Candidate Name: _____ ( ) Class: _____

4E
Session 1

KRANJI SECONDARY SCHOOL
Preliminary Examination
Secondary 4 Express

CHEMISTRY **6092/02**
Paper 2

Monday **19 August 2024** 1 hr 45 min

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class 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.

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 22.

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

For Examiners' Use	
Section A	/70
Section B	/10
Total	/80

Set by: Mrs Toh-Chong Keting

This Question Paper consists of **22** printed pages.

[Turn over

Section A (70 marks)

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 70.

A1 The following solutions are commonly found in a science laboratory.

$Ba(NO_3)_2$	H_2SO_4	NH_3
KI	$AgNO_3$	$CuSO_4$
$Ca(OH)_2$	NH_4Cl	HNO_3

Use the list above to answer the following questions. You may use each solution once, more than once or not at all.

(a) Which two solutions have a pH that is more than 7?

..... and ..... [1]

(b) Which solution gives a light blue precipitate with aqueous sodium hydroxide?

..... [1]

(c) Which two solutions give a yellow precipitate when mixed?

..... and ..... [1]

(d) Which solution turns brown when acidified potassium manganate(VII) is added?

..... [1]

(e) Which solution can be added to treat soil that is too acidic?

..... [1]

[Total: 5]

A2 Fractional distillation is a key separation technique used in both laboratory settings by students and on an industrial scale in the petroleum industry.

(a) A class of students are asked to separate components in various mixtures using fractional distillation.

Fig. 2.1 shows an erroneous set-up that was spotted by the teacher.

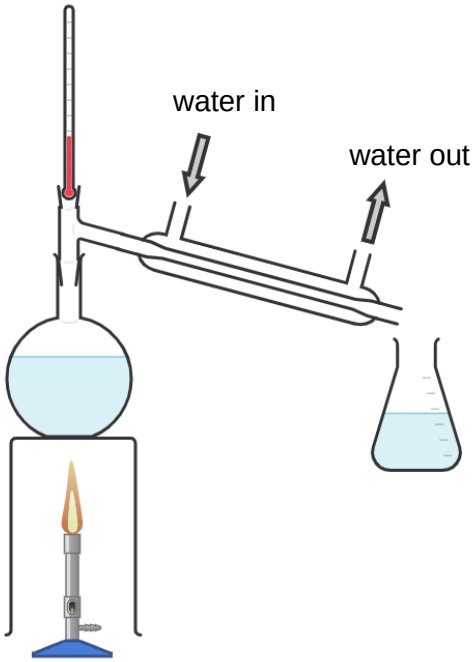


Fig. 2.1

Complete Table 2.1 by filling in the description of one error and how the experiment will be affected.

Table 2.1

description of error	effect on experiment

[2]

(b) Describe the separation of crude oil by fractional distillation.

…….....

…….....

…….....

…….....

…….....

…….....

…….....

…….....

……..... [3]

[Total: 5]

A3 Silver dichromate, $Ag_2Cr_2O_7$, is a reddish-brown insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with potassium dichromate solution. The equation for the precipitation reaction is shown below.

$$2AgNO_3(aq) + K_2Cr_2O_7(aq) \rightarrow Ag_2Cr_2O_7(s) + 2KNO_3(aq)$$

(a) **(i)** Deduce the oxidation state of chromium in $Ag_2Cr_2O_7$. ..... [1]

(ii) Write the ionic equation for the formation of silver dichromate.

..... [1]

(b) In a separate experiment, solid silver nitrate and solid potassium dichromate are added to a trough of water, as shown in the set-up below.

After five minutes, a reddish-brown solid appeared at the position marked **S** on Fig. 3.1.

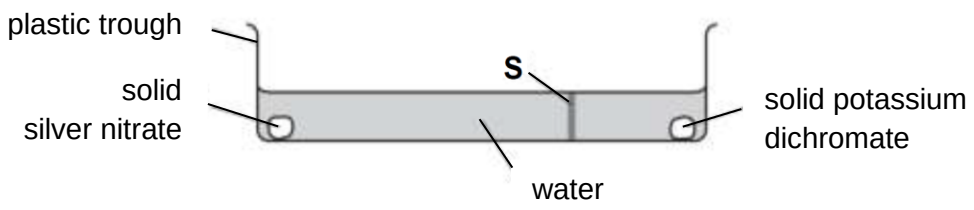


Fig. 3.1

(i) Explain why a reddish-brown solid appeared at the position marked **S**.

.....

.....

..... [2]

(ii) 2 g of solid silver nitrate and 4 g of potassium dichromate were added to the trough of water. Calculate the number of moles of silver nitrate and potassium dichromate used respectively.

number of moles of silver nitrate = …… mol

number of moles of potassium dichromate = …… mol
[3]

(iii) Silver nitrate and potassium nitrate solutions are colourless while potassium dichromate solution is orange.

Based on your answer in **(b)(ii)**, predict the colour of the solution in the trough after the reaction is complete. Explain your answer.

.....

.....

..... [2]

(c) Chromium exists as several naturally-occuring isotopes, including chromium-52 and chromium-54.

Complete Table 3.1 to show the number of subatomic particles in these two isotopes of chromium.

Table 3.1

	chromium-52	chromium-54
number of protons		
number of neutrons		
number of electrons		

[2]

[Total: 11]

A4 Both hydrazine (represented as N_2H_4 or H_2NNH_2) and hydrogen can be used as rocket fuel propellants.

Hydrogen undergoes combustion with oxygen to form water only whereas hydrazine undergoes combustion with oxygen to produce nitrogen and water. Both reactions are exothermic.

