TANJONG KATONG GIRLS' SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR EXPRESS
CHEMISTRY

CANDIDATE NAME							
CLASS				INDEX NUMBER			

CHEMISTRY 6092/02

Paper 2 **14 August 2026**

1 hour 45 minutes

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

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 HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided. **Overall -1m for all wrong units**

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 23.

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

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

This document consists of **22** printed pages and **2** blank pages.

Section A

Answer **all** questions.

1 Table 1.1 shows information about the preparation of three pure samples of solid salts.

Complete the table by filling in the missing information. Include state symbols with the formulae of the reagents.

Table 1.1

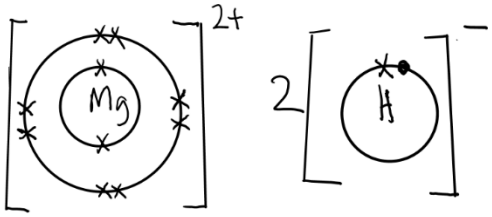
formulae of salt	formulae of reagent 1	formulae of reagent 2	method of preparation
$BaCO_3$ (s)	**$Ba(OH)_2$ (aq) / $Ba(NO_3)_2$(aq) / $BaCl_2$ (aq)**	**K_2CO_3 (aq) / Na_2CO_3 (aq) / $(NH_4)_2CO_3$ (aq)/ H2CO3** **Any other group 1 carbonate**	precipitation filtration
$FeSO_4$ (s)	**FeO (s) / $Fe(OH)_2$ (s) / $FeCO_3$ (s) / Fe (s)**	H_2SO_4 (aq)	addition of excess solid to acid evaporation and crystallisation
NH_4NO_3 (s)	**NH_3(aq)/ $(NH_4)_2CO_3$/** **NH_4OH(aq) BOD**	HNO_3 (aq)	**titration** evaporation and crystallisation

Key issues – chemical formula

Penalise state symbols once for wrong or missing state symbols[Total: 5]

2 Hydrogen reacts with magnesium to form magnesium hydride, MgH_2.
Hydrogen reacts with oxygen to form water.

(a) (i) Magnesium hydride is an ionic compound.
Draw the dot-and-cross diagram of magnesium hydride, **showing all the electrons.**



1 for one Mg^{2+} showing **all** electrons

1 for two H^- ions (with both dot and cross drawn)
(dot and cross are interchangeable)

Issue – some students thought MgH_2 is covalent

[2]

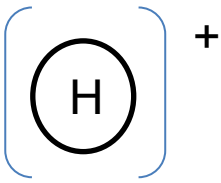
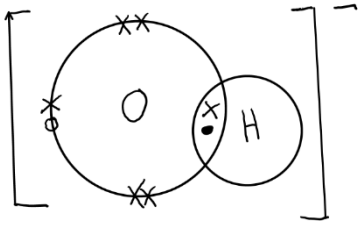
(ii) Water can partially dissociate to produce hydrogen ions and hydroxide ions.

The structure of the hydroxide ion can be represented as shown.

$$[O - H]^-$$

The electronic structure of hydrogen ion has been drawn below.

Draw the dot-and-cross diagram of the hydroxide ion, showing the outer shell electrons only.

Hydrogen ion	hydroxide ion
	

[2]

1 foreign electron on O drawn using another symbol)
1 for shared pair of e between O and H atom
(dot and cross are interchangeable)

Issue – some students drew 7 electrons for O (wrong symbol used)

(iii) Hence, in terms of electrons, explain why hydrogen exhibits the behaviour of both metals as well as non-metals.

Hydrogen **loses electron(s) which behaves as a metal. [1]**

Hydrogen **shares electrons or gains electron(s) which behaves as a non-metal**. [1]

Issue – some students were not specific about metal/non-metals losing/gaining electrons

(b) Explain, using structure and bonding, the difference in melting point between magnesium hydride and water.

Magnesium hydride has a **giant ionic (lattice)** structure with **strong electrostatic forces of attraction between (oppositely charged) ions**. This requires **a lot of energy** to **overcome/ weaken** and hence **high melting point**
[1m structure + bonding]

Water has a **simple covalent / simple molecular** structure with **weak intermolecular forces of attraction** (between molecules). This requires **low amount of energy** to **overcome/weaken** and hence **low melting point.**
[1m structure + bonding]
[1m energy + mp, award independently]

OR 1m for both structures/bonding

3 Table 3.1 below shows four different experiments that were conducted with various concentrations of three different acids that reacted with excess lumps of zinc.

Table 3.1

experiment	acid	concentration of acid in mol / dm^3	volume of acid in cm^3
1	hydrochloric acid	0.10	100
2	hydrochloric acid	0.20	100
3	ethanoic acid	0.10	100
4	sulfuric acid	**M**	**N**

(a) The chemical equation for the reaction between zinc and hydrochloric acid is shown.

$$Zn + 2\,HCl \rightarrow ZnCl_2 + H_2$$

(i) Calculate the number of moles of hydrochloric acid that reacted in Experiment 1.

