Candidate Name: ______________________________ (   ) Class: ________

4E
Session 2

KRANJI SECONDARY SCHOOL
Preliminary Examination
Secondary 4 Express

CHEMISTRY **6092/01**
Paper 1 Multiple Choice

Wednesday **28 August 2024** 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

There are **forty** questions in this paper. Answer **all** questions. For each question there are four possible answers, **A, B, C** and **D**.
Choose the one you consider to be 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 booklet.
A copy of the Periodic Table is printed on page 18.
The use of an approved scientific calculator is expected, where appropriate.

Set by: Mrs Toh-Chong Keting

This Question Paper consists of **18** printed pages.

[Turn over

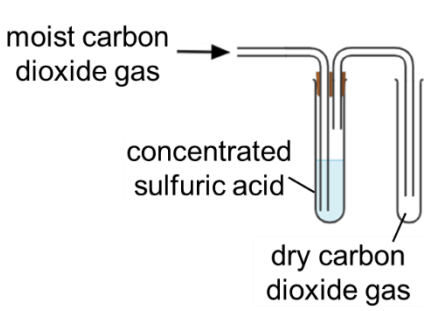
1 Which piece of apparatus could be used to determine the end-point of the reaction between hydrochloric acid and potassium hydroxide?

A electronic balance
B gas syringe
C stopwatch
D thermometer

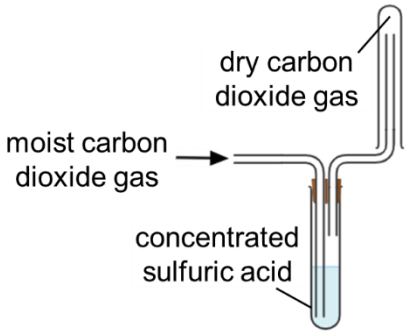
2 A student is provided with two drying agents: concentrated sulfuric acid and calcium oxide.

Which method should he use to collect a sample of dry carbon dioxide gas?

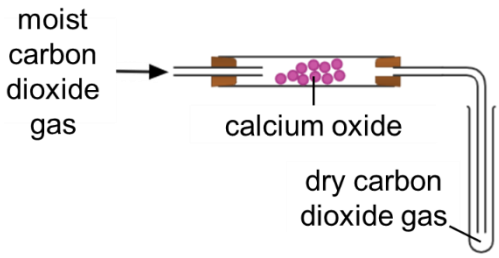
A



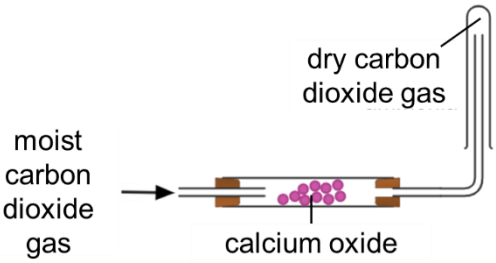
B



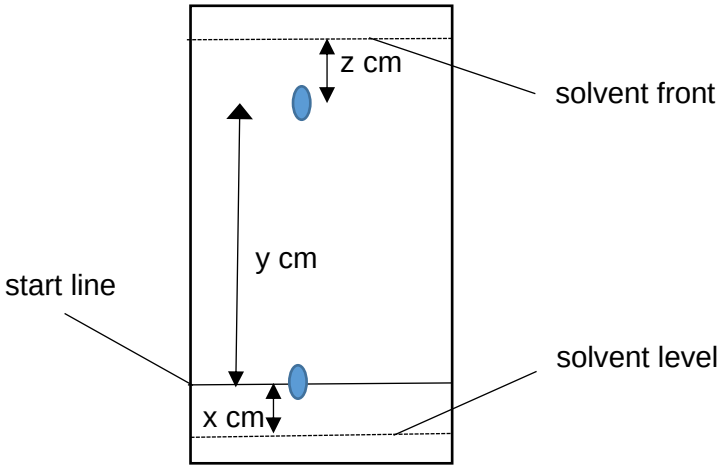
C



D



3 The diagram shows the chromatogram obtained by analysis of a single dye. Three measurements are shown in the diagram below.



How is the R_f value of the dye calculated?

A x/(x+y) **B** y/(y+z) **C** y/(x+y+z) **D** z/(x+y+z)

4 The labels fell off two bottles each containing a colourless solution, one of which was sodium carbonate solution and the other was sodium chloride solution.

Which of the following tests would allow for the identification of the solutions?

A addition of aqueous ammonia

B addition of dilute nitric acid

C addition of lead(II) nitrate solution

D addition of sodium hydroxide solution

5 Two solutions, W and X, were tested as shown.

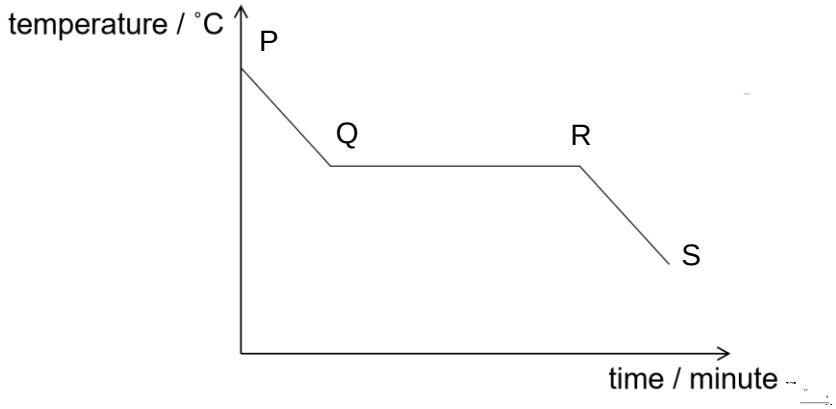
	W	X
dilute sulfuric acid	no visible reaction	no visible reaction
dilute nitric acid added, then aqueous barium nitrate	white precipitate	white precipitate
aqueous ammonia added	no precipitate seen	white precipitate, soluble in excess, forming a colourless solution
aqueous sodium hydroxide and aluminium foil added, then warmed	gas given off which turns red litmus paper blue	no gas given off

What are solutions W and X?

	W	X
A	sodium carbonate	zinc sulfate
B	lead(II) nitrate	ammonium carbonate
C	sodium nitrate	ammonium carbonate
D	ammonium sulfate	zinc sulfate

[Turn over

6 A sample of solid X is heated strongly until it has completely melted. The graph shows how its temperature varies with time as molten X is cooled.



Which of the following statements are true about the particles in X?

1 The arrangement is more orderly at stage RS than at stage PQ.
2 The forces of attraction are stronger at stage P than at stage S.
3 Their total energy content at stage QR is lower than at stage RS.
4 They are closer to each other at stage RS than at stage PQ.

A 1 and 3 only

B 1 and 4 only

C 1, 2 and 3 only

D 1, 3 and 4 only

7 The table shows the boiling points of the elements found in a sample of liquid air.

element	argon	helium	neon	nitrogen	oxygen
boiling point / ^{o}C	-186	-269	-246	-196	-183

Which elements would be gaseous at -190 ^{o}C?

A argon, helium and nitrogen

B argon, nitrogen and oxygen

C helium, neon and nitrogen

D helium, neon and oxygen

8 The descriptions of three substances are given as follows:

substance	description
P	When heated, carbon dioxide and a black solid are produced.
Q	Grey solid that reacts with water to give bubbles of gas.
R	It is a white solid that melts over a range of temperature.

Which row correctly classifies substances P, Q and R?

