TANJONG KATONG GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS

CANDIDATE NAME						
CLASS	**4**			INDEX NUMBER		

CHEMISTRY

6092/02

Paper 2

12 August 2024
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.
DO **NOT** WRITE ON ANY BARCODES.

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 26.

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

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

Setter : Ms Vina Ng
Markers : Mrs Lee Suan Ching, Ms Esther Foo, Mrs Chan Liying, Ms Vina Ng

Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 shows part of the Periodic Table.

				He
C	N	O	F	Ne
		S	C*l*	Ar
			Br	Kr

Fig. 1.1

Select elements from Fig. 1.1 to answer the following questions. You may use each element once, more than once or not at all.

Write down the symbol for an element which:

(i) exists as diatomic molecules,

……[1]

(ii) is a noble gas,

……[1]

(iii) has seven electrons in its outer shell.

……[1]

(b) Some versions of the Periodic Table place hydrogen in Group 1 (Fig. 1.2). Other versions place hydrogen alone and not with any other group (Fig. 1.3).

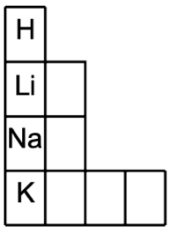


Fig. 1.2

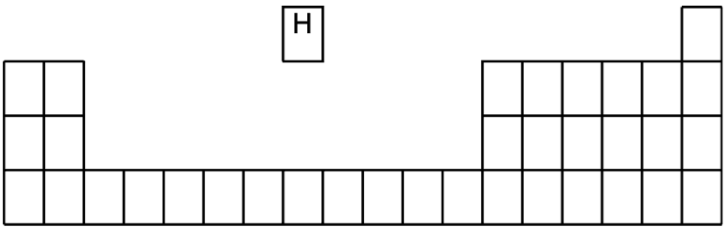


Fig. 1.3

(i) Give one similarity between hydrogen and the elements in Group 1.

……..

…….[1]

(ii) Give one property of hydrogen that does **not** fit with the properties of the elements in Group 1.

……..

…….[1]

(iii) Hydrogen is in Period 1 of the Periodic Table.

Explain why Period 1 only contains 2 elements.

……..

…….[1]

(c) Hydrogen is used to make margarine from vegetable oil.

Describe, in terms of bonds, what happens when hydrogen reacts with vegetable oil.

…….

…….[2]

[Total: 8]

2 **(a)** There is a universal way for describing atoms across all scientific disciplines. In this system, the nuclide of an element is represented by the atomic symbol, atomic number and the nucleon number.

Naturally occurring lithium contains the isotopes $^{6}_{3}Li$ and $^{7}_{3}Li$.

(i) What is meant by the term, nucleon number?

…….[1]

(ii) The isotopes $^{6}_{3}Li$ and $^{7}_{3}Li$ have accurate isotopic masses of 6.015 and 7.016 respectively. The A_r of lithium is 6.942.

Calculate the relative percentage abundances of the two isotopes, to **two** decimal places.

[2]

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

An experimental nuclear reactor uses $^{6}_{3}Li$ and deuterium, $^{2}_{1}H$, as a fuel. Three nuclear reactions between these two atoms are described below (p^+ is a proton; n is a neutron). The number of protons and neutrons must be conserved in each reaction.

