# HUA YI SECONDARY SCHOOL
# PRELIMINARY EXAM 2024

# 4-G3

| | | | |
|---|---|---|---|
| NAME | | | |
| CLASS | | INDEX NUMBER | |

**CHEMISTRY** **6092/02**

**PAPER 2**

**20 August 2024**

**1 hour 45 minutes**

Additional Materials: Nil

## READ THESE INSTRUCTIONS FIRST

Write your Name, Class, and Index Number 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, highlighters, 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.

| | |
|---|---|
| **Section A** | /70 |
| **Section B** | |
| | /10 |
| **Total** | /80 |

The use of an approved scientific calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.
The Periodic Table is provided on page 27.

This document consists of **27** printed pages and **1** blank page.



Setter: Mr Chong KQ

## Section A [70 marks]

Answer **all** questions in the spaces provided.

**1** Fig. 1.1 shows part of the Periodic Table with some elements shown.

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | H | | | | | | | | | | |
| | | | | | | | | | | | | C | N | O | | | |
| Na | Mg | | | | | | | | | | | Al | Si | P | | | |
| K | Ca | | | | | | Fe | | | Cu | Zn | | | | | | |
| Rb | | | | | | | | | | | | | | | | | |

**Fig. 1.1**

Each element may be used once, more than once or not at all.

Using the symbols in the diagram, give **one** element which

**(a)** has a giant molecular structure,

……..... [1]

**(b)** combines with oxygen to form a gas which contributes to acid rain,

……..... [1]

**(c)** forms an ion of type $X^+$ which has only three completely filled shells of electrons,

……..... [1]

**(d)** forms a chloride that is soluble and with excess sodium hydroxide solution; the white precipitate remains insoluble,

……..... [1]

**(e)** is often used in galvanisation to prevent rusting.

……... [1]

[Total: 5]

**2** Silicon is a Group 14 element and is the second most abundant element in the Earth's crust. It can be extracted by heating sand (silicon dioxide, $SiO_2$) with carbon to temperatures approaching 2200 °C, producing carbon monoxide as a side product.

Naturally occurring silicon is composed of three stable isotopes and the mass spectrum of the isotopes are as shown in Fig. 2.1.

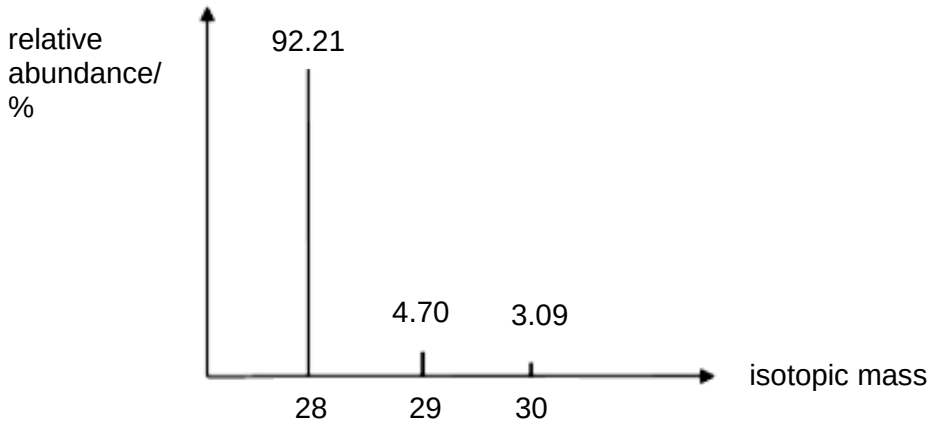



**Fig. 2.1**

**(a)** Write a balanced chemical equation for the reduction of sand into silicon.

……..... [1]

**(b)** Using the relative abundance of the 3 isotopes of silicon, calculate the relative atomic mass of silicon.

relative atomic mass of silicon = ……. [2]

**(c)** Using the information in Fig. 2.1, explain why the isotopic mass for the 3 isotopes of silicon is different.

……..... [2]

**(d)** Use ideas about bonding and structure to explain the high melting point of sand.

…….....

…….....

…….....

……..... [2]

[Total: 7]

**3** Fig. 3.1 shows the set-up used to investigate the relative reactivity of metals **A**, **B**, **C** and **D**. The metal strips and copper were first cleaned with sandpaper. Various metal strips were connected in turn with the copper sheet and the voltage recorded.

