JUNYUAN SECONDARY SCHOOL
Secondary Four Express
Preliminary Examination 2025

CANDIDATE NAME

CLASS

INDEX NUMBER

CHEMISTRY

6092 / 02

Paper 2

28 Aug 2025

1 hour 45 min

Candidates answer on the Question Paper.

No additional materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.
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 in page 26.

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

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

Section A

Answer **all** questions.

1 Use the compounds listed below to answer the following questions.

$Zn(NO_3)_2$ MgO $A/(NO_3)_3$

CO Na_2SO_4 PbO NO_2

You may use the compound once, more than once or not at all.

State a:

(a) soluble compound that reacts with excess aqueous ammonia to produce a white precipitate.

……[1]

(b) compound that causes acid rain when released into the atmosphere.

……[1]

(c) metal oxide that can be reduced by hydrogen gas.

……[1]

(d) compound that reacts with aqueous sodium hydroxide to form a salt and water.

……[1]

(e) compound that can be prepared by titration.

……[1]

[Total: 5]

2 Chlorophyll is a green pigment found in green leaves. When these leaves are harvested and become less fresh, the chlorophyll can decompose into phaeophytin, which is a grey pigment.

A student carries out a chromatographic experiment to compare the extracts of spinach leaves obtained from two different sources. Fig. 2.1 shows the chromatogram obtained.

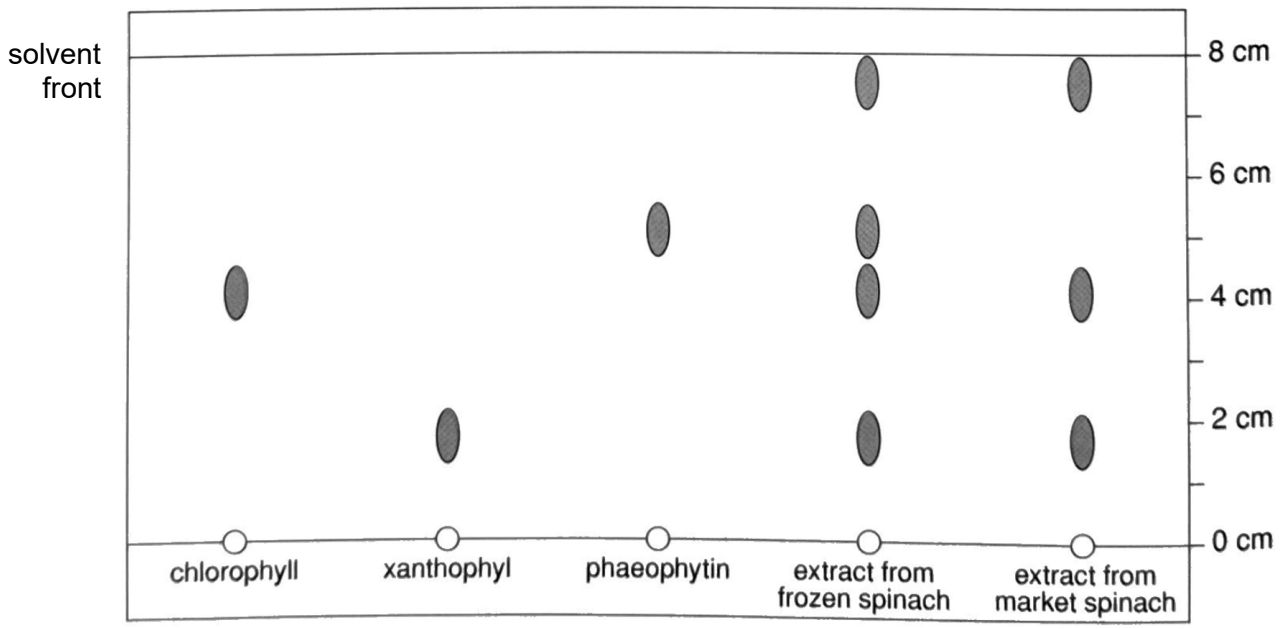


Fig. 2.1

(a) Calculate the R_f value of chlorophyll in the experiment.

