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GREENDALE SECONDARY SCHOOL
Preliminary Examination 2022

CHEMISTRY **6092/01**

Paper 1 Multiple Choice
Secondary 4 Express

31 August 2022
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class and register number on the Answer Sheet and on the Question Paper in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on this question paper.
A copy of the Periodic Table is printed on Page 18.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **18** printed pages.

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1 A student put exactly 25.0 cm^3 of dilute hydrochloric acid into a conical flask.

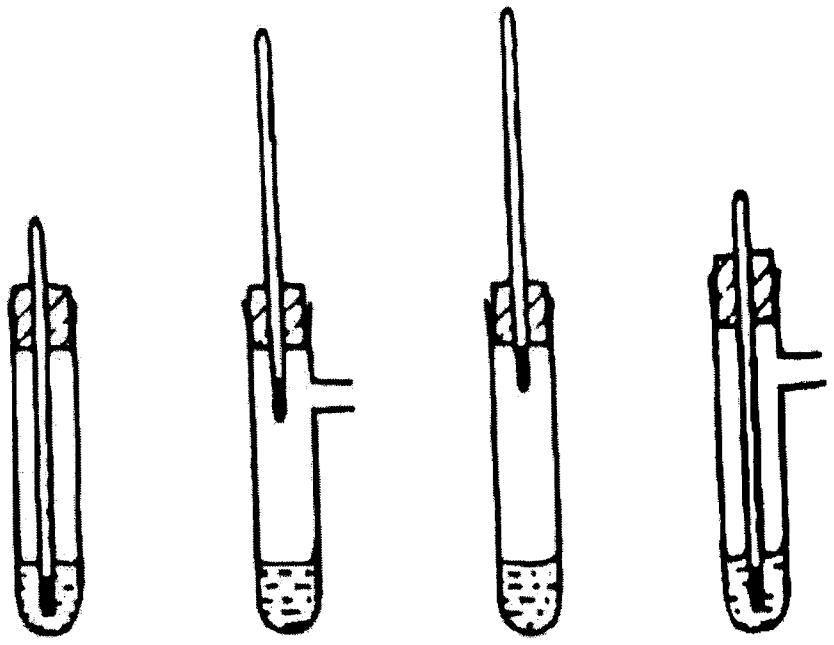
The student added 2.5 g of solid sodium carbonate and measured the change in temperature of the mixture.

Which apparatus does the student need to use?

A balance, measuring cylinder, thermometer
B balance, pipette, stopwatch
C balance, pipette, thermometer
D burette, pipette, thermometer

2 The tubes shown all contain a dilute solution of a solid X dissolved into a liquid Y.

Which apparatus is most suitable for finding the boiling point of liquid Y?



3 Which description of brass are correct?

1 It is an alloy.
2 It is a mixture.
3 It is a non-metal.

A 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 3 only

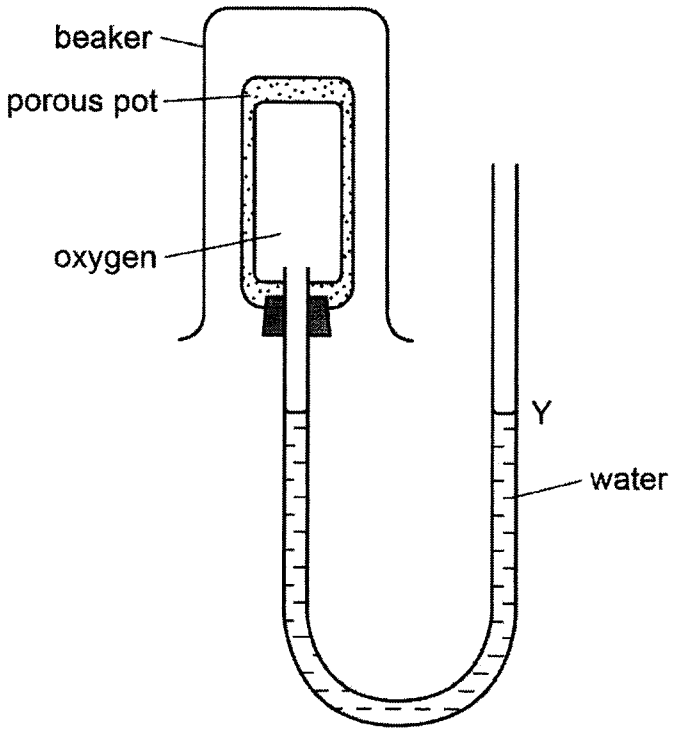
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4 Which one of the following correctly describes the particles in a dilute sugar solution at room temperature?

	sugar molecules	water molecules
A	widely separated, moving at random	close together, moving at random
B	widely separated, moving at random	close together, not moving
C	close together, moving at random	widely separated, moving at random
D	close together, vibrating slightly	close together, moving at random

5 The diagram shows a diffusion experiment.



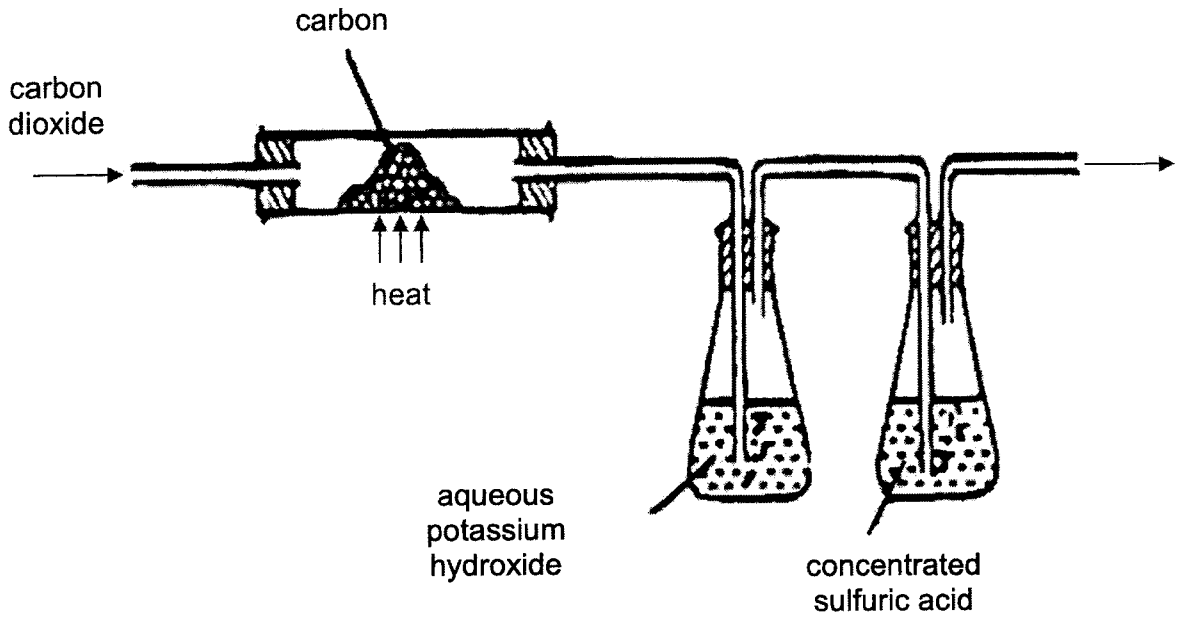
Which gas, when present in the beaker over the porous pot, will cause water level at Y to initially rise?

A CO_2
B Cl_2
C CH_4
D NO_2

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6 The apparatus shown is used to prepare carbon monoxide.



What is the purpose of the aqueous potassium hydroxide?

A to absorb any oxygen formed
B to cool the carbon monoxide
C to dry carbon monoxide
D to remove traces of carbon dioxide

7 A bottle of copper(II) oxide has been contaminated with some solid sodium chloride.

How can the sodium chloride be removed from the copper(II) oxide?

A Place the mixture in a separating funnel.
B Heat the mixture and allow it to cool.
C Add aqueous silver nitrate to the mixture and filter.
D Add water to the mixture and filter.

8 A particle consists of three electrons, four protons and five neutrons.

Which of the statement about the particle are correct?

1 The particle has an atomic number of 3.
2 The particle has a mass number of 7.
3 The particle has a charge of 1+.

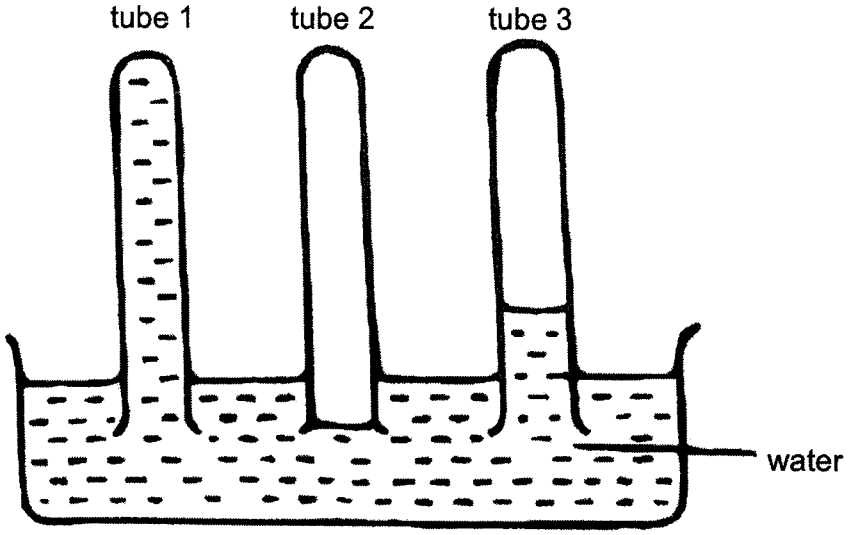
A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 3 only

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9 Three dry test-tubes were filled with different gases and placed in a trough of water.