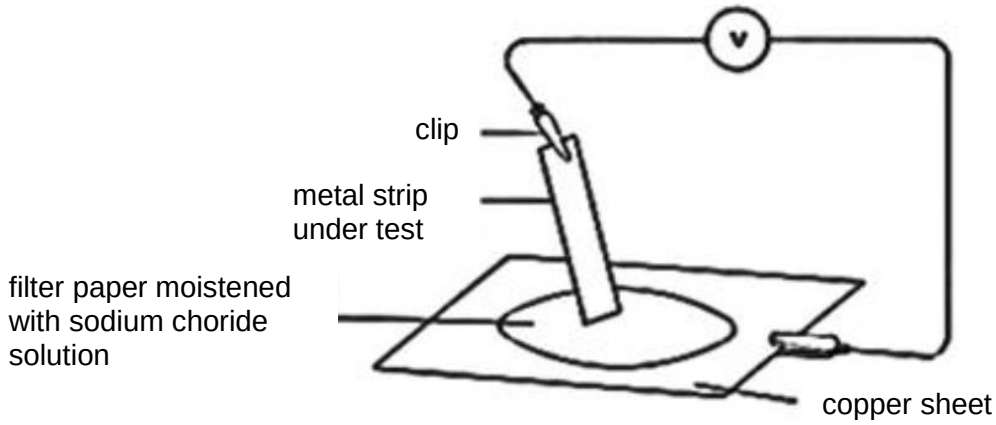



**Fig. 3.1**

Table 3.1 gives the results of the investigation.

**Table 3.1**

| metal under test | direction of electron flow in the external circuit | voltage recorded/ v |
|---|---|---|
| **A** | A to Cu | + 1.40 |
| **B** | B to Cu | - 2.22 |
| **C** | A to C | + 0.77 |
| **D** | A to D | + 0.28 |

**(a)** Arrange the four metals **A**, **B**, **C** and **D** in decreasing order of reactivity.

……..... [1]

**(b)** Which of these metal(s) is/are less reactive than copper?

Explain your answer using concepts of tendencies of electron flow.

……..... 

……..... [2]

[Total: 3]

**4** Six samples of metal carbonates are heated strongly until there is no further change in mass.

Table 4.1 shows the mass of solid remaining at the end of the heating.

**Table 4.1**

| metal carbonate | mass before heating /g | mass after heating /g |
|---|---|---|
| calcium carbonate | 2.00 | 1.30 |
| copper(II) carbonate | 2.00 | 0.95 |
| iron(II) carbonate | 2.00 | 1.12 |
| magnesium carbonate | 2.00 | 1.29 |
| sodium carbonate | 2.00 | 2.00 |
| zinc carbonate | 2.00 | 1.24 |

**(a)** State and explain, with the use of information from Table 4.1, which of the above carbonates is the least thermally stable.

……..... 

……..... [2]

**(b)** Explain why sodium carbonate has no change in mass as compared to the other carbonates in Table 4.1.

……..... 

……..... [1]

**(c)** Metals are extracted from the metal carbonates by different methods.

Suggest and explain the methods that would be suitable for the extraction of metals from the metal carbonates listed in Table 4.1.

……..... [2]

……..... 

**(d)** Apart from the ease of thermal decomposition of metal carbonate, explain why the mass of solid obtained **after** heating is different for each metal carbonate.

……..... 
[2]
……..... 

[Total: 7]

**5** Transition elements are a block of metals found in Group 3 to 12 of the Periodic Table. Some information about the transition elements in Period 4 are shown in Tables 5.1 and 5.2.

**Table 5.1**

| **element** | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| **density / g/cm$^3$** | 2.99 | 4.50 | 5.96 | 7.20 | 7.20 | 7.86 | 8.90 | 8.90 | 8.92 | 7.14 |
| **melting point / °C** | 1541 | 1660 | 1890 | 1857 | 1244 | 1535 | 1495 | 1455 | 1083 | 420 |

**Table 5.2**

| **element** | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| **common oxidation states that occur in compounds** | +3 | +4<br>+3<br>+2 | +5<br>+4<br>+3<br>+2 | +6<br>+5<br>+4<br>+3<br>+2 | +7<br>+6<br>+5<br>+4<br>+3<br>+2 | +6<br>+5<br>+4<br>+3<br>+2 | +4<br>+3<br>+2 | +4<br>+3<br>+2 | +2<br>+1 | +2 |

**(a)** State one characteristic property of a transition metal that is **not** shown in both Tables 5.1 and 5.2.

……..... [1]

**(b)** Two students were discussing their observation on the elements shown in Tables 5.1 and 5.2. The following are excerpts from their conversation.

Student A, “All elements shown are transition metals.”

Student B, “There are two metals shown that should not be considered as transition metals.”

**(i)** Which **two metals** is Student B referring to?

……..... [1]

**(ii)** Using relevant information in both Tables 5.1 and 5.2, explain why Student B thinks in that way.

……..

……..

……..

……..

……..

