Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

CHEMISTRY

6092/01

Paper 1 Multiple Choice

29 August 2023
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, pencil clips, glue or correction fluid.
Write your name, index number and class on the Answer Sheet in the spaces provided.

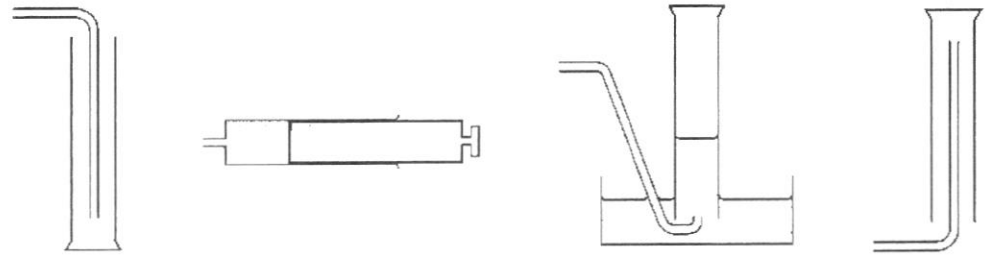
There are **forty** questions in this Paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

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 given on page **19**.
The use of an approved scientific calculator is expected, where appropriate.

For examiner's use only:	**Total**	**/ 40**

This document consists of **19** printed pages.

1 The diagrams show four different methods of collecting gases.



1 2 3 4

Which method is suitable for collecting a gas which has the properties described?

	method for collecting gas	properties of gas
A	1	less dense than air and soluble in water
B	2	denser than air and soluble in water
C	3	less dense than air and soluble in water
D	4	denser than air and insoluble in water

2 A mixture of three liquids is separated by fractional distillation in the school laboratory.

Which two statements are correct?

1 A pure sample of each liquid can be obtained after separation.

2 The mixture boils at constant temperature throughout the separation.

3 The three liquids are miscible with each other.

4 The three liquids are collected at the same time at different parts of the fractionating column.

A 1 and 3

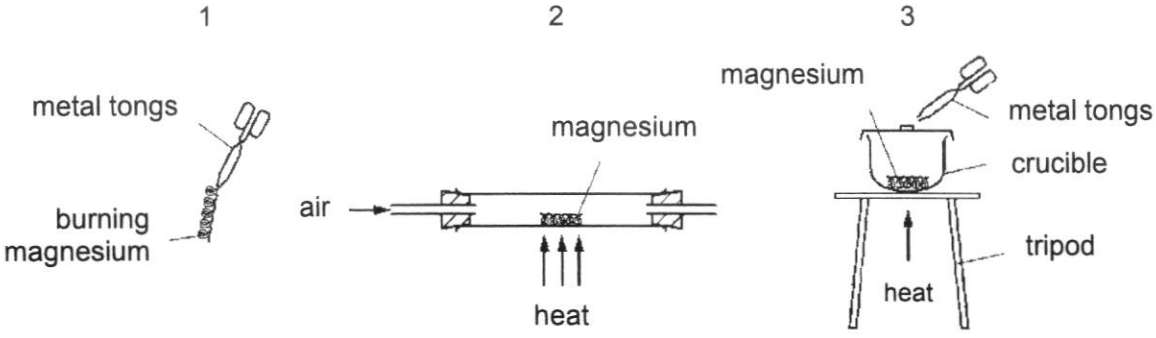
B 1 and 4

C 2 and 3

D 2 and 4

3 When heated, magnesium reacts with oxygen in the air to form magnesium oxide, a white powder.

A student wants to investigate the percentage purity of a piece of magnesium ribbon. The student is given a balance and three sets of apparatus shown.



Which sets of apparatus are suitable for his investigation?

A 1, 2 and 3

B 1 and 3 only

C 2 and 3 only

D 2 only

4 Which substance should be pure for the intended use?

A a drug for curing diseases

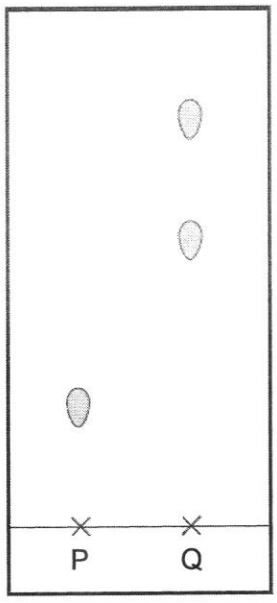
B aluminium for making airplane bodies

C petrol for car fuels

D tap water for human consumption

5 P and Q are all samples of colourless alcohols.

A paper chromatogram is obtained for samples of P and Q.



Which row is correct?

	statement 1	statement 2
A	A locating agent was used.	P may be a pure substance.
B	A locating agent was used.	P must be a pure substance.
C	No locating agent was used.	Q contains a substance that is least soluble in the solvent used.
D	No locating agent was used.	Q contains a substance that is most soluble in the solvent used.

6 Substance Y is added to an excess of hot water.

A blue solution forms and a brown solid remains.

The brown solid is filtered off and dried.

The brown solid conducts electricity.

Which statement about the substance Y, the blue solution, or the brown solid is **incorrect**?

A Substance Y may be a mixture which contains a metal.

B Substance Y may contain copper(II) carbonate.

C The blue solution must be an impure substance.

D The brown solid may be an impure substance.

7 P is a white powdery solid.

When a small spatula of P was added to a boiling tube filled with distilled water, P dissolved to form a blue solution.

The blue solution was divided into two separate test-tubes.

In the first test-tube, a blue precipitate was formed on dropwise addition of aqueous ammonia which dissolved in excess to form a deep-blue solution.

In the second test-tube, a white precipitate was formed on addition of an equal volume of acidified aqueous barium nitrate. The mixture was filtered and the filtrate crystallised to obtain solid Q.

What is P and Q?

	P	Q
A	barium sulfate	barium sulfate
B	barium sulfate	copper(II) nitrate
C	copper(II) sulfate	barium sulfate
D	copper(II) sulfate	copper(II) nitrate

8 25.0 cm^3 of aqueous silver nitrate was added to 25.0 cm^3 of aqueous zinc nitrate to form mixture L.

Mixture L was then added to 150 cm^3 of 0.05 mol/dm^3 sodium iodide in a beaker.

1.18 g of precipitate was formed.

What is the concentration of silver nitrate present in mixture L?

A 0.065 mol/dm^3

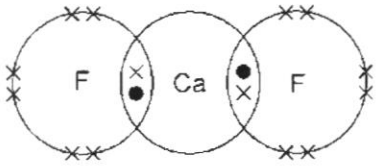
B 0.100 mol/dm^3

C 0.150 mol/dm^3

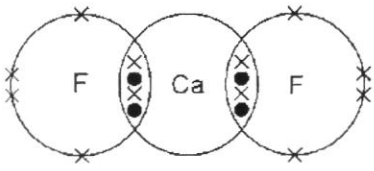
D 0.200 mol/dm^3

9 Which diagram shows the arrangement of the outermost electrons in calcium fluoride?

A



B



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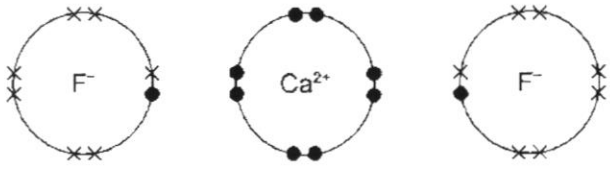

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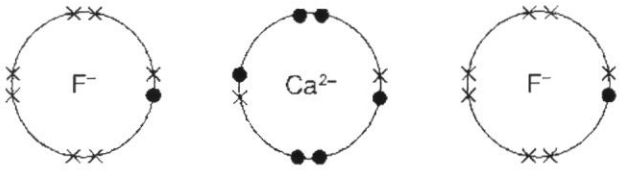
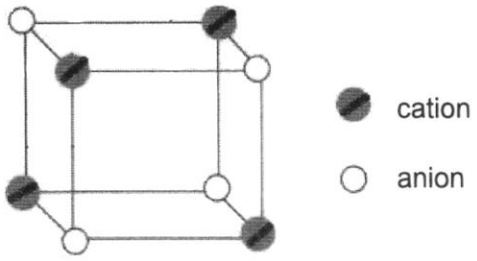


10 Part of the giant lattice structure of an ionic compound is shown.



The structure repeats to make a giant lattice.

Which statement is **incorrect**?

A The ions are held by strong electrostatic forces of attraction.

B The lattice structure is broken down when this ionic compound dissolves in water.

C There are three anions directly surrounding each cation in the giant lattice.

D This lattice structure could resemble that of calcium oxide.