Table 4.1 shows some properties of hydrogen and hydrazine.

Table 4.1

fuel	melting point / °C	boiling point / °C	enthalpy change of combustion / kJ/mol
hydrogen	-259	-253	-286
hydrazine	2	114	

(a) Draw a 'dot-and-cross' diagram to show the bonding in hydrazine.

Show outer electrons only.

[2]

(b) Write a balanced chemical equation for the combustion of hydrazine.

…….……...……..... [1]

(c) Using the data in Table 4.2 and the equation in **(b)**, calculate the enthalpy change of combustion for hydrazine.

Table 4.2

bond	bond energy / kJ/mol
N−N	163
N≡N	941
N−H	388
O=O	495
O−H	463

[3]

(d) It was found that the combustion of hydrazine in the rocket engines led to oxides of nitrogen being formed.

(i) With the aid of an equation, explain how these oxides of nitrogen could have been formed.

.....

.....

..... [2]

(ii) Identify a harmful effect caused by oxides of nitrogen.

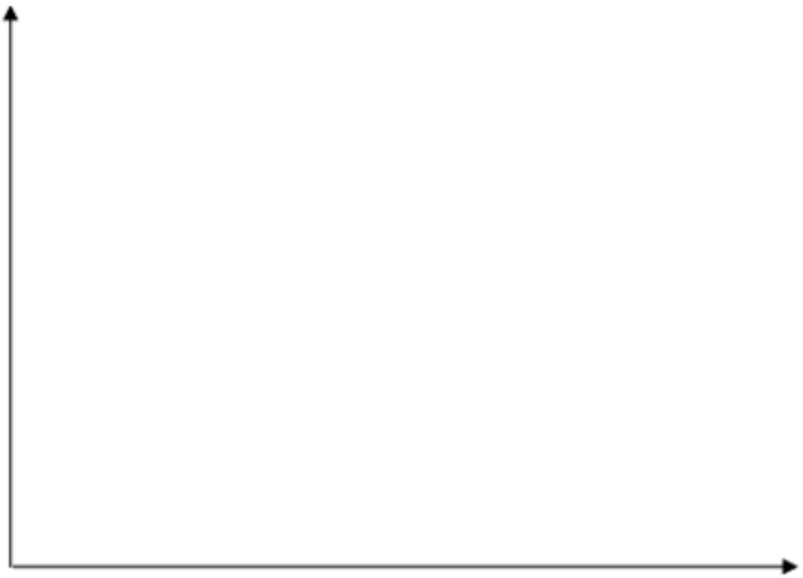
.....

..... [1]

(e) Draw an energy profile diagram to represent the reaction between hydrazine and oxygen. Your diagram should show:

- the reactants and products of the reaction
- the energy profile and activation energy, E_a
- the enthalpy change of the reaction, ΔH

energy / kJ/mol



progress of reaction

[3]

[Total: 12]

A5 Silver is a popular metal and silver-plated products are seen to be more desirable and valuable.

(a) Using pencil and ruler, draw the scientific diagram of a complete set-up to electroplate a copper coin with silver. You only need to label the appropriately chosen electrolyte and electrodes.

[2]

(b) The pure silver required for electroplating can be obtained from impure sources, where contamination by other heavy metals such as copper and lead is common.

A student attempts to perform electrolytic purification on a silver sample contaminated with large amounts of copper and lead. His thinking process is shown below.

- In this setup, the pure silver metal shall be connected to the positive terminal of the battery, while the impure sample shall be connected to the negative terminal.
- Dilute hydrochloric acid is a suitable electrolyte for my setup.

Describe and explain **two** issues with the student's set-up.

….....

….....

….....

….....

….....

….....

….....

….....

……..……..……..... [4]

(c) When a piece of metal **X** is submerged in aqueous silver nitrate solution, the piece of metal **X** is covered with silver after some time.

(i) Suggest a possible identity for metal **X**. Explain your answer.

.....

.....

..... [2]

(ii) While this method also results in the deposition of silver, this method cannot replace electroplating. State one major disadvantage of this method in plating objects as compared to electroplating.

.....

.....

..... [1]

[Total: 9]

[Turn over

A6 Group 1 and Group 17 show similarities and differences in the trends in their properties. Table 6.1 shows the atomic radii of their elements.

Table 6.1

	element	atomic radii / pm
Group 1	Li	145
	Na	180
	K	220
Group 17	C*l*	100
	Br	115
	I	140

(a) Describe and explain the trend in atomic radii down Group 1 and Group 17.

…….....

…….....

……..……..……..... [2]

(b) Describe and explain how the trends in reactivity down Group 1 and Group 17 differ.

…….....

…….....

…….....

…….....

…….....

……..……..……..... [3]

(c) Astatine (symbol At), a Group 17 element, is so rarely found in nature that a sample of the pure element has never been isolated. Scientists can only estimate its properties.

(i) Suggest the state and colour of astatine at room temperature.

..... [1]

(ii) Suggest the observation if astatine is added to aqueous sodium chloride. Explain your answer.

.....

.....

