TANJONG KATONG GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS

CANDIDATE NAME	MARK SCHEME

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.

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

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

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 (some students gave more than one element):

(i) exists as diatomic molecules,

N / O / F / C*l* / Br [1]

No marks awarded if student gives more than one answer and there is a wrong answer given among the correct ones.

(ii) is a noble gas,

He / Ne / Ar / Kr [1]

(iii) has seven electrons in its outer shell.

F / C*l* / Br [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).

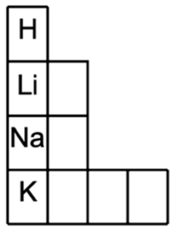


Fig. 1.2

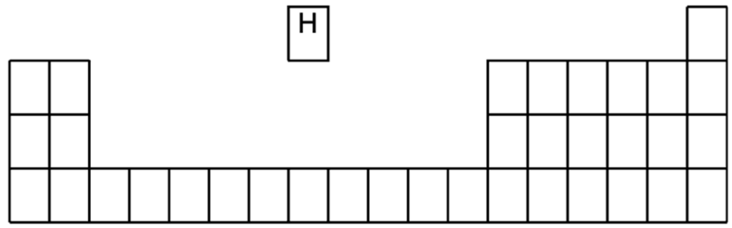


Fig. 1.3

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

Any one point **[1]**:
They have one electron in the outer shell.
They have one valence electron.
They form ions with the 1+ charge.
They lose one electron to form ions.
They react with non-metals.
They act as reducing agents.
They form charge of +1/1+
They have valency 1

Reject:
They have one valence electron shell
They have high reactivity
They have oxidation state of +1

Accept:
Valance (BOD for spelling error)

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

Any one point **[1]**:

It is a non-metal/ not a metal.
It does not conduct electricity.
It is a gas.
It has lower boiling and melting point.
It has lower density.
It exists as a simple covalent compound.
It does not react with water.
It does not react with acids.
It does not form basic oxide.
It can form acidic compounds.
It is a diatomic molecule.

It gains one electron.

Reject:
It is not shiny / dull.
It has low reactivity (without specifying the reactant).

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

Explain why Period 1 only contains 2 elements.

The first electron shell can hold up to two electrons. **[1]**
OR
The two elements in Period 1 have two or less electrons. (WTTE)

(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]

The **carbon-carbon double bond/ C=C** **[1]** in vegetable oil undergoes an **addition/hydrogenation** **[1]** reaction with hydrogen/**hydrogen is added**.

Reject:
Double carbon/ double carbon-carbon bond

Accept:
Double covalent bonds between carbon atoms

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?

Nucleon number is the **total number of protons and neutrons in the nucleus**. **[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]

Let the relative percentage abundance of $^{6}_{3}Li$ be x%

$(\frac{x}{100})(6.015) + (\frac{100-x}{100})(7.016) = 6.942$ **[1]**

$(x)(6.015) + (100 - x)(7.016) = 694.2$

$6.015x + 701.6 - 7.016x = 694.2$

$-1.001x = -7.4$

$x = 7.3926\%$

relative percentage abundance of $^{6}_{3}Li$ is **7.39%**

relative percentage abundance of $^{7}_{3}Li$ is **92.61%** **[1]** for both

(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**.

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

	$^{6}_{3}Li$	$^{2}_{1}H$	$^{4}_{2}He$	n
no. of protons	3	1	2	[redacted]
no. of neutrons	3	1	2	1

No. of protons on reactants side = 4
No. of neutrons on reactants side = 8 – 4 = 4

No. of protons and neutrons must be conserved. Hence, **X** must have 2 protons and 1 neutron.

X must have proton number of 2 and a nucleon number of 2 + 1 = 3 .

Hence, **X** = $\mathbf{^{3}_{2}He}$ **[1]** no need to show working

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

	$^{6}_{3}Li$	$^{2}_{1}H$	p^{+}
no. of protons	3	1	1
no. of neutrons	3	1	[redacted]

No. of protons on reactants side = 4
No. of neutrons on reactants side = 8 – 4 = 4

No. of protons and neutrons must be conserved. Hence, **X** must have 3 protons and 4 neutrons.