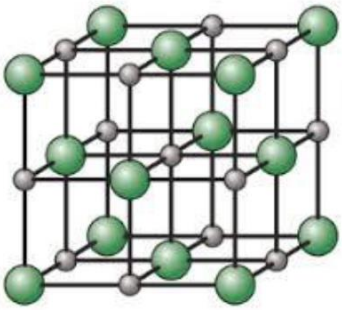
	P	Q	R
A	compound	compound	mixture
B	compound	element	mixture
C	element	element	compound
D	element	mixture	element

9 Which element has the most number of electrons in the outermost shell of its atoms?

A argon **B** boron

C chlorine **D** potassium

10 The diagram shows the arrangement of the particles in a compound.



Which compound would likely have this arrangement?

A diamond **B** graphite

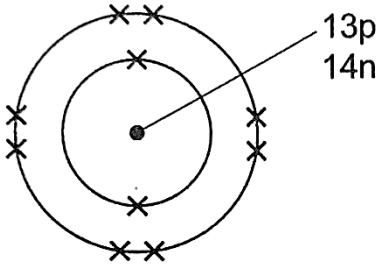
C sodium chloride **D** water

[Turn over

11 Which of the following substances contains both ionic and covalent bonds?

A aluminium carbonate
B hydrogen chloride
C silicon dioxide
D sodium

12 The diagram shows a structure of an ion.



p = proton
n = neutron
× = electron

What is the correct position in the Periodic Table of the element from which this ion was formed?

	period	group
A	2	13
B	2	18
C	3	13
D	3	18

13 A cartoon hero was famous for his shiny armour, a gold-titanium alloy, which allowed him to fly to Mars and back to Earth without melting.

Which of the following best describes the chemical bonds that exist within the structure of his armour?

A Ions and atoms of gold and titanium are held by strong ionic forces.
B Ions and atoms of gold and titanium are held by strong electrostatic forces.
C Ions and electrons of gold and titanium are held by strong ionic forces.
D Ions and electrons of gold and titanium are held by strong electrostatic forces.

14 Which quantity is the same for one mole of ethanol and one mole of ethane?

A mass
B number of atoms
C number of molecules
D volume at room temperature and pressure

15 Zinc oxide is produced by heating zinc carbonate.

$$ZnCO_3 \rightarrow ZnO + CO_2$$

What is the percentage yield of zinc oxide if 125 g of zinc carbonate produces 75 g of zinc oxide on heating?
[M_r: $ZnCO_3$, 125]

A $125 \times \frac{81}{75} \times 100$

B $125 \times \frac{75}{81} \times 100$

C $\frac{1}{125} \times \frac{75}{81} \times 100$

D $\frac{75}{81} \times 100$

16 20 cm^3 of propene C_3H_6, reacts with 500 cm^3 of oxygen according to the equation shown below.

$$2C_3H_6\ (g) + 9O_2\ (g) \rightarrow 6CO_2\ (g) + 6H_2O\ (l)$$

What is the total volume of gas remaining at the end of the reaction? (all volumes are measured at room temperature and pressure)

A 120 cm^3 **B** 410 cm^3

C 470 cm^3 **D** 530 cm^3

17 An organic acid, W, contains the elements carbon, hydrogen and oxygen.

The composition by mass of each element is shown.

element in W	percentage composition by mass
carbon	35.8
hydrogen	4.5
oxygen	59.7

What is the empirical formula of W?

A CH_2O **B** $C_2H_3O_3$ **C** $C_4H_6O_5$ **D** $C_8H_{12}O_{10}$

[Turn over

18 What does the term strong acid mean in relation to hydrochloric acid, HC*l*?

A Each molecule can produce a maximum of one hydrogen ion.

B It forms an insoluble salt, silver chloride.

C It is completely dissociated in aqueous solution.

D Its aqueous solution has a pH above 7.

19 Elements H, J, L are in the same period in the Periodic Table.

The oxide of H dissolves in water to form a solution with a pH 12.5. The oxide of J forms a solution with a pH less than 4.5. The oxide of L is soluble in both aqueous potassium hydroxide and dilute nitric acid.

Which option shows the position of the elements in order of increasing atomic number?

A H, J, L

B H, L, J

C J, L, H

D L, J, H

20 Which pair of compounds could be used in the preparation of calcium sulfate?

A calcium and sulfuric acid

B calcium carbonate and sodium sulfate

C calcium chloride and ammonium sulfate

D calcium nitrate and lead(II) sulfate

21 A method used to make copper(II) sulfate crystals is shown.

1 Place dilute sulfuric acid in a beaker.
2 Warm the acid.
3 Add copper(II) oxide until it is in excess.
4 Filter the mixture.
5 Evaporate the filtrate until it is saturated.
6 Leave the filtrate to cool.

What are the purposes of carrying out step 3 and step 4?

	step 3	step 4
A	to ensure all of the acid has reacted	to obtain solid copper(II) sulfate
B	to ensure all of the acid has reacted	to remove excess copper(II) oxide
C	to speed up the reaction	to obtain solid copper(II) sulfate
D	to speed up the reaction	to remove excess copper(II) oxide

22 When aqueous potassium iodide is added to hydrogen peroxide, the following reactions are observed.

$$H_2O_2\,(aq) + I^-\,(aq) \rightarrow IO^-\,(aq) + H_2O\,(l)$$

$$H_2O_2\,(aq) + IO^-\,(aq) \rightarrow I^-\,(aq) + H_2O\,(l) + O_2\,(g)$$

There is a vigorous reaction and energy is liberated very rapidly, leading to a rise in temperature of the reaction mixture.

What is one of the roles of aqueous potassium iodide during any of the reactions?

A as a base

B as a dehydrating agent

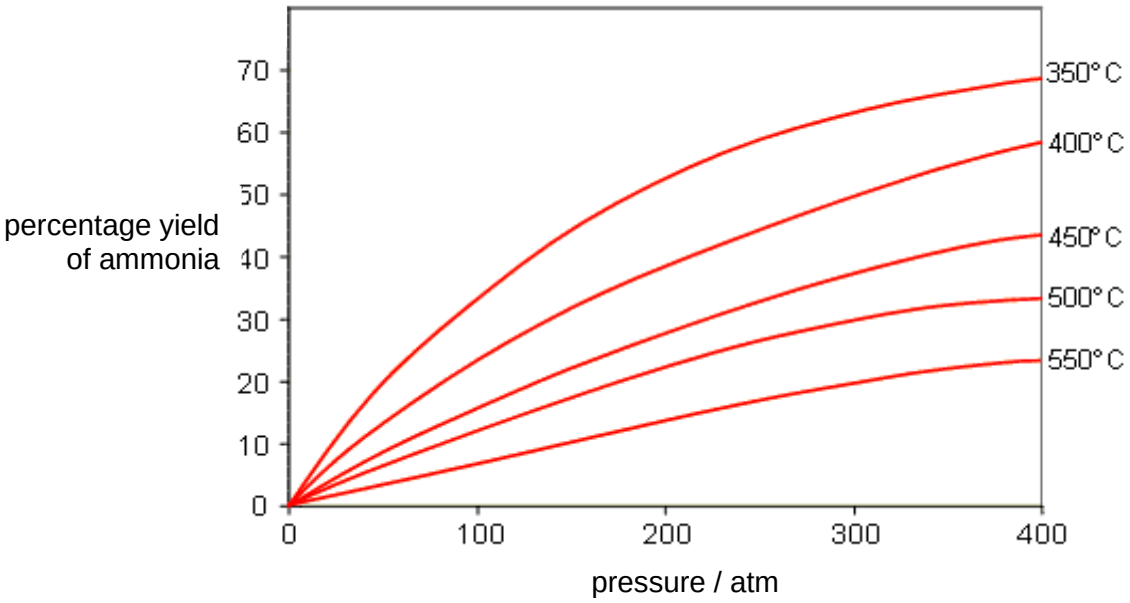
C as a reducing agent

D as an oxidising agent

[Turn over

23 Ammonia is a very important intermediate in the manufacture of fertilisers. Ammonia is made in the Haber process by the reversible reaction between nitrogen and hydrogen at 450 °C.