$$^{6}_{3}Li + {}^{2}_{1}H \rightarrow 2\,{}^{4}_{2}He$$

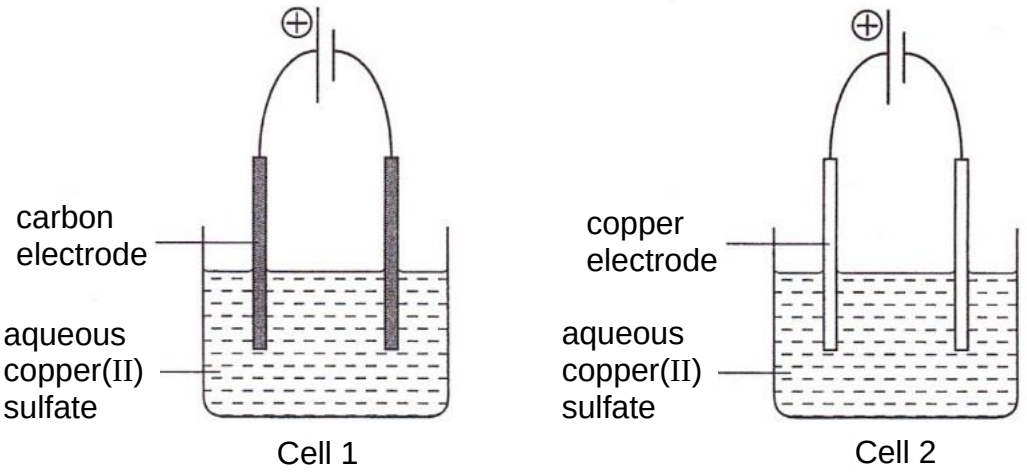
$$^{6}_{3}Li + {}^{2}_{1}H \rightarrow {}^{4}_{2}He + \mathbf{X} + n$$

$$^{6}_{3}Li + {}^{2}_{1}H \rightarrow \mathbf{Y} + p^+$$

Suggest the identities of **X** and **Y**.

[2]

(b) Aqueous copper(II) sulfate was electrolysed in two cells using different electrodes as shown in cells 1 and 2.



Cell 1 Cell 2

(i) Write ionic equations for the reactions at the positive electrodes.

Cell 1 ……[1]

Cell 2 ……[1]

(ii) Describe the change that would be seen at the negative electrode in both cells.

……..

……[1]

(iii) Describe the changes that would be seen in Cell 1, but not in Cell 2.

……..

……..

……..

……[2]

[Total: 10]

3 **(a)** Salts that are insoluble in water are prepared by precipitation.

Describe how you will prepare a pure and dry sample of lead(II) iodide, PbI_2, by precipitation.

Your answer should include:

- starting reagents that you would use
- practical details
- an ionic equation for the precipitation reaction.

……

……

……

……

……

……

……

……

……

……[4]

(b) A student observed the reaction of hydrochloric acid with four different metals. The student used the same concentration and volume of hydrochloric acid and the same mass of metal in each experiment.

Table 3.1

metal	observations
cobalt	dissolved very slowly and a few bubbles produced
iron	dissolved slowly and few bubbles produced slowly
magnesium	dissolved very quickly and many bubbles produced very rapidly
zinc	dissolved quickly and many bubbles produced rapidly

Use the information in Table 3.1 to suggest the order of reactivity of these metals.

most reactive ……, ……, ……, …… least reactive

[2]

(c) Magnesium oxide is classified as a basic oxide, but zinc oxide is classified as an amphoteric oxide.

Explain the meaning of the terms *basic* and *amphoteric* as applied to these oxides. Include one equation in your explanation.

…….

…….

…….

…….[2]

[Total: 8]

4 **(a)** **(i)** Potassium fluoride is a white crystalline solid with a melting point of 860°C. It dissolves in water to form a solution which conducts electricity.

Silicon dioxide is a white crystalline solid with a melting point of 1715°C. It does not conduct electricity in the solid state nor in the liquid state. It is insoluble in water.

Name the type of structure and describe the bonding in the solids potassium fluoride and silicon dioxide.

……

……

……

……

……

……

……

……[3]

(ii) The melting point of silicon dioxide is 1715°C and of silicon fluoride is –90°C. Explain why silicon fluoride is a gas at room temperature.

……

……

……[2]

(iii) Explain why graphite is soft and slippery.

……

……[1]

(b) Draw ‘dot-and-cross’ diagrams to show the bonding in potassium fluoride.

Show outer shell electrons only.

[2]

[Total: 8]

5 **(a)** Long chain alkanes can be cracked to produce shorter chain alkanes and alkenes.

(i) What is the molecular formula of an alkane with 12 carbon atoms in each molecule?

……[1]

(ii) The alkane in **(a)(i)** can be cracked to produce butene and one other product. Write the equation to show this reaction.

……[1]

(iii) Explain why cracking makes the oil industry more profitable.

……..

……[1]

(b) Ethene is also produced by cracking and is used to manufacture ethanol.

Write an equation to produce ethanol from ethene and state the conditions under which the reaction takes place.