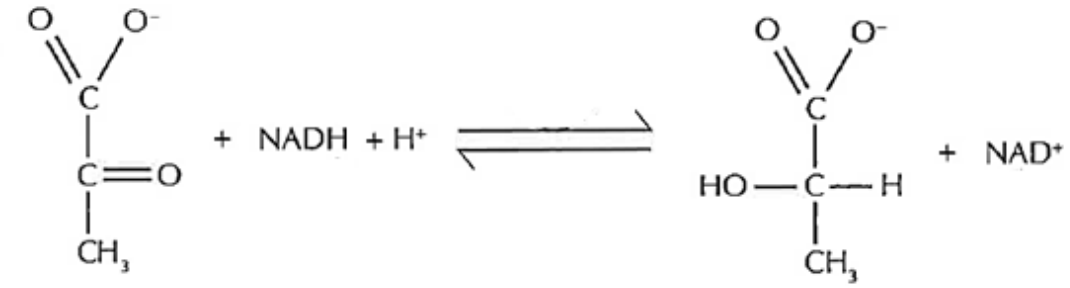
……..... [3]

[Total: 5]

**6** Redox reactions are commonly found in biological and industrial reactions.

**(a)** During strenuous exercises, parts of the human body may experience low oxygen levels, causing glucose in the human cells to be broken down into lactic acid to provide energy for the cells.

The process of breaking down glucose into lactic acid involves many reactions. One of the reactions is shown in Fig. 6.1. [NADH represents Nicotinamide Adenine Dinucleotide]




pyruvate lactate

**Fig. 6.1**

**(i)** State which substance is reduced in the equation.

Using relevant information from Fig. 6.1, explain your answer in terms of hydrogen.

…….....

…….....

……..... [2]

**(ii)** State the reducing agent.

……..... [1]

**(b)** The chemical equation between cyanide solution (sodium cyanide) and the gold present in the ore is shown below:

$$4Au + 8NaCN + O_2 + 2H_2O \rightarrow 4Na[Au(CN)_2] + 4NaOH$$

Use oxidation states to explain why this reaction is a redox reaction.

…….....

…….....

…….....

……..... [2]

[Total: 5]

**7** Hydrogen peroxide is unstable and decomposes to form oxygen gas and water. At room temperature, the reaction can be very slow but the reaction can be sped up by heating the mixture.

**(a)** Explain, in terms of collisions between particles, why a higher temperature affects the rate of reaction.

…….....

…….....

…….....

……..... [2]

**(b)** Manganese dioxide can be used as a catalyst for the decomposition of hydrogen peroxide. A student investigated the effect of the particle size of manganese dioxide on the rate of the reaction. She added 3 g of fine manganese dioxide powder to 25 $cm^3$ of 0.4 $mol/dm^3$ hydrogen peroxide solution in a conical flask and measured the volume of gas produced every minute for 10 minutes. She then repeated the experiment with 3 g of coarse manganese dioxide granules.

Fig. 7.1 shows the results she obtained.

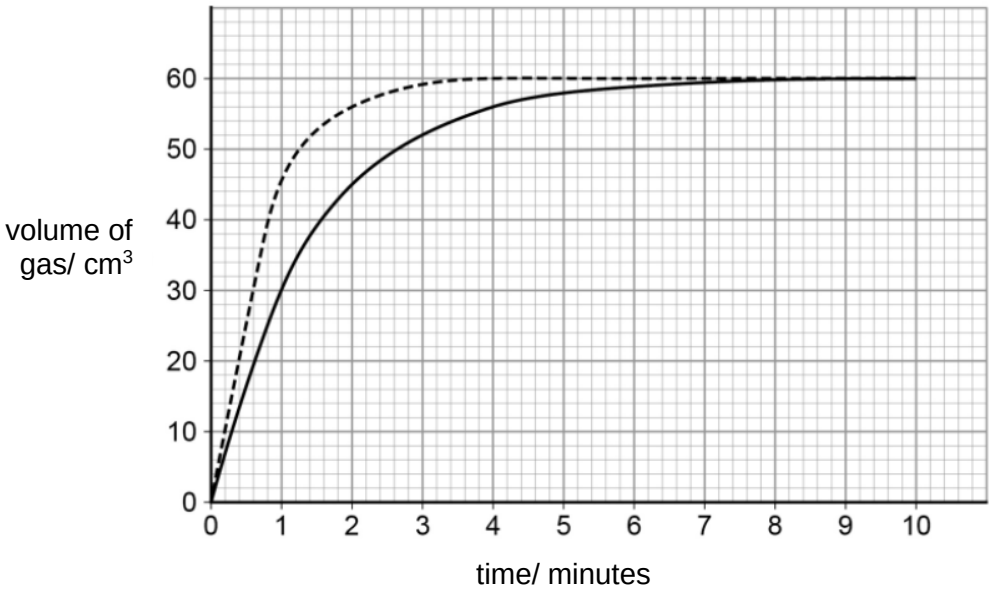



**Fig. 7.1**

Key:

| graph type | type of manganese dioxide |
|---|---|
| - - - - - - | |
| ——— | |

**(i)** Indicate in the key, the type of manganese dioxide used for the corresponding graph in Fig. 7.1. [1]

**(ii)** Describe and explain the difference in the shapes of the two graphs obtained.

…….....

…….....

…….....

……..... [2]

**(iii)** Sketch on Fig. 7.1, the graph obtained if 25 $cm^3$ of 0.2 $mol/dm^3$ hydrogen peroxide is decomposed using 2 g of coarse manganese dioxide granules as catalyst. The reaction completes at 4 minutes. [1]

**(iv)** The concentration of hydrogen peroxide is often described as volume strength.

This relates to the volume of oxygen that can be produced from a hydrogen peroxide solution.

