NAME _____ CLASS **21S**

JURONG PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2022

CHEMISTRY **9729/02**

Higher 2

Paper 2 Structured Questions

14 September 2022
2 hours

Candidates answer on the Question Paper.

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

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
A *Data Booklet* is provided.
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	**/ 10**
2	**/ 10**
3	**/ 17**
4	**/ 10**
5	**/ 11**
6	**/ 12**
7	**/ 5**
Penalty (delete accordingly)	
Bond linkages	**–1 / NA**
Significant figures & units	**–1 / NA**
Total	**/ 75**

This document consists of **20** printed pages.

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

For Examiner's Use

1 **(a)** Figure 1.1 shows the **third** ionisation energies of eight consecutive elements **A** to **H,** in the Periodic Table.
[Note that letters **A** to **H** are not the atomic symbols of the elements concerned.]

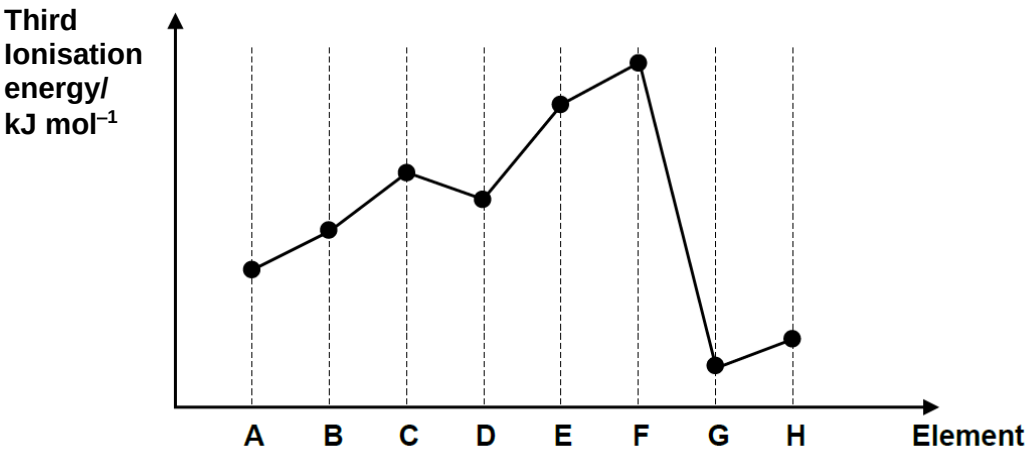


Figure 1.1

(i) Write an equation, including state symbols, to represent the *third ionisation energy* of element **A**. [1]

$A^{2+}(g) \longrightarrow A^{3+}(g) + e^-$

(ii) From Figure 1.1, suggest the identity of **B**. Explain how you arrived at your answer. [2]

The large decrease in 3rd IE from F to G implies that G^{2+} has 1 more quantum shell of electrons than F^{2+} / 3rd electron to be removed from F is from the inner quantum shell.

The valence shell configuration of G^{2+} is ns^1 and hence, the valence shell configuration of G is $ns^2\ np^1$ (*i.e.* Al).
OR
This also implies that the valence shell configuration of B^{2+} is $(n-1)s^2\ np^2$ and hence, the valence shell configuration of B is $ns^2\ np^4$.

OR
F is in group 2 / G is in group 13

Hence, B is oxygen.
Cannot accept sulfur.

(iii) Explain why the third ionisation energy of element **D** is slightly lower than that of element **C**. [1]

C^{2+}: $1s^2 2s^2 2p^3$ D^{2+}: $1s^2 2s^2 2p^4$

The inter–electronic repulsion / repulsion between the paired 2p electrons in D^{2+} makes it easier to remove a paired electron than an unpaired 2p electron of C^{2+} which do not experience such repulsion.

Hence, the 3rd IE of D is lower than that of element C.

(b) Nitrogen and phosphorus are elements of Group 15 in the Periodic Table.
Nitrogen exists naturally as gaseous diatomic N≡N molecules whereas phosphorus is a solid and exists as P_4 molecules comprising of P-P single bonds.

(i) Account for the difference in their physical states in terms of structure and bonding. [2]

Both N_2 and P_4 have simple molecular structures.

As P_4 has larger number of electrons/ bigger electron cloud to be polarised, more energy is required to overcome the stronger instantaneous dipole-induced dipole interactions/attractions between the P_4 molecules.

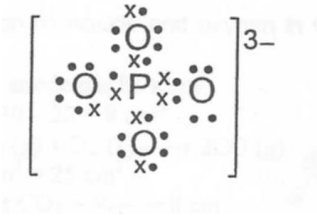
This results in higher melting point in P_4, hence P_4 exists as solid.

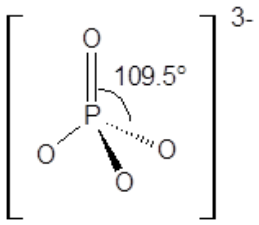
(ii) Suggest why phosphorus does **not** occur naturally as P≡P molecules. [1]

Phosphorus is a relatively big atom with diffused orbitals, side-on overlap of its p orbitals to form π bonds is much less effective than head-on overlap to form sigma bond.

(iii) Nitrate, NO_3^-, and phosphate, PO_4^{3-}, are oxoanions of nitrogen and phosphorus respectively. [3]

Draw a dot-and-cross diagram to show the bonding PO_4^{3-}, deducing the shape and the bond angle around the phosphorous atom. Hence explain why it is not possible for nitrogen to form an oxoanion with formula of NO_4^{3-}.





4 bond pairs around central atom P
Shape of PO_4^{3-} is tetrahedral, angle O—P—O: 109.5°

To form NO_4^{3-}, N must be able to accommodate 10 electrons in its valence shell. Since N is in Period 2, it has no energetically accessible/low lying d orbital to expand its octet.