11 Which statement about the structure or bonding of metals is correct?

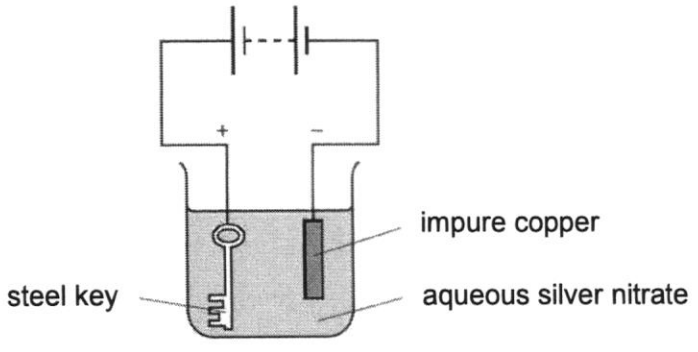
A A metal lattice consists of negative ions in a 'sea of electrons'.

B Electrons in a metal move randomly through the lattice.

C Metals are malleable because the ions present are mobile.

D The ions in a metal move when positive and negative electrodes are attached.

12 The apparatus shown is set up to plate a steel key with copper.

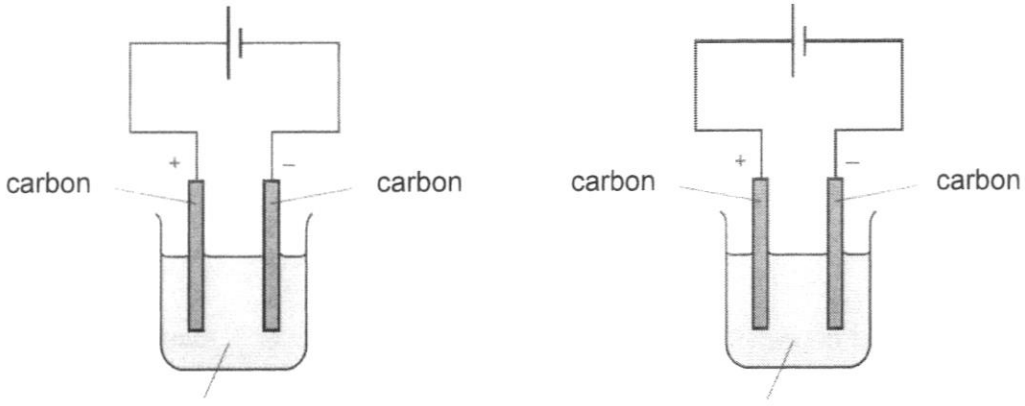


The steel key does not get plated with copper.

What is the **minimum** number of changes that needs to be made to plate the key with copper?

A 1 **B** 2 **C** 3 **D** 4

13 The diagram shows the electrolysis of concentrated hydrochloric acid and concentrated aqueous sodium chloride using carbon electrodes.



Which is a similarity between the two electrolysis experiments?

A A gas which extinguishes a lighted splint with a 'pop' sound is produced at the negative electrode.

B A gas which relights a glowing splint is produced at the positive electrode.

C A gas which turns damp red litmus paper blue and then bleaches it is produced at the positive electrode.

D Electrons flow from the negative terminal of the battery towards the negative electrode, electrolyte, positive electrode and back to the positive terminal of the battery.

14 A simple cell can be made using two different metals as the electrodes and an aqueous solution as the electrolyte.

Which statements about simple cells are correct?

1 A greater voltage is produced using magnesium and silver than using magnesium and copper.

2 Ethanol can be used as the electrolyte.

3 The more reactive metal will release electrons.

4 An anion always gets discharged at the negative electrode.

A 2 only

B 1 and 3 only

C 1, 3 and 4 only

D 1, 2, 3 and 4

15 The reaction between hydrogen and iodine to form hydrogen iodide is exothermic.

Which statement explains why the reaction is exothermic?

A More bonds are formed than broken.

B The activation energy is less than the energy released when bonds are formed.

C The bond energies of the reactants are greater than the bond energies of the products.

D The products are at a higher energy level than the reactants.

16 Lumps of copper(II) carbonate was added to 100 cm^3 of 1.00 mol/dm^3 dilute sulfuric acid which is in excess.

$$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$$

The rate of the reaction and total volume of gas produced can be changed by varying the conditions.

Which changes always increase **both** the rate of the reaction and the total volume of gas produced?

1 adding more powdered copper(II) carbonate

2 increasing the concentration of sulfuric acid

3 increasing the temperature

4 increasing the volume of sulfuric acid

A 1 only **B** 1 and 2 **C** 1, 2 and 4 **D** 2, 3 and 4

17 Aqueous iron(III) chloride reacts with aqueous potassium iodide.

$$v FeCl_3 + w KI \rightarrow x FeCl_2 + y KCl + I_2$$

Which statements are correct?

1 In the balanced equation, *v*, *w*, *x* and *y* have the same value.

2 A purplish-black vapour is produced in the reaction.

3 Potassium iodide is used to test for the presence of an oxidising agent.

A 1 and 2 only **B** 1 and 3 only **C** 2 only **D** 2 and 3 only

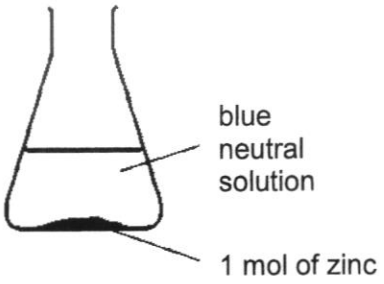
18 In an experiment, 1 mole of powdered copper and 1 mole of powdered zinc are placed in a flask.

1 mole of a dilute monobasic acid is added to the flask.

The flask is left to stand until all reactions, if any, are complete.

Which diagram shows the result of the experiment?

A



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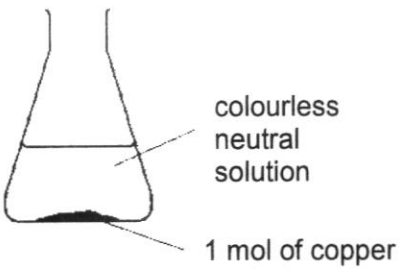

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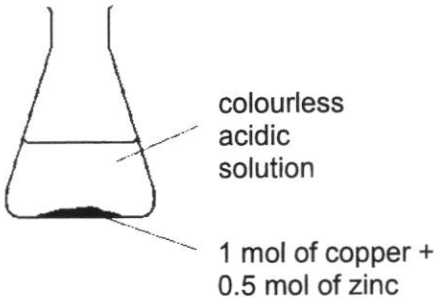

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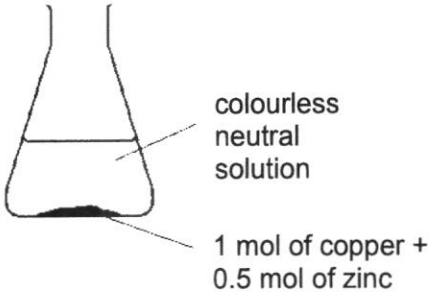


19 Which statements about sulfuric acid are correct?

1 Sulfuric acid can be used to treat excess acidity in soil.

2 Sulfuric acid is used as a battery acid.

3 Sulfuric acid is used in the manufacture of detergents.

4 The reaction between dilute sulfuric acid and any soluble base can be represented by the equation $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$.

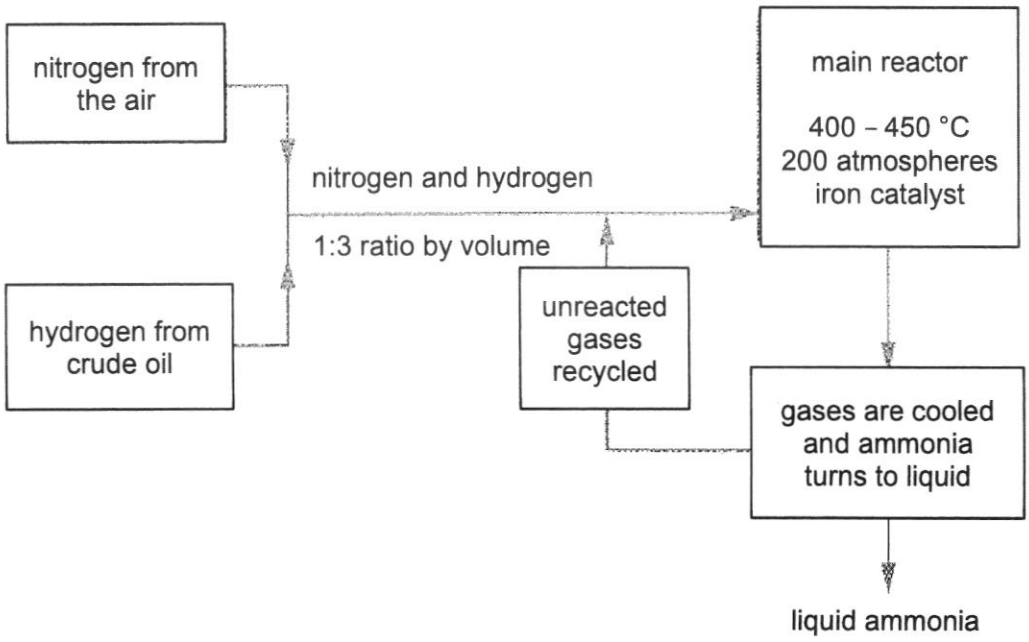
A 4 only

B 1 and 2 only

C 2 and 4 only

D 2, 3 and 4 only

20 The Haber process for making ammonia can be represented using a flow diagram.



Which change in conditions would produce a greater **final** amount of ammonia made from a fixed amount of nitrogen and hydrogen?