No. of moles of acid
= 0.10 x (**100** /**1000**)
= 0.0100 mol [1]

moles of hydrochloric acid …… [1]

(ii) Calculate the volume of gas that is evolved in Experiment 1.

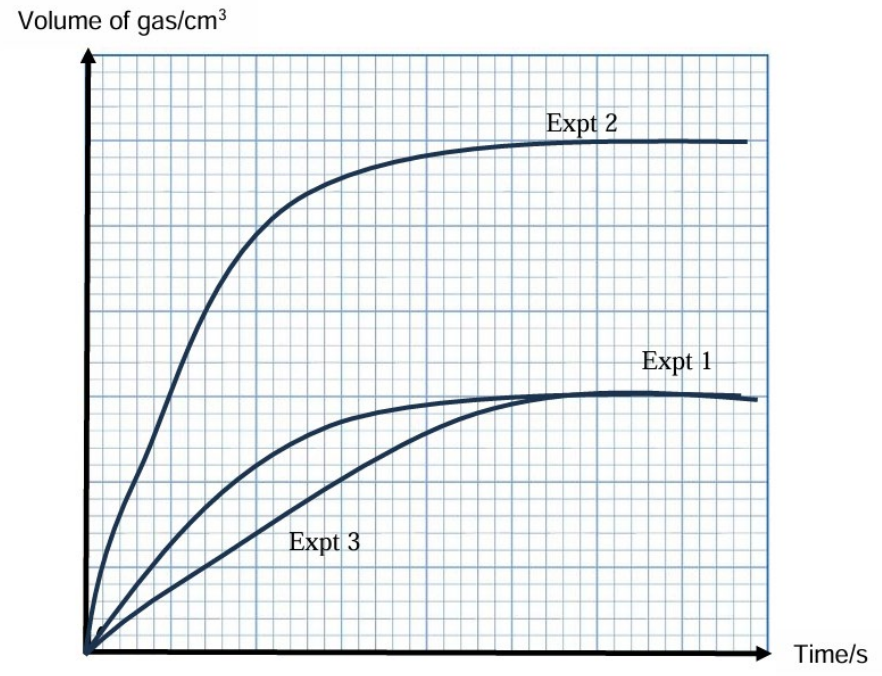
$HCl : H_2$
2 : 1
0.0100 : 0.005 [1]

Volume of gas
= 0.005 x 24 dm^3
= 0.120 dm^3 or 120 cm^3 [1]

volume of gas …… [2]

(iii) Fig 3.1 shows the graph for Experiment 1.

Sketch the graph for Experiment 2 in the same diagram below and label it as **Expt 2**. [1]



Expt 2: faster speed and twice the yield [1]

Expt 3: slower speed and same yield [1]

Fig. 3.1

(b) **(i)** Write a chemical equation for the reaction between ethanoic acid and zinc.

$2CH_3COOH + Zn \rightarrow Zn(CH_3COO)_2$ or $(CH_3COO)_2Zn + H_2$ [1]

(ii) Sketch the graph for Experiment 3 in the same diagram above and label it as **Expt 3**. [1]

(iii) 0.10 mol/dm^3 ethanoic acid has a higher pH than 0.10 mol/dm^3 hydrochloric acid.

Explain why.

Ethanoic acid is a weak acid while hydrochloric acid is a strong acid. [1]
Ethanoic acid dissociates partially in water to form **lower concentration of H^+ ions.** Hence it has a higher pH. [1]

(c) Suggest a way to increase the rate of reaction in Experiment 1, without changing the volume and concentration of the acid.

Increase temperature or use powdered zinc
[1]

(d) Suggest values for **M** and **N** in the Table 3.1 such that Experiment 4 will have the same graph as Experiment 2.

M: 0.10 mol/dm^3 (2dp as per table) (✓) N: 100 cm^3 (✓)

2(✓) : 1mark
No units needed

[Total: 10]

4 Methane, methanol and hydrogen have been investigated as possible alternative sources of fuels for motor vehicles that currently use petrol. Table 4.1 below compares the energy released on combustion of these fuels.

Table 4.1

fuel	density in g / dm^3	enthalpy change of combustion in kJ / mol	enthalpy change of combustion in kJ / g
petrol	710 – 770	–	– 47.3
methane	0.667	– 890	– 55.7
methanol	792	– 726	
hydrogen	0.0884	– 285	– 142.5

(a) (i) Calculate the enthalpy change of combustion for methanol in kJ / g.

Enthalpy change for methanol
= - 726 / Mr
= - 726 / 32
= -22.7 kJ/g [1]

(ii) Suggest why no value is quoted for the enthalpy change of combustion for petrol in the table above.

Petrol is a mixture of hydrocarbons**.** Hence, it does not have a fixed enthalpy change.[1]

(b) (i) The equation shows the combustion of methane.

