Paya Lebar Methodist Girls' School (Secondary)
Preliminary Examination 2024
Secondary 4 Express / G3

CANDIDATE NAME		CLASS		CLASS INDEX NO	

CENTRE NUMBER	S					INDEX NUMBER				

CHEMISTRY **6092/01**

Paper 1 Multiple Choice **26 August 2024**

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 class index number on the separate Answer Sheet 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.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this paper.

A copy of the Periodic Table is printed on page 2.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of 18 printed pages

The Periodic Table of Elements

Group 1	Group 2											Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
							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	3	4	5	6	7	8	9	10	11	12	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 thullum 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 –

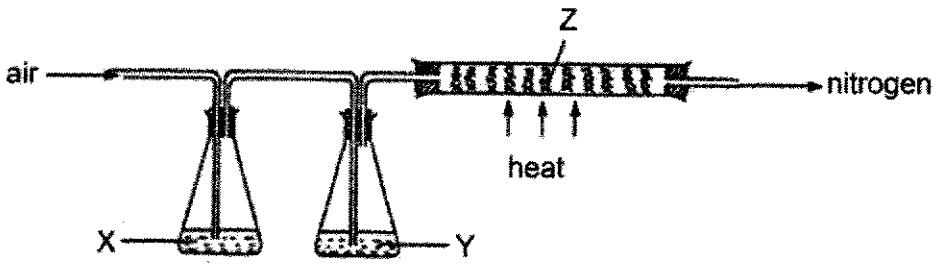
Multiple Choice Questions (40 marks)

1 A student wants to investigate the strength of an unknown monobasic acid, as compared with a sample of hydrochloric acid which has the same concentration.

Which of the following correctly shows the method and apparatus needed to investigate strength of the unknown acid?

	method	apparatus
A	measure pH	voltmeter
B	measure volume of sodium hydroxide needed for neutralisation	burette and pipette
C	measure temperature change when acid reacts with metal	thermometer
D	measure final volume of gas produced when acid reacts with metal	gas syringe

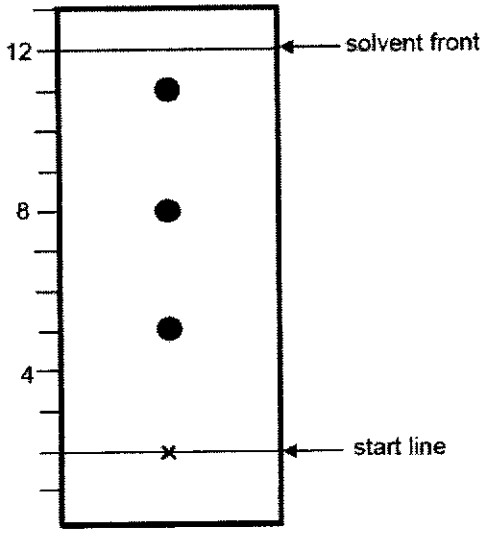
2 The diagram below shows an experimental set-up that can be used to obtain a stream of nitrogen from air.



Using this set-up, which set of substances labelled X, Y and Z gives the purest sample of nitrogen?

	X	Y	Z
A	aqueous calcium hydroxide	calcium chloride solution	sulfur
B	calcium chloride solution	aqueous calcium hydroxide	copper
C	concentrated sulfuric acid	sodium hydroxide solution	carbon
D	sodium hydroxide solution	concentrated sulfuric acid	copper

3 A scientist tested a skincare product to investigate if it contains harmful ingredients. The chromatogram of the skincare product is obtained as shown below, along with a reference table of R_f values of some harmful ingredients.



ingredient	R_f value
diethanolamine	0.3
hydroquinone	0.5
butylated hydroxyanisole	0.8
oxybenzone	0.9

What are the harmful ingredients present in the skincare product?

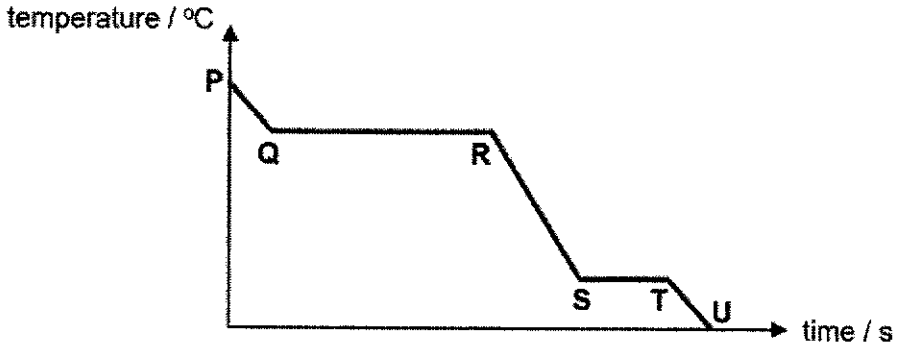
A diethanolamine only
B diethanolamine and oxybenzone only
C hydroquinone and butylated hydroxyanisole only
D hydroquinone and oxybenzone only

4 Two gases, CH_3Cl and SO_2, were separately released from one end of a laboratory on a hot day. The experiment was repeated on a cold day. The time taken for the gases to reach the opposite end of the laboratory was recorded for each experiment.

Which gas on which day would take the shortest time to reach the end of the laboratory?

	gas	day
A	CH_3Cl	hot
B	CH_3Cl	cold
C	SO_2	hot
D	SO_2	cold

5 The graph below shows the change in temperature as a sample of X_2 is cooled.



Which stage (**P** to **U**) reflects a change in the movement of particles from moving around each other to vibrating about in fixed positions?

A **P** to **Q**
B **Q** to **R**
C **R** to **S**
D **S** to **T**

6 In which particle are the number of protons, neutrons and electrons all different?

A O^{2-} **B** Mg^{2+} **C** Ne **D** P^{3-}

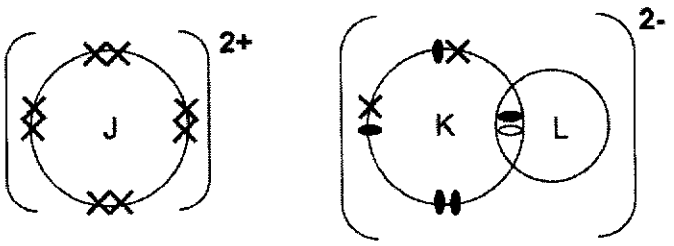
7 Element M exists as 3 stable isotopes and has a relative atomic mass of 65.1.

Which row shows the correct compositions of isotopes?

	^{64}M	^{66}M	^{67}M
A	32.1%	56.4%	11.5%
B	54.6%	6.6%	38.8%
C	56.3%	31.3%	12.6%
D	53.5%	25.5%	21.2%

8 The formula of an ionic compound, containing elements J, K and L is shown below.

The letters J, K and L are **not** the chemical symbols of the elements.

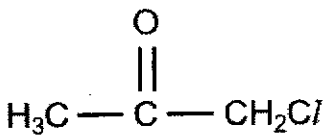


Which statements are correct?

I. Element J could be magnesium.
II. Element K belongs to Group 14 of the Periodic Table.
III. Element L belongs to Group 1 of the Periodic Table.
IV. Element K and element L are bonded together by a covalent bond.

A I and II
B I and IV
C II and III
D I, III and IV

9 Chloroacetone is used to make dye couplers for colour photography.



Which statements about chloroacetone are correct?

I. Chloroacetone cannot conduct electricity in any state.
II. Chloroacetone has high boiling point.
III. The total number of electrons that are involved in bonding in one chloroacetone molecule is 10.
IV. The chlorine atom has 6 valence electrons which are not involved in bonding.

A I and II
B I and IV
C II and III
D I, III and IV

10 In the lattice structure of ionic compounds, the coordination number of each ion is the number of neighbouring ions of opposite charge.

The table below shows the ions present and the coordination number of ions in some ionic compounds. Taking sodium chloride for instance, each sodium ion is surrounded by 6 chloride ions, while each chloride ion is surrounded by 6 sodium ions. Hence, the coordination number for both the sodium ions and chloride ions is 6.

ionic compound	ions present		coordination number of		Formula
	cation	anion	cation	anion	
sodium chloride	Na^+	Cl^-	6	6	$NaCl$
titanium(IV) oxide	Ti^{4+}	O^{2-}	6	3	TiO_2
compound **X**	Y	Z	6	4	?

Using the information from the table, determine the formula of compound **X**.

A Y_2Z **B** YZ_4

C Y_3Z_2 **D** Y_2Z_3

11 Solution X and solid Y are mixed in a beaker. After mixing, the final mass of the substances and the beaker is less than the initial mass.

What can solution X and solid Y be?

	solution X	solid Y
A	sulfuric acid	potassium hydroxide
B	nitric acid	copper metal
C	hydrochloric acid	aqueous ammonia
D	calcium hydroxide	ammonium carbonate

12 Which element will react with oxygen to form a product that will not react with both sodium hydroxide and nitric acid?

A hydrogen
B aluminum
C magnesium
D sulfur

[Turn Over

13 A student is given five reagents as shown below to make salts.

dilute hydrochloric acid
dilute sulfuric acid
dilute nitric acid
solid lead(II) oxide
solid calcium carbonate

How many soluble salts can be prepared by mixing any two of the five reagents?

A 3
B 4
C 5
D 6

14 Which of the following does **not** show the appropriate reagents used for preparation of the named salts?

	salt	Reagent
A	silver chloride	silver nitrate + hydrochloric acid
B	ammonium chloride	ammonium carbonate + hydrochloric acid
C	zinc sulfate	zinc oxide + sulfuric acid
D	potassium sulfate	potassium metal + sulfuric acid

15 The following substances are used in the laboratory to test for various ions.

reaction 1	warming with aqueous sodium hydroxide
reaction 2	warming with dilute hydrochloric acid
reaction 3	warming with aluminium and aqueous sodium hydroxide

Which reaction(s) could produce a gas that turns moist red litmus paper blue?

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

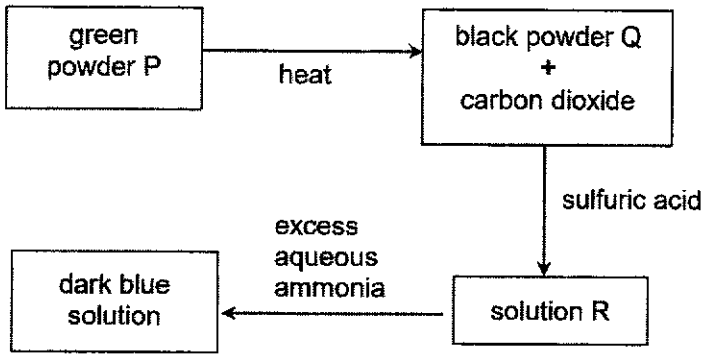
16 A salt, P, dissolved in water to give a colourless solution. A series of tests were conducted with the solution, and the results are seen below.