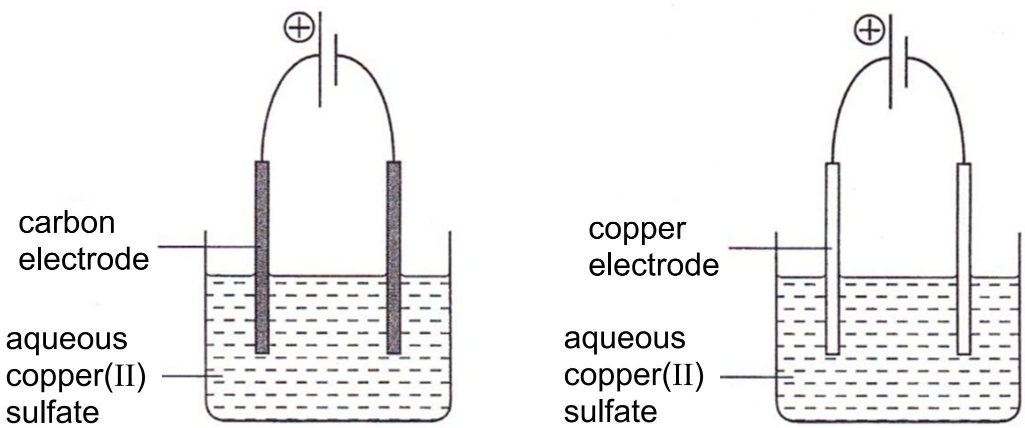
Y must have proton number of 3 and a nucleon number of 3 + 4 = 7

Hence, **Y** = $^{7}_{3}$**Li** **[1]** no need to show working

Since the question asks for the identity of **X** and **Y**, the identities, i.e. He and Li should be written. This is in addition to the proton numbers and nucleon numbers.

Reject:
Isotopes of He/ Li
Lithium and Helium

(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: $\mathbf{4OH^{-}(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^{-}}$ **[1]**

Cell 2: $\mathbf{Cu(s) \rightarrow Cu^{2+}(aq) + 2e^{-}}$ **[1]**

Reject: e^{+}
Marks will be deducted if no state symbols are written

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

Red-brown/ brown/ pink solid / copper is **deposited/coated** onto the electrode.**[1]**
OR
The **cathode increases in mass/ increase in size.**

Reject:

specks
precipitate

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

Any two of the following:

The colour of the aqueous copper(II) sulfate changes from **blue to colourless** **[1]**

Effervescence/ Bubbles of O_2 at the anode **[1]**

Reject:
Copper concentration decreases.
Electrolysis will stop after copper ions are used up.

Note:

The oxygen produced at the anode would react with the carbon electrode forming carbon dioxide and the anode gradually become smaller.
This reaction is not due to the redox reactions in the electrolysis process.
Hence, the anodes must be replaced frequently.

The focus of this question is the redox reactions happening due to the electrolysis process.

[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.

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....[4]

- **lead(II) nitrate, $Pb(NO_3)_2$, and sodium iodide, NaI. [1]**

accept either spelt out or formulae written.
accept other answers if the two reagents used are soluble salts that contain the respective Pb^{2+} and I^- ions.
Iodine solution contains the iodine molecule, not the ion I^-, it is not accepted.

- Add excess aqueous lead(II) nitrate to aqueous sodium iodide and stir until no more precipitate forms.
- **Filter** **[1]** the mixture to collect the lead(II) iodide precipitate.
- **Wash** the precipitate with distilled water to remove impurities.
- Allow the precipitate to **dry** between a few sheets of filter paper.

description of washing and drying **[1]**

$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$ [1]

Marker's comment
Using filter paper without filter funnel is not accepted.
Once there is a wrong technique mentioned, eg heating to dryness, carrying out crystallisation, no marks given for washing and drying.

A lot of students left out '2' in front of I^- when balancing the ionic equation.

(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]

most reactive magnesium, zinc, iron, cobalt least reactive

[2] for all correct

[1] for any two metals arranged correctly

(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]

<u>Basic oxides</u> <u>react with acids</u> whereas **<u>amphoteric oxides react with both acids and bases</u>**. **[1]**

$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

[1] for any reaction between MgO / ZnO with an acid or ZnO with a base.

Reject:
display acidic and alkaline properties
react with acidic substances, basic substances, acidic oxide, basic oxides
act as acid, act as base

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.