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

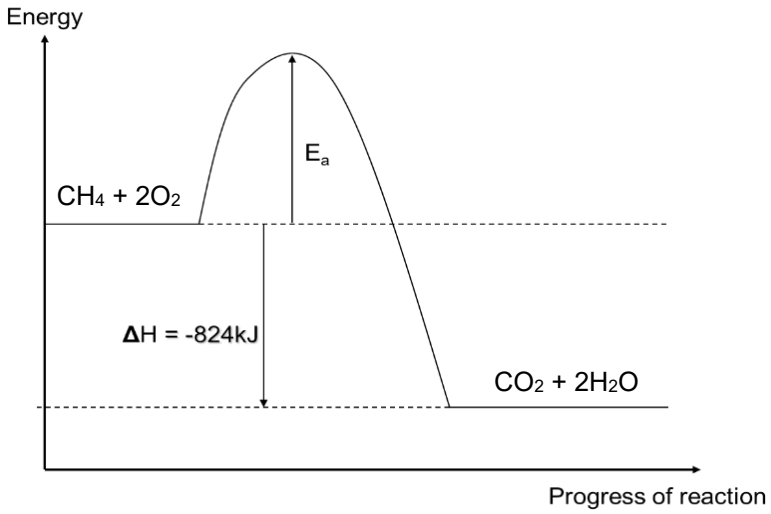
Using ideas about bond breaking and bond forming, explain why the enthalpy change for the complete combustion of methane has a negative sign.

The energy **taken in to break** the bonds in methane and oxygen is **less** than the **energy give out in the bond formation in** carbon dioxide and water. Hence the reaction is exothermic and has a negative sign for enthalpy change.

1m: compare energy taken in and given out

1m: relate energy taken in to that of bond breaking of the reactants and energy given out as bond forming of products

(ii) Draw an energy profile diagram for the complete combustion of methane. Indicate the enthalpy change, ΔH and activation energy, E_a on the diagram clearly.



[1 mark for correct shape of graph, 1 mark for correct labelling of reactant and product, 1 mark for correct labelling of enthalpy change and activation energy]. These 3 marks independently marked
Single arrow head must be used to show E_a and ΔH

If **double arrow** heads are used for E_a, no 1 mark is awarded
If **double arrow** heads are used for ΔH, no 1 mark is awarded

[3]

(c) Other than the amount of heat given out, state one advantage and one disadvantage of using methanol as a fuel compared to hydrogen

advantage: Methanol is a liquid while hydrogen is a gas at r.t.p. Easier to transport methanol as transporting hydrogen would require use of pressurized tanks. [1]

disadvantage: Burning methanol releases carbon dioxide which is a greenhouse gas that cause global warming, leading to melting of polar ice caps. While burning hydrogen produces only water which is non-pollutive] [1]

[Total: 9]

5 Table 5.1 shows the properties of the homologous series of ethanoate esters.

Table 5.1

name	molecular formula	boiling point/ °C	solubility in water	scent
methyl ethanoate	$C_3H_6O_2$	57	highly soluble	-
ethyl ethanoate	$C_4H_8O_2$	77	moderately soluble	glue
propyl ethanoate	$C_5H_{10}O_2$	102	slightly soluble	pear
butyl ethanoate	$C_6H_{12}O_2$	126	nearly insoluble	apple
pentyl ethanoate	$C_7H_{14}O_2$	149	insoluble	banana

(a) Deduce the general formula for the homologous series of ethanoate esters.

$C_nH_{2n}O_2$ / $C_{n+2}H_{2n+4}O_2$

[1]

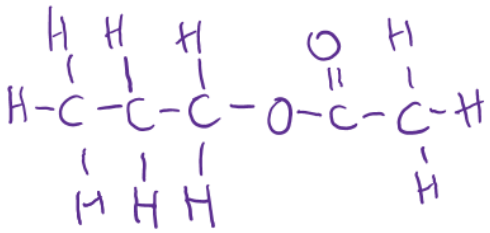
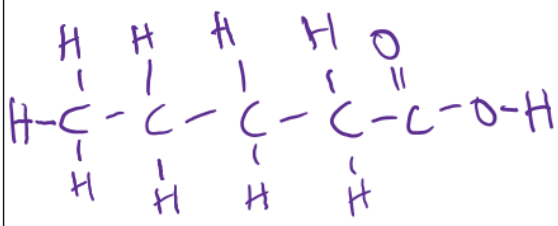
(b) Explain how the boiling point of ethanoate esters changes with increasing carbon atoms.

The boiling point **increases** with increasing carbon atoms. [1]

Larger amount of energy required to **overcome the stronger intermolecular forces of attraction** as the molecules get bigger. [1]

(c) An isomer of propyl ethanoate was found to have a pH of 4.6 and reacts with sodium carbonate readily.

Draw the full structural formulae of propyl ethanoate and its isomer.