- On adding chlorine, the colourless solution turned brown.
- On adding aqueous silver nitrate, a yellow precipitate was seen.
- On adding aqueous ammonia, no precipitate was seen.
- On adding sodium hydroxide solution, no precipitate was seen.

What is the chemical formula of P?

A KI **B** CaF_2 **C** $ZnSO_4$ **D** $NaNO_3$

17 The diagram below shows a series of tests starting with substance P.



Which statement is true?

A P consists of a metal that has only one oxidation state.
B Q reacts with acids to liberate hydrogen gas.
C Solution R can also be formed by reacting P with sulfuric acid.
D Solution R also reacts with excess aqueous sodium hydroxide to give a dark blue solution.

18 The nitrate salt of element Y undergoes thermal decomposition.

$$2YNO_3\,(s) \rightarrow 2Y\,(s) + 2NO_2\,(g) + O_2\,(g)$$

8.5 g of YNO_3 is heated and 1.8 dm^3 of gases, measured at room temperature and pressure, are produced.

What is the relative atomic mass of Y?

A 57
B 108
C 113
D 227

19 Ammonium nitrate, NH_4NO_3, can be manufactured from ammonia, NH_3, in a two-step process.

Step 1: $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

Step 2: $HNO_3 + NH_3 \rightarrow NH_4NO_3$

What is the maximum mass of NH_4NO_3 that can be made from 17 tonnes of ammonia?
(1 tonne = 1 000 000 g)

A 34 tonnes
B 40 tonnes
C 80 tonnes
D 97 tonnes

20 A sample of solid magnesium hydroxide is prepared by adding an excess of aqueous sodium hydroxide to an aqueous solution containing 1.20 g magnesium sulfate.
The mass of magnesium hydroxide collected is 0.32 g.

What is the percentage yield for this reaction?

A 26.7% **B** 34.2% **C** 55.2% **D** 73.3%

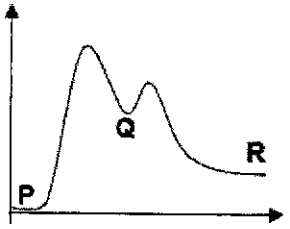
21 Pentene can be converted into carbon dioxide and water in the following stages:

$$C_5H_{12}\ (l) \xrightarrow{1} C_5H_{12}\ (g) \xrightarrow{2} 5CO_2\ (g) + 6H_2O\ (g) \xrightarrow{3} 5CO_2\ (g) + 6H_2O\ (l)$$

Which stage(s) is/are exothermic?

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

22 In the conversion of compound P into compound R, it was found that the reaction occurred in a two-step reaction, with Q as the intermediate. The energy profile diagram for the reactions is shown below.



step 1: **P** → **Q**
step 2: **Q** →**R**

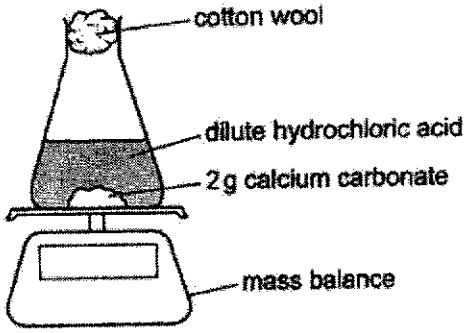
What can be deduced from the diagram?

A Both steps are endothermic.
B The backward reaction to form P from R is exothermic.
C Step 1 has a higher activation energy than step 2 because more bonds have to be broken.
D Step 2 involves breaking stronger bonds than step 1 because Q is at a higher energy level.

23 Which statement about ammonia is correct?

A It dissolves in rain to form acid rain.
B It is formed when ammonium salts are heated with sulfuric acid.
C Both of its raw materials can be obtained from the fractional distillation of air.
D It decomposes when heated to a high temperature to form nitrogen and hydrogen.

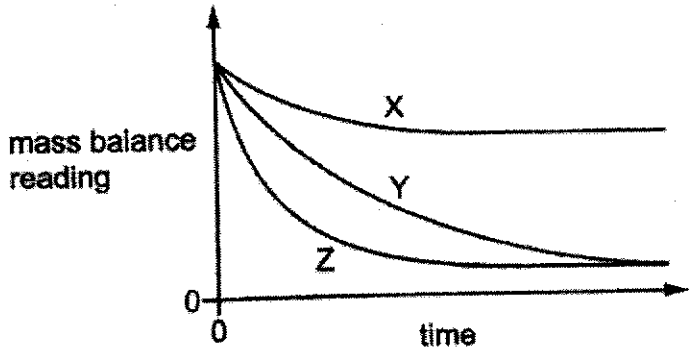
24 The rate of reaction between calcium carbonate and hydrochloric acid is measured in three separate experiments.



The conditions at which each experiment is performed are as follows:

Experiment	particle size of calcium carbonate	moles of hydrochloric acid provided for reaction
1	powdered	in excess
2	lumps	in excess
3	lumps	insufficient

The results of these experiments are shown.



Which statement is correct?

A Experiment 1 is shown by curve X.
B Experiment 1 is shown by curve Y.
C Experiment 2 is shown by curve Y.
D Experiment 3 is shown by curve Z.

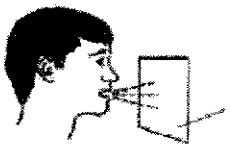
25 Concentrated sulfuric acid is able to react with potassium halide solids, according to the following equations:

reaction 1: $H_2SO_4 + 2KCl \rightarrow 2HCl + K_2SO_4$
reaction 2: $2H_2SO_4 + 2KBr \rightarrow 2H_2O + Br_2 + K_2SO_4 + SO_2$
reaction 3: $5H_2SO_4 + 8KI \rightarrow 4H_2O + 4I_2 + 4K_2SO_4 + H_2S$

What is the change in the oxidation state of sulfur in the above reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	2	4	8

26 Acidified potassium manganate (VII) can be used to detect the presence of ethanol vapour in the breath of a person who has consumed alcohol.

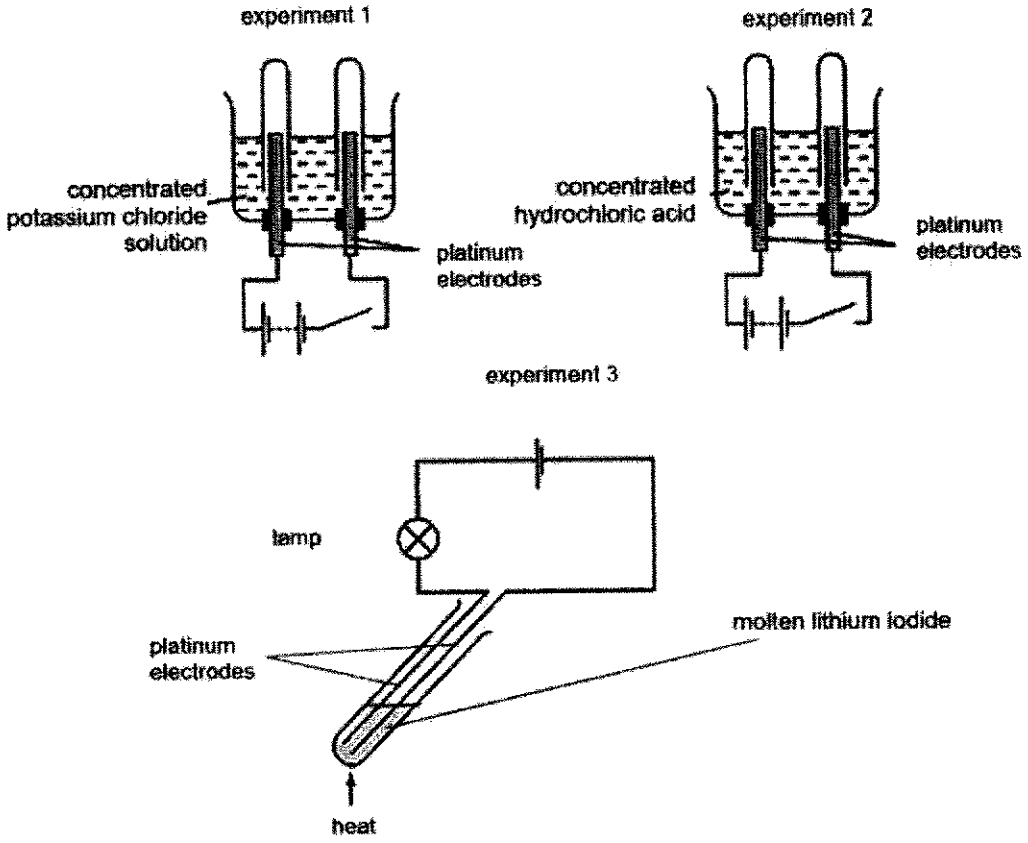


It was observed that the acidified potassium manganate (VII) turned from purple to colourless in the presence of ethanol vapour.

Which explanation is correct?

A Ethanol has been oxidised.
B Ethanol is an oxidising agent.
C Acidified potassium manganate (VII) has been oxidised.
D Acidified potassium manganate (VII) is a reducing agent.

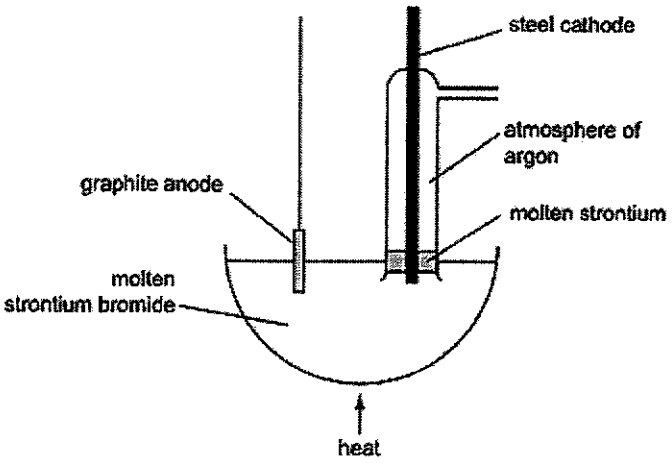
27 In three separate experiments, various types of electrolytes were used.



Which statement is correct?

