the anode.

Explain why the main gas given off at the anode is carbon dioxide and **not** oxygen.

.....

..... [2]

(e) State why aluminium is used in food containers.

..... [1]

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(f) Aluminium reacts with fluorine to form the ionic compound aluminium fluoride.

Complete the dot-and-cross diagram in Fig. 2.1 of the ions in aluminium fluoride.

Give the charges on the ions.

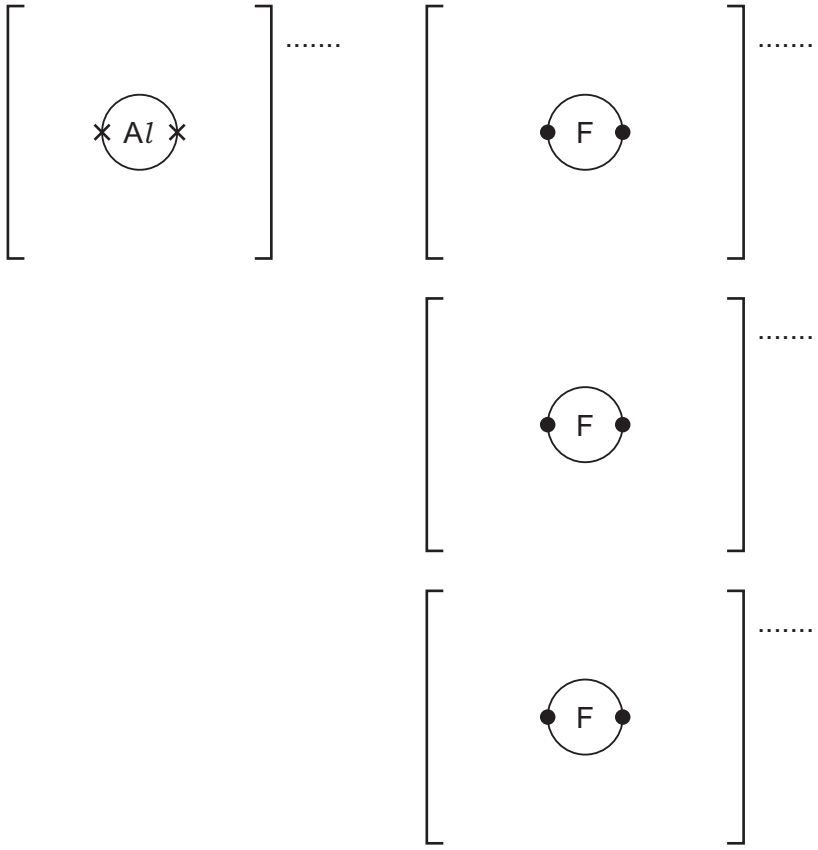

Fig. 2.1

[3]

[Total: 13]

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3 Sulfur forms two chlorides, **P** and **Q**.
Chloride **P** has the formula S_2Cl_2. Chloride **Q** has the formula SCl_2.

(a) Both chlorides are covalently bonded and have low melting points.

Suggest, in terms of attraction between particles, why these chlorides have low melting points.

.....

..... [2]

(b) Chloride **P**, S_2Cl_2, forms when sulfur reacts with chlorine.

Write the symbol equation for this reaction.

..... [1]

(c) Complete the dot-and-cross diagram in Fig. 3.1 of a molecule of chloride **Q**, SCl_2.

Show outer electrons only.

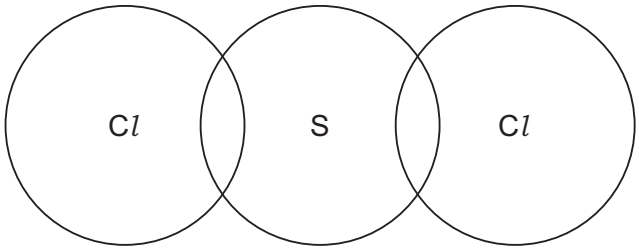

Fig. 3.1

[3]

(d) Chloride **P** is converted to chloride **Q** by reaction with chlorine in a closed system.
The reversible reaction reaches an equilibrium.

$$\underset{\textbf{P}}{S_2Cl_2(g)} + Cl_2(g) \rightleftharpoons \underset{\textbf{Q}}{2SCl_2(g)}$$

The forward reaction is exothermic.

Suggest **two** changes to the conditions which will result in a decrease in the concentration of chloride **Q** at equilibrium.

1 .....

2 .....

[2]

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(e) The rate of the forward reaction in **(d)** is determined by collision theory.

The rate of reaction depends upon two factors:

- the frequency of collisions between particles
- the proportion of collisions which have energy greater than or equal to the activation energy.

(i) Define the term activation energy.

..... [1]

(ii) Give the symbol for activation energy.

..... [1]

(iii) Complete Table 3.1 to show the effect, if any, when the conditions are changed.

Use only the words **increases**, **decreases** or **no change**.

