Name:	Form Class	Index No		Teaching Group			

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UNITY SECONDARY SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY 6092/01 **22 Aug 2024**

Paper 1 Multiple Choice **1 hour**

Additional Materials: Multiple Choice Answer Sheet

MARKS	/40

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluids.
Write your Name, Form Class, Index Number and Teaching Group on the Question Paper and Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 18.
The use of an approved scientific calculator is expected, where appropriate.

This paper consists of **18** printed pages, including this cover page.

[Turn over

1 A student follows the rate of the reaction when 0.08 g of magnesium reacts with excess hydrochloric acid at room temperature and pressure.

What is most suitable for measuring the volume of gas produced at different times during the experiment?

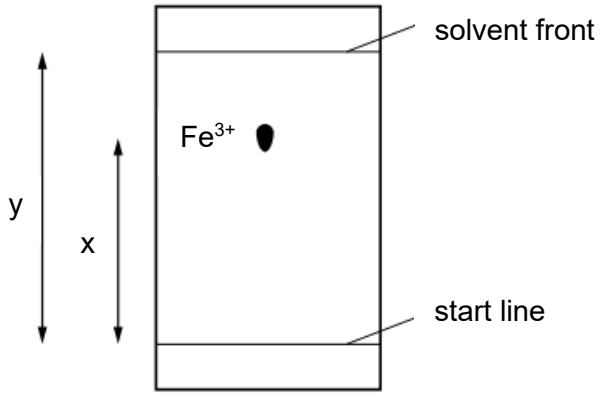
A a 50 cm^3 gas syringe

B an inverted 50 cm^3 burette filled with water

C an inverted 100 cm^3 measuring cylinder filled with water

D place the apparatus on a balance and measure the loss in mass

2 A student uses paper chromatography to find an R_f value for $Fe^{3+}(aq)$. The result is shown below.



To make the spot containing $Fe^{3+}(aq)$ more visible, the paper is sprayed with aqueous sodium hydroxide so that a precipitate of iron(III) hydroxide forms.

Under the conditions of the experiment, the R_f value of $Fe^{3+}(aq)$ is given by …..1….. and the colour of the precipitate is …..2…..

Which row correctly completes gaps 1 and 2?

	gap 1	gap 2
A	$\frac{x}{y}$	green
B	$\frac{x}{y}$	red-brown
C	$\frac{y}{x}$	green
D	$\frac{y}{x}$	red-brown

3 Three separations are listed.

1 obtaining ethanol from the fermentation of glucose
2 obtaining nickel from a solid mixture of iodine and nickel
3 obtaining nitrogen from liquid air

Which techniques would be involved in these separations?

	1	2	3
A	distillation	sublimation	fractional distillation
B	distillation	crystallisation	evaporation
C	using a separating funnel	sublimation	fractional distillation
D	using a separating funnel	crystallisation	evaporation

4 A sample of clean, dry air is cool to –190 °C. The carbon dioxide forms a solid at –79 °C.

element in clean, dry air	melting point / °C	boiling point / °C
argon	–189	–186
oxygen	–218	–183
nitrogen	–210	–196

What is the state of argon, oxygen and nitrogen at –190 °C?

	argon	oxygen	nitrogen
A	gas	gas	gas
B	gas	solid	liquid
C	solid	liquid	gas
D	solid	liquid	liquid

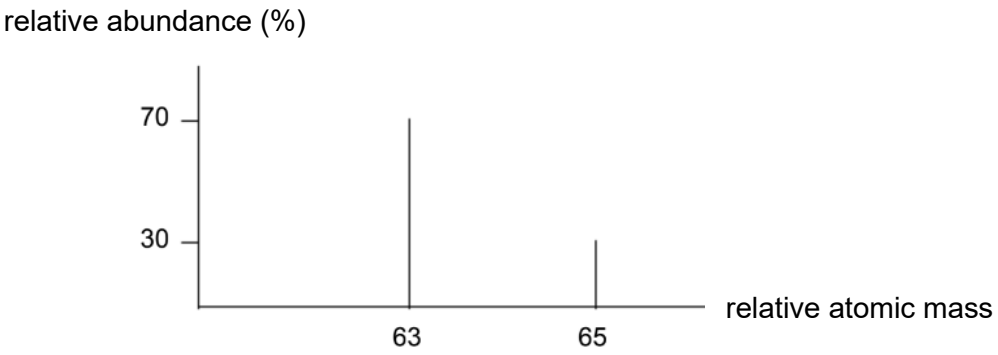
5 The nucleus of M^{3+} contains a total of 27 particles. 13 of the particles have a charge.

Which statement about the ion is correct?

A It contains 13 neutrons and 10 electrons.
B It contains 13 protons and 10 electrons.
C It contains 13 protons and 13 electrons.
D It contains 14 neutrons and 13 electrons.

6 A sample of X was analysed and found to contain only two isotopes, X-63 and X-65.

The graph below shows the relative abundances of the two isotopes.



What is the relative atomic mass of X?

A 63.2

B 63.4

C 63.6

D 64.0

7 Both calcium chloride and potassium chloride are ionic compounds.

Which statement about these compounds is correct?

A Potassium chloride has a higher melting point than calcium chloride because the potassium ion has a greater charge than calcium ion.

B Calcium chloride and potassium chloride conduct electricity because positive and negative ions flow through the solid material.

C Molten calcium chloride has a greater electrical conductivity than molten potassium chloride because calcium contributes more electrons to the delocalised ‘sea of electrons’ than potassium.

D In the calcium chloride lattice, the ratio of calcium ions to chloride ions is half that of the ratio of potassium ions to chloride ions in the potassium chloride lattice.

8 Which statement about metals is **not** correct?

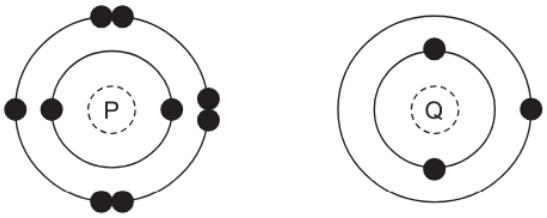
A They conduct electricity because delocalised electrons can move throughout the metal.

B They consist of layers of atoms that can slide over each other.

C They have a giant lattice of oppositely charged ions in a ‘sea’ of delocalised electrons

D They have a giant lattice of positive ions in a ‘sea’ of delocalised electrons

9 The electronic structures of two atoms, P and Q, are shown.

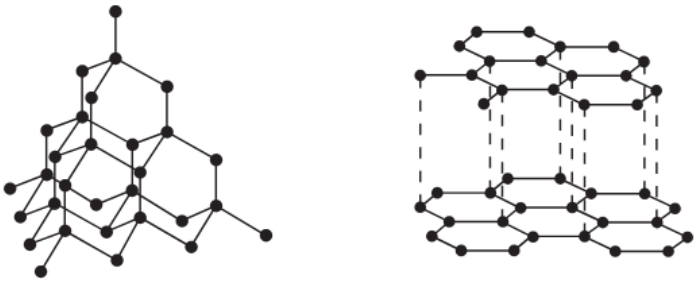


P and Q combine to form a compound.

What is the type of bonding in the compound and what is the formula of the compound?

	type of bonding	formula
A	ionic	PQ
B	ionic	PQ_2
C	covalent	PQ_2
D	covalent	PQ

10 The structures of diamond and graphite are shown.



Which statement about diamond and graphite is correct?

A Diamond and graphite have low melting points.
B Diamond and graphite have mobile electrons.
C Diamond and graphite have layered structures.
D Diamond and graphite contain strong covalent bonds between carbon atoms.

11 70 cm^3 of butane was burnt with 300 cm^3 of oxygen according to the equation below.

$$C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$$

The reaction was then cooled to room temperature and the gases collected.

What is the volume of gases collected?

A 200 cm^3
B 220 cm^3
C 400 cm^3
D 560 cm^3

12 The equation for the reaction between sodium carbonate and excess dilute hydrochloric acid is shown.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

When 26.5 g of sodium carbonate reacts with excess dilute hydrochloric acid, what is the maximum volume of carbon dioxide produced?

A 6 dm^3

B 12 dm^3

C 18 dm^3

D 24 dm^3

13 Powdered calcium carbonate reacts with dilute hydrochloric acid to produce calcium chloride, water and carbon dioxide.

Which of the following shows the correct ionic equation, including state symbols, for this reaction?

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

B $Ca^{2+}(aq) + CO_3^{2-}(aq) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

C $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

D $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

14 A farmer spreads ammonium nitrate, a nitrogenous fertiliser, on a field. The next day he spreads calcium hydroxide on the same field. This caused a loss of nitrogen from the ammonium nitrate.

Which chemical reaction occurred?

A The calcium ions reacted with the ammonium ions, producing ammonia gas.

B The calcium ions reacted with the nitrate ions, producing oxides of nitrogen.

C The hydroxide ions reacted with the ammonium ions, producing ammonia gas.

D The ammonium nitrate is oxidised by the base, producing ammonia gas.

15 Ammonia is manufactured by the Haber Process. The equation for the Haber process is given below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ/mol}$$

Which statement about the Haber Process is true?

A Hydrogen used is obtained from the hydrogenation of alkenes.

B Nitrogen used is obtained from the fractional distillation of crude oil.

C The reaction is exothermic as energy is absorbed to break the strong N≡N bonds.

D The yield of the reaction is always lower than 100% as the reaction is reversible.

16 A method used to make copper(II) sulfate crystals with the steps taken is shown.

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

What are the purposes of step 3 and step 4?