A Effervescence was observed at the cathode in experiments 1 and 2 only.
B Effervescence was observed at the anode in experiments 2 and 3 only.
C Silvery-grey deposits were formed at the cathode in experiments 1 and 3 only.
D Silvery-grey deposits were formed at the anode in experiments 1 and 3 only.

28 In the experimental set-up shown below, strontium metal can be obtained by electrolysis of molten strontium bromide, $SrBr_2$.



Which of the following explains why argon and strontium bromide are used?

	argon	molten strontium bromide
A	helps lower the melting point of strontium bromide, requiring less heat	ions are free to move around and act as mobile charge carries
B	prevents the strontium from overflowing	low melting point, requiring less heat
C	reacts with strontium to form a compound that protects the metal from oxidation	low melting point, requiring less heat
D	prevents the formation of strontium oxide	ions are free to move around and act as mobile charge carries

29 In an electrolysis experiment, the same amount of charge deposited 2.17 g of chromium and 4 g of copper. The charge on the copper ion was 2+.

What is the charge on the chromium ion?

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

30 In electroplating a chromium bracelet with silver, which combination is correct?

	anode	cathode	electrolyte
A	bracelet	silver	aqueous silver nitrate
B	silver	bracelet	aqueous silver nitrate
C	bracelet	silver	chromium nitrate
D	silver	bracelet	molten sodium chloride

31 Which row correctly shows air pollutants and their sources?

	pollutant	source	pollutant	source
A	carbon dioxide	photosynthesis	sulfur dioxide	decomposition
B	carbon monoxide	incomplete combustion of petrol	methane	volcanic activity
C	sulfur dioxide	incomplete combustion of petrol	carbon dioxide	burning of fossil fuels
D	nitrogen dioxide	lightning flashes	carbon monoxide	incomplete combustion of petrol

32 The following waste gases from a coal burning power station are passed through wet powdered calcium carbonate to reduce gaseous pollutants from escaping into the atmosphere.

sulfur dioxide	carbon monoxide	sulfur trioxide
nitrogen monoxide	nitrogen dioxide	carbon dioxide

How many waste gases from the table above will be removed by the wet powdered calcium carbonate?

A 2 **B** 3 **C** 4 **D** 5

33 Which statement correctly shows the general trend of the Period 3 elements from sodium to chlorine?

A The melting point increases.
B The number of protons decreases.
C The ability to conduct electricity increases then decreases.
D The number of electrons involved in bonding decreases then increases.

34 Which of the following statements are true about the elements in Group 1 of the Periodic Table?

I. They are soft and can be cut easily.
II. They are oxidising agents.
III. The melting point decreases down the group.
IV. The reactivity decreases down the group.

A I and II
B I and III
C II and IV
D I, II and III

35 Reactions of three metals and their oxides are shown.

metal	add dilute hydrochloric acid to metal	heat metal oxide with carbon
1	✓	✓
2	✓	✗
3	✗	✓

key
✓ = reacts
✗ = does not react

What is the order of reactivity of these metals, from most reactive to least reactive?

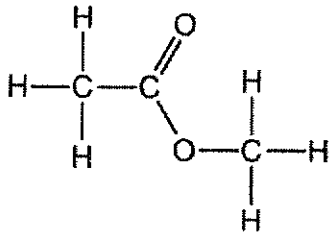
A 1 → 2 → 3 **B** 1 → 3 → 2 **C** 2 → 1 → 3 **D** 2 → 3 → 1

36 Which of the following must be the same for molecules which are isomers?

1 empirical formula
2 structural formula
3 molecular formula
4 functional group

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

37 The structure of ester X is shown.



Which row gives the name and property of ester X, and the number of electrons used in bonding?

	name	property of ester X	number of electrons used in bonding
A	ethyl methanoate	high boiling point	11
B	ethyl methanoate	soluble in water	22
C	methyl ethanoate	cannot conduct electricity	11
D	methyl ethanoate	exist as liquid at room temperature	22

[Turn Over

38 Ethanol is manufactured in industries by the fermentation of glucose or by the catalytic addition of steam to ethene.

Which statement describes an advantage of fermentation compared to catalytic addition?

A Products from fermentation are harmless to the environment.
B Fermentation produces many types of alcohol but catalytic addition only produces ethanol.
C Fermentation uses a higher temperature than catalytic addition.
D Fermentation is more environmentally sustainable as it uses a renewable resource.

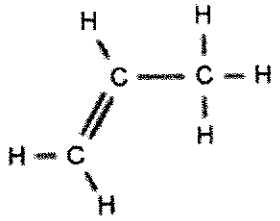
39 A molecule of compound P contains three carbon atoms and has a relative molecular mass of 44.

Which row represents P?

	name of compound	reaction with aqueous bromine
A	propane	no effect
B	propene	decolourises
C	butane	no effect
D	butene	decolourises

40 Which monomers, without the addition of any other reagent, would undergo polymerisation?

1



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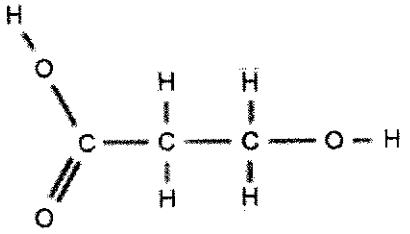

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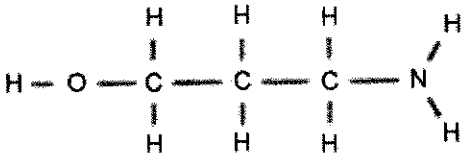
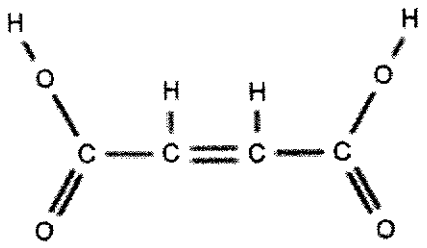


4



A 1 and 4
B 2 and 3
C 1, 2 and 4
D All of the above

End of paper

Paya Lebar Methodist Girls' School (Secondary)
Preliminary Examination 2024
Secondary 4 Express / G3

CANDIDATE NAME		CLASS		CLASS INDEX NUMBER	

CENTRE NUMBER	S					INDEX NUMBER				

CHEMISTRY **6092/02**
Paper 2 **14 August 2024**
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer all questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

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 27.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Section A	/70
Section B	/10
Total	/80

This document consists of **27** printed pages.

[Turn Over

Section A

Answer **all** questions.

1. Barium hydroxide, $Ba(OH)_2$ is a strong base.

Fig 1.1 shows a reaction scheme involving barium hydroxide.

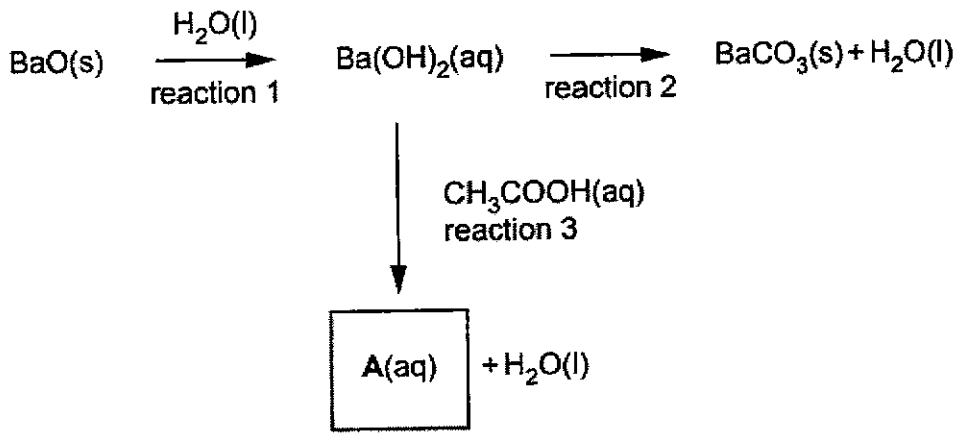


Fig. 1.1

(a) State what is observed in reaction 1.

..... [1]

(b) Suggest a reactant for reaction 2.

..... [1]

(c) Identify **A**.

..... [1]

(d) $Ba(OH)_2$ is made by reaction of Ba with water. Write a balanced chemical equation for this reaction.

..... [1]

(e) The mineral barytocalcite contains both $BaCO_3$ and $CaCO_3$. Both compounds decompose on heating.

(i) Using your knowledge on the reactivity of metals, predict which compound decomposes first when barytocalcite is heated.

Explain your answer.

.....

.....

.....

.....

..... [2]

(ii) Construct an equation for the complete thermal decomposition of barium carbonate.

..... [1]

[Total: 7]

2. The elements phosphorus, sulfur and chlorine are elements in Period 3 of the Periodic Table.

Table 2.1 shows some properties of these three elements.

property	P	S	Cl
number of valence electrons	5	6	7
formula of most common ion	P^{3-}	S^{2-}	Cl^-

Table 2.1

(a) P^{3-}, S^{2-} and Cl^- have the same number of electrons.

Describe and explain the trend in ionic radius shown by P^{3-}, S^{2-} and Cl^-.

.....

.....

.....

..... [2]

(b) Chlorine forms various ions with different oxidation states. Table 2.2 shows some of the ions of chlorine.

Ion	chlorate	perchlorate	hypochlorite	chloride
formula	ClO_3^-	ClO_4^-	ClO^-	Cl^-
oxidation state of chlorine				

Table 2.2

(i) Fill in Table 2.2 with the oxidation state of the chlorine in the various ions. [2]

(ii) A disproportionation reaction is a reaction where an element is both reduced and oxidised at the same time.

Potassium chlorate, $KClO_3$ decomposes according to equation below.

$$4KClO_3 \rightarrow 3KClO_4 + KCl$$

Explain why the above reaction is a disproportionation reaction.

.....

.....

.....

.....

..... [2]

(c) A student does two tests on separate samples of $NaCl(aq)$.

Complete Table 2.3 with the correct observations for each test.

test	observation
addition of a few drops of $Br_2(aq)$	
addition of a few drops of $AgNO_3(aq)$	

[2]

Table 2.3

[Total: 8]

3. $POCl_3$ has a melting point of 1°C and a boiling point of 106°C.

(a) Based on the information provided, suggest the structure and bonding in $POCl_3$.

.....

..... [1]

(b) Phosphorus shares a double bond with oxygen. Draw the 'dot and cross' diagram to show the bonding in $POCl_3$. Show only the outermost electrons.

[2]

(c) $POCl_3(g)$ forms when $PCl_3(g)$ reacts with $O_2(g)$.

$$2PCl_3(g) + O_2(g) \longrightarrow 2POCl_3(g)$$

Table 3.1 shows some relevant information on energy changes.