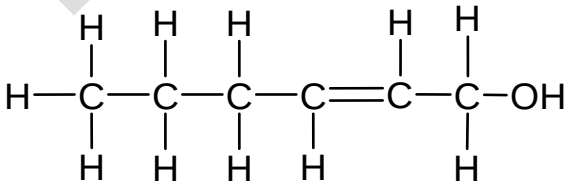
……

……

……[2]

(c) When grass is cut, it releases chemicals which give the characteristic freshly cut grass smell.

One of these chemicals is



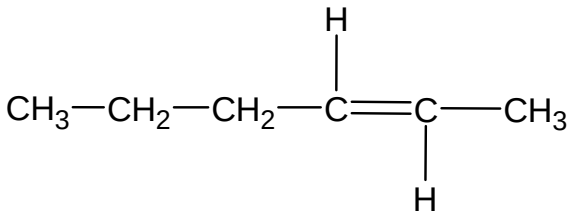
(i) Describe a chemical test to confirm the presence of the carbon-carbon double bond functional group in $CH_3CH_2CH_2CH{=}CHCH_2OH$.

……..

……..

……[2]

(ii) Hexene has three straight-chain isomers.



One of them is

Draw the structures of the other two straight-chain isomers of hexene.

[2]

(d) Propanol reacts in a similar way to ethanol.

Name the organic product of the reaction between propanol and warm, acidified potassium manganate(VII).

……[1]

[Total: 10]

6 The partial structure of a polymer is shown in Fig. 6.1.

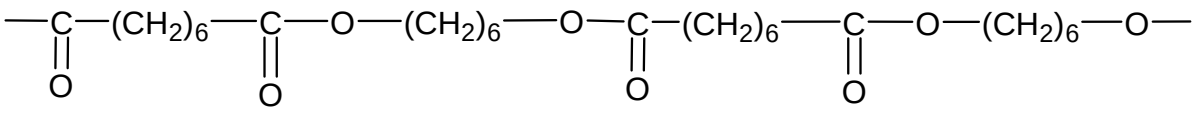


Fig. 6.1

(a) Draw the structures of the monomers that react to form this polymer.

[2]

(b) **(i)** Name the structural linkage that joins the monomers in polymer together as shown in Fig. 6.1.

……[1]

(ii) The polymer can undergo depolymerisation to convert back into its monomers. State the conditions required for the depolymerisation process.

……[1]

(c) The condensation polymerisation of monomers in **(a)** can be compared with the addition polymerisation of ethene.

Outline **one** similarity and **one** difference between the condensation polymerisation of the monomers in **(a)** and the addition polymerisation of ethene.

……

……

……

……[2]

[Total: 6]

7 **(a)** Ethanoic acid reacts with ethanol to form an ester.

$$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

A chemist performs three different experiments to find out how the initial rate is affected by the temperature and initial concentration of ethanoic acid.

experiment	temperature /°C	concentration of ethanol in mol/dm^3	concentration of ethanoic acid in mol/dm^3
1	65	1.0	1.0
2	65	1.0	0.5
3	75	1.0	1.0

(i) State and explain, in terms of collisions between particles, how the initial rate of experiment 1 compares to that of experiment 2.

……

……

……

……

……

……[3]

(ii) The chemist finds that initial rate of experiment 3 is higher than that of experiment 1.

Explain, in terms of collisions between particles, why an increase in temperature will increase the initial rate of reaction.

……

……

……

……[2]

(b) Propanoic acid also reacts with ethanol in the presence of a concentrated sulfuric acid catalyst.

Name and draw the full structural formula of the organic product and name the functional group present.

(i) Name the organic product formed.

……[1]

(ii) Draw the full structural formula of the organic product.

[1]

(iii) Name the functional group present in the organic product.

