



TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME

CIVICS GROUP

H2 CHEMISTRY

9729/02

Paper 2 Structured Questions

18 September 2025

2 hours

Candidates answer on the Question Paper.

Additional materials: *Data Booklet*

READ THESE INSTRUCTIONS FIRST

Write your name and civics group in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams and graphs.

Do not use 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.

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

For Examiner's Use		Percentage
Paper 1	/ 30	/ 15
Paper 2		
1	/ 7	
2	/ 16	
3	/ 11	
4	/ 12	
5	/ 16	
6	/ 13	
Paper 2 Total	/ 75	/ 30
Paper 3	/ 80	/ 35
Paper 4	/ 55	/ 20
Grand Total		/ 100

1(a) The graph in Fig. 1.1 shows the atomic radii of some Period 4 metals.

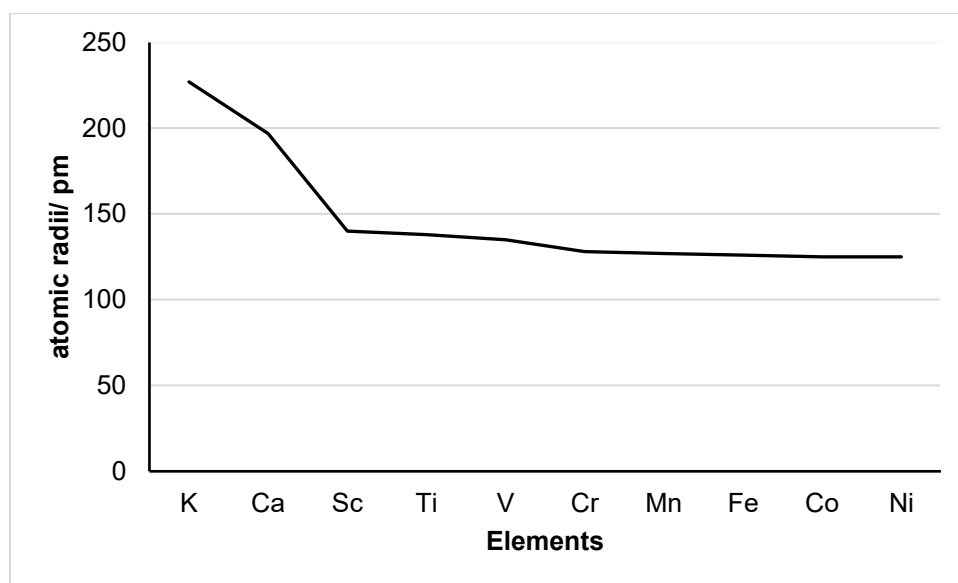


Fig. 1.1

- (i) With reference to Fig 1.1, explain briefly why the atomic radius of Ca is smaller than K.

Ca has greater nuclear charge than K while shielding effect remains relatively constant. Hence, Ca has a stronger electrostatic forces of attraction between nucleus and valence electrons than K, and the valence electrons of Ca are closer to the nucleus.

[1]

- (ii) With reference to Fig 1.1, describe and explain why the atomic radii from Cr to Ni are relatively constant.

From Cr to Ni,

- Nuclear charge increases.
- Electrons are added to the inner 3d orbitals and provide shielding for the 4s / valence electrons.
- Effective nuclear charge varies slightly **OR** Increase in nuclear charge is offset by the increase in shielding effect.

Atomic radius remains relatively invariant/ relatively constant.

[2]

- (b) (i) Shibuichi is an alloy of copper and silver and is used in traditional Japanese sword fittings. A particular sample of Shibuichi produced the following peaks in its mass spectrum as shown in Fig 1.2.

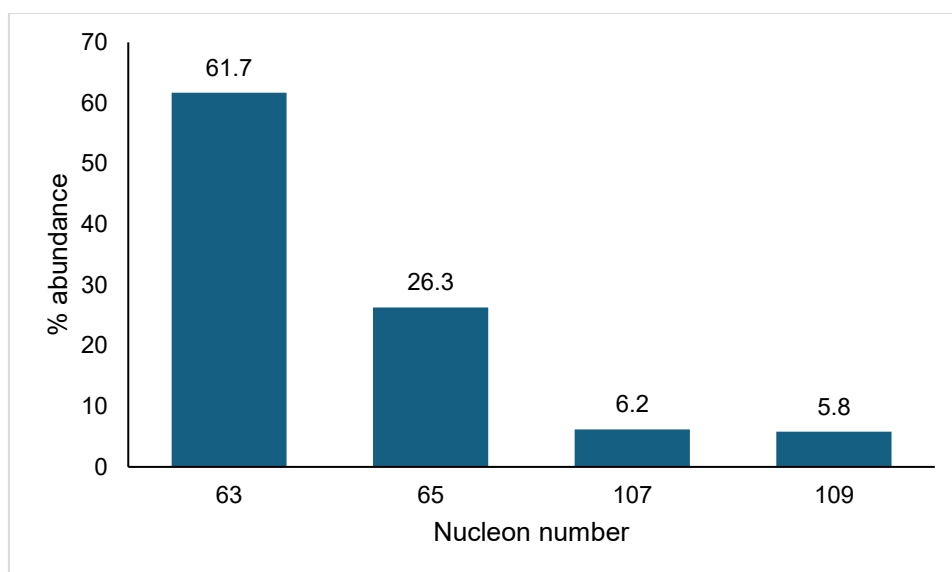


Fig. 1.2

Calculate the average A_r of copper from these data.

[1]

$$A_r = \frac{[63 \times 61.7] + [65 \times 26.3]}{88} = \underline{63.6}$$

- (ii) With reference to Fig. 1.2, state the number of protons and neutrons present in the atom with nucleon number 109.

Number of protons: 47

Number of neutrons: 62

[1]

(c) Table 1.2 shows the successive ionisation energies of element **B**.

Table 1.2

	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th
I.E. / kJ mol ⁻¹	900	1800	3250	4900	6050	12690	14200	16250

(i) State which group does element **B** belongs to.

Group 15 [1]

(ii) Both element **A** and element **B** are consecutive elements in the Periodic Table and that element **A** is positioned to the left of element **B**.

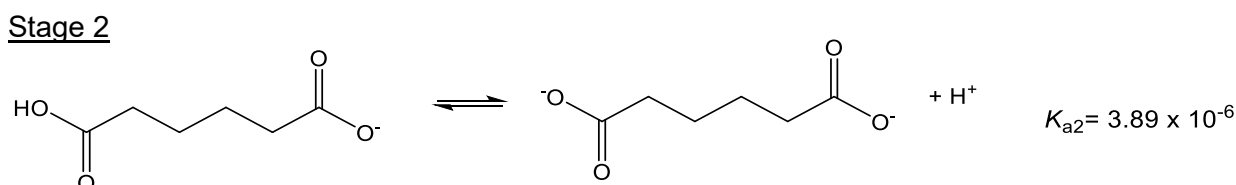
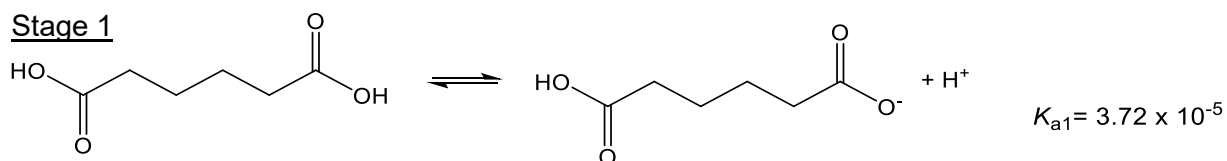
Explain why the 3rd ionisation energy of element **B** is lower than element **A**.