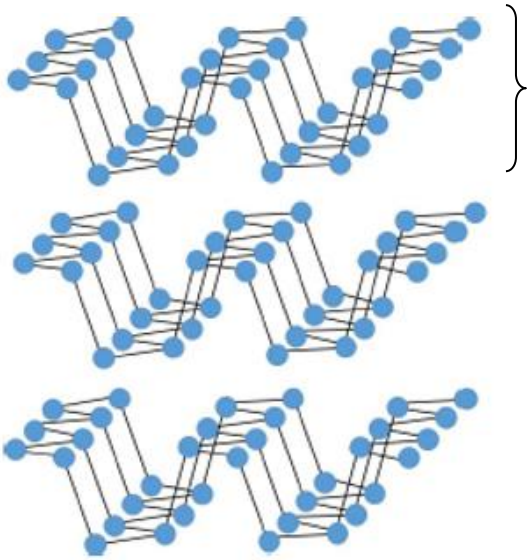
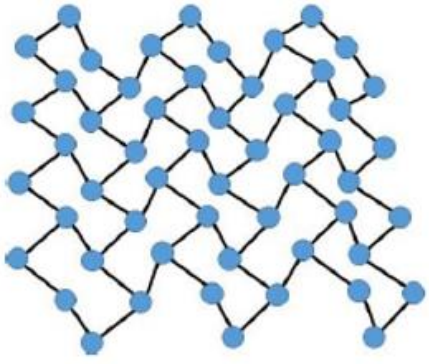
..... [2]

[Total: 8]

A7 Phosphorus exists as several allotropes such as white phosphorus and black phosphorus.

As shown in Table 7.1, white phosphorus exists as molecules while black phosphorus exists as stacked layers of phosphorene. Each phosphorus atom is represented by ●.

Table 7.1

allotrope	structure	melting point / °C
white phosphorus		44
black phosphorus	Part of the structure of black phosphorus  Top down view of one layer of phosphorene 	610

(a) Using Table 7.1, deduce the chemical formula of white phosphorus.

……..……..…….... [1]

(b) With reference to structure and bonding, explain why white phophorus has a much lower boiling point than black phosphorus.

…

…

…

…

…

…

…… [3]

(c) Phosphorene in black phosphorus was recently discovered by scientists and holds exciting potential for its application in electronic devices and lubricants.

Using concepts involving chemical bonding, suggest and explain why phosphorene can be used in electronic devices and lubricants.

electronic devices: .....

…

…

…

…

lubricants: .....

…

…

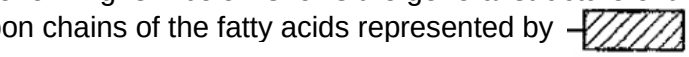
…

…… [4]

[Total: 8]

A8 Comparison between different vegetable oils and their uses

Composition of vegetable oils

Vegetable oils such as avocado oil, palm oil and soybean oil contain a mixture of triesters. Triesters are compounds formed from an esterification reaction between glycerol and three fatty acids. The three fatty acids may be the same or different depending on the type of oil. Fig. 8.1 below shows the general structure of the triesters with the long hydrocarbon chains of the fatty acids represented by  .

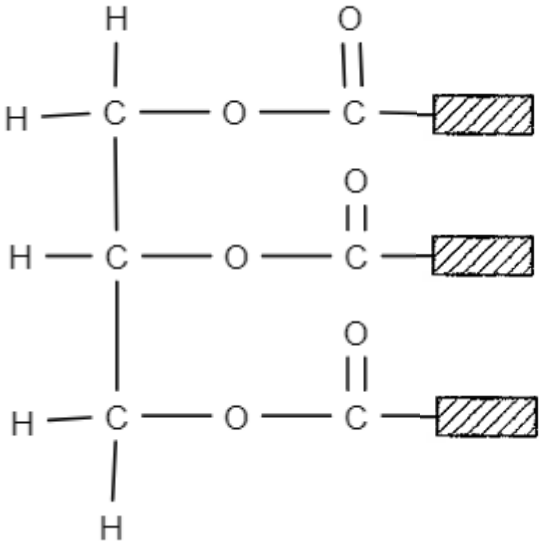


Fig. 8.1

Due to the different composition of carboxylic acids, the different vegetable oils have varied properties leading to a variety of uses. Table 8.1 outlines the main fatty acids present in each vegetable oil.

Table 8.1

name	primary composition
avocado oil	linoleic acid (10%), oleic acid (67%), palmitic acid (15%)
palm oil	linoleic acid (10%), oleic acid (39%), palmitic acid (44%)
soybean oil	linoleic acid (51%), oleic acid (23%), palmitic acid (10%)

Melting points of vegetable oils

Table 8.2 shows the structure, relative molecular mass and melting point of each fatty acid. The melting points of the vegetable oils play a role in determining their uses.

Table 8.2

name	condensed structural formula	M_r	melting point / °C
linoleic acid	$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7CO_2H$	280	-5
oleic acid	$CH_3(CH_2)_7CH=CH(CH_2)_7CO_2H$	282	13
palmitic acid	$CH_3(CH_2)_{14}CO_2H$	256	63

.

Some food products such as ice cream, require these oils to exist in a semi-solid fat state, i.e. as a mixture of liquids and solids, between 0 °C and 30 °C for better texture and mouthfeel. The fats found in milk are also semi-solids but milk is costly as a raw material. Therefore, suitable vegetable oils which exist as semi-solids at room temperature may be used as cheap substitutes for milk fats. On the other hand, vegetable oils used in cosmetics would have to be mostly solid between 0 °C and 20 °C, yet melt quickly at body temperature.

Fig. 8.2 is a liquid fat curve which shows the percentage of oil or fat that exists as a liquid at the respective temperatures.