Potassium fluoride has a **giant ionic structure** with **strong electrostatic forces of attraction between its oppositely charged ions**, **[1]** K^+ and F^-.

accept if students write ionic bonds between oppositely charged ions, K^+ and F^-.
accept if students use K^+ and F^- instead of oppositely charged ions as they show understanding that the attraction is between oppositely charged species.

Silicon dioxide has a **giant molecular / covalent structure** with **strong covalent bonds between Si and O atoms**. **[1]**

Both structure names **[1]**

(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.

Silicon fluoride has a **simple molecular/ covalent structure[1]** with weak intermolecular forces of attraction.

At room temperature, the **energy is sufficient to overcome the weak intermolecular forces of attraction** **[1]** hence, silicon fluoride exists as a gas.
Student must show clearly the concept that at room temperature the energy is sufficient to overcome the intermolecular forces of attraction to answer the question.

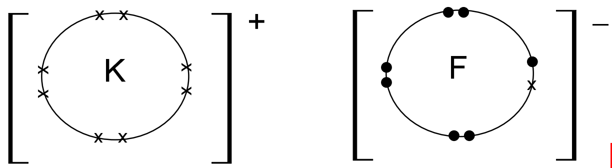
(iii) Explain why graphite is soft and slippery.

The **layers** of carbon atoms are held by **weak intermolecular forces of attraction**, allowing them to **slide easily** over one another. **[1]**

Marker's comments
Many students missed out 'slide easily'. This is important as you are talking about graphite being soft and slippery.

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

Show outer shell electrons only.



[1] for cation and [1] for anion

[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?

$C_{12}H_{26}$ [1]

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

$C_{12}H_{26} \rightarrow C_4H_8 + C_8H_{18}$ [1]

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

Cracking produces **more useful shorter chain / lower M_r compounds** **[1]** that are in higher demand.

Accept:
Cracking produces shorter-chain alkenes which are starting materials for many important industrial processes.

Cracking produces shorter-chain alkanes which are in high demand as fuel.

Cracking allows the supply from refining crude oil to match the industrial demand of shorter-chain alkanes and alkenes.

Cracking produces hydrogen which can be used in important industrial reactions.

Note: above taken from textbook page 351.

(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.

$C_2H_4 + H_2O \rightarrow C_2H_5OH$ [1]

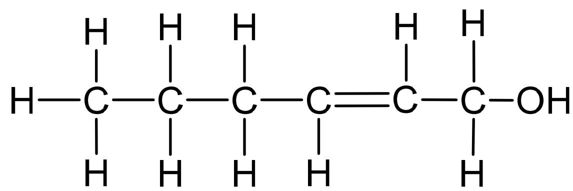
High Temperature and Pressure. H_3PO_4 catalyst [1]

Markers' Comments

Many students confused this reaction with the fermentation reaction of glucose.

(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 $CH_3CH_2CH_2CH=CHCH_2OH$.

Aqueous Br_2 **[1]**

<u>Brown / red-brown</u> aqueous Br_2 **<u>decolourise</u>**. **[1]**

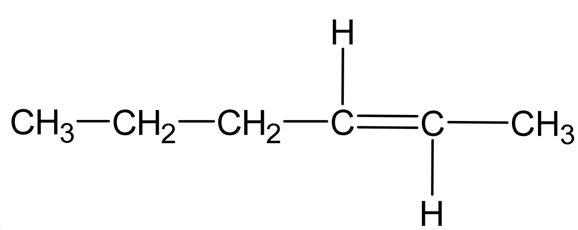
<u>Markers' Comments</u>

The correct answer should be aqueous bromine. Students should take note that we don't use liquid bromine as chemical test for alkenes.

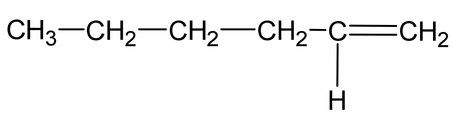
Common errors include giving the result "decolourised" without stating initial colour of aqueous bromine.

(ii) Hexene has three straight-chain isomers.

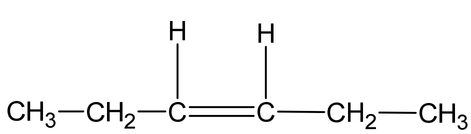
One of them is



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



[1]



[1]

Markers' Comments

Many students were unable to differentiate between the various isomers often giving the same molecules as isomers. These students are to seek clarifications from their teachers.

