



JURONG JUNIOR COLLEGE
2015 JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE
NAME

Suggested Answers

CLASS

15S

CHEMISTRY

Paper 2 Structured Questions

8872/02

28 August 2015

2 hours

Candidates answer Section A on the Question Paper.

Additional Materials: Answer Paper
 Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and exam index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** the questions.

Section B

Answer **two** questions on separate answer paper.

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	
1	
2	
3	
4	
B5	
B6	
B7	
Total	

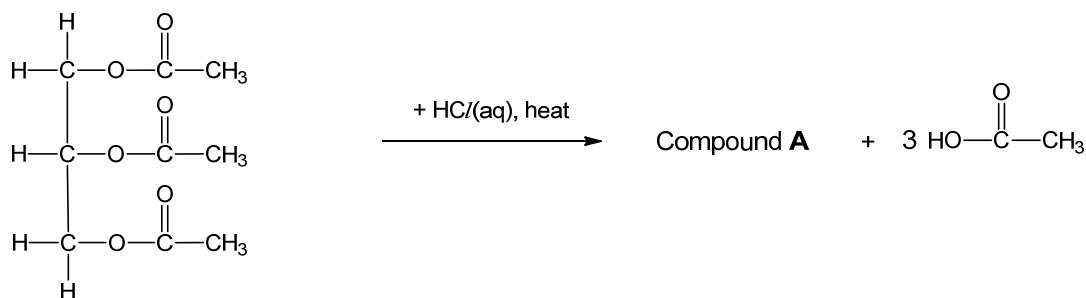
This document consists of **14** printed pages and **no** blank page.

[Turn over

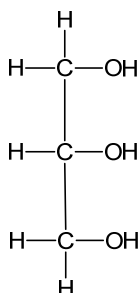
Section A

Answer **all** the questions.For
Examiner's
Use

- 1 Ethanoic acid, also known as acetic acid, is a colourless liquid that has a strong and distinct pungent and sour smell. Aside from culinary uses, as flavouring and as a preservative, ethanoic acid is used to make many polymers and fibres. It can be made by the following method:



- (a) Draw the structure of compound A.

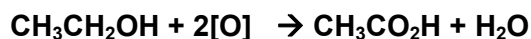


[1]

- (b) (i) Ethanoic acid can be formed from the oxidation of ethanol. Suggest suitable reagent and conditions to perform this reaction.

acidified KMnO_4 / $\text{K}_2\text{Cr}_2\text{O}_7$, heat

- (ii) Write a balanced equation to represent the reaction in (b)(i).



[3]

- (c) 2-chloroethanoic acid can be formed from ethanoic acid using suitable reagents and conditions via substitution reaction. Explain why 2-chloroethanoic acid and ethanoic acid has different acidity.

2-chloroethanoic acid is a stronger acid. Cl is an electron withdrawing atom which disperses the negative charge on the O^- and stabilises the $\text{ClCH}_2\text{CO}_2^-$ ion.

[2]

- 1 (d) A gas is said to exhibit *ideal* gas behavior if it obeys the **ideal gas equation**

$$pV = nRT$$

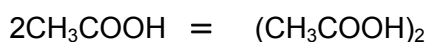
where p = pressure of gas in Pa,
 V = volume of gas in m^3 ,
 n = amount of gas (mol),
 $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ (a constant),
 and T = temperature in K.

Three experiments were performed where different masses of ethanoic acid were expanded into a vessel of volume 0.0150 m^3 at different pressures and at a temperature of 100°C .

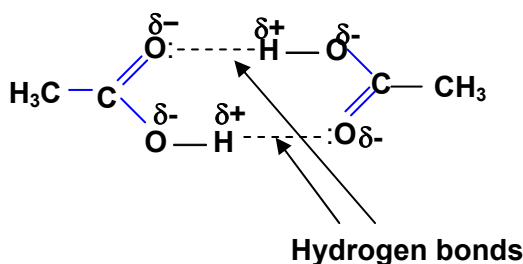
Experiment	Mass of ethanoic acid/ g	Pressure/ Pa	Relative molecular mass
1	0.002	6.346	65.1
2	0.015	31.011	100
3	0.050	86.128	120

Accept exact answer 100.0, 120.0

- (i) Assuming ideal behaviour, calculate the relative molecular mass of ethanoic acid for each experiment 1 to 3 and enter the values into the above table.
- (ii) In gaseous state just above the boiling point, the monomer and dimer forms of ethanoic acid exist together in equilibrium.