[Total: 10]

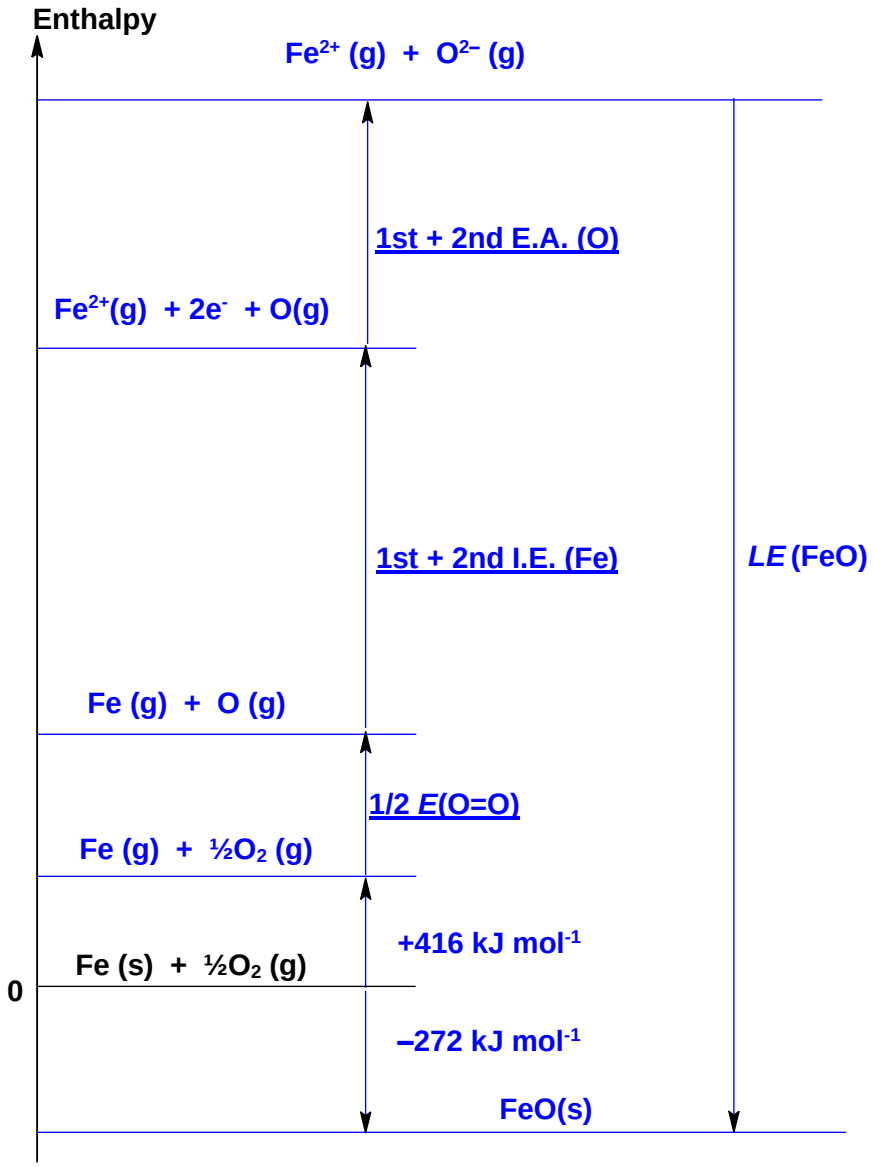
2 Iron oxides are chemical compounds composed of iron and oxygen. Most iron ores are oxides, making them important precursors to iron metal and its many alloys.

(a) Iron (II) compounds are generally only stable in neutral, non-oxidising conditions. It is difficult to determine the lattice energy of FeO experimentally.

(i) Given the following data in Table 2.1 and data from the *Data Booklet*, use the energy diagram below to calculate the lattice energy of FeO(s) in kJ mol^{-1}. [3]

standard enthalpy change of atomisation of Fe(s)	+416 kJ mol^{-1}
standard enthalpy change of formation of FeO(s)	–272 kJ mol^{-1}
Sum of 1st and 2nd Electron Affinity of oxygen	+157 kJ mol^{-1}

Table 2.1



By Hess Law,

$-272 = +416 + ½ (496) + 762 + 1560 + 157 + LE\,(FeO)$

$LE\,(FeO) = -3415$ (or -3420) kJ mol^{-1}

(ii) Most naturally occurring samples of iron(II) oxides are found as the mineral Wüstite. [1]

Wüstite has the formula $Fe_{20}O_x$. It contains both Fe^{2+} and Fe^{3+} ions. 90% of the iron is present as Fe^{2+} and the remaining as Fe^{3+}.

Deduce the value of x.

Balancing of charges:

$20 \times \left[0.9(+2) + 0.1(+3)\right] - 2x = 0$

Solving x = 21

(iii) State and explain how the lattice energies of FeO compares with the lattice energies of Fe_2O_3. [2]

Fe^{3+} ion has a higher (ionic) charge and smaller radius/size than Fe^{2+} ion.

Since $|\mathbf{LE}| \propto \left|\frac{q_+ \times q_-}{r_+ + r_-}\right|$, hence, the magnitude of LE for Fe_2O_3 is larger / LE for Fe_2O_3 is more exothermic than that in FeO.

(b) Another common iron oxide as hematite, Fe_2O_3 is the main source of iron for the steel industry. Fe_2O_3 will readily react with acids to form soluble salts such as the following reaction.

$$Fe_2O_3(s) + 6HI(aq) \rightarrow 2FeI_2(aq) + I_2(aq) + 3H_2O(l)$$

(i) Define standard enthalpy change of solution. [1]

It is the heat *change* when *1 mole of a substance is completely dissolved in water* under the standard conditions of 298 K and 1 bar so that there is no further heat change upon adding more water.