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

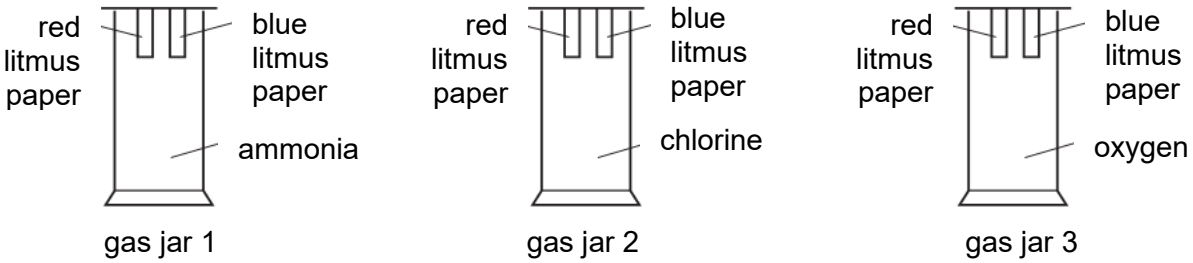
17 Three tests are carried out on salt S.

	test	result
1	Add dilute nitric acid to S.	Effervescence of a colourless odourless gas evolved.
2	To 2 cm^3 of the mixture from test 1, add aqueous sodium hydroxide until no further changes is observed.	Blue precipitate formed. Precipitate is insoluble in excess aqueous sodium hydroxide.
3	To 2 cm^3 of the mixture from test 1, add aqueous silver nitrate.	No precipitate formed.

What is salt S?

A copper(II) chloride
B copper(II) carbonate
C iron(II) chloride
D iron(II) carbonate

18 Pieces of damp red litmus paper and damp blue litmus paper are placed in three different gas jars.



In which gas jars does at least one piece of litmus paper change colour?

A 1, 2 and 3

B 1 and 2

C 1 and 3

D 2 and 3

19 Three metals, X, Y and Z, were reacted with water.

The oxides of the same three metals were also heated strongly with carbon.

The results are shown.

metal	reaction of the metal with water	reaction of the metal oxide with carbon
X	vigorous reaction with cold water	no reaction
Y	no reaction	metal and carbon dioxide produced
Z	no reaction observed with cold water but reaction observed with steam	no reaction

What is a correct conclusion about X, Y and Z?

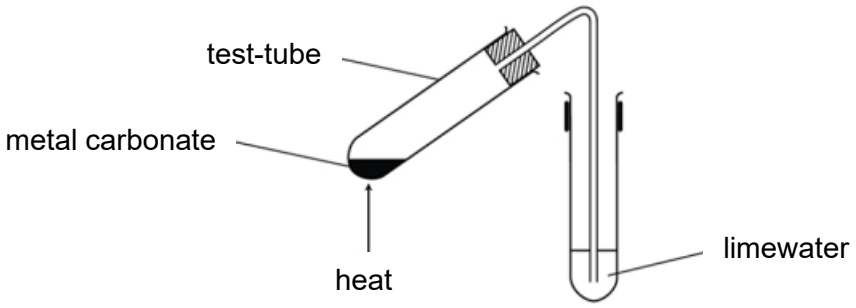
A X is sodium and Y is magnesium.

B X is the least reactive and Y is the most reactive.

C Z is less reactive than Y.

D Z is magnesium and Y is copper.

20 The following is an experimental setup to determine the relative thermal stability of metal carbonates.



Which row shows the correct observations?

	relative time taken for the white precipitate to form in limewater	limewater remain colourless
A	$CuCO_3 < MgCO_3$	K_2CO_3
B	$K_2CO_3 < CuCO_3$	$MgCO_3$
C	$K_2CO_3 < MgCO_3$	$CuCO_3$
D	$MgCO_3 < CuCO_3$	K_2CO_3

21 Which row describes the properties of a transition element?

	property 1	property 2
A	forms colourless compounds	acts as a catalyst
B	forms colourless compounds	low electrical conductivity
C	high density	acts as a catalyst
D	high density	low electrical conductivity

22 In an electrolysis experiment, the same quantity of charge deposited 27.0 g of silver and 4.33 g of chromium.
[A_r: Ag,108; Cr, 52]

What was the charge on the chromium ion?

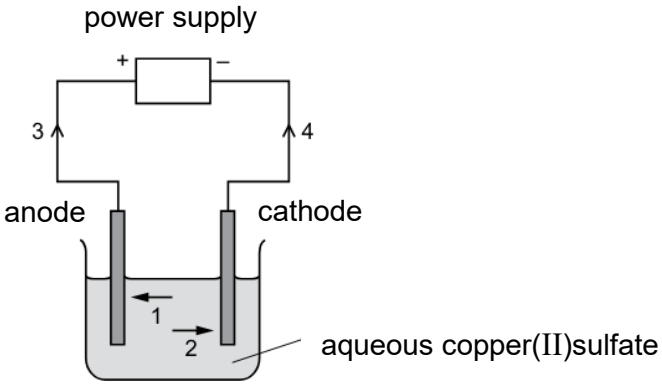
A 1+

B 2+

C 3+

D 4+

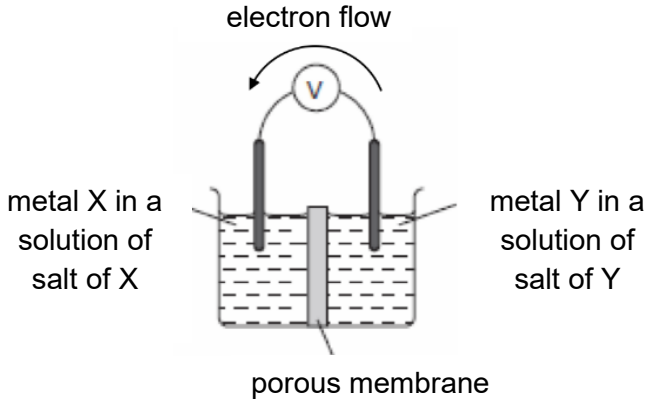
23 The diagram shows a circuit used to electrolyse aqueous copper(II) sulfate.



Which arrows indicate the movement of the copper ions in the electrolyte and of the electrons in the external circuit?

	copper ions	electrons
A	1	3
B	1	4
C	2	3
D	2	4

24 Which pair of metals X and Y will produce the highest voltage when used as electrodes in a simple cell?



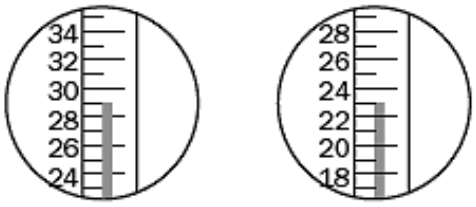
	metal X	metal Y
A	copper	magnesium
B	copper	zinc
C	magnesium	silver
D	magnesium	zinc

25 A bicycle is electroplated with chromium to make it more resistant to scratches and rusting. Chromium lies above zinc in the reactivity series of metals.

Which set-up will allow the chromium to be plated onto the bicycle?

	anode	cathode	electrolyte
A	bicycle	chromium	molten chromium(III) sulfate
B	bicycle	chromium	aqueous chromium(III) sulfate
C	chromium	bicycle	aqueous chromium(III) sulfate
D	chromium	bicycle	molten chromium(III) sulfate

26 A thermometer is inserted into a beaker of water to measure its temperature. When ammonium chloride is dissolved in the water, the following temperature change is observed.

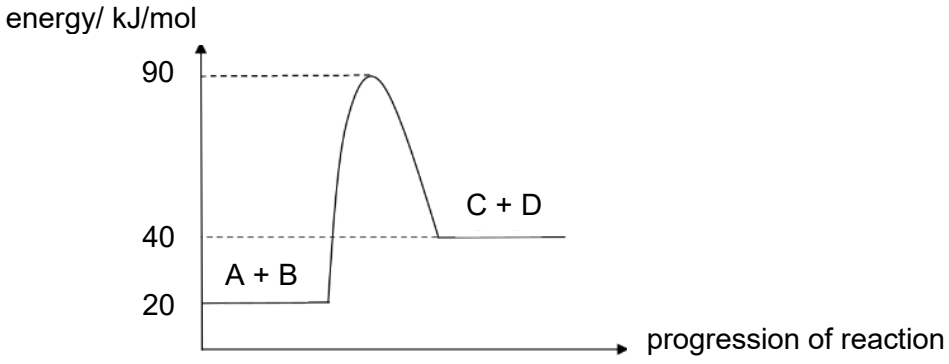


Which statement correctly explains this change?

A The temperature falls because heat energy is given off from ammonium chloride.
B The temperature falls because heat energy is taken in by ammonium chloride.
C The temperature rises because heat energy is given off from ammonium chloride.
D The temperature rises because heat energy is taken in by ammonium chloride.

27 The energy profile diagram of a reversible reaction is shown below.

$$A + B \rightleftharpoons C + D$$



Which of the following statements is correct about the energy profile diagram?

A Activation energy of the backward reaction is given by –50 kJ/mol.
B Enthalpy change of the backward reaction is given by +20 kJ/mol.
C Activation energy of the forward reaction is given by +70 kJ/mol.
D Enthalpy change of the forward reaction is given by +50 kJ/mol.

28 When chlorine gas dissolves in water a reaction occurs.

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

Which row of the table correctly shows the oxidation number for chlorine in the chlorine-containing species?

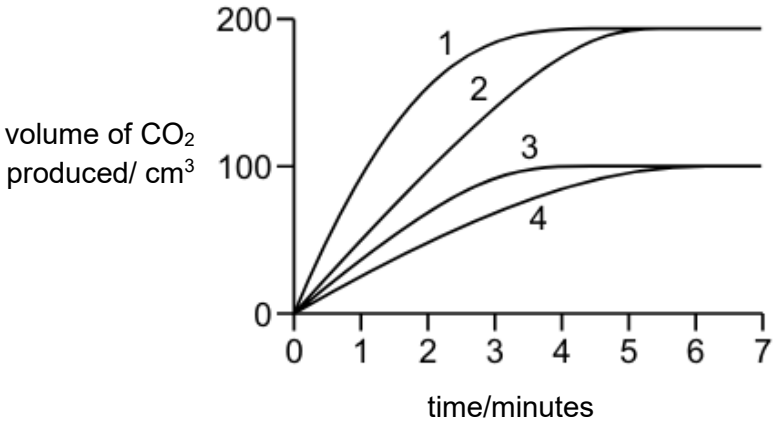
	Cl_2	HCl	HClO
A	−1	−1	−1
B	0	−1	−1
C	−1	+1	+1
D	0	−1	+1

29 In four separate experiments 1, 2, 3 and 4, nitric acid is added to an excess of marble pieces and the volume of carbon dioxide gas formed is measured.