The graph gives the percentage yield of ammonia gas under different conditions of temperature and pressure.



Which of the following statements is true of the process above?

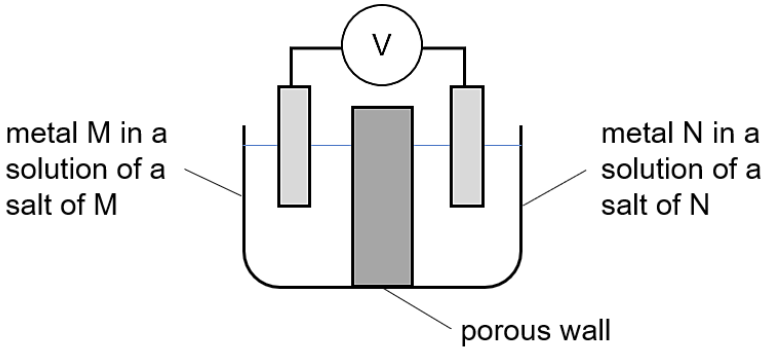
A The process is usually carried out at 450 °C rather than 200 °C as the speed of reaction would be faster.

B The yield of ammonia increases at higher temperature.

C The yield of ammonia increases at lower pressure.

D The yield of ammonia increases when a catalyst is added.

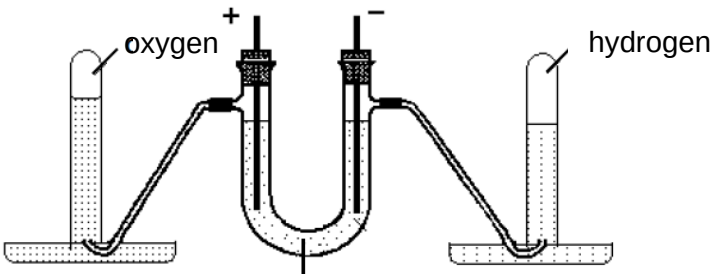
24 The diagram shows a simple cell with electrodes M and N.



Which pair of metals, M and N, will produce the highest voltage?

	M	N
A	copper	magnesium
B	magnesium	silver
C	silver	zinc
D	zinc	copper

25 The diagram shows the electrolysis of dilute sulfuric acid solution using inert electrodes.



Given that, at room temperature and pressure, *x* moles of electrons were passed in the circuit, which of the following statement is correct?

A $6x$ dm^3 of oxygen was collected at the anode.

B $6x$ dm^3 of hydrogen was collected at the cathode.

C $12x$ dm^3 of oxygen was collected at the cathode.

D $12x$ dm^3 of hydrogen was collected at the anode.

[Turn over

26 Four different conditions under which sodium chloride is electrolysed using inert electrodes are listed.

1 concentrated aqueous sodium chloride
2 dilute aqueous sodium chloride
3 molten sodium chloride
4 solid sodium chloride

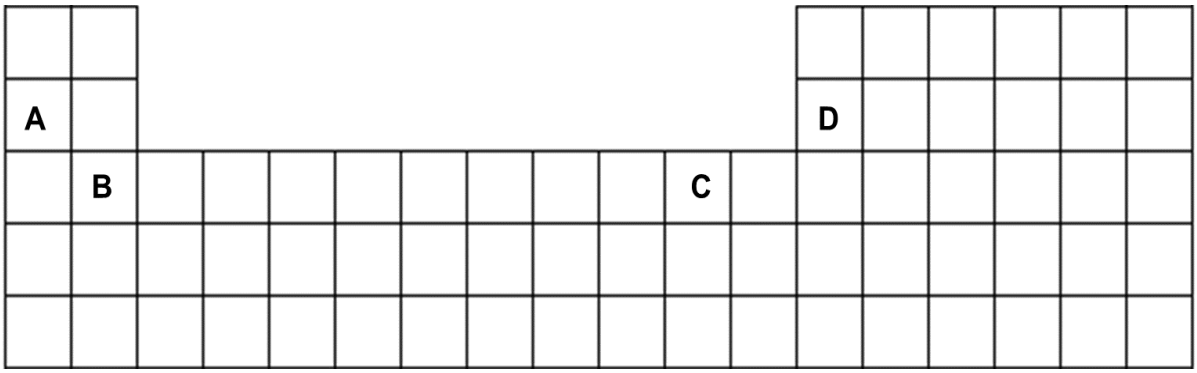
Under which conditions is a yellowish green gas formed?

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

27 The positions of four elements are shown in the outline of part of the Periodic Table.

Element X has a high melting point and is a good conductor of electricity.
It forms chlorides XCl and XCl_2.

Which element is X?



28 Which of the following statements regarding the element caesium are correct?

1 It is more reactive than potassium.
2 It reacts with chlorine to form an ionic compound.
3 It has a higher density than sodium.
4 It has a higher melting point than lithium.

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

29 The table below refers to four metals and some of their compounds.

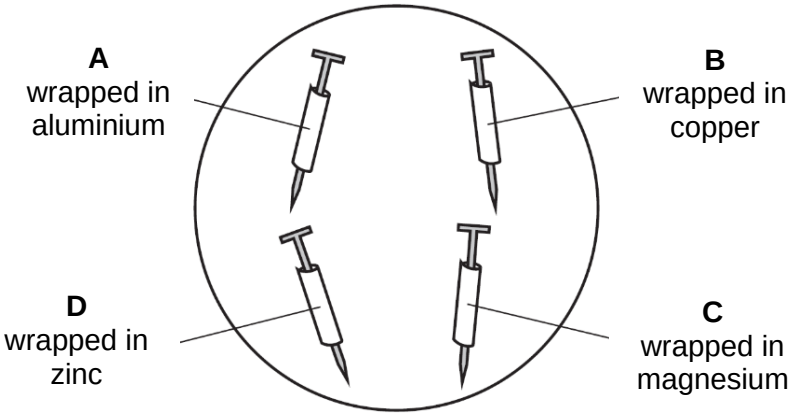
metal	action of dilute acid on metal	effect of hydrogen on heated oxide	action of metal on a solution of sulfate of J
G	hydrogen evolved	reduced	no reaction
H	no reaction	reduced	no reaction
I	hydrogen evolved	no reaction	J formed
J	hydrogen evolved	no reaction	no reaction

What is the correct order of reactivity of the metals?

	least reactive ⟶ most reactive			
A	H	G	J	I
B	H	J	G	I
C	I	J	G	H
D	I	G	J	H

30 Four iron nails had different metals wrapped around them.
The nails were placed in an open dish filled with water and left for a week.

Which iron nail has no protection against rusting?



31 Which change is endothermic?

A $CH_4\ (g) + 2O_2(g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$

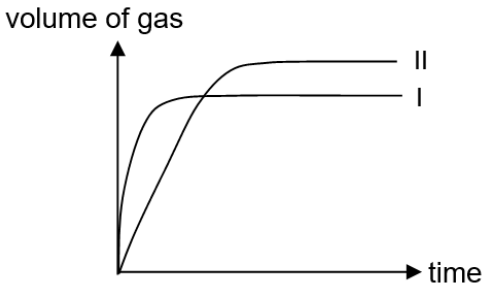
B $H\ (g) + Cl\ (g) \rightarrow HCl\ (g)$

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

D $H_2O\ (l) \rightarrow H_2O\ (s)$

[Turn over

32 In the graph, curve I represents the result of a reaction between 1.0 g of calcium granules and excess water at 25 °C.



Which conditions would produce curve II?

