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CHEMISTRY **0620/43**

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 **20** pages. Any blank pages are indicated.

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[Turn over

1 A list of substances is shown.

bauxite
carbon dioxide
cryolite
ethane
ethanol
ethene
graphite
helium
hematite
hydrogen
silicon(IV) oxide
sodium chloride

Answer the following questions using only the substances from the list.

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

State which substance:

(a) is manufactured by fermentation

..... [1]

(b) is monatomic

..... [1]

(c) is a reactant in photosynthesis

..... [1]

(d) is a solvent in the extraction of aluminium

..... [1]

(e) is an ore of iron

..... [1]

(f) is manufactured from methane

..... [1]

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(g) is a compound with a giant covalent structure

..... [1]

(h) is used as a lubricant

..... [1]

(i) is tested for with limewater.

..... [1]

[Total: 9]

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2 This question is about electrolysis.

(a) State the meaning of the term electrolysis.

.....

..... [2]

(b) Table 2.1 gives some information about the electrolysis of two electrolytes using graphite electrodes.

Table 2.1

	anode (positive electrode)		cathode (negative electrode)	
electrolyte	observation	name of product	observation	name of product
concentrated aqueous potassium iodide			bubbles of colourless gas	
aqueous copper(II) sulfate	bubbles of colourless gas	oxygen	pink-brown solid	

(i) Complete Table 2.1. [4]

(ii) Oxygen is produced at the anode by the electrolysis of aqueous copper(II) sulfate.

Write the ionic half-equation for this reaction.

..... [2]

(c) Aqueous copper(II) sulfate is electrolysed using copper electrodes instead of graphite electrodes.

(i) Explain why the mass of the anode decreases during this electrolysis.

..... [1]

(ii) Name the product formed at the cathode.

..... [1]

(iii) State what change, if any, is observed in the appearance of the aqueous copper(II) sulfate.

..... [1]

[Total: 11]

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3 This question is about compounds of tin.

(a) Tin(IV) oxide has the formula SnO_2.

The relative formula mass, M_r, of SnO_2 is 151.

Calculate the percentage by mass of tin in SnO_2.

percentage by mass of tin in SnO_2 = ...% [1]

(b) SnO_2 is an amphoteric oxide.

SnO_2 reacts with aqueous sodium hydroxide, NaOH, to form a sodium salt and water only. The sodium salt contains a negative ion with the formula SnO_3^{2-}.

(i) State the meaning of the term amphoteric.

.....

..... [1]

(ii) Write the symbol equation for the reaction between SnO_2 and NaOH.

..... [2]

(c) Tin is a metal that forms both covalent and ionic compounds.

Suggest why this is unusual for a metal.

..... [1]

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(d) (i) Tin(IV) chloride, $SnCl_4$, is covalently bonded.

A tin atom has four electrons in its outer shell.

Complete the dot-and-cross diagram in Fig. 3.1 for a molecule of $SnCl_4$.
Show the outer shell electrons only.

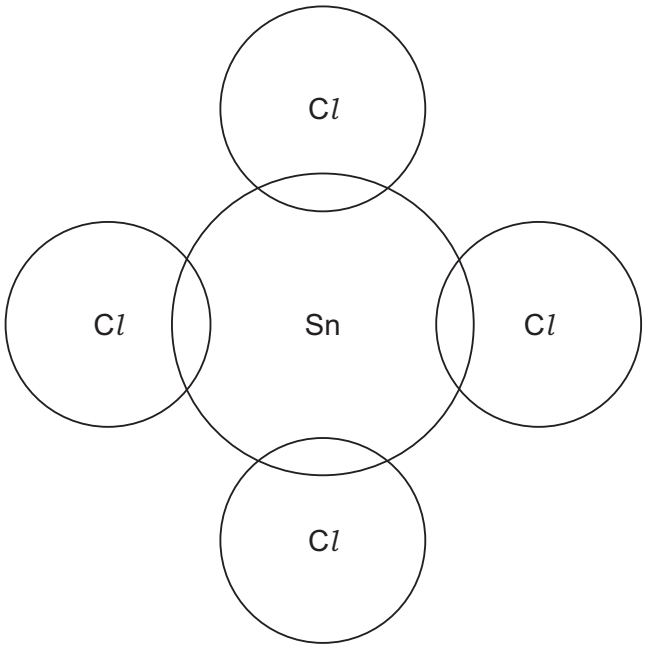


Fig. 3.1

[2]

(ii) Tin(II) oxide, SnO, is ionically bonded.