[1]

(b) Using the results from Fig. 2.1, compare the freshness of frozen spinach to spinach bought from the market.

Explain your reasoning.

……

……[2]

(c) State two other conclusions that can be made about the extract from frozen spinach in terms of the solubility and number of components.

……

……

……[2]

[Total: 5]

3 In 1897, J.J. Thompson discovered electrons. In 1904, electrons were first incorporated into the model of an atom, called the 'Plum Pudding' model by Thompson. Fig. 3.1 shows the 'Plum Pudding' model of an atom.

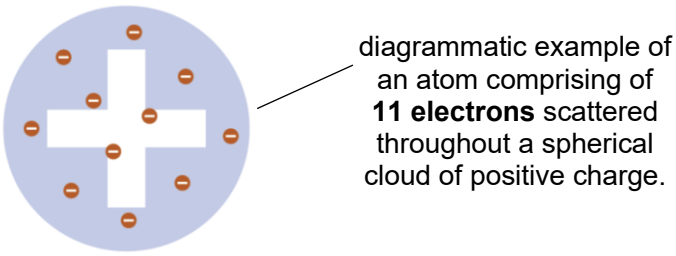


Fig. 3.1

(a) List three features of the 'Plum Pudding' model in Fig. 3.1 that are inaccurate in this current age.

……

……

……

……[3]

(b) Based on the 'Plum Pudding' model and the understanding of subatomic particles, a student proposed a model of the ion **formed by the atom in Fig. 3.1**.

Fig. 3.2 shows the proposed model.

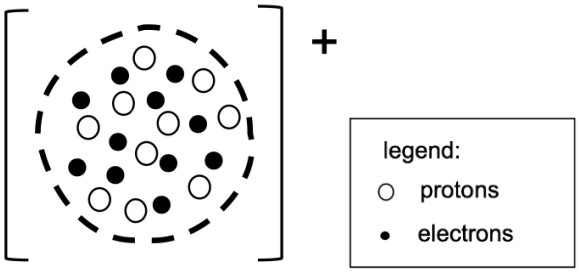


Fig. 3.2

In terms of the number of subatomic particles, explain why the model in Fig. 3.2 is also not an accurate representation of the structure of the ion formed.

……

……

……[2]

(c) Further experiments led to more accurate developments of the atomic model, leading to the identification of three subatomic particles. In one of these experiments, a beam of subatomic particles **x**, **y** and **z** was passed through a pair of oppositely charged plates.

Fig. 3.3 shows how the particles were affected.

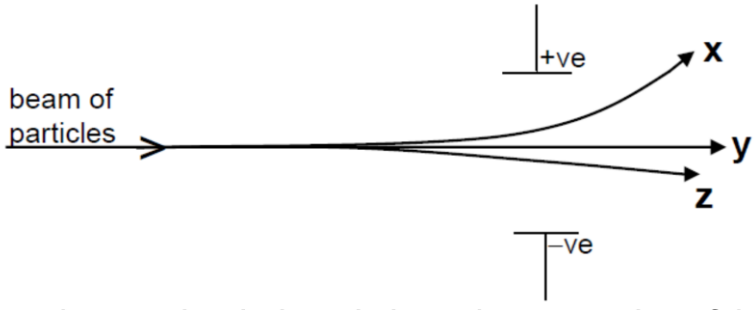


Fig. 3.3

From the results in Fig. 3.3, deduce the nature of the charge on each of the particles **x**, **y** and **z**.

Support your deductions with evidence.

……

……

……

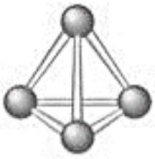
……

……[3]

[Total: 8]

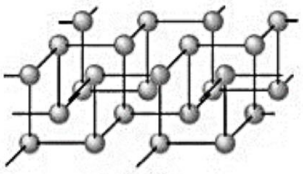
4 Phosphorus is an interesting element that can exist in several forms with very different properties. Fig. 4.1 shows the structures and melting points of two forms of phosphorus.

white phosphorus



melting point: 44.1 °C

black phosphorus



melting point: 416 °C

Fig. 4.1

(a) Describe the similarities and differences in the bonding and structures of the two forms of phosphorus.