	adding a catalyst	increasing the pressure
A	✓	✓
B	✓	×
C	×	✓
D	×	×

key

✓ = produce a greater final amount of ammonia

× = does not produce a greater final amount of ammonia

21 Which compound when warmed with aqueous calcium hydroxide would give the largest mass of ammonia gas?

A 0.5 mol of $(NH_4)_3PO_4$

B 1.0 mol of $Al(NO_3)_3$

C 1.0 mol of NH_4Cl

D 1.0 mol of $(NH_4)_2SO_4$

22 A student wrote down part of the method used to make lead(II) chloride.

1 Add excess dilute nitric acid to lead(II) carbonate.

2 Add excess dilute hydrochloric acid to the filtrate.

3 Filter the mixture.

What is the purpose of each of the underlined words in steps 1, 2 and 3?

	step 1	step 2	step 3
A	to ensure all the lead(II) carbonate has reacted	to ensure maximum yield of lead(II) chloride	to obtain the residue
B	to ensure all the lead(II) carbonate has reacted	to speed up reaction	to obtain the filtrate
C	to remove carbonate ions	to ensure maximum yield of lead(II) chloride	to obtain the residue
D	to remove carbonate ions	to speed up reaction	to obtain the residue

23 Excess barium oxide and barium carbonate are added separately to dilute hydrochloric acid.

Which row correctly shows whether a pure sample of barium chloride can be obtained from the resultant mixture?

You may assume that barium oxide is soluble in water.

	barium oxide	barium carbonate
A	✓	✓
B	✓	×
C	×	✓
D	×	×

key
✓ = can obtain pure barium chloride
× = cannot obtain pure barium chloride

24 Which statement about the elements in the Periodic Table is correct?

A Atoms of elements lose electrons less easily down a group of the Periodic Table.

B Elements are arranged in the order of increasing relative atomic masses.

C Elements in the same group of the Periodic Table have the same number of completely filled electron shells.

D The metallic character of the elements decreases from left to right across a period of the Periodic Table.

25 Which statement about the properties of the elements in Group 0 of the Periodic Table, helium to xenon, is correct?

A Argon reacts with iron to form a compound.

B Helium is less dense than air.

C The elements change from gas to solid down the group.

D The elements exist as covalent molecules.

26 Which property is common to ^{40}Ca, ^{39}K and ^{23}Na?

A Their atoms all have more neutrons than protons.

B Their ions all have eight electrons in their outer shell.

C They all sink when added to water.

D They are all deposited at the positive electrode when their molten chloride is electrolysed.

27 Which statement is true for all metals?

A They form alloys with other elements through chemical means.

B They form either amphoteric or basic oxides.

C They have a high density.

D They have a high melting point.

28 Which pair of substances, when added together, would result in heat being evolved?

A Ag(s) and $Cu(NO_3)_2$ (aq)

B Cu(s) and $Mg(NO_3)_2$ (aq)

C Mg(s) and $Ca(NO_3)_2$(aq)

D Zn(s) and $Cu(NO_3)_2$ (aq)

29 Scrap iron is often recycled.

Which reason for recycling is **incorrect**?

A It reduces the amount of carbon dioxide formed at the site of the ore extraction.

B It reduces the amount of waste taken to landfill sites.

C It reduces the need to collect scrap iron.

D It saves finite resources.

30 Mild steel is galvanised to prevent corrosion of the iron.

Which statements about galvanising are correct?

1 Galvanising makes a steel alloy.

2 Galvanising provides a sacrificial protection against rusting.

3 Galvanising coats a layer of zinc onto steel.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

31 A student wrote four statements about some of the gases that can be found in polluted or unpolluted air.

- Carbon dioxide is absent in unpolluted air.
- Dry air contains about 78% of oxygen.
- Sulfur dioxide is released by volcanoes.
- The noble gases make up about 5% of dry air.

How many statements are correct?

A 1 **B** 2 **C** 3 **D** 4

32 Which row gives the correct problems associated with the gaseous pollutant in the atmosphere?

	pollutant	problems
A	carbon monoxide	causes shortness of breath and hence death in humans
B	chlorofluorocarbons	more ultraviolet radiation reaches the Earth hence worsening global warming
C	nitrogen monoxide	acid rain
D	sulfur dioxide	irritates respiratory tract, causing bronchitis

33 Petroleum is separated into fractions by fractional distillation.

Some properties of three of these fractions are shown.

fraction	boiling point range / °C	number of carbon atoms in the molecules
1	?	5 – 10
2	320 – 350	16 – 24
3	120 – 210	?

Which statement is correct?

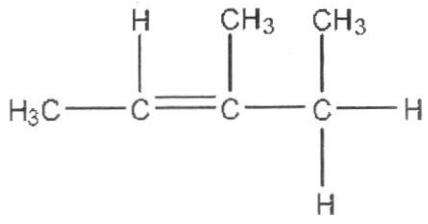
A Fraction 1 has a higher boiling point than fraction 2.

B Fraction 2 is removed from higher up the fractionating column than fraction 1.

C Molecules in fraction 3 have shorter chains than those in fraction 2.

D Fraction 2 is used as a fuel in cars.

34 The structure of alkene J is shown.



Four statements are made about alkene J.

1 Addition of hydrogen to J gives the alkane $(CH_3)_2CHCH(CH_3)_2$.

2 J can be manufactured by cracking.

3 J does not burn in air to form carbon dioxide and water.

4 The number of C–C single bonds is increased by reacting J with bromine.

Which statements are correct?

A 1 and 3 only

B 1 and 4 only

C 2 and 3 only

D 2 and 4 only

35 Which alkene, on addition of steam, can produce only **one** alcohol?

A $CH_3CH=CH_2$

B $CH_3CH_2CH=CH_2$

C $(CH_3)_2C=CHCH_3$

D $(CH_3)_2C=C(CH_3)_2$

36 Ethanol is made industrially by the fermentation of glucose or by the catalytic addition of steam to ethene.

Which statement describes an advantage of fermentation compared to catalytic addition?

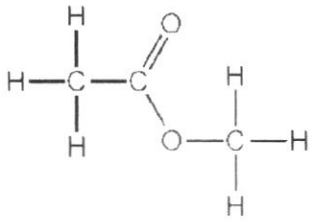
A Fermentation does not contribute to global warming.

B Fermentation produces a higher yield of ethanol.

C Fermentation produces pure ethanol.

D Fermentation uses a renewable resource.

37 The structure of ester W is shown.



Which statement about ester W is **incorrect**?

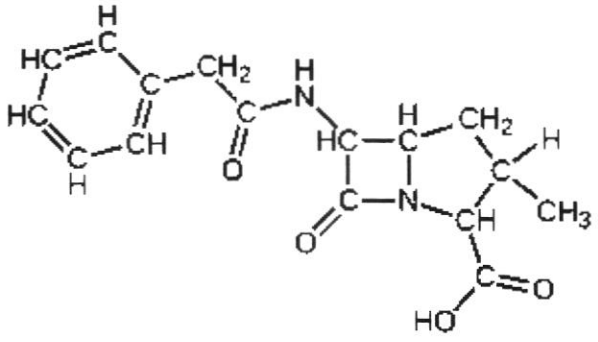
A Ester W can be used to make solvents.

B Ester W is formed by a condensation reaction.

C One mole of methanol reacts with one mole of ethanoic acid to give one mole of ester W and one mole of water.

D Propanoic acid is an isomer of ester W.

38 The structure of an organic compound is shown.



Which statement about this organic compound is correct?

A It gives off a sweet-smelling substance when reacted with a carboxylic acid.

B It is a hydrocarbon.

C It is polyunsaturated.

D Its empirical formula is $C_8H_8O_2N$.

39 Hexane and hexene are organic compounds with the molecular formulae, C_6H_{14} and C_6H_{12} respectively.

Some properties of colourless liquid L and M are listed.

liquid L	liquid M
• When added to water, two layers form which do not mix. • It does not react with sodium hydroxide. • It boils at 65 °C.	• When added to water, two layers form which do not mix. • It does not react with sodium hydroxide. • It decolourises bromine water.

What could liquid L and M be?

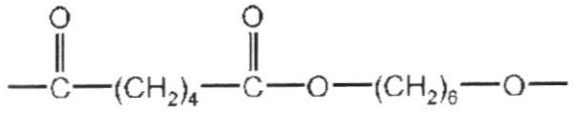
	liquid L	liquid M
A	ethanol	hexene
B	ethanol	ethane
C	hexane	ethene
D	hexene	hexene

40 P is a polymer that:

- has six carbon atoms in each of the monomers from which it is formed
- is not a polyester
- is non-biodegradable and suitable to use in parachutes and sleeping bags

What is the partial structure of P?