Draw a fully labelled diagram to illustrate the bond formed when ethanoic acid dimerises.



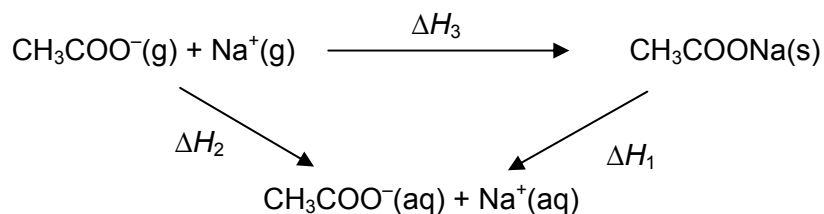
- 1 (d) (iii) Use Le Chatelier's Principle to predict and explain how an increase in pressure will affect the position of equilibrium in d(ii) and the trend in relative molecular mass of ethanoic acid.

When pressure increases, equilibrium position will shift to right to reduce the number of gas particles, so as to reduce the increased [4]

pressure. The equilibrium mixture will
contain a higher proportion of dimers, giving a **higher M_r** .

- (e) The salt of ethanoic acid, sodium ethanoate, may be added to food as a seasoning. It is often used to give potato chips a salt and vinegar flavor.

The enthalpy change for the solution of sodium ethanoate in water, ΔH_1 can be determined by using the energy cycle given below.



$$\Delta H_2 = -780 \text{ kJ mol}^{-1}$$

$$\Delta H_3 = -763 \text{ kJ mol}^{-1}$$

- (i) Name the enthalpy change that is represented by ΔH_3 .

Lattice energy of CH_3COONa

- (ii) With reference to the energy cycle and the data given above, calculate ΔH_1 .

$$-763 = -780 - \Delta H_1$$

$$\Delta H_1 = \underline{\underline{-17 \text{ kJ mol}^{-1}}}$$

[2]

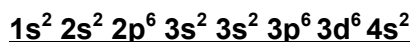
[Total: 12]

- 2 (a) The element iron is a transition metal that is very common in our planet. It has many uses in different industries and even in the human body.
 It has four naturally occurring isotopes.

isotope	Relative abundance / %
^{54}Fe	5.845
^{56}Fe	91.754
^{57}Fe	2.119
^{58}Fe	0.282

- (i) Write the full electronic configuration of iron.

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Use

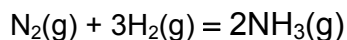


- (ii) Use the relative abundance data to calculate the relative atomic mass of iron to 3 decimal places. Show your working.

$$\begin{aligned} A_r &= 54(0.05845) + 56(0.91754) + 57(0.02119) + 58(0.00282) \\ &= \underline{55.910} \end{aligned}$$

[2]

- (b) Iron is used as a catalyst in the manufacture of ammonia in the Haber process.



- (i) State the optimum industrial conditions of temperature and pressure used in the Haber process.

450°C, 250 atm

- (ii) Explain why these particular conditions are chosen.

At low temperature, even though equilibrium yield of NH_3 is high as equilibrium position in $N_2(g) + 3H_2(g) = 2NH_3(g)$ shifts to the right to favour the exothermic reaction.

However, equilibrium is reached at a slower rate. Hence a moderately high temperature is chosen.

A high pressure is used as equilibrium position in $N_2(g) + 3H_2(g) = 2NH_3(g)$ shifts to the right to reduce number of gas molecules, resulting in high equilibrium yield of NH_3 which is achieved at a faster rate.