Some students did not read the question hence, drew branched-chain isomers instead.

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

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

propanoic acid [1]

[Total: 10]

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

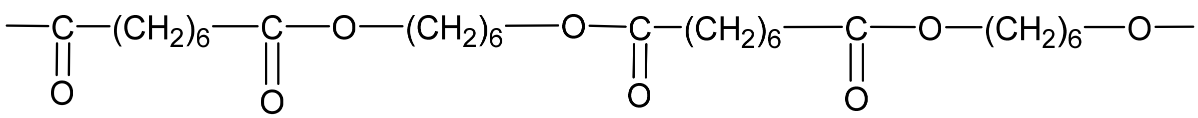
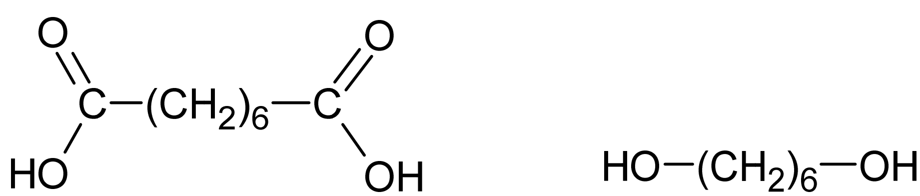


Fig. 6.1

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



[1] for each monomer

Reject:
Wrong bonding of atoms. eg. OH-$(CH_2)_6$-OH or COOH-$(CH_2)_6$-COOH
Include bracket/n/polymer line extension

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

ester [1] linkage

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

Hot **aqueous acid** **[1]**

Accept:
Any acid / any acid catalyst (BOD)

Reject:
High temperature & pressure/water/any concentrated acids

(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.

[Total: 6]

Similarity:**[1]**

Both polymerisation involve the joining of molecules/ monomers to form a bigger one/ form a polymer.

Reject: addition of monomers

Both require high temperature/pressure.
Both forms synthetic polymers.

Reject: both break and form bonds

Difference: **[1]**

For addition polymerisation, the total mass of the monomers used to make up the polymer is the same as the mass of the polymer.

For condensation polymerisation, the total mass of the monomers used to make up the polymer is more than the mass of the polymer.

Accept:
For addition polymerization, empirical formula of the monomer and polymer are the same.

For condensation polymerization, empirical formula of the monomer and polymer are different.

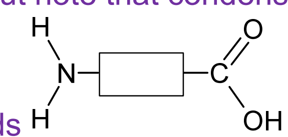
Condensation polymerisation produces molecules of water whereas only one single product / no water is formed for the addition polymerisation.

Accept:
No atoms are lost for addition polymerization but water is lost for condensation polymerization.

Reject:
Lost/no loss of molecules (without specifying water).
Form polyethene vs polyester

Same monomer is used for addition polymerisation while two different monomers are used for condensation polymerisation.

Accept:
Saturated monomer is used for addition polymerization and unsatured monomers are used for condensation polymerization.

Monomers undergoing condensation polymerisation contain carboxyl and hydroxyl functional groups while monomers undergoing addition polymerization contain carbon-carbon double bonds/C=C.
Note:
The last point is true for Q6a but note that condensation polymerisation of similar monomers such as amino acids  can occur.

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.

The initial rate of experiment 1 would be **higher** / **faster** **[1]** than the initial rate of experiment 2.

Experiment 1 has a higher concentration of ethanoic acid. Hence, there are **more particles/ions/molecules per unit volume/per volume ratio.** **[1]**

Reject:
More moles / dm^3

The **frequency of effective/successful collisions increases**.**[1]**

Reject:
Chance/number/rate/more effective collisions

(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.

When temperature increases, the reactant particles gain kinetic energy, move, and vibrate faster.

More particles possess energy equal or greater than activation energy. **[1]**

The **frequency of effective collisions increases**.**[1]** Rate of reaction increases.