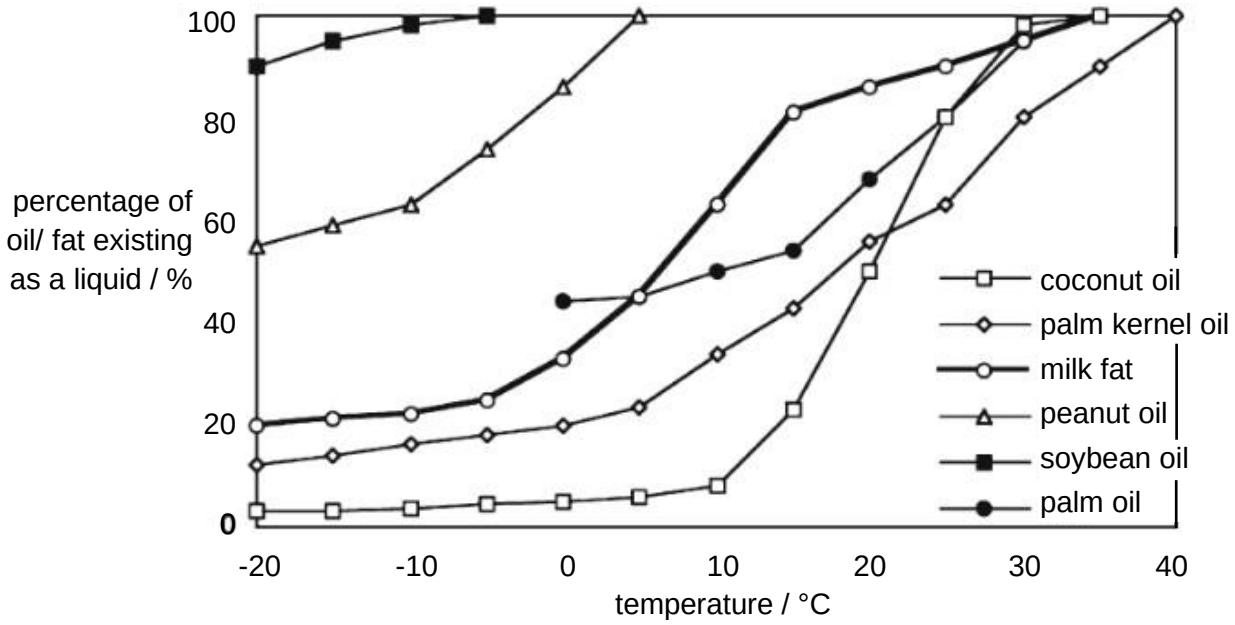


Fig. 8.2

Shelf life

The shelf life of the vegetable oils also determines its use. Shelf life depends on the oxidative rancidity which refers to the process in which fats and oils react with oxygen leading to the formation of unpleasant flavors and odors. This process is influenced by the degree of unsaturation in the fatty acids due to the higher reactivity of carbon-carbon double bonds with oxygen compared to carbon-carbon single bonds. The higher the oxidative rancidity of the vegetable oil, the lower its shelf life.

Hydrogenation

Vegetable oils that exist as liquids at room temperature would need to be hydrogenated or blended with other suitable vegetable oils to turn them into semi-solids. The process of hydrogenation causes these oils to become saturated. This increases their shelf life and allows for more varied uses. However, hydrogenation also has the risk of forming trans fats which are well known for increasing the risk of cardiovascular diseases. Hence, consuming hydrogenated fats is not recommended.

(a) Suggest reagents and conditions to produce glycerol and the carboxylic acids from the vegetable oil.

…

……..……[1]

(b) From Fig. 8.1, deduce the full structural formula of glycerol.

[1]

(c) Student **A** commented that the higher the relative molecular mass, the higher the melting point of fatty acids.

Do you agree with Student **A**? Use data from Table 8.2 to explain your answer.

…

…

…

…

……..…… [2]

(d) With reference to Fig 8.2, suggest and explain which oil is most suitable as a substitute for milk fats to make dairy products such as ice cream.

…

…

…

…

…

…

……..…… [2]

(e) With reference to Fig 8.2, suggest and explain which vegetable oil would be more suitable for use in cosmetics.

…

…

…

…

…

…

……..…… [2]

(f) Using data from Table 8.1 and 8.2, suggest how the shelf life of palm oil compares to soybean oil.

…

…

…

…

……..…… [2]

(g) Write the condensed structural formula of the product formed after linoleic acid undergoes complete hydrogenation. Deduce its M_r.

…

……..…… [2]

[Total: 12]

Section B

Answer **one** question from this section.

EITHER

B9 The speed of reaction was investigated for the reaction between excess sodium thiosulfate and different acids.

Experiment **A**: 5.00 cm^3 of 1.00 mol/dm^3 hydrochloric acid

Experiment **B**: 5.00 cm^3 of 1.00 mol/dm^3 ethanoic acid

Fig. 9.1 shows the set-up to investigate the rate of the reaction between the acids and sodium thiosulfate solution.

As the reaction progresses, it becomes more difficult to see the cross "X" through the solution. The time taken was recorded when the cross "X" disappears from the top view in Fig. 9.1.

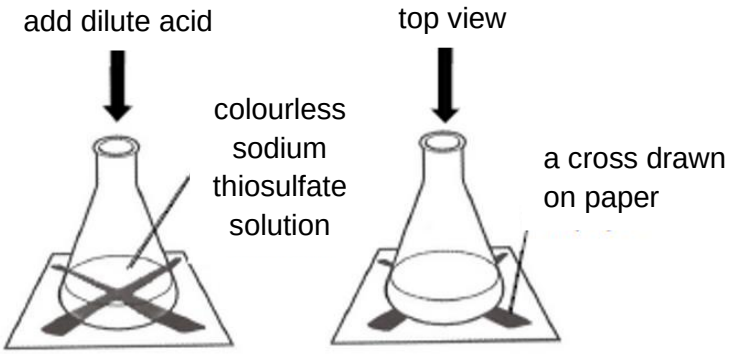


Fig. 9.1

The equation for the reaction between sodium thiosulfate and hydrochloric acid is given below.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

(a) Explain why it becomes more difficult to see the cross as the reaction progresses.