(ii) Use the data in Table 2.2 to calculate the enthalpy change of solution of iron (II) iodide, FeI_2. [1]

ΔH_{latt} (FeI_2(s))	– 2440 kJ mol^{-1}
ΔH_{hyd} (Fe^{2+} (g))	– 1950 kJ mol^{-1}
ΔH_{hyd} (I^- (g))	– 308 kJ mol^{-1}

Table 2.2

ΔH_{soln} = –(–2440) + (–1950) + (2(–308))
= – 126 kJ mol^{-1}

(iii) A yellow precipitate of PbI_2 forms when 25 cm^3 of x mol dm^{-3} Pb^{2+} ions are added to 10 cm^3 of 0.100 moldm^{-3} FeI_2 (aq). [2]

Given that the solubility product, K_{sp}, of PbI_2 = 9.8 x 10^{-9} mol^3 dm^{-9}, find the minimium value for x, concentration of Pb^{2+}.

For ppt to occur,

Ionic product > K_{sp} $[Pb^{2+}]$ $[I^-]^2$

$[Pb^{2+}]$ $[I^-]^2 > 9.8 \times 10^{-9}$

$$\left(\frac{\frac{25}{1000}\times x}{\frac{35}{1000}}\right)\left(\frac{2\times\frac{10}{1000}\times 0.100}{\frac{35}{1000}}\right)^2 > 9.8 \times 10^{-9}$$

(diluted conc to be given mark)

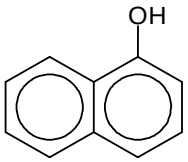
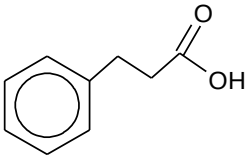
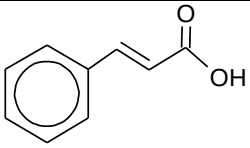
$x > 4.20 \times 10^{-6}$ mol dm^{-3}

[Total: 10]

3 Carboxylic acids and their derivatives are classes of organic compounds that play important roles in our everyday lives. Some of their uses include the manufacturing of polymers, production of pharmaceutical drugs, as food additives and industrial solvents.

This question deals with some of the properties of acidic organic compounds, including carboxylic acids and their derivatives.

(a) The table below shows three organic compounds that can be found in nature.

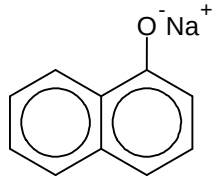
Name	**1-naphthol**	**hydrocinnamic acid**	**cinnamic acid**
Where it can be found	*selaginella sinensis* tree	cowberries	cinnamon
Structural Formula			
pK_a	9.51	4.70	4.37

(i) By reference to the structures, explain why cinnamic acid will be the first to react when aqueous potassium hydroxide is added dropwise to a mixture containing both cinnamic acid and hydrocinnamic acid. [2]

Cinnamic acid is a stronger acid than hydrocinnamic acid, as can be seen from its lower pK_a value.

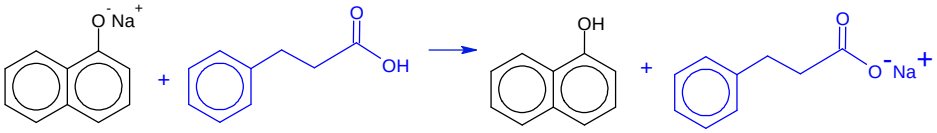
There is overlap between the p orbital of O atom of the anion of cinnamic acid and the p orbitals of the –C=O, C=C, benzene, and -OH groups. This allows the negative charge on the O of the anion of cinnamic acid to be delocalised/dispersed. This stabilises the anion and hence is it a stronger acid.

(ii) With the aid of balanced equation(s), explain any reaction(s) that occurs when a solution containing sodium 1-naphtholate is added to a solution containing hydrocinnamic acid.



sodium 1-naphtholate

Hydrocinnamic acid is a stronger acid (lower pK_a) than 1-naphthol. It will dissociate in water to protonate/donate its H^+ to the 1-naphtholate ion to form back 1-naphthol.



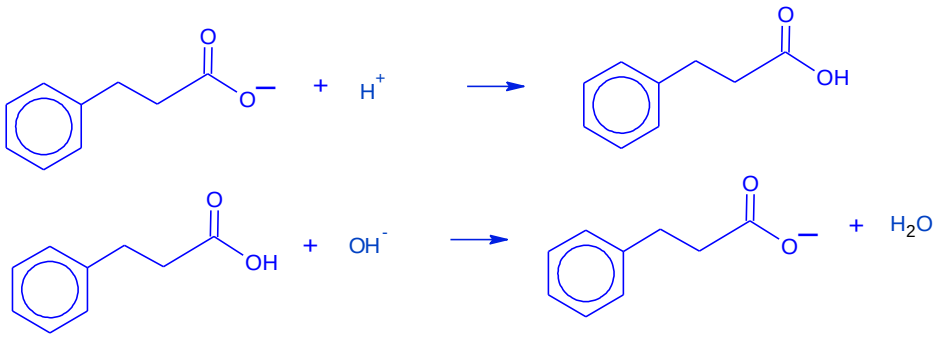
[2]

A laboratory technician was tasked to prepare a buffer solution made up of hydrocinnamic acid and aqueous potassium hydroxide.

(iii) What is a buffer solution? [1]

A buffer solution is made up of a weak acid/weak base and its conjugate acid / base OR salt , and it is able to resist changes in pH when a small amount of acid/base is added to it, or upon dilution.