A



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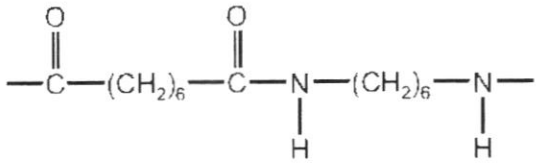

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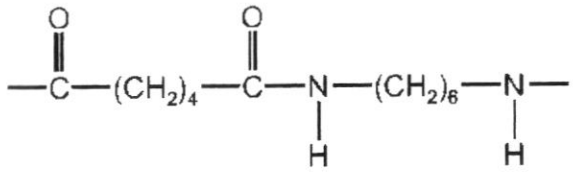

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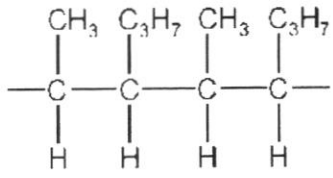

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Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

A

CHEMISTRY

6092/02

Paper 2

22 August 2023
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

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

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

The number of marks is given in brackets [ ] at the end of each question or part question.

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

For examiner's use only:	Section A	/ 50

This document consists of **12** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The table consists of four different experimental procedures.

(a) Put a tick (✓) if a redox reaction had occurred.

		Put a tick (✓) if a redox reaction had occurred.
(i)	a copper strip added to lead(II) nitrate solution	
(ii)	aqueous chlorine added to potassium iodide solution	
(iii)	hydrogen gas passed over heated copper(II) oxide	
(iv)	potassium nitrate solution warmed with sodium hydroxide solution	

[3]

(b) A student repeated **(a)(ii)** by replacing aqueous chlorine with aqueous bromine.

Describe a difference in the rates of the two reactions and explain your answer.

.....

.....

.....

..... [2]

[Total: 5]

A2 The boiling points of ethane and some chlorine-containing organic compounds are given in Table 2.1.

Table 2.1

formula of compound	C_2H_6	C_2H_5Cl	$C_2H_4Cl_2$	$C_2H_3Cl_3$	$C_2H_2Cl_4$
boiling point / °C	–89	12	84	114	147

(a) Describe the general trend shown by the data in Table 2.1.

.....

..... [1]

(b) Use the formulae of the compounds to answer the following questions.

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

(i) Which compound is a hydrocarbon?

..... [1]

(ii) Which compound belongs to the same homologous series as $C_4H_8Cl_2$?

..... [1]

(c) State the total number of compounds in Table 2.1 which are soluble in organic solvents.

..... [1]

(d) Draw the displayed formulae of **two** isomers of $C_2H_4Cl_2$.

[2]

[Total: 6]

A3 Some physical properties of five different substances are given in Table 3.1.

Table 3.1

substance	melting point / °C	conducts electricity in the solid state?
A	1410	no
B	340	no
C	–56	no
D	70 – 80	no
E	2595	yes

Figs. 3.1 and 3.2 show the structure of a molecule of carbon dioxide and phosphorus pentoxide respectively.

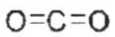


Fig. 3.1

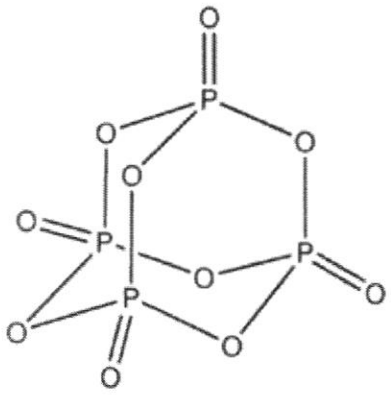


Fig. 3.2

(a) Which substance (A to E) would be carbon dioxide and phosphorus pentoxide respectively?

Use ideas about structure and bonding to explain your choice.

carbon dioxide .....

phosphorus pentoxide .....

.....

.....

.....

.....

..... [5]

(b) Silicon is a semiconductor. When adequately heated, silicon can conduct electricity.

Figs. 3.3 and 3.4 show the structure of silicon and graphite.

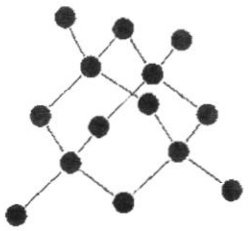


Fig. 3.3 Structure of silicon

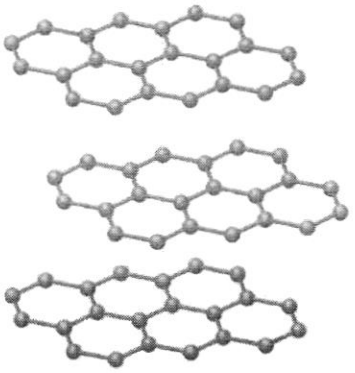


Fig. 3.4 Structure of graphite

(i) Compare the structure and bonding of silicon and graphite.

.....

.....

.....

.....

.....

..... [2]

(ii) Explain if Fig. 3.3 shows that silicon can act as a semiconductor.

.....

.....

.....

..... [2]

[Total: 9]

A4 **(a)** Photosynthesis is part of the carbon cycle.

(i) Explain why photosynthesis is important in the carbon cycle.

.....

..... [1]

(ii) Catalytic converters do **not** solve all environmental problems caused by car exhausts.

Explain why this is so. You should include a chemical equation in your answer.

.....

.....

..... [2]

Fig. 4.1 shows the apparatus set up by a student to conduct a photosynthesis experiment in the school laboratory.

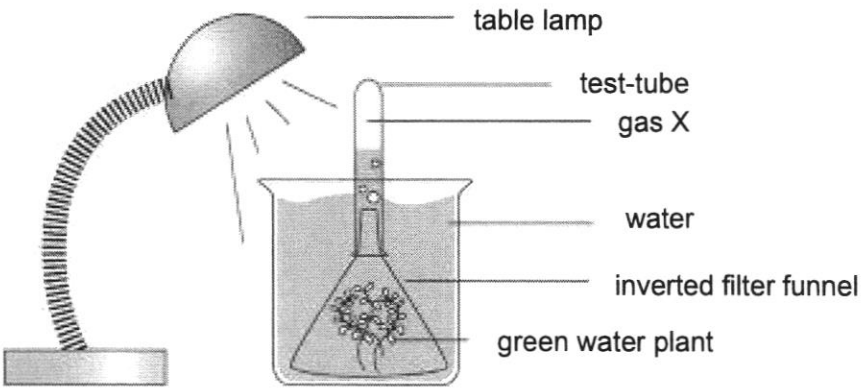


Fig. 4.1

He repeated his experiment by removing the table lamp and placing the rest of the apparatus in a dark room.

(b) **(i)** Describe a difference in the results of the two experiments.

.....

..... [1]

(ii) The student made a conclusion from his results:
'Since light energy is taken in for photosynthesis to occur, it is an endothermic reaction.'

Explain why the student's conclusion is incorrect.

.....

..... [1]

[Total: 5]

A5 Fig. 5.1 shows some reactions starting with propanol.

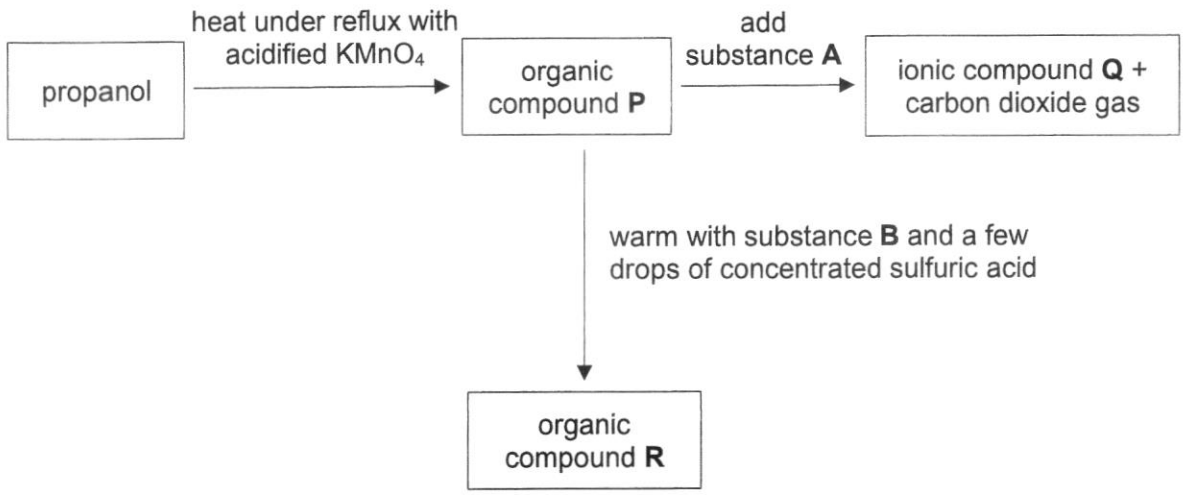


Fig. 5.1

(a) Write a balanced chemical equation for the reaction that occurs when propanol is heated under reflux with acidified $KMnO_4$ to form organic compound **P**.