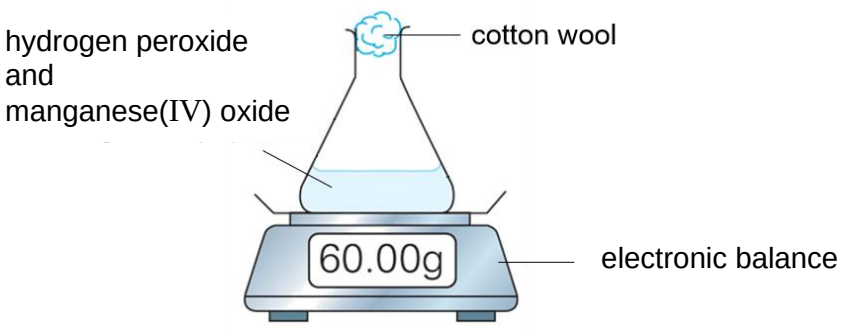
A 1.0 g of calcium granules with excess water at 15 °C

B 1.0 g of calcium powder with excess water at 25 °C

C 1.15 g of calcium granules with excess water at 15 °C

D 1.15 g of calcium granules with excess water at 50 °C

33 A small amount of manganese(IV) oxide powder is used as a catalyst in the decomposition of hydrogen peroxide to form oxygen gas and water.



Which of the following is **not** true about the reaction?

A The manganese(IV) oxide can be recovered by filtration.

B The mass of the flask and its contents decreases.

C The reaction becomes slower as the reaction proceeds.

D The reaction stops when all the manganese(IV) oxide is used up.

34 Which statement correctly describes the members of any homologous series?

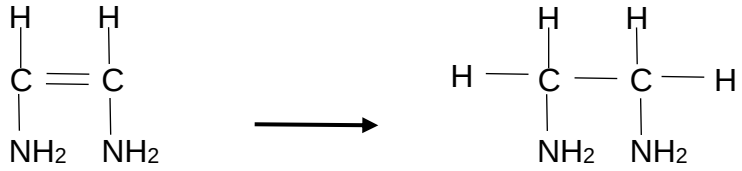
A They have the same empirical formula.

B They have the same physical properties.

C They undergo similar chemical reactions.

D The relative molecular masses of consecutive members differ by 12.

35 Compound X can be converted into compound Y as shown.



Compound X compound Y

Which correctly shows the reagents and conditions needed for the conversion?

	reagent	conditions
A	concentrated sulfuric acid	heat
B	hydrogen	high temperature, nickel catalyst
C	monomer	high temperature, iron catalyst
D	steam	high temperature and high pressure, phosphoric acid

36 What process/reaction is occurring when ethene and octane are obtained from decane, $C_{10}H_{22}$?

A combustion

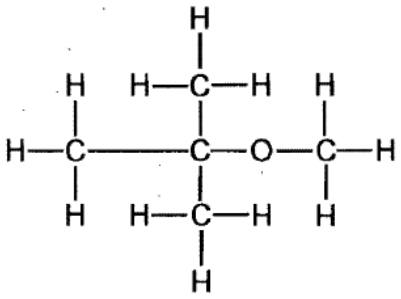
B cracking

C fractional distillation

D polymerisation

[Turn over

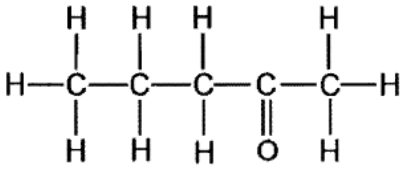
37 The structural formula of compound Z is shown.



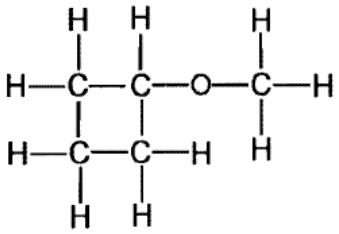
Compound Z

Which of the following compound is an isomer of compound Z?

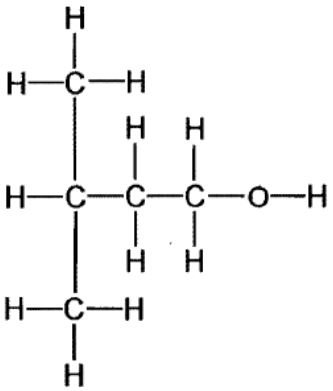
A



B



C



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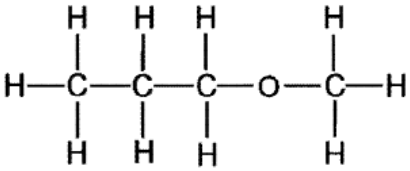


38 Which statement about alcohols are correct?

1 All alcohols contain the hydroxide ion, OH^-.

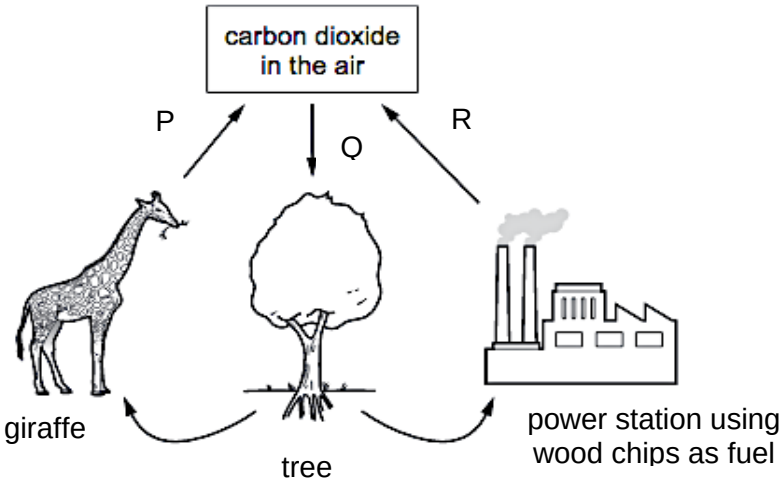
2 Ethanol can be formed from ethene using a reaction catalysed by yeast.

3 Ethanol can undergo neutralisation with aqueous sodium hydroxide.

4 Methanol can be oxidised to methanoic acid.

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

39 The diagram shows part of the carbon cycle. P, Q and R refer to specific processes of the carbon cycle.



Which row correctly describe the energy changes of these processes?

	P	Q	R
A	endothermic	endothermic	exothermic
B	endothermic	exothermic	endothermic
C	exothermic	endothermic	exothermic
D	exothermic	exothermic	endothermic

40 Methane, chlorofluorocarbons (CFCs) and carbon dioxide are all gases which affect the atmosphere and the environment.

In what way do these gases affect the environment?

	methane	chlorofluorocarbons (CFCs)	carbon dioxide
A	acid rain	global warming	photochemical smog
B	depletion of ozone layer	photochemical smog	global warming
C	global warming	depletion of ozone layer	global warming
D	global warming	depletion of ozone layer	acid rain

[Turn over

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

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.

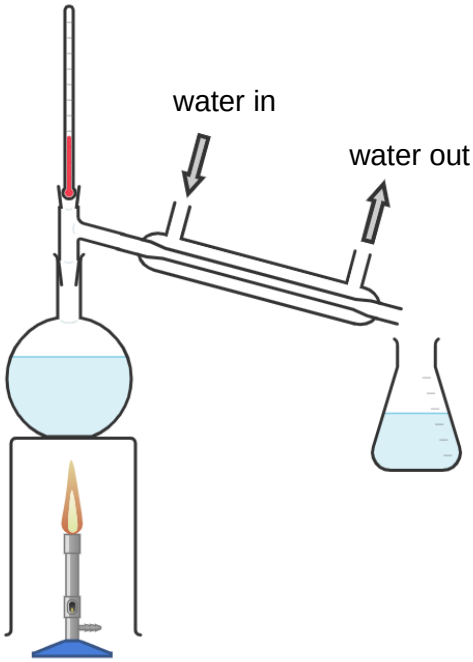


Fig. 2.1

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]

[Turn over

(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.