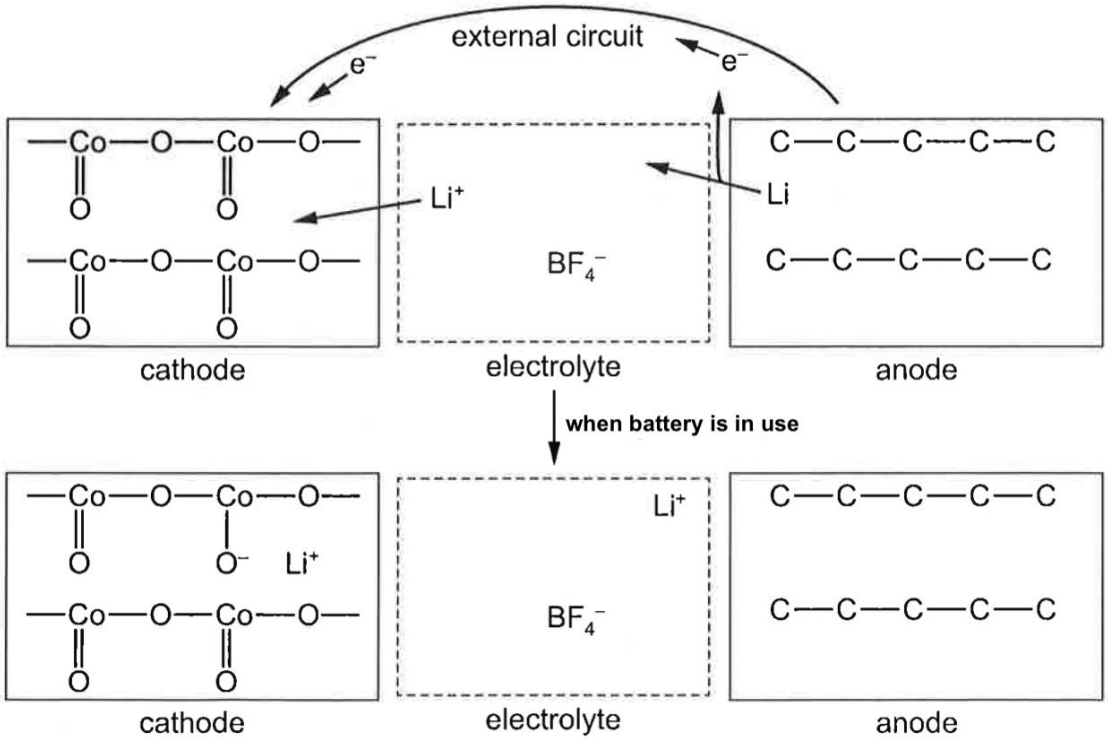
……[1]

[Total: 8]

8 **(a)** A battery is a portable source of electric power.

Lithium-ion batteries are light weight and can hold a large amount of charge. One type of lithium-ion battery consists of a cathode made from cobalt oxide, CoO_2; an anode made from graphite with lithium atoms inserted between the layers. The anode is considered as a reactive electrode in this context. The electrolyte used is $LiBF_4$ dissolved in an organic solvent.

When the battery is in use, Li atoms at the anode give up electrons to become Li^+ ions. The electrons travel round the external circuit, and are picked up by the cathode. A Li^+ ion from the electrolyte also moves to the cathode. This is illustrated in the following diagram in which C–C–C–C–C is a simplified representation of a layer of carbon atoms in a graphite.



(i) Explain the difference between an inert electrode and an electrode that is not inert.

……..

……..

…….[1]

(ii) At the anode, the Li atoms lose their valence electrons to become Li^+ cations.

It was found that metallic bonding can exist between the Li^+ cations and the layers of carbon atoms in graphite. Suggest why this is possible.

……..

……[1]

(iii) Write the half-equation for the reaction at the anode. State symbols are not required.

……[1]

(b) **(i)** Lithium peroxide, Li_2O_2, has been used in submarines and manned spacecraft to regenerate breathable air from exhaled air. Lithium carbonate is one product of this reaction.

Suggest a balanced equation for the reaction that generates breathable air from exhaled air.

……[1]

(ii) Unlike other Group 1 carbonates, lithium carbonate decomposes on heating in a similar manner to magnesium carbonate.

Write the chemical equation for the decomposition of lithium carbonate.

……[1]

(c) At the International Space Station, compound **A** is used for oxygen storage. Elemental analysis shows that compound **A** contains 6.52% lithium and 33.32% chlorine and 60.16% oxygen by mass.

(i) Deduce the empirical formula of compound **A**. Show your working.

[3]

(ii) The molecular and empirical formula of compound **A** are identical. Compound **A** decomposes to form LiC*l* and O_2.

