



KUO CHUAN PRESBYTERIAN SECONDARY SCHOOL

2023 PRELIMINARY EXAMINATION

Secondary 4 Express

NAME

CLASS

REG. NO

CHEMISTRY

Paper 1 Multiple Choice

6092 / 01

25 August 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet.

Setter: Ms. Lim Zi Min

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your name, class and register number on the Answer Sheet in the spaces provided unless this has been done for you.

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.

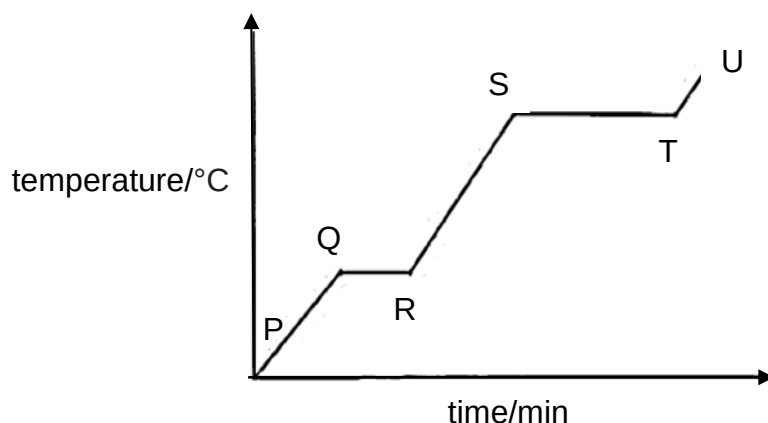
Any rough working should be done in this booklet.

A copy of the Periodic Table is printed on page **16**.

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

Section A (40 marks)

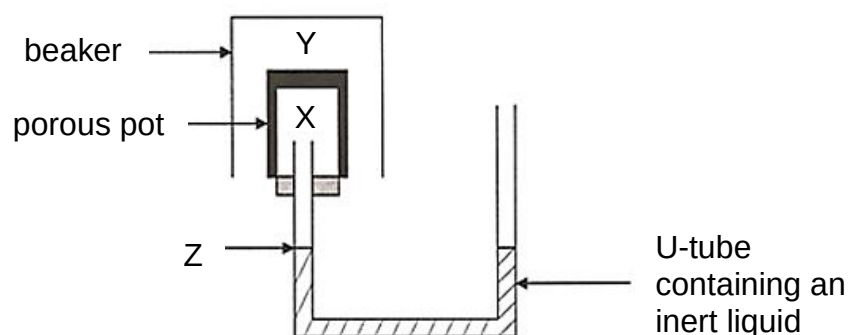
- 1 The following shows the heating curve of ice.



Which description in the table below best explains the respective section of the graph?

	section	description
A	P to Q	The particles are stationary and held in fixed positions
B	Q to R	Heat energy taken in is used to overcome forces of attraction between particles.
C	R to S	The volume of water is increasing as the particles expand and become larger.
D	T to U	Water is boiling to form steam.

- 2 The apparatus shown below consists of a porous pot containing gas X which is surrounded by gas Y in a beaker.

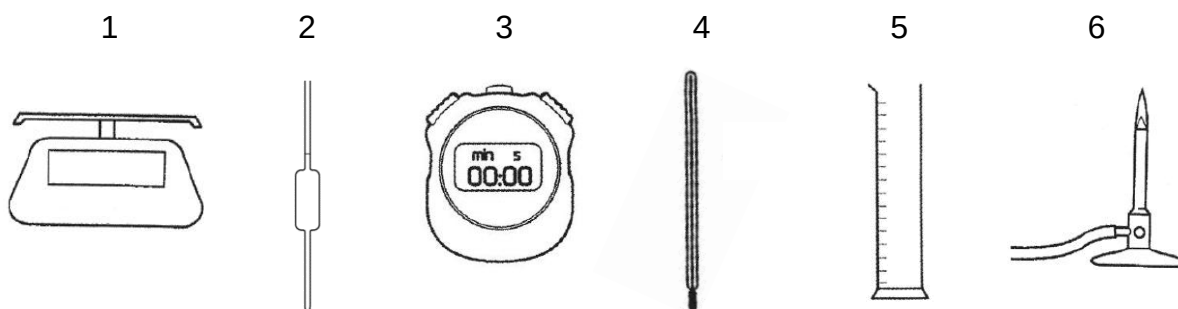


Which one of the following pairs of gases will cause an upward movement of the inert liquid at level Z?

	gas X	gas Y
A	H ₂	O ₂
B	CH ₄	H ₂
C	C ₃ H ₈	H ₂
D	CO ₂	C ₃ H ₈

- 3 A student is given 250 cm^3 of a saturated solution of sodium salt S and 500 cm^3 of a saturated solution of potassium salt P in respective beakers. Both salts do not decompose on heating.

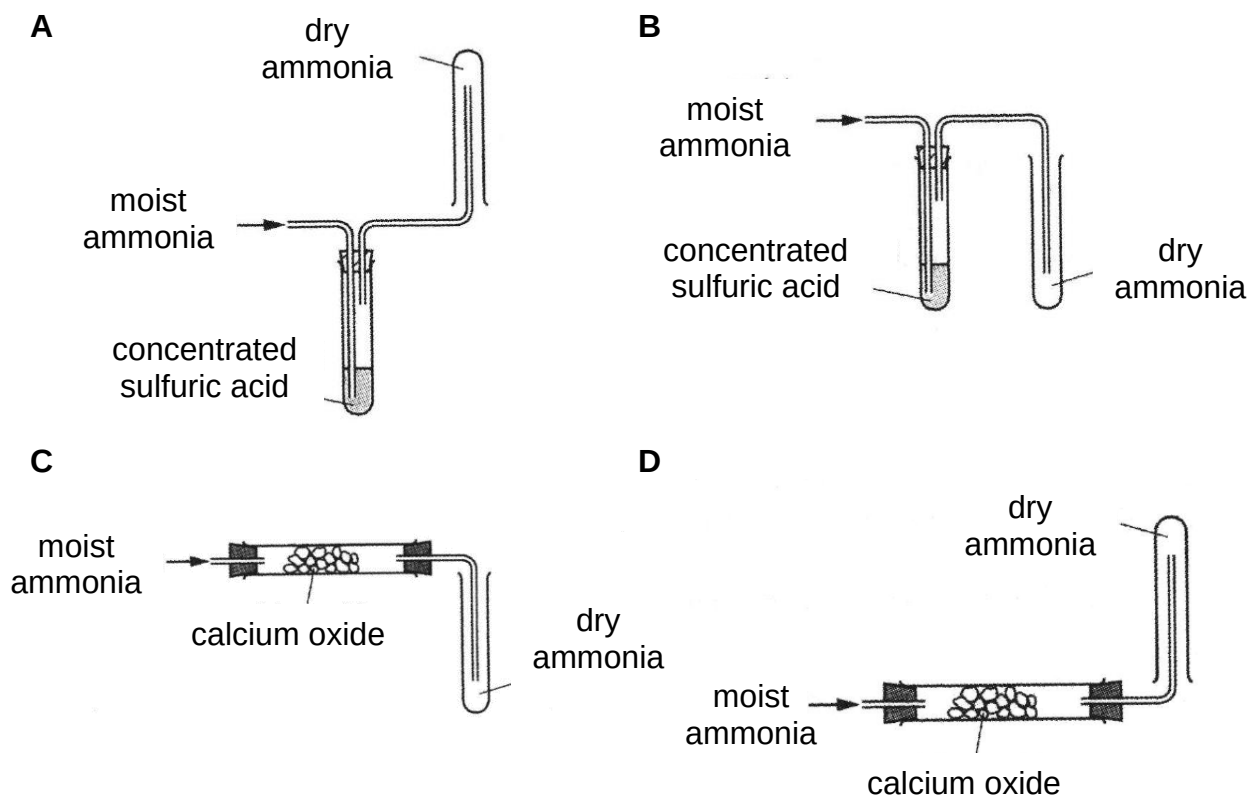
Which of the following apparatus must she use in order to determine which salt is more soluble in water?



- A 1, 2, 3 and 4
 B 1, 4 and 6
 C 1, 5 and 6
 D 2, 4, 5 and 6
- 4 A student is provided with two drying agents, concentrated sulfuric acid and calcium oxide.

Which method should he use to collect a sample of dry ammonia?

[M_r : NH_3 , 17]



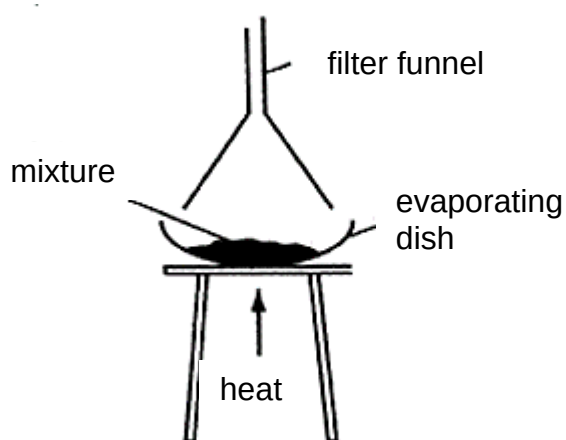
- 5 Propyl ethanoate and water are two liquids which are immiscible.

Which method could be used to separate a mixture of propyl ethanoate and water?

- 1 fractional distillation
- 2 evaporation
- 3 filtration
- 4 use of a separating funnel

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

- 6 A mixture is heated using the set-up shown.



Which of the following mixtures can be separated into its components using this set-up?

- A** ammonium chloride and iodine
- B** copper(II) sulfate and sodium chloride
- C** potassium iodide and copper(II) sulfate
- D** sodium chloride and ammonium chloride

- 7 Some properties of substances P, Q, R and S are given in the table below.

substance	percentage composition by mass	electrical conductivity when solid	effect of heat
P	constant	yes	solid burns in air to form an oxide
Q	varies	no	liquid burns to form carbon dioxide and water
R	constant	no	solid decomposes to form two products
S	varies	yes	solid melts

Which classification of the substances as an element, a mixture or a compound is correct?

	element	mixture	compound
A	P	Q, S	R
B	P	S	Q, R
C	R	Q, S	P
D	S	Q	P, R

- 8 Which row correctly shows the number of particles in $^{34}_{16}\text{S}^{2-}$?

	protons	neutrons	electrons
A	16	18	14
B	16	18	18
C	18	16	14
D	18	16	18

- 9 The element sodium has several isotopes, including ^{23}Na and ^{24}Na .