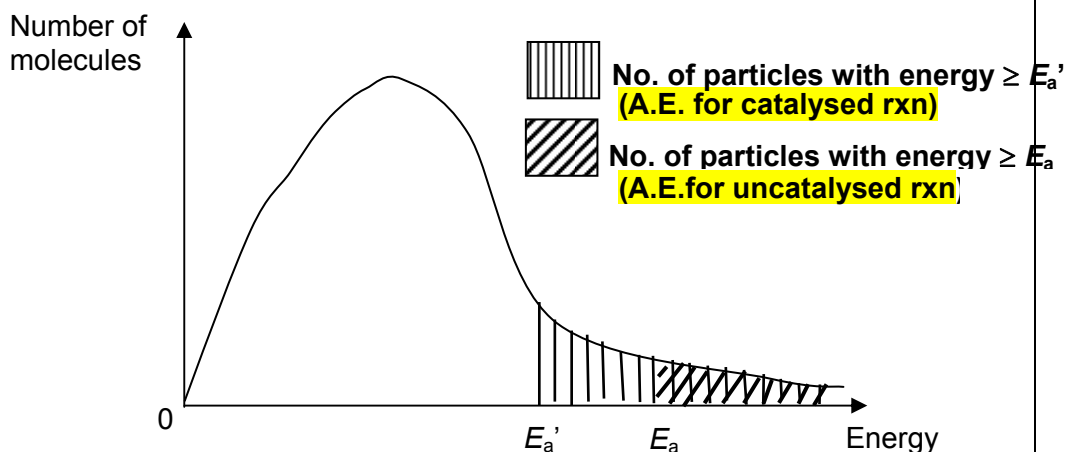
Pressure which is too high is not used because it would require a higher cost.

- 2 (b) (iii) With the aid of the Boltzmann distribution curve, explain how the presence of a catalyst affects the rate of this process.

A catalyst provides an alternative reaction path of lower activation energy.

[7]

For
Examiner's
Use



Thus, the number of molecules with energy \geq lowered activation energy/ E_a' , increases. Therefore, the frequency of effective collisions between molecules increases and hence, the reaction rate increases.

- (c) Nitrogen is one of the Period 2 elements and it forms the nitride ion, N^{3-} . State and explain how you would expect the radius of the following ions to compare with the radius of nitride ion.

- fluoride ion, F^-
- lithium ion, Li^+

Both N^{3-} and F^- are isoelectronic and have similar shielding effect by inner shell electrons, but F^- has a greater nuclear charge than N^{3-} . Hence F^- has a smaller radius than N^{3-} .

Li^+ has one less quantum shell of electrons compared to N^{3-} . Hence shielding effect by inner shell electrons is lesser for Li^+ . Hence Li^+ has a smaller radius than N^{3-} .

[2]

[Total: 11]

- 3 Halogenoalkanes are used widely in the industry to produce organic compounds commercially. Halogenoalkanes can also undergo hydrolysis with sodium hydroxide to produce alcohol commercially.

- (a) Using monohalogenohexanes, $C_6H_{13}X$, as an example, describe and explain the relative reactivity of chloro and iodo-compounds towards aqueous sodium hydroxide.