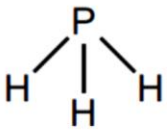
……

……

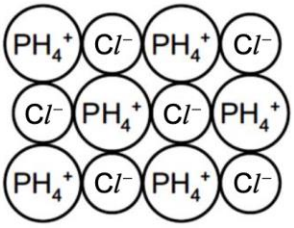
……

……[3]

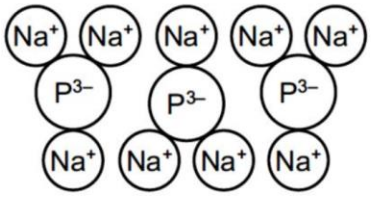
(b) Fig. 4.2 shows the structures of some substances containing phosphorus.



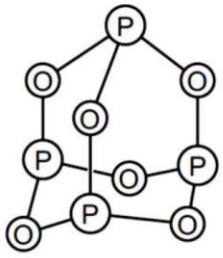
phosphine



phosphonium chloride



sodium phosphide



phosphorus trioxide

Fig. 4.2

(i) Draw a 'dot-and-cross' diagram to show the bonding in a phosphonium ion. Show the outer shell electrons only.

[2]

(ii) The following are statements about the substances containing phosphorus.

Using Fig. 4.2 and your understanding of bonding and structure, put a tick (✓) in one box in each row, to show which statements are true and which are false.

	true	false
Sodium phosphide is likely to be insoluble in water.		
Phosphorus trioxide is likely to be a poor conductor of electricity.		
Phosphine is likely to be a gas at room temperature.		

[2]

[Total: 7]

5 A class of students received a home-based learning assignment involving the use of 'invisible ink' to conceal a written message. The idea behind the design of invisible inks requires a colourless substance that produces a coloured product when a "revealer" is applied.

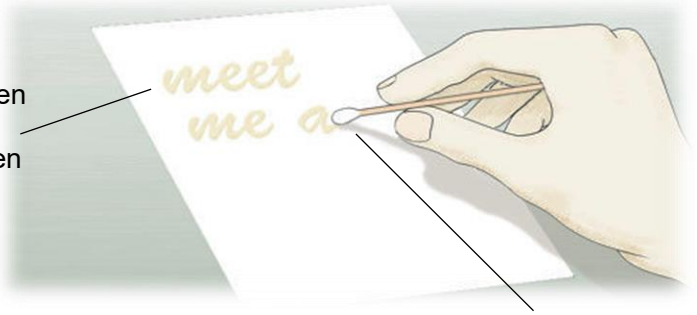


Fig. 5.1

(a) Phenolphthalein is an acid-base indicator. It is colourless in solutions with pH less than 10 and pink in solutions with pH above 10. Phenolphthalein is a suitable reagent for making an invisible ink.

(i) Suggest the name of a suitable 'revealer' for the invisible ink made of phenolphthalein.

……[1]

(ii) The revealed message was left in the open to dry. After a few days, it was observed that the ink started to fade.

A student suggests that the drying led to a lower concentration of hydroxide ions which then affected the pH.

Explain why the student is likely to be correct and how the pH is affected.

……

……

……[2]

(b) The students are tasked to design new pairs of invisible ink and its 'revealer'. The following chemicals are provided for them.

sodium hydroxide	calcium carbonate	copper(II) oxide
lead(II) nitrate	potassium iodide	aqueous chlorine

(i) Complete Table 5.1 to show one other pair of chemicals that can act as the invisible ink and the revealer.

Briefly explain why the pairing will work.

An example has been done for you. The selected substance can be used more than once.

Table 5.1

ink number	invisible ink	revealer	reason for choice
1	potassium iodide	lead(II) nitrate	lead(II) iodide which is yellow in colour is formed.
2			

[2]

(ii) Write a balanced chemical equation for any one of the reactions in **(b)(i).**

……..……...…….[2]

[Total: 7]

6 On 12 June 2025, US president Donald Trump said a trade framework with China has been completed. In this deal, China will supply rare earths and magnets to the US.