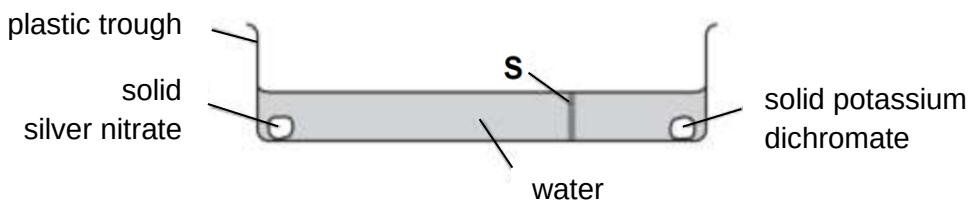


Fig. 3.1

(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]

[Turn over

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.

.....

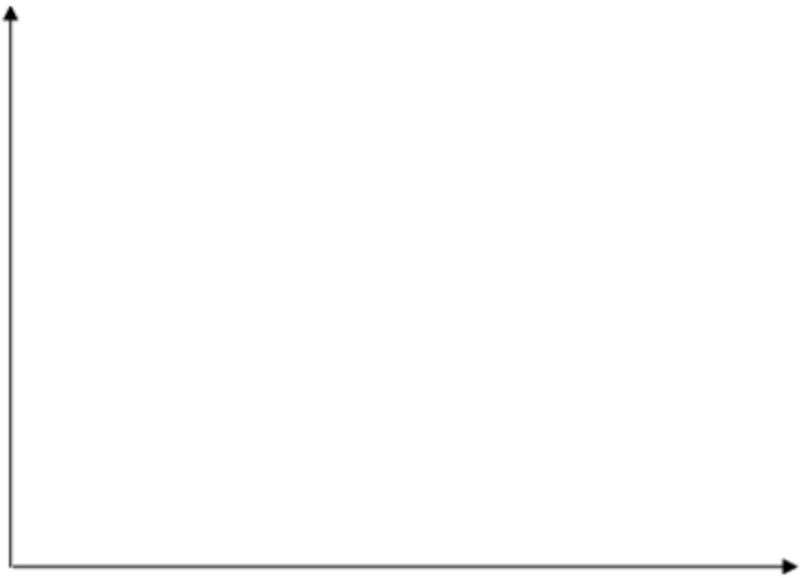
..... [1]

[Turn over

(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.

.....

.....

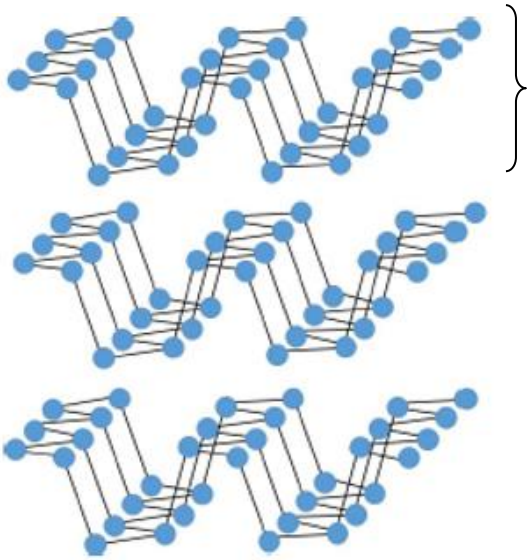
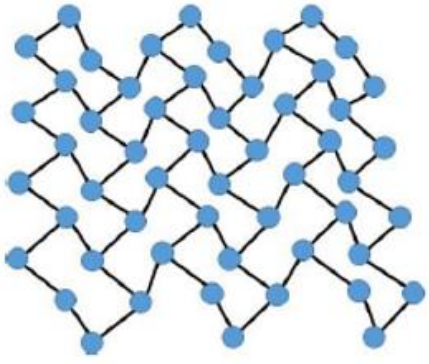
..... [2]

[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]

[Turn over

(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: .....

…

…

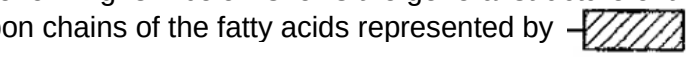
…

…… [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  .

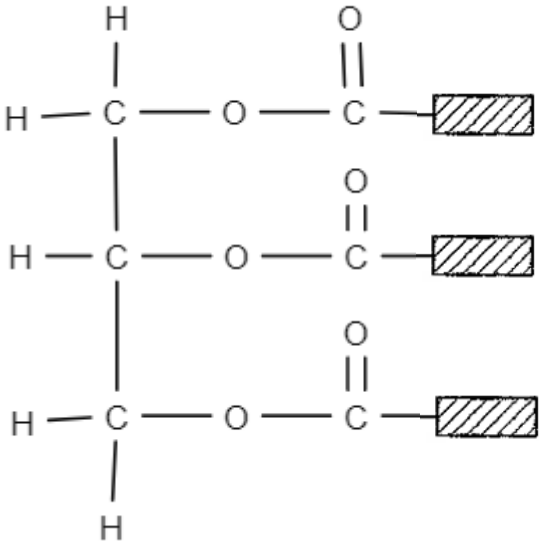


Fig. 8.1

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

.

[Turn over

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.

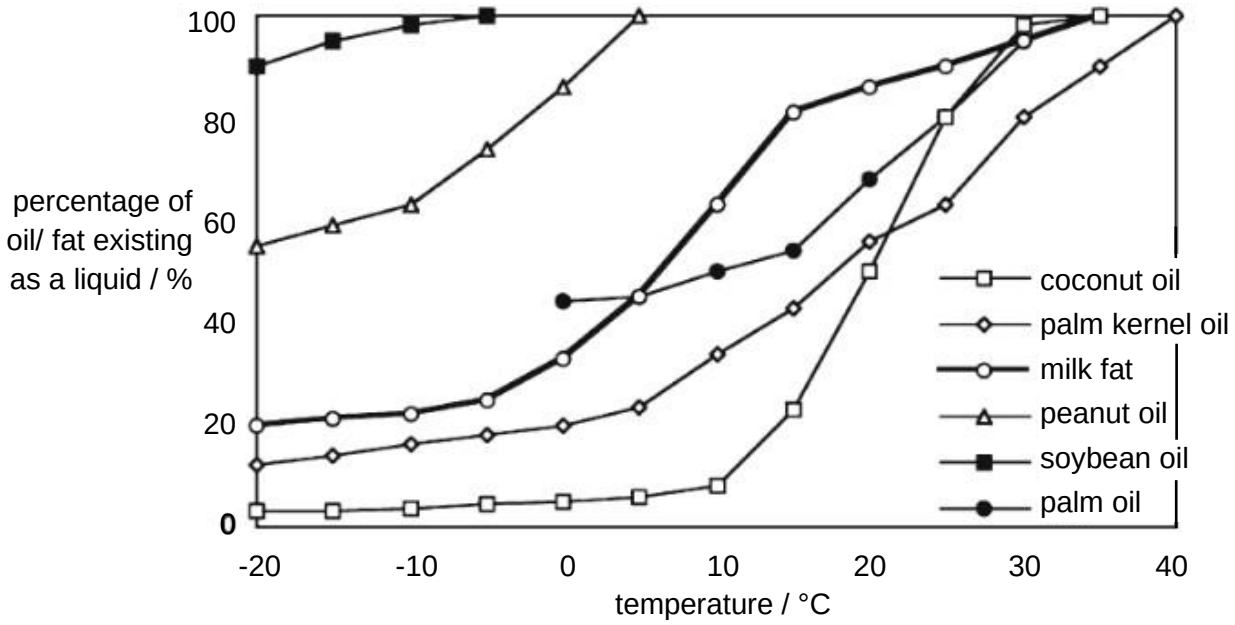


Fig. 8.2

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]

[Turn over

(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.