**volume of oxygen produced = volume strength x volume of hydrogen peroxide solution**

Using relevant information from Fig. 7.1 and the formula above, calculate the volume of oxygen produced if 18 $cm^3$ of hydrogen peroxide solution was used.

volume of oxygen produced …….. $cm^3$ [1]

**(v)** Another student carried out an experiment to investigate the effect of concentration of hydrogen peroxide solution on the reaction rate.

The results are shown in Fig. 7.2.

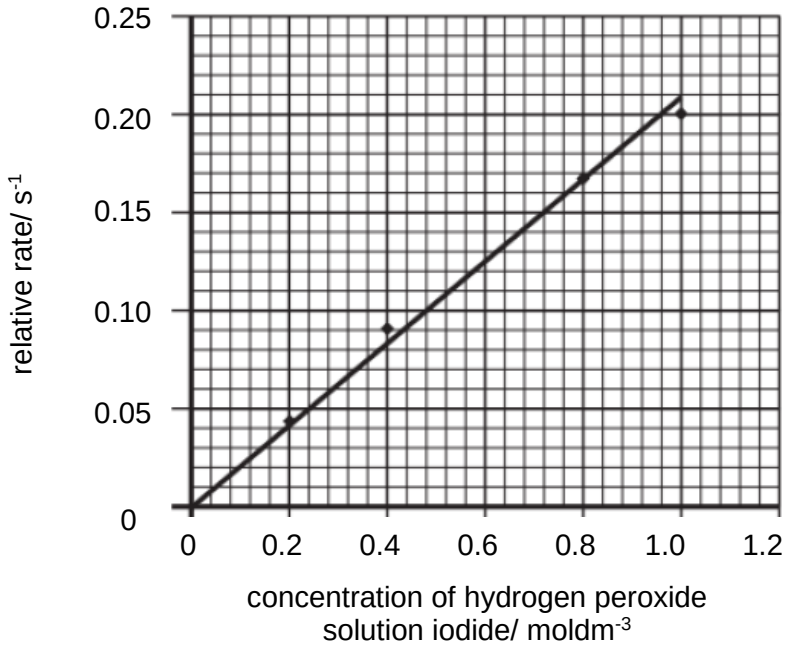



**Fig. 7.2**

Using relevant information in Fig. 7.2, calculate the time taken, in s, for the reaction when the concentration of hydrogen peroxide solution used was 0.6 mol/dm$^3$.

time taken …….. s [1]

[Total: 8]

**8** The electrolysis of concentrated aqueous hydrochloric acid was carried out using the apparatus as shown in Fig. 8.1.

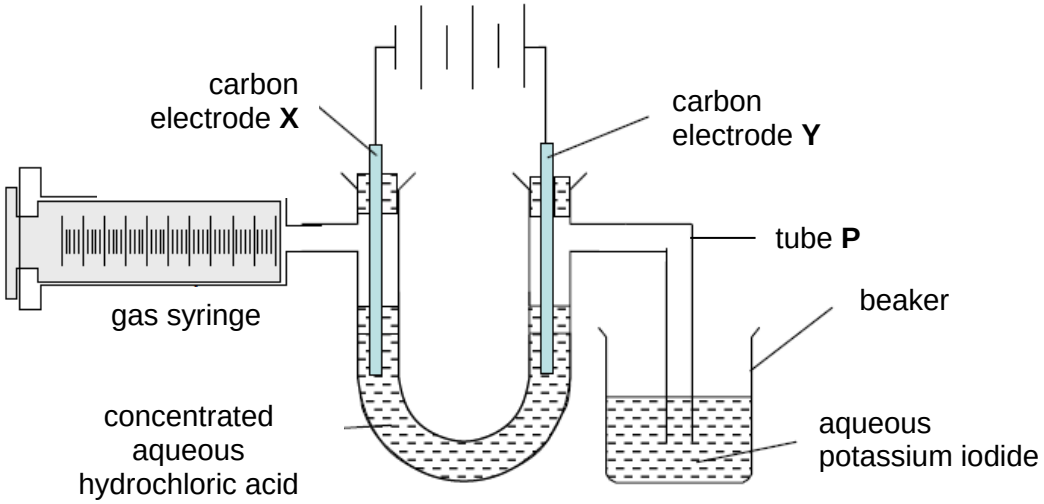



**Fig. 8.1**

**(a)** Construct the half equations, with state symbols, for the reactions at the electrodes.

electrode **X**

……

electrode **Y**

…… [2]

**(b)** The gas discharged at electrode **Y** is bubbled into a beaker containing aqueous potassium iodide.

With the aid of a balanced chemical equation, describe what you would observe in the beaker.

……

…… [2]

**(c)** After the electrolysis was allowed to proceed for some time, it was observed that a new product was formed at carbon electrode **Y**.

