Cambridge Assessment International Education

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CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **May/June 2025**

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 Using numbers only, state the:

(a) percentage of nitrogen in clean, dry air

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..... [1]

(b) typical operating temperature of the Contact process in °C

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..... [1]

(c) number of metals in Period 3 of the Periodic Table

View solution

..... [1]

(d) number of halogens which are gases at r.t.p.

View solution

..... [1]

(e) typical temperature for the fermentation of aqueous glucose in °C

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..... [1]

(f) number of unbranched structural isomers of C_4H_8 which decolourise aqueous bromine

..... [1]

(g) number of covalent bonds in one molecule of ethanol

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..... [1]

(h) number of carbon atoms in one molecule of propyl butanoate.

..... [1]

[Total: 8]

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2 This question is about covalent compounds.

(a) State what is meant by a covalent bond.

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.....

..... [2]

(b) Chlorine(I) oxide, Cl_2O, is a simple molecule with covalent bonds.

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(i) State what is meant by (I) in the name chlorine(I) oxide.

..... [2]

(ii) Complete the dot-and-cross diagram in Fig. 2.1 of a molecule of chlorine(I) oxide.

Show outer electrons only.

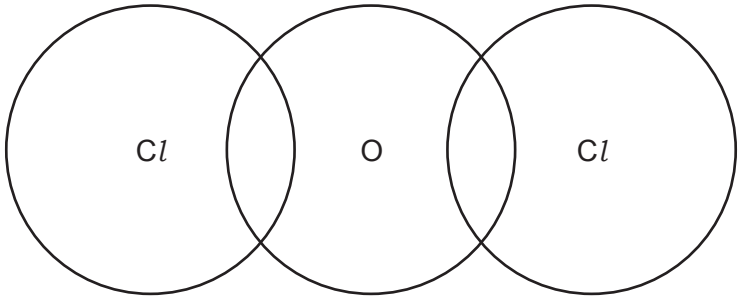

Fig. 2.1

[3]

(iii) Explain, in terms of structure and bonding, why Cl_2O boils at a low temperature and does **not** thermally decompose into its constituent elements, Cl_2 and O_2.

.....

.....

.....

..... [3]

(iv) Give **two** reasons why liquid Cl_2O is a poor conductor of electricity.

1 .....

2 .....

[2]

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(c) Carbon and silicon(IV) oxide both exist as giant covalent structures.

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(i) Name a giant covalent structure of carbon which conducts electricity.

..... [1]

(ii) Identify the particles responsible for the conduction of electricity in this covalent structure of carbon.

..... [1]

(iii) Silicon(IV) oxide contains silicon atoms, Si, and oxygen atoms, O.

Fig. 2.2 shows part of the giant covalent structure of silicon(IV) oxide.

Complete the diagram in Fig. 2.2 by adding the symbol for each of the 9 atoms shown.

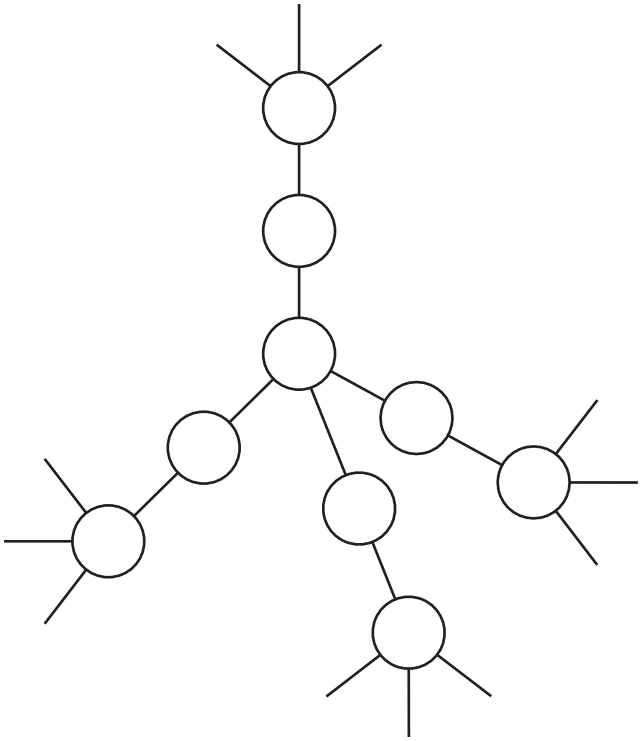

Fig. 2.2

[2]

[Total: 16]

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3 This question is about electrolysis.