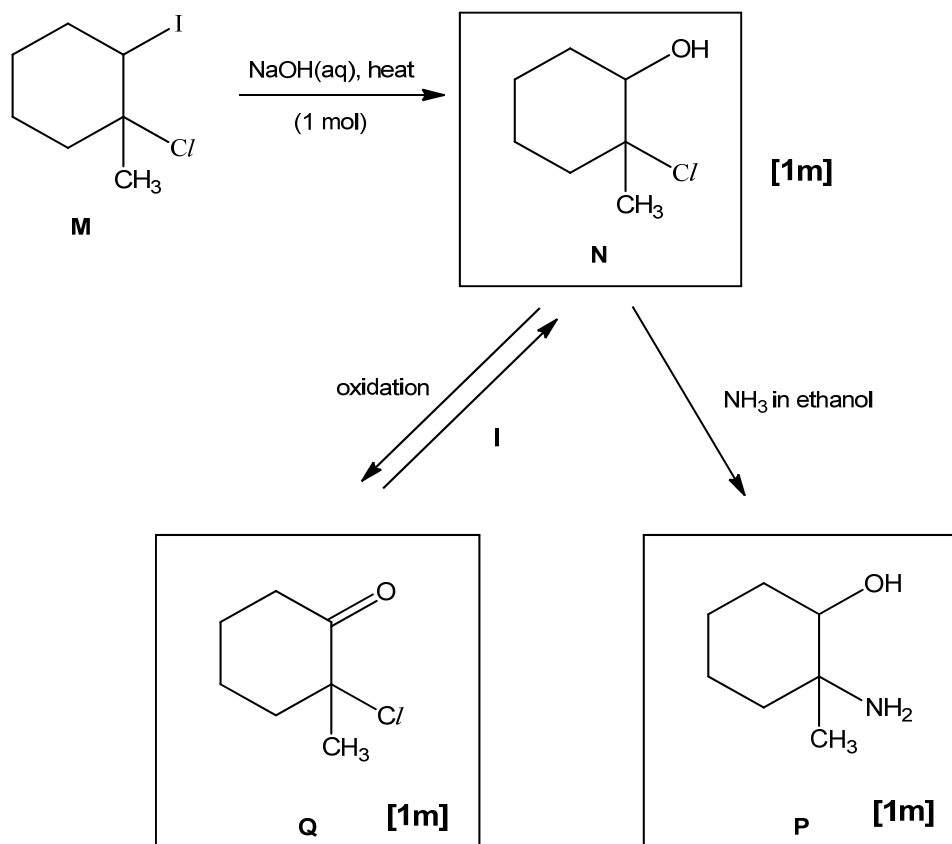
Iodo-compounds are more reactive towards $NaOH(aq)$.

The bond energy of C–I is lower / C–I bond weaker than C–Cl. C–I bond is more easily broken.

[2]

For
Examiner's
Use

- (b) (i) A sequence of reactions, starting from compound **M**, a dihalogeno compound, is shown below.



In the appropriate boxes draw the structures of compounds **N**, **P** and **Q**.

- 3 (b) (ii) For the reactions in the scheme shown above suggest

- the reagents and conditions for reaction **I**,

LiAlH_4 in dry ether or H_2 Ni, heat or NaBH_4

Reject if 'heat' is given for LiAlH_4 in dry ether

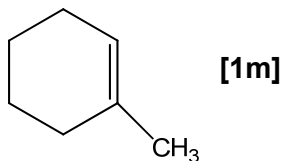
- the type of reaction in reaction **I**,

For
Examiner's
Use

reduction

[5]

- (c) Draw the structure of a suitable alkene needed to form compound **M** in (b)(i).



[1]

[Total: 8]

- 4 Dental hygiene is big business; sales of teeth-whitening products are soaring. There are two ways that teeth may become discoloured. The antibiotic tetracycline, excess fluoride, or trauma can darken or reveal the yellow inner tooth. Coffee, tea or smoking attacks the outer surface. Common whitening methods target only outer stains.

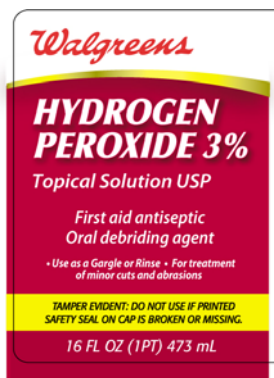
The yellow layer beneath the white enamel protects your teeth as you chew. Enamel, the hardest substance in your body, is composed primarily of calcium phosphate. When spaces between the **rods** fill with organic material, the stain become too deep to brush away.

For
Examiner's
Use

All teeth-whitening options, except natural method, use hydrogen peroxide (H_2O_2) as the oxidising agent. Carbamide peroxide is used as the H_2O_2 source in many products. The molecule decomposes in water yielding H_2O_2 as indicated in the equation below.



H_2O_2 reacts rapidly with the electron-rich molecules that discolour the teeth. The stain molecules are broken into smaller molecules with lighter colour, so the teeth appear whiter. The whiteness of the teeth and the time required depend upon the concentration of the solution.



According to the American Dental Association, bleaching with 3% hydrogen peroxide is considered safe and effective. Bleaching may initiate temporary sensitivity or gum irritation, and the stronger concentrations may cause damage, but they generally contain fluoride to protect the enamel.