	
Propyl ethanoate	isomer

[2]

(d) **(i)** An ester responsible for the scent of a fruit is analyzed and found to contain 62.04 % carbon, 10.41 % hydrogen, and 27.55 % oxygen by mass.

Determine the empirical formula of this ester.

	C	H	O
Mass in 100g	62.04	10.41	27.55
No. of mol	**62.04 /12 =5.17**	**10.41 / 1 = 10.41**	**27.55 / 16 = 1.7219**
Smallest ratio	5.17 / 1.7219 = 3	10.41/ 1.7219 = 6	1.7219/1.721 = 1

Number of moles [1]

empirical formula **C_3H_6O** [1]

(ii) Predict the **scent** of this ester.

Apple Scent[1]

(e) Suggest a method to separate pentyl ethanoate from water in the laboratory.

Separating funnel/ [1]

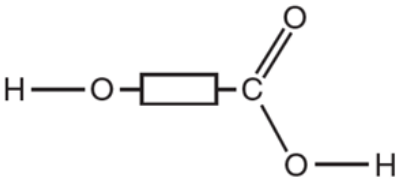
(f) A beaker of ethanol was left to stand for 3 hours. Then a few drops of concentrated sulfuric acid was added to this beaker of ethanol before heating the mixture. The scent of glue was detected.

Explain how this ester was formed.

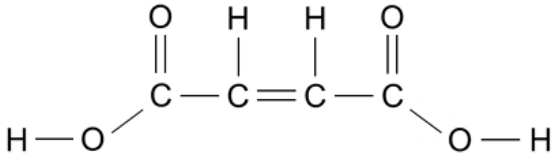
On standing, **some of the ethanol was oxidised** to ethanoic acid by air**. [1]**
Then the **remaining ethanol and ethanoic acid reacted together** through esterification to form the ester. [1]

[Total:11]

6 A liquid mixture contains two organic compounds, **A** and **B**. The structures of compounds **A** and **B** are shown below.



A



B

(a) Describe a chemical test that can be carried out to differentiate compound **A** and **B**.

Add **acidified potassium manganate(VII)** to sample of compound A and B separately and warm gently. [1]
In **compound A**, the **purple $KMnO_4$ will be decolourised**. [1]
In **compound B**, **purple $KMnO_4$ remains**.
Or

Add **aqueous bromine** to sample of compound A and B separately. [1]
In compound **A**, **reddish brown bromine remains**.
In compound **B**, **reddish brown bromine decolorized** rapidly [1]

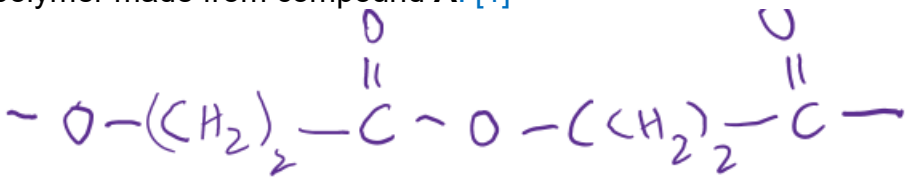
[1] for correct reagents
[1] for positive results

(b) Monomers of compound **A** can self-polymerise to form a polymer.
Monomers of compound **B** can also self-polymerise to form a different polymer.

For each compound, state the type of polymerisation it undergoes and draw the structural formula of the polymer formed, showing two repeat units.

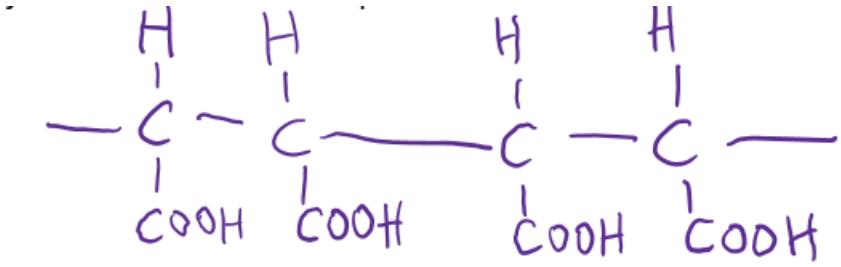
type of polymerisation that compound **A** undergoes: **condensation** polymerisation [1]

polymer made from compound **A**: [1]



type of polymerisation that compound **B** undergoes: **addition** polymerisation [1]

polymer made from compound **B**: [1]



[4]

[Total: 6]

7 Order of Reactions

Determining rates of reaction using concentration-time graphs

Fig. 7.1 shows a concentration vs. time graph when magnesium is added to dilute nitric acid. The gradient of the graph gives the rate of reaction at that point of time.