The 3rd I.E. of element B is lower as the *np* electron to be removed from B has higher energy compared to the *ns* electron to be removed from element A. Less energy is needed to remove 3rd electron of element B.

.....
.....
.. [1]

[Total: 7]

- 2 Adipic acid, $\text{HOOC}(\text{CH}_2)_4\text{COOH}$, is a flexible food additive used as a gelling aid, firming and buffering agent and can be found in many foods. It is a dibasic acid that ionises in 2 stages.



- (a) (i) Write an expression for the first acid dissociation constant of adipic acid, K_{a1} .

$$K_{a1} = \frac{[\text{HO}_2\text{C}(\text{CH}_2)_4\text{CO}_2^-][\text{H}^+]}{[\text{HO}_2\text{C}(\text{CH}_2)_4\text{CO}_2\text{H}]}$$

[1]

- (ii) Suggest a reason why the value of K_{a2} is lower than that of K_{a1} .

More energy is required to remove a H^+ from a negatively charged anion after the 1st H^+ is removed from the acid.

[1]

A mixture of adipic acid and its potassium salt can function as a buffer.

- (iii) With the aid of a chemical equation, briefly explain how this mixture can act as a buffer when a small amount of base is added.

The effects of K_{a2} can be ignored in any buffer action.

When a small amount of OH^- is added:
 $\text{OH}^- + \text{HOOC}(\text{CH}_2)_4\text{COOH} \rightarrow \text{HOOC}(\text{CH}_2)_4\text{COO}^- + \text{H}_2\text{O}$
 (or $\text{OH}^- + \text{H}_2\text{A} \rightarrow \text{HA}^- + \text{H}_2\text{O}$)
 The added OH^- is removed as H_2O .
 $[\text{H}^+]$ is slightly changed hence pH remains fairly constant.

[2]

- (iv) Determine the volume of $0.200 \text{ mol dm}^{-3}$ KOH(aq) that needs to be added to 100 cm^3 of $0.200 \text{ mol dm}^{-3}$ adipic acid to form a buffer of pH 4.7.

Let the volume of KOH be $v \text{ dm}^3$ and total buffer volume be $V_t \text{ dm}^3$.

After neutralisation with KOH, the remaining excess acid will form a buffer with the conjugate base of the salt formed.

No of mol of salt = no of mol of KOH added = $0.200 v$

No of mol of remaining acid = $0.200 (0.100 - v)$

$$\text{pH} = -\lg K_{a1} + \lg \frac{[\text{salt}]}{[\text{acid}]}$$

$$4.7 = 4.43 + \lg \frac{\frac{0.2v}{V_t}}{\frac{0.2(0.1-v)}{V_t}}$$

$$0.27 = \lg \frac{\frac{0.2v}{V_t}}{\frac{0.2(0.1-v)}{V_t}} = \lg \frac{v}{(0.1-v)} \Rightarrow 10^{0.27} = \frac{v}{(0.1-v)} = 1.862$$

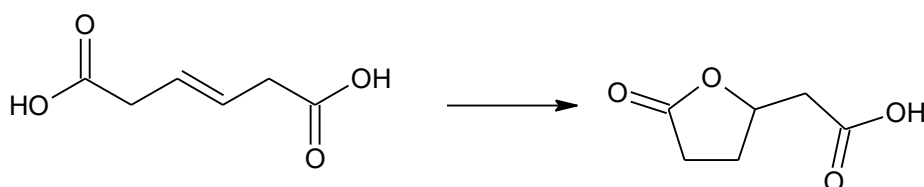
$$v = 0.1862 - 1.862v \Rightarrow 2.862v = 0.1862$$

Volume of KOH added, $v = \underline{0.0651 \text{ dm}^3}$

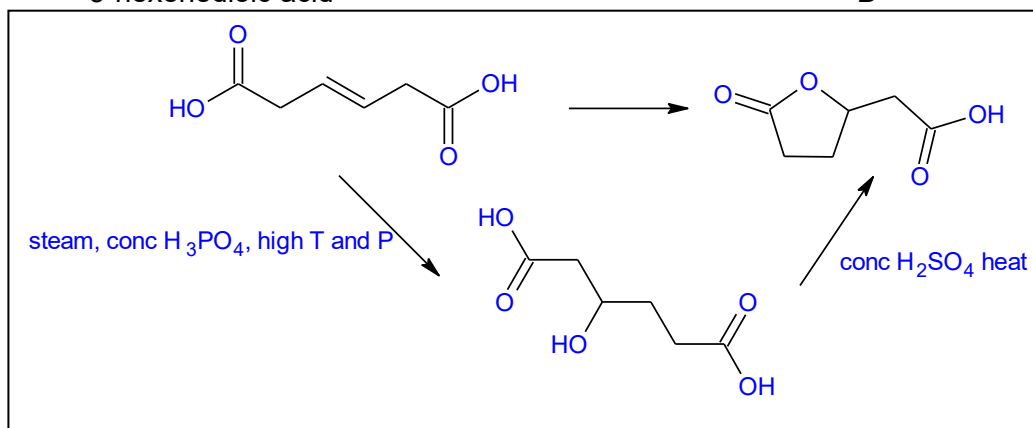
[2]

3-hexenedioic acid can be converted to adipic acid and 3-bromohexanedioic acid which serve as precursors or intermediates for organic synthesis.

- (b) (i) Propose a 2-step reaction synthesis to convert 3-hexenedioic acid to **D**. Show clearly all reagents and conditions and the structures of intermediates for each step.

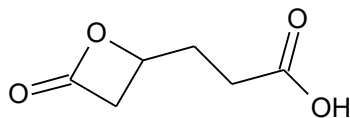


3-hexenedioic acid

D

[3]

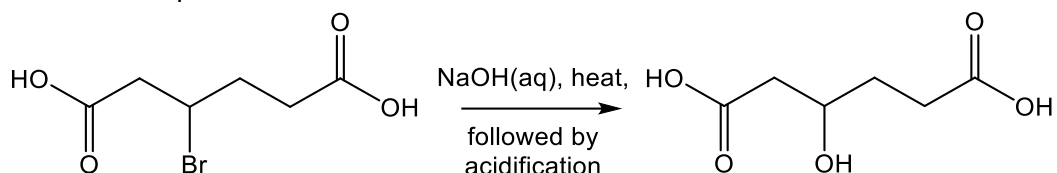
- (ii) Another possible product that could be produced from the synthesis method in (i) is shown below. Suggest why **D** is more likely to be formed than **E**.