Write the equation for the decomposition of compound **A**.

……[1]

The efficiency of a compound to store oxygen is given by its oxygen: volume ratio (*OV*)

$$OV = \frac{\text{Volume of oxygen released}}{\text{Volume of compound that released it}}$$

The density of compound **A** is 2.42 g/cm^3.

(iii) Using the equation in **(c)(ii)**, calculate the oxygen:volume ratio (*OV*) of 1 mole of compound **A** at room temperature and pressure.

[3]

[Total: 12]

Section B

Answer **one** question from this section.

9 Kerosene is one of the fractions obtained from the fractional distillation of petroleum. It is commonly used as fuel for jet engines in aeroplanes.

Kerosene is a liquid mixture of hydrocarbons whose molecules contain between six and thirteen carbon atoms. These hydrocarbons are flammable. The equation for the combustion of one of these hydrocarbons is shown.

$$C_{13}H_{28}(l) + 20O_2(g) \rightarrow 13CO_2(g) + 14H_2O(g) \qquad \Delta H_c = -2944 \text{ kJ/mol}$$

Scientists are investigating the possibility of replacing liquid kerosene with ammonia gas. Ammonia is less flammable than kerosene.

The ammonia gas is heated and passed over a catalyst where it is cracked into nitrogen and hydrogen. The enthalpy of combustion is –374 kJ/mol.

(a) (i) Construct a balanced equation for the cracking of ammonia into nitrogen and hydrogen.

……[1]

(ii) State and explain, with reference to oxidation states, which element is oxidised and which element is reduced in **(a)(i)**.

……..

……..

……..

……[2]

(b) The combustion reaction is an exothermic reaction.

Complete and label the energy profile diagrams to show the effect of the catalyst on the energy changes in the combustion reaction.

Your diagram should show:

- the products of the reaction
- the energy profile and activation energy, $E_a(1)$, for the uncatalysed reaction
- the energy profile and activation energy, $E_a(2)$, for the catalysed reaction
- the enthalpy change of reaction, ΔH.

[2]

(c) When 1 kg of $C_{13}H_{28}$ burns, 46000 kJ of energy is given out.

Show by calculation that ammonia gives out less energy per kg than $C_{13}H_{28}$.

[3]

(d) Suggest and explain one disadvantage of aeroplanes carrying tanks of ammonia instead of tanks of kerosene.

……

……[1]

(e) At high temperatures present in a conventional jet engine, nitrogen usually reacts with oxygen and forms nitrogen monoxide as a waste gas.

Identify a health problem caused by nitrogen monoxide.

……[1]

[Total: 10]

10 **(a)** A farmer finds that the shells of several eggs from his hens crack when they are picked up. He sends some eggs to a chemist to find the percentage of calcium carbonate in the eggshell. The eggshells of hens should contain a minimum of 88% calcium carbonate so that they do not crack. If it is less than 88% then the feed given to the hens will need to be changed.

The chemist grinds the eggshells into a powder and then adds 3.62 g of the eggshell powder to 100 cm^3 of 0.500 mol/dm^3 hydrochloric acid. The acid reacts with the calcium carbonate in the eggshell powder.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The acid is in excess.

When the reaction stops, the chemist conducts another experiment to determine the amount of excess acid present.

The amount of excess acid present was found to be 0.0102 mol.

(i) Suggest how the chemist knows when the reaction between the eggshell powder and dilute hydrochloric acid is complete.

……..

……[1]

(ii) Explain why the chemist does **not** use sulfuric acid to react with the calcium carbonate in the eggshell powder.

$$CaCO_3(s) + 2H_2SO_4(aq) \rightarrow CaSO_4(s) + CO_2(g) + H_2O(l)$$

……..

……[1]

(iii) Calculate the number of moles of calcium carbonate present in the eggshell powder.

[3]

(iv) Calculate the percentage of calcium carbonate in the eggshell.

[2]

(v) Explain if the farmer needs to change the feed given to the hens.

……..

…….[1]

(b) Describe how you would carry out a test to show the presence of calcium ions in a solution.

Include the observations you would expect to see.

……

……

……

……

……

……[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											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

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 –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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 x 10^{23} mol^{-1}