(iv) Write equations to show how a mixture of hydrocinnamic acid and its salt can function as a buffer. [2]



(v) Using appropriate data from the table in **(a)**, determine the volume of 0.100 mol dm^{-3} KOH(aq) the student needs to add to 0.100 dm^3 of 0.100 mol dm^{-3} hydrocinnamic acid to form a buffer of pH 5.50. [2]

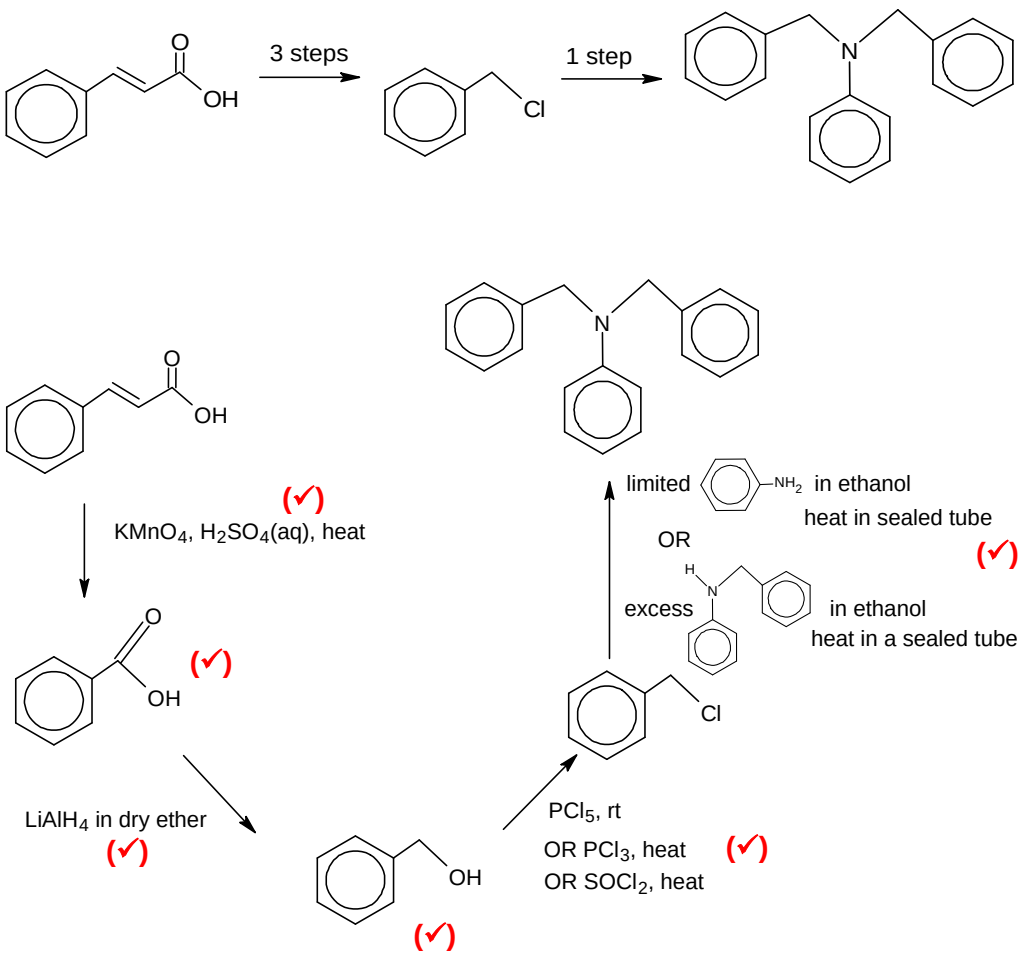
Let HA be hydrocinnamic acid.
Let the volume of KOH(aq) to be added be v dm^3.

To form a buffer, you need to add limited KOH, so that the final mixture will contain HA and KA.

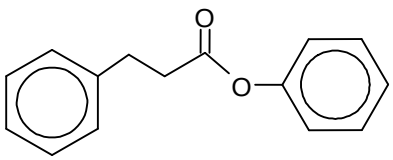
	HA	+	KOH	→	KA	+	H_2O
i / mol	0.01		0.1v		0		-
c / mol	-0.1v		-0.1v		+0.1v		-
f / mol	0.01-0.1v		0		0.1v		-

Acidic buffer:
$pH = pK_a + lg([KA] / [HA])$
$5.50 = 4.70 + lg[(0.1v / (0.1+v)) / (0.01-0.1v / (0.1+v))]$
$5.50 – 4.70 = 0.8 = lg[0.1v / (0.01-0.1v)$
$0.1v = 0.063096 – 0.63096v$
$v = 0.08632\ dm^3 = 86.3\ cm^3$

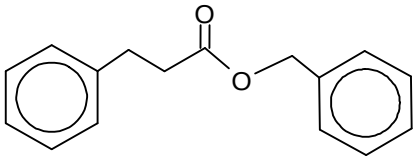
(b) The diagram below shows a reaction scheme involving cinnamic acid. [3]
Suggest a possible synthetic pathway involving 4 steps, stating clearly the reagents and conditions required, and the intermediate organic compounds formed for every step.



(c) Hydrocinnamic acid form many different types of esters that have great commercial uses. Two such esters are shown below:



ester P



ester Q

(i) Suggest a simple chemical test that would enable the laboratory technician to distinguish between the two esters. [2]

Test 1:
Reagents and conditions: 1) H_2SO_4(aq) or HCl(aq), heat
2) Br_2(aq)
Observations: Orange Br_2(aq) decolourises, and a white ppt forms for P but not for Q.
Test 2: Reagents and conditions: $K_2Cr_2O_7$, H_2SO_4(aq), heat
Observations: Orange $K_2Cr_2O_7$ turns green for Q but not for P.

(ii) State the type of reaction that occurred when hydrocinnamic acid forms these esters. [1]

Nucleophilic Acyl Substitution OR Condensation

(d) Describe and explain the trend observed in the thermal stability of the carbonates of the Group 2 elements.

$MCO_3 \rightarrow MO + CO_2$ Let M^{2+} represent the Group 2 cation.

Down the group, the radius/size of M^{2+} increases and

- hence, the charge density of M^{2+} decreases .
- Thus, the ability of M^{2+} to polarise the large carbonate ion decreases and
- the C–O bond is weakened to decreasing extent.
- Therefore, the thermal stability of MCO_3 increases down the group.