Process	value/ kJ mol^{-1}
enthalpy change for breaking bonds in one mole of PCl_3	+289
enthalpy change for forming bonds in one mole of $POCl_3$	-592
$O_2(g) \rightarrow 2O(g)$	+496

Table 3.1

Calculate the enthalpy change, ΔH, for the reaction shown in the equation in **(c)**.

enthalpy change = ... kJ [2]

(d) Hence, draw the energy profile diagram in Fig. 3.1 for the reaction shown in **(c)**. Indicate clearly the **value** of the activation energy and enthalpy change on Fig. 3.1.

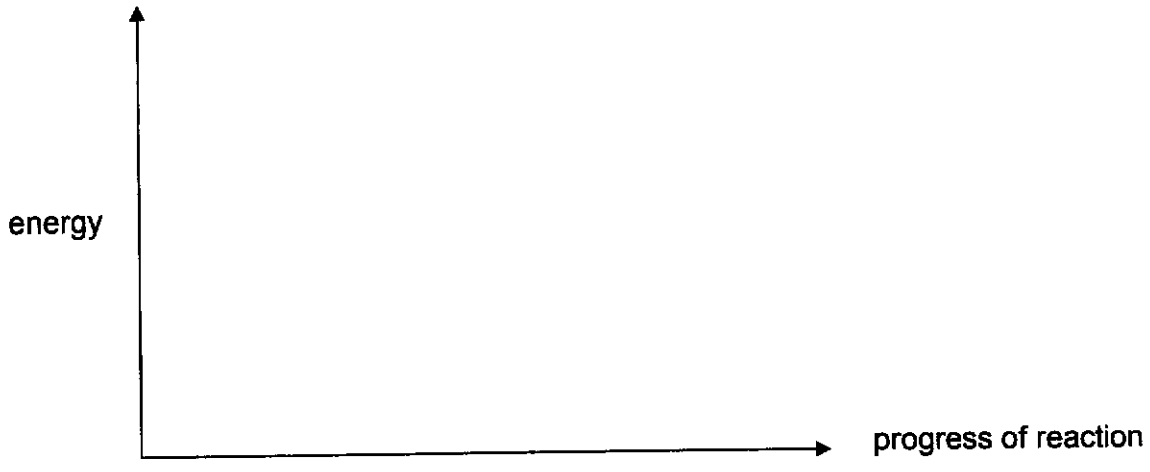


Fig. 3.1 [3]

[Total: 8]

4. Concentrated aqueous magnesium iodide and molten magnesium iodide are electrolysed separately using graphite electrodes.

(a) Describe one similarity and one difference in terms of the products formed at the electrodes for the different electrolytes.

One similarity: .....

..... [1]

One difference: .....

..... [1]

(b) Describe and explain what is observed when aqueous chlorine is bubbled into aqueous magnesium iodide.

.....

.....

.....

.....

..... [2]

(c) Iodide ions react with manganese (IV) oxide as shown in the equation.

$$2I^- + MnO_2 + 4H^+ \rightarrow Mn^{2+} + I_2 + 2H_2O$$

Explain the role played by the iodide ions in the reaction, in terms of oxidation state.

.....

.....

.....

.....

..... [2]

(d) Iodine has several radioactive isotopes. Two of the isotopes, iodine-131 and iodine-123 has clinical usage. Tiny amounts of radiation that are emitted by the radioactive iodine isotopes help the doctor to see how the organ is functioning or to treat certain cancers. Radiation emitted can be in the form of a beta particle, $^{0}_{-1}\beta$.

(i) Explain whether iodine-131 and iodine-123 will have similar chemical properties.

.....

.....

..... [1]

(ii) The equation below shows iodine-131 breaking down to produce a beta particle.

$$^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}\beta$$

Radioactive phosphorus-32 also breaks down to produce a beta particle, similar to radioactive iodine-131. Write an equation to show this reaction.

..... [1]

[Total: 8]

5. A piece of copper ore containing copper (II) oxide has a mass of 0.567g. It is dissolved in an acid, giving 100.0 cm^3 of a blue solution in which all the copper is present as Cu^{2+} ions.

An excess of KI (aq) is added to a **25.0 cm^3 sample** of this solution.

All the copper is precipitated as white CuI(s).

Cu^{2+} ions are the only component in the solution that react with KI (aq).

This is reaction 1.

reaction 1 $\quad 2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

The liberated iodine is then titrated with 0.0200 mol/dm^3 of $S_2O_3^{2-}$. This is reaction 2.

reaction 2 $\quad I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

The titration requires 20.10 cm^3 of 0.0200 mol/dm^3 of $S_2O_3^{2-}$ to reach the end point.

(a) Calculate the number of moles of I_2 that are reduced in the titration.

number of moles of I_2 = ... mol [1]

(b) Calculate the number of moles of copper in the **original** piece of ore.

number of moles of copper in the original piece of ore = ... mol [2]

[Turn Over

(c) Calculate the percentage of copper in the ore.

% of copper in the ore = ... % [2]

(d) Pure copper is usually converted to an alloy before being used to make water pipes.

Describe and explain the advantage of using an alloy of copper over pure copper.

.....

.....

.....

..... [2]

[Total: 7]

6. An experiment is set up to investigate the rate of diffusion of solutions. Aqueous barium nitrate is added from one side of a 10 cm length of black paper, while aqueous copper (II) sulfate is added from the other side at the same time. The time taken for a white precipitate to appear on the black paper is recorded. Fig. 6.1 shows the experimental set up.

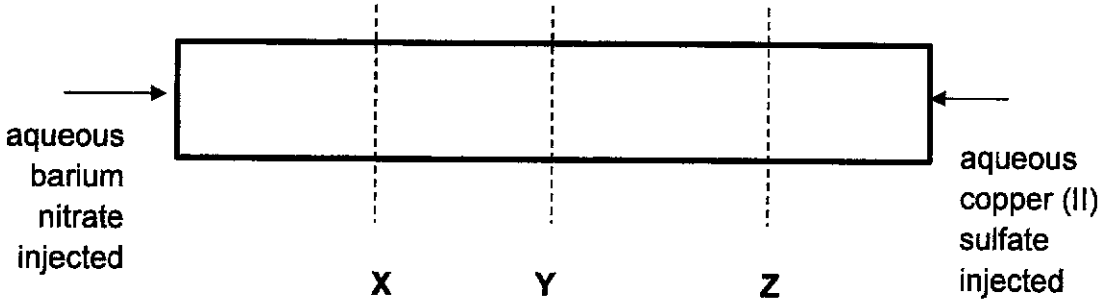


Fig. 6.1

(a) Write the ionic equation for the formation of the white precipitate.

..... [1]

(b) Predict the position of the white precipitate on the black paper. Will the white precipitate appear at position marked **X, Y** or **Z**? Provide an explanation for your answer.

.....

.....

.....

..... [2]

(c) Instead of using aqueous barium nitrate, aqueous barium hydroxide is used, with all other reactants and conditions kept constant. Describe what will be observed.

Observation: ..... [1]

(d) Copper (II) sulfate is made by adding excess copper (II) carbonate to sulfuric acid, at room temperature and pressure.

The equation for reaction is shown below.

$$CuCO_3\,(s) + H_2SO_4\,(aq) \rightarrow CuSO_4\,(aq) + CO_2\,(g) + H_2O\,(l)$$

The volume of gas collected as the reaction proceeds in shown in Fig. 6.2.

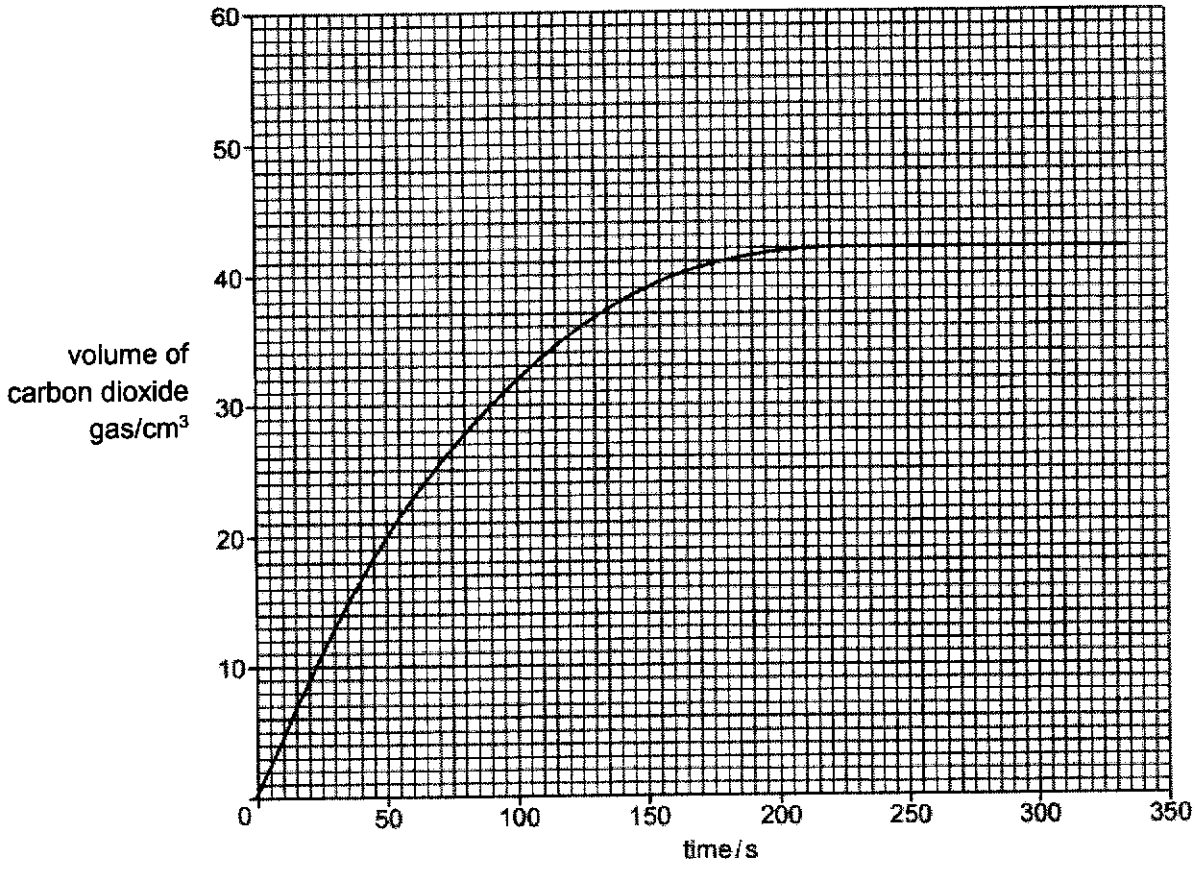


Fig. 6.2

(i) Calculate the number of moles of sulfuric acid used.

number of moles of sulfuric acid = ... mol [2]

(ii) If the concentration of sulfuric acid used is 0.0500 mol/dm^3, calculate the volume of sulfuric acid used.

volume of sulfuric acid = ... cm^3 [1]

(iii) The experiment is repeated with the same volume of sulfuric acid in **(ii)** but concentration of sulfuric acid is 0.0643 mol/dm^3, and all other conditions are kept constant.