The 'rare earths' refer to a group of seventeen elements in the Periodic Table, including scandium (Sc), yttrium (Y) and the fifteen lanthanides as shown in Fig. 6.1 below.

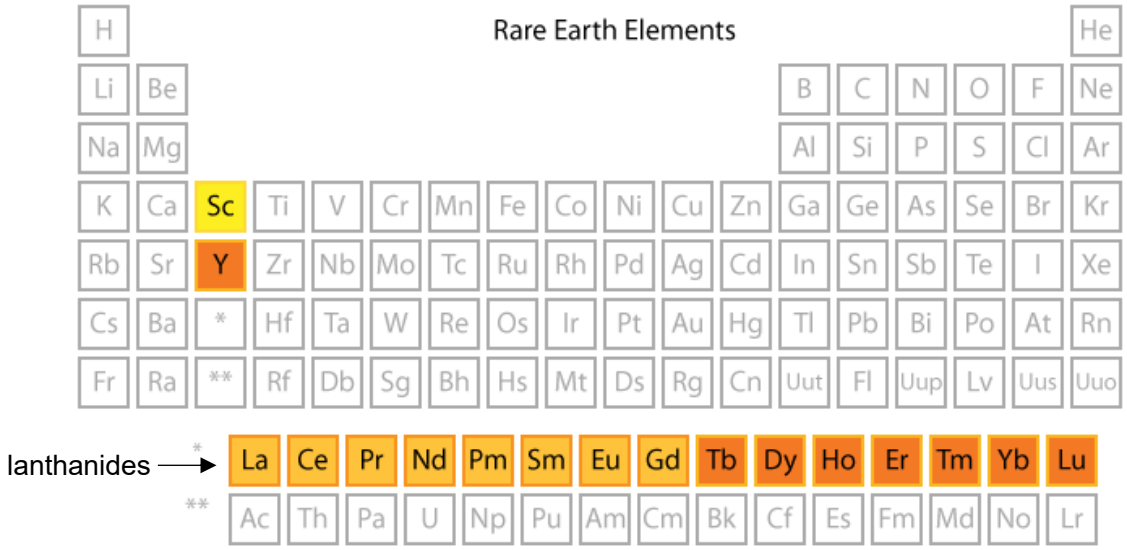


Fig. 6.1

(a) Based on the positions of scandium and yittrium in the Periodic Table, deduce which element has a bigger atomic size.

Explain your answer.

……

……

……[2]

(b) State two physical properties of rare earth elements which are typical of most metals.

……

……[2]

(c) Cerium, Ce, is one of the most abundant rare earth elements. It forms an oxide in the solid state that can be used as a catalyst in catalytic converters.

(i) Name the type of reaction that takes place in a catalytic converter.

……[1]

(ii) In terms of collision theory, explain how cerium oxide speeds up reactions.

……………………………………………………………………………………………………

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……………………………………………………………………………………………………[2]

(iii) Solid cerium oxide is usually crushed when packed into the catalytic converters.

Explain why this is so.

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……………………………………………………………………………………………………[1]

[Total: 8]

7 Electroplating is a process of using an electrical current to deposit a thin layer of metal onto an electrically conductive object. Gold plating is one such example.

In the gold plating of a spoon, aqueous sodium dicyanoaurate, $NaAu(CN)_2$, is used as the electrolyte. Fig. 7.1 shows the setup. The spoon is placed at the cathode and a piece of gold is used as the anode.

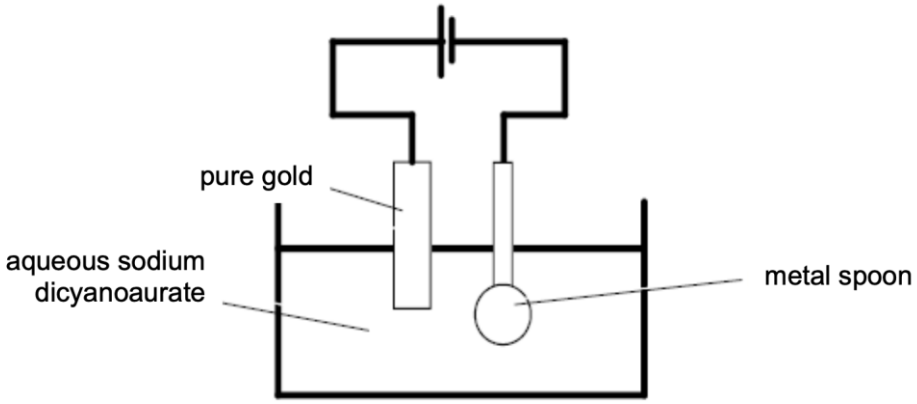

Fig. 7.1

(a) Sodium dicyanoaurate ionises in water to form sodium ions, gold ions and cyanide ions.