[Total: 17]

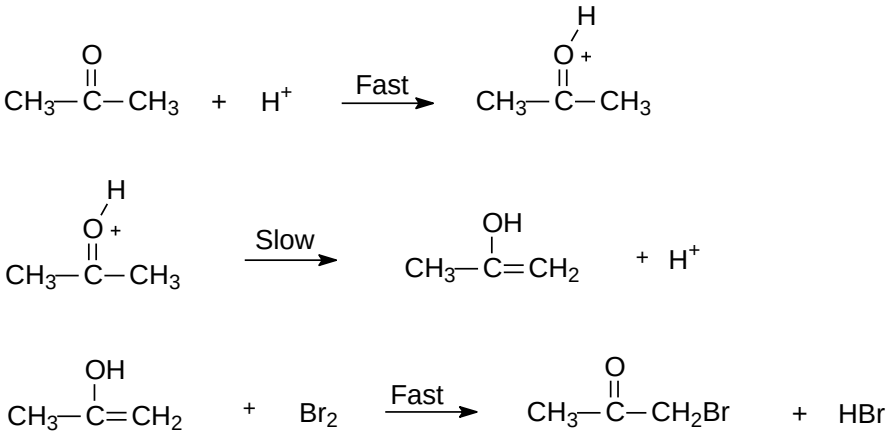
For Examiner's Use

4 Carbonyl compounds can react with halogens in acidic or alkaline medium to form different products. Kinetic studies are conducted to investigate the orders of reaction and the mechanisms of these reactions.

In acidic medium, propanone reacts with bromine to form bromopropanone as shown in the equation below:

$$CH_3COCH_3 + Br_2 \xrightarrow{H^+} CH_3COCH_2Br + HBr$$

The kinetic studies of the above reaction suggest that a three-step mechanism is involved in this reaction.



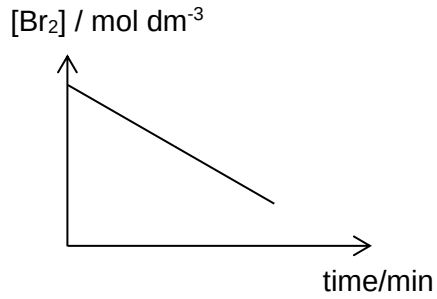
(a) Based on the mechanism above, construct the rate equation for the above reaction. [1]

Rate = k $[CH_3COCH_3]$ $[H^+]$

(b) From the mechanism of the reaction, how can you deduce that H^+ is acting as a catalyst? [1]

H^+ is consumed/reacted in step 1 but is regenerated in step 2.

(c) Sketch, in the space below, the graph of $[Br_2]$ against time in minutes, given that the initial concentration of bromine is 0.008 mol dm^{-3} and the initial concentration of propanone is 0.80 mol dm^{-3}. [1]



Rate = k $[CH_3COCH_3]$ $[H^+]$ $[Br_2]^0$

Given: $[Br_2]$ = 0.008 mol dm^{-3} and $[CH_3COCH_3]$ = 0.80 mol dm^{-3}

Since CH_3COCH_3 is used in large excess, its conc. remains effectively constant as only a small fraction of CH_3COCH_3 reacted during the reaction.

Since H^+ is a catalyst, its conc. remains constant throughout the reaction.

$\therefore$ the rate equation can be simplified as

rate = k' $[Br_2]^0$, where k' = k $[CH_3COCH_3][H^+]$ = constant

Hence the reaction is an overall zero order. Any change in $[Br_2]$ has no effect on the reaction rate. So the graph of $[Br_2]$ vs time graph is a straight line with a constant negative gradient.

(d) Explain what will happen to the rate of reaction if chlorine is used in place of bromine, assuming that the mechanism remains unchanged? [1]

There will be no change to the rate of reaction
as halogen is not involved in the rate determining/slow step
(or $[X_2]$ is not in the rate equation)
(or the reaction is zero order with respect to $[X_2]$)

(e) The kinetics data for the experiment may be collected using a continuous sampling method, which requires a sample of the chemical reaction to be extracted at various time intervals from a reaction mixture followed by titration. [1]

Briefly describe a physical property that you can use to determine the $[Br_2]$ at various times.

The colour intensity of the reaction solution can be measured at various time using a **colorimeter/spectrometer.

As the $[Br_2]$ decreases, the orange-brown colour intensity of the reaction solution decreases.

Hence, the absorbance measured a various time *t* is directly proportional to the $[Br_2]$ left at *t*.

(f) The reaction between propanone and bromine was carried out in experiments **1** and **2**, and the following results were obtained: [2]

Experiment	Initial $[(CH_3)_2CO]$/ mol dm^{-3}	Initial $[H^+]$ / mol dm^{-3}	Initial $[Br_2]$ / mol dm^{-3}	Half-life / min
1	0.40	0.30	0.20	22.5
2	0.60	0.10	0.20	S

The half-life of propanone in experiment **1** was found to be constant at about 22.5 minutes. Predict the half-life of propanone in experiment **2**, **s**, giving your reasoning.

rate = k $[H^+]$ [propanone], an overall second order reaction.

Since H^+ is a catalyst, $[H^+]$ remains constant throughout the reaction.

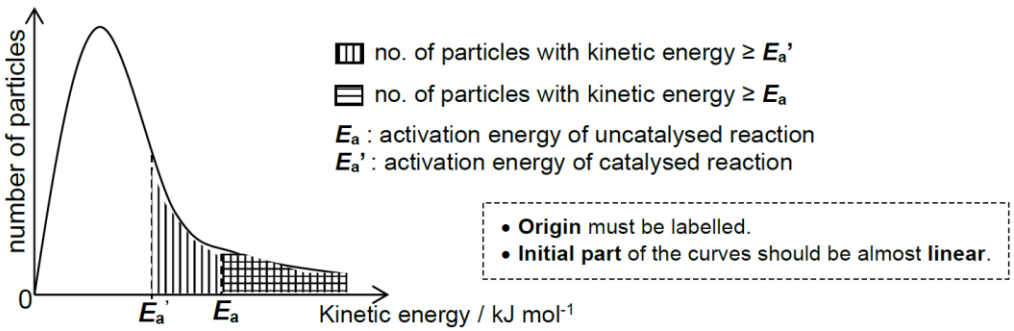
$\therefore$ rate = k' [propanone] where $k' = k$ $[H^+]$ = constant.