**(i)** Suggest the identity of this new product.

Explain your answer.

……

……

……

…… [2]

**(ii)** After allowing the electrolysis to carry on for a while with the new gas identified in **8(c)(i)** coming out from tube **P**, it was found that 30 $cm^3$ of gas was collected in the gas syringe in Fig. 8.1.

Deduce and explain the volume of this new gas produced at electrode **Y** as identified in **8(c)(i)**.

…….....

…….....

…….....

……..... [2]

**(iii)** Determine the number of moles of electrons that have passed through when 30 $cm^3$ of the gas, as identified in **8(a)**, was collected at the gas syringe.

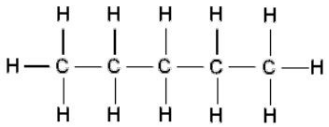
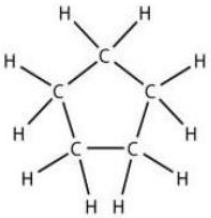
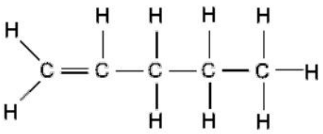
number of moles of electrons……..…… [2]

[Total: 10]

**9** Organic substances are commonly found amongst us.

**(a)** Table 9.1 shows the names and structural formulae of some hydrocarbons with 5 carbon atoms.

**Table 9.1**

| no. of carbon atoms | alkane | cycloalkane | alkene |
|---|---|---|---|
| 5 |  pentane |  cyclopentane |  pentene |

**(i)** Using the information from Table 9.1, explain why pentene and cyclopentane are isomers, but pentane and cyclopentane are not.

……

…… [2]

**(ii)** Describe a chemical test that can be used to distinguish between cyclopentane and pentene.

test

……

observation in cyclopentane

……

……

observation in pentene

……

…… [2]

**(b)** Pentene can go through a series of reaction to form a sweet-smelling liquid, as shown in Fig. 9.1.

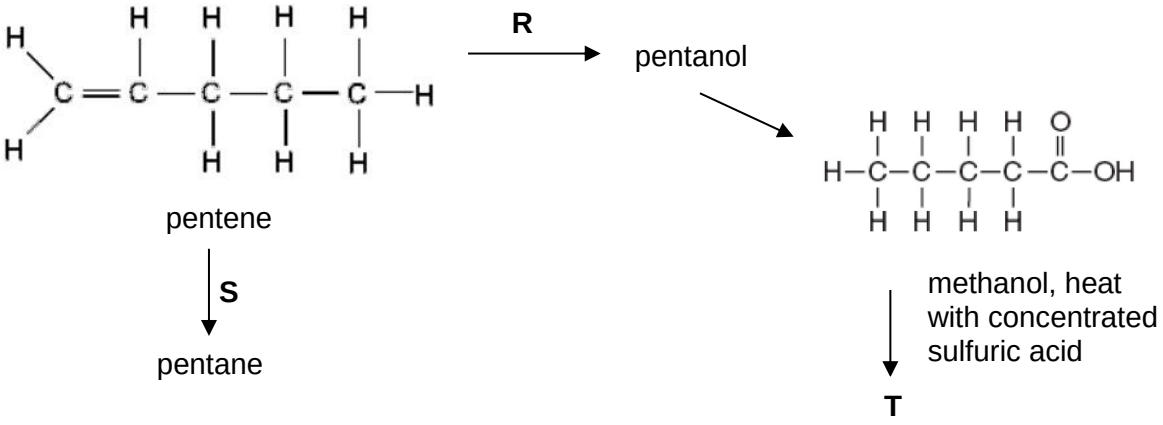



**Fig. 9.1**

**(i)** State the reagents and / or conditions required for the following reactions.

**R** ……...

**S** ……... [1]

**(ii)** Draw the full structural (displayed formula) of **T**. [1]

full structural formula of **T**:

**(iii)** State the chemical name of **T**.

……..…….…….. [1]

**(c)** Styrene exists as a colourless oily liquid at room temperature. Fig. 9.2 shows the structure of styrene is shown below.

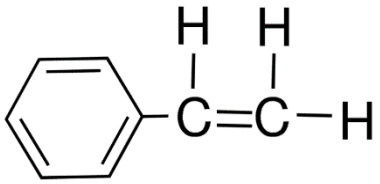


**Fig. 9.2**

For this question, it may be assumed that the benzene ring (  ) is inert.

When styrene is exposed to air, heat or light, it quickly undergoes addition polymerisation to form a hard, rubber-like solid, poly(styrene).

**(i)** Draw poly(styrene), showing at least 2 repeat units. [1]

**(ii)** Describe **one** environmental problem that poly(styrene) poses.

…… [1]

[Total: 9]

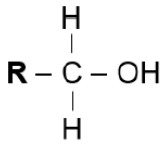
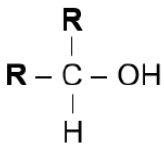
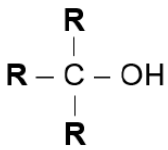
**10** Alcohols can be classified into different types - primary, secondary or tertiary alcohols, according to the number of alkyl groups bonded to the central carbon atom to which the hydroxyl functional group is attached to.