**E**

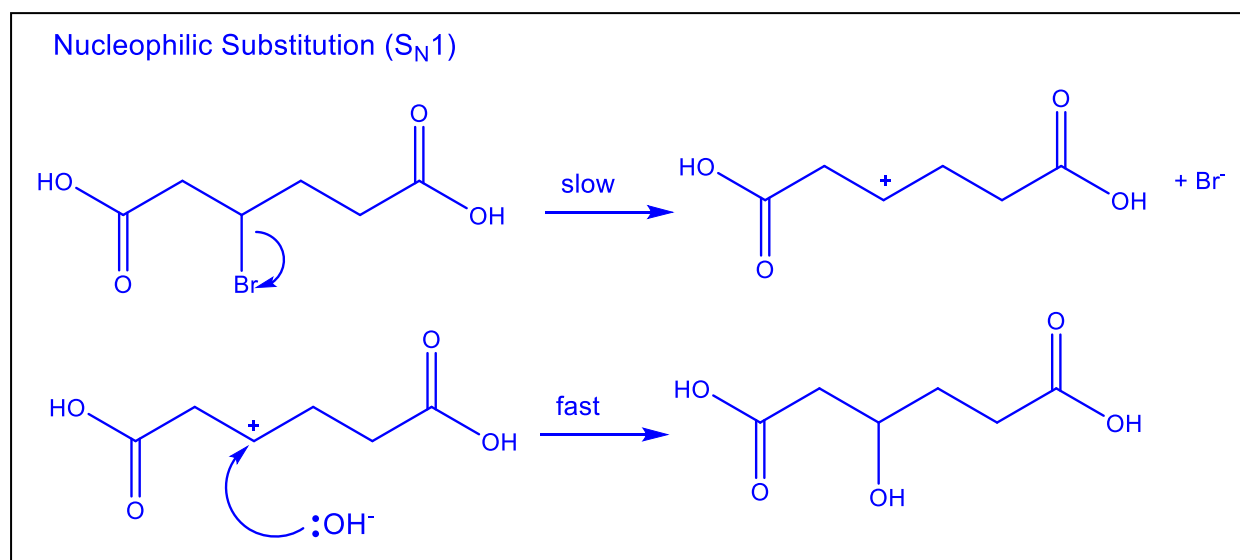
Compound **B** will experience ring strain / angle strain due to creation of a 4-membered ring and is thus less stable to be formed.

[1]

- (c) A sample of 3-bromohexanedioic acid was able to rotate plane polarised light. After reacting with hot NaOH(aq) followed by acidification, the product obtained was no longer able to rotate plane polarised light. The reaction between 3-bromohexanedioic acid and NaOH(aq) is shown in the equation below.



- (i) Describe the mechanism for the reaction between 3-bromohexanedioic acid and NaOH(aq). Include all relevant lone pairs, dipoles, curly arrows and charges.



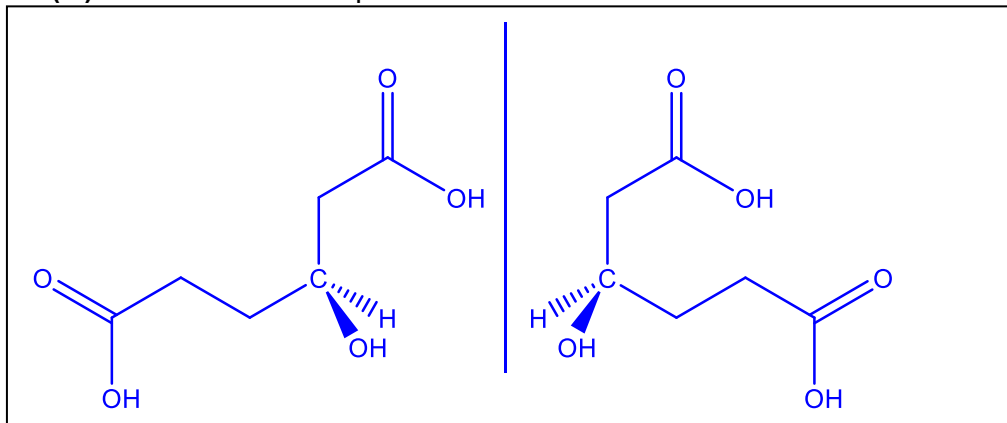
[3]

(ii) State the type of isomerism displayed by the products of the above reaction.

enantiomerism

[1]

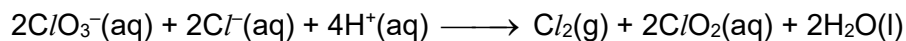
(iii) Draw the isomers produced in the above reaction.



[2]

[Total: 16]

3(a) Chlorate(V), ClO_3^- , reacts with chloride ions according to the equation as shown below.



An experiment was conducted using a mixture in which the concentrations of the reactants are as follows: $4.80 \times 10^{-4} \text{ mol dm}^{-3}$ of ClO_3^- , 0.1 mol dm^{-3} of Cl^- and 0.4 mol dm^{-3} of H^+ .

At five-minute intervals, small samples of the reaction mixture were withdrawn, quenched and placed into the UV-vis spectrometer to record its absorbance value. The absorbance value corresponds to the concentration of the product ClO_2 .

The graph of absorbance against time is shown in Fig. 3.1.

absorbance

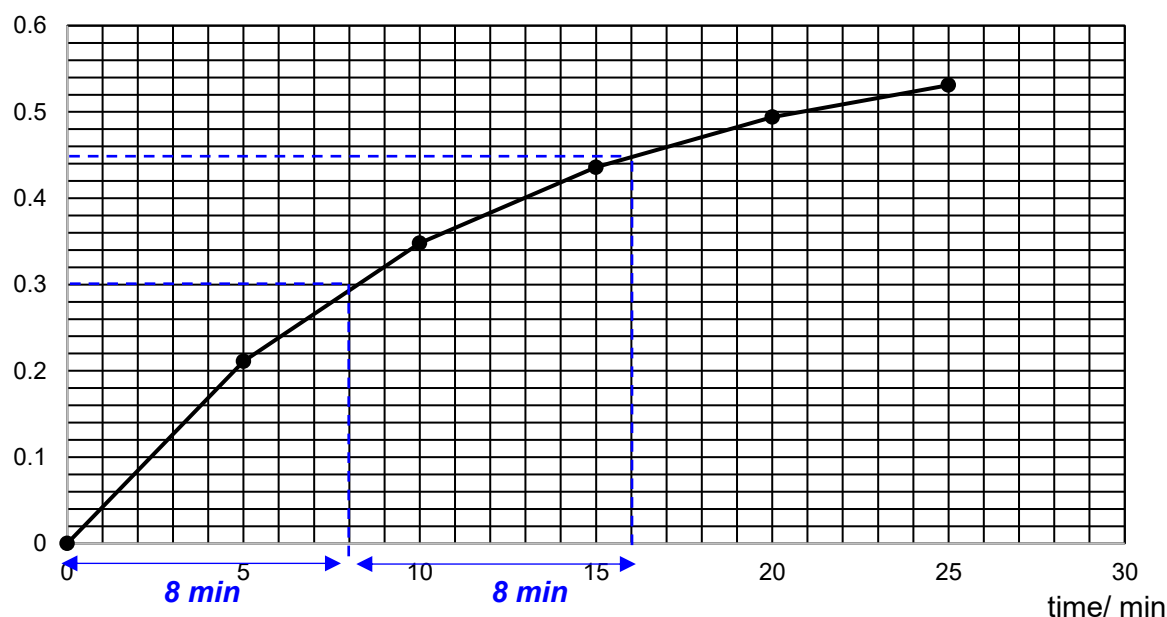


Fig. 3.1

- (i) Beer-Lambert's Law states that the absorbance values is directly proportional to the concentration of absorbing species, c , as shown below.