In all four experiments the same volume of nitric acid is used.

The concentration, or temperature, or both concentration and temperature of the nitric acid, are changed.

The results of the experiments are shown on the graph.



Which statement is correct?

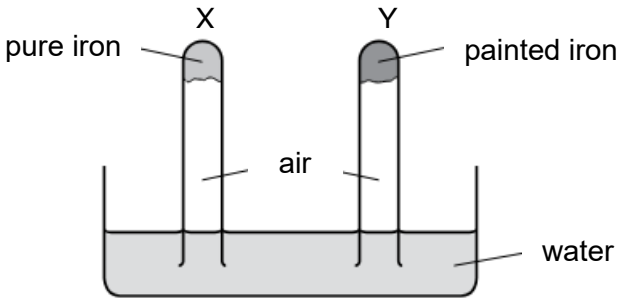
A A lower concentration of acid is used in experiment 3 than in experiment 1.

B Experiment 4 is faster than experiment 3.

C The acid used in experiment 2 is of a lower concentration than in experiment 1.

D The temperature of the acid is the same in experiments 1 and 2.

30 An experiment is carried out to investigate the effect of painting iron.

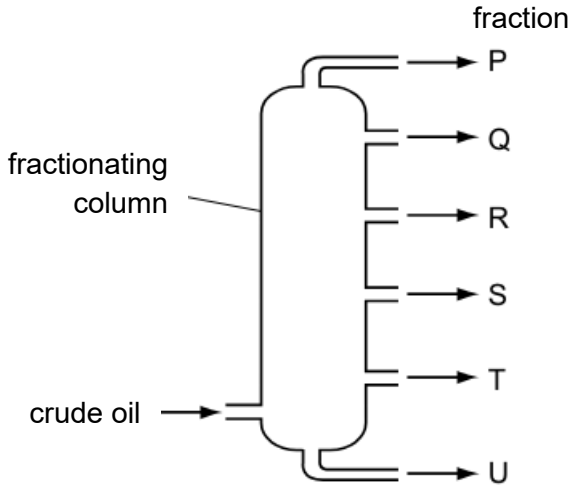


The experiment is left for seven days.

What happens to the water level in test-tubes X and Y?

	test-tube X	test-tube Y
A	falls	rises
B	no change	no change
C	rises	falls
D	rises	no change

31 The diagram shows a fractionating column used in the separation of petroleum.

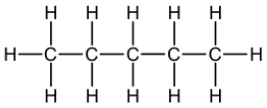


Which row explains why fraction R is collected above fraction S?

	boiling point of R	average molecular mass of R
A	higher than S	greater than S
B	higher than S	smaller than S
C	lower than S	greater than S
D	lower than S	smaller than S

32 Which three hydrocarbons are isomers of each other?

1



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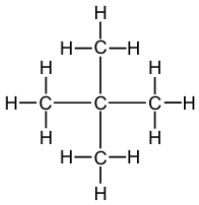

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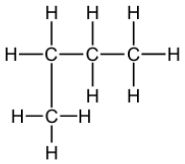

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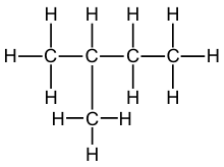

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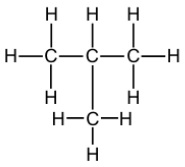
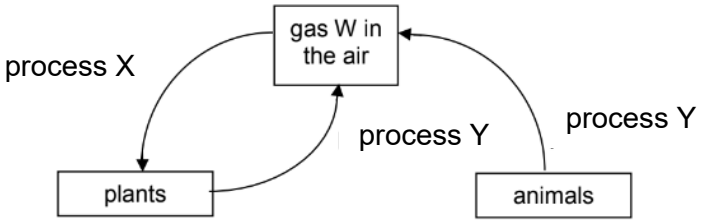


A 1, 2 and 4
B 2, 3 and 5
C 2, 3 and 4
D 3, 4 and 5

33 The diagram below shows part of the carbon cycle.



What is the correct combination of the identity of gas W and processes X and Y?

	gas W	process X	process Y
A	carbon dioxide	photosynthesis	respiration
B	carbon dioxide	respiration	photosynthesis
C	carbon monoxide	photosynthesis	respiration
D	carbon monoxide	respiration	photosynthesis

34 One mole of each of the compounds shown is completely combusted.

$C_5H_{12}O$ C_6H_{12} C_6H_{14} $C_6H_{14}O$

How many of the compounds need exactly nine moles of oxygen for complete combustion?

A 1
B 2
C 3
D 4

35 5 g of vegetable oil (M_r = 800) reacted completely with 900 cm^3 of hydrogen gas (measured at room temperature and pressure) to form margarine which is a saturated fat.

How many C=C bonds are there in one molecule of the oil?

A 3

B 4

C 5

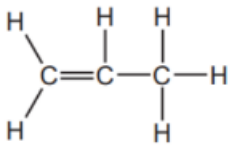
D 6

36 Z is a compound that

- can be formed, as the only other product, when the alkane C_8H_{18} is cracked to produce butane;
- decolourises bromine water;
- can undergo addition polymerisation.

What is the structural formula of Z?

A



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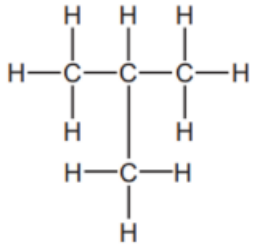

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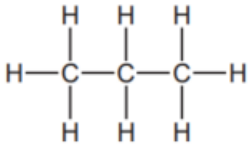

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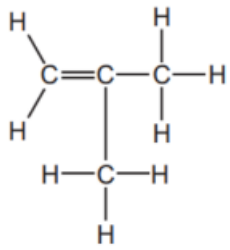
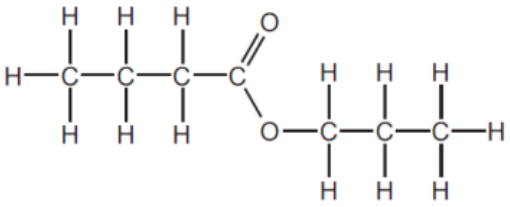


37 Ethanol can be produced by fermentation or by the catalytic addition of steam to ethene.

Which row shows an advantage and a disadvantage for each process?

	fermentation		catalytic addition of steam to ethene	
	advantage	disadvantage	advantage	disadvantage
A	batch process	slow reaction	continuous process	fast reaction
B	fast reaction	continuous process	pure ethanol formed	renewable raw material
C	renewable raw material	batch process	pure ethanol formed	slow reaction
D	renewable raw material	impure ethanol formed	fast reaction	finite raw material

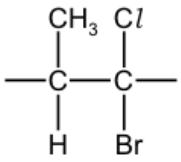
38 The structure of ester X is shown.



Which row gives the names of ester X and the carboxylic acid and alcohol from which it is made?

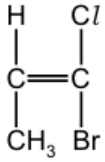
	carboxylic acid	alcohol	name of ester X
A	propanoic acid	butanol	butyl propanoate
B	butanoic acid	propanol	butyl propanoate
C	propanoic acid	butanol	propyl butanoate
D	butanoic acid	propanol	propyl butanoate

39 The repeat unit of a polymer is shown.

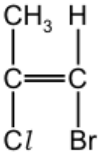


Which monomer would produce this polymer?

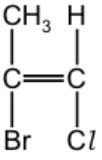
A



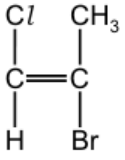
B



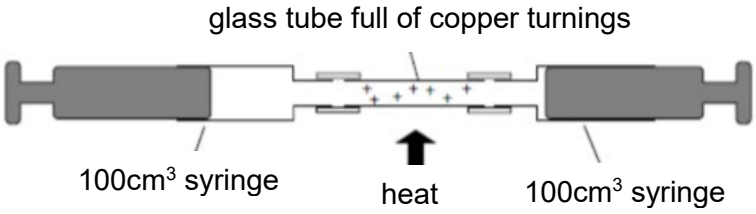
C



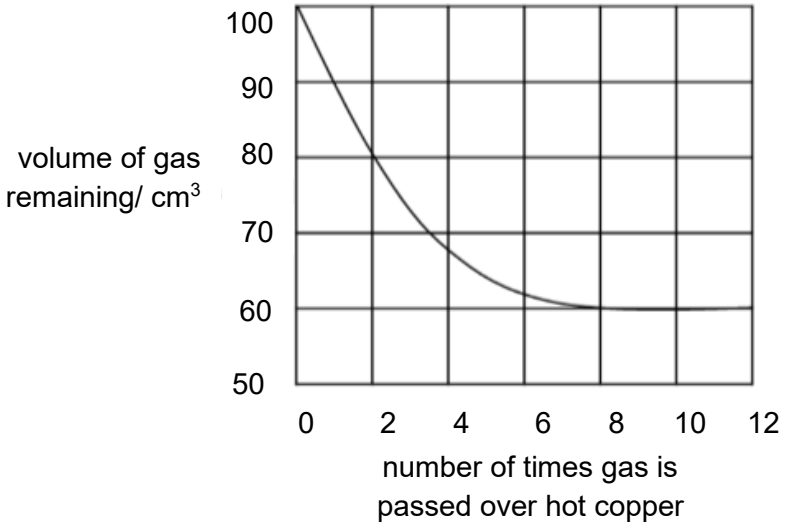
D



40 The percentage of oxygen in the air is found using the apparatus shown in the diagram below. The air is passed over the heated copper turnings until there is no further decrease in volume.