…….....

……..…… [1]

(b) Describe the motion of the particles in sulfur dioxide, SO_2.

…….....

……..…… [1]

(c) Fig. 9.1 shows the graph obtained for experiments **A** and **B**.

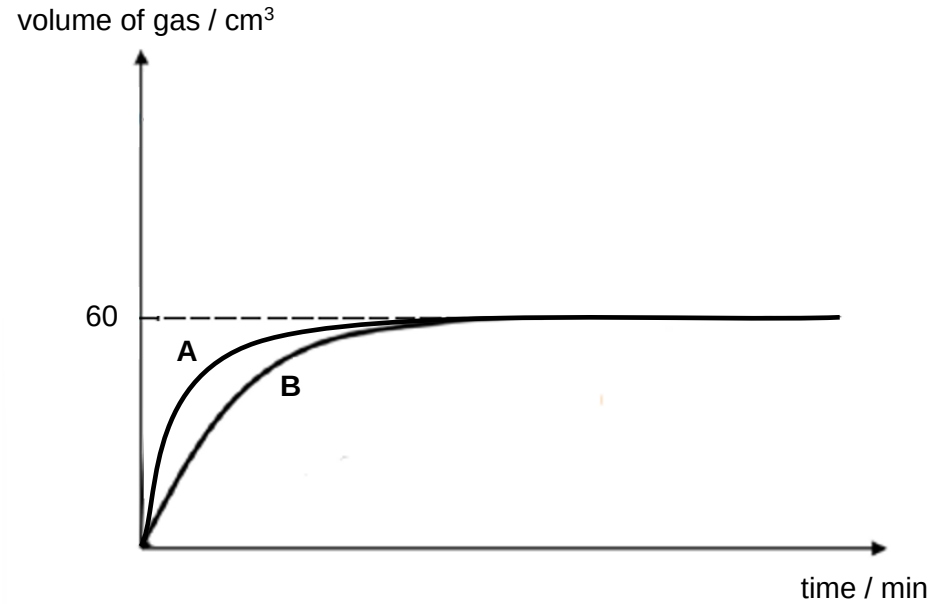


Fig. 9.1

(i) Show, with calculations, why the volume of sulfur dioxide gas produced is 60 cm^3 for experiment **A**.

[2]

(ii) Describe how the graphs obtained for experiment **A** and **B** differ. Explain your answer using collision theory.

.....

.....

.....

.....

.....

..... [3]

(iii) Experiment **A** was repeated by changing hydrochloric acid to sulfuric acid while keeping the concentration and volume of acid constant. On Fig. 9.1, sketch the graph for the results obtained for the experiment using sulfuric acid. Label the graph **C**. [1]

(iv) A student suggested that hydrochloric acid acts as a catalyst for the reaction.

Define *catalyst*. Explain with evidence why the student is wrong.

.....

.....

.....

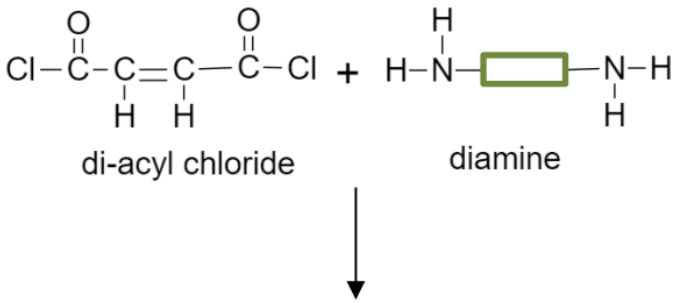
.....

..... [2]

[Total: 10]

OR

B10 Fig. 10.1 shows the reaction between a di-acyl chloride and a diamine to form a polymer which is used commonly in making clothing. Acyl chlorides react with amines in a similar manner as carboxylic acids.



polymer **X** + HCl

Fig. 10.1

(a) (i) Describe a chemical test to distinguish between the di-acyl chloride and diamine in Fig. 10.1, including all expected observations.

.....

.....

.....

.....

..... [2]

(ii) State the type of polymerisation shown in Fig. 10.1.

..... [1]

(iii) Draw the full structural formula of the polymer **X** formed between di-acyl chloride and diamine in the space below.

[2]

(b) (i) The di-acyl chloride in Fig. 10.1 also undergoes another type of polymerisation that the diamine in Fig. 10.1 cannot undergo. What is this polymerisation? Explain why it can undergo this polymerisation but the diamine cannot.

.....

.....

.....

.....

..... [2]

(ii) Draw the full structural formula of the polymer formed in **(b)(i)**, showing two repeat units.

[1]

(c) Some polymers are non-biodegradable in nature and improper disposal of these polymers affect the environment. Describe a suitable method for recycling the polymer in **(b)(i)**.

…….....

…….....

…….....