Calculate the volume of carbon dioxide produced.

volume of carbon dioxide = ... cm^3 [2]

(iv) Use ideas about collisions between particles to explain how the change in concentration of sulfuric acid in **(iii)** affects the rate of reaction.

.....

.....

.....

.....

..... [2]

(v) Hence, sketch the graph obtained for the experiment in **(iii)** on Fig. 6.2. [1]

[Total: 12]

7. Plastics can be categorised into 7 types. Fig. 7.1 shows three of the most used plastics. The plastics industry depends on non-renewable resources. More than 90% of global plastic production consists of primary plastics—which are newly manufactured, rather than recycled—made from petroleum products. This production requires a huge amount of energy and produces greenhouse-gas emissions. By 2050, emissions from plastic production could amount to 15% of the estimated carbon budget needed to keep global warming below 1.5 °C.

Credits: https://www.scientificamerican.com/article/why-its-so-hard-to-recycle-plastic/

type of plastic	name	ease of recycling
	polyethylene terephthalate	easy
	high density polyethylene	easy
	polyvinyl chloride	almost impossible

Fig. 7.1

(a) Explain why the production of plastic is not environmentally sustainable and harmful to the environment.

.....

.....

.....

.....

..... [2]

(b) PET and HDPE are easy to recycle. Describe how plastics can be recycled using a physical and chemical method.

Physical method: .....

.....

..... [1]

Chemical method: .....

.....

..... [1]

(c) The structure of PET and PVC are shown in Fig. 7.2

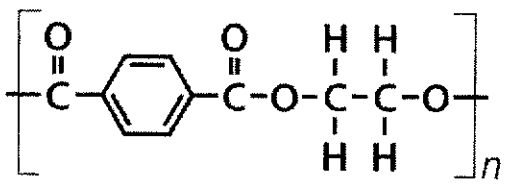
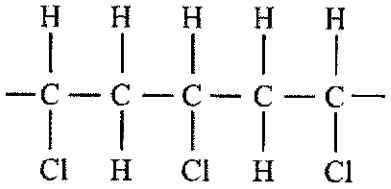
PET	PVC
	

Fig. 7.2

(i) Draw the monomer(s) that are used to make PET and PVC.

Monomers of PET	Monomer of PVC

[2]

(ii) PET and PVC are made by different methods of polymerisation.

Identify the polymer formed by:

addition polymerisation : .....

condensation polymerisation: ..... [1]

(iii) Describe **one** difference between addition and condensation polymerisation.

.....

.....

..... [1]

[Total: 8]

8. Infrared spectroscopy can be used to detect bonds and atoms present in organic molecules. As the bonds and types of atoms differ, the molecules absorb radiation at different wavelengths, represented by a wavenumber. As the bonds absorb radiation, they stretch. Table 8.1 shows the wavenumber at which the different bonds absorb radiation.

Bond	Wavenumber/ cm^{-1}
C-C	1100 - 750
C-O	1300 - 1000
C=C	1680 – 1650
C=O	1725 – 1700
C-H	2990 – 2600
O-H (in carboxylic acids)	3200 - 2900
O-H (in alcohols)	3700 - 3300

Table 8.1

Fig. 8.1 shows the infrared spectrum of ethanol. In an infrared spectrum, the vertical axis shows an increasing transmittance while the horizontal axis shows a **decreasing** wavenumber.

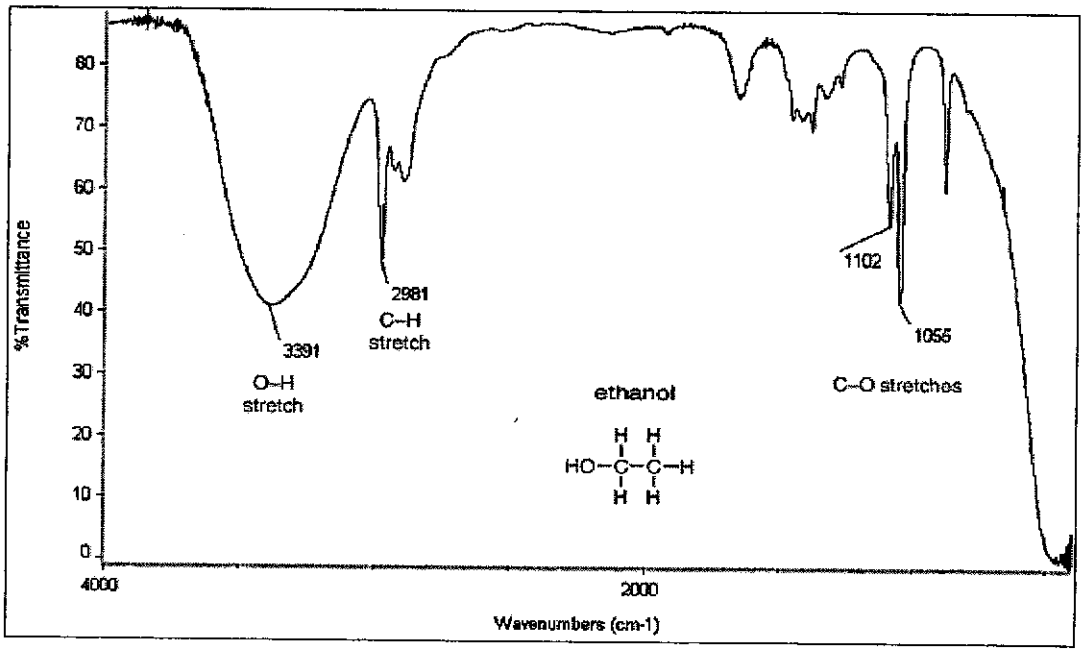


Fig. 8.1

A peak at 3391 cm^{-1} corresponds to a O-H bond as it falls in the region of 3700- 3300 cm^{-1}.
A peak at 2981 cm^{-1} corresponds to a C-H bond as it falls in the region of 2990- 2850 cm^{-1}.
A peak at 1102 and 1055 cm^{-1} corresponds to a C-O bond as it falls in the region of 1300- 1000 cm^{-1}.

[Turn Over

Alcohols fall into different classes depending on how the hydroxyl group, -O-H is positioned on the chain of carbon atoms. Table 8.2 shows the differences between the different classes of alcohol for butanol.

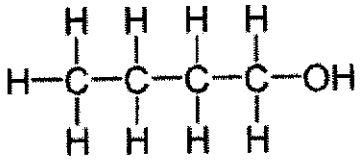
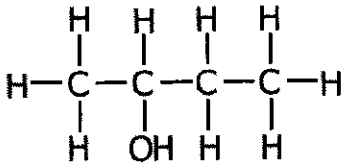
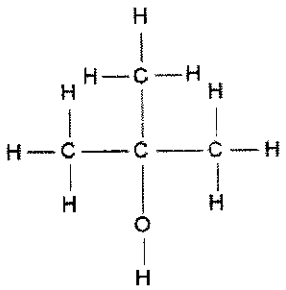
Primary (1^0)	Secondary (2^0)	Tertiary (3^0)
		
butan-1-ol	butan-2-ol	2-methylpropan-2-ol
In a primary (1^0) alcohol , the carbon which carries the -OH group is attached to only one *alkyl* group.	In a secondary (2^0) alcohol , the carbon which carries the -OH group is attached to two *alkyl* groups, which may be same or different.	In a tertiary (3^0) alcohol , the carbon which carries the -OH group is attached to three *alkyl* groups, which may be same or different.

Table 8.2

An *alkyl* group is a group such as methyl, $-CH_3$, or ethyl, $-CH_3CH_2$. These are groups containing chains of carbon atoms which may be straight or branched. Alkyl groups are given the general symbol **R**.

Alcohols have a higher boiling point than that of an alkane with the same number of carbon atoms as shown in Fig. 8.2 due to the presence of hydrogen bonding. Hydrogen bonding occurs in molecules due to the hydroxyl functional group, -O-H. The weak intermolecular forces of attraction between the molecules and hydrogen bonding determine the boiling point of an alcohol.

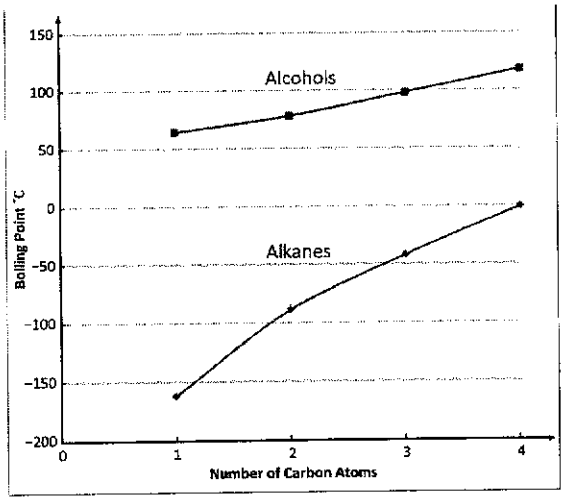


Fig. 8.2

(a) What is the phenomenon exhibited by the three different molecules of butanol shown in Table 8.2?

..... [1]

(b) Table 8.3 shows three alcohols **P, Q** and **R**.

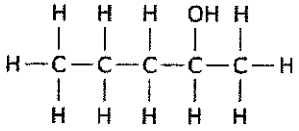
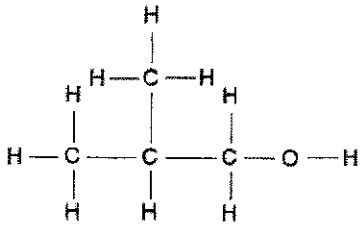
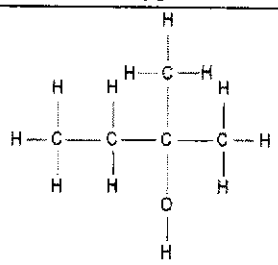
Alcohol	**P**	**Q**	**R**
Structural formula			
Class of alcohol			
Name		2-methylpropan-1-ol	2-methylbutan-2-ol

Table 8.3

Fill in the missing blanks in Table 8.3 with the correct class and name of the alcohols **P, Q** and **R**. [2]

(c) A molecule **T**, with two hydroxyl groups has the structure shown in Fig. 8.3.