The results obtained were used to plot the graph.



The gas was passed backward and forward over heated copper turnings.

What is the percentage of oxygen in the bottled glass?

A 20%
B 40%
C 60%
D 80%

Section A

Answer **all** questions.

1 Choose from the following compounds to answer the questions.

NH_4Cl

$BaSO_4$

$KMnO_4$

CO_2

KI

$BaCl_2$

Na_2CO_3

Na_3PO_4

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

State which compound

(a) reacts with dilute nitric acid to form a gas that produces white precipitate in limewater.

……..[1]

(b) reacts with warm aqueous sodium hydroxide to form a gas that turns damp red litmus paper blue.

……..[1]

(c) contains an anion with a charge of –3.

……..[1]

(d) is prepared using the method of precipitation reaction.

……..[1]

(e) is used to test for a reducing agent.

……..[1]

[Total: 5]

2 **(a)** Fig. 2.1 shows the behaviour of liquids and gases in two closed containers, **A** and **B**.

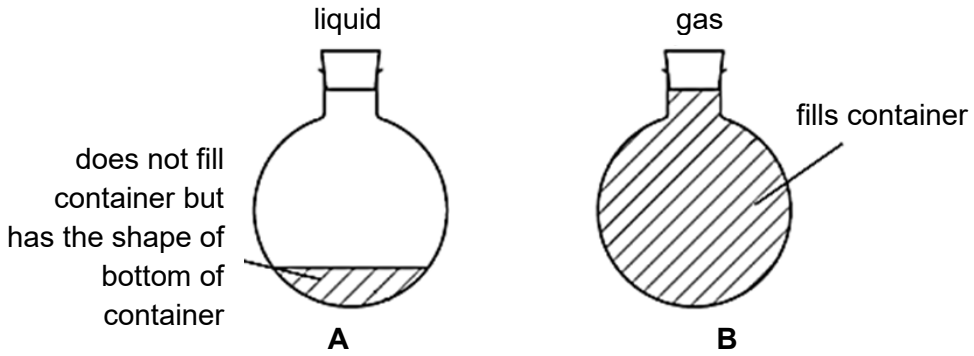


Fig. 2.1

Using the Kinetic Particle Theory, explain why both liquids and gases take the shape of the container but a gas always fills the container.

……..

……..

……..

……..

……..[2]

(b) Container **B** is filled with a mixture of nitrogen dioxide and sulfur dioxide.

When the container is opened, state and explain which gas would diffuse out faster.

Include working where relevant in your answer.

……..

……..

……..

……..[2]

[Total: 4]

3 Lithium, sodium, potassium and rubidium are Group 1 metals. They are also called '*alkali metals*'.

Table 3.1 shows the melting points of some Group 1 metals.

Table 3.1

Group 1 metals	melting point /°C
lithium	180
sodium	98
potassium	63

(a) Explain why Group 1 metals are called 'alkali *metals*'.

……..

……..[1]

(b) State two observations that could be made when a small piece of sodium is added to a large trough containing water.

…….....

…….....

……..[2]

(c) Rubidium is below potassium in Group 1.

Predict the melting point of rubidium. Explain your reasoning.

melting point ……°C

……..

……..

……..[2]

(d) Dimitri Mendeleev compiled the first version of the Periodic Table in 1871.

Mendeleev's version of the Periodic Table placed silver in Group 1.

Describe one similarity and one difference between the chemical properties of silver and the Group 1 elements.

……..

……..

……..[2]

[Total: 7]

4 Carboxylic acids are organic compound containing a carboxyl functional group.

Table 4.1 shows information about the first three carboxylic acids in a homologous series.

Table 4.1

name of acid	formula	pH of a 0.01 mol/dm^3 solution
…….	HCOOH	2.91
ethanoic acid	CH_3COOH	3.39
propanoic acid	……..	3.44

(a) Complete Table 4.1 above. [1]

(b) Ethanoic acid ionises in water and it can be represented by the following equation.

$$CH_3COOH\ (aq) \rightleftharpoons CH_3COO^-\ (aq) + H^+\ (aq)$$

Explain what the equation above tells you about the strength of ethanoic acid and the concentration of hydrogen ions produced.

……..

……..[1]

(c) **(i)** Carboxylic acids can react with metals such as magnesium. Arrange the three acids in order of increasing rate of reaction between carboxylic acid and magnesium.

Explain your answer using information from Table 4.1.

……

……

……..……[2]

(ii) Write a balanced chemical equation for the reaction between ethanoic acid and magnesium.

……..[1]

(d) Name the substance that is used to oxidise ethanol to ethanoic acid.

……..[1]

(e) Fig. 4.2 below shows the label printed on a bottle of vinegar. The label shows that it contains 1.5 g of ethanoic acid, CH_3COOH per 100 cm^3 of vinegar.

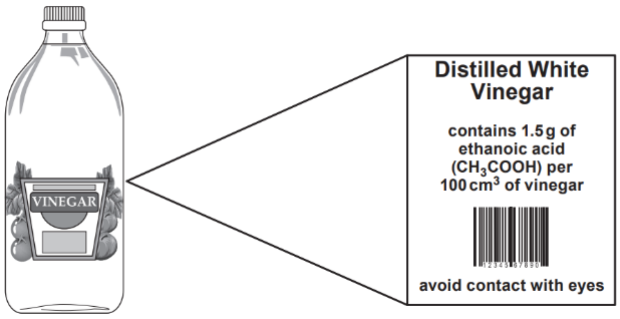


Fig. 4.2

A student reacted 20.0 cm^3 of vinegar with 25.00 cm^3 of 0.20 mol/dm^3 of sodium hydroxide.

With the help of the equation given, determine whether the information printed on the label is correct.

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

[3]

[Total: 9]

5 Salts can exist in hydrated and anhydrous forms.

(a) Hydrated magnesium sulfate crystals can be used as a bath salt to provide additional minerals to the skin.

Describe the steps to be taken to prepare a pure and dry sample of hydrated magnesium sulfate crystals.

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..[3]

(b) Anhydrous sodium carbonate is a salt that absorbs water readily and can be used as a dehumidifier. It can be formed from hydrated sodium carbonate.

The chemical formula of one formula unit of hydrated sodium carbonate is $Na_2CO_3.\boldsymbol{x}H_2O$, where ***x*** is the number of water of crystallisation in sodium carbonate.

Fig. 5.1 shows the apparatus which can be used to determine the number of moles of water of crystallisation in a sample of hydrated sodium carbonate. The water of crystallisation will be removed by evaporation upon strong heating.

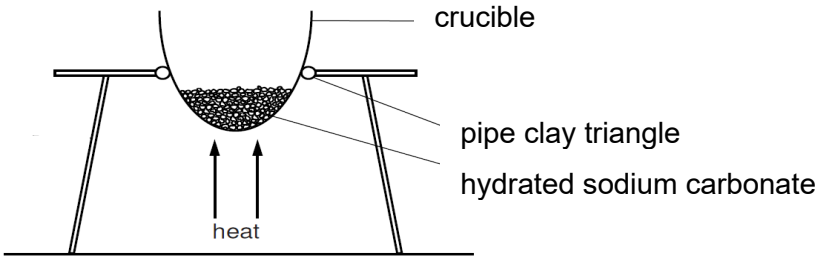


Fig. 5.1

Heating can only stop when a constant mass of the cooled crucible and contents is achieved.

(i) Suggest the importance of heating until a constant mass of the cooled crucible and contents is achieved.

……

……..[1]

(ii) In an experiment, 0.715 g of hydrated sodium carbonate crystals were heated strongly till the mass remained constant. The final mass of the anhydrous sodium carbonate was 0.265 g.

Calculate the value of ***x***, the number of water of crystallisation in hydrated sodium carbonate.

[3]

(iii) The same experimental set-up can be used to determine the number of moles of water of crystallisation in copper(II) sulfate. However, care must be taken to not overheat the copper(II) sulfate until it decomposes further to the metal oxide.

Suggest why this precaution is **not** necessary for sodium carbonate.

……

……..[1]

[Total: 8]

6 In an experiment, lumps of magnesium carbonate were added to dilute hydrochloric acid.

$$MgCO_3\,(s) + 2HCl\,(aq) \rightarrow MgCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$$

In experiment 1, an excess of magnesium carbonate pieces was added to 50.0 cm^3 dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 30 seconds.

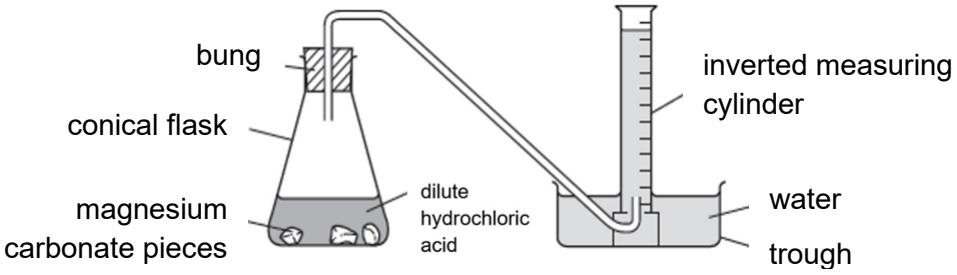


Fig. 6.1

The results are shown in the Fig. 6.2.

