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CHEMISTRY **0620/43**

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 A list of substances is shown.

aluminium oxide **calcium oxide** **chlorine** **ethanol** **graphite**

nitrogen **oxygen** **propane** **propene** **silicon(IV) oxide**

Answer the questions using the list of substances.

Each substance may be used once, more than once, or not at all.

State which of the substances:

(a) is a compound with a giant covalent structure

View solution

..... [1]

(b) is an unsaturated hydrocarbon

View solution

..... [1]

(c) is an amphoteric oxide

View solution

..... [1]

(d) is a good conductor of electricity when solid

View solution

..... [1]

(e) contains simple molecules with 9 atoms

View solution

..... [1]

(f) react together to form slag in the blast furnace

View solution

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

(g) belongs to a homologous series whose general formula is C_nH_{2n+2}

View solution

..... [1]

(h) is manufactured by the catalytic addition of steam to ethene

View solution

..... [1]

(i) is a gas that is approximately 78% of clean, dry air.

..... [1]

[Total: 10]

View solution

2 Atoms are made of electrons, neutrons and protons.

(a) State which of these particles are found in the nucleus of an atom.

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..... [1]

(b) Atoms of the same element are known as isotopes.

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$^{32}_{16}S$ and $^{34}_{16}S$ are isotopes of sulfur.

(i) Complete Table 2.1 to show the number of electrons, neutrons and protons in one atom or ion of these isotopes.

Table 2.1

isotope	electrons	neutrons	protons
$^{34}_{16}S$			
$^{32}_{16}S^{2-}$			

[3]

(ii) Table 2.2 shows the relative masses and the percentage abundances of the two isotopes in a sample of sulfur.

View solution

Table 2.2

relative mass of isotope	percentage abundance of isotope
32	95
34	5

Calculate the relative atomic mass of this sample of sulfur to **one** decimal place.

relative atomic mass = ... [2]

(iii) The relative atomic masses of all elements are compared to one atom of an isotope.

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Identify this isotope.

..... [1]

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(c) Ions are atoms or groups of atoms that have gained or lost one or more electrons.

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An oxygen atom has the electronic configuration of 2,6.

Give the formula of **one** atom and **one** positive ion that has the same electronic configuration as O^{2-}.

- atom .....
- positive ion .....

[2]

[Total: 9]

3 This question is about zinc and compounds of zinc.

(a) Zinc is held together by electrostatic forces of attraction between particles.

View solution

(i) Name the type of bonding in zinc.

..... [1]

(ii) Name the **two** types of particles held together by the bonding in **(a)(i)**.

View solution

1 .....

2 .....

[2]

(iii) Name the type of particle whose movement allows zinc to conduct electricity.

View solution

..... [1]

(b) Zinc is present in alloys such as brass.

View solution

(i) State the meaning of the term alloy.

..... [1]

(ii) Name the substance that is present in brass, other than zinc.

View solution

..... [1]

(c) Zinc sulfate crystals are made by the reaction between zinc carbonate and dilute sulfuric acid, using the following steps.

View solution

step 1 An excess of powdered zinc carbonate is added to dilute sulfuric acid.

step 2 Excess zinc carbonate is separated from aqueous zinc sulfate by filtration.

step 3 Aqueous zinc sulfate is heated until a saturated solution is formed.

step 4 The saturated solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(i) Give **two** observations which show that the zinc carbonate is in excess in **step 1**.

1 .....

2 .....

[2]

(ii) Name the filtrate in **step 2**.

..... [1]

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(iii) Name a compound, other than zinc carbonate, that can be added to dilute sulfuric acid to produce aqueous zinc sulfate in **step 1**.

..... [1]

(iv) State what is meant by the term saturated solution.

.....

..... [2]

(v) **Step 1** is repeated using large pieces of zinc carbonate instead of powdered zinc carbonate.

All other conditions are the same.

The rate of reaction decreases.

Explain why the rate of reaction decreases. Give your answer in terms of particles.

.....

.....

..... [2]

(vi) Hydrated crystals form in **step 4**.

State what is meant by the term hydrated.

..... [1]

[Total: 15]

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4 This question is about compounds of sulfur.

View solution

(a) Sulfuric acid is manufactured in a four-stage process.

stage 1 Sulfur dioxide is produced from ores containing sulfur.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide reacts with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum reacts with water to form concentrated sulfuric acid.

(i) Iron pyrite is an ore containing sulfur. The ore contains a compound with the formula FeS_2.

FeS_2 reacts with oxygen in the air to produce sulfur dioxide.

Balance the symbol equation for this reaction.

$$4FeS_2 + ...O_2 \rightarrow .....SO_2 + ...Fe_2O_3$$

[1]

(ii) Complete the dot-and-cross diagram in Fig. 4.1 to show the electronic configuration in an oxygen molecule, O_2. Show outer-shell electrons only.

View solution

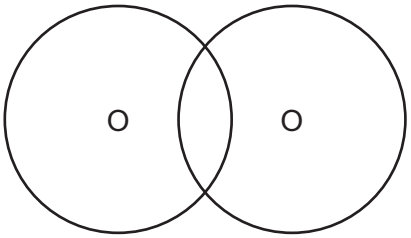

Fig. 4.1

[2]

(b) **(i)** State **three** typical conditions for the reaction between sulfur dioxide and oxygen in **stage 2**.