The melting points of $SnCl_4$ and SnO are shown in Table 3.1.

Table 3.1

	melting point / °C
$SnCl_4$	–33
SnO	1080

Explain, in terms of structure and bonding, why $SnCl_4$ has a much lower melting point than SnO.

.....

.....

.....

.....

..... [3]

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(e) Part of the reactivity series is shown.

magnesium	most reactive
aluminium	↑
tin	
copper	least reactive

(i) When aluminium foil is added to aqueous tin(II) sulfate, a reaction does **not** occur even though aluminium is above tin in the reactivity series.

Explain why a reaction does **not** occur.

.....

..... [1]

(ii) An aqueous solution of tin(II) sulfate contains Sn^{2+} ions.

Two experiments are carried out.

Experiment 1 Copper is added to aqueous tin(II) sulfate.

Experiment 2 Magnesium is added to aqueous tin(II) sulfate.

Write an ionic equation for any reaction that occurs in each experiment.
If no reaction occurs, write 'no reaction'.

Experiment 1 .....

Experiment 2 .....

[2]

(f) Hydrated tin(II) nitrate, $Sn(NO_3)_2 \cdot 20H_2O$, decomposes when it is heated.

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

.....

..... [1]

(ii) Complete the equation for the decomposition of $Sn(NO_3)_2 \cdot 20H_2O$.

$$2Sn(NO_3)_2 \cdot 20H_2O \rightarrow .....SnO + ...NO_2 + O_2 + ...H_2O$$

[2]

[Total: 16]

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4 This question is about sulfuric acid, H_2SO_4.

(a) Dilute sulfuric acid and aqueous sodium hydroxide can be used to prepare sodium sulfate crystals using a method that involves titration.

The apparatus for titration is shown in Fig. 4.1.

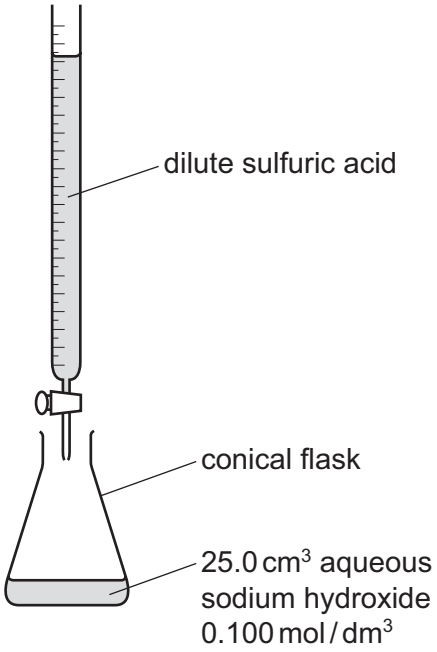


Fig. 4.1

Thymolphthalein is used as an indicator for this titration.

(i) State the colour change of thymolphthalein at the end-point of this titration.

from ..... to ..... [2]

(ii) Suggest why universal indicator is **not** used for this titration.

.....

..... [1]

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(b) 25.0 cm^3 of aqueous sodium hydroxide, NaOH, of concentration 0.100 mol/dm^3 is neutralised by 20.0 cm^3 of dilute sulfuric acid, H_2SO_4.

The equation for the reaction is shown.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of H_2SO_4 using the following steps.

- Calculate the number of moles of NaOH used.

..... mol

- Determine the number of moles of H_2SO_4 that react with the NaOH.

..... mol

- Calculate the concentration of H_2SO_4.

..... mol/dm^3
[3]

(c) A student is provided with an aqueous solution of sodium sulfate.

Describe how to prepare a **pure** sample of sodium sulfate crystals from this solution.

.....

.....

.....

.....

..... [3]

(d) Potassium hydrogen sulfate, $KHSO_4$, can be prepared by a reaction between aqueous potassium hydroxide and dilute sulfuric acid. Water is the only other product.