After a short time, the water had risen in two of the tubes as shown.



Which gases could the tubes have contained?

	tube 1	tube 2	tube 3
A	ammonia	carbon dioxide	hydrogen
B	ammonia	hydrogen	carbon dioxide
C	carbon dioxide	ammonia	oxygen
D	oxygen	ammonia	carbon dioxide

10 The elements T, X and Y have consecutive, increasing atomic numbers.

If element T is a noble gas, what will be the symbol for the ion of element Y in its compounds?

A Y^{+} **B** Y^{2+} **C** Y^{2-} **D** Y^{-}

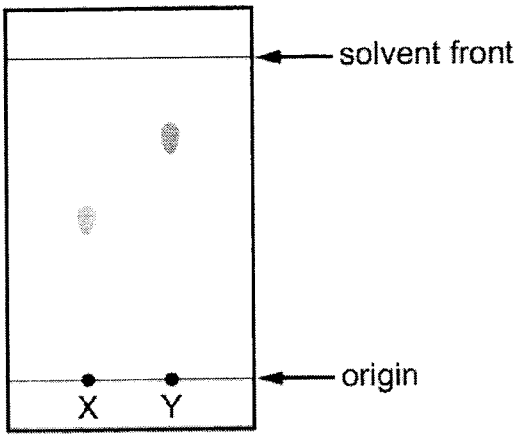
11 What are the different forms for the same element in the same physical state called?

A allotropes **B** isomers **C** isotopes **D** polymers

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12 The results of a paper chromatography experiment are shown.



X is an aqueous solution of a salt of a Group I element.

Y is an aqueous solution of a salt of a transition element.

Which row is correct?

	larger R_f value	requires a locating agent
A	X	X
B	X	Y
C	Y	X
D	Y	Y

13 Hydrogen gas is produced when sodium is added to water.

What is the volume of hydrogen gas, measured at r.t.p., produced when 18.4 g of sodium reacts with excess water?

A 9.6 dm^3 **B** 15.0 dm^3 **C** 19.2 dm^3 **D** 30.0 dm^3

14 Iron can be electroplated with zinc to make it resistant to corrosion.

Which row about electroplating iron with zinc is correct?

	positive electrode	negative electrode	electrolyte
A	iron	zinc	iron(II) nitrate
B	iron	zinc	zinc nitrate
C	zinc	iron	iron(II) nitrate
D	zinc	iron	zinc nitrate

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15 Element P has an electronic configuration of 2.8.6.

Element R has an electronic configuration of 2.8.8.1.

What is likely to form if P and R combine?

A a covalent compound RP
B a covalent compound R_2P
C an ionic compound RP
D an ionic compound R_2P

16 One mole of compound Q gives three moles of ions in aqueous solution. Q reacts with ammonium carbonate to give an acidic gas.

What is compound Q?

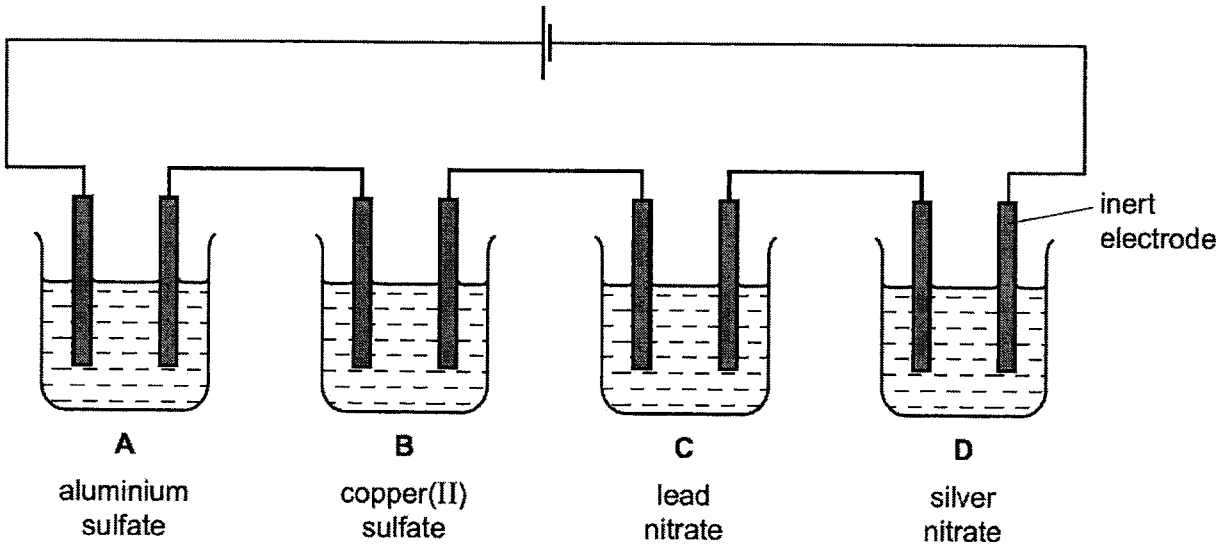
A calcium hydroxide
B nitric acid
C sodium hydroxide
D sulfuric acid

17 124 g of phosphorus vapour has the same volume as 71 g of chlorine gas at the same temperature and pressure.

What is the formula of a molecule of phosphorus?

A P_8 **B** P_4 **C** P_2 **D** P

18 When electrolysed using inert electrodes, which dilute solution would produce the greatest increase in mass of the negative electrode?
[A_r: Al, 27; Cu, 64; Pb, 207; Ag, 108]



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19 Which of the following involves the largest number of electrons for complete discharge during electrolysis?

A 5 moles of OH^- ions
B 6 moles of Cu^{2+} ions
C 7 moles of O^{2-} ions
D 12 moles of Na^+ ions

20 High carbon steel is used in manufacturing processes.

Which properties does high carbon steel have?

1 It is brittle.
2 It is malleable.
3 It is soft.
4 It is strong.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

21 The table shows the energy released by the complete combustion of some compounds used as fuel.

compound	M_r	ΔH in kJ/mol
methane	16	– 880
ethanol	46	– 1380
propane	44	– 2200
heptane	100	– 4800

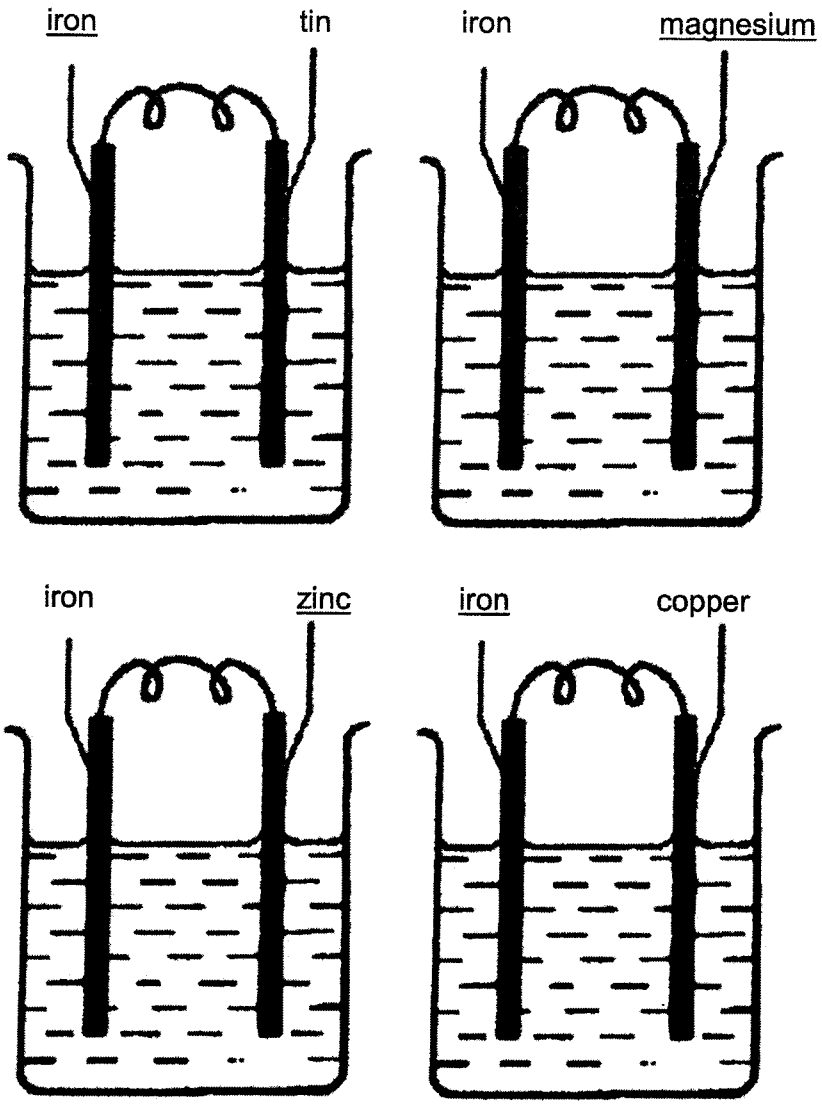
Which fuel produces the most energy when 1 g of the compound is completely burned?