..... [1]

(b) Compound **R** contains 64.6% carbon, 10.8% hydrogen and 24.6% oxygen by mass.

(i) Determine the empirical formula of **R**.

[2]

(ii) Name compound **R**.

..... [1]

(c) **(i)** Suggest an identity for substance **A**.

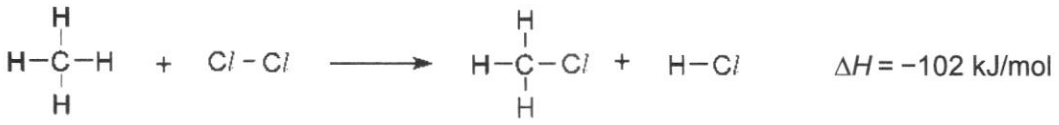
..... [1]

(ii) Hence, give the chemical formula of ionic compound **Q**.

..... [1]

[Total: 6]

A6 The substitution reaction of methane by chlorine is an exothermic process.



methane chloromethane

(a) In terms of bond breaking and bond forming, explain why the reaction is exothermic.

.....

.....

..... [2]

(b) Chloromethane undergoes a similar substitution reaction as methane.

(i) Write the chemical equation for this reaction, showing the displayed formulae of all organic compounds.

[1]

(ii) Suggest a value for the enthalpy change of the reaction between chloromethane and chlorine.

Explain your reasoning.

.....

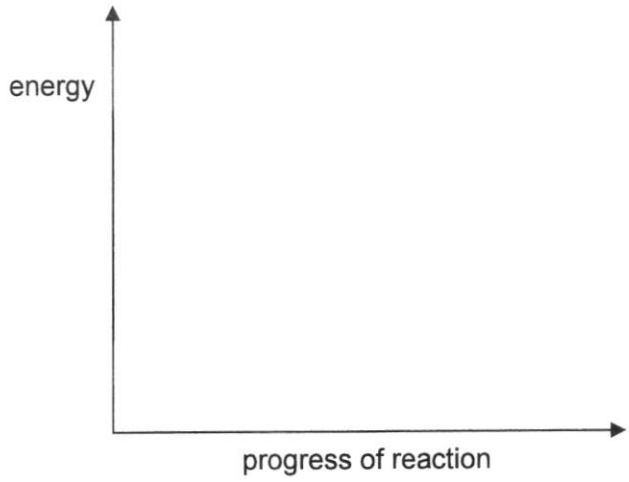
.....

..... [2]

(iii) Hence, draw the energy profile diagram for the reaction between chloromethane and chlorine in the axes below.

Your diagram should show:

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



[2]

[Total: 7]

A7 In the electrolysis set-up (Fig. 7.1), the filter paper is first soaked with a dilute solution containing potassium sulfate and purple litmus solution.

The circuit is then closed.

After running the electrolysis for some time, a few barium nitrate crystals are placed in the middle of the filter paper.

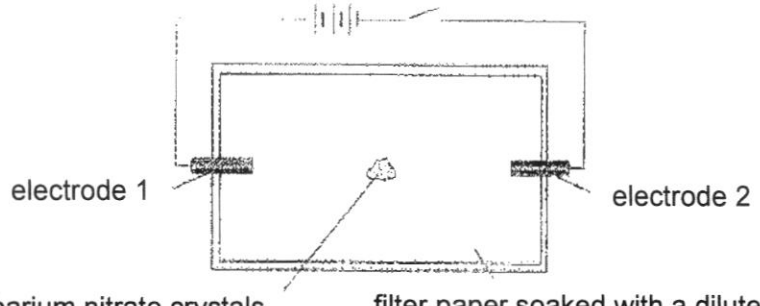


Fig. 7.1

(a) **(i)** Write the half-equations for the reactions occurring at electrodes 1 and 2 **before** the barium nitrate crystals were placed.

electrode 1 .....

electrode 2 ..... [2]

(ii) Describe and explain how the reaction occurring at **each** electrode, before the barium nitrate crystals were placed, would affect the appearance of the filter paper that is soaked with purple litmus solution.

.....

.....

.....

..... [3]

(b) After the barium nitrate crystals were placed in the middle of the filter paper, a student observed that the crystals dissolved.

(i) Explain his observation.

.....

..... [1]

(ii) Describe **another** observation that could be made.

.....

..... [1]

[Total: 7]

A8 A student added powdered manganese(IV) oxide into two separate solutions, dilute hydrochloric acid and aqueous hydrogen peroxide.

The chemical equations for both reactions are given below.

Reaction A: $MnO_2(s) + 4HCl(aq) \longrightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$

Reaction B: $2H_2O_2(aq) \xrightarrow{MnO_2(s)} 2H_2O(l) + O_2(g)$

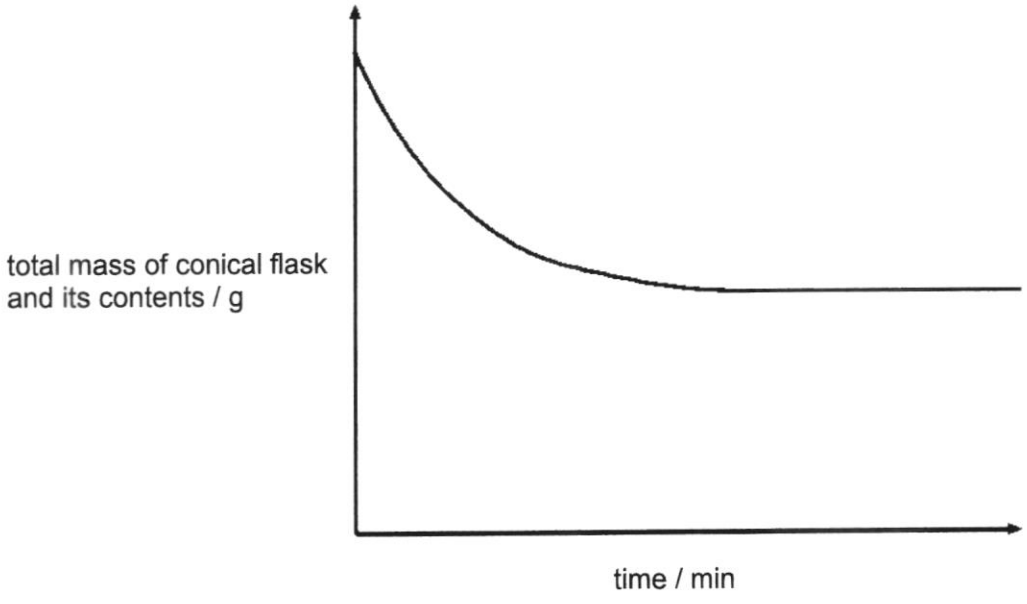
(a) The student followed the rate of reaction B by measuring the total mass of the conical flask and its contents over time.

Table 8.1 shows his results.

Table 8.1

time / min	0	5	10	15	20	25
mass / g	550.00	549.84	549.76	549.71	549.69	549.69

(i) He plotted his results and obtained the graph below.



He repeated the experiment at a **lower** temperature.

On the axes above, sketch the graph of his **repeated** experiment. [1]

(ii) The student used the same method to follow the rate of reaction A.

Suggest a reason to explain why this method is **not** accurate in investigating the rate of reaction A.

.....

..... [1]

(iii) The time taken for the reaction to be half-complete is **not** determined by halving the total time taken for the reaction to reach completion.

Using the graph given, explain why this is so.

.....

..... [1]

(b) The student modified his experiments such that he was able to accurately determine the rate of both reactions.

He then repeated the experiment for each reaction using a larger mass of powdered manganese(IV) oxide and made the following conclusions from his results.

Conclusion 1: The rate of reaction for A was significantly higher than the previous experiment.

Conclusion 2: The total volume of oxygen gas collected in B remained unchanged.

Explain why both his conclusions are correct.

.....

.....

.....

..... [2]

[Total: 5]

Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

B

CHEMISTRY

6092/02

Paper 2

22 August 2023
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Section B
Answer all **three** questions. The last question is in the form either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **12**.

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

For examiner's use only:

B9	**/ 12**
B10	**/ 8**
B11 EITHER / OR	**/ 10**
Total	**/ 30**

This document consists of **12** printed pages.

Section B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 The pH scale

The pH scale was developed in 1909 by Søren Sørensen to express the concentration of hydrogen ions.

The scale is important for a wide range of areas in everyday life, such as treating soil, reducing tooth decay, medicine, and monitoring the acidity of water.