1 .....

2 .....

3 .....

[3]

View solution

(ii) Write a symbol equation for the reaction that occurs in **stage 2**.

..... [1]

(iii) Write the symbol equation for the reaction in **stage 3**.

..... [1]

(c) Sulfuric acid reacts with carbon. The equation for the reaction is shown.

View solution

$$2H_2SO_4 + C \rightarrow CO_2 + 2H_2O + 2SO_2$$

Give the oxidation number of carbon in:

- C .....
- CO_2. .....

[2]

(d) Dilute sulfuric acid reacts with sodium hydrogencarbonate, $NaHCO_3$, to produce carbon dioxide gas, CO_2.

View solution

$$H_2SO_4(aq) + 2NaHCO_3(s) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_2O(l)$$

4.20 g of $NaHCO_3$ is added to excess dilute sulfuric acid.

Calculate the volume of $CO_2(g)$, measured at r.t.p., produced using the following steps.

- Calculate the number of moles of $NaHCO_3$ in 4.20 g.

  The M_r of $NaHCO_3$ is 84.

..... mol

- Deduce the number of moles of $CO_2(g)$ that are produced.

..... mol

- Calculate the volume of $CO_2(g)$ produced in cm^3.

  One mole of any gas occupies 24 000 cm^3 at r.t.p.

..... cm^3

[3]

[Total: 13]

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5 Ethanoic acid is manufactured in the reaction between methanol and carbon monoxide.

An equilibrium mixture is produced.

$$CH_3OH(g) + CO(g) \rightleftharpoons CH_3COOH(g)$$

View solution

(a) State **two** characteristics of an equilibrium.

1 .....

2 .....

[2]

View solution

(b) Both a high yield of ethanoic acid and a high rate of reaction are needed.

The reaction is carried out at 300 °C.

The forward reaction is exothermic.

(i) State the disadvantage of using a temperature:

- below 300 °C

.....

- above 300 °C.

.....

[2]

View solution

(ii) Complete Table 5.1 using **only** the words **increases**, **decreases** or **no change**.

Table 5.1

	effect on the equilibrium concentration of $CH_3COOH(g)$	effect on the rate of the forward reaction
catalyst is added		increases
pressure is increased		

[3]

View solution

(iii) Suggest which element from the list is a suitable catalyst for the reaction.

Give a reason for your answer.

aluminium **carbon** **cobalt** **magnesium** **sodium**

catalyst .....

reason .....

[2]

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(c) Ethanoic acid is a member of the carboxylic acid homologous series.

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(i) Name the carboxylic acid that contains only one carbon atom.

..... [1]

(ii) State the molecular formula of a carboxylic acid that contains four carbon atoms.

..... [1]

(d) Carboxylic acids react with alcohols to form esters.

View solution

(i) Draw the displayed formula of the ester which contains two carbon atoms.

[2]

(ii) Propyl butanoate is an ester.

View solution

Name the carboxylic acid and alcohol that react to produce propyl butanoate.

carboxylic acid .....

alcohol .....

[2]

(e) An organic compound has the following composition by mass:

View solution

C, 58.82%; H, 9.80%; O, 31.38%.

Calculate the empirical formula of the compound.

empirical formula = ... [3]

[Total: 18]

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6 This question is about the Periodic Table.

(a) State the name given to Group I elements.

View solution

..... [1]

(b) State which Group I element is least reactive.

View solution

..... [1]

(c) Lithium is in Group I of the Periodic Table.

View solution

When lithium is added to water a chemical reaction occurs.

(i) Give **two** observations when lithium is added to water.

1 .....

2 .....

[2]

(ii) Write a symbol equation for this reaction.

View solution

..... [2]

(d) Group I elements have lower melting points and lower boiling points than transition elements.

Describe **two other** physical properties of Group I elements that are different from transition elements.

1 .....

2 .....

[2]

(e) The Group VII elements are known as the halogens.

View solution

(i) Give the physical state and colour of chlorine at room temperature and pressure.

state .....

colour .....

[2]

(ii) When chlorine is passed through aqueous potassium bromide, a displacement reaction occurs.

View solution

The equation for the reaction is shown.

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

Write an ionic equation for the reaction.

..... [2]

(iii) Iodine and chlorine react at high temperatures to form iodine monochloride, IC*l*.

View solution

The equation for the reaction is shown.

$$I_2(g) + Cl_2(g) \rightarrow 2ICl(g)$$

The structures of the molecules involved in the reaction are I–I, C*l*–C*l* and I–C*l*.

Table 6.1

bond	bond energy in kJ / mol
I–I	150
C*l*–C*l*	242
I–C*l*	218

Calculate the enthalpy change, ΔH, for the reaction using the bond energies in Table 6.1.

Use the following steps.

- Calculate the **total** amount of energy required to break the bonds in 1 mol of $I_2(g)$ and 1 mol of $Cl_2(g)$.

..... kJ

- Calculate the total amount of energy released when the bonds in 2 mol of IC*l*(g) are formed.

..... kJ

- Calculate the enthalpy change, ΔH, for the reaction.
  Your answer should include a sign.

..... kJ / mol
[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.).