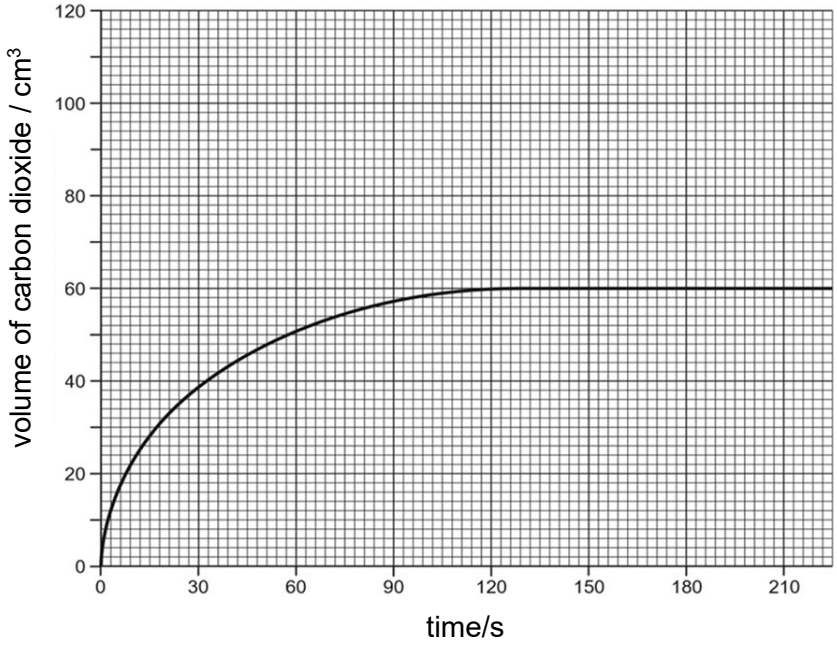


Fig. 6.2

(a) **(i)** Suggest a change that can be made to the experiment, other than changing temperature, such that the rate of reaction is increased while keeping the maximum volume of carbon dioxide produced the same.

……...[1]

(ii) Using ideas about colliding particles, explain your answer in **(a)(i)**.

……

……

……

……...[2]

(b) On Fig. 6.2, sketch the graph for experiment **2** and **3**.

(i) Experiment **2**: The experiment was repeated using the same mass of magnesium carbonate but twice the concentration of 50.0 cm^3 dilute hydrochloric acid. Label the graph "**2**", [1]

(ii) Experiment **3**: The experiment was repeated using dilute ethanoic acid in place of dilute hydrochloric acid, with all other conditions kept constant. Label the graph "**3**". [1]

(c) Explain the shape of the graph **3** in **(b)(ii)**.

……..

……..

……..

……..

……..

……..[3]

[Total: 8]

7 Emission from vehicles is one of the main contributors to the air pollutants, namely carbon monoxide, oxides of nitrogen and unburnt hydrocarbons, into the atmosphere. Catalytic converter is installed in vehicles to help to reduce emission of these air pollutants.

(a) **(i)** Describe the harmful effects of carbon monoxide and oxides of nitrogen.

……

……

……

……...[2]

(ii) The catalytic converter removes carbon monoxide and nitrogen monoxide by oxidation and reduction.

Write an overall equation to show how carbon monoxide and nitrogen monoxide react together in the converter.

……...[1]

(iii) Cars fitted with catalytic converters still give out environmentally harmful gases.

Name one environmentally harmful gas that is emitted in large amounts and describe the problem it causes.

……

……

……...[1]

(b) Oxides of nitrogen in the upper atmosphere can also cause damage to the ozone layer.

Nitrogen monoxide, NO, damages the ozone layer by reacting with ozone in a two-step reaction.

$$\text{step 1} \quad NO + O_3 \rightarrow NO_2 + O_2$$

$$\text{step 2} \quad NO_2 + O_3 \rightarrow NO + 2O_2$$

Explain how the equations show that one nitrogen monoxide molecule can destroy thousands of ozone molecules.

……..

……..

……..[1]

(c) Brazil uses biofuel to run their vehicles. Biofuel mainly consists of ethanol obtained from the fermentation of sugarcane juice. Explain how biofuel helps to maintain the level of carbon dioxide in air.

……..

……..

……..

……..[2]

[Total: 7]

8 Octane, C_8H_{18} is the main component in petrol used in cars. However, some cars use Liquefied Petroleum Gas (LPG) fuel. The main component of LPG fuel is butane.

Different types of engines also require different octane levels. High-performance engines, such as those in sports cars or large trucks, often require higher-octane fuel. The key is to use the octane rating recommended by the vehicle's manufacturer to ensure optimal performance and longevity of the engine.

Data about energy output

The enthalpy change of combustion is the energy given out when one mole of a pure compound burns completely in excess oxygen. Table 8.1 shows the enthalpy change of combustion when one mole of octane and one mole of butane are completely burned.

Table 8.1

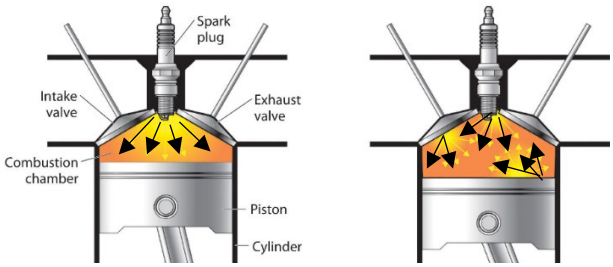
type of fuel	main compound	enthalpy change of combustion of main compound in kJ/mol
petrol	octane (C_8H_{18})	−5470
Liquefied Petroleum Gas (LPG)	butane	−2880

Octane Ratings

In 1927, the octane rating was established using a standard test engine and two pure compounds: *n*-heptane and isooctane (2,2,4-trimethylpentane).

The quality of a fuel is indicated by its octane rating, which is a measure of its ability to burn in a combustion engine without knocking or pinging. Knocking or pinging refers to the noise you will hear when the air-fuel mixture in the cylinders detonates in more than once place at a time. The higher the octane number, the greater the fuel's resistance to knocking or pinging during combustion. High-octane fuels are considered more ‘premium’ and more desirable.

Knocking and pinging signal premature combustion (see Fig. 8.2) which can be caused either by an engine malfunction or by a fuel that burns too fast. In either case, the gasoline-air mixture detonates at the wrong point in the engine cycle, which reduces the power output and can damage valves, pistons, bearings, and other engine components. The various gasoline formulations are designed to provide the mix of hydrocarbons least likely to cause knocking or pinging in a given type of engine performing at a particular level.

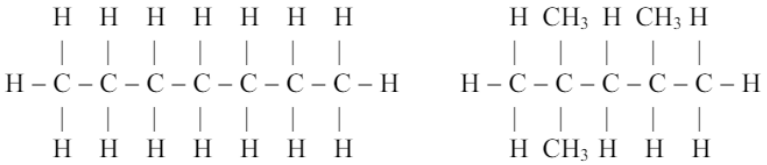


(a) Normal combustion (b) Premature combustion

Fig. 8.2 The Burning of Gasoline in an Internal Combustion Engine

(a) Normally, fuel is ignited by the spark plug, and combustion spreads uniformly outward. (b) Gasoline with an octane rating that is too low for the engine can ignite prematurely, resulting in uneven burning which causes knocking and pinging.

In Fig. 8.3, the structures of *n*-heptane and isooctane are shown. *n*-heptane, which causes a great deal of knocking on combustion, was assigned an octane rating of 0, whereas isooctane, a very smooth-burning fuel, was assigned an octane rating of 100. Hence, it was recognised that straight-chain hydrocarbons are far more prone to inducing engine knock than highly branched compounds.



n-heptane
octane rating 0

2,2,4-trimethylpentane
octane rating 100

Fig. 8.3

Chemists assign octane ratings to different blends of gasoline by burning a sample of each in a test engine and comparing the observed knocking with the amount of knocking caused by specific mixtures of *n*-heptane and isooctane.

Additives

The use of additives in petrol manufacture also provides a means of preventing knocking. Two types of additives have been in use in recent decades, lead compounds and oxygenates.

Lead compounds e.g. tetraethyl lead

Lead compounds work by preventing reactions that cause knocking. They have been in use since the 1920s but have long been criticised for their harmful environmental effects as the lead compounds present in exhaust fumes are toxic and have been phased out since 1975 as gasoline additives.

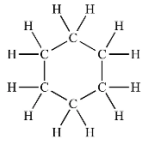
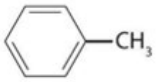
Oxygenates e.g. alcohols or ethers

Oxygenates work by raising the octane rating of the fuel. They cause less pollution, because apart from not containing lead, they produce lower levels of carbon monoxide when they burn. The most commonly used oxygenate is MTBE (methyl *t*-butyl-ether) with octane rating of 118. They combine a high octane rating with minimal corrosion to engine and fuel system parts.

Many compounds that are now available have octane ratings greater than 100, which means they are better fuels than pure isooctane (see Table 8.4). In addition, anti-knock agents, also called octane enhancers, have been developed.

Over the years, the use of alternative octane enhancers such as ethanol, which can be obtained from renewable resources such as corn, sugar cane, and, eventually, corn stalks and grasses, is also increasing.

Table 8.4 The octane rating of some hydrocarbons and common additives

name	condensed structural formula	octane rating
n-butane	$CH_3CH_2CH_2CH_3$	94
n-pentane	$CH_3CH_2CH_2CH_2CH_3$	62
n-hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$	25
cyclohexane		97
n-heptane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	0
2-methylhexane	$CH_3CH(CH_3)(CH_2)_3CH_3$	23
2-methylheptane	$CH_3CH(CH_3)CH_2(CH_2)_3CH_3$	23
isooctane	$(CH_3)_3CCH_2CH(CH_3)_2$	100
benzene		106
toulene		118
methanol	CH_3OH	107
ethanol	CH_3CH_2OH	108
t-butyl alcohol	$(CH_3)_3COH$	113
methyl *t*-butyl ether	$H_3COC(CH_3)_3$	100

(a) (i) The equation for the combustion of butane is given below.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$$

Draw the energy profile diagram for the combustion of butane in the space below.

Your diagram should show:

- the formula of the reactants and products of the reaction
- the energy profile and the activation energy, E_a for the combustion
- the enthalpy change for the reaction, ΔH.