It is an overall pseudo first order reaction

and $\boldsymbol{t_{1/2} = \frac{\ln 2}{k'} = \frac{\ln 2}{k\,[H^+]}}$ or $\boldsymbol{t_{1/2} \propto \frac{1}{[H^+]}}$

Since $[H^+]$ decreases by a factor of 1/3 from expt 1 to expt 2, $t_{1/2}$ would increase by a factor of 3, from 22.5 min in expt 1 to 67.5 min in expt 2.

(g) With the aid of a labelled Boltzmann distribution diagram, explain how the presence of a catalyst affects the rate of a chemical reaction. [3]



- A catalyst provides an alternative reaction pathway/mechanism of lower activation energy (E_a') than that of the uncatalysed reaction.
- There is a greater proportion/number of particles of reactant molecules with kinetic energy ≥ E_a' (as indicated by the larger shaded area). Hence the frequency of effective collision between reactant particles increases and the rate of reaction increases.

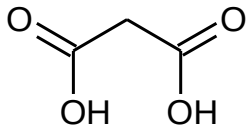
5 **(a)** Compound **P**, $C_5H_{10}O_2$ is optically active. It reacts with 2,4–dinitrophenylhydrazine to give an orange precipitate. However, **P** does not react with Tollens' reagent.

Upon reaction with sodium metal, **P** produces effervescence that extinguishes a lighted splint with pop sound. **P** forms gave a yellow precipitate when treated with alkaline aqueous iodine, and upon acidification, **Q**, $C_3H_4O_4$ is formed as the resulting compound.

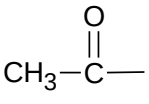
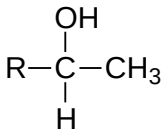
Q reacts with Na_2CO_3(aq) to produce effervescence that forms white precipitate with limewater.

(i) Suggest the structure of **Q**. [1]

Q:



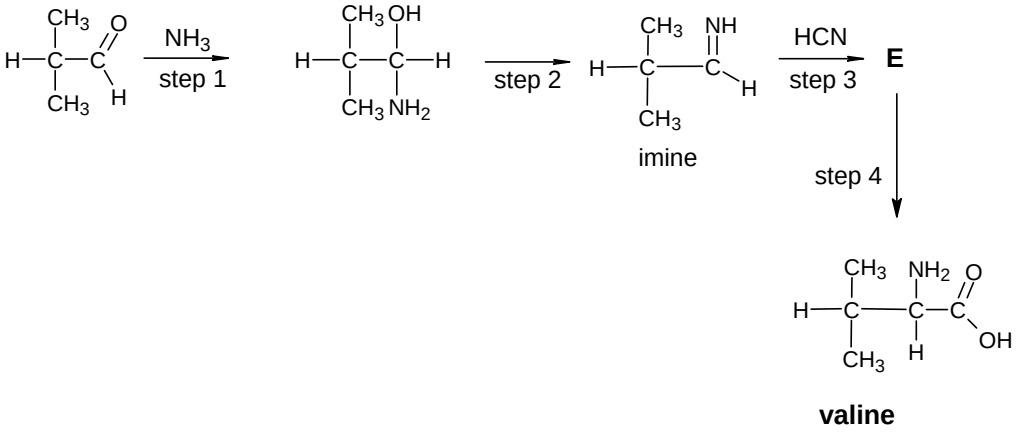
(ii) Suggest a structure of **P** that is consistent with the information provided, giving your reasoning. [3]

P, $C_5H_{10}O_2$ is optically active	P has at least 1 chiral carbon
P undergoes condensation with 2,4–dinitrophenylhydrazine.	➔ P contains aldehyde or ketone
P does not undergo oxidation with Tollens' reagent	P is not aldehyde OR (thus, P is ketone)
P undergoes redox reaction with Na	➔ P contains alcohol group (BOD: accept –OH group)
P undergoes oxidation with alkaline aqueous iodine	P contains either  Or 
Q undergoes acid base reaction with Na_2CO_3(aq)	Q contains carboxylic acid

Link to reagent must be clearly stated

P is $CH_3COCH_2CH(OH)CH_3$

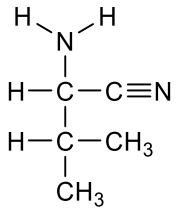
(b) The Strecker synthesis is a method to prepare ∝-amino acids. The amino acid valine can be prepared from 2-methylpropanal via Strecker synthesis as shown below.



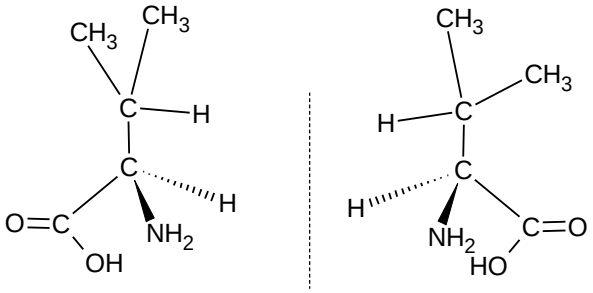
(i) Suggest the type of reaction occurring in step 2. [1]

Step 2: Elimination

(ii) Given that the reaction of the imine in step 3 with HCN is similar to the reaction of a carbonyl compound with HCN, suggest the structure of **E**. [1]

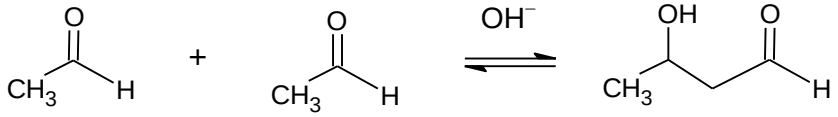


(iii) Valine can exist as a pair of stereoisomers. Draw the 2 stereoisomers of valine. [2]



(c) The aldol reaction is a useful method of making new carbon–carbon bonds in organic chemistry. It involves combining two molecules of the same aldehyde to form a product which contains both an aldehyde and alcohol functional groups. Thus, it is also known as the aldol reaction.