Which of the following statements is true about the isotopes?

- A** The densities of two metal coins consisting of ^{23}Na and ^{24}Na respectively are different.
- B** The formulas of the chlorides formed between ^{23}Na and ^{24}Na and chlorine are different.
- C** The isotopes ^{23}Na and ^{24}Na differ in their rate of reaction with water.
- D** The rate of thermal decomposition of the carbonates of ^{23}Na and ^{24}Na are different.

10 The elements X and Y form the compound X_2Y .

What is the correct electronic configuration in the atoms of X and Y?

	atom of X electronic configuration	atom of Y electronic configuration
A	2, 1	2, 7
B	2, 2	2, 7
C	2, 1	2, 6
D	2, 2	2, 6

11 Which of the following compounds does **not** have both covalent and ionic bonding?

- A** ammonium chloride
- B** copper(II) carbonate
- C** phosphorus pentachloride
- D** sodium nitrate

12 Which of the following substances contain delocalised electrons?

- 1 iron
- 2 steel
- 3 diamond
- 4 graphite

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

13 Which gas sample contains the most molecules?

- A** 4 g of hydrogen, H_2
- B** 14 g of nitrogen, N_2
- C** 24 dm³ of carbon dioxide, CO_2
- D** 36 dm³ of hydrogen chloride, HCl

14 Oxalic acid has the formula $C_2H_2O_4 \cdot 2H_2O$.

What is the mass of oxalic acid crystals needed to prepare 100 cm³ of 0.1 mol/dm³ oxalic acid solution?

- A** 1.26 g
- B** 2.52 g
- C** 32.4 g
- D** 126 g

- 15 A 15 cm³ sample of a gaseous hydrocarbon is completely burnt in oxygen. The total volume of the products is 75 cm³.

Which equation correctly shows the complete combustion of this hydrocarbon?

- A $\text{CH}_4 (\text{g}) + 2\text{O}_2 (\text{g}) \rightarrow \text{CO}_2 (\text{g}) + 2\text{H}_2\text{O} (\text{g})$
 - B $\text{C}_2\text{H}_4 (\text{g}) + 3\text{O}_2 (\text{g}) \rightarrow 2\text{CO}_2 (\text{g}) + 2\text{H}_2\text{O} (\text{g})$
 - C $\text{C}_3\text{H}_8 (\text{g}) + 5\text{O}_2 (\text{g}) \rightarrow 3\text{CO}_2 (\text{g}) + 4\text{H}_2\text{O} (\text{g})$
 - D $2\text{C}_2\text{H}_6 (\text{g}) + 7\text{O}_2 (\text{g}) \rightarrow 4\text{CO}_2 (\text{g}) + 6\text{H}_2\text{O} (\text{g})$
- 16 Solutions P and Q were tested with a few drops of universal indicator. Solution P turned the indicator red while solution Q turned the indicator yellow.
- Which of the following can be deduced from the experiment?
- A Solution P has a higher concentration of hydrogen ions than solution Q.
 - B Solution P has a higher pH than solution Q.
 - C Solution Q is a strong acid while solution P is a weak acid.
 - D Solution Q is more concentrated than solution P.
- 17 An element burns in air to form a compound which does **not** react with both acids and alkalis.

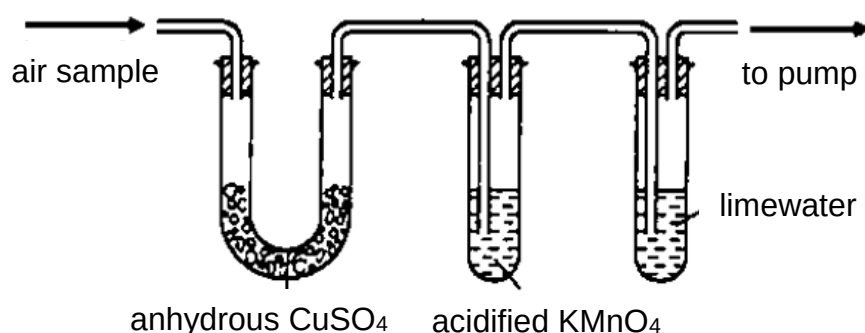
Which element could it be?

- A aluminium
 - B carbon
 - C iron
 - D phosphorus
- 18 Which reagent, when heated and mixed with ammonium sulfate, liberates ammonia?
- A acidified potassium manganate(VII) solution
 - B aqueous copper(II) chloride
 - C dilute hydrochloric acid
 - D limewater
- 19 Which one of the following salts is prepared differently?
- A ammonium nitrate
 - B beryllium chloride
 - C copper(II) sulfate
 - D zinc sulfate

- 20 Which is the best way to prepare barium sulfate, starting from barium carbonate?
- A Add dilute sulfuric acid to barium carbonate and then filter.
 B Add excess aqueous sodium sulfate to barium carbonate and then filter.
 C Add excess nitric acid to barium carbonate followed by dilute sulfuric acid and filter.
 D Heat barium carbonate and then react the barium oxide with dilute sulfuric acid, then filter.
- 21 An aqueous solution containing a mixture of copper(II), iron(II) and lead(II) ions was treated with an excess of aqueous ammonia in a test-tube.

What precipitate is left in the test-tube at the end of the reaction?

- A copper(II) hydroxide only
 B iron(II) hydroxide only
 C iron(II) hydroxide and lead(II) hydroxide
 D iron(II) hydroxide and copper(II) hydroxide
- 22 A sample of air was passed through the following reagents in the set-up below.



The results are shown in the table below.

reagent	anhydrous CuSO_4	acidified KMnO_4	limewater
observation	turned from white to blue	remained purple	white precipitate was formed

Which gases were present in the sample of air?

	1	2	3
A	H_2O	SO_2	CO_2
B	H_2O	N_2	CO_2
C	N_2	H_2O	H_2
D	N_2	SO_2	H_2O

23 In which of the following does vanadium have the lowest oxidation state?

- A** NH_4VO_3
- B** V^{3+}
- C** VO^{2+}
- D** V_2O_5

24 The reactions of four metals, P, Q, R and S are as described below.

- Metals Q and S can be extracted by reacting their metal oxides with carbon, but metals P and R can only be extracted by electrolysis of its molten compounds.
- Metal Q can also be extracted by heating its metal oxide with metal S.
- The metal carbonate of P decomposes more readily than the metal carbonate of R.

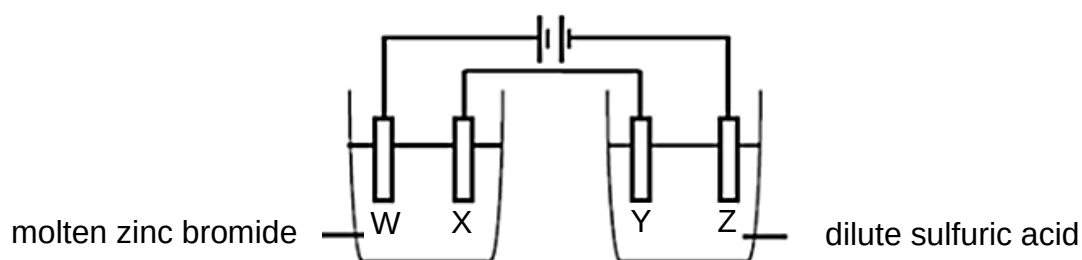
What is the correct order, in decreasing reactivity, for the four metals?

- A** P, R, Q, S
- B** P, R, S, Q
- C** R, P, Q, S
- D** R, P, S, Q

25 Which statement about the production of iron from haematite is correct?

- A** Coke is used to oxidise slag.
- B** Limestone is used to remove basic impurities.
- C** Molten iron floats on slag at the base of the furnace.
- D** The haematite is reduced by carbon monoxide.

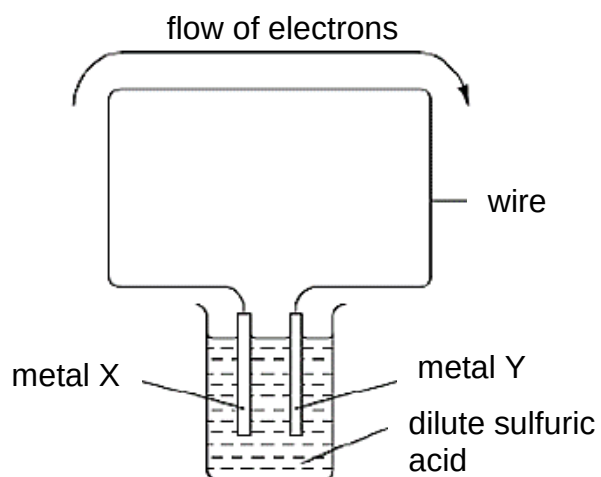
26 Refer to the following electrolytic set-up. All electrodes used are graphite.



What will be observed after a few minutes?

- A** A colourless and odourless gas is formed at electrode Z.
- B** A colourless gas with a pungent smell gas is formed at electrode Y.
- C** A reddish-brown liquid is formed around electrode X.
- D** A silvery solid is formed on electrode W.

27 The diagram shows a simple cell.



For which pair of metals would the electrons flow as shown in the diagram?