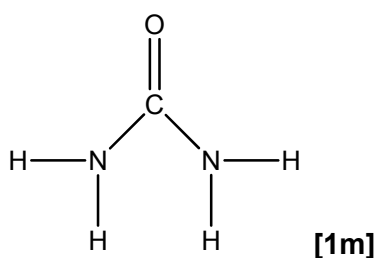
- (a) Carbamide peroxide contains 12.6% carbon, 6.4% hydrogen, 29.0% nitrogen and 52.0% oxygen by mass. Calculate the empirical formula of carbamide peroxide.

	C	H	N	O
% by mass	12.6	6.4	29.0	52.0
amount/mol	12.6/12 =1.05	6.4/1 = 6.4	29.0/14 = 2.07	52.0/16 =3.25
Mole ratio	1.05/1.05=1	6.095	1.97	3.09
Simplest ratio	1	6	2	3

Empirical formula is $\text{CH}_6\text{N}_2\text{O}_3$

[2]

- 4 (b) Using your answer to part (a), the information given above and that the oxygen atom is only bonded to the carbon atom, deduce the structural formula of urea and draw its displayed formula.



[1]

For
Examiner's
Use

- (c) Calculate the amount of hydrogen peroxide that is present in one bottle of 16 FL OZ (473 ml) of $0.100 \text{ mol dm}^{-3}$ hydrogen peroxide (3%) topical solution.

$$\text{Amount of H}_2\text{O}_2 = 0.100 \times 0.473 \times 0.03$$

$$= \underline{1.42 \times 10^{-3} \text{ mol}}$$

[2]

- (d) Hence, calculate the mass of carbamide peroxide powder required to prepare the hydrogen peroxide topical solution.

$$\text{Amount of carbamide peroxide} = 1.42 \times 10^{-3} \text{ mol}$$

$$\text{Mass of carbamide peroxide} = 1.42 \times 10^{-3} \times (94)$$

$$= \underline{0.133 \text{ g}}$$

[1]

- (e) A cheaper alternative to whiten teeth without spending tons of money on expensive products or treatments is to make use of one of the common household products, baking powder. Baking powder, which contains sodium hydrogencarbonate, NaHCO_3 , is a mild abrasive which effectively removes stains from the teeth.

- (i) Identify the anion present in sodium hydrogencarbonate.



- (ii) How many electrons are present in the anion? 32

- (iii) Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water. Write a balanced equation for this reaction.



[3]

[Total: 9]

2015 H1 Chemistry Preliminary Exam Paper 2 Section B
Suggested Mark scheme

5 (a) (i)



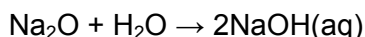
1m for each correct diagram

- (ii) Na_2O has a giant ionic structure whereas SO_2 has a simple covalent/molecular structure.

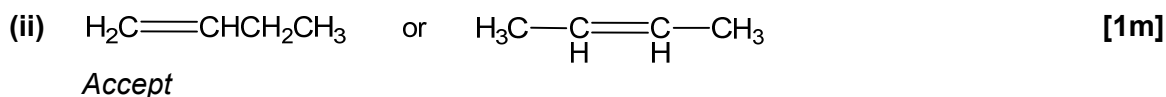
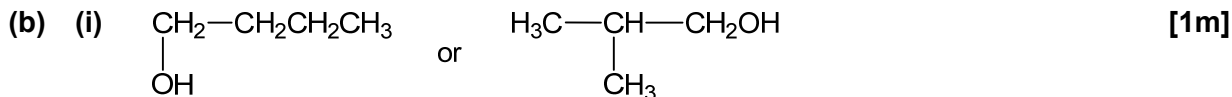
More energy is required to overcome stronger electrostatic forces of attraction /stronger ionic bond between oppositely charged / Na^+ and O^{2-} ions than (weaker) permanent dipole–(permanent) dipole attractions between SO_2 molecules.

Hence, Na_2O has a higher melting point (than SO_2) / SO_2 has a lower melting point (than Na_2O).