Ethanal undergoes base-catalysed aldol reaction as shown below.



3-hydroxybutanal

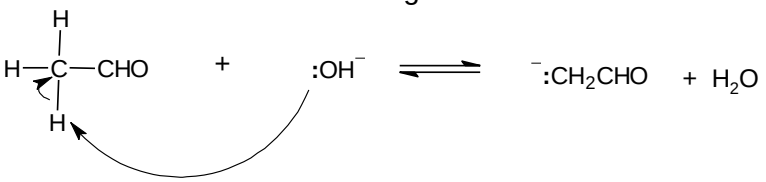
(an aldol)

The aldol synthesis involved the following reactions in two stages**:**

Stage 1**:**

An acid-base reaction takes place between the OH^- base and the acidic H atom bonded to alpha C of an ethanal molecule, forming a carbanion.

The first stage is drawn below.

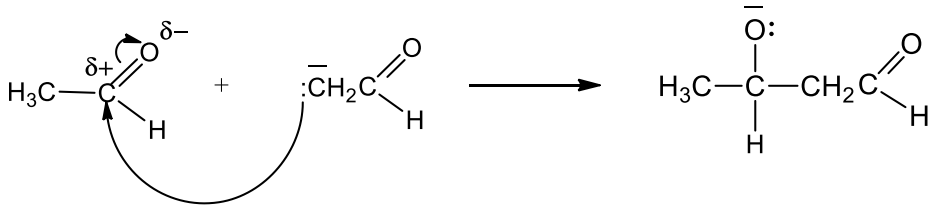


Stage 2:

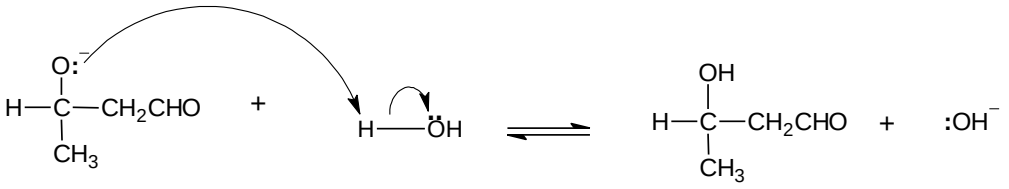
The carbanion formed in stage 1 attacks the delta positive carbon of another ethanal molecule, forming a tetrahedral intermediate which is negatively charged. The tetrahedral intermediate rapidly reacts with H_2O to form the aldol product and regenerates back the OH^- catalyst.

Name and outline the mechanism for stage 2.

Nucleophilic addition



step 3



[3]

[Total:11]

For Examiner's Use

6 **(a)** The value of the equilibrium constant is 4.0 for the reaction below:

$$CH_3CO_2H(l) + C_2H_5OH(l) \rightleftharpoons CH_3CO_2C_2H_5(l) + H_2O(l)$$

(i) Write an expression for the equilibrium constant, K_c, of the **reverse** reaction, i.e. the hydrolysis of ethyl ethanoate, stating its numerical value. [2]

$$K_c = \frac{[CH_3CO_2H][C_2H_5OH]}{[CH_3CO_2C_2H_5][H_20]} = \frac{1}{4} = 0.25$$

(ii) In an experiment, 2 mol of ethyl ethanoate and 2 mol of water are mixed.

Calculate the number of moles of each substance present when equilibrium is reached.

[2]

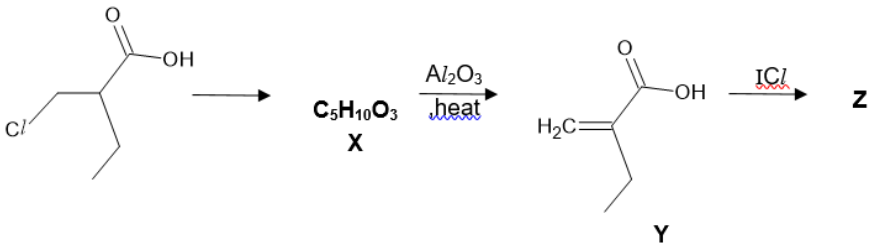
	CH_3CO_2H +	C_2H_5OH ⇌	$CH_3CO_2C_2H_5$ +	H_2O
Initial amount/mol	0	0	2	2
Change in amount/ mol	+*x*	+*x*	-*x*	-*x*
Equilibrium amount/ mol	*x*	*x*	2-*x*	2-*x*
Equilibrium conc /mol dm^{-3}.	*x*/v	*x*/v	*(2-x)*/v	*(2-x)*/v

$$K_c = \frac{(x / v)^2}{((2 - x) / v)^2} = 0.25$$

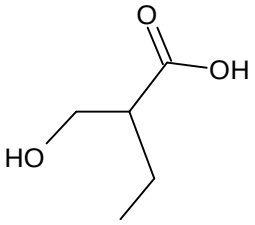
$\therefore x = 0.667$

Therefore, amount of acid = amount of alcohol = 0.667 mol
Amount of water = amount of ester = 1.33 mol

(b) The following shows a flow scheme involving a chloro-carboxylic acid to form compounds **X**,**Y** and **Z**.



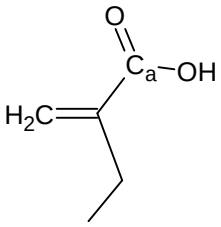
(i) Suggest the structure of compound **X**. [1]



(ii) Give the reagents and conditions for step 1. [1]

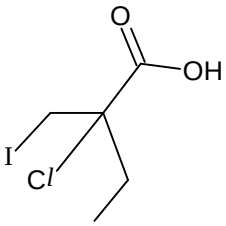
NaOH(aq), heat

(iii) State the hybridisation of C_a in the structure of **Y** below.