No ecf if 'frequency' is not mentioned in both (i) and (ii)

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

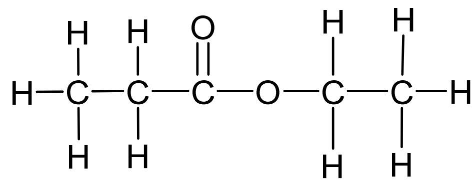
Name and draw the full structural formula of the organic product and name the functional group present.

(i) Name the organic product formed.

name of product: **ethyl propanoate** **[1]**

Reject: ethyl proponoate

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



[1]

[1]

Some students drew a 4C carboxylic acid. i.e. ethyl butanoate

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

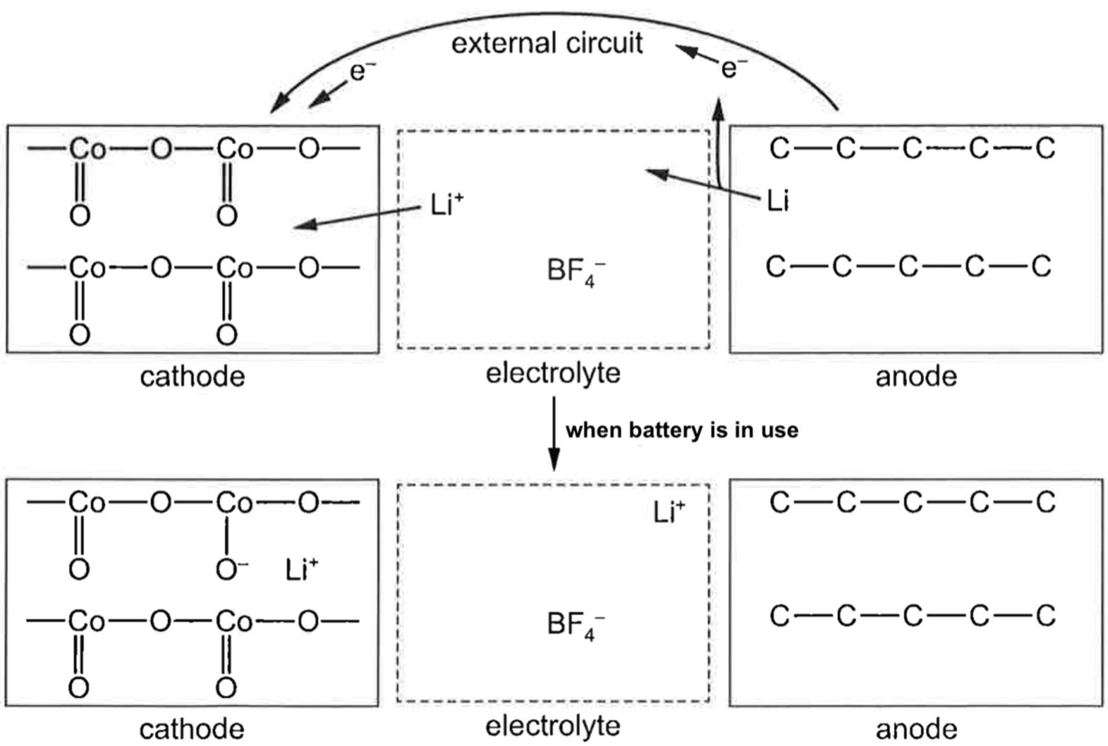
[Total: 8]

functional group: **ester** **[1]**

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.

Inert electrodes are electrodes that **<u>do not take part in the</u>** redox **<u>reactions</u>**. An electrode that is not inert **<u>takes part</u>** in the redox reactions.**[1]**

<u>Markers' Comments</u>

It is surprising that many students do not know the difference between an inert electrode and an electrode that is not inert. Students are reminded to remember the definitions and use the key phrases.

(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.

There are **electrostatic forces of attraction between Li^+ cations** and the **delocalised / free-moving electrons** in graphite. **[1]**

Markers' Comments

No marks were awarded to incomplete answers. Many students merely stated that there were delocalised electrons present but were unable to relate it to the electrostatic forces of attraction with Li^+ cations.

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

$Li \rightarrow Li^+ + e$ **[1]**

Markers' Comments

Many students were unable to recognise that oxidation occurred at the anode therefore the Li atom must have oxidised to form Li^+ ions.

(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.