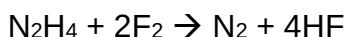
	metal X	metal Y
A	iron	calcium
B	iron	zinc
C	zinc	magnesium
D	zinc	copper

28 Element Z is in the same group in the Periodic Table as bromine but has a lower boiling point.

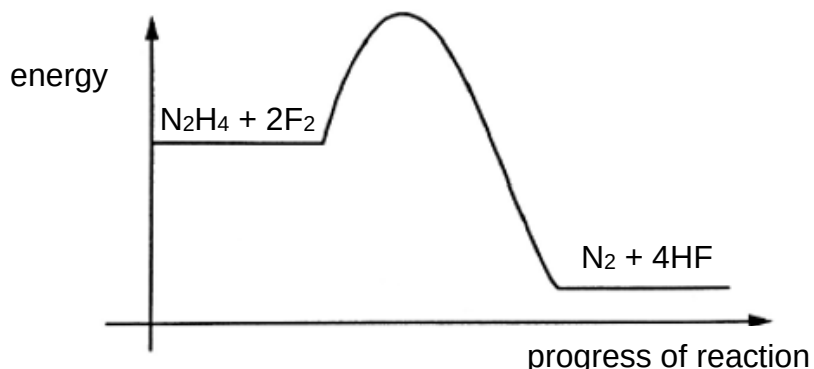
Which statement about Z is correct?

- A** It can displace bromine from aqueous potassium bromide.
- B** It has an atomic number greater than 35.
- C** It is a solid at room temperature.
- D** It loses an electron when it reacts with a metal.

- 29 Hydrazine, N_2H_4 , is often used in rocket fuel and it reacts with fluorine to produce nitrogen and hydrogen fluoride.



The energy profile diagram for the reaction is shown below.

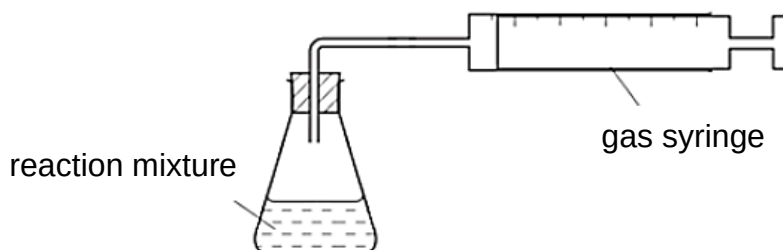


Which statement about the reaction is correct?

- A Heat is absorbed from the surroundings during the reaction.
 B The enthalpy change for the reaction is positive.
 C The products have more energy than the reactants.
 D The total energy given out during bond formation is more than the total energy taken in during bond breaking.
- 30 What are the effects of temperature of the reactants and use of a catalyst on the activation energy and enthalpy change of a reaction?

	effect of temperature		effect of catalyst	
	activation energy	enthalpy change	activation energy	enthalpy change
A	decreases	no change	lower	no change
B	decreases	decreases	no change	decreases
C	no change	no change	lower	no change
D	no change	no change	lower	decreases

- 31 The apparatus shown below can be used to measure the rate of some chemical reactions.



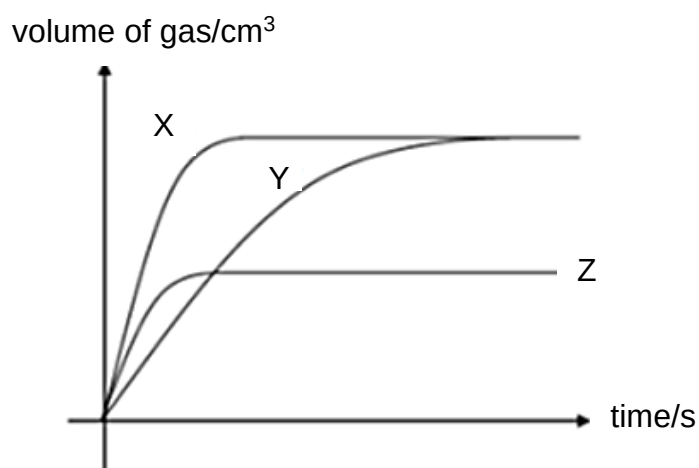
Which of the following reactions would this apparatus be suitable for?

- A $\text{AgNO}_3 + \text{HCl} \rightarrow \text{AgCl} + \text{HNO}_3$
 B $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
 C $\text{MgO} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$
 D $\text{Zn} + \text{CuO} \rightarrow \text{ZnO} + \text{Cu}$

- 32** A student performed three experiments to produce carbon dioxide gas using excess magnesium carbonate and dilute nitric acid at 30°C.

experiment	magnesium carbonate	dilute nitric acid	
	particle size	volume/cm ³	concentration /mol dm ⁻³
1	powdered	20	1.00
2	lumps	10	1.00
3	lumps	40	0.50

The volume of gas collected over time for each experiment was recorded and plotted into a graph.



Which graph best represents each of the three experiments?

	experiment 1	experiment 2	experiment 3
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	X	Y

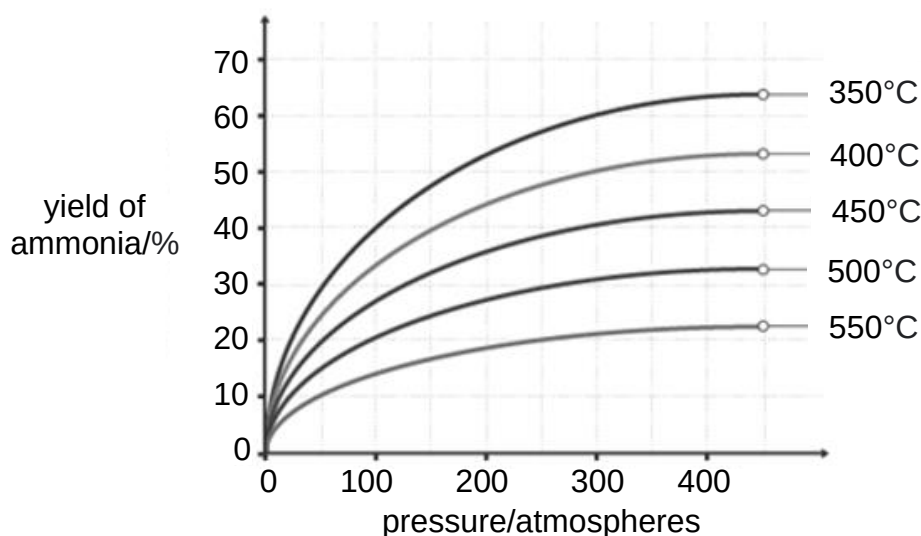
- 33** The following are statements about air pollutants.

- 1 Carbon monoxide is responsible for the formation of acid rain.
- 2 Oxides of nitrogen can be produced during volcanic eruptions.
- 3 Sulfur dioxide can be produced by combustion of fossil fuels.
- 4 Methane contributes to global warming.

Which of the statements are correct?

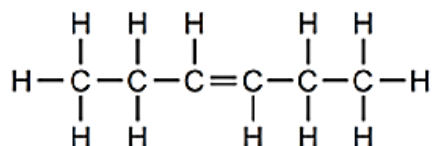
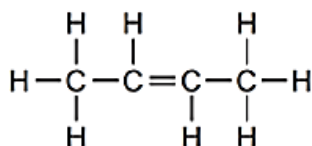
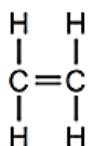
- A** 1, 2, 3 and 4 **B** 1 and 2 only **C** 2, 3 and 4 only **D** 3 and 4 only

- 34 The graph below shows the yield of ammonia from Haber process at different temperatures.



Which of the following statements can be inferred from the graph?

- A** A higher percentage yield of ammonia can be obtained at higher pressure.
B As temperature increases, the yield of ammonia increases.
C At the right temperature and pressure, all of the hydrogen and nitrogen can be converted to ammonia.
D The speed of reaction is dependent on only the temperature.
- 35 The structures of three compounds are shown.



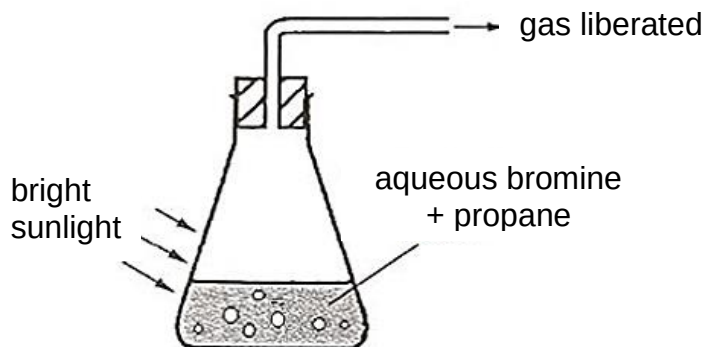
Why do these compounds all belong to the same homologous series?

- A** They all contain an even number of carbon atoms.
B They all contain the same functional group.
C They are all hydrocarbons.
D They are all saturated.
- 36 A molecule of $\text{C}_{17}\text{H}_{36}$ undergoes catalytic cracking. The products of the reaction are one butane molecule, one propene molecule and some ethene molecules.

How many ethene molecules are being produced in the reaction?

- A** 1
B 2
C 5
D 10

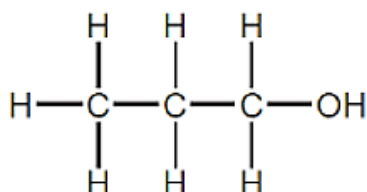
- 37** A mixture of bromine and excess propane was exposed to bright sunlight. The mixture in the flask began to bubble, giving off a colourless gas that turns moist blue litmus paper red.



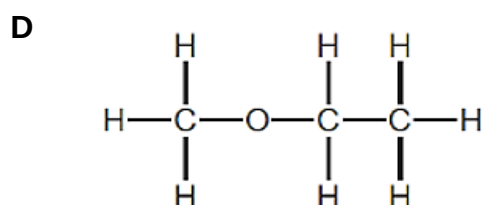
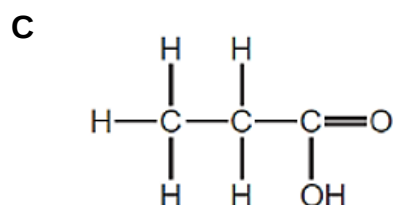
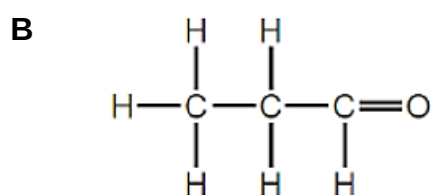
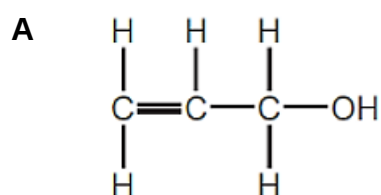
Which row shows the correct type of reaction and gas liberated in the reaction?

	type of reaction	gas liberated
A	addition	hydrogen
B	catalytic cracking	hydrogen
C	combustion	carbon dioxide
D	substitution	hydrogen bromide

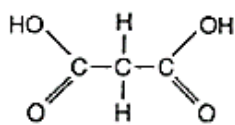
- 38** The diagram below shows the structure of propanol.