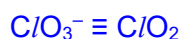
$$A = \epsilon cl$$

where ϵ is the molar extinction coefficient and l is the path length, which is usually 1.0 cm.

This equation can be used to calculate the absorbance value when maximum amount of ClO_2 was formed.

Calculate the concentration of ClO_2 in the reaction mixture. Show that the maximum absorbance value of the reaction is 0.600, given that ϵ of ClO_2 is $1250 \text{ mol}^{-1} \text{ dm}^3 \text{ cm}^{-1}$.

Since there are $4.80 \times 10^{-4} \text{ mol dm}^{-3}$ of ClO_3^- , 0.1 mol dm^{-3} of Cl^- and 0.4 mol dm^{-3} of H^+ ,
 $\Rightarrow \text{ClO}_3^-$ is the limiting reagent.



$$[\text{ClO}_2] = \underline{4.80 \times 10^{-4} \text{ mol dm}^{-3}}$$

$$\text{Absorbance value} = 1250 \times 0.000480 \times 1.0 = 0.600 \text{ (shown)}$$

[2]



istry

- (ii) With reference to Fig. 3.1, show that the reaction is first order with respect to C/O_3^- . Draw clearly any construction lines on the graph.

Since $t_{1/2}$ is relatively constant at 8 min, the order of reaction w.r.t C/O_3^- is 1.

At first $t_{1/2}$ (50%), absorbance = $\frac{1}{2} \times 0.6 = 0.3$

At second $t_{1/2}$ (75%), absorbance = $\frac{3}{4} \times 0.6 = 0.45$

- (iii) Another experiment was carried out using $2.40 \times 10^{-4} \text{ mol dm}^{-3}$ of C/O_3^- while keeping concentration of Cl^- and H^+ the same.

Deduce the half-life of C/O_3^- in this experiment.

$t_{1/2}$ would remain constant at 8 min.

For first order reaction, $t_{1/2}$ is independent of the initial concentration of reactant.

- (b) A series of experiments were carried out to investigate the order of reaction with respect to H^+ . The results are shown in Table. 3.2.

Table 3.2

Experiment	$[\text{C/O}_3^-]$ / mol dm^{-3}	$[\text{Cl}^-]$ / mol dm^{-3}	$[\text{H}^+]$ / mol dm^{-3}	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
1	0.050	0.100	0.300	3.38×10^{-4}
2	0.100	0.100	0.100	7.50×10^{-5}

- (i) Using the information in Table. 3.2, determine the order of reaction with respect to H^+ .

Let rate = $k [\text{C/O}_3^-] [\text{Cl}^-]^x [\text{H}^+]^y$

Comparing Expt 1 & 2,

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{k [\text{C/O}_3^-]_1 [\text{Cl}^-]_1^x [\text{H}^+]_1^y}{k [\text{C/O}_3^-]_2 [\text{Cl}^-]_2^x [\text{H}^+]_2^y}$$

$$\frac{3.38 \times 10^{-4}}{7.50 \times 10^{-5}} = \frac{k (0.050) (0.100)^x (0.300)^y}{k (0.100) (0.100)^x (0.100)^y}$$

$$z = 2$$

Order of reaction w.r.t. H^+ is 2.

- (ii) The rate of reaction was measured using different initial $[H^+]$ and keeping $[C/O_3^-]$ and $[Cl^-]$ constant. Sketch the graph of rate against initial $[H^+]$ in Fig. 3.3.

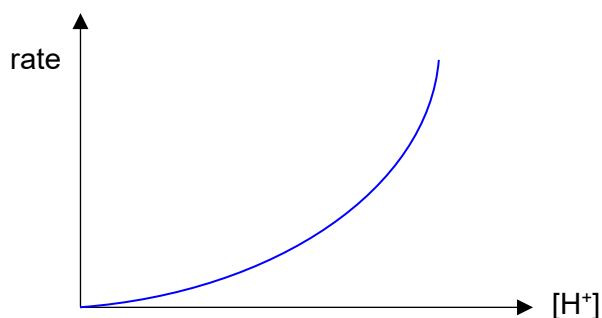
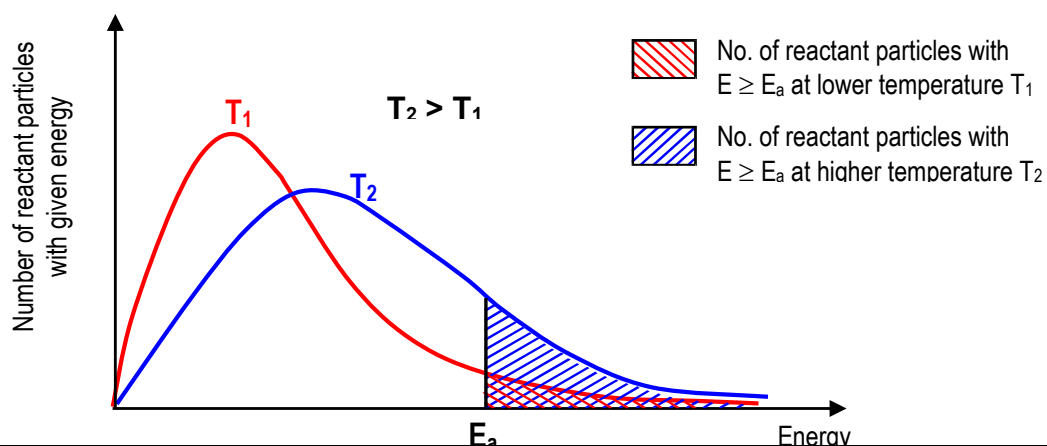


Fig. 3.3

[1]

- (iii) Explain, with the aid of a labelled Boltzmann distribution diagram, the effect on a rate constant of increasing temperature.

Maxwell–Boltzmann distribution



When temperature increases,

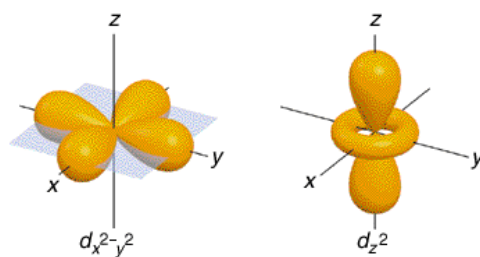
- number of reactant particles with energy $\geq E_a$ increases,
- frequency of effective collisions increases,
- resulting in larger rate constant, and hence rate of reaction increases..

[2]

- (iv) The reaction between C/O_3^- and Cl^- can take place in the presence of Mn^{2+} catalyst. The five d orbitals in Mn^{2+} ion are degenerated but split into two levels when it is in an octahedral complex.

Sketch and label one d orbitals that is found in the higher energy level.