……..…… [2]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									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 –

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

Answer Key for 4Exp 6092 Chemistry Prelim 2024

Paper 1

1-5: DABBD	6-10: BCBAC	11-15 ACDCD	16-20: CCCBC
21-25: BCABA	26-30: BCAAB	31-35: CCDCB	36-40: BCDCC

Paper 2

Section A

Qn	Answer	Mark
A1a	NH_3 and $Ca(OH)_2$	1
A1b	$CuSO_4$	1
A1c	$AgNO_3$ and KI	1
A1d	KI	1
A1e	$Ca(OH)_2$	1
A2a	error: wrong direction of water in and water out (wtte) effect: loss of component due to ineffective cooling (wtte) or error: thermometer placed at wrong position (wtte) effect: component will be impure as temperature that it is collected at is inaccurate (wtte)	1 1 or 1 1
A2b	**The crude oil / petroleum is heated and boils. The vapour enters the fractionating column which is cooler at the top and hotter at the bottom.** Inside the column, each fraction (mixture of compounds) condenses at a different temperature **Fractions with higher boiling points condense at higher temperatures and are collected at lower levels of the column** **Fractions with lower boiling points condense at lower temperatures and are collected at higher levels of the column**	1 1 1
A3a(i)	+6	1
(ii)	$2Ag^+(aq) + Cr_2O_7^{2-}(aq) \rightarrow Ag_2Cr_2O_7(s)$ (state symbols not required)	1
A3b(i)	silver nitrate and potassium dichromate are soluble and dissolve to form ions silver ions (Mr = 106) have a lower Mr than dichromate ions (Mr = 216). (ignore if Mr values not provided but correct ions must be stated) Silver ions diffuse faster and travel a longer distance than dichromate ions. Hence both ions meet at a position closer to solid potassium dichromate.	1 each (Award any 2 out of 3)

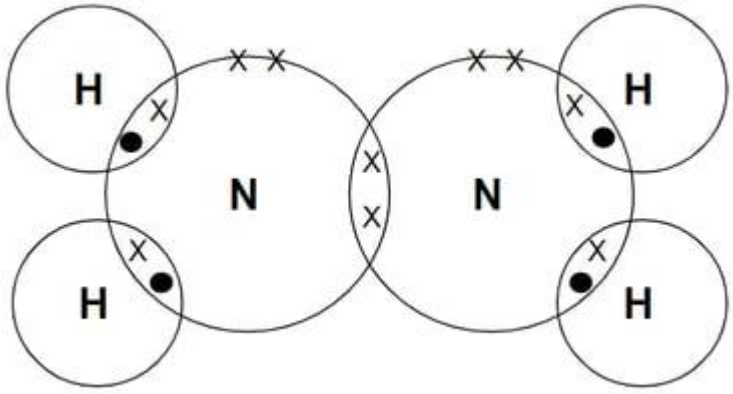
<table>
<tr><td>(ii)</td><td>No. of mol of silver nitrate = 2 / (108 + 14+ 3 x 16) = 0.0118 mol

No. of mol of potassium dichromate = 4/ (39 x 2 + 52x 2 + 7 x 16) = 0.0136 mol</td><td>1 for both Mr

1 for each no. of mol x 2</td></tr>
<tr><td>(iii)</td><td>Since mole ratio of $AgNO_3$: $K_2Cr_2O_7$
2:1
0.0118: 0.0118/2 = 0.0059

0.0118 mol of silver nitrate required 0.0059 mol of potassium dichromate for complete reaction. Since there is 0.0136 mol of potassium dichromate which is more than enough, potassium dichromate is in excess. (Note: some calculated evidence is necessary)

The solution is orange in colour</td><td>1

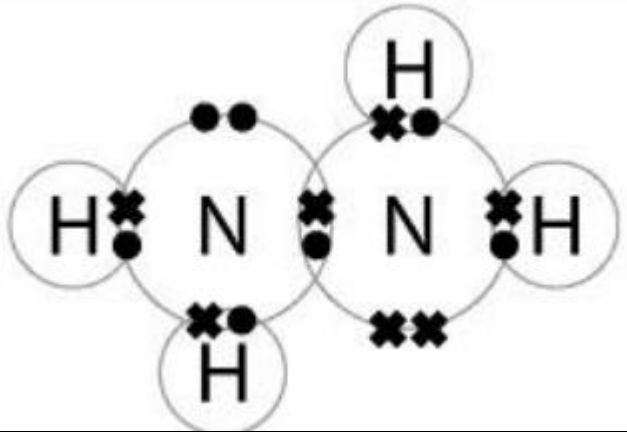
1</td></tr>
<tr><td>(c)</td><td><table><tr><td></td><td>chromium-52</td><td>chromium-54</td></tr><tr><td>number of protons</td><td>24</td><td>24</td></tr><tr><td>number of neutrons</td><td>28</td><td>30</td></tr><tr><td>number of electrons</td><td>24</td><td>24</td></tr></table></td><td>1 for every 3 correct boxes x 2</td></tr>
<tr><td>A4a</td><td> 