The term 'pH' means 'potential of hydrogen', and the scale is the negative base 10 logarithm of the concentration of hydrogen ions in a solution.

$$pH = -\log_{10}[H^+]$$

where $[H^+]$ represents the concentration of hydrogen ions in a solution

The concentration of hydrogen ions, which are also known as 'protons', in a solution determines how acidic or basic the solution is. Since this concentration can vary drastically, a logarithmic scale is used. And since the scale is negative, the smaller the pH value, the higher the concentration of the 'protons'.

The Universal Indicator

A Universal Indicator is a mixture of different types of indicators that displays several colour changes at various pH levels across the pH scale. It is used to detect the acidic or basic nature of a substance or a solution. It can be in the form of a paper strip or a solution.

The main components of a Universal Indicator, in the form of a solution, are thymol blue, methyl red, bromothymol blue and phenolphthalein.

Table 9.1

indicator	colour in lower pH range	pH range in which it changes colour	colour in upper pH range
thymol blue	red	1.2 to 2.8	yellow
	yellow	8.0 to 9.6	blue
methyl red	red	4.2 to 6.3	yellow
bromothymol blue	yellow	6.0 to 7.6	blue
phenolphthalein	colourless	8.0 to 10.5	pink

(a) Using ideas about sub-atomic particles, explain why a hydrogen ion is also known as a 'proton'.

.....

..... [1]

(b) Table 9.2 shows the pH value of a solution given the concentration of hydrogen ions.

Table 9.2

pH value	concentration of hydrogen ions in solution in mol/dm^3
1.3	0.0500
1.6	0.0250
1.9	0.0125
2.0	0.0100

(i) Determine the pH of a sample of 0.0250 mol/dm^3 of sulfuric acid.

[2]

(ii) A student claims that the pH value of a solution is inversely proportional to the concentration of hydrogen ions in a solution.

By means of a calculation, determine if the student's claim is true or false.

[3]

(c) Secondary colours such as purple, orange and green can be made by mixing primary colours which are red, blue and yellow.

Red and blue make purple, red and yellow make orange, and yellow and blue make green.

(i) Using relevant information, explain why a solution of pH 3 turns the Universal Indicator orange.

.....

.....

.....

..... [2]

(ii) A student performed a titration experiment using dilute hydrochloric acid and aqueous sodium hydroxide.

The graph in Fig. 9.1 shows how the pH changes during his titration experiment.

The graph shows an equivalence point which occurs at pH 7.

The equivalence point is the point in a titration experiment at which the volume of titrant added from a burette is just enough to completely neutralise the solution in the conical flask.

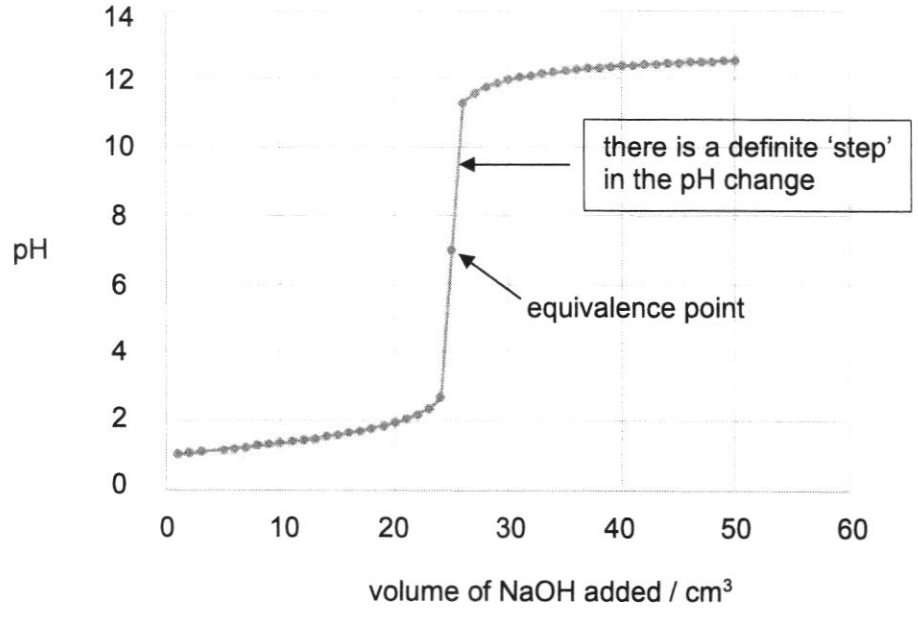


Fig. 9.1

An indicator is suitable to be used in a titration experiment if it fulfils the criteria below.

These include:

- has a narrow pH range in which it changes colour
- has a distinctive colour at lower pH and a different colour at higher pH
- changes colour only once during the titration
- pH range of indicator in which indicator changes colour falls within the definite 'step' of the reaction

Explain whether the Universal Indicator fulfils **each** of these criteria for the titration experiment above.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

B10 **(a)** Transition elements have variable oxidation states.

State two **other** properties typical of transition elements.

.....

.....

..... [2]

(b) Figs. 10.1 to 10.3 show the 'dot-and-cross' diagrams of the compounds formed when an unidentified element J (not its actual chemical symbol) bonds with various elements.

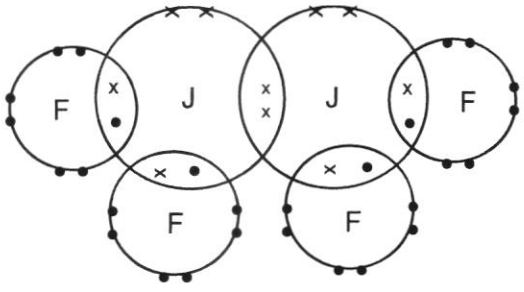


Fig. 10.1

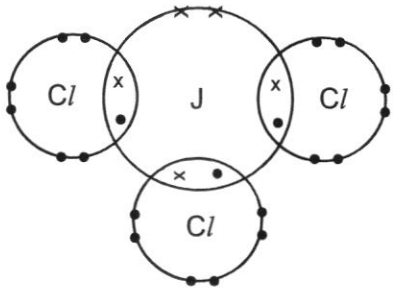


Fig. 10.2

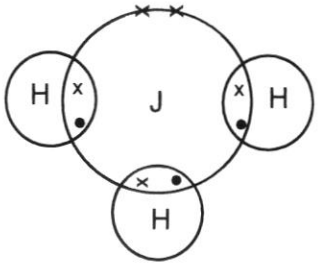


Fig. 10.3

(i) Determine the oxidation state of J in the various compounds.

chemical formula	oxidation state of J
J_2F_4	
JCl_3	
JH_3	

[2]

(ii) A student claims that since element J has variable oxidation states, J must be a transition element.

Give **two** pieces of evidence from Figs. 10.1 to 10.3 and your answer in **(b)(i)** which suggest that the student's claim is false.

Explain your reasoning.

evidence.....

.....

reasoning.....

.....

evidence.....

.....

reasoning.....

..... [4]

[Total: 8]

EITHER

B11 Haematite, limestone and coke are heated together in a blast furnace in the manufacture of iron.

(a) Explain why each of the substances below are needed in a blast furnace.

limestone

.....

.....

.....

coke.....

.....

.....

... [2]

(b) Scrap high carbon steel can be recycled to make pure iron. To remove the carbon impurities, oxygen is blown on the molten scrap high carbon steel in a large vessel known as a converter. The carbon impurities are removed as carbon dioxide.

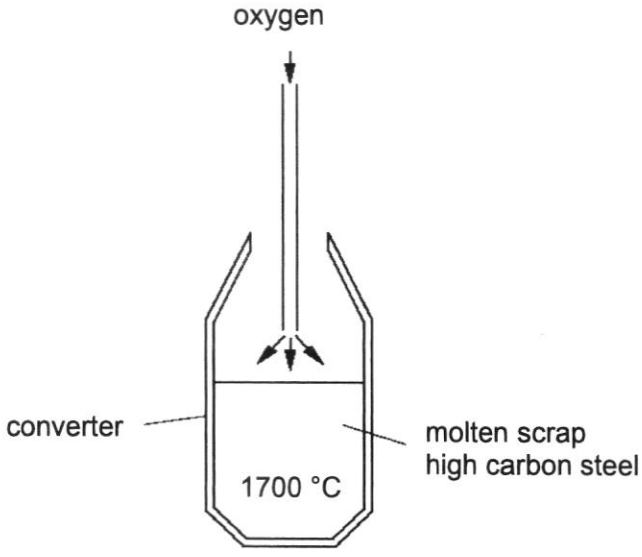


Fig. 11.1

(i) Write the chemical equation to show how carbon impurities from molten scrap high carbon steel are removed as carbon dioxide.

.....

.. [1]

(ii) The temperature of the molten scrap high carbon steel increases as oxygen is blown onto it. Explain why.

.....

.. [1]

(iii) Fig. 11.2 shows the arrangement of atoms in pure iron.