[2]

(ii) Suggest reasons why the enthalpy of combustion of octane is more negative than the enthalpy change of combustion of butane.

……

……

……

……[2]

(iii) Calculate the mass of butane that gives the same amount of energy when combusted as 30.0 kg of octane.

Give your answer to **three** significant figures.

mass of butane = …….. kg [3]

(b) Certain structural features are desirable in ensuring that compounds have high octane ratings. State and explain two factors that can affect the octane rating of a compound using information from Table 8.4.

……

……

……

……[2]

(c) Butane has two structural isomers. Draw the full structural formula of the isomer of butane with the higher octane rating.

[1]

(d) The name of a straight-chain alkane consisting of five carbon atoms is called pentane. With reference to the structure in Fig. 8.3, explain why the branched compound is named *2,2,4-trimethylpentane*.

……..

……..[1]

(e) Suggest one advantage of adding oxygenates, such as ethanol, to petrol.

……..[1]

[Total: 12]

9 Nylon and *Terylene* are synthetic polymers.

Fig. 9.1 and Fig. 9.2 show the structures of nylon and *Terylene* respectively.

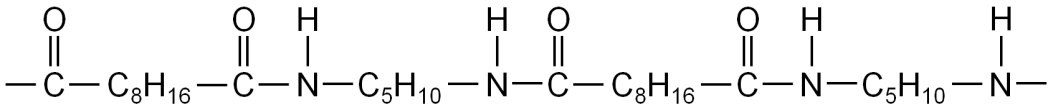


Fig. 9.1 structure of nylon

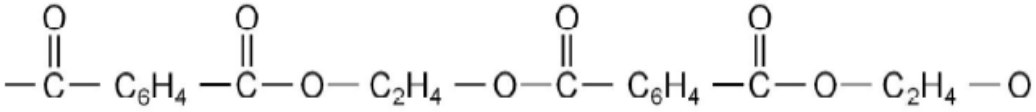


Fig. 9.2 structure of *Terylene*

(a) Construct a table to show the following information about nylon and *Terylene*.

- the formula and name of the type of linkages present in each type of polymer
- the structures of the monomers that react to form each polymer
- the formula of the molecule that is eliminated when the polymer forms.

[5]

(b) Both nylon and *Terylene* are condensation polymers.

Explain the term *polymer*.

……..

……..

……..[1]

(c) Both nylon and *Terylene* are used to make tents for camping. One reason that they are suitable for this purpose is that they are non-biodegradable.

Explain why being non-biodegradable is both an advantage and a disadvantage.

……..

……..

……..

……..[2]

[Total: 8]

Section B

Answer **one** question from this section.

10 An experiment involving 3 cells with 3 different electrodes was carried out in Fig. 10.1.

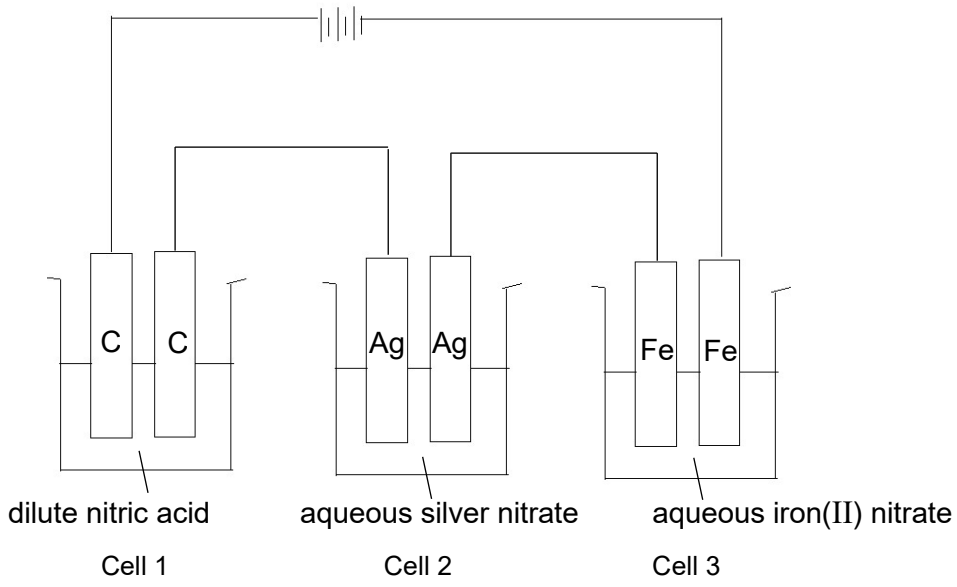


Fig. 10.1

(a) Describe and explain what happens in each of the cells.

You answer should:

- describe the expected observations in each of cells 1, 2 and 3
- explain why each change occurs
- give half equations for each change.

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..

……..[6]

(b) In another experiment, the electrolyte has been changed to aqueous silver nitrate for both Cells 1 and 3.

State and explain the changes in observations you would predict in

(i) Cell 1

……

……

……

……...……[2]

(ii) Cell 3 that is different from the change mentioned in **(b)(i)**.

……

……

……

……..…….. [2]

[Total: 10]

11 A student investigated the electrolysis of aqueous copper(II) sulfate using the apparatus shown in Fig. 11.1.

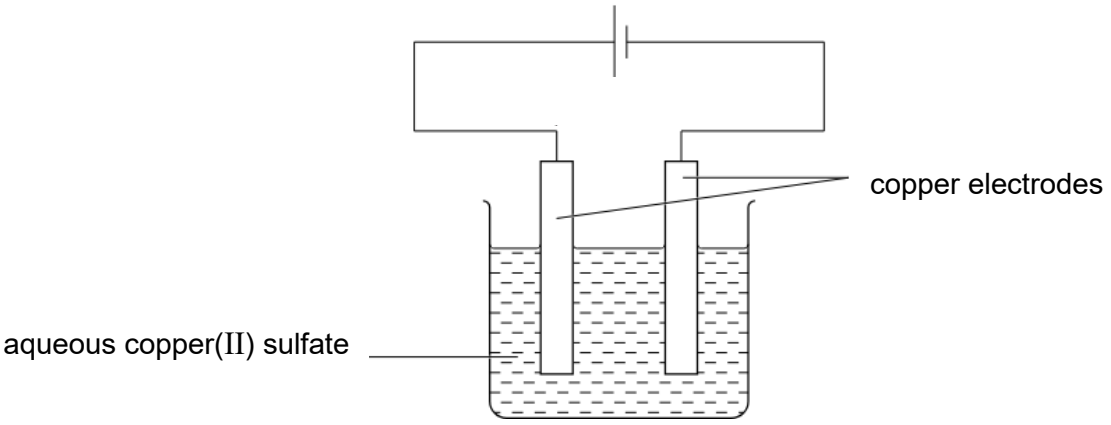


Fig. 11.1

The student uses this method and his procedures are listed below.

- measure the mass of two clean strips of copper
- use one strip of copper as the positive electrode and the other strip of copper as the negative electrode
- wash the strips of copper with ethanol (a liquid that boils at 78 °C) after electrolysis
- dry the strips of copper and reweigh them.

(a) **(i)** Suggest why the copper strips would dry more quickly when washed with ethanol rather than with water.

……...[1]

(ii) Write equations for the reaction that happen at each electrode during the electrolysis. Include state symbols.

at the positive electrode: ……

at the negative electrode: ……...
[2]

(iii) The student carried out the first experiment to measure the mass of the positive and negative electrode.

The decrease in mass of the positive electrode was 0.32 g while the increase in mass of the negative electrode was 0.28 g.

Suggest one reason why the increase in mass of the negative electrode in the student's experiment was less than expected.

……

……...…[1]

(b) **(i)** The student carried out another three experiments and the results obtained are shown in Table 11.2.

Table 11.2

experiment number	current used/ A	time taken/ s	mass of electrode	
			before electrolysis/ g	after electrolysis/ g
1	2.0	180	1.24	1.36
2	4.0	180	1.20	1.44
3	2.0	360	1.34	1.58
4	8.0	90	1.51	

In experiment 2, the student measured the mass of the anode before and after electrolysis. The mass of the anode at the start was 1.45 g.

Determine the mass of the anode after electrolysis.

mass of anode: ..... g [2]

(ii) The student carries out a fourth experiment, using a current of 8.0 A for 90 seconds. The mass of the cathode at the start was 1.51 g.

Deduce the mass of the cathode after electrolysis.

mass of cathode: ..... g [1]

(iii) The student carried out a fifth experiment. In experiment 5, carbon electrodes are now used instead of copper electrodes, with all other conditions kept the same as experiment 1.

State and explain how the observations for experiment 5 differ from those in Fig. 11.1.