An alkyl group consists of carbon and hydrogen atoms. It is formed by removing one hydrogen atom from the alkane chain. The alkyl group will then attach to a carbon chain, forming a branch. An alkyl group is usually represented using the symbol **R**.

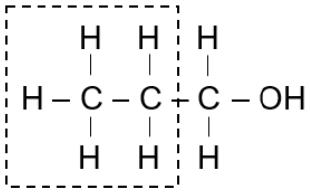
Examples of alkyl groups can be methyl ($-CH_3$), ethyl ($-C_2H_5$), propyl ($-C_3H_7$), butyl ($-C_4H_9$), etc.

Table 10.1 shows the different types of alcohols and their structures.

**Table 10.1**

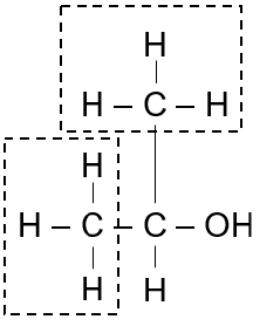
| type of alcohol | no. of alkyl groups attached to the carbon atom with hydroxyl group | structure |
|---|---|---|
| primary | 1 |  |
| secondary | 2 |  |
| tertiary | 3 |  |

Some examples of the different types of alcohols are shown in Fig. 10.1 and 10.2.



propan-1-ol

**Fig. 10.1**



propan-2-ol

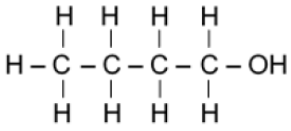
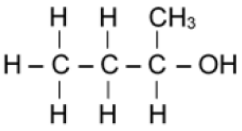
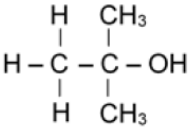
**Fig. 10.2**

Each dotted box in Fig. 10.1 and Fig. 10.2 shows one alkyl group. Propan-1-ol contains one alkyl group, hence it is a primary alcohol and propan-2-ol, having two alkyl groups attached to the carbon atom with the hydroxyl functional group, is a secondary alcohol.

The boiling point of an alcohol is affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

Table 10.2 shows the boiling points of three different alcohols with molecular formula $C_4H_{10}O$.

**Table 10.2**

| alcohol | butan-1-ol | butan-2-ol | 2-methylpropan-2-ol |
|---|---|---|---|
| structure |  |  |  |
| boiling point/ $^oC$ | 118 | 99 | 82 |

Alcohols can behave as weak acids and react with sodium metal to form alkoxides and hydrogen gas. Some examples of the reactions between alcohols and sodium metal are shown.

$$2C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na^+ + H_2$$
ethanol — sodium ethoxide

$$2C_3H_7OH + 2Na \rightarrow 2C_3H_7O^-Na^+ + H_2$$
propanol — sodium propoxide

The acidity of an alcohol is also affected by the number of alkyl groups attached to the carbon atom with the hydroxyl group.

The strength of an acid is indicated by pKa. The smaller the value of pKa, the stronger the acid. The larger the value of pKa, the weaker the acid.

Table 10.3 below shows the pKa values of the three alcohols from Table 8.2 and a few carboxylic acids.

**Table 10.3**

| **substance** | **pKa** |
|---|---|
| butan-1-ol | 16.1 |
| butan-2-ol | 17.6 |
| 2-methylpropan-2-ol | 19.2 |
| ethanoic acid | 4.77 |
| butanoic acid | 4.82 |

**(a)** Which alcohol shown in Table 10.2 is a tertiary alcohol? Explain your answer.

……

…… [1]

**(b)** Draw the structure of a secondary alcohol with the molecular formula $C_5H_{12}O$. [1]

**(c)** **(i)** Describe the trend in the boiling point and the number of alkyl groups attached to the carbon atom with the hydroxyl functional group in Table 10.2.

……

…… [1]

**(ii)** Suggest a reason for your answer in **(c)(i)**.

……

…… [1]

**(d)** State **one** similarity and **one** difference between the reaction of an alcohol with sodium compared to the reaction of a carboxylic acid with sodium.

similarity:

……

……

difference:

……

…… [2]

**(e)** Describe the relationship between the number of alkyl groups attached to the carbon atom with the hydroxyl group and the acidity of the alcohol.

……

…… [1]

**(f)** With reference to Table 10.3, suggest the substance that will react most vigorously with sodium.

Using information from Table 10.3, explain your answer.

……

…… [2]

**(g)** Butanoic acid can be produced from butanol using a laboratory reagent.

**(i)** Name a suitable reagent for the above reaction.

……..... [1]

**(ii)** Describe the observations for **(g)(i)**.

……..... [1]

[Total: 11]

## Section B [10 marks]

Answer **one** question from this section.