Write a symbol equation for this reaction.

..... [1]

(e) Potassium hydrogen sulfate, $KHSO_4$, dissolves in water to form solution **X**.

Solution **X** contains K^+, H^+ and SO_4^{2-} ions.

(i) Name the **type** of solution that contains H^+ ions.

..... [1]

(ii) State the observations when the following tests are done.

- A flame test is carried out on **X**.

.....

- Solid copper(II) carbonate is added to **X**.

.....

.....

.....

- Aqueous barium nitrate acidified with dilute nitric acid is added to **X**.

.....

[5]

(f) 0.325 g of Zn is added to dilute sulfuric acid which contains 0.0100 moles of H_2SO_4.

The equation for this reaction is shown.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

(i) Determine whether Zn or H_2SO_4 is the limiting reactant.
Explain your answer.

.....

.....

.....

..... [2]

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(ii) In another experiment, 48.0 cm^3 of hydrogen gas, H_2, is produced. The experiment is carried out at room temperature and pressure, r.t.p.

Calculate the number of molecules in 48.0 cm^3 of H_2 gas measured at r.t.p.

The value of the Avogadro constant is 6.02×10^{23}.

..... molecules [2]

[Total: 20]

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5 This question is about rate of reaction and equilibrium.

A student investigates the rate of decomposition of aqueous hydrogen peroxide, H_2O_2, using manganese(IV) oxide as a catalyst.

The equation for the reaction is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The student uses the apparatus shown in Fig. 5.1.

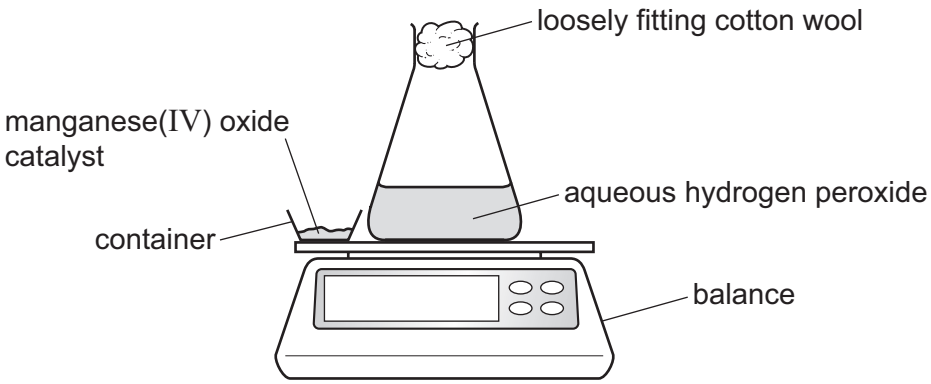


Fig. 5.1

The student:
- adds the catalyst to the aqueous hydrogen peroxide
- replaces the container on the balance
- starts a stop-watch
- records the mass at regular time intervals.

(a) Table 5.1 shows the mass recorded at regular time intervals.

Table 5.1

time / s	mass / g
0	50.64
30	49.80
60	49.38
90	49.17
120	49.07
150	49.02
180	48.99
210	48.97
240	48.97
270	48.97

(i) Suggest why the mass decreases as time increases.

..... [1]

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(ii) After a certain time the reaction stops.

Explain why the reaction stops.

..... [1]

(iii) Suggest why it is **not** possible to use the results in Table 5.1 to determine the **exact** time when the reaction stops.

.....

..... [1]

(b) Fig. 5.2 shows a graph of the mass against time.