State the oxidation states of each element present in the electrolyte.

The cyanide ion has the formula, CN^-.

element	oxidation state in $NaAu(CN)_2$
carbon	
gold	
nitrogen	−3
sodium	

[2]

(b) State the formulae of all ions attracted to the cathode.

……[1]

(c) Gold is discharged at the cathode.

(i) Write the half equation, with state symbols, for this reaction at the cathode.

……[1]

(ii) Explain why gold ions are discharged preferentially over other ions at the cathode.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(d) Explain whether the concentration of the electrolyte changes throughout the plating process.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(e) The same gold plating process is repeated by replacing the gold electrode with graphite electrode. All other factors remained constant.

State and explain why the plating process stopped after a period of time and bubbles were observed at the cathode instead.

……………………………………………………………………………………………

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……………………………………………………………………………………………[2]

[Total: 10]

8 Globally, the demand for biofuels is growing. Bioethanol is one example of a biofuel.

Bioethanol is ethanol that can be obtained by converting glucose in sugarcane. It is widely used in Brazil as a fuel, where the vehicle engines are designed to burn ethanol.

(a) Briefly describe how bioethanol is obtained from converting glucose solution in sugarcane.

Include a balanced chemical equation in your answer.

……

……

……

……

……[4]

(b) Explain why bioethanol is often known as a carbon-neutral fuel.

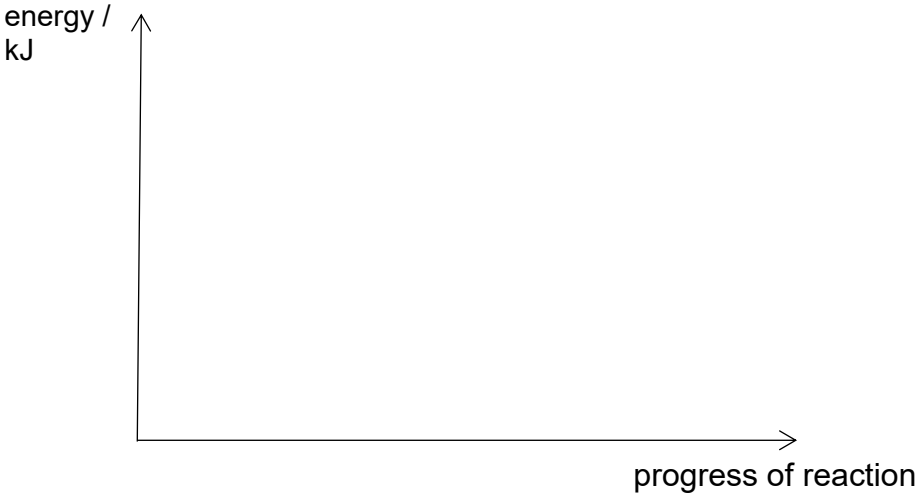
……

……[1]

(c) Draw an energy profile diagram to show the complete combustion of bioethanol.

In your diagram:

- display the names of the reactants and products (chemical formulae are not required).
- label the activation energy and enthalpy change for the reaction.