A ethanol
B heptane
C methane
D propane

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22 Four cells were set up using aqueous sodium chloride as the electrolyte.



In each cell, only the underlined electrode dissolved. To establish the order of reactivity of the metals, it is necessary to set up two or more cells.

Which of the following pairs of cells are needed in addition to the four cells above?

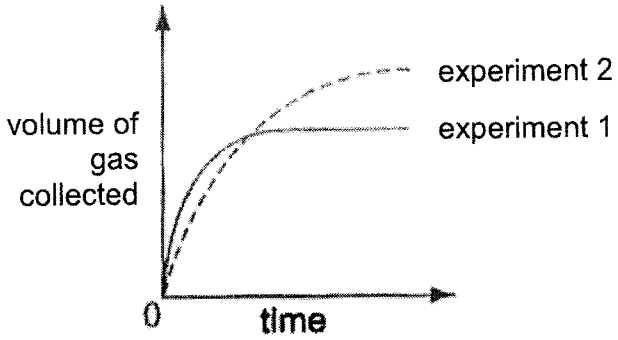
	first cell electrodes	second cell electrodes
A	tin/copper	magnesium/zinc
B	tin/magnesium	zinc/copper
C	tin/zinc	magnesium/copper
D	tin/zinc	zinc/copper

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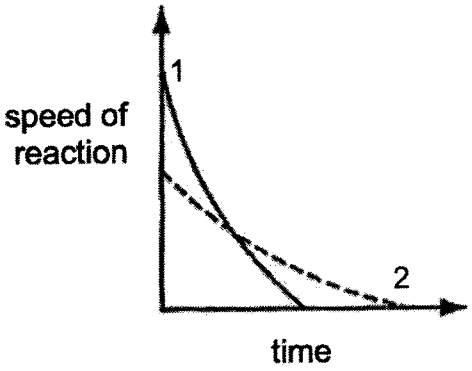
23 In two separate experiments, a substance was decomposed and the gas evolved was collected.

The graph shows the total volume of gas collected against time for each experiment.

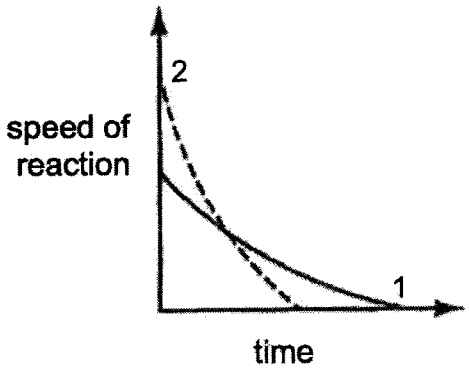


Which graph shows how the speed of reaction varied with time in each experiment?

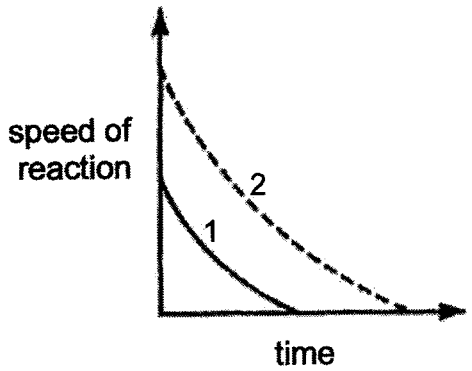
A



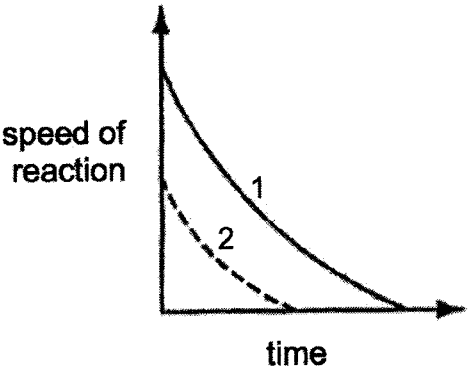
B



C



D



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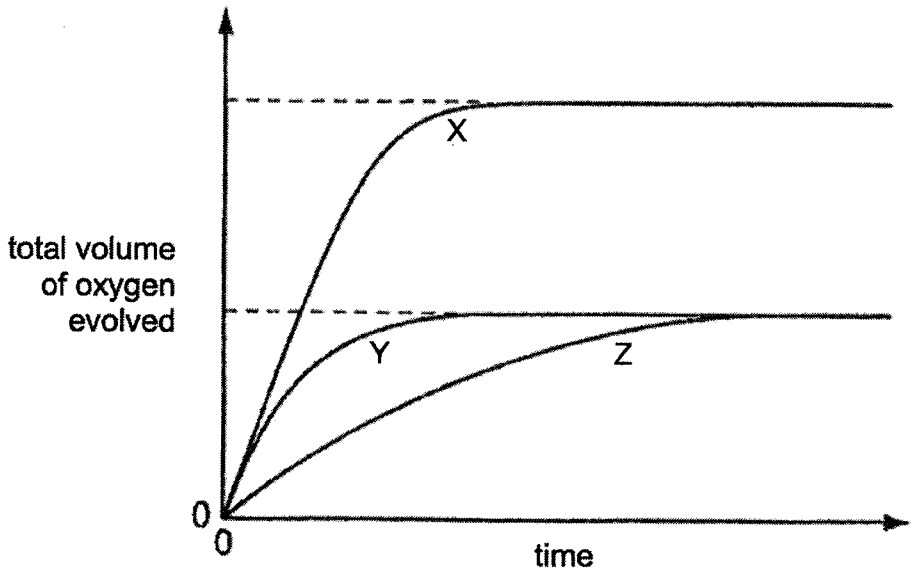
24 The hydrogen peroxide solution is catalytically decomposed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

To study the effect of the concentration of the solutions on the rate of reaction, the total volume of oxygen evolved was recorded against time.

Three experiments were performed using a fixed mass of catalyst but with

(i) 50 cm^3 of 2.0 mol/ dm^3 hydrogen peroxide.
(ii) 100 cm^3 of 1.0 mol/ dm^3 of hydrogen peroxide.
(iii) 100 cm^3 of 2.0 mol/dm^3 of hydrogen peroxide.



On the graph above, which of the curves, X, Y and Z relate to the solutions (i), (ii) and (iii)?

	(i)	(ii)	(iii)
A	X	Y	Z
B	X	Z	Y
C	Z	X	Y
D	Y	Z	X

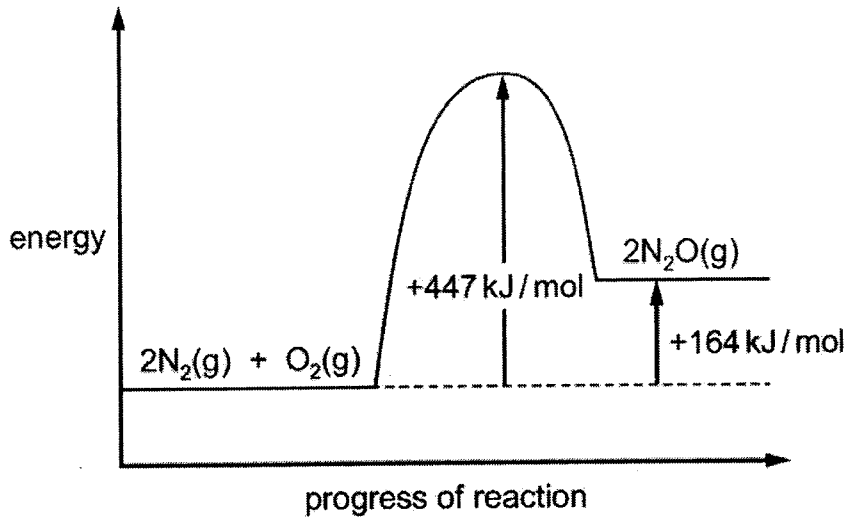
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25 Under certain conditions nitrogen reacts with oxygen to form dinitrogen monoxide.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$$

The energy profile diagram for the reaction is shown.



What is the activation energy for the reverse reaction?

A – 447 kJ/mol
B – 283 kJ/mol
C + 141.5 kJ/mol
D + 283 kJ/mol

26 The formation of liquid water from hydrogen and oxygen is thought to occur in three stages.

1 $2H_2(g) + O_2(g) \rightarrow 4H(g) + 2O(g)$

2 $4H(g) + 2O(g) \rightarrow 2H_2O(g)$

3 $2H_2O(g) \rightarrow 2H_2O(l)$

Which stages would be exothermic?

A 1, 2 and 3 **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

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27 Iron is extracted from iron ore in a blast furnace.

Which substances are fed into the top of the blast furnace?