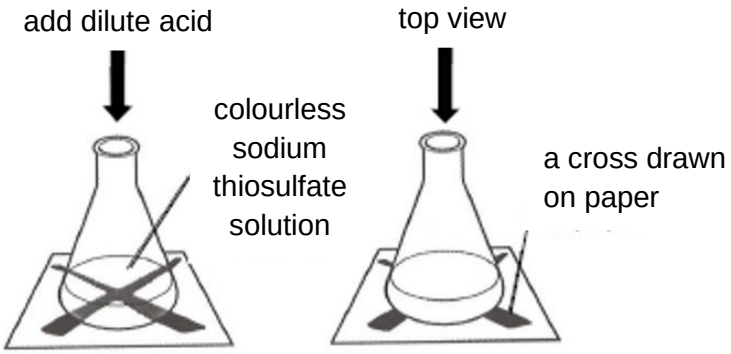


Fig. 9.1

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]

[Turn over

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

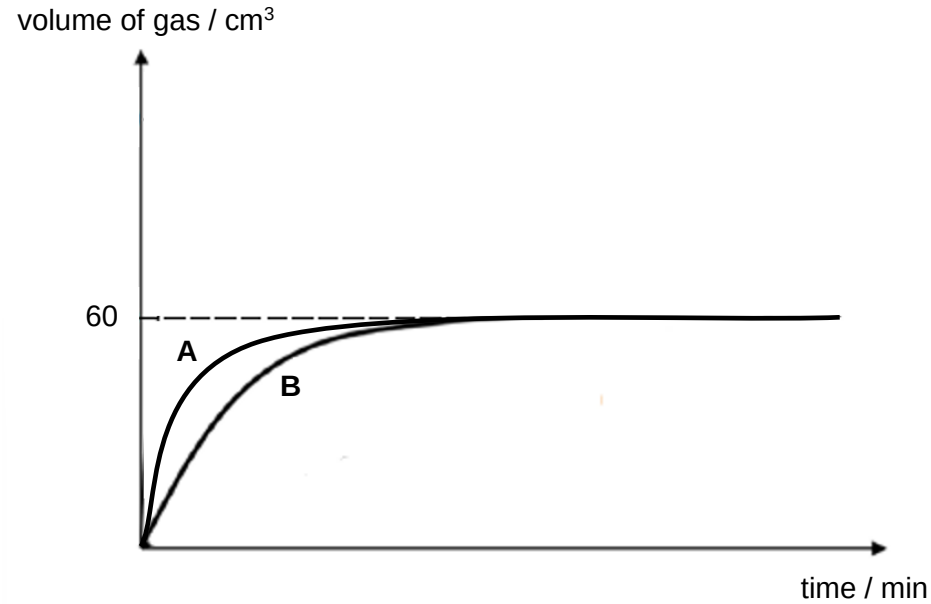


Fig. 9.1

(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.

.....

.....

.....

.....

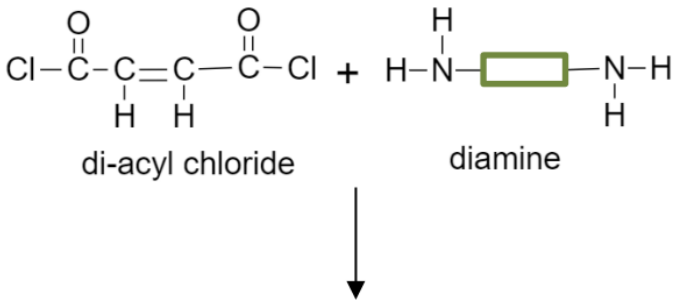
..... [2]

[Total: 10]

[Turn over

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]

[Turn over

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)

[Turn over

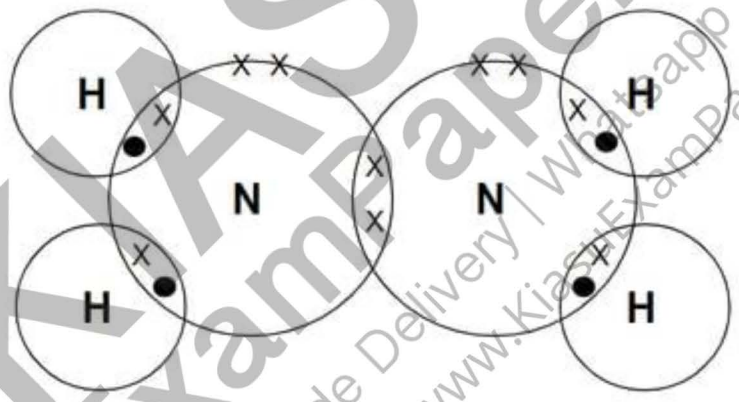
<table>
<tr><td>(ii)</td><td>No. of mol of silver nitrate = 2 / (108 + 14+ 3 x 16) = 0.0118 mol

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

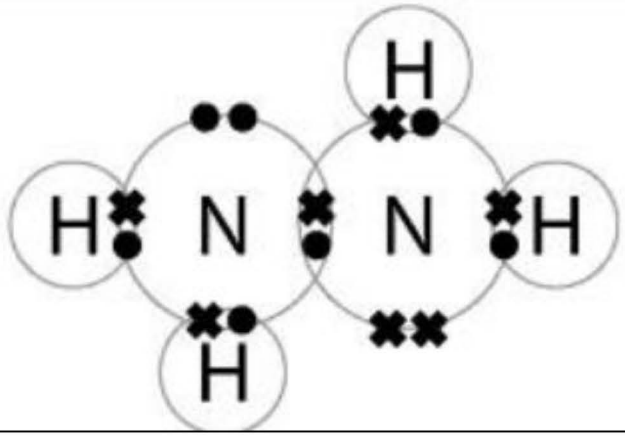
1</td></tr>
<tr><td>(c)</td><td><table><tr><td></td><td>chromium-52</td><td>chromium-54</td></tr><tr><td>number of protons</td><td>24</td><td>24</td></tr><tr><td>number of neutrons</td><td>28</td><td>30</td></tr><tr><td>number of electrons</td><td>24</td><td>24</td></tr></table></td><td>1 for every 3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