[3]

[Total: 8]

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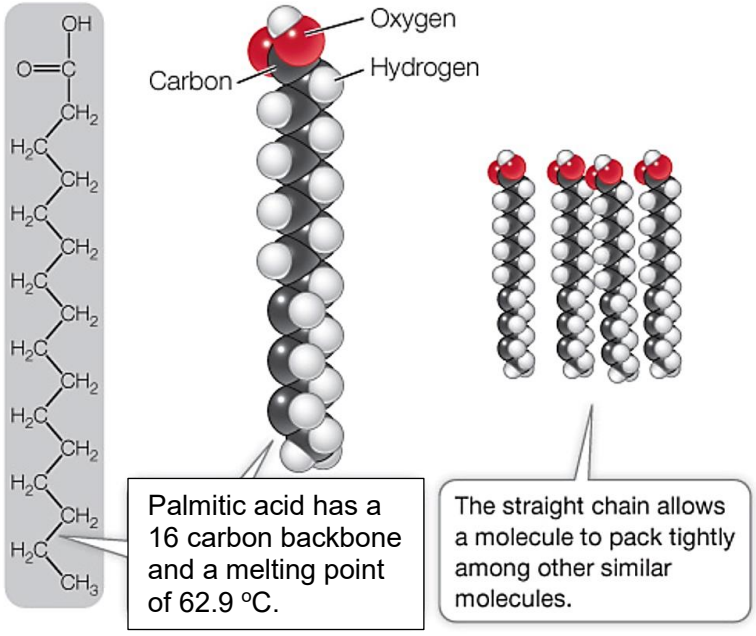
9 Fatty acids

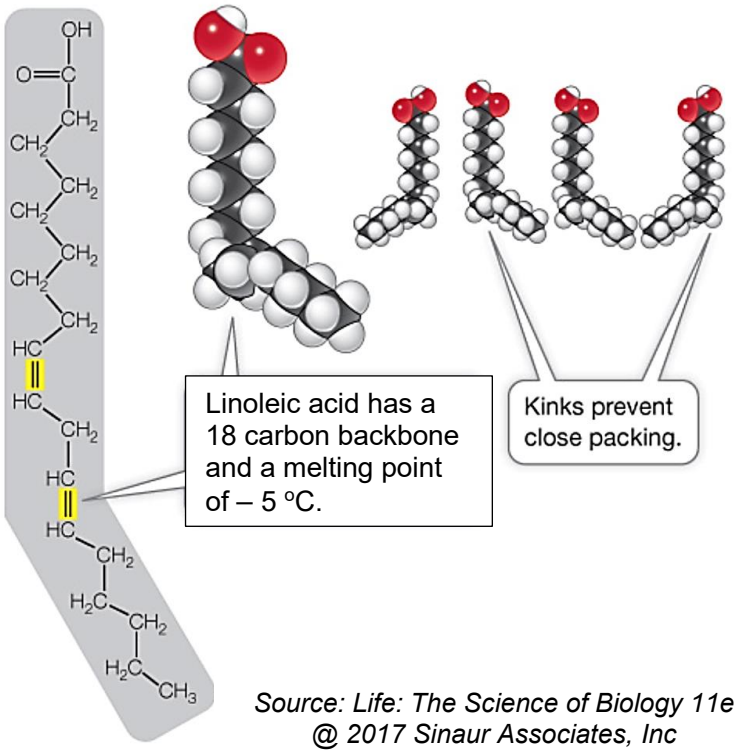
Fatty acids are carboxylic acids that can undergo reactions to become fats and oils. The following are information about some common fatty acids.

(A) Palmitic acid



It is also known that a fatty acid with a 17 carbon straight chain backbone (without C=C bonds) has a melting point of 69.6 °C. Usually, the larger the number of straight chain carbon atoms in a fatty acid molecule, the higher the melting point of the substance.

(B) Linoleic acid



Source: Life: The Science of Biology 11e
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(a) The melting point of an organic molecule can be affected by the degree of unsaturation and its molecular size.

With reference to the information given on fatty acids, discuss which factor is likely to have a larger influence on their melting points.

……..

……..

……..

.....……[2]

(b) In terms of the forces of attraction between molecules, explain how the shape of molecules affect melting point.

……..

……..