1 coke
2 limestone
3 hot air

A 1, 2 and 3 **B** 1 and 2 **C** 1 and 3 **D** 2 and 3

28 Which noble gas is present in the largest percentage by volume in air?

A argon **B** helium
C krypton **D** neon

29 Which gas can be removed from the exhaust gases of a petrol-powered car by its catalytic converter?

A carbon monoxide **B** carbon dioxide
C nitrogen **D** steam

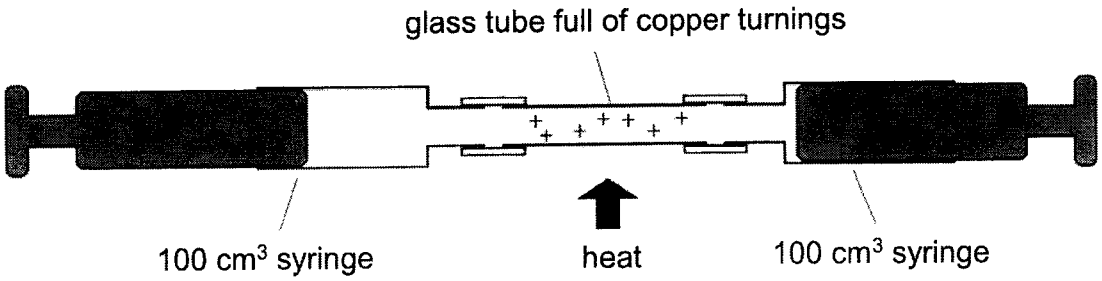
30 Which gas will react with ozone in the upper atmosphere of the Earth?

A CF_2Cl_2 **B** CH_4 **C** CO_2 **D** CF_4

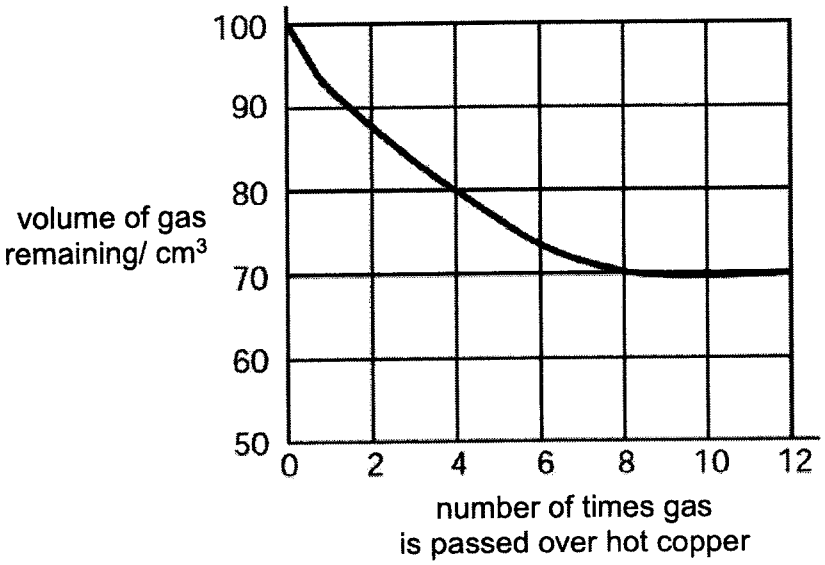
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31 A 100 cm^3 sample of bottled gas used for diving was placed in a gas syringe in the apparatus shown.



The gas was passed backward and forward over heated copper turnings. The results obtained were used to plot the graph.



What is the percentage of oxygen in the bottled gas?

A 20% **B** 30% **C** 70% **D** 80%

32 Which physical properties of the alkanes does **not** increase as relative molecular mass increases?

A boiling point
B flammability
C melting point
D viscosity

33 When 20 cm^3 of a gaseous alkene burns in an excess of oxygen, 60 cm^3 of carbon dioxide are formed. Both volumes are measured at r.t.p.

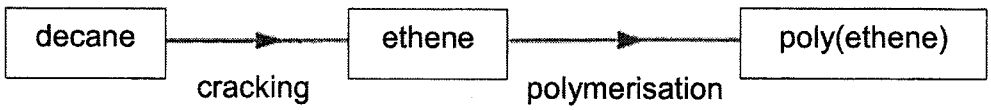
What is the formula of the alkene?

A C_3H_6 **B** C_3H_8 **C** C_6H_{12} **D** C_6H_{14}

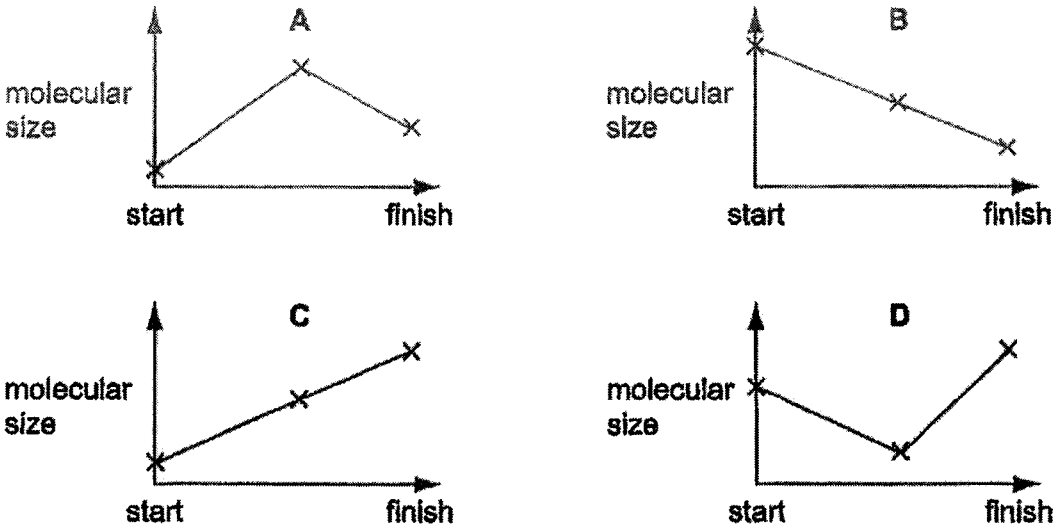
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34 Poly(ethene) can be manufactured by the process below.



Which diagram shows the change in molecular size during this process?



35 Which bond in a molecule of ethanoic acid is broken when it reacts with magnesium?

A the C — H bond
B the C — C bond
C the O — H bond
D the C = O bond

36 An alcohol contains 60% carbon by mass.

What is its formula?

A CH_3OH
B C_2H_5OH
C C_3H_7OH
D C_4H_9OH

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37 Some synthetic products are said to be non-biodegradable.

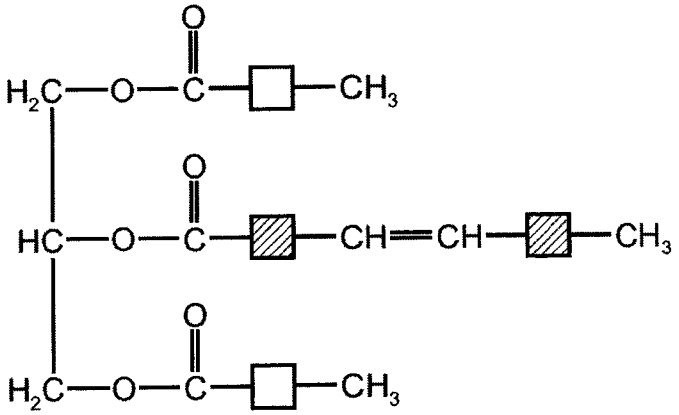
What does this term mean?

A cannot act as catalysts for biological process
B not harmful to living organisms
C not decomposed by strong heat
D not broken down by bacteria

38 What is the catalyst used in the preparation of ethyl ethanoate from ethanol and ethanoic acid?

A concentrated sulfuric acid
B nickel
C phosphoric acid
D yeast

39 The diagram shows a simplified structure of a fat.



Which compounds in the table have functional groups that can be found in this fat?

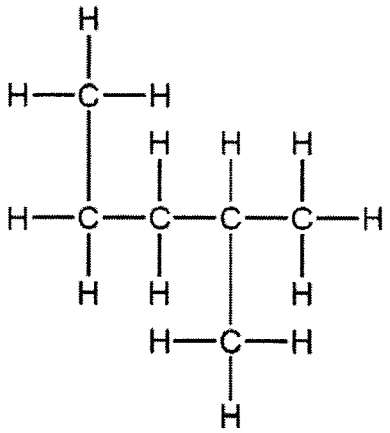
	ethene	nylon	ethanoic acid
A	✓	✓	✓
B	✓	✓	X
C	✓	X	X
D	X	X	X

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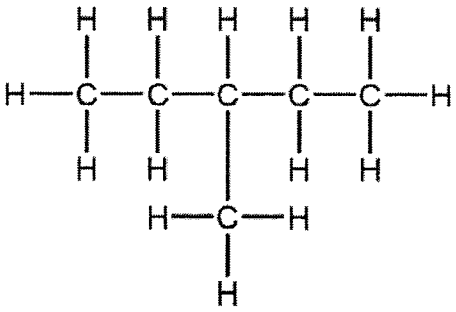
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40 Structures 1, 2, 3 and 4 are hydrocarbons.

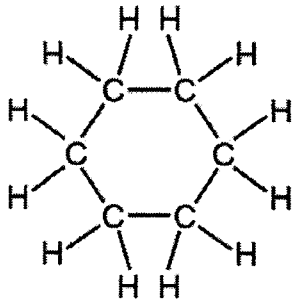
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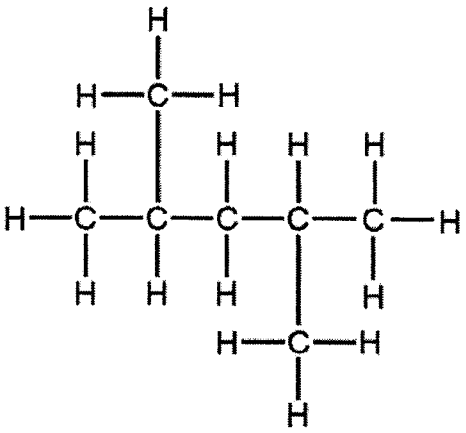
2



3



4



Which pair of structures are isomers?