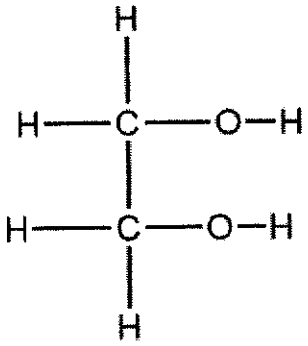


Fig 8.3

Using information from Fig 8.2, predict the boiling point of molecule **T**. Provide an explanation for your prediction.

.....

.....

.....

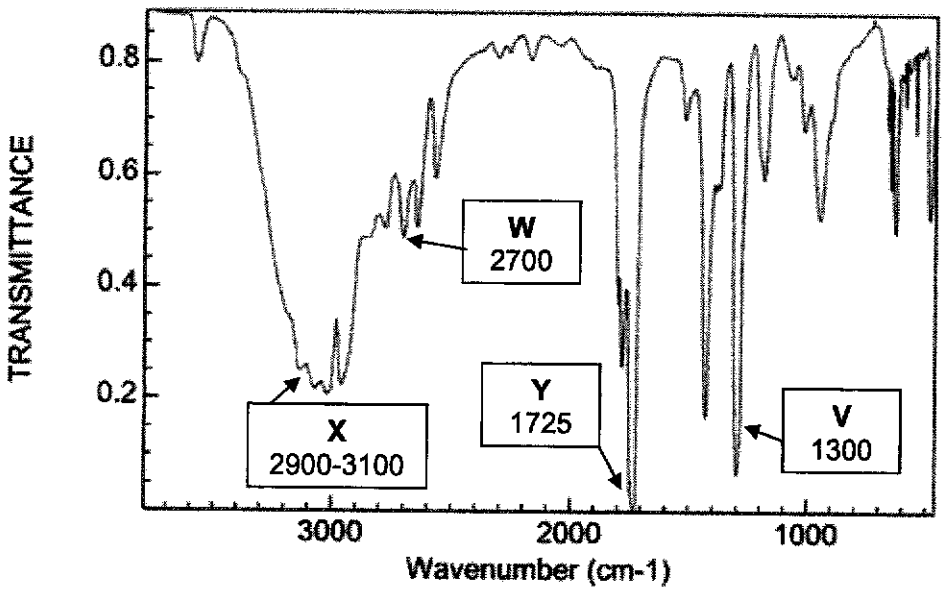
.....

.....

.....

..... [3]

(d) Fig. 8.4 shows the infrared spectrum of a molecule **Z**.



NIST Chemistry WebBook (https://webbook.nist.gov/chemistry)

Fig. 8.4

(i) Based on Fig 8.4 and Table 8.1, identify the bonds represented by the peaks at **V, W, X** and **Y**. Bonds represented by **X** and **Y** make up the only functional group of molecule **Z**.

V represents bond: .....

W represents bond: .....

X represents bond: .....

Y represents bond: ..... [2]

(ii) State the homologous series molecule **Z** is in.

..... [1]

(iii) Molecule **Z** has a total of two carbon atoms. Hence, draw the displayed formula of molecule **Z**.

[2]

(iv) Name the reagents that can react to produce molecule **Z**.

..... [1]

[Total: 12]

[Turn Over

Section B

Answer **one** question from this section.

9. Table 9.1 shows the melting points and relative electrical conductivities of three elements.

	carbon (graphite)	magnesium	iodine
melting point/^{0}C	3652	649	114
relative electrical conductivity of solid	good	good	poor

Table 9.1

(a) Use ideas about bonding and structure to explain:

(i) the difference in the melting points of magnesium and iodine.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) the difference in the electrical conductivities of graphite and iodine.

.....

.....

.....

.....

.....

.....

..... [2]

(b) A compound of phosphorus, oxygen and chlorine contains 20.2% phosphorus, 10.4% oxygen and 69.4% chlorine by mass.

Deduce the empirical formula of this compound.

empirical formula ..... [2]

[Turn Over

(c) The cell reaction for an electrochemical cell is shown below.

$$Cl_2\,(aq) + 2Fe^{2+}\,(aq) \rightarrow 2Fe^{3+}\,(aq) + 2Cl^-\,(aq)$$

Table 9.2 shows some standard electrode potentials.

Half - reaction	Standard Electrode Potential, E° (volts)
$2Fe^{3+}\,(aq) + 2e^- \rightarrow 2Fe^{2+}\,(aq)$	+ 0.77
$Cl_2\,(aq) + 2e^- \rightarrow 2Cl^-\,(aq)$	+ 1.36

Table 9.2

(i) Use the information in Table 9.2 to calculate the potential difference of the electrochemical cell in **(c)**.

potential difference = ... V [1]

(ii) Describe the colour change of the solution in the electrochemical cell as electricity is being generated.

.....

..... [1]

(iii) Describe a simple test to determine that all the chlorine is fully used up. Aqueous chlorine behaves the same way as chlorine gas.

.....

.....

..... [1]

[Total: 10]

10. Solid fuel used for outdoor cooking is made of hexamine. A student suggested using moth balls made of naphthalene as solid fuels instead. Table 10.1 shows some information about hexamine and naphthalene.

Solid fuel	Molecular formula	Enthalpy of combustion kJ/mol
hexamine	$C_6H_{12}N_4$	-4 200
naphthalene	$C_{10}H_8$	-5 133

Table 10.1

Energy density is the amount of energy released per gram of fuel combusted, kJ/g.

(a) Calculate the energy densities of hexamine and naphthalene.

energy density of hexamine = ... kJ/g [1]

energy density of naphthalene = ...kJ/g [1]

(b) Hence, explain whether moth balls containing naphthalene are a better alternative to solid fuel containing hexamine for camping, with reference to their energy densities and mass.

.....

.....

..... [1]

[Turn Over

(c) Burning hexamine solid fuels may be more harmful than burning moth balls as a harmful air pollutant is produced. Name the air pollutant produced and describe the harmful effect caused by this air pollutant.

air pollutant ..... [1]

effect of air pollutant .....

.....

..... [1]

(d) Aluminium nitrate decomposes on heating according to the equation below.

$$4Al(NO_3)_3\,(s) \rightarrow 2Al_2O_3\,(s) + 12NO_2\,(g) + 3O_2\,(g)$$

Student A then adds aqueous hydrochloric acid while student B adds aqueous potassium hydroxide to the solid left after decomposition.

(i) Describe what will be observed by:

Student A .....

Student B ..... [1]

Explanation for observations: .....

.....

..... [1]

(ii) Use ideas of structure and bonding to explain why aluminium oxide exists as a solid while nitrogen dioxide exists as a gas at room conditions.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group 1	Group 2											Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
							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	3	4	5	6	7	8	9	10	11	12	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

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.). The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}

Answers to Sec 4 Pure Chemistry prelim 2024

Qn	Ans	Explanation
1	C	**Strength of acids can be tested by measuring the temperature change during acid-metal reaction.** Hence, thermometer would be required. pH is measured using the Universal Indicator or pH meter. Volume of sodium hydroxide needed for neutralisation and final volume of gas produced during acid-metal reaction will be similar, given that the concentrations of the unknown acid and hydrochloric acid are the same.
2	D	Sodium hydroxide solution will neutralise the acidic carbon dioxide, concentration sulfuric acid will dry the gases, and copper will react with oxygen. Hence, nitrogen gas will remain.
3	B	Rf values of the 3 spots are 0.3, 0.6 and 0.9 – distance travelled by ink divided by distance travelled by solvent front. Hence, only diethanolamine and oxybenzone are present.
4	A	Mr of CH_3Cl = 12 + 3 + 35.5 = 50.5 Mr of SO_2 = 32 + 16x2 = 64 CH_3Cl will travel the fastest due to its lower mass, on the hot day.
5	D	S to T is where the sample will freeze and change from liquid to solid. Hence, this will result in a change in movement from moving around each other to vibrating about in fixed positions.
6	D	P^{3-} has 16 neutrons, 15 protons and 18 electrons. O^{2-} has 8 neutrons, 8 protons and 10 electrons. Mg^{2+} has 12 neutrons, 12 protons and 10 electrons. Ne has 10 neutrons, 10 protons and 10 electrons.
7	C	32.1% x 64 + 56.4% x 66 + 11.5% x 67 = 65.5 54.6% x 64 + 6.6% x 66 + 38.8% x 67 = 65.3 **56.3% x 64 + 31.3% x 66 + 12.6% x 67 = 65.1** 53.5% x 64 + 25.5% x 66 + 21.2% x 67 = 65.3
8	B	**J has a charge of +2 – hence, it could be magnesium which is in Group 2.** K has 5 valence electrons – hence, it should be in Group 15. L has 1 valence electron – hence, it should be hydrogen. It cannot be Group 1 metals as metals do not form covalent bonds. **K and L shared 2 electrons – hence, they formed a covalent bond.**
9	B	Chloroacetone is a covalent compound, which **will not be able to conduct electricity in any state**, and has low melting and boiling points. There are 10 covalent bonds, hence there are 20 electrons involved in bonding. Chlorine shares one electron and **has 6 valence electrons not involved in bonding.**
10	D	Based on the coordination number, each Y is surrounded by 6Z while each Z is surrounded by 4Y. This means that the **ratio between Y and Z is 2:3**. Hence, formula is Y_2X_3.
11	D	**Calcium hydroxide reacts with ammonium carbonate to give off ammonia gas,** resulting in a loss in overall mass.