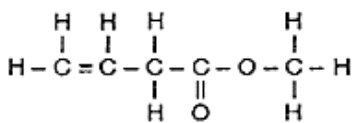
Which of the following is an isomer of this compound?



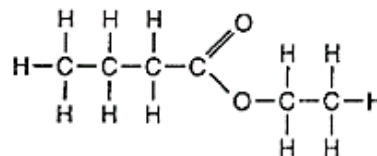
- 39 Which of the following tests can be carried out together to distinguish the following compounds, I, II and III separately from each other?



I



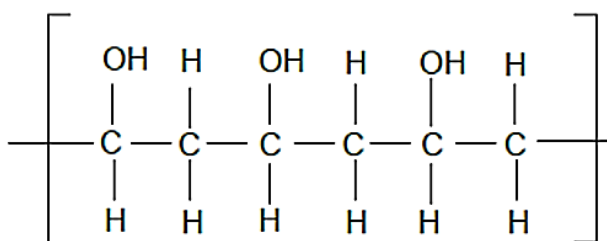
II



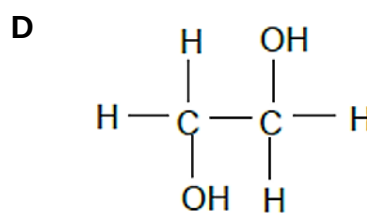
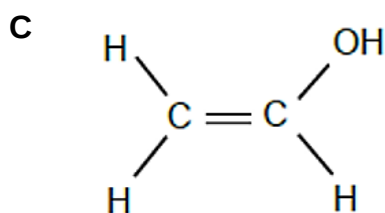
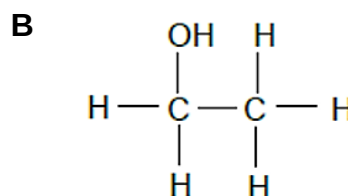
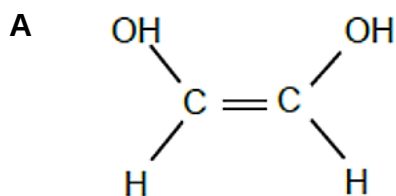
III

Test 1	Adding aqueous bromine
Test 2	Adding powdered magnesium
Test 3	Warming with acidified potassium manganate(VII)

- A 1, 2 and 3 B 1 and 2 only C 1 and 3 only D 2 and 3 only
- 40 A section of a polymer is shown below.



Which of the following shows the monomer involved in the formation of the above polymer?



- End of Section -



KUO CHUAN PRESBYTERIAN SECONDARY SCHOOL

2023 PRELIMINARY EXAMINATION

Secondary 4 Express

NAME

CLASS

REG. NO

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CHEMISTRY

6092 / 02

24 August 2023

Setter: Mr Sam Yew Yishen

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.

Write in dark blue or black pen.

You may use a 2B pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

Section A

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

Write your answers in the spaces provided on the Question Paper.

Section B

Answer **all** three questions. The last question is in the form of **either/or**.

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

Electronic calculators may be used.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.

A copy of the Periodic Table is printed on page **28**.

At the end of the examination, fasten all your work securely together.

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

FOR EXAMINER'S USE		
	Section A	50
	Q9	10
	Q10	10
	Either Or	10
	Total	80
..... Parent's signature/ Date		

Section A (50 marks)

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

- 1** Use the list of substances to answer the questions.

ammonium sulfate

barium sulfate

carbon dioxide

coke

hydrogen

lead(II) nitrate

limestone

- (a)** Which substance liberates a colourless gas when added to sulfuric acid?

..... [1]

- (b)** Which substance can be prepared by reacting an acid with an alkali?

..... [1]

- (c)** Which substance is responsible for the increase of Earth's average temperature?

..... [1]

- (d)** Which substance is added to remove impurities during the extraction of iron in the blast furnace?

..... [1]

- (e)** Which substance can be used to detect the presence of chloride ions in an aqueous solution?

..... [1]

- (f)** Which substance is used to extract zinc from zinc oxide?

..... [1]

[Total: 6]

- 2 Glasses are mainly made of silicates. Soda-lime glass is made by heating a mixture of calcium carbonate, sodium carbonate and sand in a furnace to a high temperature.

The simplified structures of silicate and soda-lime glass are shown in Fig. 2.1.

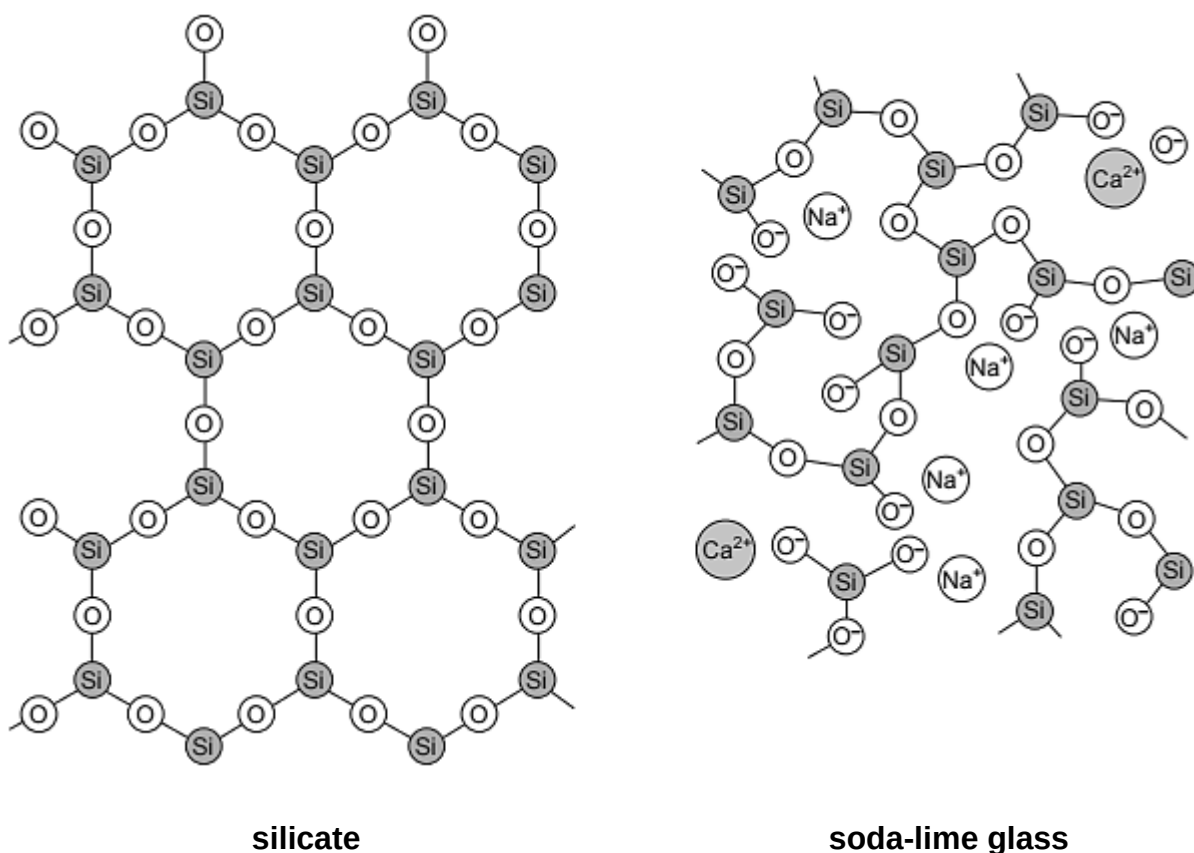


Fig. 2.1

- (a) Describe **two** differences in the structure and/or bonding in silicate and soda-lime glass.

difference 1

.....

difference 2

..... [2]

(b) Predict the electrical conductivity of soda-lime glass.

Explain why.

.....

 [2]

[Total: 4]

- 3 Fig. 3.1 shows the design of a can of self-heating coffee beverage. When the bottom of the can is pushed, the rod will pierce the aluminium foil, causing the water to mix with calcium oxide. The coffee beverage in the can will then be heated up.

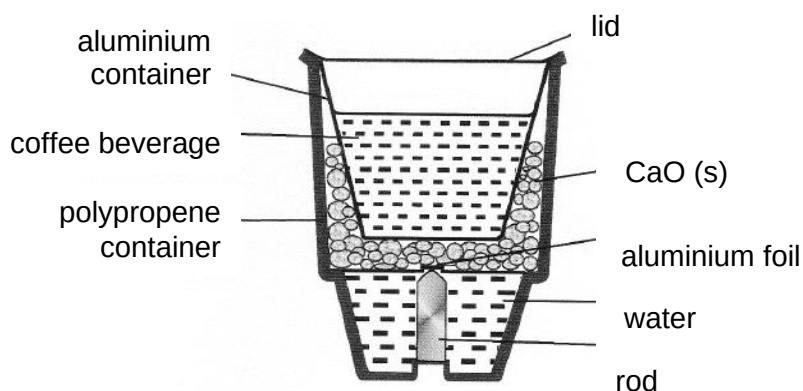
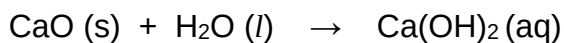


Fig. 7.1

The chemical equation of the reaction between calcium oxide and water is shown below.



- (a) Based on the information provided, Is the value of the enthalpy change for the reaction between calcium oxide and water positive or negative?

Explain your answer.

.....

 [2]

- (b) Use ideas about the energy involved in the breaking and forming of bonds to explain why the enthalpy change has the positive or negative value mentioned in (a).