- (iii) When Na_2O is added to a solution of universal indicator, the colour will turn to blue/violet as Na_2O dissolves in water to form a strongly alkaline solution.



When Al_2O_3 is added to universal indicator solution, the colour remains green as Al_2O_3 is insoluble in water.



- (iii) **Reagent & conditions:**

Add acidified KMnO_4 or acidified $\text{K}_2\text{Cr}_2\text{O}_7$ and heat/warm.

Or Add $\text{I}_2(\text{aq})$, $\text{NaOH}(\text{aq})$ or alkaline aqueous iodine and heat/warm.

Observation:

A will decolourise purple KMnO_4 while **B** does not (solution remains purple)

or

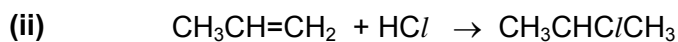
A will turn orange $\text{K}_2\text{Cr}_2\text{O}_7$ solution green while **B** does not (solution remains orange)

or

A gives yellow ppt/crystals while **B** does not (no ppt)

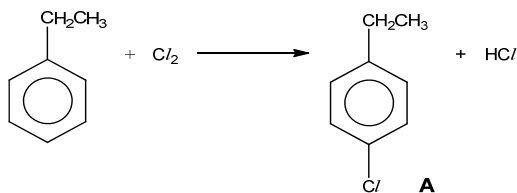
5 (c) (i) Type of reaction: Substitution

Reagent: PCl_5 / PCl_3 / SOCl_2 / conc. HCl



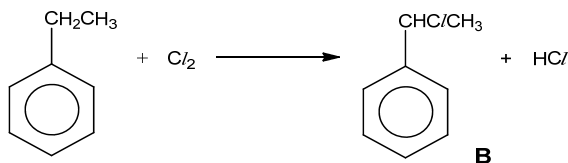
$$\begin{aligned}\Delta H_r &= [\text{BE}(\text{C}=\text{C}) + \text{BE}(\text{H}-\text{Cl})] - [\text{BE}(\text{C}-\text{C}) + \text{BE}(\text{C}-\text{H}) + \text{BE}(\text{C}-\text{Cl})] \\ &= (610 + 431) - (350 + 410 + 340) \\ &= 1041 - 1100 \\ &= \underline{\underline{-59.0 \text{ kJ mol}^{-1}}}\end{aligned}$$

(d) (i)



Cl_2 and anhydrous FeCl_3 or AlCl_3 or Fe catalyst

Reject aqueous Cl_2 / FeCl_3



Limited Cl_2 and UV light

(accept further substitution)

(ii) Test:

Heat each compound with $\text{NaOH}(\text{aq})$, cool and acidify with $\text{HNO}_3(\text{aq})$ followed by adding $\text{AgNO}_3(\text{aq})$.

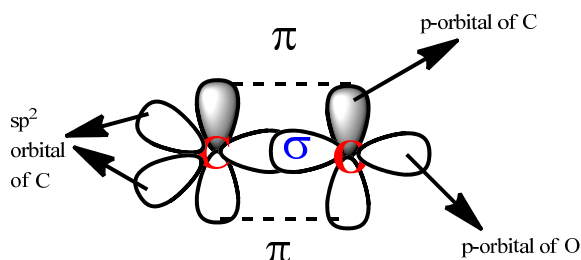
Accept: Heat with aqueous $\text{AgNO}_3(\text{aq})$

Observation:

Product from FRS reaction/side-chain reaction / **B** forms a white ppt, whereas no ppt is observed for product from ES reaction / **A**.

- 6 (a) The sp^2 (hybrid) orbital of C overlaps head on with the p-orbital of O to form a sigma bond

The (unhybridised) p-orbital of C overlaps side on with the p-orbital of O to form a pi bond (accept sideways overlap)



- (b) (i) Comparing expt (1) and (4):

When $[H^+]$ is halved/doubled, $[(CH_3)_2CO]$ and $[CN^-]$ kept constant, rate of reaction remains the same.

Thus, **order of reaction wrt $[H^+]$ is 0.**

Comparing expt (1) and (3):

when $[CN^-]$ increase 1.2 times ($\frac{6}{5}$), $[(CH_3)_2CO]$ and $[H^+]$ kept constant, rate of reaction also increased by 1.2 times.