Either one of the two orbitals:



[1]

[Total: 11]

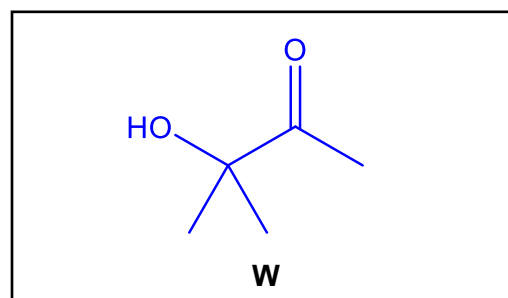
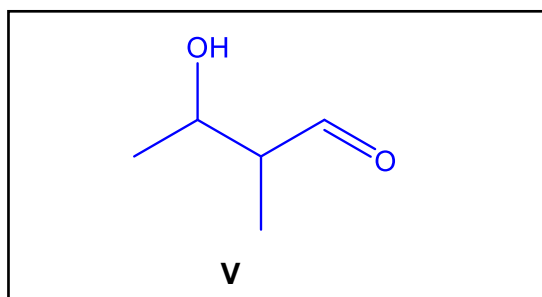
- 4(a) Compounds **V** and **W** both have molecular formula $C_5H_{10}O_2$. **V** has 2 chiral centres whereas **W** has none.

Table 4.1 shows the observations that occurred when separate samples of **V** and **W** were added to different reagents under specific conditions in two separate tests.

Table 4.1

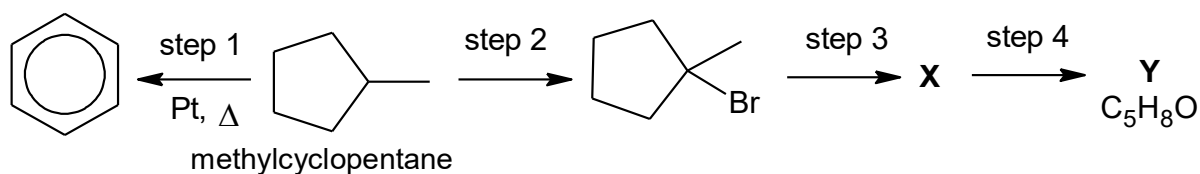
test	reagents and conditions	observations with V	observations with W
1	heat with acidified $KMnO_4$ (aq)	mixture changes from purple to colourless single organic product made that <ul style="list-style-type: none"> forms an orange precipitate with 2,4-dinitrophenylhydrazine forms effervescence with Na_2CO_3 (aq) 	no change
2	heat with alkaline I_2 (aq)	pale yellow precipitate forms	pale yellow precipitate forms

Draw a structure for **V** and for **W**.



[2]

- (b) The following flowchart shows reactions of methylcyclopentane.

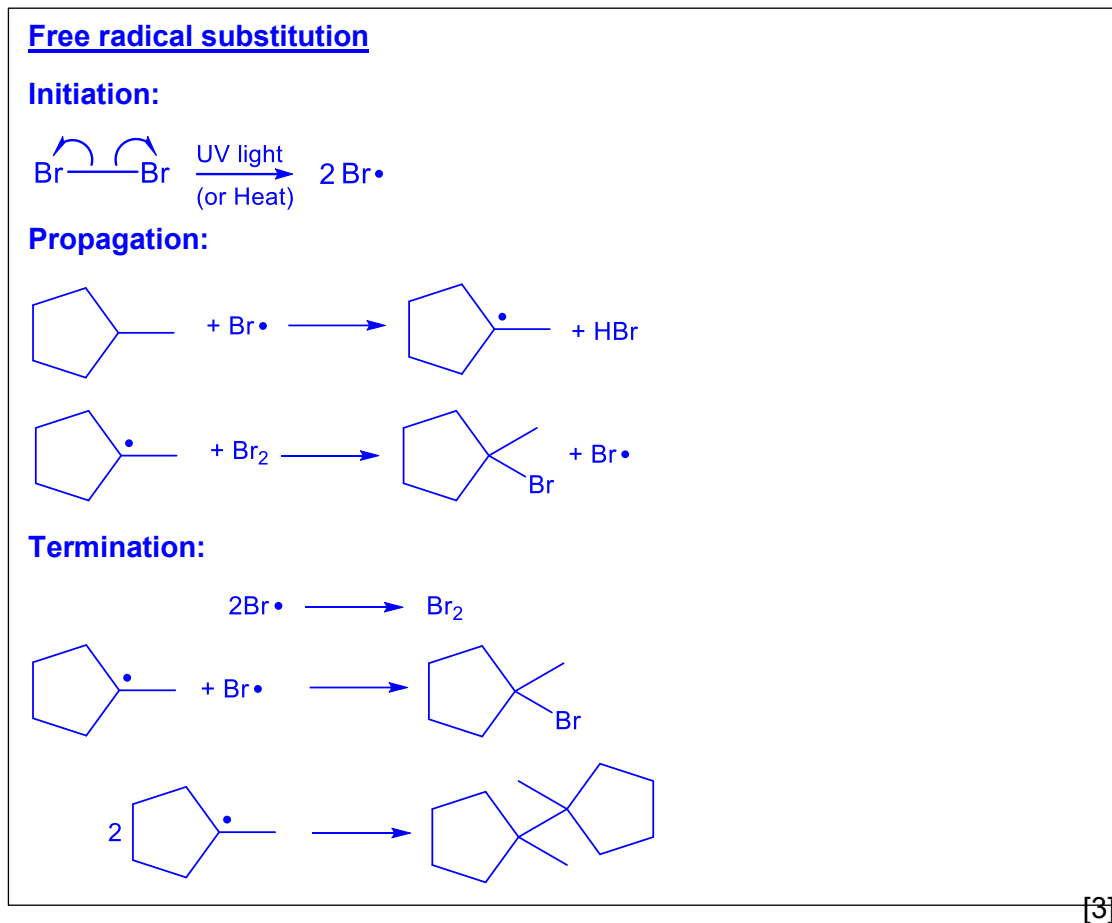


- (i) In Step 1, methylcyclopentane is converted into benzene for the production of gasoline from petroleum. Suggest the type of reaction of Step 1.

Elimination / Oxidation

[1]

(ii) Name and describe the mechanism in step 2.

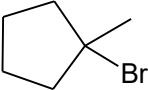
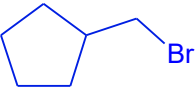
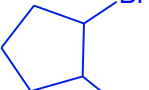
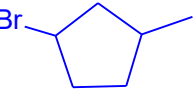


(iii) Other than the product shown in step 2, three other mono-substituted bromo-alkanes can also be formed in step 2.

Complete Table 4.2 with

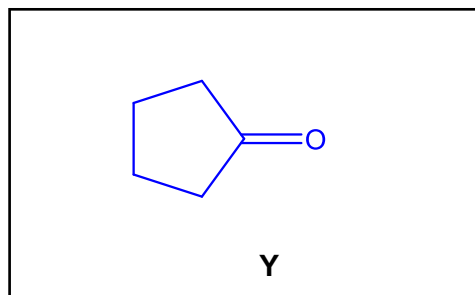
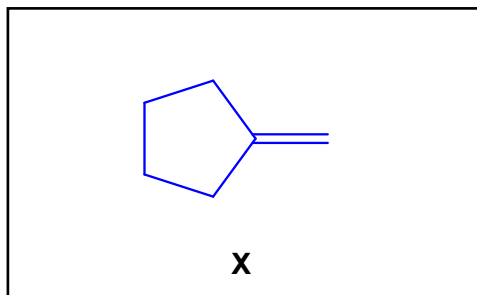
- the structures of the three other bromo-alkanes
- the expected ratio in which the four bromo-alkanes will be formed

Table 4.2

Bromo-alkane				
Ratio	1	3	4	4

[2]

- (iv) Given that **Y** reacts with 2,4-DNPH, draw the structures of **X** and **Y**. Suggest the reagents and conditions for steps 3 and 4.