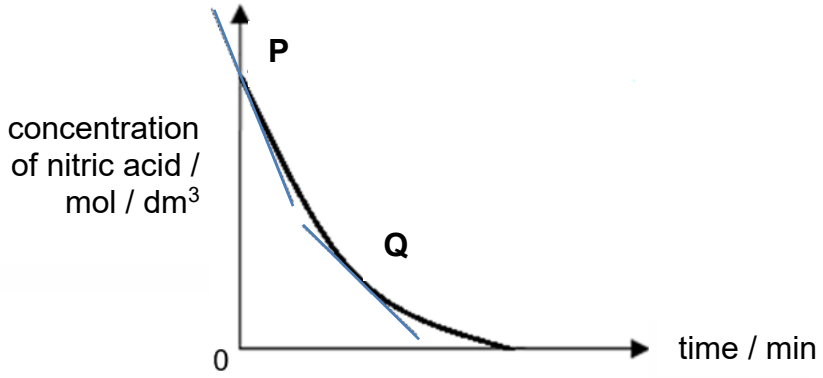


Fig. 7.1

Determining the order of reaction for reactants

Changing the concentration of different reactants can have different effects on the rate of reaction. The **order of reaction** with respect to a reactant describes how the reactant's concentration affects the rate of reaction.

Consider the reaction between phenylamine, $C_6H_5NH_2$, and bromine.

$$C_6H_5NH_2 + 3\ Br_2 \rightarrow C_6H_2NH_2Br_3 + 3\ HBr$$

Table 7.1 shows the initial rates of this reaction when varying concentrations of both reactants are used in experiments 1 to 3.

Table 7.1

experiment	concentration of $C_6H_5NH_2$ in mol / dm^3	concentration of Br_2 in mol / dm^3	initial rate of reaction in mol / (dm^3s)
1	0.001	0.001	0.007
2	0.001	0.002	0.014
3	0.002	0.002	0.056

Comparing experiments 1 and 2, when the concentration of Br_2 doubles, the initial rate of reaction doubles too. The initial rate of reaction is directly proportional to the concentration of Br_2. Hence, the reaction is **first order** with respect to Br_2.

Comparing experiments 2 and 3, when the concentration of $C_6H_5NH_2$ doubles, the initial rate of reaction increases by four times (i.e. by 2^2 times). The initial rate of reaction is directly proportional to the **square** of the concentration of $C_6H_5NH_2$. Hence, the reaction is **second order** with respect to $C_6H_5NH_2$.

The reaction can also be **zero order** with respect to a reactant. In this case, changing the concentration of this reactant will have no impact on the rate of reaction.

Acid-catalysed reaction of propanone and iodine

The order of reaction for reactants can also be determined in reactions where three substances are involved. Table 7.2 shows the initial rates of reaction when varying concentrations of propanone, CH_3COCH_3, and aqueous iodine react together in the presence of dilute sulfuric acid catalyst.

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_3COCH_2I + HI$$

Table 7.2

experiment	concentration of CH_3COCH_3 in mol / dm^3	concentration of I_2 in mol / dm^3	concentration of H^+ in mol / dm^3	initial rate of reaction in mol / (dm^3s)
A	0.6	0.0002	0.2	3.2×10^{-6}
B	0.6	0.0002	0.4	6.4×10^{-6}
C	1.8	0.0002	0.2	9.6×10^{-6}
D	1.2	0.0002	0.2	
E	0.6	0.0004	0.2	

In experiments **A** and **E**, the concentrations of iodine in the reaction mixtures were monitored. This is shown in Fig. 7.2, where both graphs were found to be parallel.

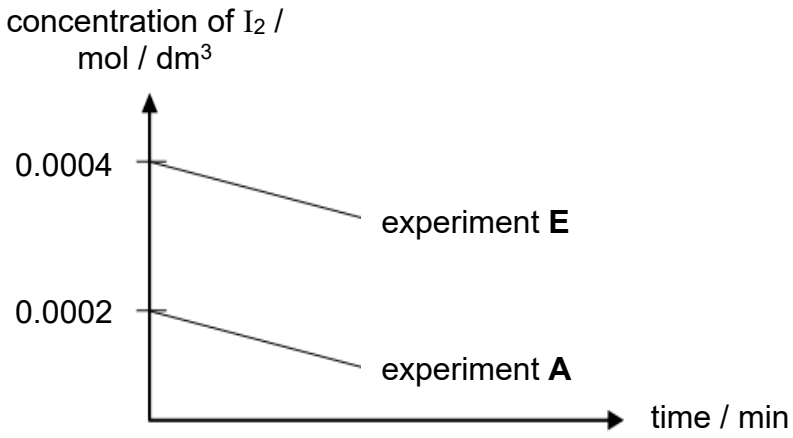


Fig.7.2

(a) **(i)** **Using Fig. 7.1**, state and explain how the reaction rate at **Q** compares with the reaction rate at **P**.

The reaction rate is **slower** at **Q** than at **P**, as the **gradient is less steep** at **Q** than at **P**.[1]

(ii) A student claimed that excess magnesium is added to dilute nitric acid.

Do you agree? Explain your reasoning.

Yes. [must state but no mark]
All the nitric acid is used up in the reaction, [1] as its concentration became 0 mol/dm^3 . Nitric acid is thus the limiting reagent, and Mg is added in excess.