You do not need to refer to the bonds involved in the reaction above.

.....

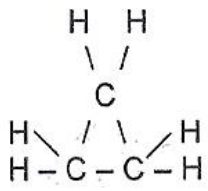
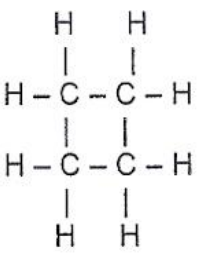
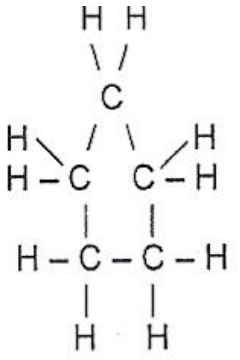
.....

..... [1]

[Total: 3]

- 4 Table 4.1 shows some information about a homologous series of organic compounds called cycloalkanes.

Table 4.1

molecular formula / name	number of carbon atoms	full structural formula	boiling point (°C)
C ₃ H ₆ cyclopropane	3		- 33.0
C ₄ H ₈ cyclobutane	4		12.5
C ₅ H ₁₀ cyclopentane	5		40.2

- (a) Explain how the formulae in the table show that the organic compounds belong to the same homologous series.

.....

..... [2]

- (b) Put a tick (✓) in one box in each row to show which statements about the cycloalkane homologous series are true and which statements are false.

	true	false
They have the same percentage by mass of carbon.		
They have the same empirical formula.		
They are unsaturated hydrocarbons.		
They decolourise aqueous bromine in the absence of sunlight.		

[2]

- (c) Describe and explain the relationship between the number of carbon atoms and boiling points of cycloalkanes.

.....

.....

..... [2]

- (d) Draw the full structural formula of an isomer of a cyclopentane.

[1]

[Total: 7]

- 5 The amount of air pollutants emitted by a car depends on its driving mode – whether it is waiting at traffic junction (idling) or if it is zooming off (accelerating) when the light turns green.

Table 5.1 shows the composition of unburnt hydrocarbons (C_xH_y), nitrogen oxides (NO_x) and carbon monoxide (CO) emitted by a car engine in the two different driving modes.

Table 5.1

driving mode	air / petrol mixture	temperature of the car engine	concentration of air pollutant (ppm*)		
			C_xH_y	NO_x	CO
idling	less air	lower	2800	130	45 000
accelerating	more air	higher	20	820	21 000

*'ppm' refers to part per million

- (a) Describe how nitrogen oxides and carbon monoxides are formed in a car engine.

.....

.....

.....

..... [2]

- (b) What environmental problems do nitrogen oxides cause?

.....

..... [1]

- (c) Comment on the difference in the concentration of air pollutants when the car is in the two different driving modes.
Suggest reasons for the difference.

.....

.....

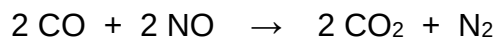
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.....

..... [3]

- (d) One way of reducing the amounts of carbon monoxide and nitrogen oxides from cars is to use catalytic converters.

The chemical equation for one such reaction that happens in a catalytic converter is shown below.



A student made a following statement regarding the chemical equation.

“The reaction that takes place in the catalytic convertor is a redox reaction.”

Do you agree with the student’s statement?

Explain your answer.

.....

.....

.....

..... [2]

[Total: 8]

6 Metal **X** belongs to Group II of the Periodic Table.

0.50 g of metal **X** was placed into a flask containing 80 cm³ of 1.00 mol/dm³ HCl. The volume of hydrogen gas was measured at regular intervals at 25 °C. The whole experiment was repeated using 0.50 g of metal **X** and 50 cm³ of 2.00 mol/dm³ HCl.

Table 6.1 shows the experimental results of the reaction between metal **X** and HCl.

Table 6.1

experiment	mass of Metal X	volume and concentration of HCl
1	0.50 g	80 cm ³ , 1.00 mol/dm ³
2	0.50 g	50 cm ³ , 2.00 mol/dm ³

Fig. 6.2 shows graphical analysis by a datalogger.

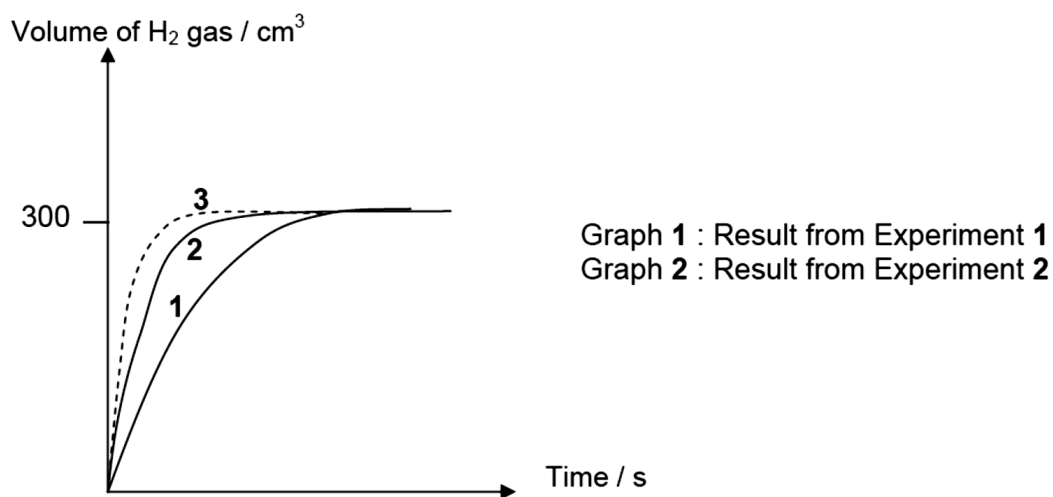


Fig. 6.2

- (a)** Calculate the number of moles for HCl present in Experiments **1** and **2**.

[1]

- (b)** Which reagent is in excess, metal **X** or HCl in Experiment **1**? Explain your answer.

.....

.....

..... [2]

- (c) Calculate the relative atomic mass of metal X.

[3]

- (d) Experiment 2 was repeated by changing one of the conditions to obtain Graph 3. Suggest **two** possible ways of changing the condition of the experiment that might lead to the result shown by 3.

.....

..... [2]

- (e) On Fig. 6.2, draw the graph obtained if Experiment 1 was repeated using 0.25 g of metal X keeping all other conditions unchanged. Label the graph as 4.

[1]

[Total: 9]

- 7 Fig 7.1 shows the electrolysis of dilute aqueous copper(II) chloride with carbon electrodes. Gas W was evolved at electrode R and was collected over water.

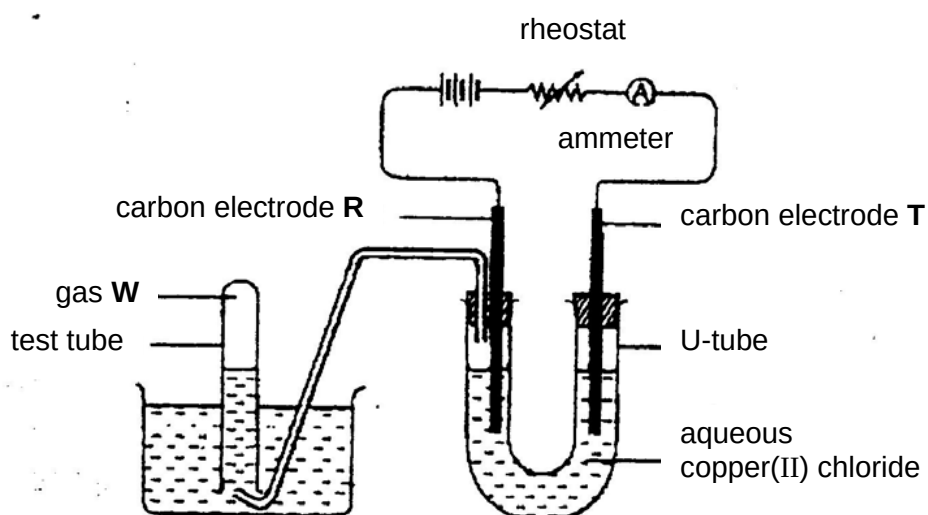


Fig. 7.1

- (a) State which electrode is the cathode and which electrode is the anode.

anode

cathode [2]

- (b) Write the ionic equations for the reaction taking place at each electrode.

electrode **R**:

electrode **T**: [2]

- (c) The experiment was repeated, with a silver electrode replacing electrode **R**. Explain the following observations.

- (i) After a while, a cloud of white precipitate was observed around the silver electrode.

.....

.....

..... [2]

- (ii) The current flowing through the circuit decreased significantly as the experiment progresses.

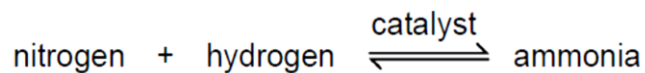
.....

.....

..... [2]

[Total: 8]

- 8 Ammonia is manufactured by combining nitrogen and hydrogen at high temperature and pressure.



- (a) What does the symbol $\rightleftharpoons$ represent?

..... [1]

- (b) Fig. 8.1 shows a graph of the percentage yield of ammonia at different temperatures.