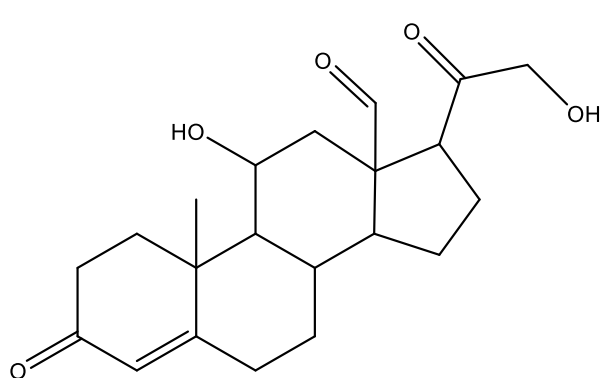
	reagents and conditions
Step 3	Alcoholic KOH, heat
Step 4	Dilute H₂SO₄, KMnO₄, heat (cannot use K₂Cr₂O₇)

[4]

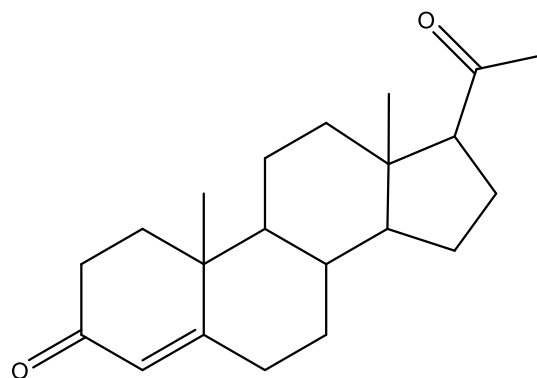
[Total: 12]

- 5 Steroids are a class of natural or synthetic organic compounds characterised by a molecular structure of 17 carbon atoms arranged in four rings. Natural-occurring steroids are found in hormones in living organisms while synthetic steroids have anti-inflammatory properties.

(a) The chemical structures of some of the naturally occurring steroids are shown below.



aldosterone



progesterone

(i) Identify all the functional groups found in aldosterone

2° alcohol, 1° alcohol, alkene, ketone and aldehyde

[2]

(ii) Describe a chemical test that can be performed to distinguish between aldosterone and progesterone.

1. Add **Fehlings' reagent** to each of the compound and **heat**. Aldosterone – **brick red ppt** observed; Progesterone - **No brick red ppt** observed.

2. Add **aq iodine, NaOH** to each compound and **heat**.

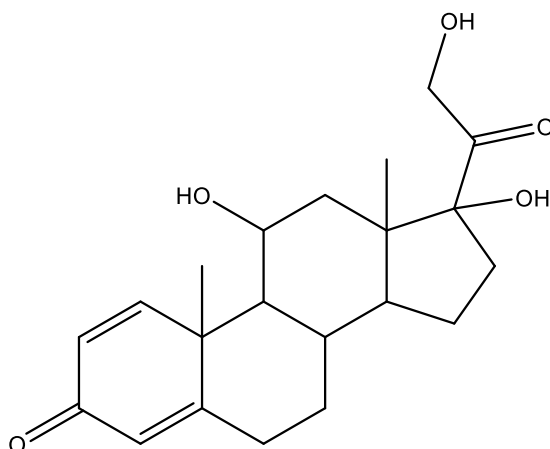
Progesterone - **pale yellow ppt** of CHI_3 observed; Aldosterone - **no pale yellow ppt** observed.

3. Add **Tollens' reagent** to each compound and **heat**.

Aldosterone – **silver mirror/black ppt** observed; Progesterone – **No silver mirror/black ppt** observed.

[2]

Another steroid prednisolone ($M_r = 360.4$) is a medicine used to treat allergies, blood disorders and inflammation. However, prolonged use of prednisolone comes with side-effects like fatigue and mood swings.



prednisolone

Prednisolone tends to be more fat-soluble than water soluble. When a medicine, such as prednisolone, is not very soluble in blood stream, it will have a low bioavailability, which gives a low efficiency. Bioavailability is defined as the percentage of the administered drug that reaches the blood circulation system. To increase the bioavailability of prednisolone, it is micronised into a smaller size than a conventional drug particle. On average, micronized prednisolone has a bioavailability of 86%.

The prescription of prednisolone depends on the severity of the patient's condition and body weight. The maximum intake of prednisolone each day should not exceed 0.5 mg per kg of the body weight of the patient. [1 mg = 0.001 g]

- (b) A patient who weighs 60kg was put on a prednisolone course for four weeks. He was told to consume the maximum intake of prednisolone each day for the first week. This is what his prescription looked like on his medication packaging.

Tampines Meridian Clinic	
Prescription:	
First Week	X tablets each day, taken after breakfast
Second Week	4 tablets each day, taken after breakfast
Third Week	2 tablets each day, taken after breakfast
Fourth Week	1 tablet each day, taken after breakfast
Each tablet contains 5 mg of prednisolone.	

- (i) Based on the information given, show that the number of tablets, **X**, the patient ingested each day during the first week is 6.

$$\text{No. of tablet taken each day during first week} = (60 \times 0.5) \div 5 = 6$$

[1]

- (ii) Taking into consideration the bioavailability of prednisolone, calculate the total amount of prednisolone that reaches the blood circulation system of the patient in the four weeks.

$$\text{Number of tablets taken during the 4 weeks} = (6+4+2+1) \times 7 = 91$$

$$\text{Amount of prednisolone} = [91 \times (5 \times 10^{-3}) \div 360.4] \times 0.86 = \underline{1.127 \times 10^{-3} \text{ mol}}$$

[2]

- (iii) In theory, if two patients have the same body weight and severity of the same condition, suggest why the patient who has higher percentage of body fat will require a higher dosage of prednisolone.

It is because as prednisolone is more fat-soluble, there will be less prednisolone in the blood circulation system of the patient with higher percentage fat mass, resulting in a decrease of the efficiency of the medication.

[1]

- (iv) Suggest why micronising a medicine into particles with a smaller size can increase its bioavailability and lead to higher efficiency.

Micronised particles have a greater surface area allowing the medicine to dissolve more readily in blood/more extensive interactions with water in the body to get better dissolved. This enhances absorption.

[1]

(c) The following Table 5.1 shows the solubility of prednisolone in some common solvents.

Table 5.1

solvent	solubility of prednisolone
water	sparingly soluble
ethanol	soluble

- (i) By considering all types of interactions between the solute and solvent, explain why ethanol is a better solvent than water to dissolve prednisolone.

Both water and ethanol can form hydrogen bond with the hydroxy group of prednisolone. On top of this, the presence of the ethyl group in ethanol allows instantaneous dipole – induced dipole interaction extensively with (the non-polar and bulky hydrophobic carbons rings) prednisolone to allow them to dissolve in ethanol better.