X: electrons from nitrogen

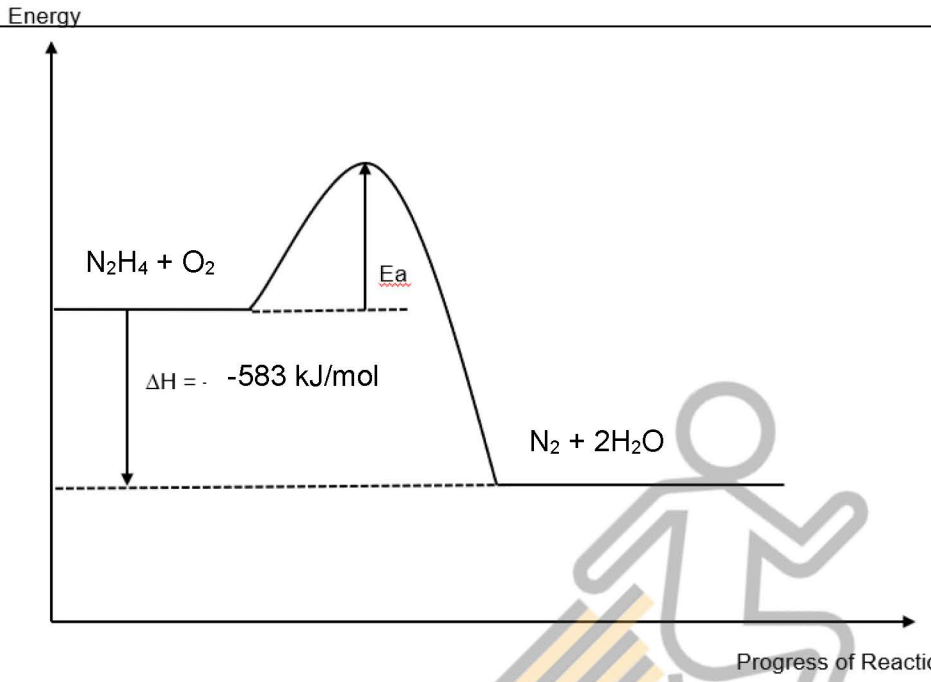
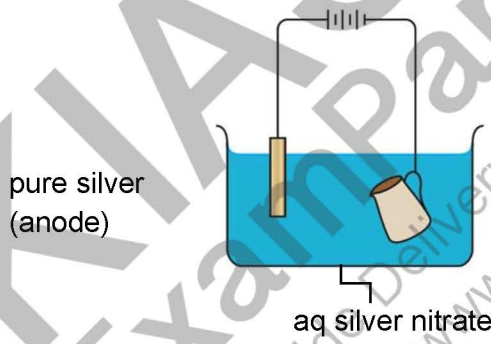
•: electron from H

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

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

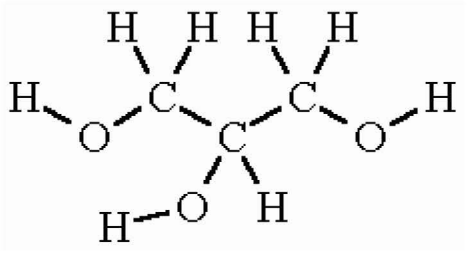
		
A4b	$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$ (no state symbols required)	1
A4c	BE (bonds broken) = 163 + 4 x 388 + 495 = 2210 kJ/mol BE (bonds formed) = 941 + 4 x 463 = 2793 kJ/mol Enthalpy change of combustion = BE (bonds broken) – BE (bonds formed) = 2210 – 2793 = -583 kJ/ mol	1 1 1
d(i)	$N_2 + O_2 \longrightarrow 2NO$ 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)

[Turn over

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

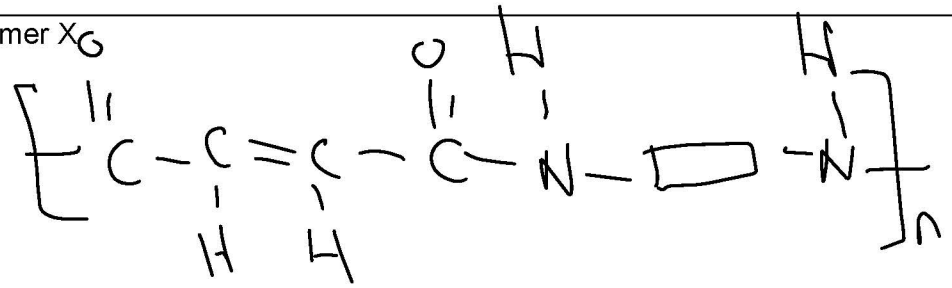
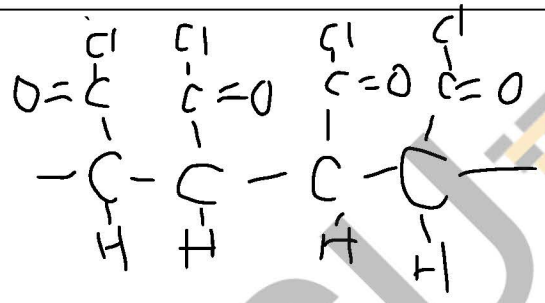
[Turn over

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

[Turn over

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

Suggested Answers for 2024 4Exp Prelim 6092 Chemistry P3

<table>
<tr><th>Q No.</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1ai</td><td>records initial burette reading, final burette reading, volume of P added with correct headings & units in titration table,
all burette readings recorded to nearest 0.05 cm^3,
at least 2 titre values within 0.20 cm^3, (Do not award marks for wrong calculations)*
average titre of consistent readings with 0.20 cm^3 of Supervisor's average value
[Award 1 m if average titre of consistent readings with 0.30 cm^3 of Supervisor's average value] (Do not award marks for accuracy if the concordance is not within 0.20 cm^3)

<table>
<tr><td>Titration No.</td><td>1</td><td>2</td></tr>
<tr><td>Final Burette Reading / cm^3</td><td>22.70</td><td>22.70</td></tr>
<tr><td>Initial Burette Reading / cm^3</td><td>0.00</td><td>0.00</td></tr>
<tr><td>Volume of P Used / cm^3</td><td>22.70</td><td>22.70</td></tr>
<tr><td>Best Results</td><td>√</td><td>√</td></tr>
</table>
Markers' Comment: This standard titration table was surprisingly badly done. .</td><td>1

1
1

2</td></tr>
<tr><td>1aii</td><td>Average volume (based on identified values) correctly calculated to 2 d.p.

[Allow ECF from part 1ai]*</td><td>1</td></tr>
<tr><td>1bi</td><td>No. of moles of thiosulfate ions= 0.120mol/dm^3 x (23.25 /1000) dm^3
= 0.00279 mol (3 s.f)</td><td>1</td></tr>
<tr><td>1bii</td><td>Compare mole ratio $S_2O_3^{2-}$ to Cu^{2+}
No. of moles of $S_2O_3^{2-}$: No. of moles of Cu^{2+}
1:1
No. of moles of Cu^{2+} in 25 cm^3 = 0.00279 mol
No. of moles of Cu^{2+} in 1 dm^3 = 0.00279 x (1000/25) = 0.1116 mol = 0.112 mol (3 s.f)

[Allow ECF]</td><td>2</td></tr>
<tr><td>1biii</td><td>Mass = no of moles of Cu x Ar of Cu = 0.1116 mol x 64 = 7.1424 g = 7.14g

[Allow ECF]</td><td>1</td></tr>
<tr><td>1biv</td><td>%mass of Cu = 7.1424/9.50 x 100%= 75.2% [1M]

[1M–unit (for answers in Q2aii and 2biii)]

[1M–3 sig fig (for answers in Q2bi, ii, iii and iv)]</td><td>3</td></tr>
<tr><td>1c</td><td>If potassium iodide is not in excess, not all Cu^{2+} will be reacted. Less I_2 will be produced. [1M] The volume of $Na_2S_2O_3$ used will be lower which leads to a smaller mass of copper calculated and smaller percentage by mass of copper. [1M]</td><td>2</td></tr>
<tr><td>2a</td><td>
<table>
<tr><th>test</th><th>observations</th></tr>
<tr><td>Test 1
Put about 1 cm depth of hydrogen peroxide in a clean test-tube. Add an equal volume of dilute sulfuric acid. Then add 10 drops of C with shaking.
You do not need to test any gas evolved in Test 1.</td><td>Purple acidified potassium manganate (VII) turns colourless.