		A and C show neutralisation reaction with no gas produced, while copper does not react with acid.
12	A	Hydrogen reacts with oxygen to form **water, which is neutral.** Aluminium oxide is amphoteric, magnesium oxide is basic and sulfur dioxide is acidic.
13	A	**Lead(II) nitrate, calcium chloride and calcium nitrate are soluble.** Lead(II) sulfate, lead(II) chloride and calcium sulfate are insoluble.
14	D	**Potassium is a very reactive metal**, hence will react explosively with acid. Reaction is unsafe to proceed.
15	D	Test for **ammonium ions** with reaction 1 and **nitrate ions** with reaction 3 could produce ammonia gas, which will turn moist red litmus paper blue. Hydrochloric acid is used to test for carbonate ions, which produces carbon dioxide gas.
16	A	Displacement by chloride produces brown solution – iodine is produced. Precipitation of yellow precipitate – silver iodide is produced. No ppt with aqueous ammonia and sodium hydroxide – sodium, potassium or ammonium ions possible Hence, P is KI.
17	C	R is copper(II) sulfate, which can be produced by reacting copper(II) carbonate with sulfuric acid. Copper is a transition metal with variable oxidation states. Q is copper(II) oxide which reacts with acids to give salt and water. Copper(II) ions give a blue ppt insoluble in excess sodium hydroxide.
18	B	Number of moles of gases = 1.8 / 24 = 0.075 Number of moles of salt = 0.075/3 x 2 = 0.05 Mr of salt = 8.5 / 0.05 = 170 Ar of salt = 170 – 14 – (16x3) = 108
19	B	Number of moles of ammonia = 17 000 000 / 17 = 1 000 000 Number of moles of ammonium nitrate = 1 000 000 / 2 = 500 000 Maximum mass of ammonium nitrate = 500 000 x (2x14 + 4 + 3x16) = 40 000 000 g = 40 tonnes
20	C	$2NaOH + MgSO_4 \rightarrow Mg(OH)_2 + Na_2SO_4$ Number of moles of magnesium sulfate = 1.20 / (24 + 32 + 4x16) = 0.01 Mass of magnesium hydroxide = 0.01 x (24 + 2x16 + 2) = 0.58g Percentage yield = 0.32/0.58 x 100 = 55.2%
21	C	Combustion and condensation are exothermic. Boiling/vapourisation is endothermic.
22	B	P has lower energy level, hence R gives out energy to form P in the backward reaction – exothermic. Step 1 is endothermic but step 2 is exothermic. While step 1 has higher activation energy than step 2, it is because the amount of energy needed to break bonds is

		higher – not because more bonds are broken. Step 1 involves breaking stronger bonds.
23	D	**Ammonia is formed via a reversible reaction, hence it will decompose when heated to a high temperature.** Ammonia is alkaline, and will be formed when ammonium salts are heated with bases. Ammonia is made from hydrogen – obtained from cracking of petroleum, and nitrogen – obtained from fractional distillation of air.
24	C	Experiment 1 is shown by curve Z – fastest reaction due to the use of powdered calcium carbonate, and greatest change in mass as HCl is used in excess. **Experiment 2 is shown by curve Y – slower reaction due to the use of calcium carbonate in lumps.** Experiment 3 is shown by curve X – slower reaction due to the use of calcium carbonate in lumps, and smaller change in mass due to insufficient HCl used.
25	C	Reaction 1: oxidation state of sulfur **remains the same** (+6). Reaction 2: oxidation state of sulfur changes from +6 in H_2SO_4 to +4 in SO_2 – **change by 2.** Reaction 3: oxidation state of sulfur changes from +6 in H_2SO_4 to -2 in H_2S – **change by 8.** *Comments: badly done. Many chose B.*
26	A	$KMnO_4$ has been reduced as the oxidation state of Mn has decreased from +7 to +2, and acts as an oxidising agent. Ethanol is oxidised and acts as a reducing agent.
27	A	Experiment 1: hydrogen is discharged at cathode and chlorine gas is discharged at anode. Experiment 2: hydrogen is discharged at cathode and chlorine gas is discharged at anode. Experiment 3: lithium is discharged at cathode and iodine gas is discharged at anode.
28	D	**Argon is inert** and is used to prevent the oxidation of strontium. **Molten strontium bromide is used as electrolyte** as its ions act as mobile charge carriers to conduct electricity.
29	C	$Cu \rightarrow Cu^{2+} + 2e$ Number of moles of copper = 4 / 64 = 0.0625 Number of moles of electrons = 0.0625 x 2 = 0.125 $Cr \rightarrow Cr^{n+} + ne$ Number of moles of chromium = 2.17 / 52 = 0.0417 Number of moles of electrons = 0.0.417 x n = 0.0417n Same amount of charge for Cu and Cr: 0.0417n = 0.125 Hence, n = +3.0
30	B	**Cations are discharged at the cathode**, hence the bracelet must be at the cathode. **Silver anode will discharged to give silver ions**, and the electrolyte must contain silver ions.
31	D	Carbon dioxide is not a pollutant. Sulfur dioxide is from volcanic activity, methane from cattle farming, **nitrogen dioxide from lightning flashes and carbon monoxide from incomplete combustion of petrol**.

32	C	Sulfur dioxide, sulfur trioxide, nitrogen dioxide and carbon dioxide are acidic gases that can be removed by calcium carbonate.
33	C	Melting point increases then decreases across the period. Number of protons increases. **Ability to conduct electricity increases then decreases.** The number of electrons involved in bonding increases then decreases.
34	B	**They are soft and melting point decreases down the group.** They are reducing agents and their reactivity increases down the group.
35	C	2 is the most reactive as it reacts with acid and its oxide cannot be reduced by heating with carbon. 3 is the least reactive as it cannot react with acid and its oxide can be reduced by heating with carbon.
36	B	Isomers have the same molecular formula, hence they will also have the same empirical formula. They will have different structural formula and could have different functional group.
37	D	It is methyl ethanoate, a covalent molecule that cannot conduct electricity and has low melting and boiling point. It has 22 electrons involved in bonding to form 11 bonds.
38	D	**Ethene is obtained from the cracking of hydrocarbons**, which is a non-renewable resource. However, glucose is obtained from plants like sugarcane, which is a renewable resource.
39	A	It is propane and Mr is 44 (C_nH_{2n+2}). Hence, it does not decolourise bromine.
40	C	**1 and 4 can undergo addition polymerisation.** **2 can undergo condensation polymerisation.** 3 cannot undergo condensation polymerisation as alcohol and amine group cannot react to form linkage.

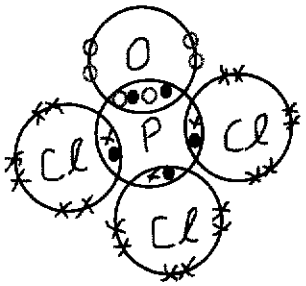
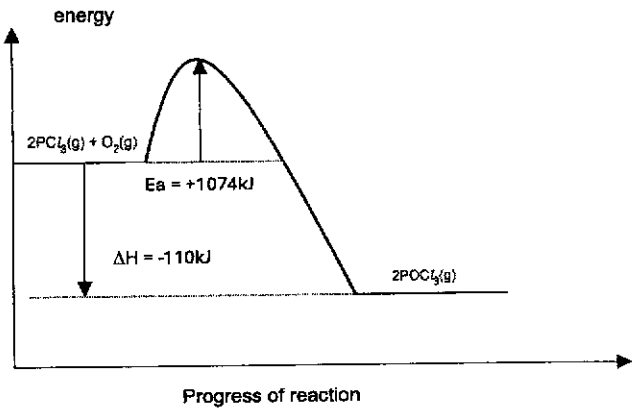
Answers to Sec 4 Pure Chem Preliminary Exam P2 2024

<table>
<tr><td>1(a)</td><td>The solid dissolves/disappears/becomes smaller.</td><td>[1]</td></tr>
<tr><td>(b)</td><td>Carbonic acid</td><td>[1]</td></tr>
<tr><td>(c)</td><td>Barium ethanoate or $(CH_3COO)_2Ba$</td><td>[1]</td></tr>
<tr><td>(d)</td><td>$Ba + 2H_2O \rightarrow Ba(OH)_2 + H_2$</td><td>[1]</td></tr>
<tr><td>(e)(i)</td><td>$CaCO_3$ decomposes first. $CaCO_3$ has a <u>lower thermal stability</u> as <u>calcium is less reactive than barium.</u></td><td>[1]
[1]</td></tr>
<tr><td>(ii)</td><td>$BaCO_3 \rightarrow BaO + CO_2$</td><td>[1]</td></tr>
<tr><td>2(a)</td><td>The ionic radius decreases from P to Cl. As you move across the Period from P to Cl, the <u>nuclear charge increases</u> (OR number of protons increases), the <u>electrons are more closely attracted to the nucleus</u> (attraction between protons and electrons increases).</td><td>[1]
[1]</td></tr>
<tr><td>(b)(i)</td><td>
<table>
<tr><td>Ion</td><td>chlorate</td><td>perchlorate</td><td>hypochlorite</td><td>chloride</td></tr>
<tr><td>formula</td><td>ClO_3^-</td><td>ClO_4^-</td><td>ClO^-</td><td>Cl^-</td></tr>
<tr><td>oxidation state of chlorine</td><td>+5</td><td>+7</td><td>+1</td><td>-1</td></tr>
</table>
</td><td>2m- all correct

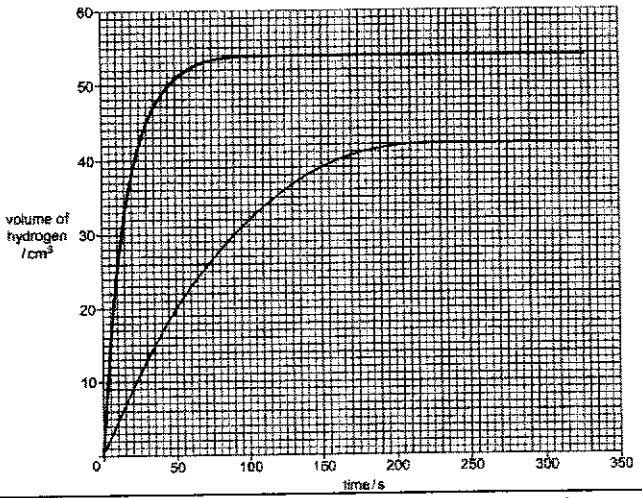
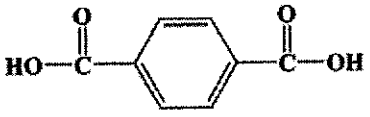
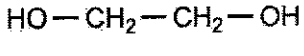
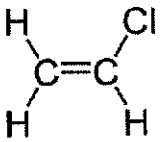
1m-2 or 3 correct</td></tr>
<tr><td>(ii)</td><td>Oxidation state of chlorine increases from +5 in $KClO_3$ to +7 in $KClO_4$. Chlorine is oxidised. (accept if $KClO_3$ oxidised)
Oxidation state of chlorine decreases from +5 in $KClO_3$ to -1 in KCl, Chlorine is reduced. (accept if $KClO_3$ reduced)
Since chlorine is both oxidised and reduced, it is a disproportionation reaction.</td><td>[1]