- (ii) Another way to increase the solubility of prednisolone in water is to synthesise prednisolone as prednisolone phosphate salt without compromising its anti-inflammatory property.

Using Fig. 5.1, illustrate how a water molecule interacts with the prednisolone phosphate ion to increase its solubility. Label the main type of interaction involved.

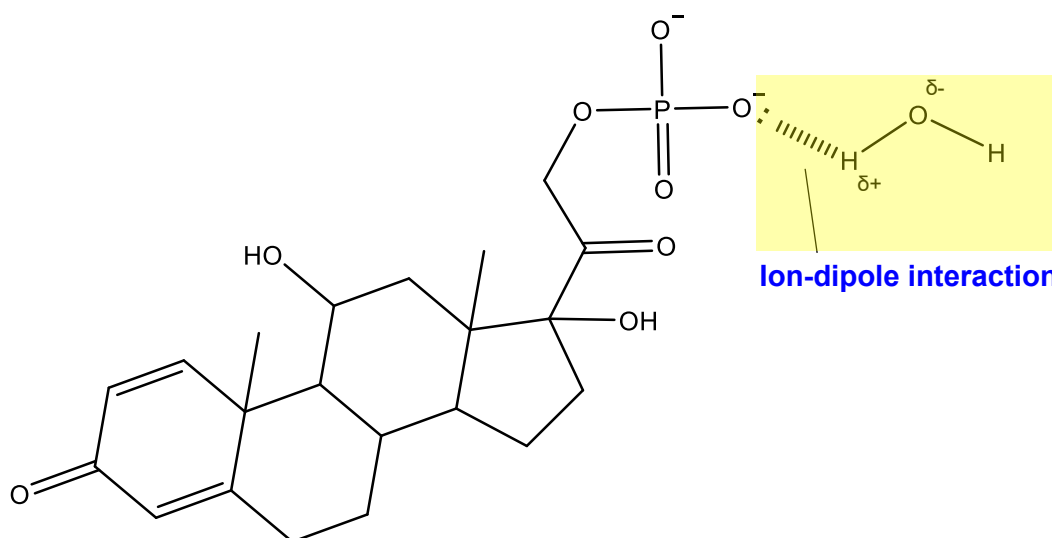


Fig. 5.1

[1]

(d) The half-life of a drug refers to the amount of time it takes for the concentration of its active component in the body to decrease by 50%. A drug is generally regarded as eliminated from the body, with no remaining clinical effect, after 5.5 half-lives.

(i) Calculate the half-life of prednisolone given that the effect of prednisolone will last 16.5 hours after ingestion.

$$\text{Half-life of prednisolone} = 16.5 \div 5.5 = \underline{\underline{3 \text{ hours}}}$$

[1]

(ii) Calculate the percentage of prednisolone that remained in the body after 5.5 half-lives.

$$[A]_t = [A]_0 \times \left(\frac{1}{2}\right)^n$$

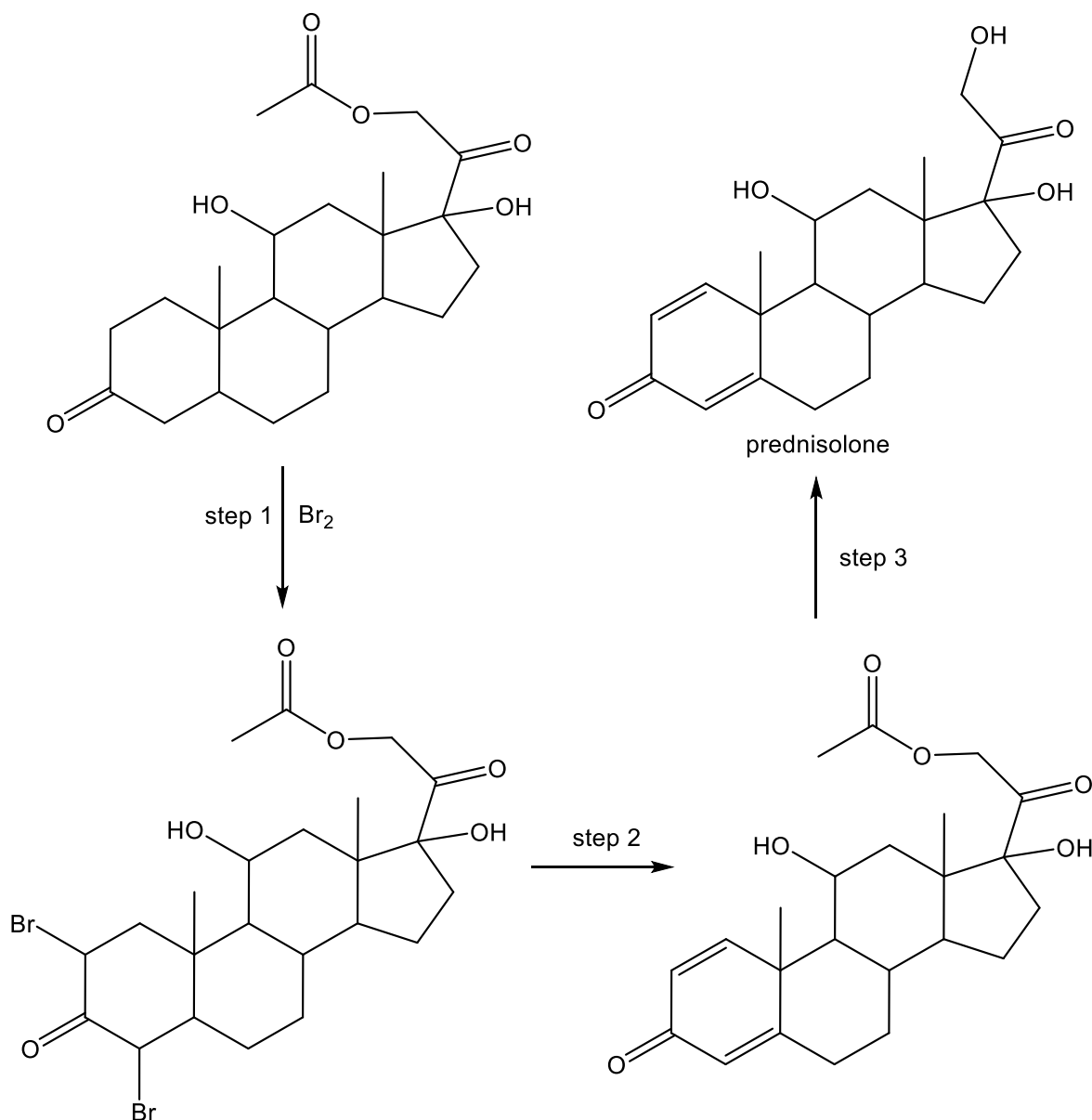
where $[A]_t$ is concentration of prednisolone remained; $[A]_0$ is the concentration of prednisolone at the start

$$\text{Percentage of prednisolone remained} = \left(\frac{1}{2}\right)^{5.5} \times 100 \% = \underline{\underline{2.21\%}}$$

[1]



- (e) The reaction scheme below shows the synthesis of prednisolone in the pharmaceutical industry.