(a) Complete the definition of electrolysis by filling in the missing words.

View solution

The decomposition of ..... compounds when .....

or ..... by the passage of an electric current.

[3]

(b) Electrolysis of aqueous copper(II) sulfate is carried out using the apparatus shown in Fig. 3.1. The electrodes are made of platinum.

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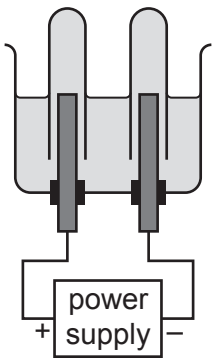

Fig. 3.1

(i) State whether the mass of the cathode increases, decreases or remains the same when platinum electrodes are used.

..... [1]

(ii) Describe the change in appearance, if any, of the electrolyte when platinum electrodes are used.

..... [1]

(iii) Describe what is seen at the anode when platinum electrodes are used.

..... [1]

(iv) Write the ionic half-equation for the reaction at the anode.

..... [3]

(c) The electrolysis is repeated using copper electrodes.

View solution

(i) State whether the mass of the cathode increases, decreases or remains the same when copper electrodes are used.

..... [1]

(ii) Describe the change in appearance, if any, of the electrolyte when copper electrodes are used.

.....[1]

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(d) Aluminium is extracted from its purified ore by electrolysis.

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(i) Name this ore of aluminium.

..... [1]

(ii) Name the substance added to this process to reduce the operating temperature.

..... [1]

(iii) Explain why the anodes need to be continually replaced during this process.

.....

..... [2]

[Total: 15]

4 Chromium is the element with atomic number 24 in the Periodic Table.

View solution

(a) The main ore of chromium is chromite. Chromite contains $FeCr_2O_4$.

$FeCr_2O_4$ reacts with carbon.

(i) Complete the equation for this reaction.

$$FeCr_2O_4 + 4C \rightarrow Fe + 2Cr + \text{.....}$$ [1]

(ii) Suggest **one** disadvantage of extracting chromium by reacting chromite with carbon.

..... [1]

View solution

(b) Chromium can be mixed with nickel and other elements to form stainless steel.

Name the type of substance formed when a metal is mixed with other elements.

..... [1]

View solution

(c) $(NH_4)_2Cr_2O_7$ is a compound containing chromium.

The negative ion in $(NH_4)_2Cr_2O_7$ is $Cr_2O_7^{2-}$.

(i) State the sum of the oxidation numbers in the $Cr_2O_7^{2-}$ ion.

..... [1]

View solution

(ii) The oxidation number of each O in $Cr_2O_7^{2-}$ ions is –2.

Determine the oxidation number of each Cr in $Cr_2O_7^{2-}$ ions. Show your working.

..... [2]

(iii) When $(NH_4)_2Cr_2O_7$ is heated the following reaction occurs.

View solution

$$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + 4H_2O + N_2$$

Calculate the volume of nitrogen gas produced at r.t.p., in cm^3, when 1.26 g of $(NH_4)_2Cr_2O_7$ is heated using the following steps.

The M_r of $(NH_4)_2Cr_2O_7$ is 252.

- Calculate the number of moles of $(NH_4)_2Cr_2O_7$ used.

..... mol

- Determine the number of moles of N_2 formed.

..... mol

- Calculate the volume of N_2 formed at r.t.p. in cm^3.

..... cm^3
[3]

[Total: 9]

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5 Alkali metals are reactive elements.

(a) State the group number of the alkali metals.

View solution

..... [1]

(b) Identify the alkali metal which:

View solution

(i) has the highest melting point

..... [1]

(ii) has the highest density View solution

..... [1]

(iii) has the lowest reactivity View solution

..... [1]

(iv) burns with a lilac flame View solution

..... [1]

(v) is found in fertilisers to improve plant growth. View solution

..... [1]

(c) Sodium sulfide, Na_2S, is an ionic compound.

View solution

Complete Fig. 5.1 to show the electronic configurations of the ions in sodium sulfide.

Show the charges on the ions.