[1]</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><td>test</td><td>observation</td></tr>
<tr><td>addition of a few drops of $Br_2(aq)$</td><td><u>Solution remains reddish brown</u></td></tr>
<tr><td>addition of a few drops of $AgNO_3(aq)$</td><td><u>White precipitate</u></td></tr>
</table>
</td><td>[1]

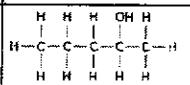
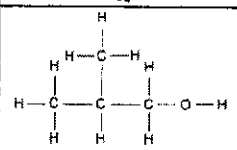
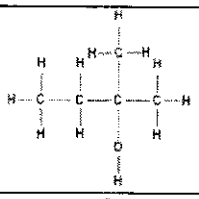
[1]</td></tr>
</table>

3(a)	Covalent bonding, simple covalent (molecular) structure	[1]-both answers
(b)		[1-bonding electrons between O & P, O electrons] [1-bonding electrons between Cl & P, electrons of Cl]
(c)	Enthalpy change for bond breaking in reactants = 2(289) + 496 = +1074 kJ Enthalpy change for bond formation in products = - (2 x 592) = -1184 kJ Enthalpy change for reaction = + 1074 – 11 84 = -110 kJ	 [1] [1]
(d)		[1- exo + labelling of reactants & products [1-Ea labelling & value] [1-ΔH & value]
4(a)	Similarity: At the anode, iodine is produced. Difference: At the cathode, for molten magnesium iodide, magnesium is produced while hydrogen is produced for concentrated aqueous magnesium iodide.	[1] [1]
(b)	Colourless solution <u>turns brown</u>. <u>Chlorine which is more reactive than iodine displaces iodine from magnesium iodide</u>, producing the brown iodine.	[1] [1]
(c)	The oxidation state of iodine increases from -1 in I^- to 0 in I_2. I^- is oxidised, hence it is acting as the reducing agent.	[1] [1]

(d)(i)	Iodine -123 and iodine-131 have the same number of 7 valence electrons, hence will have similar chemical properties.	[1]
(ii)	$^{32}_{15}P \rightarrow {}^{32}_{16}S + {}^{0}_{-1}\beta$	[1]
5(a)	No of moles of $S_2O_3^{2-}$ = 0.0200 x 20.10/1000 = 0.000402 mol Mole ratio I_2: $S_2O_3^{2-}$ = 1: 2 = 0.000402/2 : 0.000402 mol No of moles of I_2 = 0.000402/2 = 0.000201 mol	[1]
(b)	Mole ratio I_2: Cu^{2+} = 1: 2 = 0.000201: 0.000201 x 2 No of moles of Cu^{2+} = 0.000402 mol No of moles of Cu^{2+} in original piece of ore = 100/25 x 0.000402 = 0.001608 mol	[1] [1]
(c)	Mass of copper in ore = 0.001608 x 64 = 0.1029 g % of copper in ore = 0.1029/0.567 x 100% =18.15% = 18.2 % (3sf)	[1] [1]
(d)	Alloy of copper is harder than pure copper as the atoms in the alloy have different sizes, which disrupts the orderly layered arrangement of copper atoms, making it harder for the layers of atoms to slide past one another.	[1] [1]
6(a)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$	[1]
(b)	Mr of SO_4^{2-} = 32 + 4(16) = 96 Ar of Ba^{2+} = 137 SO_4^{2-} has a smaller Mr, hence will diffuse faster, so they will meet and react nearer to barium nitrate at X.	[1- calculation of Ar & Mr] [1m for explanation]
(c)	Observation: white ppt and blue ppt	[1]
(d)(i)	Volume of CO_2 = 42 cm^3 No of moles of CO_2 = 42/24000 = 0.00175 mol Mole ratio CO_2: H_2SO_4 = 1:1 No of moles of H_2SO_4 = 0.00175 mol	[1] [1]
(ii)	No of moles of H_2SO_4 = 0.00175 = 0.0500 x V Volume of H_2SO_4 = 0.00175/0.0500 = 0.035 dm^3 = 35 cm^3	[1]
(iii)	No of moles of H_2SO_4 = 0.0643 x 0.035 = 0.002251 mol Mole ratio CO_2: H_2SO_4 = 1:1 No of moles of CO_2 = 0.002251 mol Volume of CO_2 = 0.002251 x 24 = 0.054 dm^3 = 54 cm^3	[1] [1]
(iv)	At higher concentrations, there are more particles per unit volume. Frequency of effective collisions increases, rate of reaction increases.	[1] [1]

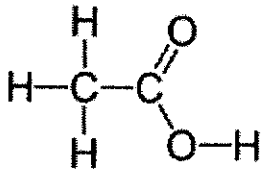
(v)		[1- vol of gas = 54 cm^3 & steeper curve]
7(a)	Plastics are made from <u>non-renewable petroleum,</u> hence it is not environmentally sustainable. As <u>greehouse gases</u> are produced in the plastic production process, it is harmful to the environment as green house gases cause <u>global warming</u>, causing polar ice caps to melt, resulting in flooding.	[1] [1]
(b)	Physical method: The plastic is melted, cooled and made into pellets. Chemical method: The plastic is cracked or depolymerised.	[1] [1]
(c)(i)	Monomers of PET:  and  Monomer of PVC 	[1] [1]
(ii)	Addition polymer: PVC Condensation polymer: PET	[1]
(iii)	Any one:	

<table>
<tr><td></td><td>In condensation polymerisation, there is removal of small molecules but in addition polymerisation, there is no removal of small molecules.

The monomers in addition polymerisation are unsaturated while in condensation polymerisation, the monomers have different functional groups.</td><td>[1]</td></tr>
<tr><td>8(a)</td><td>Isomerism</td><td>[1]</td></tr>
<tr><td>(b)</td><td>
<table>
<tr><td>Alcohol</td><td>P</td><td>Q</td><td>R</td></tr>
<tr><td>Structural formula</td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Class of alcohol</td><td>Secondary(2⁰)</td><td>Primary (1⁰)</td><td>Tertiary (3⁰)</td></tr>
<tr><td>Name</td><td>Pentan-2-ol</td><td>2-methylpropan-1-ol</td><td>2-methylbutan-2-ol</td></tr>
</table>
</td><td>Every 2 correct 1m

[2]</td></tr>
<tr><td>(c)</td><td>Accept any value between 75 to 130
As molecule T has <u>two hydroxyl groups</u>, there will be <u>more/stronger hydrogen bonding</u>,
<u>requiring more energy to overcome</u>, hence higher boiling point than ethanol.</td><td>[1]

[1]

[1]</td></tr>
<tr><td>(d)(i)</td><td>V represents C-O bond
W represents C-H bond
X represents O-H (in carboxylic acids)
Y represents C=O</td><td>Every 2 correct 1m
[2]</td></tr>
<tr><td>(ii)</td><td>Z is a carboxylic acid</td><td>[1]</td></tr>
<tr><td>(iii)</td><td>Z is ethanoic acid.
  </td><td>[2]</td></tr>
<tr><td>(iv)</td><td>Ethanol and acidified potassium manganate (VII) or oxygen</td><td>[1]</td></tr>
<tr><td>9(a)(i)</td><td>Metallic bonding exists in magnesium. Magnesium has <u>giant metallic lattice structure</u>. There are <u>strong electrostatic forces of</u></td><td>[1-description of ionic</td></tr>
</table>

<table>
<tr><td></td><td>attraction between positive metal ions and the sea of delocalized electrons which require a lot of energy to overcome, hence high mpt.
Iodine is a covalent molecule with simple covalent/molecular structure. There are weak intermolecular forces of attraction between the molecules which require little energy to overcome, hence low mpt.</td><td>bonding & structure] [1- description of bonding & structure] [1- energy]</td></tr>
<tr><td>(ii)</td><td>Each carbon atom in graphite has one valence electron not used up in bonding, hence there are mobile electrons between the layers of atoms which act as mobile charge carriers to conduct electricity.
Iodine exists as molecules, absence of mobile charge carriers/ions or electrons, hence unable to conduct electricity.</td><td>[1]

[1]</td></tr>
<tr><td>(b)</td><td><table><tr><td></td><td>P</td><td>O</td><td>Cl</td></tr><tr><td>No of moles</td><td>20.2/31 = 0.652</td><td>10.4/16 =0.65</td><td>69.4/35.5 =1.95</td></tr><tr><td>Mole ratio</td><td>0.652/0.65 = 1</td><td>0.65/0.65 = 1</td><td>1.95/0.65 = 3</td></tr></table>Empirical formula = $POCl_3$</td><td>[1]
[1]</td></tr>
<tr><td>(c)(i)</td><td>Potential difference = +1.36 – 0.77 = 0.59V</td><td>[1]</td></tr>
<tr><td>(ii)</td><td>Green solution turns reddish brown</td><td>[1]</td></tr>
<tr><td>(iii)</td><td>Test using moist blue litmus paper. If the litmus paper is not bleached, the chlorine is fully used up.</td><td>[1]</td></tr>
<tr><td>10 (a)</td><td>Mr of $C_6H_{12}N_4$ = 140
Mr of $C_{10}H_8$ = 128
Energy density of hexamine = 1/140 x (- 4200) = -30kJ/g
Energy density of naphthalene = 1/128 x (-5133) = 40.1 kJ/g</td><td>

[1]
[1]</td></tr>
<tr><td>(b)</td><td>Naphthalene has a higher energy density and it has a lower mass, so it is better to bring moth balls than solid fuel for camping as it gives more energy per gram of fuel.</td><td>[1]</td></tr>
<tr><td>(c)</td><td>Air pollutant: nitrogen dioxide
Effect of air pollutant: Nitrogen dioxide dissolves in rain water to form acid rain which corrodes limestone and metal structures/harms aquatic plants & animals</td><td>[1]

[1]</td></tr>
<tr><td>(d)(i)</td><td>Student A: The solid dissolves
Student B: The solid dissolves or white precipitate</td><td>[1-both correct]
[1]</td></tr>
</table>

	Explanation: Aluminium is an amphoteric oxide, so it reacts with both hydrochloric acid and potassium hydroxide.	
(ii)	Aluminium oxide has a giant ionic crystal lattice structure which has strong electrostatic forces of attraction between oppositely charged ions, requiring a lot of energy to overcome, hence has high mpt and so exists as a solid. Nitrogen dioxide has a simple molecular structure and has weak intermolecular forces of attraction between the molecules which require little energy to come, hence low mpt and exist as a gas.	[1- descirption of ionic bonding & structure] [- description of bonding & structure] [1- energy]