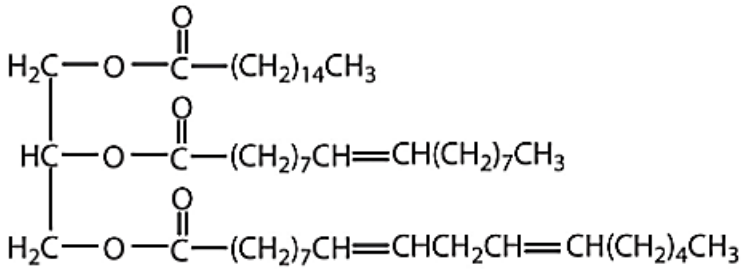
……..

.....……[2]

Triglycerides

A triglyceride is a molecule that contains three ester functional groups.

When different fatty acids react with triols (an alcohol molecule containing three hydroxyl groups), different triglycerides are formed. An example of the structural formula of a triglyceride is shown below. This triglyceride can be found in peanut oil.



Fats and oils

A triglyceride is considered a fat if it is a solid at 25 °C. It is an oil if it is a liquid at that same temperature. These differences in melting points are usually affected by the degree of unsaturation and molecular size of the constituent fatty acids.

One method for checking the unsaturation level in fatty acids is by determining the iodine number. Iodine number is the number of grams of iodine that will react with 100 g of fat or oil. A higher iodine value indicates a higher degree of unsaturation.

Table 9.1 below shows the average or range of figures for the percentage of fatty acid composition of some common fats and oils.

Table 9.1

source of fat or oil	% saturated fatty acids (total)	% monounsaturated fatty acid	% polyunsaturated fatty acids	
		oleic acid ($C_{17}H_{33}COOH$)	linoleic acid ($C_{17}H_{31}COOH$)	linole**n**ic acid ($C_{17}H_{29}COOH$)
beef fat	59	38	3	-
peanut oil	16 - 18	36 - 67	15 - 46	< 1
coconut oil	90	8	2	-
corn oil	25	26	47	2
olive oil	15	78	7	-
soybean oil	14	28	50	8

To compare the relative health benefits of different fats and oils in a person's diet, the polyunsaturated/saturated (P/S) index can be used.

$$\text{P/S index} = \frac{\text{\% polyunsaturated fatty acids}}{\text{\% saturated fatty acids}}$$

A higher P/S index is often associated with a healthier diet choice and a reduced risk of heart diseases.

(c) Draw the structural formula of the triol and one of the fatty acid that are used to produce the triglyceride found in peanut oil.

- structural formula of the triol:

- structural formula of one of the fatty acids:

[2]

(d) Deduce, using data given in Table 9.1, which fat or oil has the lowest iodine number.

.....[1]

(e) Linole**n**ic acid (not shown in diagrams above) is a polyunsaturated fatty acid with molecular formula of $C_{17}H_{29}COOH$.

Determine the number of double bonds between carbon atoms present in one molecule of this acid. Display your working clearly.

number of double bonds between carbon atoms =.....[2]

(f) It is a common belief that plant-based oils are healthier substitutes for animal fats in a person's diet.

With reference to beef fat and soybean oil, calculate the P/S indexes (giving your answers to 3 significant figures) and hence, determine which substance is a healthier choice.

healthier substance:.....[3]

[Total: 12]

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Section B

Answer one question from this section.

10 It is a tradition at the Olympic Games to pass a burning torch. The material used for the body of the torch and the fuel used for the flame involves much consideration. Table 10.1 shows some information relating to the type of torch fuel used over the years.

Table 10.1

year of Olympics	host city	type of fuel used
2008	Beijing	propane
2012	London	mixture of propane & butane
2016	Rio	mixture of propane & butane
2020	Tokyo	hydrogen
2024	Paris	nil (special LED lighting)

(a) In the early years, the body of relay torches were made of iron. Painting and galvanising were two ways to protect the torch from rusting. During the transportation and handling of the relay torches, they can also be easily scratched.

Describe one advantage and one disadvantage of using galvanising, compared to painting.

……..……...

……..……...

……..……..[2]

(b) The fuel used for the Olympic torches are usually stored under pressure in a container at the base of the torch.

Suggest why the fuels are stored under pressure.

……..……...

……..……..[1]

(c) The higher the percentage of carbon in a fuel, the more likely the fuel will undergo incomplete combustion and produce a brighter orange/yellow flame.