(b) **(i)** The reaction between propanone and iodine is catalysed by dilute acid.

Using ideas about colliding particles, explain why using a catalyst increases the rate of this reaction.

A catalyst **provides an alternative pathway with a lower activation energy**. [1]

More particles would thus **have energies equal to or greater than the activation energy**. This **increases the frequency of effective collisions** between reacting particles, [1] and thus the rate of reaction increases.

(ii) Identify the reducing agent in the acid-catalysed reaction between propanone and iodine.

Explain your answer using oxidation states.

Propanone / CH_3COCH_3 [1]

The **oxidation state of iodine decreased from 0 in I_2 to -1 in HI (or -1 in CH_3COCH_2I).** Iodine has been reduced by propanone so propanone is the reducing agent. [1]

(c) **(i)** The acid-catalysed reaction between propanone and iodine is first order with respect to propanone.

Using information from Table 7.2, explain why the reaction is first order with respect to propanone.

Clearly identify which experiments you are comparing.

Comparing Experiments A and C, (not critical) where the concentration of I_2 and H^+ was kept constant, **when the concentration of propanone triples from 0.6 mol/dm^3 to 1.8 mol/dm^3, the rate of reaction triples from 3.2 x 10^{-6} to 9.6 x 10^{-6}**. [1]

As the **rate of reaction is directly proportional to the concentration of propanone**, [1] the reaction is first order with respect to propanone.

(ii) **Hence**, calculate the initial rate of reaction for experiment **D** in mol / (dm^{3}s).

Rate of reaction of Experiment **D**
= 3.2 x 10^{-6} x 2
= 6.4 x 10^{-6} mol/(dm^{3}s) [1]

initial rate of reaction for experiment **D** ..... in mol / (dm^{3}s) [1]

(d) **(i)** State the initial rate of reaction for experiment **E** in mol / (dm^{3}s).

Explain your answer **using information from Fig. 7.**2 and Table 7.2.

initial rate of reaction for experiment **E** **= 3.2 x 10^{-6}** in mol / (dm^{3}s) [1]

Experiments **A** and **E** have the same rates of reaction, as the **gradients** of their concentration-time graphs **are identical** (since both graphs were found to be parallel). [1]

(ii) Hence, state the order of reaction with respect to iodine.

Zero order [1]

[Total: 12]

8 Singapore maintains its air quality by strict laws and enforcement measures. Table 8.1 shows the ambient air quality targets set by the National Environment Agency (NEA) for three air pollutants.

Table 8.

pollutant	sulfur dioxide	nitrogen dioxide	carbon monoxide

target (g / 1000 dm^3 sample of air)	15 x 10^{-6}	40 x 10^{-6}	30 000 x 10^{-6}

(a) Explain why carbon monoxide is considered a harmful air pollutant.

Carbon monoxide binds irreversibly with haemoglobin in the red blood cells which lowers the ability of the haemoglobin to transport oxygen to the rest of our body.

(This sentence is compulsory to score the 1m)

(b) Describe how sulfur dioxide affects aquatic life.

Sulfur dioxide reacts with oxygen and rainwater **to form acid rain**. [1]
Lowering the pH of the water bodies and **kill the aquatic life**.[1]

(c) A researcher working with the NEA takes a 200 dm^3 sample of gaseous emissions from a factory. The composition of this sample of air is shown in Table 8.2.

Table 8.2

gas	volume / cm^3
sulfur dioxide	0.0022
nitrogen dioxide	0.0031
nitrogen	157000
oxygen	42900
carbon dioxide	99.9

Show, by calculation, that the factory has exceeded the sulfur dioxide target set by NEA.

Volume in 1000dm^3 = 0.0022 x 5 = 0.011cm^3
Mole of SO_2 = 0.011/24000 = 0.00000045833 mol [1]

Mass of SO_2 = 0.00000045833 x 64 = 0.000029333 g
= 29.3 x 10^{-6} g [1]
Hence exceed target of 15 x 10^{-6} g

Or

Target at 200 cm^3 = 15 x 10^{-6} /5 = 3 x 10^{-6}
Mole of SO_2 = 0.0022/24000 = 0.00000009166667 mol
Mass of SO_2 = 0.00000009166667 x 64 = 0.00000586667 g Hence exceed target of 3 x 10-6 g at 200 cm^3

(d) The efficiency of car engines is tested in a test facility. The mass of various gaseous pollutants is measured from the exhaust pipe of a car at different speeds. The higher the speed of the car, the faster the rate of airflow through the engine. The results are shown in Fig. 8.1.