**11 (a)** Fig. 11.1 shows citric acid ionises when it is dissolved in water.

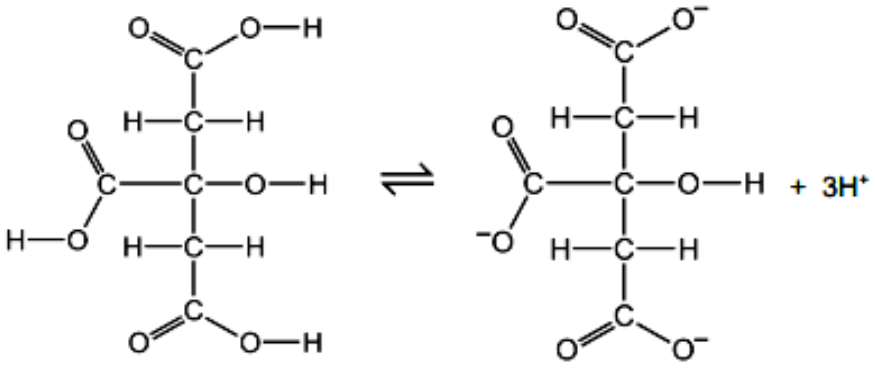



**Fig. 11.1**

Two conical flasks, **X** and **Y**, both contain 100 $cm^3$ of 0.50 $mol/dm^3$ of different acids. Flask **X** contains dilute sulfuric acid while Flask **Y** contains citric acid.

Excess iron was added into both flasks. The gas produced was collected and measured. The following observations were made and recorded in the table.

| | |
|---|---|
| observation 1 | Effervescence of colourless gas was more rapid in flask **X**. |
| observation 2 | The volume of gas collected from flask **Y** is larger. |

Explain **observations 1** and **2**.

**observation 1**

……

……

……

**observation 2**

……

……

…… [2]

**(b)** Bath bombs are a mixture of dry ingredients, packed lightly into various shapes. The label shows some common ingredients found in a typical bath bombs.

Ingredients:
sodium hydrogen carbonate, citric acid, titanium dioxide, tin oxide, benzyl alcohol

Suggest why a bath bomb will produce effervescence when dropped into water.

……

…… [1]

**(c)** A sample of aqueous citric acid was titrated with aqueous potassium hydroxide to obtain potassium citrate salt, which decomposes at 230 °C.

Describe, in steps, how you would obtain pure dry crystals of potassium citrate from its solution.

……

……

……

…… [2]

**(d)** Outline a simple experiment which you could carry out to determine whether a mixture with water contains an ionic or a covalent compound.

Your answer should also describe the observations that would lead to the conclusion.

……

……

……

…… [2]

**(e)** A student investigates the amount of silver that forms on the negative electrode during the electrolysis of aqueous silver nitrate using carbon electrodes.

The following shows the half-equations at the electrodes.

Anode: $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$

Cathode: $Ag^+(aq) + e^- \rightarrow Ag(s)$

**Table 11.1**

| experiment | temperature / °C | duration of electrolysis / s | current passed through solution/ A | concentration of solution/ mol/dm$^3$ | mass of silver / g |
|---|---|---|---|---|---|
| 1 | 25 | 100 | 9.65 | 1.0 | 0.108 |
| 2 | 30 | 100 | 9.65 | 1.0 | 0.108 |
| 3 | 25 | 100 | 9.65 | 0.5 | 0.108 |
| 4 | 25 | 200 | 9.65 | 0.5 | 0.216 |
| 5 | 25 | 100 | 19.3 | 1.0 | 0.216 |

Table 11.1 shows how the mass of the silver formed is affected by four factors.

Suggest how the mass of the silver formed is affected by the four factors.

Use evidence from the table to explain your reasoning.

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…… [3]

[Total: 10]

**12 (a)** Halogens can react with hydrogen to form hydrogen halides.

The following equations show the formation of hydrogen halides, hydrogen chloride and hydrogen fluoride.

reaction 1: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

reaction 2: $H_2(g) + F_2(g) \rightarrow 2HF(g)$

Fig. 12.1 shows the energy profile diagrams for reactions 1 and 2.