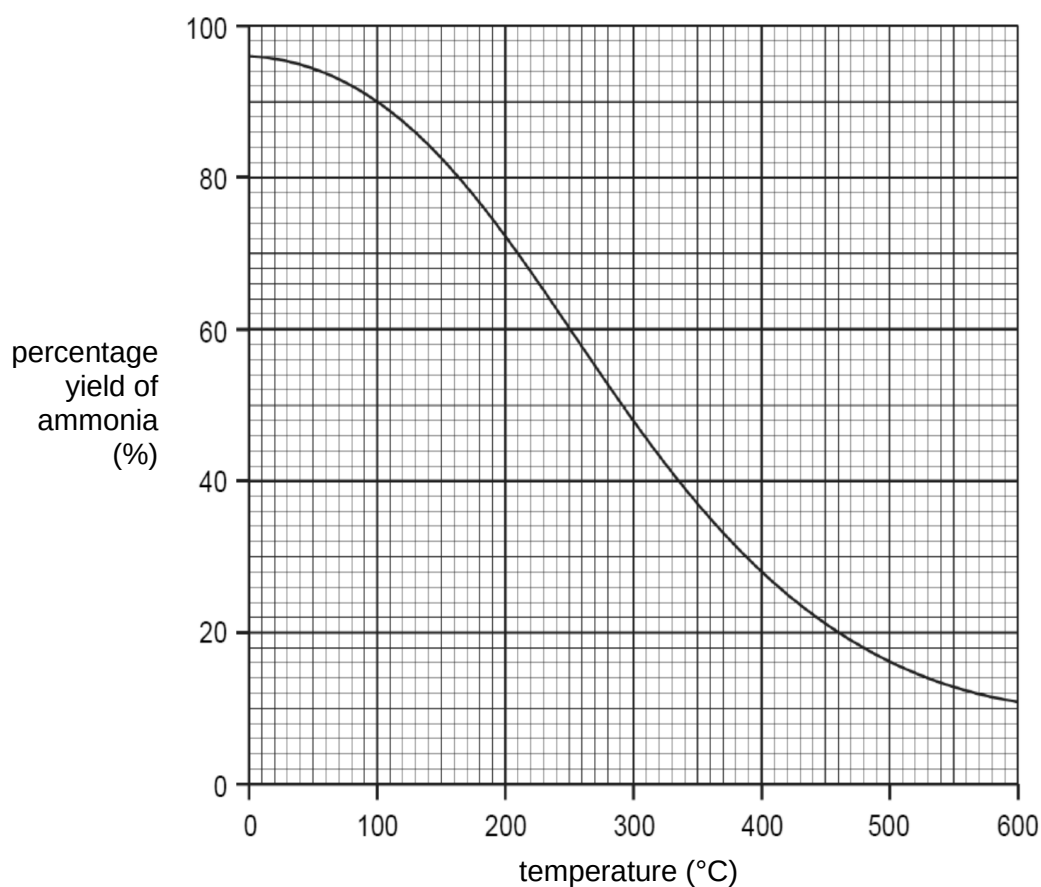


Fig. 8.1

- (i) Deduce the percentage yield of ammonia at 400 °C.

..... [1]

- (ii) State an advantage and a disadvantage of using 450 °C rather than 200 °C as the working temperature.

advantage.....

disadvantage [2]

- (iii) Based on the information provided in Fig. 8.1, deduce if the forward or backward reaction is favoured at 500 °C.

Explain your answer.

.....

..... [1]

[Total: 5]

Section B (30 marks)

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.

- 9 (a) The ionisation energy of an atom describes the minimum amount of energy required to remove an electron (to infinity) from an atom to form an ion.

Fig. 9.1 shows a plot of $\log_{10}$ (ionisation energy) against the number of the electron removed for sodium.

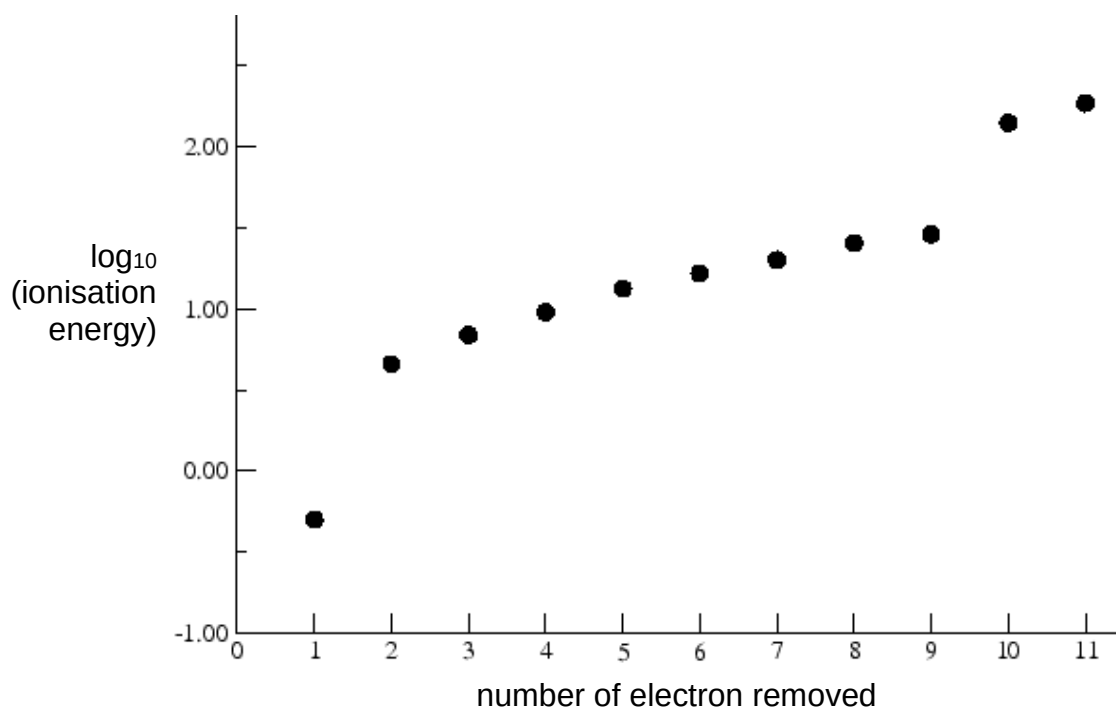


Fig. 9.1

Based on the information provided in Fig. 9.1, describe and explain the trend in ionisation energy for sodium with reference to its electronic structure.

.....

.....

.....

.....

.....

.....

..... [3]

- (b) The equation for an ionisation energy of sodium is shown below:



Table 9.2 shows the first ionisation energy (energy required to remove the first electron from the atom) of elements in Period 3.

Table 9.2

element	Na	Mg	Al	Si	P	S	Cl	Ar
first ionisation energy (kJ / mol)	496	738	577	786	1060	1000	1256	1520
formula of the hydride of the element	NaH	MgH ₂	AlH ₃			H ₂ S	HCl	

- (i) Complete Table 9.2 by filling in the formulae of the hydrides of Si and P. [1]
- (ii) Explain why there is a great difference in the first ionisation energy between sodium and argon.

.....

.....

.....

..... [2]

- (iii) Ionisation of an atom is an endothermic reaction.

Complete the energy level diagram to show the products and energy changes for the ionisation of sodium atom.



- (c) An element in Period 3 has the following properties:

- melting point: 98 °C
- electrical conductivity: good

State the element in Period 3 that this data is most likely to refer to.
Explain your answer.

.....

..... [2]

[Total: 10]

- 10 (a) Some hundred years ago, France presented the United States of America with the Statue of Liberty. The statue was constructed by mounting 'Copper skin' on high carbon steel support rods, as observed in Fig. 10.1.

The statue needed refurbishing before its 100th anniversary in 1986. The work was needed because the high carbon steel support rods 'weakened' a lot faster than expected.



Fig. 10.1

- (i) With the aid of diagrams, explain the difference in the structures of high carbon steel and copper.

structure of high carbon steel	structure of copper

.....

.....

..... [3]

- (ii) Explain what could have brought about a faster rate of 'weakening' of the steel support rods.

.....

.....

..... [2]

- (b) Small pieces of different metals were added to aqueous solutions of their ions. The results are summarized in Table 10.2.

Table 10.2

solution	metal added				
	copper	nickel	iron	scandium	zinc
copper(II) sulfate	-	copper displaced	copper displaced	copper displaced	copper displaced
nickel nitrate	no reaction	-	nickel displaced	nickel displaced	nickel displaced
iron(II) chloride	no reaction	no reaction	-	iron displaced	iron displaced
scandium chloride	no reaction	no reaction	no reaction	-	no reaction
zinc chloride	no reaction	no reaction	no reaction	zinc displaced	-

- (i) Arrange the five metals in order of reactivity, stating from the most reactive to the least reactive.

..... [1]

- (ii) Excess zinc was added to copper(II) chloride.

Describe the observation you would expect to see. Write the balanced chemical equation for the reaction.

.....

.....

..... [2]

- (iii) Suggest the method typically used to extract nickel from its ore.

..... [1]

- (iv) Scandium chloride has the formula ScCl_3 .
With reference to Table 10.2, write the ionic equation for the reaction you would expect when scandium is added to zinc chloride solution.

..... [1]

[Total: 10]

EITHER

- 11** Perfumes usually contain three groups of compounds called the top note, the middle note and the end note.

Top notes consist of small, light molecules that evaporate quickly. The structure of an example of a top note compound is styrallyl acetate, as shown in Fig. 11.1.

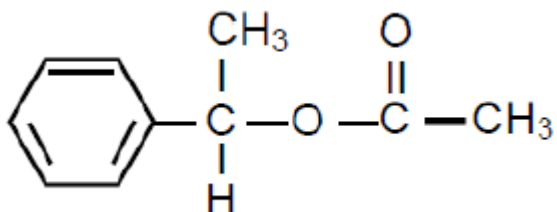


Fig. 11.1

The middle note compounds form vapours less rapidly than the top note compounds. A typical compound of the middle note is 2-phenylethanol. The structure of 2-phenylethanol is shown in Fig. 11.2.

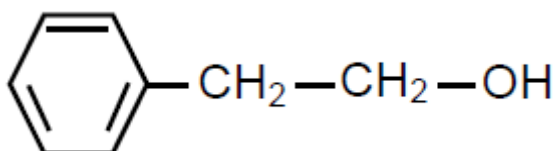


Fig. 11.2

The end note compound of a perfume has a long lasting odour which stays with the user. An example of an end note compound, civetone, is shown in Fig. 11.3.

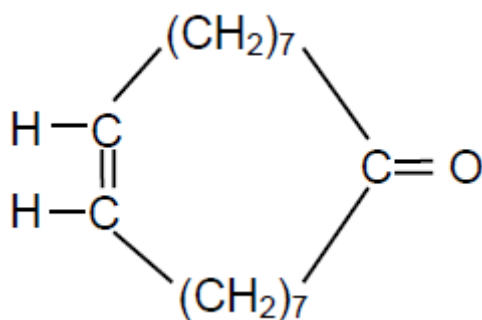


Fig. 11.3

- (a)** With reference to Fig. 11.1, explain why styrallyl acetate is likely to have a pleasant smell.