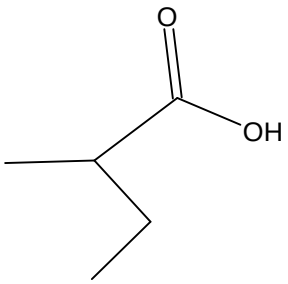


sp^2 hybridised

(iv) Give the structure of compound **Z**. [1]



(v) Give the structure of the product formed when compound Y is reacted with hydrogen with nickel, upon heating.



Only C=C is reduced by H_2, Ni, heat, -COOH is not reduced.

Aluminium objects that have had the aluminium oxide layer removed may then be oxidised.

(c) (i) State why aluminium objects are anodised. [1]

To increase the thickness of a protective corrosion–resistant Al_2O_3 layer on the surface of Al object**.**

(ii) Complete Table 6.1 below to show the type of reaction occurring, with the relevant half-equations, during the anodising of an aluminium object. [2]

	Type of reaction	**Half-equation(s)**
Anode	Oxidation	$2Al(s) + 3H_2O(l) \rightarrow Al_2O_3(s) + 6H^+(aq) + 6e^-$
Cathode	Reduction	$2H^+(aq) + 2e^- \rightarrow H_2(g)$

Table 6.1

[Total:12]

7 (a) Baryta water, barium hydroxide, $Ba(OH)_2(aq)$ is a Bronsted base. Define what is meant by a Bronsted base.

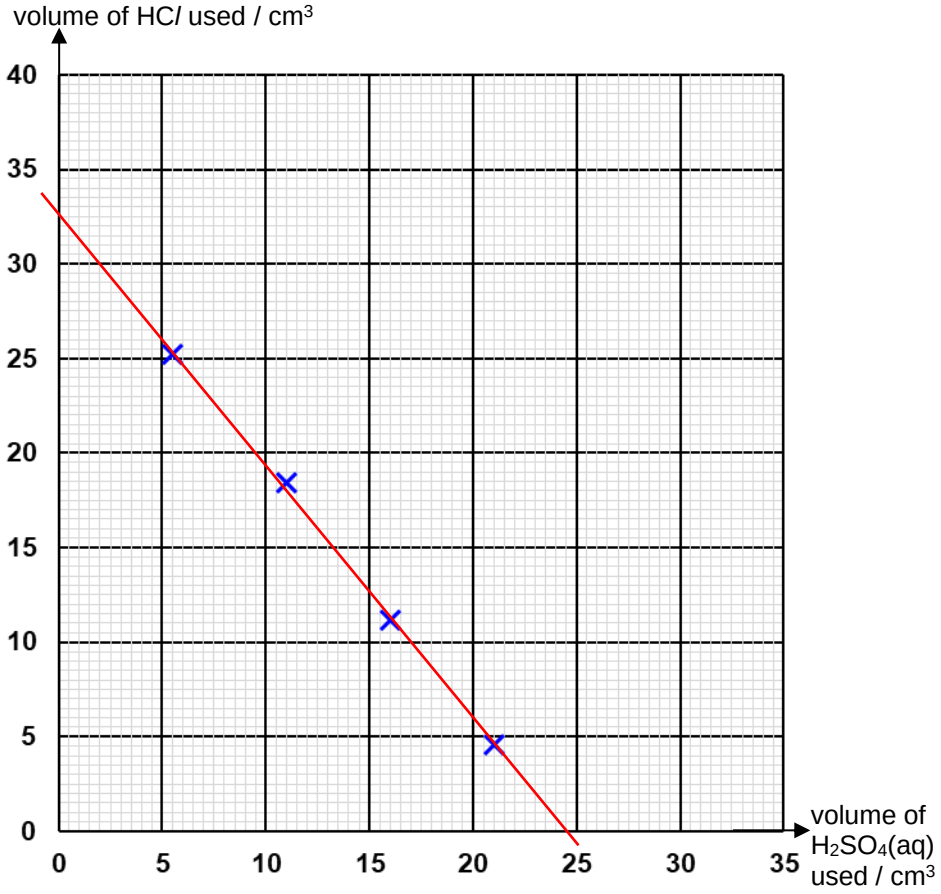
For Examiner's Use

Bronsted base is H^+ or proton acceptor.

[1]

(b) $Ba(OH)_2$(aq) neutralises both H_2SO_4 and HC*l* acid. In an experiment, a student prepared 4 mixtures, each containing the same volume of 25.0 cm^3 of $Ba(OH)_2$ solution, but with different volumes of sulfuric acid added.

In each mixture, neutralisation has not been completed, the solution remains alkaline and is neutralised by titration with 0.150 mol dm^{-3} HC*l* acid. A graph of volume of HC*l* on the y-axis was plotted against volume of H_2SO_4 for each of the 4 mixtures. The graph is extrapolated until it touches both axes.



(i) Read from the graph, and record the volume of HC*l* (Vol.HC*l* (max), required to exactly neutralise 25.0 cm^3 of $Ba(OH)_2$.

VHC*l* (max) = 32.50 cm^3 read correctly from the graph to ±½ small square

……

[1]

(ii) Calculate the concentration of $Ba(OH)_2$.

For Examiner's Use

Using [HC*l*] and Vol. HC*l*(max):

$n(HCl)\ \text{used} = 0.150 \times \frac{32.50}{1000} = 0.004875\ \text{mol}$

Since 1 $Ba(OH)_2 \equiv 2HCl$,

$nBa(OH)_2\ \text{in}\ 25.0\ cm^3 = ½ \times 0.004875 = 0.002438\ \text{mol}$

$[Ba(OH)_2] = 0.002438 \div \frac{25.0}{1000} = 0.0975\ \text{mol}\ dm^{-3}$

[2]

(iii) Explain in terms of the chemistry involved, why the direction of the slope of the graph is negative.

Negative gradient because the more sulfuric acid is added to 25.0 cm^3 of sodium carbonate, the less sodium carbonate remaining, the less hydrochloric acid is required for neutralisation (or words to that effect).

[1]
[Total:5]

End of paper