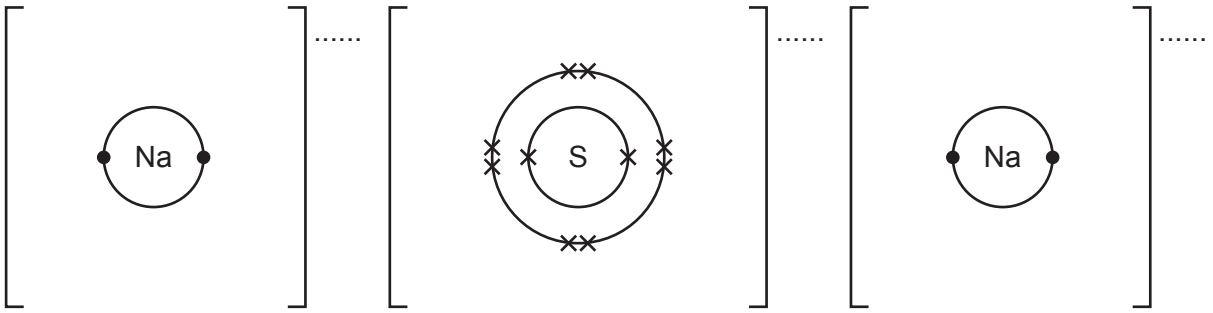

Fig. 5.1

[3]

(d) Rubidium has only two naturally occurring atoms, ^{85}Rb and ^{87}Rb.

View solution

(i) State the term given to these naturally occurring atoms of rubidium.

..... [1]

(ii) Complete Table 5.1 to show the number of protons, neutrons and electrons in the atom and ion of rubidium shown.

View solution

Table 5.1

	^{85}Rb	$^{87}Rb^{+}$
protons		
neutrons		
electrons		

[3]

(iii) The relative atomic mass of rubidium to one decimal place is 85.5.

Determine the relative abundance of ^{85}Rb in rubidium. Express your answer as a percentage.

View solution

.....% [1]

[Total: 14]

6 Ethene, C_2H_4, is the first member of a family of similar compounds which contains the alkene functional group.

(a) State the term for a family of similar compounds which contain the same functional group.

View solution

..... [1]

(b) Determine the difference in relative molecular mass between C_2H_4 and the next member in this family of similar compounds.

..... [1]

(c) Write the symbol equation for the complete combustion of C_2H_4.

View solution

..... [2]

(d) C_2H_4 reacts with steam to form ethanol.

View solution

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ/mol$$

The process happens in a closed system and the reaction reaches an equilibrium.
The conditions for this process are 300 °C and 60 atm pressure. H_3PO_4 is used as a catalyst.

(i) Complete Table 6.1 to show the effect, if any, on the concentration of $C_2H_4(g)$ when the following changes to the conditions are applied.

Only use the words **increases**, **decreases** or **no change**.

Table 6.1

change to condition	effect on the concentration of $C_2H_4(g)$ at equilibrium
temperature is decreased	
some $C_2H_5OH(g)$ is removed	
pressure is increased	
a more effective catalyst is used	

[4]

(ii) Explain, in terms of collision theory, why the rate of the forward reaction increases if the temperature increases.

.....

.....

.....

.....

..... [3]

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(e) Compound **B** has the displayed formula shown in Fig. 6.1.

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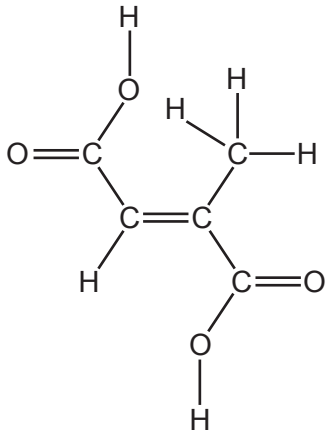

Fig. 6.1

(i) Deduce the molecular formula of compound **B**.

..... [1]

(ii) State why compound **B** is unsaturated.

View solution

..... [1]

(iii) Draw the structure of **one** repeat unit of the polymer formed when compound **B** undergoes addition polymerisation.

View solution

[2]

(iv) Explain why 1 mol of compound **B** reacts with 2 mol of sodium hydroxide, NaOH.

View solution

.....

..... [1]

(v) Calculate the volume, in cm^3, of 0.250 mol / dm^3 NaOH that reacts with 0.100 mol of compound **B**.

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volume = ... cm^3 [2]

[Total: 18]

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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.).