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

END OF PAPER

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The Periodic Table of Elements

Group																										
I	II												III	IV	V	VI	VII	0								
																		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 -		114 Fl flerovium -		116 Lv livermorium -											

Key

proton (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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GREENDALE SECONDARY SCHOOL
Preliminary Examination 2022

Chemistry **6092/02**

Paper 2 **19 August 2022**
Secondary 4 Express **1 hour 45 minutes**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form of either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 26.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Paper 1	**/ 40**
Paper 2 Section A	**/ 50**
Paper 2 Section B	**/ 30**
Total	**/ 120**

This document consists of **26** printed pages.

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Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Use the list of the substances to answer the questions.

potassium	lead(II) bromide	oxygen
zinc oxide	hydrogen	carbon

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

Name a substance from the list above which

(a) reacts violently with water,

..... [1]

(b) conducts electricity when molten but not when solid,

..... [1]

(c) is amphoteric,

..... [1]

(d) has a formula of the type XY_2,

..... [1]

(e) has the lowest boiling point,

..... [1]

(f) is produced at the negative electrode during electrolysis of dilute sulfuric acid.

..... [1]

[Total: 6]

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A2 **(a)** Table 2.1 shows information about the preparation of pure samples of solid salts.

Complete the table by filling in the missing information. Include state symbols with any formula.

Table 2.1

formula of salt	formulae of reagents used	method used
$CuCl_2$(s)	.....	addition of excess solid to acid
		filtration
	HCl(aq)	evaporation and crystallisation
.....	KOH(aq)	.....
	HNO_3(aq)	evaporation and crystallisation
$PbSO_4$(s)	.....	.....
	.....	.....

[5]

(b) Explain why

(i) excess solid is added to acid to prepare the salt, $CuCl_2$,

.....

..... [1]

(ii) crystals are formed in the process of crystallisation.

.....

..... [1]

[Total: 7]

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A3 Fig. 3.1 shows giant molecular structures of diamond and graphite.

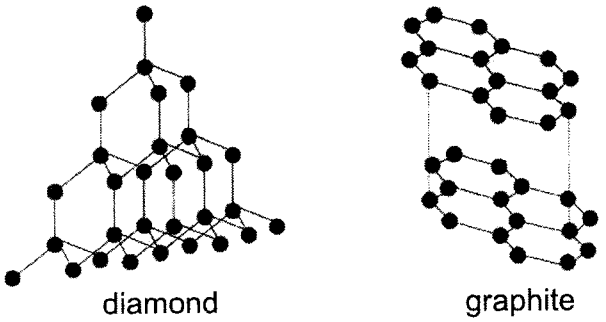


Fig. 3.1

(a) Describe how a simple molecular structure differs from a giant molecular structure.

.....

.....

..... [2]

(b) Diamonds are used as drill tips because they are very hard.

Explain why diamond is very hard. Refer to the structure of diamond in your answer.

.....

.....

.....

..... [2]

(c) Graphite is used as lubricant for engines.

Explain why graphite acts as a lubricant. Refer to the structure of graphite in your answer.

.....

.....

.....

..... [2]

[Total: 6]

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A4 Lithium metal and its compounds have many uses, ranging from nuclear chemistry, rechargeable batteries and pharmaceuticals.

(a) Naturally occurring lithium contains the isotopes ^{6}Li and ^{7}Li.

(i) Describe the similarities and differences between the structure of the nuclei of the two isotopes of lithium.

.....

.....

..... [2]

(ii) A nuclear reaction is a reaction in which there is a change to an atomic nucleus.

An experimental nuclear reactor uses ^{6}Li and deuterium, ^{2}H, as fuel. Three nuclear reactions between these two atoms are described below.
(p^{+} is a proton; n is a neutron).

$$^{6}Li + {}^{2}H \rightarrow 2\,{}^{4}He$$

$$^{6}Li + {}^{2}H \rightarrow {}^{4}He + \mathbf{X} + n$$

$$^{6}Li + {}^{2}H \rightarrow \mathbf{Y} + p^{+}$$

Given that the number of nucleons is conserved in these nuclear reactions, suggest the identities of **X** and **Y**.

X ..... **Y** ..... [2]

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(b) Lithium-ion batteries are light in weight and can hold a large amount of charge.

One type of lithium-ion battery consists of

- an electrolyte of $LiBF_4$ dissolved in an organic solvent,
- a cathode made from cobalt oxide, CoO_2,
- and an anode made from graphite with lithium atoms inserted between layers.

During discharge, Li atoms at the anode give up electrons to become Li^+ ions. The electrons travel round the external circuit and are picked up by the cathode. A Li^+ ion from the electrolyte also moves to the cathode.

This is illustrated in Fig 4.1 in which C–C–C–C–C is also a simplified representation of a layer of carbon atoms in graphite.

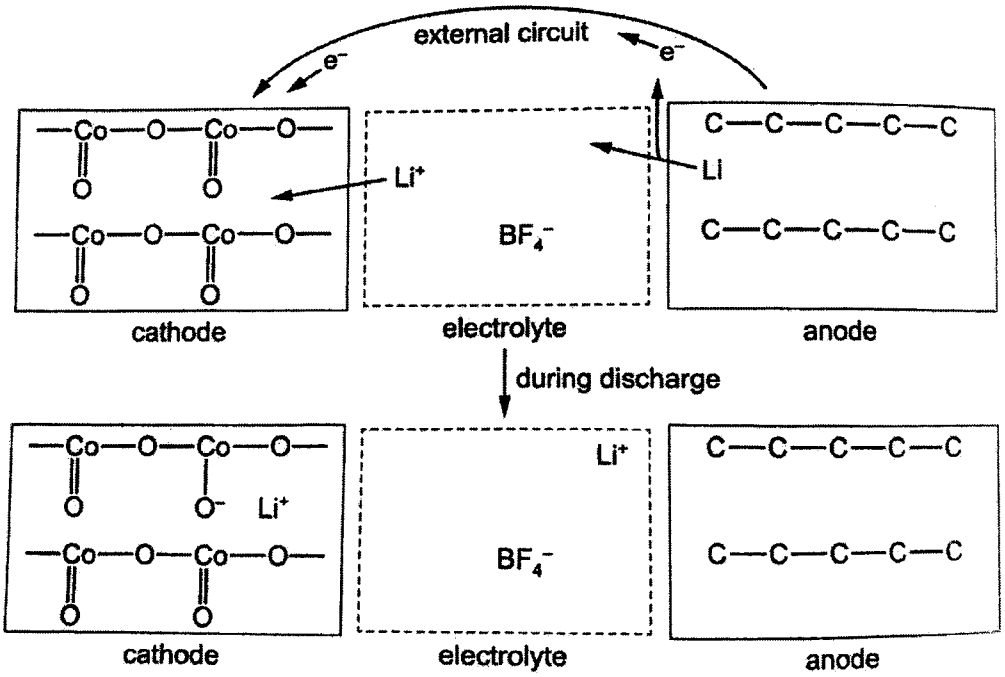


Fig. 4.1

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(i) Suggest the type of bonding between lithium atoms and the layers of carbon atoms in graphite.

Give your reasoning.

.....

.....

.....

..... [2]

(ii) State the oxidation state of cobalt in the cobalt oxide cathode before discharge and after the cell is totally discharged.

before discharge .....

after cell is totally discharged ..... [2]

[Total: 8]

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A5 Ethanol belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

.....[1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

.....

..... [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation. Give the formulae of these substances.

substance which reacts with steam to form ethanol .....

substance which will undergo fermentation to form ethanol .....[2]

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(d) Fig. 5.1 shows ethane-1,2-diol has two alcohol functional groups.

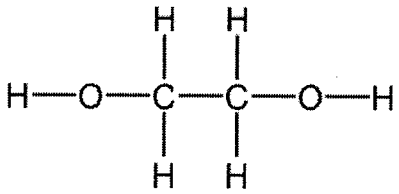


Fig. 5.1

One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

X has two ester functional groups and a molecular formula of $C_6H_{10}O_4$.

(i) State the empirical formula of **X**.

.....[1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[1]

(iii) Name the other substance formed in this reaction.

.....[1]

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(e) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional group formed in **Y**.

.....[1]

(ii) Draw the structure of **Y**.

Show all of the atoms and all of the bonds.

[1]

[Total: 9]

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A6 **(a)** Hydrogen peroxide can behave as an oxidising agent or a reducing agent depending on the reactant added to it. When solid silver(I) oxide is added to aqueous hydrogen peroxide, the reaction shown in equation 1 takes place.

equation 1 $Ag_2O(s) + H_2O_2(aq) \rightarrow 2Ag(s) + O_2(g) + H_2O(l)$

(i) State, with reasoning, whether hydrogen peroxide is behaving as an oxidising agent or a reducing agent in this reaction.

.....

.....

..... [1]

(ii) Describe a simple test and its result that would identify the gas given off in the reaction.

.....

.....