……

……

……

……

……

……

……

……...…[3]

[Total: 10]

2024 Sec 4E Pure Chemistry Prelim Marks Scheme

Paper 1

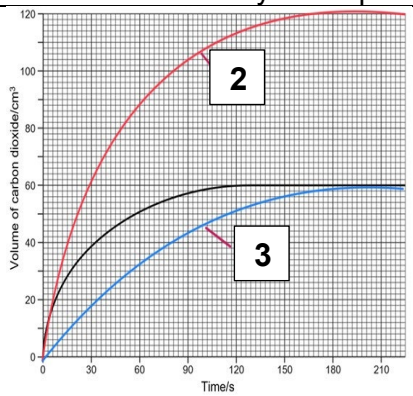
1	2	3	4	5	6	7	8	9	10
C	B	A	C	B	C	D	C	A	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	A	D	C	D	B	B	B	D	A
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
C	C	C	A	C	B	C	D	A	D
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
D	A	A	B	D	D	D	D	A	B

1	**(a)**	Na_2CO_3	1
	(b)	NH_4Cl	1
	(c)	Na_3PO_4	1
	(d)	$BaSO_4$	1
	(e)	$KMnO_4$	1
		Reject if student copied wrongly	
2	**(a)**	• In liquid, the particles are held by <u>strong forces of attraction</u> (√) hence volume remains unchanged / has a definite volume. • However, the forces of attraction is not strong enough to hold them in fixed position, liquid particles can <u>move and slide past each other (within liquid)</u> (√) to take up the shape of the container. • In gas, the <u>forces of attraction between the particles are weak and easily overcomed,</u> (√) hence • they can <u>move freely in all directions /move rapidly and randomly</u> (√) to fill up any available space. 2(√) : 1m 4 (√) : 2m no bonds/very weak forces between particles in gases (√) molecules can move apart/separate/move freely (to fill entire volume) (√) accept: move around/float around bonds/forces /IMF between particles in liquids (√) molecules cannot move apart/ separate/ slide past each other (so fixed volume in liquids) (√) Any 2 (√): 1mark	2

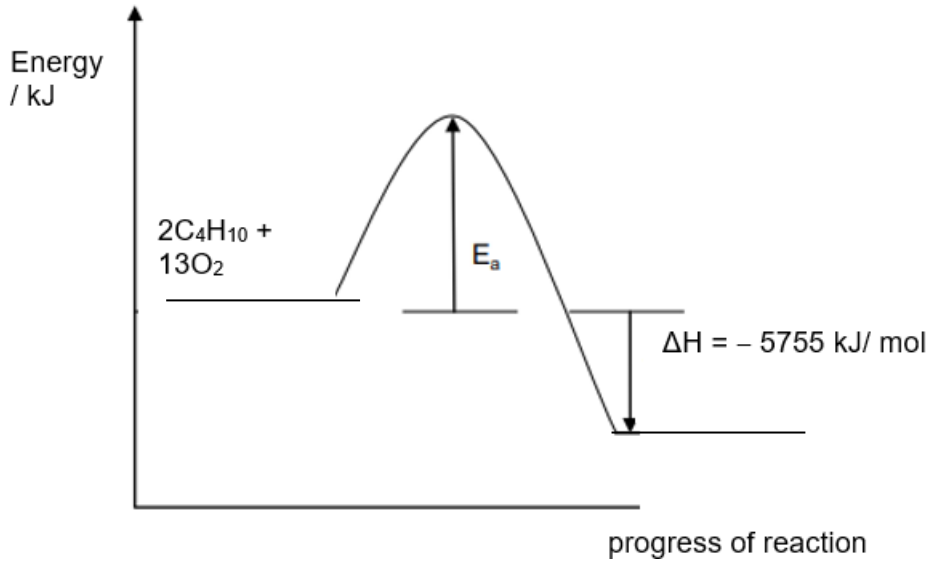
	(b)	Nitrogen dioxide. [1] It has <u>lower relative molecular mass/ M_r</u> (**46)** than sulfur dioxide **(64**), hence diffuse faster. [1] 1m for lower and showing calculation of M_r note: comparison must be made	2

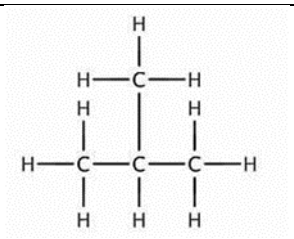
3	**(a)**	Group 1 metals react with water (√) to form soluble base/metal hydroxides (√) which are alkalis. Accept: can form aqueous metal hydroxide solution in water. Reject vague answer like Group 1 metals reacts with water to form alkali. (did not explain what alkali is in the question)	1
	(b)	**1.** bubbles / fizzing / effervescence [1] Accept gas given off/evolved/formed/produced Accept hydrogen gas given off (ignore identity of gas) **2**. sodium moves/darts around/ floats/ sodium gets smaller/disappears sodium melts / forms ball /leaves a white trail [1] Accept: sparks/ flames/ dissolves/ shoots/ small explosion/ sodium reacts violently/vigorously in water (ignore wrong colour flame)	2
	(c)	Melting point: 39°C (accept temperature below 63 and above 30°C) (√) Rubidium has bigger/bigger atomic size/radius/ more electron shells (√) than potassium. The electrostatic forces of attraction between the positive metal cations and negative sea of delocalised valence electrons is weaker.(√) Lower amount of energy is needed to overcome (√) the forces of attraction, hence lower melting point than potassium 2 (√) : 1m 4 (√) : 2m Reject 'electrostatic forces of attraction between positive nucleus and valence electron is weaker.' Ignore wrong melting point if the explanation is all correct.	2
	(d)	Similarity [1m] Silver and Group 1 metals form ions with a 1+ charge / O.S. of silver and Group 1 metals is +1 in their compounds. Both silver and Group I metals lose 1 valence electron when reacting to form ions. Accept: Both have 1 valence electron. Difference [1m] Silver does not react with cold water / steam / acid, while Group 1 metals are highly reactive with cold water / steam / acid. Accept: Silver is unreactive while Group 1 are reactive. Note: Comparison must be made.	2
4	**(a)**	Methanoic acid [√] Reject: methanoic	1

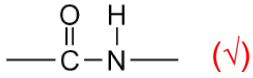
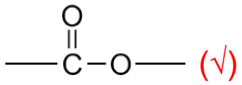
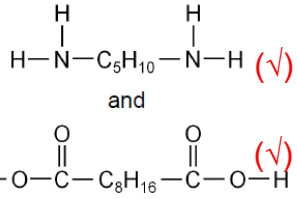
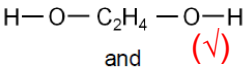
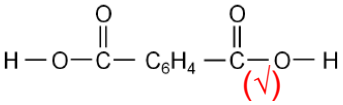
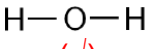
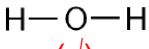
		CH_3CH_2COOH / C_2H_5COOH/ $C_3H_6O_2$[√]	
	(b)	It is a weak acid (√) Reaction is reversible which shows partial ionisation/dissociation(√) of acid to produce low concentration of hydrogen ions. (√)	1
	(ci)	Propanoic acid, ethanoic acid, methanoic acid (1m) idea of quote value & comparison of concentration of hydrogen ions made (1m) Methanoic acid has a lower/lowest pH/(√), hence higher concentration of hydrogen ions (√), Propanoic acid has a higher/ highest pH/(√), hence lower concentration of hydrogen ions (√), ~~hence more particles per unit volume(√)/,~~ ~~higher frequency of collisions, Higher frequency of effective collisions between hydrogen ions and reactant particles per unit time(√), resulting in higher rate of reaction~~ 4(√): 2 mark 2(√): 1 mark	2
	(cii)	$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$	1
	(d)	Acidified potassium manganate (VII) Reject if no acidified Ignore if no VII.	1
	(e)	number of moles NaOH = 0.20 × 25/1000 = 0.00500 mol since mole ratio of NaOH: CH_3COOH = 1:1, number of moles of ethanoic acid = 0.00500 mol [1] concentration of ethanoic acid = 0.005 ÷ 20/1000 = 0.25 mol/dm^3 [1] M_r of CH_3COOH = (12x2 + 4 + 16x2) = 60 mass of CH_3COOH in 1 dm^3 = (0.25 × 60) = 15.0 g mass of CH_3COOH in 100 cm^3 = 1.50 g therefore label is correct [1] Accept if student use mole/concentration to compare.	3
5	**(a)**	Add **excess magnesium metal / magnesium oxide / magnesium hydroxide / magnesium carbonate to dilute sulfuric acid**. (√) Stir until no further reaction occurs. **Filter** to remove excess magnesium metal / magnesium oxide / magnesium hydroxide / magnesium carbonate OR filter to obtain magnesium sulfate solution. (√) Heat the filtrate / solution until ***saturated***.(√) Allow the solution to cool and crystallise/for crystals to form(√)	3

		Filter to collect the crystals. Wash the crystals with a little cold distilled water(√) and dry between pieces of filter paper(√). 6(√): 3 marks Ignore if students never wash.	
	(bi)	Heating the crystals until the mass is constant ensures that **all the water of crystallisation has been removed / evaporated away** from the crystal.	1
	(ii)	Mass of water of crystallisation = 0.715 – 0.265 = 0.45 g Number of moles of water of crystallisation = 0.45 ÷ [2(1) + 16] = 0.025 mol [1] Number of moles of anhydrous Na_2CO_3 = 0.265 ÷ [2(23) + 12 + 3(16)] 0.0025 mol [1] $Na_2CO_3 : H_2O = 0.0025 : 0.025 = 1 : 10$ Hence, ***x*** = 10 [1]	3
	(iii)	Sodium is a highly reactive metal that forms **heat/ thermally stable carbonates**(√) **that will not/difficult to decompose**(√) to the metal oxide	1
6	**(ai)**	Use powdered magnesium carbonate instead of lumps Reject: catalyst (cos it is an spontaneous reaction) and temperature (stated in the qnes)	1
	(ii)	powdered magnesium carbonate provides a larger **exposed** surface area/ in contact/ surface area to volume ratio between reacting particles(√) Accept: larger surface area Increasing the frequency of collision(√) between the reacting particles and hence, increased frequency of effective collisions between the reacting particles. (√) Allow ECF for catalyst/ temperature explanation.	2
	(bi)		2
	(c)	Dilute ethanoic acid is a **weak acid** and ionises partially in water to form a lower concentration of H^+ ions (√) as compared to hydrochloric acid which dissociates completely in water to form a high concentration of H^+ ions [1]	3