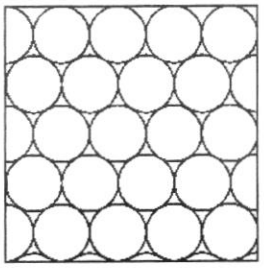


Fig. 11.2

Describe what changes to the diagram are necessary to show the arrangement of atoms in molten scrap high carbon steel as it was blown with oxygen.

.....
.....

.....
.....

.....
.....

.....
. [3]

(c) Metals in the middle of the reactivity series such as iron and lead are extracted from their oxides by 'reduction reactions'.

Carbon or carbon monoxide can be used as reducing agents in the 'reduction reactions'.

Iron can be extracted by reacting its oxide with carbon monoxide in the blast furnace while lead can be extracted by reacting its oxide with carbon.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

$$PbO(s) + C(s) \rightarrow Pb(l) + CO(g)$$

(i) Explain, in terms of oxygen atoms, why the extraction of iron and lead from their oxides are known as 'reduction reactions'.

.....
.....

.....
. [2]

(ii) Describe an advantage of carbon monoxide as a reducing agent compared to carbon in 'reduction reactions'.

.....
.....

.....
. [1]

[Total: 10]

OR

B11 Many carbonates thermally decompose to form carbon dioxide and an oxide.

Six 2.00 g samples of carbonates are heated strongly until there is no further change in mass.

Table 11.1 shows the mass of solid remaining at the end of the reaction.

Table 11.1

carbonate	mass before heating / g	mass remaining at the end / g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
1	2.00	0.95
2	2.00	2.00
3	2.00	1.30

(a) Using relevant information, determine which carbonate is the most thermally stable.

Explain your answer.

.....

.....

..... [2]

(b) The metal in carbonate 3 has an ionic charge of 2+.

By means of a calculation, identify carbonate 3.

[3]

(c) Explain why the mass remaining at the end of the reaction is different for each carbonate.

.....

.....

..... [2]

(d) The carbonates of mercury and silver decompose to the metal on heating.

$$2HgCO_3 \rightarrow 2Hg + 2CO_2 + O_2$$

(i) Write the chemical equation to show the thermal decomposition of silver carbonate.

..... [1]

(ii) Suggest the position of mercury relative to copper in the reactivity series.

Explain your reasoning.

.....

.....

..... [2]

[Total: 10]

- End of Paper -

2023 CHS S4 Prelim Mark Scheme

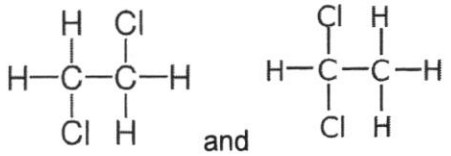
Paper 1

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

Paper 2 Section A

<table>
<tr><td>A1</td><td>(a)</td><td>
<table>
<tr><th></th><th></th><th>Put a tick (✓) if a redox reaction would occur.</th></tr>
<tr><td>(i)</td><td>a copper strip added to lead(II) nitrate solution</td><td></td></tr>
<tr><td>(ii)</td><td>aqueous chlorine added to potassium iodide solution</td><td>✓</td></tr>
<tr><td>(iii)</td><td>hydrogen gas passed over heated copper(II) oxide</td><td>✓</td></tr>
<tr><td>(iv)</td><td>potassium nitrate solution warmed with sodium hydroxide solution</td><td></td></tr>
</table>
4 correct – 3m , 3 correct – 2m, 2 correct – 1m</td><td></td></tr>
<tr><td></td><td>(b)</td><td>Difference: Reaction rate is slower when used with aqueous bromine OWTTE;

Explain: Chlorine is more reactive than bromine/ gains electrons more readily (and displaces iodine from iodide solution faster); OWTTE</td><td></td></tr>
<tr><td>A2</td><td>(a)</td><td>As the number of Cl <u>atoms</u> in the compound increases, the boiling point increases.

A: has more Cl atom substituted/ less H atoms
R: increasing M_r/ molecular size</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) C_2H_6</td><td></td></tr>
<tr><td></td><td></td><td>(ii) $C_2H_4Cl_2$</td><td></td></tr>
<tr><td></td><td></td><td>(iiii) 5</td><td></td></tr>
<tr><td></td><td>(c)</td><td>  and

1m for each correct structure</td><td></td></tr>
</table>

<table>
<tr><td>A3</td><td>(a)</td><td>Carbon dioxide = C;

phosphorus pentoxide = B;

both has simple molecular/ covalent structure;

where a small amount of energy is needed to overcome weak intermolecular forces;

phosphorus pentoxide is a <u>larger</u> molecule with <u>stronger intermolecular forces</u></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) 1 similarity (1m) + 1 difference (1m)

Similarity:
both has giant molecular/ covalent structure;

both consists of only the same type of atoms

difference:
<table>
<tr><td></td><td>Silicon</td><td>Graphite</td></tr>
<tr><td>Difference 1</td><td>Only has strong covalent bonds between atoms</td><td>Has both strong covalent bonds and weak intermolecular forces</td></tr>
<tr><td>Difference 2</td><td>Not layered</td><td>Layered</td></tr>
<tr><td>Difference 3</td><td>Tetrahedral structure or 1 atom bonded to 4 other atoms</td><td>Hexagonal structure or 1 atom bonded to 3 other atoms</td></tr>
</table></td><td></td></tr>
<tr><td></td><td></td><td>(ii) No. +
A semiconductor needs to have presence of mobile charged carriers such as ions or electrons;

All 4 valence electrons are used in bonding (and absence of ions/ contains only atoms)</td><td></td></tr>
<tr><td>A4</td><td>(a)</td><td>(i) removes carbon dioxide from atmosphere + hence regulating amount of carbon dioxide OWTTE</td><td></td></tr>
<tr><td></td><td></td><td>(ii) $2NO + 2CO \rightarrow 2CO_2 + N_2$;
$2CO + O_2 \rightarrow 2CO_2$
A: $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
A: $2NO_2 + 4CO \rightarrow 4CO_2 + N_2$;
R: formation of sulfur dioxide (fuel does not contain S)

Still releases large amount of carbon dioxide into the atmosphere + explain how carbon dioxide causes environmental problems (see e.g. below)

Global warming/ Melting of ice caps/ rise in sea levels/ flooding in low-lying areas etc</td><td></td></tr>
</table>

<table>
<tr><td></td><td>(b)</td><td>(i) The set-up using light will produce gas X but the set-up without light will not produce any gas X (or oxygen gas);

Or In the absence of light, carbon dioxide is produced while in the presence of light, gas X / oxygen is produced (+ CO_2)

I: if students discussed observations such as presence of effervescence
R: More gas given off for set-up with light than set-up without light</td><td></td></tr>
<tr><td></td><td></td><td>(ii) To determine if a reaction is endothermic or exothermic, we have to consider the difference in both energy taken in / absorbed and energy released / given off; OWTTE

A: Light energy used for activation energy

A: if explain in terms of bond break/ form</td><td></td></tr>
<tr><td>A5</td><td>(a)</td><td>$C_3H_7OH + 2[O] \rightarrow C_2H_5COOH + H_2O$ or

$C_3H_8O + 2[O] \rightarrow C_3H_6O_2 + H_2O$</td><td></td></tr>
<tr><td></td><td>(b)
(i)</td><td>
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>%</td><td>64.6</td><td>10.8</td><td>24.6</td></tr>
<tr><td>A_r</td><td>12</td><td>1</td><td>16</td></tr>
<tr><td>No. of moles</td><td>$\frac{64.6}{12} = 5.383$</td><td>$\frac{10.8}{1} = 10.8$</td><td>$\frac{24.6}{16} = 1.537$</td></tr>
<tr><td>Mole ratio</td><td>$\frac{5.383}{1.537} = 3.5$</td><td>$\frac{10.8}{1.537} = 7$</td><td>$\frac{1.537}{1.537} = 1$</td></tr>
<tr><td>Simplest ratio</td><td>7</td><td>14</td><td>2</td></tr>
</table>
1m for calculating no. of moles

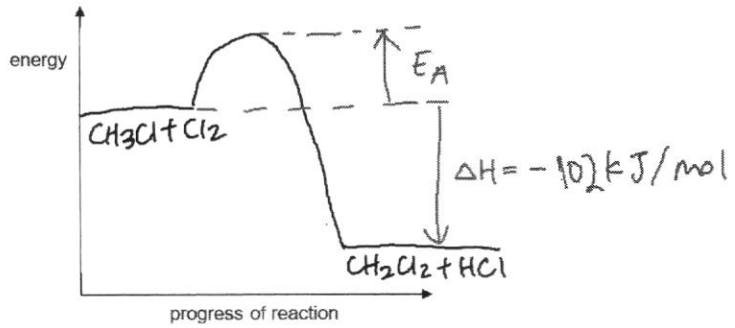
Empirical formula of R = $C_7H_{14}O_2$ [1]</td><td></td></tr>
<tr><td></td><td>(ii)</td><td>Butyl propanoate</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i) any suitable metal carbonate or ammonium carbonate</td><td></td></tr>
<tr><td></td><td></td><td>(ii) corresponding metal/ ammonium propanoate