.....

..... [1]

- (b) Draw the structural formulae of the alcohol and the carboxylic acid used to make styrallyl acetate.

[2]

- (c) Describe a chemical test which would distinguish between the top note and the middle note compounds.

.....

.....

..... [2]

- (d) Name and draw the full structural formula of the molecule formed in the positive test in (c).

[2]

- (e) The end note compound, civetone, undergoes hydrogenation reaction. State the conditions that are essential for the hydrogenation reaction to take place.

..... [1]

- (f) The iodine value is a measure of the **relative** degree of unsaturation of a compound.
It is calculated based on the mass of iodine that reacts with 100 g of the compound.

Given that 1 mole of civetone reacts with 1 mole of iodine, calculate the iodine value for civetone.

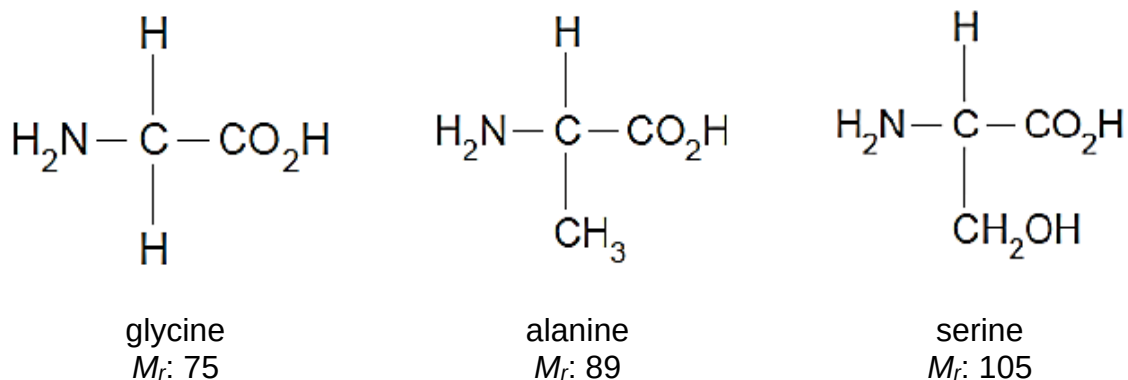
[Relative molecular mass of civetone: $C_{17}H_{30}O$, 250]

iodine value [2]

[Total: 10]

OR

- 11** The silk of a spider's web is composed of polyamide chains which are mainly made from the amino acids, glycine, alanine and serine, with smaller amounts of four other amino acids. The structures of the three main amino acids are as shown in Fig. 11.4.

**Fig. 11.4**

- (a)** The silk of a spider's web is assumed to be made from repetitive sequences of –glycine–alanine–serine–.

Draw the structural formula of the repeating unit of this polyamide.

- (b) The M_r of each spider's web silk polyamide chain is about 600 000.

Assuming the polyamide chain is made from equal amounts of the above three amino acids, calculate the minimum number of amino acids monomers in each polyamide chain.

[3]

- (c) A scientist separates the other four amino acids by paper chromatography using two different solvents. The solvent front of solvent 1 takes five minutes to reach the end of the chromatogram while the solvent front of solvent 2 takes ten minutes.

Table 11.5 shows the R_f values she obtained for these amino acids.

Table 11.5

amino acid	R_f in solvent 1	R_f in solvent 2
A	0.2	0.5
B	0.0	0.4
C	0.8	0.9
D	0.3	0.4

- (i) Which of the amino acids is the most soluble in both solvents?
Explain your answer.

..... [1]

- (ii) State how the scientist is able to calculate the R_f value of the colourless amino acids.

..... [1]

- (iii) The scientist writes the following statements about the chromatography.

Conclusion: Solvent 2 gives a better separation than solvent 1.

Source of error: Duration of chromatography for solvent 2 is longer than that for solvent 1.

Do you agree with the scientist? Explain why.

.....

.....

.....

.....

..... [2]

- (iv) Which is the better solvent to use to separate the four amino acids? Explain your answer.

.....

..... [1]

[Total: 10]

End of Paper

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The Periodic Table of Elements

Group																	
I	II	1 H hydrogen 1										III	IV	V	VI	VII	0
		Key proton (atomic) number atomic symbol name relative atomic mass															
3 Li lithium 7	4 Be beryllium 9																
11 Na sodium 23	12 Mg magnesium																
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium -	85 At astatine -	86 Rn radon -
87 Fr francium -	88 Ra radium -	89 – 103 actinoids	104 Rf Rutherfordium -	105 Db dubnium -	106 Sg seaborgium -	107 Bh bohrium -	108 Hs hassium -	109 Mt meitnerium -	110 Ds darmstadtium -	111 Rg roentgenium -	112 Cn copernicium -		114 Fl flerovium -		116 Lv livermorium -		

lanthanoids

57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium -	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
89 Ac actinium -	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium -	94 Pu plutonium -	95 Am americium -	96 Cm curium -	97 Bk berkelium -	98 Cf californium -	99 Es einsteinium -	100 Fm fermium -	101 Md mendelevium -	102 No nobelium -	103 Lr lawrencium -

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

KUO CHUAN PRESBYTERIAN SECONDARY SCHOOL
SECONDARY FOUR EXPRESS
CHEMISTRY
PRELIMINARY EXAMINATION 2023
Answer Scheme

Paper 1 – Multiple Choice Questions (40 marks)

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
B	A	C	D	D	D	A	B	A	C

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
C	A	A	A	D	A	B	D	A	C

Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
C	B	B	D	D	A	D	A	D	C

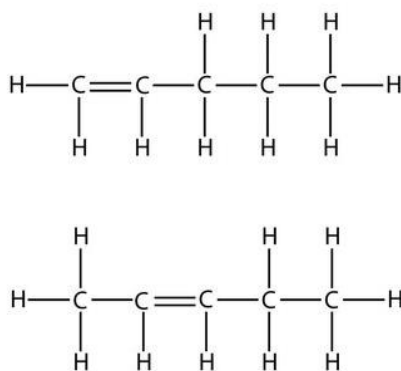
Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40
B	B	D	A	B	C	D	D	B	C

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 SECONDARY FOUR EXPRESS CHEMISTRY 6092
 PRELIMINARY EXAMINATION 2023

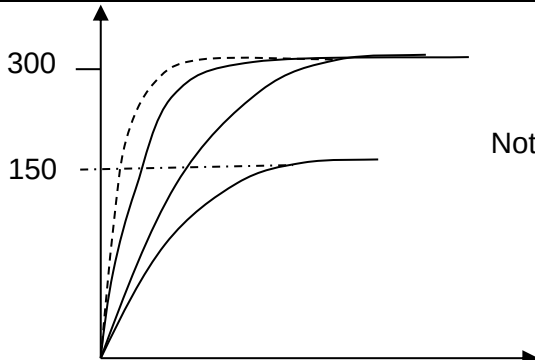
MARK SCHEME

Section A (50 marks)

1	a	limestone	[1]
	b	ammonium sulfate / barium sulfate	[1]
	c	carbon dioxide	[1]
	d	limestone	[1]
	e	lead(II) nitrate	[1]
	f	coke	[1]
2	a	Silicate has an orderly arrangement, while soda-lime glass does not have an orderly arrangement; Each oxygen atom is covalently bonded to 2 Si atoms in silicate, but not all oxygen atoms are covalently bonded to 2 Si atoms in soda-lime glass; Silicate contains only covalent bonds, but soda-lime glass contains covalent and ionic bonds; [Note: Reject if <u>only ionic bonds</u> mentioned] [Note: Any two]	[2]
	b	Conducts electricity only in molten state. There are more free-moving/mobile ions that act as charge carriers.	[1] [1]
3	a	Enthalpy is negative. <u>Heat is released to the environment</u> thus the energy level of the reaction is lowered.	[1] [1]
	b	The enthalpy change is negative because the energy absorbed for <u>breaking of CaO and H₂O</u> is <u>lesser</u> than the energy released when <u>forming Ca(OH)₂</u>.	[1]

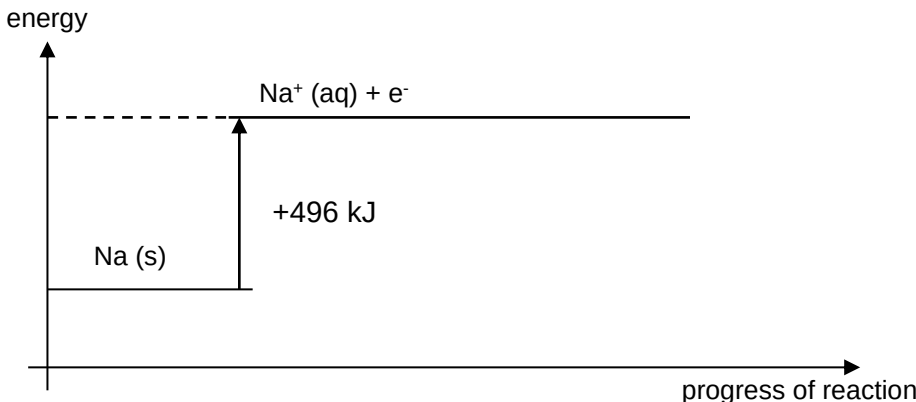
4	a	These organic compounds have the <u>same general formula</u> : C_nH_{2n}		[1] [1]	
	b		True	False	[2]
		They have the same percentage by mass of carbon.	√		
		They have the same empirical formula.	√		
		They are unsaturated hydrocarbons.		√	
		They decolourise aqueous bromine in the absence of sunlight.		√	
	[Note: 1 mark for every 2 correct]				
c	The higher the number of carbon atoms, the <u>higher the boiling points</u> of cycloalkanes. <u>More energy</u> is required to overcome the <u>stronger intermolecular forces of attraction</u> between the <u>bigger</u> cycloalkane molecules. [Note: Vice versa is accepted.]			[1] [1]	
d	 [Note: 1 mark for any structure]			[1]	
5	a	Carbon monoxide is formed due to <u>incomplete combustion</u> of hydrocarbons in petrol. At <u>high temperatures</u> , <u>nitrogen and oxygen from the air</u> react to form nitrogen oxides.		[1] [1]	
	b	Nitrogen oxides react with water and oxygen to form <u>acid rain</u> which <u>corrodes limestone building/kills marine life</u> .		[1]	