Thus, **order of reaction wrt $[CN^-]$ is 1.**

Comparing expt (1) and expt (2):

Let order with respect to $[(CH_3)_2CO]$ be x

$$\frac{rate_{expt1}}{rate_{expt2}} = \frac{1.000}{0.375} = 2.67 = \frac{k(0.020)^x(0.060)}{k(0.015)^x(0.030)}$$

$$x = 1$$

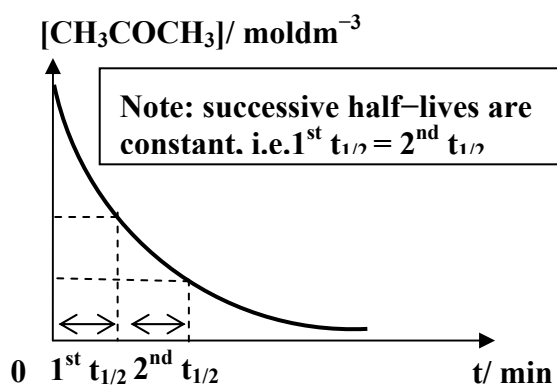
Thus, **order of reaction wrt $[(CH_3)_2CO]$ is 1**

$$\text{Rate} = k[CN^-][(CH_3)_2CO]$$

Reject: rate equation = $k[CN^-][(CH_3)_2CO]$

- (ii) Using expt 1; $k = \frac{1}{0.02 \times 0.06} = 833.3 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$

(iii)

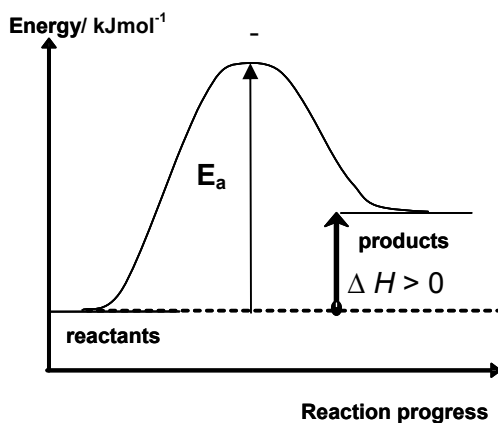


6 (b) (iv)



- (c) (i) More easily transported/easier storage since methanol is a liquid.
 Or methanol is cheaper as it is a liquid so easier to transport/store.
 Or hydrogen gas is a potentially explosive gas while methanol is not/relatively safer. [1m]

(ii)



(iii) $K_c = [\text{CH}_3\text{OH}]/[\text{H}_2]^2[\text{CO}]$

Unit: $\text{mol}^{-2} \text{dm}^6$

(iv)	CO(g)	+	$2 \text{H}_2(\text{g})$	\rightleftharpoons	$\text{CH}_3\text{OH(g)}$
Initial amt/ mol	1.00		2.00		0
Change	- 0.80		-1.60		+0.80
Eqm amt/ mol	0.20		0.40		0.80

$$K_c = (0.8/1.5)/(0.2/1.5)(0.4/1.5)^2$$
$$= \underline{56.3}$$

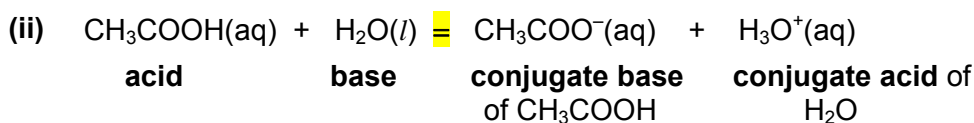
(v) Exothermic

From the graph, as temperature increases, the percentage of product at equilibrium decreases.

By Le Chatelier's principle, POE shift to the left to (partially) remove/absorb some of the added/excess heat to favour the endothermic reaction

Thus forward reaction is exothermic.