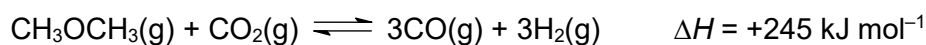
Identify the type of reaction, and suggest the reagents and conditions for each of the steps 2 and 3.

	reagents and conditions	type of reaction
step 2	ethanolic KOH, heat	elimination
step 3	sulfuric acid (aq), heat	acidic hydrolysis

[2]

[Total: 16]

- 6 Dimethyl ether, CH_3OCH_3 , is a colourless gas commonly used as a fuel, a spray and a refrigerant. It can react with carbon dioxide to produce carbon monoxide and hydrogen gas as shown in the equation below:



In an experiment, a mixture of CH_3OCH_3 and CO_2 was introduced into a 2500 dm^3 sealed vessel at 600 K and the initial total pressure was 15 atm . The reaction was allowed to reach dynamic equilibrium.

- (a) (i) Explain what is meant by *dynamic equilibrium*.

A reversible reaction is at dynamic chemical equilibrium when:

- **Rate of forward reaction = Rate of backward reaction** ✓
- the substances are **still reacting together** although the **concentrations** of the **reactants and products** remain **constant**. ✓

[1]

- (ii) Write an expression for the equilibrium constant, K_p , stating its units.

$$K_p = \frac{(\text{P}_{\text{CO}})^3 (\text{P}_{\text{H}_2})^3}{\text{P}_{\text{CH}_3\text{OCH}_3} \text{P}_{\text{CO}_2}} \quad \text{atm}^4 \text{ or } \text{Pa}^4$$

[2]

- (iii) At equilibrium, the amount of H_2 was found to be 280 mol . Show that the equilibrium partial pressure of H_2 in the vessel was 5.5 atm .

$$pV = nRT$$

$$\text{Partial pressure of } \text{H}_2 \text{ at equilibrium} = \frac{280 \times 8.31 \times 600}{2500 \times 10^{-3}} = 558432 \text{ Pa}$$

$$101325 \text{ Pa} = 1 \text{ atm}$$

$$558432 \text{ Pa} = \frac{558432}{101325} = \underline{\underline{5.5 \text{ atm (shown)}}}$$

[1]



- (b)(i) It was found that 75% of the CH_3OCH_3 had dissociated at equilibrium at 600K. Calculate the equilibrium pressures of CH_3OCH_3 and CO_2 in atm.

Let x be the initial pressure of CH_3OCH_3 .

	CH_3OCH_3	CO_2	\rightleftharpoons	3CO	3H_2
Initial partial pressure/atm	x	$15 - x$		0	0
Change in partial pressure/atm	$-0.75x$	$-0.75x$		$+3(0.75)x$	$+3(0.75)x$
Eqm partial pressure / atm	$0.25x$	$15 - 1.75x$		$2.25x$	$2.25x$

Since equilibrium partial pressure of H_2 in the vessel was 5.5 atm,
 $2.25x = 5.5 \Rightarrow x = 2.44 \text{ atm}$

$$P_{\text{CH}_3\text{OCH}_3} \text{ at equilibrium} = 0.25 \times 2.44 = \underline{\underline{0.611 \text{ atm}}}$$

$$P_{\text{CO}_2} \text{ at equilibrium} = 15 - 1.75(2.44) = \underline{\underline{10.7 \text{ atm}}}$$

[3]

- (ii) Hence, calculate the value of K_p , for this reaction. Express your answer to 2 significant figures.

$$P_{\text{CH}_3\text{OCH}_3} \text{ at equilibrium} = 0.611 \text{ atm}$$

$$P_{\text{H}_2} = P_{\text{CO}} \text{ at equilibrium} = 5.5 \text{ atm}$$

$$K_p = \frac{(P_{\text{CO}})^3 (P_{\text{H}_2})^3}{P_{\text{CH}_3\text{OCH}_3} P_{\text{CO}_2}}$$

$$K_p = \frac{(5.5)^3 \times (5.5)^3}{0.611 \times 10.7} = \underline{\underline{4.2 \times 10^3 \text{ atm}^4}} \text{ (2 s.f.)} \quad [1]$$

- (c)(i) At constant temperature and volume, partial pressure of a gas is proportional to mole fraction. Hence, calculate the average M_r of the gaseous mixture at 600K.

$$pV = nRT \Rightarrow p \propto n$$

Average M_r

$$= \left(\frac{0.611}{22.311} \times M_r \text{ of } \text{CH}_3\text{OCH}_3 + \frac{10.7}{22.311} \times M_r \text{ of } \text{CO}_2 + \frac{5.5}{22.311} \times M_r \text{ of } \text{CO} + \frac{5.5}{22.311} \times M_r \text{ of } \text{H}_2 \right)$$

$$= \underline{\underline{29.8}} \text{ (no units and 1 d.p.)}$$

[1]



- (ii) Explain the effect on the equilibrium position and the average M_r of the gaseous equilibrium mixture when the experiment was conducted at 700K instead of 600K.

When temperature was increased, the equilibrium position shifted right towards the endothermic reaction to absorb heat.

Lower amount of reactants (CH_3OCH_3 and CO_2) with higher M_r and higher amount of products (CO and H_2) with lower M_r were formed. Hence, the mixture contains a greater proportion of low M_r gases. Therefore, the average M_r of the gaseous mixture will decrease.

- (d) A key property of an aerosol propellant is that it must exist as a gas under room temperature and pressure conditions.

The behaviour of 1 mol of ideal gas and 1 mol of CH_3OCH_3 at 293 K is shown in Fig. 6.1.

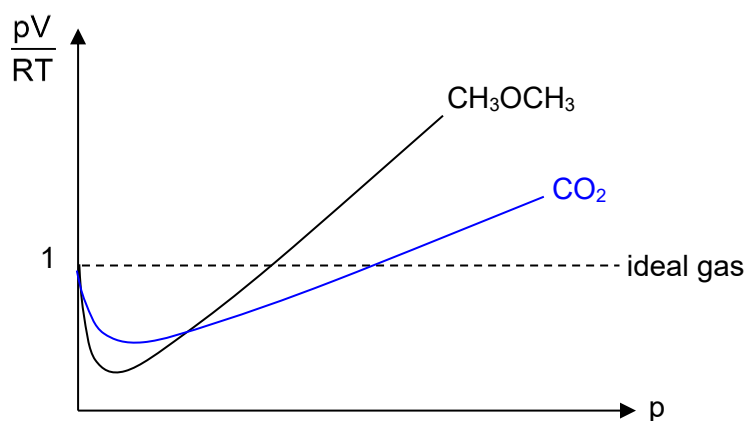


Fig. 6.1

On the **same** axes in Fig. 6.1, sketch and label the graph for 1 mol of CO_2 at 293 K. Explain your answer.

It is observed that at the same temperature, the graph for CO_2 will show a smaller deviation from ideal gas behaviour than CH_3OCH_3 gas.

Both CH_3OCH_3 ($M_r = 46.0$) and CO_2 ($M_r = 44.0$) have similar electron cloud size. The instantaneous dipole – induced dipole attractions between non-polar CO_2 molecules is weaker /less significant compared to the permanent dipole – permanent dipole attractions between the polar CH_3OCH_3 molecules.

[2]

[Total: 13]