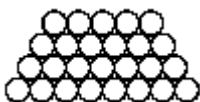
	c	When the car engine is idling, the supply of <u>air / oxygen</u> is <u>insufficient</u> for the complete combustion of petrol, leading to <u>incomplete combustion</u>. Hence, the <u>concentrations of unburnt hydrocarbons and carbon monoxide</u> are <u>higher</u> in the idling mode than in the accelerating mode. When the engine is accelerating, the <u>temperature</u> of the car engine <u>increases</u>. Hence, a <u>higher concentration of nitrogen oxides</u> is produced. [Note: 1 mark for describing the difference in concentration of air pollutants when the engine is idling and accelerating]	[1] [1] [1]
	d	Agreed. Carbon is oxidised as there is an increase in oxidation state of carbon from +2 in carbon monoxide to +4 in carbon dioxide. Nitrogen is reduced as there is a decrease in oxidation state of nitrogen from +2 in nitrogen monoxide to 0 in nitrogen. As both oxidation and reduction occurs at the same time, it is a redox reaction. OR Agreed. Carbon monoxide is oxidised as it gains oxygen to form carbon dioxide. Nitrogen monoxide is reduced as it loses oxygen to form nitrogen. As both oxidation and reduction occurs at the same time, it is a redox reaction. [Note: 1 mark is penalised if student did not answer the question and conclude.]	[1] [1]
6	a	No. of moles for experiment 1 = 0.08×1.00 = 0.0800 mol No. of moles for experiment 2 = 0.05×2.00 = 0.100 mol [Note: Both correct for 1 mark.]	[1]
	b	<u>HCl</u> is present in excess in experiment 1. <u>Same volume</u> of H_2 gas is obtained when the <u>number of moles of HCl used is increased</u> in experiment 2, keeping mass of metal constant. OR	[1] [1]

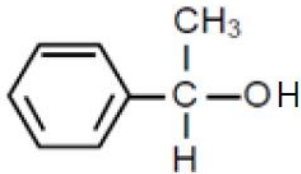
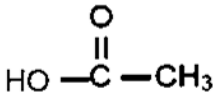
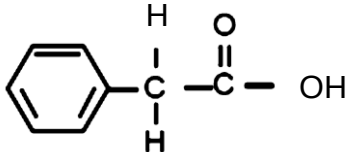
		From (a), 0.0125 mol H₂ is produced which means only 0.025 mol HCl is reacted & 0.08 mol HCl is present. ∴ HCl is in excess. [Note: To reject: There is more HCl than metal X.]	
	c	Since X is a group II element, $\text{X (s)} \equiv 2 \text{HCl (aq)} \equiv \text{H}_2 \text{(g)}$ No. of mol of H₂(g) = $\frac{300}{24000}$ = 0.0125 mol ∴ A_r of X = $\frac{0.50}{0.0125} = 40$ [Note: Relative atomic mass should <u>NOT</u> have any units.]	[1] [1] [1]
	d	- Addition of <u>catalyst</u> - Using (finely) <u>powdered form</u> of metal X - <u>Higher temperature</u> - <u>Increase</u> concentration of HCl [Note: Any 2]	[2]
	e	 Note: label & volume of H₂ = 150 cm³ must be present.	[1]

7	a	anode: R cathode: T	[1] [1]
	b	R: $4 \text{ OH}^- (\text{aq}) \rightarrow 2 \text{ H}_2\text{O} (\text{l}) + \text{O}_2 (\text{g}) + 4 \text{ e}^-$ T: $\text{Cu}^{2+} (\text{aq}) + 2 \text{ e}^- \rightarrow \text{Cu} (\text{s})$ [Note: state symbols must be present.]	[1] [1]
	ci	The <u>silver anode discharges/oxidises to form silver ions</u> . The silver ions react <u>with chloride ions</u> in the electrolyte, <u>forming insoluble white precipitate silver chloride</u> .	[1] [1]
	cii	The <u>number of mobile ions in the electrolyte will decrease</u> over the time as <u>more solid silver chloride is formed</u> . The decrease in number of mobile ions lead to a <u>decrease in the number of mobile charge carriers</u> to conduct electricity, leading to decrease in the electrical conductivity.	[1] [1]
8	a	Reversible reaction	[1]
	bi	28%	[1]
	bii	Advantage: Reaction will be faster at higher temperature Disadvantage: Lower yield is obtained / a need for expensive equipment to maintain high temperature.	[1] [1]
	biii	Backward reaction. As the percentage yield of ammonia is <u>low</u> at <u>about 16%</u> , this shows that the reaction is moving backwards.	[1]

Section B (30 marks)

9	a	Description: As the number of electrons increase from 1 to 11 electrons being removed, the ionisation energy generally increase. [1] Explanation(s): The first ionisation energy is removing one electron from the third shell which is <u>furthest away from the nucleus</u> hence <u>lowest energy</u> required. [1] Whereas, the 10th and 11th ionisation energy are the <u>highest</u> as it involve the removal from the first shell <u>closest to the nucleus</u>. There is only a slight <u>increase (or similar energy)</u> from the 2nd to 9th ionisation energy as this involves the removal of 8 electrons from <u>the same second shell</u>. [1] (Need to explain with reference to electronic structure)																					
	bi	<table border="1"><tr><td>Formula of the hydride of the element</td><td></td><td></td><td></td><td></td><td>SiH₄</td><td>PH₃</td><td></td><td></td><td></td><td></td></tr></table> [Note: Both must be present to award 1 mark]										Formula of the hydride of the element					SiH ₄	PH ₃					[1]
Formula of the hydride of the element					SiH ₄	PH ₃																	
	bii	It is easier to remove the one valence electron from sodium, as it has a high tendency to lose electrons to obtain noble gas configuration. [1] However, it is more difficult to remove electron from argon's stable configuration and hence the ionisation energy is very high. [1] [Note: Reject Na has fewer valence electrons than Ar.]																					
	biii	energy  progress of reaction [Note: 1 mark for diagram drawing with correct single-headed arrow; 1 mark for labels of sign & products & energy involved.]										[2]											

	c	Sodium. A fairly low melting point & good electrical conductivity are characteristics of Group I/alkali metals. [Note: No marks for suggesting the element.]		[1] [1]
10	ai	Structure of high carbon steel 	Structure of copper 	[1]
		In copper, atoms are <u>packed regularly</u> in layers, while in steel, <u>arrangement is irregular</u> . This is because there is only one type of <u>same-sized copper</u> atoms, while there are <u>different sizes</u> of <u>carbon & iron</u> atoms in high carbon steel.		[1] [1]
	aii	Iron more reactive / is higher in metal reactivity series than copper. Iron corrodes / rusts in place of copper.		[1] [1]
	bi	Sc, Zn, Fe, Ni, Cu [Note: accept names of elements]		[1]
	bii	Blue solution turned colourless; Orange/pink/Reddish brown deposit formed; Size of zinc metal decreases. $\text{Zn(s)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{Cu(s)} + \text{ZnSO}_4\text{(aq)}$ [Note: Any one of the three observations for one mark; Balanced chemical equation for one mark]		[1] [1]
	biii	Reduction by carbon/coke or hydrogen		[1]
	biv	$2 \text{ Sc (s)} + 3 \text{ Zn}^{2+} \text{ (aq)} \rightarrow 3 \text{ Zn (s)} + 2 \text{ Sc}^{3+} \text{ (aq)}$		[1]
EITHER				
11	a	The compound consists of a functional group named ester / The compound contains ester linkage (COO)		[1]

	b	Alcohol Carboxylic acid  	[2]
	c	Add <u>acidified potassium manganate(VII) solution</u> to each sample of top note compound and middle note compound. If the acidified potassium manganate(VII) solution <u>turned from purple to colourless</u>, the sample is <u>middle note</u>. If the acidified potassium manganate(VII) solution <u>remained purple</u>, the sample is <u>top note</u>. OR Add <u>acidified potassium dichromate(VI) solution</u> to each sample, if the solution turned <u>from orange to green</u>, the sample is middle note or if the <u>solution remained green</u>, the sample is <u>top note</u>.	[1] [1] [1] [1]
	d	2-phenylethanoic acid 	[1] [1]
	e	Temperature of 200°C and the catalyst used is nickel	[1]
	f	1 mol of end note reacts with 1 mol of iodine. No. of moles of end note $= \frac{100}{250}$ $= 0.4 \text{ mol}$ No. of moles of iodine = 0.4 mol Mass of iodine $= 0.4 \times 2 \times 127$ $= 101.6 \text{ g}$ $= 102 \text{ g (3 sig. fig.)}$ Iodine value is 102.	[1] [1]

OR			
11	a	H O H O H O —N—C— C—N—C—C—N—C—C— H H H CH₃ H CH₂OH [Note: 1m for correct linkage. 1m for correct sequence.]	[2]
	b	Mr of repeat unit = 215 Minimum no. of monomers = 600 000/215 X 3 = 8372.09 = 8373 (rounded up to nearest number) [Note: If Mr of glycine = 75; Mr of alanine = 89; Mr of serine = 105, and min. no. of monomers = 600 000/269 X 3 = 6691.4 = 6692, then only 2m.]	[1] [2]
	ci	C. It has the <u>highest R_f values</u> in both solvents.	[1]
	cii	Use a <u>locating agent</u> to make the amino acids <u>visible</u> to obtain measurement	[1]
	ciii	No, because solvent 2 does not give a better separation than solvent 1 as <u>B and D have identical R_f values</u> hence cannot be distinguished. Duration of chromatography is also <u>not a source of error</u>, because <u>R_f is a ratio</u> (of distance travelled by dye to distance travelled by solvent) / R_f is only dependent of solubility of component in a specific solvent./R_f values are not time dependent.	[1] [1]
	civ	Solvent 1. It has different R_f values for B & D.	[1]