..... [1]

(b) **(i)** 1.0 cm^3 of '20-volume' hydrogen peroxide produces 20.0 cm^3 of oxygen gas at room temperature and pressure, as shown in equation 2.

equation 2 $2H_2O_2 \rightarrow 2H_2O + O_2$

Use this information to calculate the concentration, in mol/dm^3, of '20-volume' hydrogen peroxide.

[2]

(ii) Use the value obtained in **(b)(i)** to calculate the minimum mass of silver(I) oxide which must be used to ensure that 10.0 cm^3 of '20-volume' hydrogen peroxide reacts completely at room temperature and pressure, according to equation 1.

[1]

[Total: 5]

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A7 Methane, methanol and hydrogen have all been investigated as possible alternative fuels for motor vehicles that currently used petrol. Table 7.1 shows some information of these fuels.

Table 7.1

fuel	density at r.t.p (g/dm^3)	enthalpy change of combustion (kJ/mol)	energy released per gram (kJ/g)	energy released per dm^3 at r.t.p (kJ/dm^3)
petrol	710 – 770	–	47.3	33 600 – 36 400
methane	0.645	– 891	55.7	35.8
methanol	792	– 726	22.7	18 000
hydrogen	0.0833	– 286	143	12.6

(a) Explain why no value is quoted for the enthalpy change of combustion of petrol in Table 7.1.

.....

..... [1]

(b) Both petrol and methanol have a much higher density than methane and hydrogen. Suggest why.

.....

..... [1]

(c) **(i)** Write down the chemical equation for the complete combustion of methane.

..... [2]

(ii) Use ideas of about breaking and forming bonds to explain why the value of enthalpy change of combustion for methane is negative.

.....

.....

.....

.....

.....

..... [3]

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(d) Although hydrogen releases less than half the energy per dm^3 than methane, many people believe that hydrogen is a better alternative fuel compared to methane. Explain why.

.....

.....

.....

.....[2]

[Total: 9]

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Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 Dynamics equilibrium

Many reversible reactions are incomplete. We can understand what is happening by examining what happens when a solution of iodine in potassium iodide solution is shaken with the solvent trichloroethane. Water and trichloroethane do not mix.

$$I_2 \text{ in aqueous potassium iodide} \rightleftharpoons I_2 \text{ in trichloroethane}$$

Fig. 8.1 shows the movement of iodine molecules during the shaking.

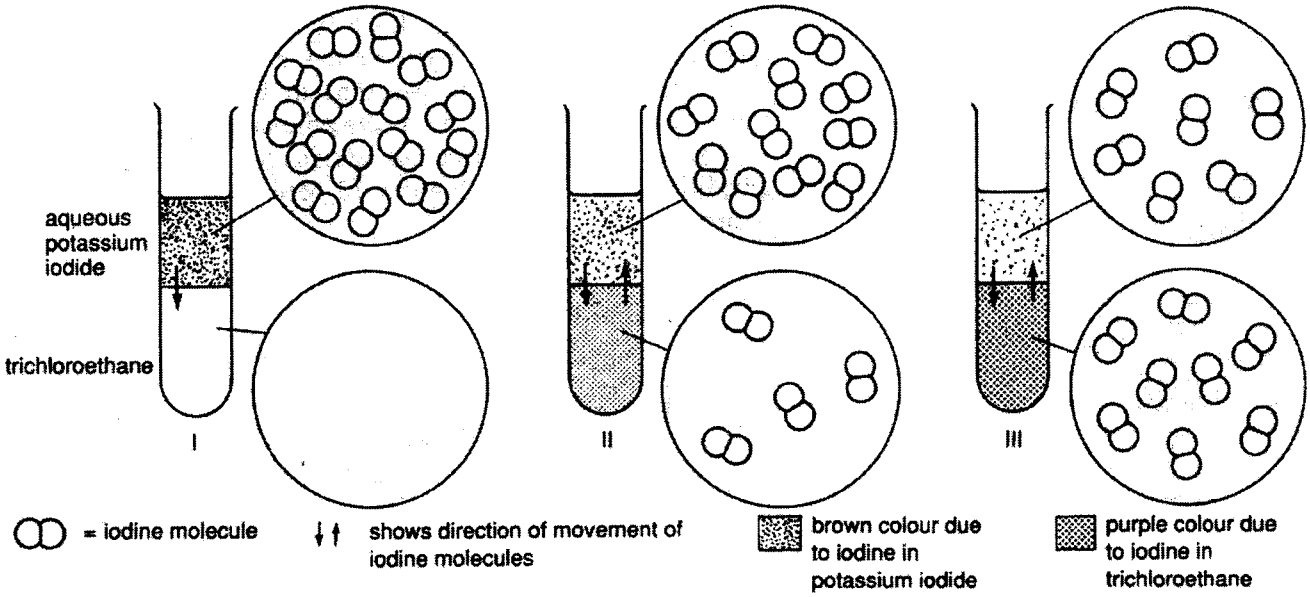


Fig. 8.1

Iodine dissolves in aqueous potassium iodide to form a brown solution, but dissolves in trichloroethane to form a purple solution.

What has happened is the iodine molecules first started going from the aqueous layer into the trichloroethane. As the concentration of iodine in the trichloroethane increased, the molecules started going back into the aqueous layer. As the concentration of iodine in the aqueous layer decreased, the forward reaction slowed down. As the concentration of iodine in the trichloroethane increased, the backward reaction became faster. Eventually *the speed of the forward reaction and backward reaction become equal.*

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When the reactants reach equilibrium in a reversible reaction, the concentration of reactants and products become constant and reaction appears to have stopped.

This situation is called *dynamic equilibrium*.

Fig 8.2 shows the concentration of iodine in the two solvents against time.

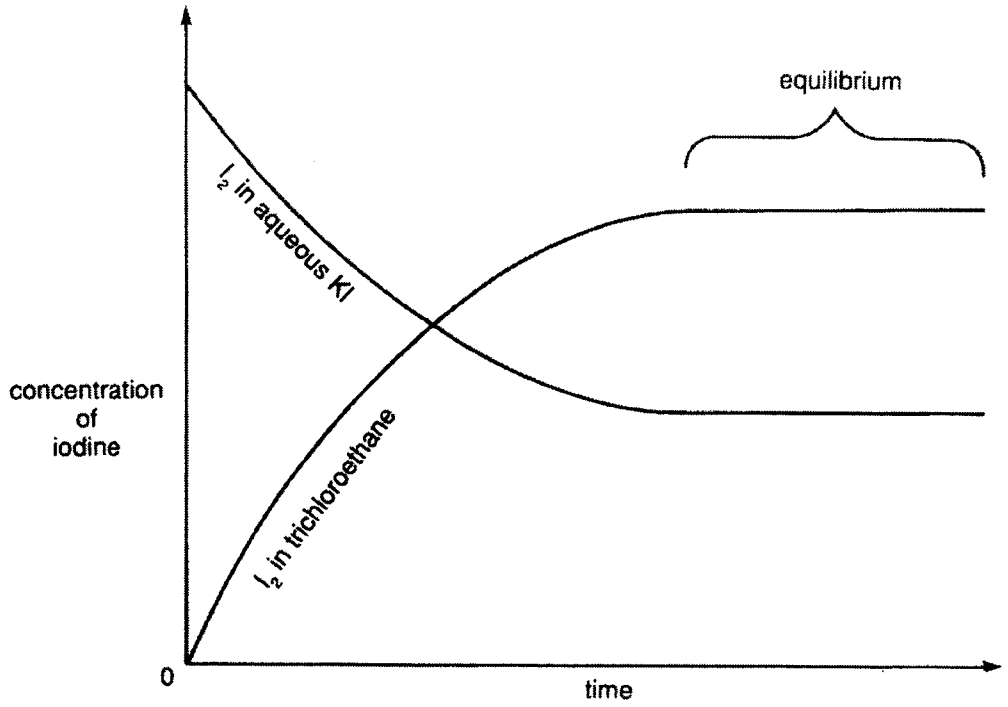


Fig. 8.2

When the graph becomes horizontal, equilibrium is reached. This is when concentration of iodine in two solvents become constant.

Factors affecting equilibrium

The composition of an equilibrium mixture in a reversible reaction can be affected by changes in concentration, temperature and pressure.

The best way to predict the effect of a change in conditions is to use *Le Chaterlier's Principle.*

Le Chaterlier's Principle state that:

If an equilibrium mixture is disturbed by changing the conditions, then the composition of the equilibrium mixture will try to remove the disturbance.

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Changing concentration

An example is the formation of a white precipitate of bismuth oxychloride, BiOC*l*, when colourless bismuth(III) chloride, BiC*l*$_3$, is added to water.

$$BiCl_3(aq) + H_2O(l) \rightleftharpoons BiOCl(s) + 2HCl(aq)$$

At equilibrium, there is a mixture of all four substances. If extra HC*l*(aq) is added to this mixture, the extra HC*l*(aq) increases the concentration of $H^+(aq)$ and $Cl^-(aq)$. This is a 'disturbance'. The mixture will try to remove this extra HC*l*(aq). It removes by increasing the backward reaction to produce more BiC*l*$_3$(aq) and $H_2O(l)$ and decreasing the amounts BiOC*l*(s) and HC*l*(aq). This removes much of the HC*l*(aq) 'disturbance'. A new equilibrium is obtained, where there are more BiC*l*$_3$(aq) and $H_2O(l)$ and less BiOC*l*(s).

Changing temperature

An example is the removal of carbon dioxide using hydrogen.