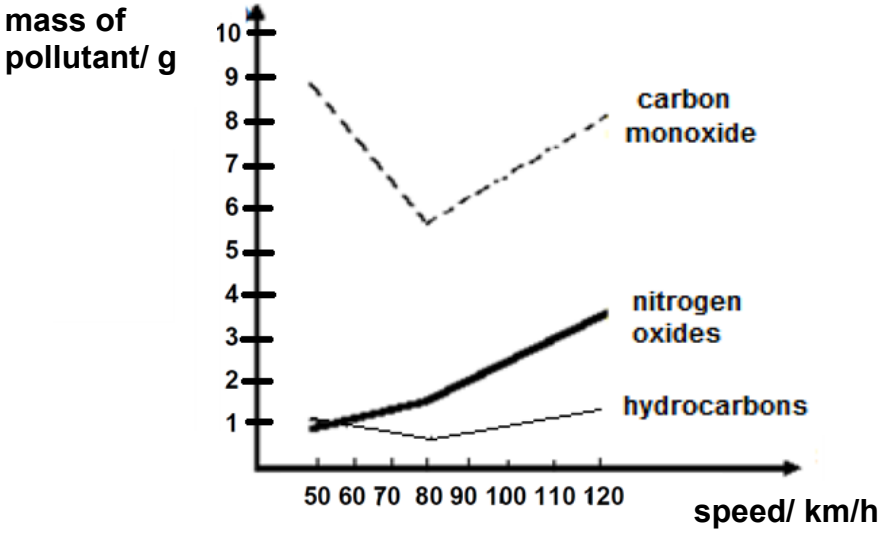


Fig. 8.1

The tests also recorded a much higher increase in temperature of the car engine when the car speed increases beyond 80 km/h.

Describe and explain the trend of carbon monoxide emissions in Fig. 8.1 as the speed of the motor car increases from 50 km/h to 120 km/h.

The CO **emissions decrease when the speed increase from 50 km/h to 80 km/h** and then **emission increases when the speed increases from 80 km/h to 120 km/h. [1]**
When the car increase **speed from 50 km/h to 80 km/h**, the car draws **in more air for more complete combustion of the fuel. [1]**
However when the speed **increases beyond 80 km/h**, the **temperature of the car increase and more of the oxygen in the air reacts with nitrogen to form nitrogen oxides**. [1]
Hence there is a limited supply of oxygen in the air and **more incomplete combustion of hydrocarbons occurs.**

Or
the rate of combustion of petrol is faster than the rate of oxygen gas drawn into the car. Hence **more incomplete combustion of petrol.**[1]

[Total: 8]

Section B

Answer **one** question from this section.

9 **(a)** Many metal carbonates thermally decompose to form carbon dioxide and metal oxide. For example, copper(II) carbonate decomposes to form carbon dioxide and copper(II) oxide.

$$CuCO_3 \rightarrow CuO + CO_2$$

Five 2.00 g samples of metal carbonates are heated strongly until there is no further change in mass. Table 9.1 shows the mass of sample before and after heating as well as the time taken for decomposition to complete.

Table 9.1

metal carbonate	mass of sample before heating / g	mass of sample after heating / g	time taken for decomposition to complete / s
calcium carbonate	2.00	1.12	109
copper(II) carbonate	2.00	1.29	28
Nickel(II) carbonate	2.00	1.26	53
iron(II) carbonate	2.00	1.24	70
sodium carbonate	2.00	2.00	

(i) Calculate the mass of carbon dioxide formed when 2.00 g of iron(II) carbonate is heated.

Mass of carbon dioxide
= 2.00 – 1.24
= 0.76 g

mass of carbon dioxide ..... [1]

(ii) Explain why the mass of carbon dioxide formed is different for each carbonate.

The **molar mass of each metal carbonate** is different. So the **number of mole of metal carbonate present in 2 g** of solid is **different.**[1]

(iii) Arrange the five metals, calcium, copper, nickel, iron and sodium, in order of reactivity, starting from the most reactive.

Explain your reasoning, using information in the table.

Sodium, calcium, iron, nickel, copper [1]
The **longer the time taken shows that the metal carbonate is more stable to heat.** [1]
That would mean the **metal is more reactive. [1]**
Sodium carbonate cannot be thermally decomposed. This shows that **sodium is the most reactive** amongst all the metals above. [1]

(b) A student set up an electrochemical cell as shown in Fig. 9.1. The reading on the voltmeter was +0.44 V.

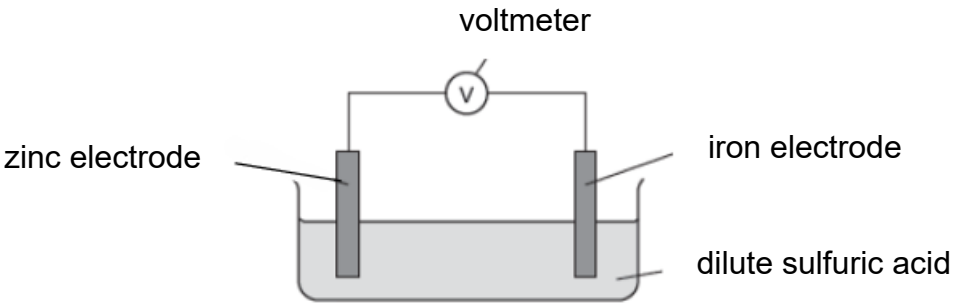


Fig 9.1

(i) Write a half equation for the reaction at the zinc electrode.