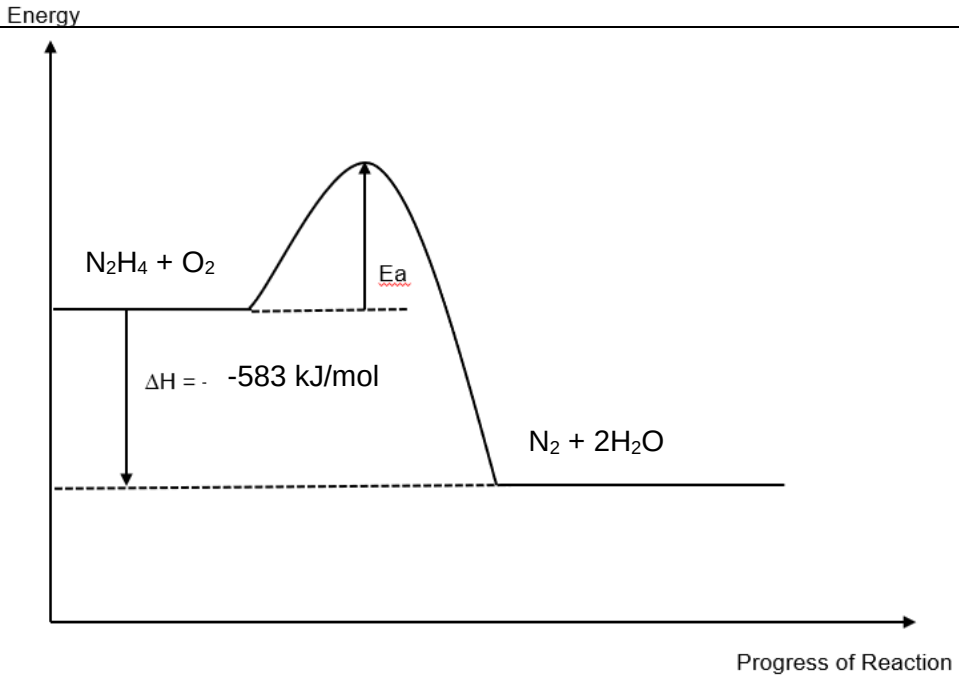
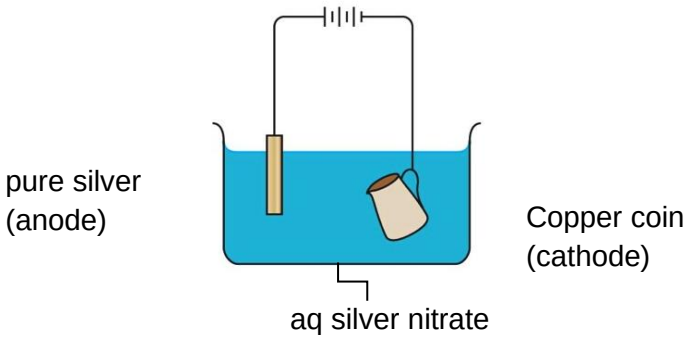
X: electrons from nitrogen

•: electron from H

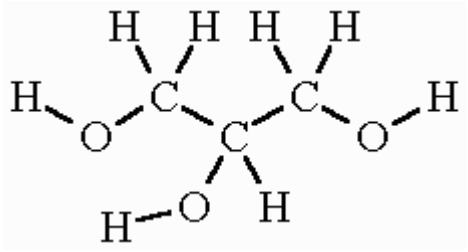
OR</td><td>1 (shared electrons)

1 (electrons not involving in bonding)</td></tr>
</table>

		
A4b	$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$ (no state symbols required)	1
A4c	BE (bonds broken) = 163 + 4 x 388 + 495 = 2210 kJ/mol BE (bonds formed) = 941 + 4 x 463 = 2793 kJ/mol Enthalpy change of combustion = BE (bonds broken) – BE (bonds formed) = 2210 – 2793 = -583 kJ/ mol	1 1 1
d(i)	$N_2 + O_2 \longrightarrow 2NO$ At **high temperatures in the rocket engines, N_2 and O_2 from air react to form nitrogen monoxide.**	1 1
(ii)	Nitrogen oxides **irritates the eyes and lungs**, resulting in **breathing difficulties.** Nitrogen dioxide gas (acidic oxide) dissolves in rainwater to form acid which • corrodes marble (calcium carbonate) buildings • kills aquatic plants and wildlife in rivers and lakes • makes soil too acidic for growth of crops	1 (any one)

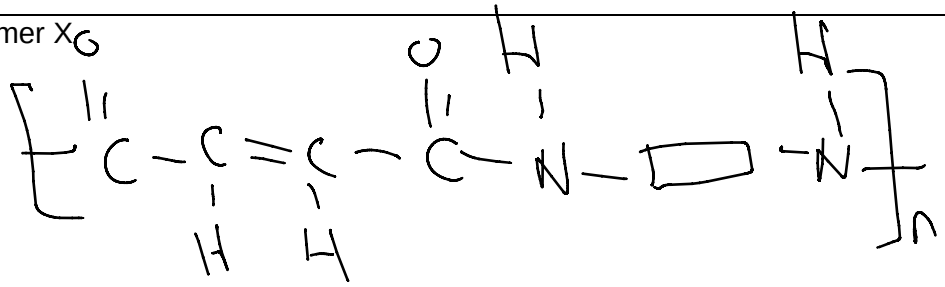
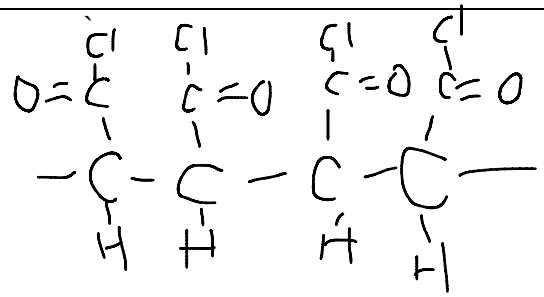
A7diii	 Correct shape of graph + labelling of reactants and products - 1 mark Correct labelling of activation energy / E_a - 1 mark Correct labelling of enthalpy change / ΔH - 1 mark	3
A5a		1 correct drawing 1 correct labels
A5b	The **impure silver metal is incorrectly connected to the negative terminal while the pure silver metal is connected to the positve terminal** This will cause the silver in the pure metal to be oxidized at the anode to form silver ions which then travel to the cathode to be reduced to silver and deposited as silver on the impure silver./ The pure silver gets smaller while the impure silver gets bigger. OR Dilute hydrochloric acid is not a suitable electrolyte as it will **form a precipitate with silver ions formed during the electrolysis** **,** thus preventing reduction of silver ions to silver at the cathode/ silver cannot be deposited.	1 1 1 1