		Hence, the rate of reaction would be lower (√) and hence, the initial **gradient of the graph would be gentler/less steep** (√) [1] The acid is the limiting reagent. Both are **monobasic acid**, hence give same number of moles of H^+ ions [1] hence, volume of carbon dioxide remains the same. Accept: concentration and volume of acid is the same, hence number of moles of H^+ ions will be same. (only holds for this qnes context)	
7	**(ai)**	Carbon monoxide is toxic, combines/binds with haemoglobin in blood, reduces the ability of haemoglobin to /prevent transport oxygen to the rest of the body. [1] Oxides of nitrogen can react with oxygen and water in the atmosphere to form acid rain which corrodes buildings and harms aquatic life and plants OR cause lung/eye irritations [1]	2
	(aii)	$2NO + 2CO \rightarrow 2CO_2 + N_2$	1
	(aiii)	**Carbon dioxide** is a **greenhouse** gas and it contributes to **global warming**/**trap heat within the atmosphere/**. Reject: Carbon dioxide degrades the ozone layer and leads to global warming. Reject: sulfur dioxide/ oxides of nitrogen	1
	(b)	No loss in NO molecules. The **NO molecules reacted/removed** in step 1 **(after reacting with ozone) are regenerated** in step 2 **(in reaction with more ozone)**. Accept: reproduced/ form back Reject if describe the step 1 and 2 as it is listing information without thinking Reject NO is a catalyst	1
	(c)	The **carbon dioxide released during combustion/burning** of biofuel is **removed from air by photosynthesis** carried out by sugarcane plant [1]. Thus, there is no net gain or loss of /offset/balance off carbon dioxide [1] Accept: remove and produce at the same rate	2
8	**(ai)**		2

		 1 mark for shape & label reactants and products 1 mark for E_a and ΔH Ignore value of ΔH Reject product and reactant Accept: If student draw endothermic, award mark for E_a and ΔH	
	(aii)	Octane has <u>more atoms/covalent bonds</u> than butane.(1) <u>More energy is **taken in** to **break** more</u> C-C and C-H bonds(√) in octane. <u>More energy is **given out** to **form** more</u> C=O and H-O bonds(√) as number of moles of CO_2 and H_2O molecules produced increases. (1) The <u>increase in amount of energy given out to form more bonds is greater than the increase in amount of energy taken in to break more bonds</u>(√), resulting in a more negative enthalpy change of combustion for octane.	2
	(aiii)	Energy given out by 30.0kg of octane = $\frac{30000}{114} \times 5470$ = 1.4394 x 10^6 kJ [1] Number of moles of butane to give same amount of energy = $\frac{1.4394 \times 10^6\ kJ}{2880}$ = 499.817mol [1] Mass of butane = 499.817 x 58 = 28989.4 g = <u>29.0 kg</u> [1]	3
	(b)	1. Length of carbon chain. Comparing n-heptane, n-hexane, n-pentane, the <u>shorter/shortest chain chain/shorter hydrocarbon (n-pentane) has a higher/highest octane rating of 62</u> compared to n-hexane (25) and h-heptane (0). 2. Degree of branching. <u>The more branched, the higher the octane number</u>. Comparing the isomers n-heptane and 2-methylhexane with chemical formula of $C_7H_{16,}$ <u>2-methylhexane being the more</u>	2

		branched structure has a higher octane rating (23) compared to n-heptane (0). 3. The existence of rings/presence of ring/ cyclic/ aromatic structure. Comparing the isomers n-hexane and cyclohexane with chemical formula of C_6H_{12}, cyclohexane being arranged in a cyclic/ring structure has a higher octane rating (97) compared to n-hexane (25). Any 2 Identify factors + quote datas to compare and show factors mentioned Reject if students wrote presence of -OH grp as the data given does not allow students to have a fair basis of comparison.	
	(c)	 Reject: if student draw 2 structures	1
	(d)	There are 2 methyl groups on carbon 2 and 1 methyl group on carbon 4. Reject: there are 3 methyl groups Accept: The 3 methyl grp are on 2nd and 4th carbon	1
	(e)	increases octane rating/ reduce knocking (pinking, pre-ignition)/ reduces pollution/ less negative environmental impact/ less harm to environment/ greener (cleaner, ecofriendly) fuel/ cleaner burn of fuel/ more complete combustion/ lower carbon monoxide emission/ lower emission of carbon (soot) particles/ eliminate need for lead compounds/ emissions less toxic/ lesser corrosion	1

9	**(a)**	<table><tr><th>polymer</th><th>nylon</th><th>*Terylene*</th></tr><tr><td>formula of the type of linkages present</td><td>  (√) *accept −CONH−* *reject CONH; i.e. without bonds at the ends*</td><td>  (√) *accept −COO−* *reject COO; i.e. without bonds*</td></tr><tr><td>name of the type of linkages present</td><td>**amide** linkage (√)</td><td>**ester** linkage (√)</td></tr><tr><td>structures of the monomers</td><td>  (√) and (√)</td><td>  and (√)  (√)</td></tr><tr><td>formula of the molecule eliminated</td><td>  (√) *accept H_2O*</td><td>  (√) *accept H_2O*</td></tr></table> Deduct one mark for untidy table e.g. lines drawn not using ruler / table without border /unclear headers 10(√): 5 marks 7-9: 4 marks 5-6 (√): 3marks 3-4 (√)2marks: 2 (√): 1 marks	5
	(b)	A polymer is a type of **long-chain molecule** / very **large molecule** / **macromolecule** that is **linked/join together** **by** many repeat units formed from small molecules known as **monomers**. [1m]	1
	(c)	Advantage: Being non-biodegradable would mean that nylon and *Terylene* are very **durable/resistant to decay** Accept: can last long. [1m] Disadvantage: However, as they are non-biodegradable, they **cannot be decomposed / broken down** by bacteria in soil **and will cause pollution** caused by disposal of such material/ingestion can be fatal to animals / animals can be caught in plastics e.g. fishing line /combustion releases toxins / land-fill uses natural resources / reject “reusable” reject “**can only be** disposed burying in landfills hence cause land pollution”	2

10	**(a)**	**In cell 1** anode/electrode on the left: Oxidation occurs. observation: bubbling/effervescence (√) explanation: H^+ is preferentially discharged over NO_3^- to form hydrogen(√**)** half-equation: $4OH^-$ (aq) → O_2 (g) + $2H_2O$ (l) + $4e^-$ (√) cathode/electrode on the right: Reduction occurs observation: bubbling/effervescence (√**)** explanation: H^+ is discharged/reduced(√) to form hydrogen. half-equation: $2H^+$ (aq) + $2e^-$ → H_2 (g)(√) **In cell 2** anode/electrode on the left: Oxidation occurs. observation: silver electrode reduces in size/become smaller/dissolves (√**)** explanation: silver anode/electrode on the left is a reactive electrode (√) and will undergo oxidation *(award once only)* half-equation: Ag (s) → Ag^+ (aq) + e^-(√**)** cathode/electrode on the right: Reduction occurs observation: silver electrode increases in size (√**)** explanation: Ag^+ ions are preferentially discharged over H^+ ions(√**)** to form silver half-equation: Ag^+ (aq) + e^- → Ag (s)(√**)** **In cell 3** anode/electrode on the left: Oxidation occurs. observation: iron electrode reduce in size.(√**)** OR and the solution will remain green explanation: iron is a reactive electrode (√**)** and will undergo oxidation *(award once only)* and half-equation: Fe (s) → Fe^{2+} (aq) + 2e (√**)** cathode/electrode on the right: Reduction occurs observation: bubbling/effervescence (√**)** explanation: H^+ is preferentially discharged over Fe^{2+} (√**)**to form hydrogen half-equation: $2H^+$ (aq) + $2e^-$ → H_2 (g)(√) 18(√**):** 6m Any 3(√**)** : 1m Penalise 1 mark overall for more than 1 missing state symbols.	3(√) 3(√) 3(√) 3(√) 3(√)
	(bi)	Ag^+ ions are lower in the electrochemical series than H^+ (√**)**and therefore will be Ag^+ preferentially reduced/discharge to form Ag (s) OR show eqn. (√**)** [1] Accept: Ag is less reactive than H/ Ag is lower in reactivity series than H. Hence a shiny grey deposit/silver solid/grey solid found at the bottomOR there will be no bubbling at the cathode [1]	2
	(bii)	Iron is more reactive than silver and will displace silver from silver nitrate. [1]	2

		Colour of solution will turn pale green/yellow OR both electrodes will reduce in size [1]	
11	**(ai)**	Ethanol is more volatile/evaporates more quickly/evaporates more easily/ evaporates in a shorter time Accept has a lower boiling point (than water) Ignore reference to melting point(s) Accept reverse arguments for water	1
	(aii)	Positive electrode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ [1] Negative electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ [1]	2
	(aiii)	some copper formed did not stick/attached to (negative) electrode/cathode and fell into solution. some copper removed during washing/drying positive electrode/anode impure OR formed (anode) sludge Accept some copper dropped off Reject some of the copper dissolve back into electrolyte.	1
	(bi)	gain in mass at cathode = loss in mass at anode = 1.44 – 1.20 = 0.24 g [1] mass of anode after electrolysis = 1.45 – 0.24 = 1.21 g [1]	2
	(bii)	gain in mass at cathode after electrolysis at 8.0A for 90 s = gain in mass at cathode after electrolysis at 4.0A for 180 s = 0.24 g mass at cathode = 1.51 + 0.24 = 1.75 g	1

	(biii)		anode	electrolyte	3
		copper	observation: decrease in size/ no effervescence (√**)** reason: copper oxidises to form copper(II) ions (√**)**	observation: remain blue (√**)** reason: every mole of copper(II) ions discharged is replaced by every mole of copper oxidised to form copper(II) ions / no net lost of copper(II) ions (√**)**	
		carbon	observation: no decrease in size(√**)** / effervescence of a colourless (odourless) gas(√**)** reason: hydroxide ions is preferentially discharged at the anode and oxygen is produced(√**)** carbon is an <u>inert electrode hence anode will not be oxidise.</u>(√**)**	observation: blue colour fades / turns light blue / becomes colourless(√**)** reason: copper(II) ions is preferentially discharged (√**)** at the cathode resulting in a lower concentration of copper(II) ions	
		10(√): 3marks 3(√): 1 mark Ignore any answers that describe electrolyte becoming acidic or decreasing in pH (NOT observation)			