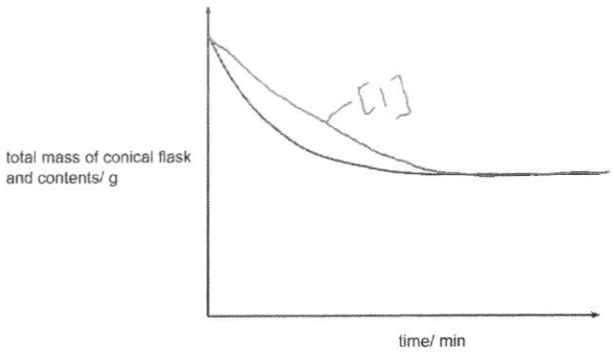
E.g. NaC_2H_5COO or C_2H_5COONa or

$Ca(C_2H_5COO)_2$ or $(C_2H_5COO)_2Ca$

A: molecular formula e.g. $NaC_3H_5O_2$</td><td></td></tr>
<tr><td>A6</td><td>(a)</td><td>Comparison of energy + recognise bond forming releases energy and bond breaking absorbs energy ; [1]

Identify forming bonds in correct products + breaking bonds in correct reactants; [1]</td><td></td></tr>
</table>

		Suggested answer: More energy is given off/ released when forming bonds in HC*l* / hydrogen chloride and CH_3Cl/ chloromethane than taken in/ absorbed when breaking bonds in methane/ CH_4 and chlorine/ Cl_2.	
	(b)	(i) 	
		(ii) −102 kJ/ mol; [1] Both require breaking 1 mole of C–H and 1 mole of C*l*–C*l* bonds in reactants and both form 1 mole of C–C*l* and 1 mole of H–C*l* bonds [1] A: 1 C-H bond etc instead of saying 1 mole	
		(iii)  • the reactants of the reaction • the products of the reaction • the energy profile and the enthalpy change of reaction, ΔH. } 1m • activation energy, E_a } 1m	
A7	(a)	(i) electrode 1: $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$; Electrode 2: $2H^+(aq) + 2e^- \rightarrow H_2(g)$	
		(ii) filter paper around electrode 1 changes from purple to red; [1] Filter paper around electrode 2 changes from purple to blue; [1] Reference to difference in concentration of H^+ and OH^- + determine acidic/ alkaline; [1] Suggested answer: concentration of OH^- < concentration of H^+, so solution around electrode 1 is acidic and turns litmus solution red	

		+ concentration of H^+ < concentration of OH^-, so solution around electrode 2 is alkaline and turns litmus solution blue	
A7	(b)	(i) barium nitrate is soluble in water (A: aqueous solution) [1]	
		(ii) A <u>white precipitate</u> was observed on the filter paper. [1]	
A8	(a)	(i)  	
		(ii) chlorine gas is soluble in water + so the mass loss is less than expected [1]	
		(iii) The rate of reaction is not constant throughout the reaction OWTTE [1]	
	(b)	Conclusion 1: increase the total surface area of MnO_2 [1] Conclusion 2: MnO_2 is a catalyst + no change in the amount/ mole of limiting reactant / no change in yield. [1]	
Section B			
B9	(a)	Hydrogen ion has 0 electrons, 0 neutrons and 1 proton only [1]	
	(b)	(i) $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ Conc. of H^+ ions = 0.025 mol/ dm^3 × 2 = 0.05 mol/ dm^3 [M1] pH = 1.3 (taken from table 9.2) [A1] A: 1.30 (3sf)	

(ii) pH = $\frac{k}{[Concentration\ of\ H+]}$; [1] (A: if embedded in working)

students use any 2 sets of data to find 2 k values [1]

conclude that since the two k values are different, students claim is false [1]

	Data 1	Data 2	Data 3	Data 4
pH	1.3	1.6	1.9	2.0
	$1.3 = \frac{k}{0.05}$	$1.6 = \frac{k}{0.025}$	$1.9 = \frac{k}{0.0125}$	$2.0 = \frac{k}{0.010}$
K value	K = 0.065	K = 0.04	K =0.02375	K = 0.02

(c) (i) when solution is pH 3,

Thymol blue appears yellow +
Methyl red appears red +
Bromothymol blue appears yellow +
Phenolphthalein appears colourless

1m

Overall is mixture of yellow and red which makes it orange ; [1]

(ii)

Criteria	Claim	Evidence + reasoning
has a narrow pH range in which it changes colour	Does not fulfil	pH range in which it changes colour is from 1.2 to 10.5 (wide range; typically the range is about 1.6 to 2.5)
has a distinctive colour at lower pH and a different colour at higher pH	Does not fulfil	Lower pH can have colours such as red and orange and higher pH can have colours such as blue or purple (state more than 1 colour for lower pH and more than 1 colour for higher pH) / More than 2 colours or has multiple colours at lower pH / higher pH
changes colour only once during the titration	Does not fulfil	Can change from orange to yellow (at pH 6) to green (at pH 7) (quote at least 2 colour change) / Changes colour twice before equivalence point
pH range of indicator in which indicator changes colour to fall within the definite 'step' of the reaction	Does not fulfil	pH range of indicator which is from pH 1.2 to 10.5 and pH change of the 'step' is between pH 3 to 11

<table>
<tr><td>B10</td><td>(a)</td><td>Catalytic properties;

Form coloured compounds;

High melting/boiling points;

High density

Any 2</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)
<table><tr><th>chemical formula</th><th>oxidation state of J</th></tr><tr><td>J_2F_4</td><td>+2</td></tr><tr><td>JCl_3</td><td>+3</td></tr><tr><td>JH_3</td><td>−3</td></tr></table>
All 3 correct – 2m, 1 or 2 correct – 1m</td><td></td></tr>
<tr><td></td><td></td><td>(ii) evidence: has negative oxidation state of −3 ; [1]

Reasoning: transition elements are metals which only lose electrons + hence only can have positive oxidation states [1]
Or
Evidence: all three compounds of J show sharing of electrons; [1]
A: forms molecules

Reasoning: covalent bonding occurs typically between two non-metals [1]

or
Evidence: J has 5 valence electrons. [1]

Reasoning: elements with 5 or more valence electrons are non-metals. [1]</td><td></td></tr>
<tr><td colspan="2">Either</td><td></td><td></td></tr>
<tr><td>B11</td><td>(a)</td><td>Limestone: remove acidic impurities (such as silicon dioxide); [1]

Coke: reducing agent/ forms carbon monoxide which is the main reducing agent [1]</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) $C + O_2 \rightarrow CO_2$ [1]</td><td></td></tr>
<tr><td></td><td></td><td>(ii) formation of carbon dioxide is an exothermic reaction / gives off heat [1]</td><td></td></tr>
<tr><td></td><td></td><td>(iii) any 3 points for 3m

additional atoms with smaller atomic size to represent carbon atoms;

all particles to be slightly further apart/ have small spaces in between</td><td></td></tr>
</table>

		distance is slightly further than liquid state (because of expansion); all particles to be disorderly arranged;	
	(c)	(i) 2 points - 1m, all 3 points - 2m both Fe and Pb loses oxygen atoms Fe_2O_3 loses oxygen to become Fe PbO loses oxygen to become Pb	
		(ii) Does not release toxic CO into the atmosphere; [1] or Using CO gas will ensure better contact with reactant compared to C solid [1]	
OR			
B11	(a)	Carbonate 2; [1] There is no loss in mass/ did not form CO_2 gas + did not decompose at all/ OWTTE [1]	
	(b)	Mass lost = mass of carbon dioxide formed = 2 – 1.30 = 0.70 g [M1] No. of moles of carbon dioxide = $\frac{0.70}{44}$ = 0.01590 mol No. of moles of metal carbonate = 0.01590 mol M_r of metal carbonate = $\frac{2.00}{0.01590}$ = 125.78 [M1] A_r of metal = 125.78 – 12 – 48 = 65.78 Carbonate 3 is zinc carbonate/ $ZnCO_3$ [A1]	
	(c)	Same mass of carbonate contains different mole of each carbonate due to different M_r/ molar mass; [1] Hence each carbonate gives off different mole of carbon dioxide gas which equates to different mass of carbon dioxide gas evolved (since ratio of mole of metal carbonate to mole of carbon dioxide is 1:1) [1]	
	(d)	(i) $2Ag_2CO_3 \rightarrow 4Ag + 2CO_2 + O_2$	
		(ii) just above or below Ag/ similar to Ag / below Cu; Compare thermal stability of copper(II) oxide with mercury oxide; E.g. Copper(II) oxide is thermally stable, does not decompose further to form Cu metal. Copper is hence more reactive than mercury.	