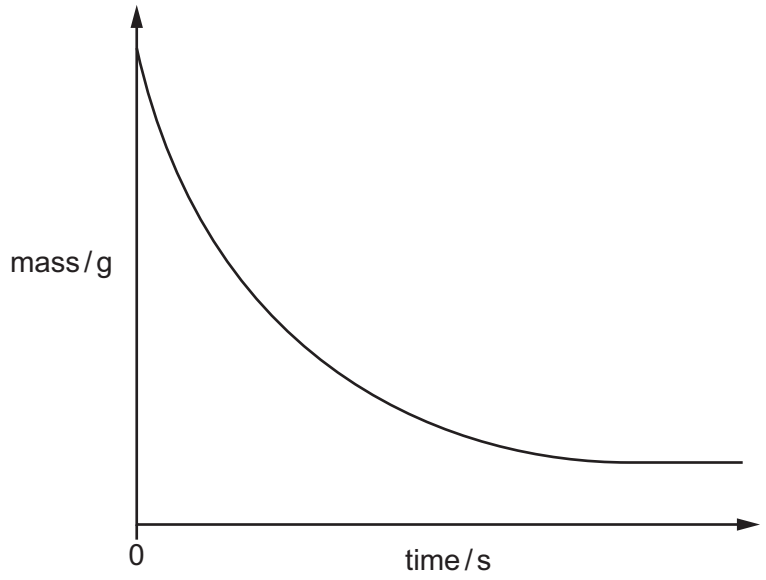


Fig. 5.2

The experiment is repeated at a higher temperature.
All other conditions remain the same.

(i) Explain, in terms of collision theory, why the rate of reaction is higher at a higher temperature.

.....

.....

.....

.....

..... [3]

(ii) On Fig. 5.2, sketch the line expected when the experiment is repeated at a higher temperature. [2]

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(c) Manganese(IV) oxide is the catalyst in this reaction.

(i) Explain the meaning of (IV) in manganese(IV) oxide.

.....

..... [2]

(ii) State how the mass of the **catalyst** has changed, if at all, at the end of the experiment.

..... [1]

(d) Nitrogen monoxide gas, NO, and oxygen gas, O_2, react to produce nitrogen dioxide gas, NO_2, at room temperature.

The reaction can reach equilibrium. The equation is shown.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = -113\,kJ/mol$$

NO(g) and O_2(g) are passed into a beaker as shown in Fig. 5.3.

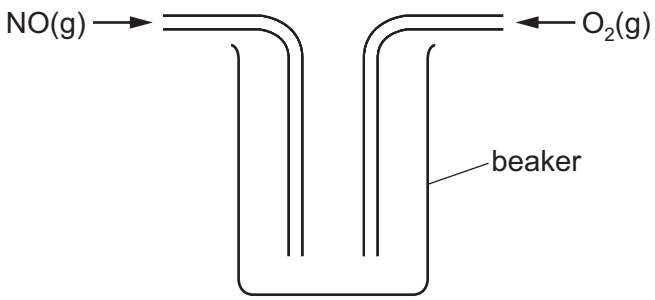


Fig. 5.3

(i) Explain why the method shown in Fig. 5.3 will **not** allow the reaction to reach equilibrium.

..... [1]

(ii) The apparatus is changed and equilibrium is reached.

The temperature of the equilibrium system is then increased and the position of equilibrium shifts to the left.

Explain why the position of equilibrium shifts to the left.

..... [1]

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(iii) The pressure of the equilibrium system is then increased.

State the direction, if any, in which the position of equilibrium shifts.
Explain your answer.

direction .....

explanation .....

[2]

[Total: 15]

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6 This question is about hydrocarbons.

(a) State the meaning of the term hydrocarbon.

..... [1]

(b) Propene, C_3H_6, can be made from long-chain alkanes such as dodecane.
Dodecane contains 12 carbon atoms.

(i) Deduce the molecular formula of dodecane.

..... [1]

(ii) Name the type of reaction that occurs when long-chain alkanes are converted into shorter chain alkenes.

..... [1]

(c) Propene is an unsaturated hydrocarbon.
Propene reacts with bromine.

(i) State the meaning of the term unsaturated.

..... [1]

(ii) Write the molecular formula of the product formed when propene reacts with bromine.

..... [1]

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(d) A styrene molecule is represented as shown in Fig. 6.1.

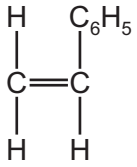


Fig. 6.1

(i) The molecular formula of styrene is C_8H_8.

Determine the empirical formula of styrene.

..... [1]

(ii) Styrene can be polymerised into poly(styrene).

State the type of polymerisation that occurs when styrene is converted into poly(styrene).

..... [1]

(iii) Draw the structure of **one** repeat unit of poly(styrene). Include all of the atoms and all of the bonds.
The C_6H_5 group should be represented as C_6H_5.

[2]

[Total: 9]

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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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