$2Li_2O_2 + 2CO_2 \rightarrow 2Li_2CO_3 + O_2$ **[1]**

Markers' Comments

Many students did not read the question properly. It is expected that students know that exhaled air contains CO_2 and breathable air contains O_2. Thus, from the product (lithium carbonate) mentioned in the question, it is not difficult to deduce that the reactant is CO_2 and the product is O_2. A few students could not get the correct formula of lithium carbonate. Common mistakes include writing it as $LiCO_3$ instead.

(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.

$Li_2CO_3 \rightarrow Li_2O + CO_2$ [1]

Markers' Comments

It is surprising that many students do not know the formula for lithium oxide, writing it as LiO instead of Li_2O. Also, many students thought that thermal decomposition involves oxygen thus included O_2 as the reactant.

(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.

	Li	C*l*	O
% mass	6.52	33.32	60.16
A_r	7	35.5	16
no. of moles	0.931	0.939	3.76
mole ratio	1	1	4

[1] for no of moles calculated correctly for the 3 elements.
[1] for table working

Empirical formula is **$LiClO_4$** **[1]** student must state the empirical formula and not leave it to the marker to infer from the workings.

Markers' Comments

No marks are awarded for incomplete or unclear table workings. Students are reminded to present their answers (especially for the table) in a clear and concise manner.

(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**.

$LiClO_4 \rightarrow 2O_2 + LiCl$ [1]
e.c.f for wrong empirical formula deduced in (ci)
equation must be balanced.

Markers' Comments

No marks are awarded if students are unable to get the empirical formula of A in (i) yet able to form an equation in (ii).

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.

$LiClO_4 \rightarrow 2O_2 + LiCl$

volume occupied by 2 mol of O_2 = 2 x 24
= 48 dm^3 **[1]** e.c.f based on (cii)
= 48000 cm^3

mass of 1 mol of compound **A** = 1 x [7 + 35.5 + 4(16)] = 106.5

volume of compound **A** = 106.5 ÷ 2.42
= 44.008 cm^3 **[1]**
e.c.f volume of compound **A** based on (ci)
Answers to volume calculated can be in dm^3 or cm^3

$OV = \frac{48000}{44} = \underline{\mathbf{1090}}$ **[1]**

Markers' Comments

Surprisingly many students do not know how to calculate volume when given M_r and density values.

Students are reminded to include correct units in their answers.

[Total: 12]

Section B

Answer **one** question from this section.

Comment : Please note that 'O' level examiner will only mark the first question if both questions in section B are attempted.

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.

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$ **[1]**

Accept $2NH_3 \rightarrow N_2 + 3H_2$

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

Nitrogen is oxidised and oxidation state of nitrogen increases from –3 in NH_3 **to 0** in N_2. **[1]**

Hydrogen is reduced and oxidation state of hydrogen decreases from +1 in NH_3 **to 0** in H_2. **[1]**

Comment: please note the proper way to phrase the explanation. A number of students are not clear how to calculate the oxidation states.

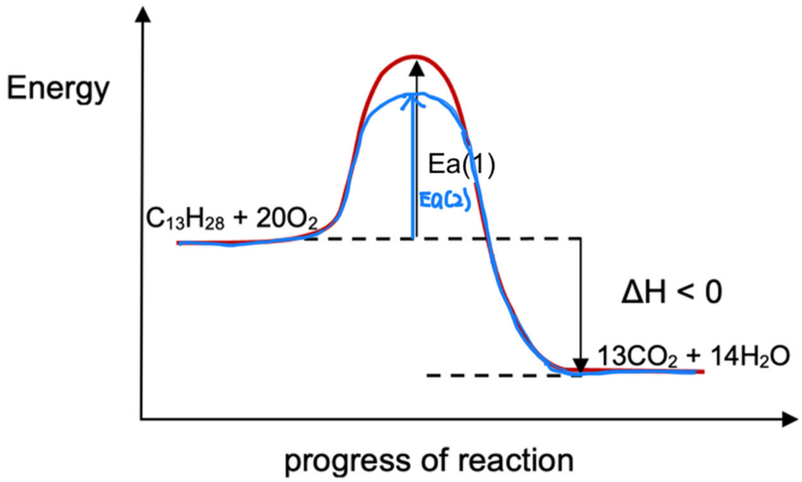
(b) The combustion reaction is an exothermic reaction.

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.