Bubbles of gas formed.
[Both observations must be recorded to get 1M]</td></tr>
</table>
</td><td>9</td></tr>
</table>

	Test 2 Put about 1cm depth of hydrogen peroxide in a clean test-tube. Use a spatula to carefully add a small amount of **D**.	Bubbles of gas formed. Gas relights glowing splint. Gas is oxygen. Test-tube feels warm. **[Any 2 observations must be recorded to get 1M]**	
	Test 3 Put about 1 cm depth of dilute sulfuric acid in a clean test-tube. Add an equal volume of aqueous potassium iodide. Then add 10 drops of **C** with shaking.	Colourless acidified KI solution turns brown. **[1M]** Purple acidified potassium manganate (VII) turns colourless. **[1M]** *Markers' Comment: This is a standard phrasing to be used for testing of reducing/oxidising agents.*	
	Test 4 Put about 2 cm depth of **C** in a clean test-tube. Add an equal volume of aqueous sodium hydroxide. Use a spatula to carefully add a small amount of **D**. Use a glass rod to stir the mixture for about 20 seconds. Filter the mixture and collect the filtrate in a clean test-tube. Then,	A green /dark green solution is obtained as the filtrate. A black solid is obtained as the residue. **[Both observations must be recorded to get 1M]**	
	put about 1 cm depth of the filtrate in a clean test-tube. Add dilute sulfuric acid slowly with shaking until no further change is seen.	Green/dark green solution turns purple/red/dark red/reddish-brown. **[1M]**	
	Test 5 Put about 1 cm depth of **E** in a clean test-tube. Add an equal volume of dilute nitric acid then add about 1 cm depth of aqueous silver nitrate.	White precipitate is formed. **[1M]**	
	Test 6 Put about 1 cm depth of **E** in a clean test-tube. Add aqueous sodium hydroxide slowly with shaking until no further change is seen. Leave to stand for a few minutes.	A beige/light brown/pale orange precipitate is formed insoluble in excess sodium hydroxide. **[1M]** **BOD yellow ppt** Upon standing the precipitate turned from light brown to brown. **[1M]**	
2b	Hydrogen peroxide acts as a reducing agent. From test 1, it changes the colour of the oxidising agent, acidified potassium manganate(VII) from purple to colourless.		1 1

<table>
<tr><td>2c</td><td>Formula of E: $MnCl_2$
Markers' Comment: Students did not realise that it was mentioned in the front that the compound contains manganese. Examiners do expect students to find clues in the earlier parts of the question.</td><td>1</td></tr>
<tr><td>2d</td><td>Approach
Measure the time taken for the fixed mass of X or Y to turn acidified potassium manganate(VII) colourless.

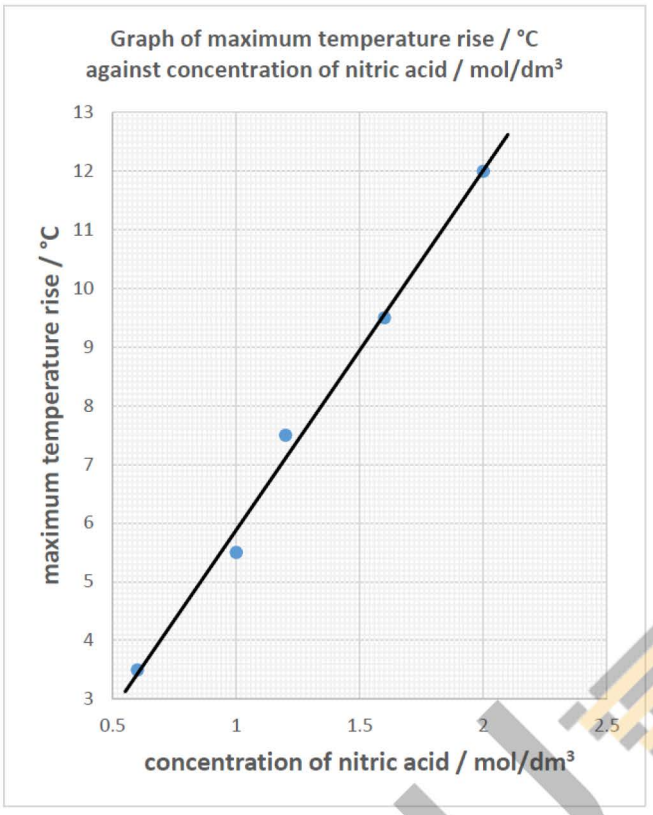
Procedure
(i) Measure 5 g/ fixed mass of X using an electronic balance and pour it into a test-tube connected to a stopper with a delivery tube.
(ii) Heat the sample strongly and pass the gas produced through a fixed volume of acidified potassium manganate(VII). Start timing with the stopwatch.
(iii) Record the time taken for the acidified potassium manganate(VII) to turn colourless.
(iv) Repeat the step with 5 g/ same mass of Y and same volume of acidified potassium manganate(VII).

Conclusion
(v) The coal that took a shorter time to turn the acidified potassium manganate(VII) colourless is the one that produces more sulfur dioxide when heated.

1M for correct method
1M for correct setup/apparatus used
1M for correct procedure and key conditions [i.e. fixed mass of X, fixed volume and concentration of acidified potassium manganate(VII)]
1M for correct data collection [i.e. time taken for acidified potassium manganate(VII) to be decolourised]
1M for correct conclusion

Markers' Comment: Students did not realise that a gas syringe set-up should not be used when heating is involved as the build-up of gas pressure in a sealed set-up will cause an explosion!</td><td>5</td></tr>
<tr><td>3a</td><td>
<table>
<tr><th>volume of nitric acid / cm^3</th><th>volume of distilled water/ cm^3</th><th>concentration of nitric acid / mol/dm^3</th><th>initial temperature of nitric acid / °C</th><th>highest temperature of mixture / °C</th><th>maximum temperature rise / °C</th></tr>
<tr><td>15.0</td><td>0.0</td><td>2.00</td><td>28.0</td><td>40.0</td><td>12.0</td></tr>
<tr><td>12.0</td><td>3.0</td><td>1.60</td><td>28.0</td><td>37.5</td><td>9.5</td></tr>
<tr><td>9.0</td><td>6.0</td><td>1.20</td><td>285</td><td>36.0</td><td>7.5</td></tr>
<tr><td>7.5</td><td>7.5</td><td>1.00</td><td>28.0</td><td>33.5</td><td>5.5</td></tr>
<tr><td>4.5</td><td>10.5</td><td>0.60</td><td>28.5</td><td>32.0</td><td>3.5</td></tr>
</table>
(Penalise if the values are not in 1 decimal place)

Markers' Comment: Quite a few students left this in 2.d.p. (wrong as should follow the d.p. of the data), or even made mistakes in this simple calculation.</td><td>1</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

3b	 1 m – correct labelling of both axes with units 1 m – correct scale (graph occupies at least half the length of both axes and no odd scales. Only accepted scales are 1:2/5/10 or equivalent) + correct plotting of points 1 m – line of best fit (No need to pass through origin)	3
3c	As the concentration of nitric acid increases (decreases), the maximum temperature rise increases (decreases). *Markers' Comment: It is not possible to tell from the graph whether it passes through the origin, hence by right not able to tell whether the relationship is directly proportional. Some students missed out the word "rise".*	1
3d	heat released (in J) = volume of solution (in cm^3) × maximum temperature rise (in °C) × 4.2 = 30 × 12 × 4.2 = 1510 J (3 s.f) *Markers' Comment: Again, most students forgot that the total volume is 30 cm3, not 15. Examiners do expect students to find clues in the earlier parts of the question.*	1
3e	$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$ Comparing Mole Ratio $HNO_3 : H_2O$ 1 : 1 number of moles of water, H_2O, produced = number of moles of HNO_3 = concentration × volume = 2.00 × (15.00 ÷ 1000) = 0.0300 mol (3 s.f)	1
3f	heat released (in kJ/mol) = (1512 ÷ 0.0300) × 1 = 50400J/mol = 50.4 kJ/mol (3 s.f) **[Accept ECF from part 3d and 3e]**	1