- 7 (a) (i) A Bronsted acid is a **proton donor** (or **H⁺ donor**) while a Bronsted base is a **proton acceptor** (or **H⁺ acceptor**).



state symbol not req'd

$$\text{pH} = -\lg[\text{H}^+]$$

In ethanoic acid solution of pH 4.0,
 $[\text{H}^+] = 10^{-4} = \underline{1.00 \times 10^{-4} \text{ mol dm}^{-3}}$

In $0.20 \text{ mol dm}^{-3} \text{H}_2\text{SO}_4$:
 $\text{H}_2\text{SO}_4(\text{aq}) \rightarrow 2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

$$[\text{H}^+] = 2 \times [\text{H}_2\text{SO}_4] = 2 \times 0.20 = 0.40 \text{ mol dm}^{-3}$$

$$\Rightarrow \text{pH} = -\lg(0.40) = \underline{0.398}$$

In $0.050 \text{ mol dm}^{-3}$ barium hydroxide, $\text{Ba}(\text{OH})_2$
 Since $\text{Ba}(\text{OH})_2 \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$

$$[\text{OH}^-] = (2 \times 0.050) = 0.10 \text{ mol dm}^{-3}$$

$$\text{pOH} = 10^{-1} = 1$$

$$\text{pH} = 14 - \text{pOH} = \underline{13} \quad [1\text{m}]$$

- (b) (i) Nucleophilic Addition

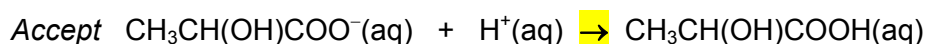
- (ii) Reagents & conditions

Step I : HCN , trace amount of NaCN or NaOH

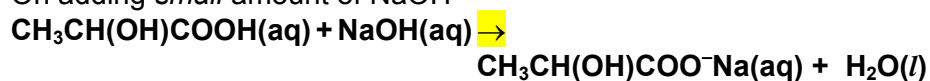
Step II : $\text{H}_2\text{SO}_4(\text{aq})/\text{HCl}(\text{aq})$ and heat (under reflux)

- (c) (i) A buffer solution is a solution which **resists changes in pH** when **small amounts of acid or base is added to it**.

On adding *small* amount of HCl



On adding *small* amount of NaOH



Accept



- 7 (c) (ii) As this is a weak acid-strong base titration where the pH at equivalence point is > 7, phenolphthalein is a suitable indicator.

or

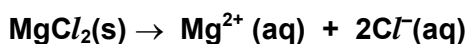
Phenolphthalein working range (8.2 to 10.0) falls within the vertical part of the pH/titration curve or coincide with the pH change at the equivalence point.

Colour change at the end point: Colourless to (pale) Pink

Accept colour just turned from colourless to red on addition of one drop of excess NaOH.

- (d) MgCl₂(s) dissolves in water to form aqueous Mg²⁺ and Cl⁻ ions.

The resulting solution is neutral and pH 7



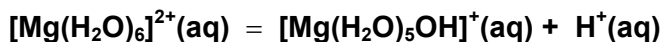
Or

MgCl₂(s) dissolves in water to form aqueous [Mg(H₂O)₆]²⁺ and Cl⁻ ions.



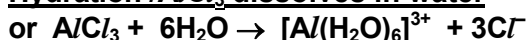
Due to the **higher charge** density of Mg²⁺ (compared to Na⁺),

[Mg(H₂O)₆]²⁺ undergo slight hydrolysis in water to give a slightly acidic solution with pH ~ 6.5



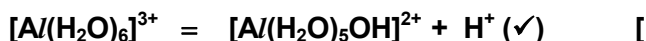
When a large amount of water is added to AlCl₃, both hydration and hydrolysis occur:

Hydration / AlCl₃ dissolves in water

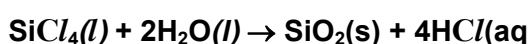


Hydrolysis of [Al(H₂O)₆]³⁺ forms an acidic solution with pH = 3-4

(due to very high charge density on Al³⁺, it draws electrons away from its surrounding water molecules and weakens the O-H bond and enable water molecule to donate H⁺ ion)



SiCl₄(l) undergo complete hydrolysis in water to form an acidic solution with pH 1-2



[Total: 20]