Table 3.1

change to conditions	effect on the frequency of collisions between particles	effect on the proportion of collisions which have energy greater than or equal to the activation energy
concentration of chlorine is increased		
temperature is increased		
a catalyst is added		

[5]

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(f) The reaction of chloride **P** with chlorine is a redox reaction.

$$\underset{\textbf{P}}{S_2Cl_2(g)} + Cl_2(g) \rightleftharpoons \underset{\textbf{Q}}{2SCl_2(g)}$$

The oxidation number of Cl in chloride **P** and chloride **Q** is –1.

Use oxidation numbers to explain why:

- sulfur is oxidised in the forward reaction

  .....

  .....

- chlorine is oxidised in the reverse reaction.

  .....

  .....

[4]

[Total: 19]

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Question 4 starts on the next page.

4 Silver bromide, AgBr, is made when aqueous silver ethanoate, CH_3COOAg, is added to aqueous sodium bromide, NaBr.

The equation for the reaction is shown in **equation 1**.

equation 1 $CH_3COOAg + NaBr \rightarrow CH_3COONa + AgBr$

The method includes the following steps.

step 1 Add 200.0 cm^3 of 0.0500 mol / dm^3 CH_3COOAg to a beaker.
This volume contains 0.0100 mol of Ag^+ ions.

step 2 Add 50.0 cm^3 of aqueous NaBr. This volume contains 0.0100 mol of Br^- ions.
A precipitate forms.

step 3 Filter the mixture.

step 4 Dry the solid residue until all the water is removed.

step 5 Record the mass of the dry residue.

(a) Complete the ionic equation for the reaction by adding the missing state symbols.

$$Ag^+(.....) + Br^-(.....) \rightarrow AgBr(.....)$$

[1]

(b) Name a different aqueous silver salt which could be used in **step 1**.

..... [1]

(c) Use the information in **step 2** to calculate the concentration of aqueous NaBr.

concentration = ... mol / dm^3 [1]

(d) State the colour of the precipitate which forms in **step 2**.

..... [1]

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(e) Use the information in **step 1**, **step 2** and **equation 1** to determine the number of moles of AgBr formed. Use this value to calculate the mass of AgBr formed.

number of moles of AgBr = ...

mass of AgBr = ... g
[3]

(f) Name the salt dissolved in the filtrate in **step 3**.

..... [1]

(g) The recorded mass of the dry residue in **step 5** is greater than the mass calculated in **(e)** because a step is missing from the procedure.

(i) Suggest the missing step.

..... [1]

(ii) Name the substance responsible for the greater mass of the dry residue.

..... [1]

(h) Barium sulfate can be made by the same method but with different aqueous solutions.

(i) Suggest **two** aqueous solutions which can be added together to make barium sulfate.

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

(ii) Write the balanced symbol equation for this reaction.

..... [2]

[Total: 14]

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5 Alkenes are manufactured by cracking larger alkane molecules.

(a) State the source of the large alkane molecules used in cracking.

..... [1]

(b) State **two** conditions needed for cracking large alkane molecules.

1 .....

2 .....

[2]

(c) When one molecule of dodecane, $C_{12}H_{26}$, is cracked, three molecules of but-1-ene and one other product are formed.

(i) Use molecular formulae to complete the symbol equation for this reaction.

$C_{12}H_{26} \rightarrow$ ..... + ...

[2]

(ii) Suggest the type of chemical reaction which happens during cracking.

..... [1]

(d) Propene will undergo polymerisation.

(i) Suggest the name of the polymer formed from propene.

..... [1]

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

[3]

(iii) State the type of polymerisation propene undergoes.

..... [1]

[Total: 11]

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Question 6 starts on the next page.

6 Polyamides and polyesters are polymers.

Polyamides can occur naturally or can be manufactured.

(a) Part of the structure of a polyamide is shown in Fig. 6.1.

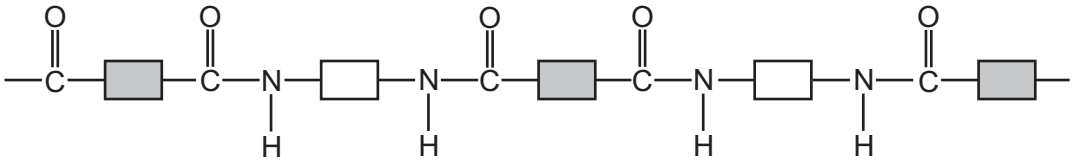

Fig. 6.1

(i) On Fig. 6.1, draw a circle around **one** amide linkage. [1]

(ii) Complete Fig. 6.2 to show the structures of the **two** monomers needed to make the polymer in Fig. 6.1.
Show all of the atoms and all of the bonds in the functional groups.

Fig. 6.2

[2]

(iii) Name the other product formed in this polymerisation.

..... [1]

(iv) State the term given to natural polyamides.

..... [1]

(v) Name the type of monomers which are used to make natural polyamides.

..... [1]

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(vi) One of the monomers which forms part of a natural polyamide has **three** carbon atoms.

Complete Fig. 6.3 to show the displayed formula of this monomer.

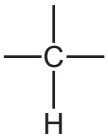

Fig. 6.3

[3]

(b) PET is a polyester.

(i) Name the **two** types of monomer molecules needed to make polyesters.

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

(ii) Draw part of the structure of PET which shows **two** repeat units.

Show all of the atoms and all of the bonds in the linkages.

[3]

[Total: 14]

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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.).

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