$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g);\ \Delta H = -165\ kJ$$

A negative ΔH means that the forward reaction at equilibrium releases heat and the backward reaction absorbs heat. If temperature is raised, the reaction mixture absorbs heat. By Le Chatelier's Principle, the reaction mixture will try to get rid of the extra heat by absorbing it. It removes the heat 'disturbance' by increasing the backward reaction to produce more CO_2 and H_2.

Changing pressure

An example is the industrial manufacture of ammonia.

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

If the pressure of the equilibrium mixture is increased, the reaction mixture will try to remove the pressure 'disturbance' by decreasing the number of moles of gas present. The forward reaction will increase as 4 moles of gas (1 mole of N_2 and 3 moles of H_2) produces only 2 mole of gas (2 moles of NH_3) – a net loss of 2 moles of gas in a fixed volume.

Adapted from Chemistry for 'O' Level – JGR Briggs

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(a) Dinitrogen tetroxide, N_2O_4, decomposes into nitrogen dioxide, NO_2. The reaction is reversible.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$
colourless gas brown gas

Fig. 8.3 shows a gas syringe containing a mixture of dinitrogen tetroxide and nitrogen dioxide gases was sealed and heated. After reaching equilibrium, the mixture was a pale brown colour.

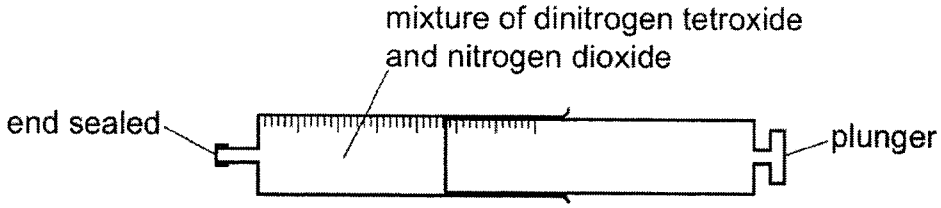


Fig. 8.3

The forward reaction is endothermic.

(i) Using Le Chaterlier's Principle, describe and explain what you would observe when the temperature of the mixture is increased.

.....

.....

.....

..... [2]

(ii) Explain, using the ideas of particles, what happens to the speed of the forward reaction when the temperature of the mixture is increased.

.....

.....

.....

.....

.....

..... [3]

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(b) The plunger of the gas syringe is pushed in as shown in Fig. 8.4. The temperature does not change. The mixture initially turns darker brown. After a few seconds, the mixture turns lighter brown.

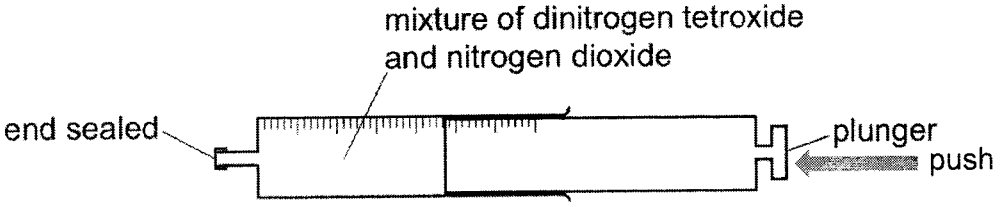


Fig. 8.4

(i) Explain why the mixture initially turns darker brown.

.....

..... [1]

(ii) Using Le Chaterlier's Principle, explain why the mixture turns lighter brown after a few seconds.

.....

.....

.....

.....

..... [2]

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(c) When hydrogen ions are added to methyl orange (Meor), a red coloured complex (H-Meor) is formed.

An equilibrium mixture between the two forms of methyl orange will be established.

$$\text{H-Meor} \rightleftharpoons \text{H}^+(\text{aq}) + \text{Meor}^-(\text{aq})$$

Meor^- is yellow in colour.

Using Le Chaterlier's Principle, suggest what you would observe when hydroxide ions are added to this equilibrium mixture.

Explain your reasoning.

.....

.....

.....

.....

.....

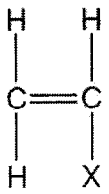
..... [2]

[Total: 10]

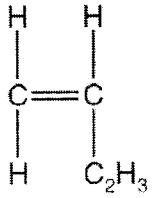
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B9 The structure of styrene and butadiene are shown in Fig. 9.1. Styrene-butadiene rubber is a synthetic rubber. It is made by polymerising a mixture of the monomers butadiene and styrene.



styrene



butadiene

Fig. 9.1

(a) What type of polymerisation will take place when the monomers polymerise? Explain your reasoning.

.....

.....

..... [2]

One possible structure for the polymer is shown in Fig. 9.2.

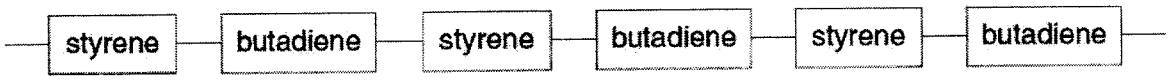


Fig. 9.2

(b) Give the **full structural formula** for the repeating unit in this polymer structure.

[2]

(c) When the mixture of styrene and butadiene polymerises, the polymer is unlikely to contain only this regular, repeating pattern. Explain why.

.....

.....

..... [1]

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Butadiene can be made by cracking butane in a cracking tower.

(d) **(i)** Butane cracks to form butadiene, C_4H_6, and one other product.

Write an equation to show this reaction.

.....[1]

(ii) Describe a test to confirm the identity of the other product.

.....

.....[1]

(e) 2.90 kg of butane entered the cracking tower. After the reaction, 2.16 kg of butadiene had been made.

Calculate the percentage yield of butadiene.

[3]

[Total: 10]

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EITHER

B10 A student carried out some experiments to place four metals, **W**, **X**, **Y** and **Z** in order of reactivity.

Table 10.1 shows the results.

key ✓ shows a reaction happened
✗ Shows no reaction happened
– Shows the experiment was not performed

Table 10.1

	metal **W**	metal **X**	metal **Y**	metal **Z**
solution of **W** nitrate	–	✗	✗	✗
solution of **X** nitrate	✓	–	✓	✓
solution of **Y** nitrate	✓	✗	–	✓
solution of **Z** nitrate	✓	✗	✗	–

(a) Place the metals in order of reactivity, starting with the most reactive.

.....[2]

(b) Metal **Z** reacts with hydrochloric acid.

What would you see when metal **Z** reacts with hydrochloric acid?

Explain your reasoning.

.....

.....

.....[2]

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(c) The student carried out further experiments to place metal **M** in the list.

She used dilute hydrochloric acid and samples of the metals.

She found out that metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out. Your answer should include

- the experiments that she carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that she made,
- how the results showed that metal **M** is the fourth most reactive metal.

.....

.....

.....

.....

.....

.....

..... [3]

(d) The five metals, **W**, **X**, **Y**, **Z** and **M** are extracted from their ores in three different ways.

Two of the metals are extracted from their ores by electrolysis.
Metal **M** and one other metal are extracted by heating their ores with carbon.
One of the metals occurs uncombined.

(i) Suggest which other metal, **W**, **X**, **Y** and **Z** is extracted by heating its ore with carbon. Explain your reasoning.

.....

.....

.....

.....[2]

(ii) Suggest the name of metal **M**.

.....[1]

[Total: 10]

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OR

B10 Sodium metal is extracted from sodium chloride by electrolysis.

Fig. 10.1 shows how the process works.

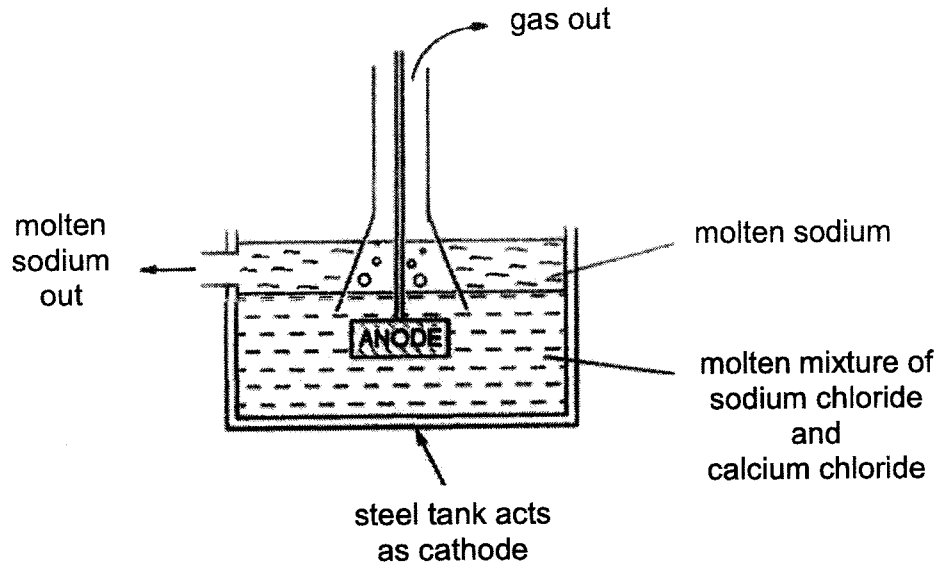


Fig. 10.1

(a) (i) Write an ionic half equation, with state symbols, to show the reaction that happens at the anode.

.....[2]

(ii) Describe a simple test and its result that would identify the gas given off at the anode.

.....

.....