$Zn\ (s) \rightarrow Zn^{2+}\ (aq) + 2e$ [1]

(ii) State the name of the rust prevention method which operates in a similar manner to the above set up.

Sacrificial protection [1]

(iii) Suggest a change that could be made to the iron electrode to increase the voltmeter reading.

Change the iron rod to **nickel/ copper/ silver/ platinum. [1]**

(iv) A student made the following comment about the electrochemical cell in Fig 9.1.

"The mass of the electrolyte increases after some time."

Do you agree? Explain your answer.

Agree. (no mark award but essential)
The zinc electrode releases (or produces) zinc ions into the electrolyte while the **hydrogen ions are discharged at the iron electrode.** [1]
Molar mass of zinc ions are higher than molar mass of hydrogen ion. Hence the overall increase in mass of electrolyte. [1]

[Total: 10]

10 **(a)** A student investigated how easily different metal oxides could be reduced by carbon.

In each experiment, 2.0 g of a metal oxide was mixed with excess carbon powder. The mixture was heated strongly for 1 minute. The volume of carbon dioxide gas produced was collected and measured.

The results are shown in Table 10.1.

Table 10.1

metal oxide	volume of carbon dioxide collected in 1 minute / cm^3
nickel(II) oxide	35
iron(II) oxide	18
barium oxide	0
copper(II) oxide	48
sodium oxide	0

(i) Arrange the elements: carbon, nickel, iron, barium and copper in decreasing order of reactivity.

Explain your reasoning, using information from Table 10.1.

Barium, carbon, iron, nickel, copper [1]
Barium oxide, similar to sodium oxide, **cannot be reduced by carbon.**
Barium is more reactive than carbon. [1]
The other metal oxide can be reduced by carbon. **The greater the volume of carbon dioxide collected within the minute,** the greater the ease of the reduction**. Hence, the less reactive the metal.** [1]

(ii) Predict the extraction method of barium from its ore.

Electrolysis of molten barium ore. [1]

(iii) Nickel(II) compounds are green in colour.

Predict one observation that would be made when nickel metal is placed in copper(II) sulfate solution.

Reddish brown deposits on the nickel metal.
or
Blue solution turn green.[1]

(b) Fig. 10.1 shows the set-up used to electrolyse concentrated aqueous sodium chloride. A few drops of purple litmus solution were added to the electrolyte.

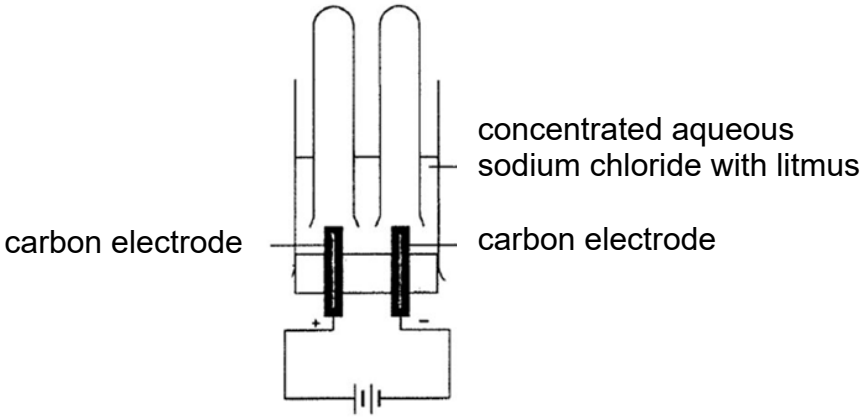


Fig. 10.1

(i) The solution around the anode turned from purple to colourless.

Explain this observation, supporting your answer with an ionic equation at the anode.

$2Cl^-$ (aq) → Cl_2 (g) + 2e [1] (ignore state symbols)
The chlorine gas produced at the anode **bleached the litmus. [1]**

(ii) The experiment is repeated with dilute aqueous sodium chloride.

Put a tick (✓) in one box in each row to show if the statements about both electrolysis is true or false.

Table 10.2

statement	true	false
pH of remaining solution in both electrolysis increases		✓
total mass of remaining solution decreases in both electrolysis	✓	

Explain your choice of answer.

In electrolysis of concentrated sodium chloride, **H^+ and Cl^- are selectively discharged.**
In the electrolysis of dilute sodium chloride, **H^+ and OH^- are selectively discharged** simultaneously**. [1]**

Since the **concentration of H^+ and OH^- remain similar** in that of dilute sodium chloride electrolyte, its **pH will remain neutral. [1]**

In both electrolysis, **all the ions discharged** produced gases that escaped from the electrolyte**.** Hence total mass of remaining electrolyte decrease. **[1]**

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The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, L = 6.02 x 10^{23} mol^{-1}

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