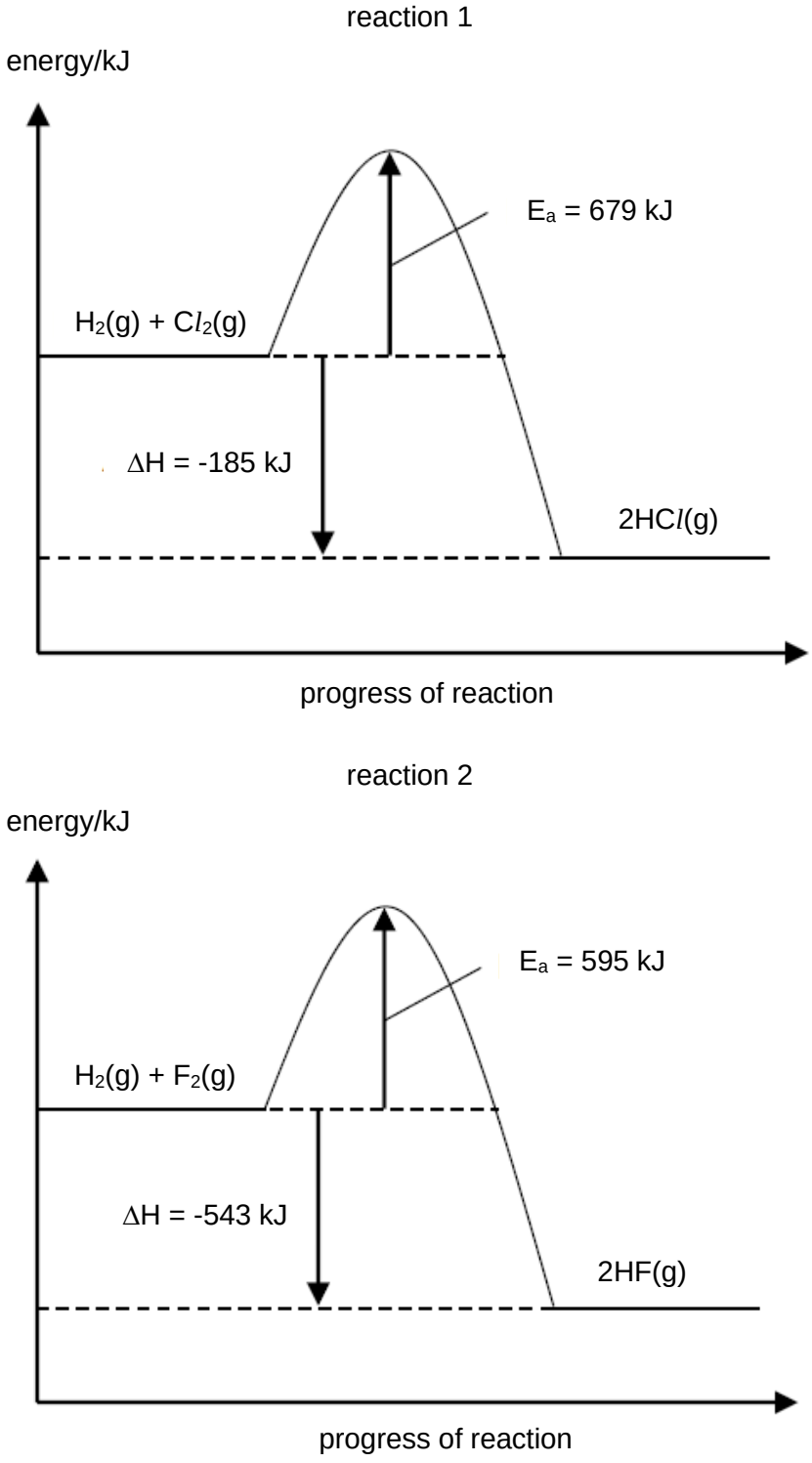


**Fig. 12.1**

**(i)** Explain why the activation energies for both reactions are different.

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…… [2]

**(ii)** Calculate the energy released during the formation of bonds for both reactions 1 and 2.

energy released for reaction 1: …… kJ

energy released for reaction 2: …… kJ [2]

**(iii)** From your results in **(a)(ii)**, state whether the hydrogen chloride bond or hydrogen fluoride bond is stronger.

…… [1]

**(b)** Respiration, combustion and photosynthesis are important processes in the carbon cycle.

Describe how the carbon cycle regulates the amount of carbon dioxide in the atmosphere.

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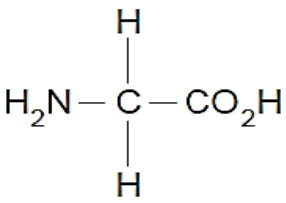
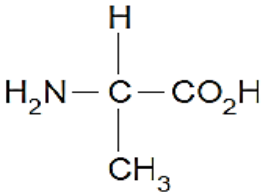
…… [3]

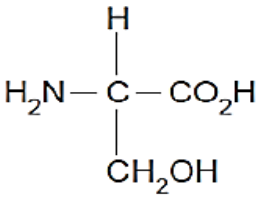
**(c)** Avocados contain amino acids like glycine, alanine and serine as shown.



glycine



alanine



serine

A polyamide is made from repetitive sequences of –glycine–alanine–serine–.

Draw the structural formula of **one** repeat unit of this polyamide. [2]

[Total: 10]

**End of paper**

# 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 – | 113 Nh nihonium – | 114 Fl flerovium – | 115 Mc moscovium – | 116 Lv livermorium – | 117 Ts tennessine – | 118 Og oganesson – |

**Key**

proton (atomic) number
atomic symbol
name
relative atomic mass

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

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**5**

**(a)**

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……..... [1]

**(b)**

xxx = ……. J [1]

**(i)**

[1]

**(iii)**

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……..... [1]

[1]

[2]

[1]

[Total: 10]