By calculating the percentage of carbon in hydrogen, propane and butane, explain why, the Beijing and Tokyo torch flames did not burn as brightly as the London and Rio torch flames.

……..……...

……..……...

……..……..[3]

(d) A scientist designed a torch that burnt an unknown hydrocarbon, C_xH_y. In an experiment, a sample of C_xH_y was burnt completely to form 0.078 mol of CO_2 and 0.080 mol of H_2O.

The molar mass of C_xH_y was found to be 84 g.

Using the information given above, determine the empirical formula and hence, the molecular formula of C_xH_y. Display your calculations clearly.

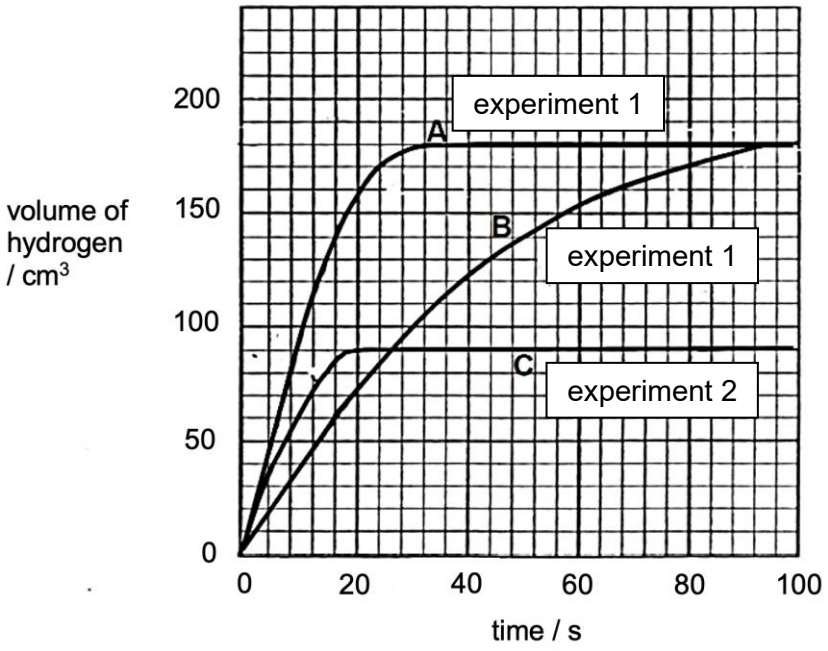
empirical formula: ……

molecular formula: …..……

[4]

[Total: 10]

11 In experiment 1, 0.488 g of zinc was separately reacted with hydrochloric acid and sulfuric acid. The volume and concentration of the acids used were both 20.0 cm^3 and 2.00 mol/dm^3. The curves A and B in the graph below show the results of the reactions.



In experiment 2, a similar reaction with an unknown mass of zinc and 20.0 cm^3 of a 2.00 mol/dm^3 acid was conducted. Curve C shows the result of the reaction.

(a) (i) The chemical equation for the reaction between zinc and hydrochloric acid is shown.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Write a balanced chemical equation for the reaction between zinc and sulfuric acid.

……[1]

(ii) With the help of calculations, determine the limiting reactant in experiment 1.

[2]

(b) Between curves A and B, identify the curve for the reaction that used sulfuric acid. Explain your choice.

……..……...

……..……...

……..……..[2]

(c) Given that either sulfuric acid or hydrochloric acid was used to obtain curve C,

(i) identify the acid used and state your reasoning.

……..……....……[1]

(ii) calculate the mass of zinc used.

[1]

(d) Experiment 3 was carried out using the same mass of zinc and the same volume and concentration of the acid as experiment 2, but this time, aqueous copper(II) sulfate was added to the reaction mixture.

Effervescence was observed and some brown deposit was formed. The volume of hydrogen collected was slightly less than in experiment 2.

Write the ionic equation for the reaction that took place and explain why less hydrogen was collected.

……..……...

……..……...

……..……...

……..……..[3]

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

http://www.ivyroses.com/Chemistry/Organic/Naming-Ethers.php

(i) Explain how solid cerium oxide speeds up the reactions in catalytic converters and why it is usually crushed when packed into the converters. [3]