.....[2]

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(b) Calcium chloride is added to the sodium chloride to lower the melting point of the mixture.

(i) Explain why lowering the melting point makes the process cheaper to run.

.....

.....

.....

.....[2]

(ii) The molten sodium contains metallic impurities.

Name the main metal impurity you would expect to find and explain how it forms.

.....

.....

.....

.....[2]

(c) Sodium chloride can be electrolysed in aqueous solution.

Describe the differences in the products of the electrolysis of concentrated aqueous sodium chloride compared to molten sodium chloride.

.....

.....

.....

..... [2]

[Total: 10]

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The Periodic Table of Elements

Group I	II											III	IV	V	VI	VII	0
						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 –		114 Fl flerovium –		116 Lv livermorium –		

Key

proton (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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Sec 4 Express Chemistry Prelim 2022

Answers

Paper 1

1	2	3	4	5	6	7	8	9	10
C	B	B	A	C	D	D	D	B	B
11	12	13	14	15	16	17	18	19	20
A	C	A	D	D	D	B	D	C	B
21	22	23	24	25	26	27	28	29	30
C	A	A	D	D	D	B	A	A	A
31	32	33	34	35	36	37	38	39	40
B	B	A	D	C	C	D	A	C	A

Paper 2 Section A

Qn	Answer	Mark
1(a)	Potassium	[1]
1(b)	lead(II) bromide **OR** zinc oxide	[1]
1(c)	zinc oxide	[1]
1(d)	lead(II) bromide	[1]
1(e)	Hydrogen	[1]
1(f)	Hydrogen	[1]
	TOTAL	[6]
2(a)	$CuCO_3(s)$ **OR** $Cu(OH)_2(s)$ **OR** $CuO(s)$;	[1]
	$KNO_3(s)$;	[1]
	titration;	[1]
	any solution containing Pb^{2+} ions **AND** any solution containing SO_4^{2-} ions	[1]
	mixing **OR** precipitation **AND** filtration	[1]
2(b)(i)	to ensure all acid is reacted	[1]
2(b)(ii)	solubility of salt decreases when temperature decreases	[1]

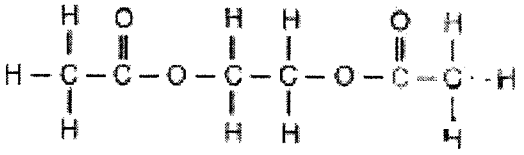
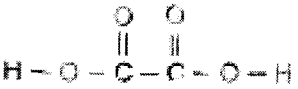
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Qn	Answer	Mark
	TOTAL	[7]
3(a)	A giant network of atoms that are covalently bonded.	[1]
	Discrete molecules held together by weak intermolecular forces.	[1]
3(b)	Three dimensional network; Strong covalent bonds between atoms.	[1] [1]
3(c)	layers of carbon atoms held loosely by weak intermolecular forces; COND layers of carbon atoms can slide over each other when a force is applied	[1] [1]
	TOTAL	[6]
4(a)(i)	3 protons; lithium-6 has 3 neutrons, lithium-7 has 4 neutrons	[1] [1]
4(a)(ii)	^{3}He; ^{7}Li	[1] [1]
4(b)(i)	ionic AND idea of formation of positive ions and negative ions OR metallic AND idea of interaction of lithium cation with delocalised electrons in graphite	[1] [1]
4(b)(ii)	+4; +3	[1] [1]
	TOTAL	[8]
5(a)	$C_nH_{2n+1}OH$	[1]
5(b)	contain oxygen not only hydrogen and carbon	[1]
5(c)	C_2H_4; $C_6H_{12}O_6$	[1] [1]
5(d)(i)	$C_3H_5O_2$	[1]

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Qn	Answer	Mark
5(d)(ii)		[1]
5(d)(iii)	Water	[1]
5(e)(i)	carboxyl	[1]
5(e)(ii)		[1]
	TOTAL	**[9]**
6(a)(i)	reducing agent AND removes oxygen from Ag_2O / decreases oxidation state of silver from +1 in Ag_2O to 0 in Ag / donates electron to Ag^+ to form Ag	[1]
6(a)(ii)	place glowing splint near the gas AND relighted / rekindled	[1]
6(b)(i)	$n_{\text{hydrogen peroxide}}$ $= 2 \times \frac{20.0}{24000}$ = 0.00[illegible]3 mol	[1]
	$c_{\text{hydrogen peroxide}}$ $= (2 \times \frac{20.0}{24000}) \div (\frac{1.0}{1000})$ = **1.67 mol/dm³ (3.s.f)**	[1]
6(b)(ii)	$m_{\text{silver(I) oxide}}$ $= (1.67 \times \frac{10}{1000}) \times 232$ = **3.87 g (3.s.f)**	[1]
	TOTAL	**[5]**
7(a)	Petrol is a mixture / enthalpy change of combustion has no fixed value.	[1]
7(b)	Petrol and methanol exist as liquids and methane and hydrogen as gas (at r.t.p)	[1]
7(c)(i)	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ Correct formulae of products; balanced equation	[1] [1]

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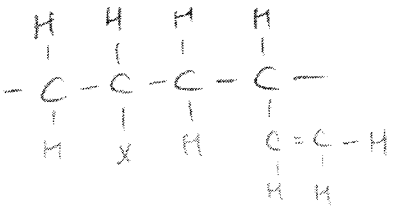
Qn	Answer	Mark
7(c)(ii)	break 4 mol of C-H bonds, 2 mol of O=O bonds;	[1]
	form 2 mol of C=O bonds, 4 mol of O-H bonds;	[1]
	more energy is given out in bond formation than energy taken in to break bond	[1]
7(d)	idea of water being produced **AND** water is non-polluting / harmless;	[1]
	idea of carbon dioxide being produced **AND** CO_2 is a greenhouse gas / causes global warming	[1]
	TOTAL	**[9]**

Paper 2 Section B

Qn	Answer	Mark
8(a)(i)	darker brown;	[1]
	the reaction mixture will try to get rid of the extra heat **AND** by increasing forward reaction / producing more NO_2	[1]
8(a)(ii)	particles have more energy / gain energy **AND** move faster;	[1]
	more proportion of particles having energy equal or greater than E_a	[1]
	frequency of effective collision/ chances of effective collision increases **AND** faster speed of reaction	[1]
8(b)(i)	more NO_2 particles in a unit volume / concentration of NO_2 increases / NO_2 particles are closer together	[1]
8(b)(ii)	get rid of the increase in pressure;	[1]
	idea of less number of mole of gaseous particle / net loss of moles of gas in the backward reaction	[1]
8(c)	turned yellow/ orange	[1]
	idea of hydroxide ions reacting with hydrogen ions **AND** increase forward reaction/ more $MeOr^-$ is present in equilibrium	[1]
		[10]
9(a)	addition polymerisation;	[1]

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Qn	Answer	Mark
	C=C / unsaturated	[1]
9(b)		[2]
9(c)	idea of self-polymerisation	[1]
9(d)(i)	$C_4H_{10} \rightarrow C_4H_6 + 2H_2$	[1]
9(d)(ii)	place a lighted splint near the gas **AND** lighted splint was extinguished with a pop sound	[1]
9(e)	amount of butane $= \frac{2.9 \times 1000}{58} = 50$ mol	[1]
	Mole ratio butane: butadiene = 1:1 Theoretical mass of butadiene = 50 x 54 = 2700 g	[1]
	percentage yield $= \frac{2160}{2700} \times 100\%$ = 80%	[1]
	Alternative:	
	amount of butane $= \frac{2.9 \times 1000}{58} = 50$ mol [1]	[1]
	amount of butadiene $= \frac{2.16 \times 1000}{54} = 40$ mol [1]	[1]
	Mole ratio butane: butadiene = 1:1 percentage yield $= \frac{40}{50} \times 100\%$	

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Qn	Answer	Mark
	= 80% [1]	
	TOTAL	**[10]**
EITHER		
10(a)	W, Z, Y, X	[2]
10(b)	effervescence; hydrogen gas is produced	[1] [1]
10(c)	Measurement that she made: using collection of volume gas over time	[1]
	control variables: such as fixed concentration and volume of acid used **AND** fixed mass of metal	[1]
	Link result to why M is the fourth most reactive metal: gradient of the graph - volume of gas produced against time	[1]
10(d)(i)	Y; W and Z are extracted using electrolysis as they are the two most reactive metals **AND** X is the least reactive metal and will be uncombined	[1] [1]
10(d)(ii)	zinc/ iron/ lead **REJECT**: copper, silver, (metal has to be able to react with acid to differentiate X and M in part c)	[1]
	TOTAL	**[10]**
OR		
10(a)(i)	$2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$	[2]
10(a)(ii)	place a damp litmus paper near the gas; gas bleached damp litmus paper	[1] [1]
10(b)(i)	lower temperature / energy to keep mixture in molten state; Idea that less energy / electricity **OR** less fuel to burn lead to cheaper cost.	[1] [1]
10(b)(ii)	calcium; calcium ions gain electrons to form calcium metal	[1] [1]

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Qn	Answer	Mark
10(c)	negative electrode / cathode: hydrogen gas produced for concentrated aqueous sodium chloride **AND** sodium produced for molten sodium chloride; electrolyte: sodium hydroxide will be produced for concentrated aqueous sodium chloride **AND** calcium chloride for molten sodium chloride	[1] [1]
	TOTAL	**[10]**

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