A5ci	Any metal above silver <insert metal name> is more reactive than silver, and loses electrons more readily, hence < > is able to displace silver from silver nitrate	1 1
A5cii	Loss of original object/object that is being plated in this method (as compared to no loss of object in electroplating)	1
A6a	Increase in atomic radii down the group More electron shells	1 1
A6b	Down group 1, reactivity increases whereas down group 17, reactivity decreases For group 1 and group 17, the valence electrons are further from nucleus, hence the electrostatic forces of attraction between valence electron and positive nucleus gets weaker, For group 1, the valence electron is held less strongly and more easily lost For group 17, it is more difficult for the nucleus to attract an additional electron into the valence shell.	1 1 1
A6ci	Black solid	1
A6cii	No visible reaction. Astatine is less reactive than chlorine and gains electrons less readily, not able to displace chlorine from sodium chloride.	1 1
A7a	P_4	1
A7b	White phosphorus has a simple molecular structure with weak intermolecular forces of attraction which requires little energy to overcome. Black phosphorus has a giant covalent structure with an extended network of strong covalent bonds between (phosphorus) atoms (in each layer) which requires a lot of energy to overcome. Comparison of structure – 1 Comparison of bonding and particles – 1 Comparison of energy - 1	3
A7c	Electronic devices: Each phosphorus atom is only bonded to 3 other phosphorus atoms, leaving 2 valence/delocalised electrons not involved in bonding. These free mobile electrons can carry charges and conduct electricity. Lubricants: The layers of phosphorus atoms are held together by weak intermolecular forces of attraction which require little energy to overcome. These layers can slide over each other easily.	1 1 1 1

A8a	Acid catalyst/ H_2SO_4, water, heat	1
A8b	 (or equivalent)	1
A8c	Do not agree Although linoleic acid has a higher Mr of 280 than palmitic acid which has a Mr of 256, linoleic acid has a lower melting point of -5°C as compared to palmitic acid which has a melting point of 63°C Comparison of correct acids – 1m Quoting of data – 1m Do not accept answer that says agree	2
A8d.	Palm oil is the most suitable as a substitute for milk fat [1] as it **exists as a semi-solid between 0 °C and 30 °C** as shown from the graph because the **percentage of palm oil existing as a liquid is between 40% and 90% at these temperatures.** (wtte) OR **Curve for palm oil is closest in values to milk fat compared to the other oils**. (wtte)	1 1 OR 1
Aa8e	Coconut oil would be most suitable for use in cosmetics as it is hard at cool temperatures This can be seen from the graph where it has low percentage of liquid oils at 0-20°C showing that it is mostly solid. (wtte)	1 1
A8f	Palm oil would have a higher shelf life (because it has lower oxidative rancidity This is because palm oil has a lower unsaturated acid composition (49%) as compared to soybean oil (74%) thus, there are fewer double bonds to react with oxygen (wtte)	1 1
A8g	$CH_3(CH_2)_4CH_2CH_2CH_2CH_2(CH_2)_7CO_2H$ OR $CH_3(CH_2)_{16}CO_2H$ Mr = 284	1 1

Section B

Qn	Answer	Mark
B9a	As the reaction progresses, **more sulfur solid is produced** which **covers the cross.** (wtte)	1
B9b	Rapidly and randomly in all directions	1
B9ci	No. of moles of hydrochloric acid = 5/1000 x 1 = 0.00500 mol HCl : SO_2 2: 1 No. of moles of sulfur dioxide = 0.005/2 = 0.00250 mol Volume of sulfur dioxide = 0.00250 x 24000 = 60 cm^3	1 1
B9cii	Graph A has a **steeper gradient** than graph B showing a **faster rate of reaction** for experiment A. Hydrochloric acid used in experiment A is a **strong acid that dissociates completely in water to form a high concentration of H^+ ions** whereas ethanoic acid in B is a **weak acid that dissociates partially in water to form a low concentration of H^+ ions.** A higher concentration of H^+ ions in A results in **increased frequency of collisions and effective collisions**, increasing the rate of reaction.	1 1 1
B9ciii	Steeper gradient Reaches 120cm^3 of gas	1
B9civ	A catalyst is a substance that is added to speed up the reaction while remaining chemically unchanged at the end of the reaction The student is wrong as HCl becomes NaCl/H_2O during the reaction.	1 1
B10ai	Bubble both the diacyl chloride and diamine separately into aqueous bromine For diacyl chloride, aqueous bromine will turn from reddish brown to colourless/decolourise (rapidly) For diamine, aqueous bromine will remain reddish brown	1 1
aii	Condensation polymerisation	1

aiii	Polymer X  Amide linkage – 1m Correct polymer – 1m	
bi	Addition polymerisation. Diacyl chloride is **unsaturated** / **contains C=C bond** whereas diamine is not/does not contain C=C bond.	1 1
ii		1
c	Cracking under high temperature and presence of silicon dioxide/aluminium oxide catalyst Breaks down polymer to form short chains which can be used to make other chemicals OR Mechamical recycling involving pre-treatment then small pieces of plastics are melted, cooled, pulled into long thin strands and cut into pellets which can be made into new products	1 1 1 1