[1] starting and ending energy levels of reactants and **products** + **correct labels** must be the same for both diagrams. Catalyst only lowers Ea not the energy levels of reactants and products.
[1] Ea(2) in the catalysed reaction must be lower than Ea(1) in reaction without catalyst
[0] if students draw endothermic energy profile diagrams.

Reject if the arrows for Ea(1) and Ea(2) are on the same line.

In general, this question is well done.

(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 $C_{13}H_{28}$.

ΔH_c = 374 ÷ (14 + 3)
= –22 kJ/g **[1]** must have negative sign
= –22000 kJ/kg **[1]** must have negative sign

students can also express the above in words:
1 kg of NH_3 burns, 22000 kJ of energy is given out.

OR
no of mol of NH_3 = 1000 ÷ (14 + 3)
= 58.823 mol **[1]**
amount of energy released = 58.823 x 374 = 22000 kJ **[1]**

When 1 kg of NH_3 burns, 22000 kJ of energy is released is lesser 46000 kJ.
Statement linking 22000 to 46000 WTTE **[1]** Students can also compare ΔH_c magnitudes instead.

Ecf (1m) in the comparison statement if the calculation for energy released in kJ/kg is incorrect.

Comment: Surprisingly, this question is challenging to many students. This questions want students to compare the energy given out in terms of KJ/ Kg. Hence students must know how to convert the energy from 374 kJ/mol to kJ/kg by proportion.
Energy released by $C_{13}H_{28}$ per kg is already given. There is not for calculations on $C_{13}H_{28}$
A comparison has to be made at the end of the calculation.

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

Ammonia is a toxic / poisonous / corrosive gas, posing significant health and safety risks in the event of a leak. **[1]** state + explain

OR

Ammonia exist as a gas at room temperature. Hence it needs to be transported in high-pressure cylinders/ compression tanks which can be dangerous to handle/ difficult to maintain.

OR

Ammonia gives out less energy than kerosene which means larger volume of ammonia would be required to achieve the same energy content as kerosene.

any other valid points

(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.

[Total: 10]

Breathing difficulties [1]

Accept: lung infection, respiratory tract irritation, lung problems, eye irritation.
Reject: headache, skin cancer, cataract, lung cancer

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.

No effervescence / bubbles **[1]** of CO_2 gas will be observed.

Reject:
No more carbon dioxide given because it is not an observation
Volume of carbon dioxide reaches maximum volume because there is no gas syringe.

Accept:
Eggshell stopped dissolving

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

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

Insoluble $CaSO_4$ will **coat onto the surface of $CaCO_3$**, **preventing further reaction** **[1]** between $CaCO_3$ and sulfuric acid.

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

No of mol of HC*l* added at the beginning = $\frac{100}{1000} \times 0.500$
= 0.0500 mol **[1]**

No of mol of HC*l* which reacted with $CaCO_3$ in the powder
= 0.0500 – 0.0102
= 0.0398 mol **[1]**

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

No of mol of $CaCO_3$ present in 3.62 g of powder = 0.0398 ÷ 2
= **0.0199 mol** **[1]**

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

Mass of $CaCO_3$ present in 3.62 g of eggshell powder
= 0.0199 x [40 + 12 + 3(16)]
= 1.99 g **[1]** e.c.f the value of no of mol of $CaCO_3$ from (iii)

% of $CaCO_3$ in eggshell = $\frac{1.99}{3.62} \times 100\%$

= **55.0%** **[1]** 3 s.f.
E.C.F. the mass of $CaCO_3$ obtained earlier based on the no of mol of $CaCO_3$ from (iii).

Reject:
Mole of $CaCO_3$ = 3.62/ (40+12+3x16) = 0.0362 mol
Because not the full 3.62g contains $CaCO_3$.

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

……………………………………………………………………………………..

…………………………………………………………………………………….[1]
Since the **% $CaCO_3$ is less than 88%,** hence the farmer **needs to change** **[1]** the feed.
E.C.F. based on students' answer in (iv)

(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.

[Total: 10]

Add **NaOH(aq)** **[1]** to the solution.

If Ca^{2+} ions are present, a **white precipitate** will be formed. The white precipitate is **insoluble** in **excess** NaOH(aq) added. **[1]**

Reject
Add aqueous ammonia, no ppt seen.