AS LEVEL CHEMISTRY

PAPER 2

PRACTICE PAPER 25

(structured questions only)

Answer all questions

Max 80 marks

Name ……..
Mark ……../80 ……....% Grade ……

Note – this paper only contains structured questions

This paper contains legacy 2016 questions

1. **(a)** Van der Waals' forces exist between all molecules.

Explain how these forces arise.

[3 marks]

(b) (i) Explain, in terms of their intermolecular forces, why the boiling points of these compounds are different.

[3 marks]

(b) (ii) Suggest how a mixture of methanol and methanethiol could be separated.

[1 mark]

(c) Suggest why methaneselenol (CH_3SeH) has a higher boiling point than methanethiol (CH_3SH).

[2 marks]

(d) (i) Draw the shape of an SF_6 and of an SF_4 molecule.
Include any lone pairs that influence the shape.
State the bond angle(s) in SF_6 and in SF_4
Name the shape of SF_6

[6 marks]

	SF_6	SF_4
Shape		
Bond angle(s)		
Name of shape		

(d) (ii) SCl_2 reacts with NaF to form SF_4 and S_2Cl_2 and one other product.

Write an equation for the reaction.

[2 marks]

[Total 17 marks]

2. Compounds **A**, **B**, **C** and **D** are isomers with the molecular formula $C_4H_{10}O$
They all have a broad absorption in their infrared spectra in the range 3230–3550 cm^{-1}.

(a) Use **Table A on the data sheet** to identify the bond and the functional group present responsible for this absorption.

[1 mark]

_____

(b) Compounds **A** and **B** are both straight-chain compounds.
A can be oxidised to form **P**.
B can be oxidised to form **Q**.
P and **Q** are isomers with molecular formula C_4H_8O

Tollens' reagent and Fehling's solution can be used to distinguish between isomers **P** and **Q**. The results shown in **Table 3** are obtained.

Table 3

Compound	Observation with Tollens' reagent	Observation with Fehling's solution
P	No visible change	No visible change
Q	Silver mirror formed	Brick-red precipitate formed

Use the information about compounds **P** and **Q** to identify compounds **A** and **B**.
Explain your answer with reference to the functional groups in **P** and **Q**.

[3 marks]

Identity of **A** _____

Identity of **B** _____

Explanation _____

_____

_____

_____

(c) Isomer **C** is resistant to oxidation.
Isomer **C** reacts to form compound **R** that has an absorption in its infrared spectrum in the range 1620–1680 cm^{-1}.

State the bond that causes the absorption in the range 1620–1680 cm^{-1}.

Give the displayed formula of isomer **C**.

Identify the reagent and give **one** reaction condition needed to convert **C** into **R**.

[4 marks]

Bond _____

Displayed formula of **C**

Reagent _____

Condition _____

(d) Compound **D** is a branched-chain isomer that can be oxidised to form compounds **S** and **T**.

(d) (i) Compound **S** is obtained by distilling it off as it forms during the oxidation.
Compound **T** is formed when the oxidation takes place under reflux.

Identify the functional groups in **S** and **T**.

Explain, with reference to intermolecular forces, why it is possible to obtain compound **S** but not **T** from the reaction mixture by distilling off **S** as soon as it forms.

[3 marks]

_____

_____

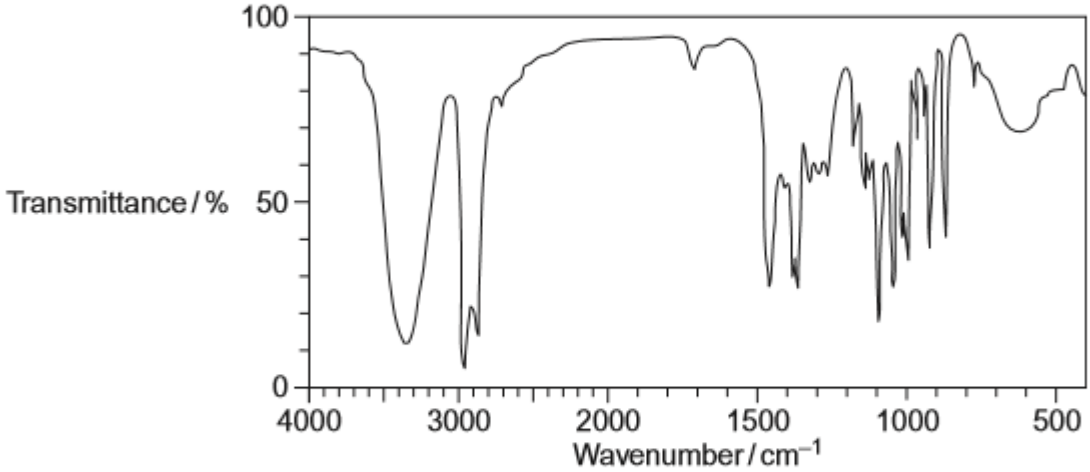
_____

_____

_____

(d) (ii) A student claims to have oxidised compound **D**.
Figure 1 shows the infrared spectrum of the product obtained by the student.

Figure 1



Suggest two ways in which the spectrum shows that compound **D** has **not** been oxidised.

[2 marks]

_____

_____

_____

_____

_____

[Total 13 marks]

3. Alcohols can be prepared from alkenes in various ways.

(a) On a laboratory scale, a mixture of propan-1-ol and propan-2-ol can be prepared from propene in two steps.

In step 1, propene reacts with cold, concentrated sulfuric acid to form intermediate compounds.

In step 2, the intermediate compounds react with water to form the mixture of alcohols.

Name and outline the mechanism for the reaction between propene and concentrated sulfuric acid to form the intermediate compound which gives propan-2-ol in step 2.

Explain why propan-2-ol is the major product of this preparation.

[7 marks]

(b) On an industrial scale ethanol can be produced from ethene by direct hydration or from glucose by fermentation.

State the conditions for the direct hydration reaction.

State two advantages and two disadvantages of the fermentation method compared with the direct hydration method.

[6 marks]

[Total 13 marks]

4. Two reactions of 2-bromopentane, ($CH_3CH_2CH_2CHBrCH_3$) are shown.

$$C_5H_{10} \xleftarrow{\text{reaction 1}} CH_3CH_2CH_2CHBrCH_3 \xrightarrow{\text{reaction 2}} C_5H_{11}OH$$

The C_5H_{10} formed in reaction **1** exists as a mixture of three isomers, one of which is pent-1-ene. Two of the isomers are a pair of stereoisomers. All three isomers decolourise bromine.

(a) The same reagent is used in both reactions. The product is determined by the choice of conditions.

State the reagent and the conditions for each of reaction **1** and reaction **2**.

State the role of the reagent in each reaction.

Name and outline the mechanism of reaction **1** for the formation of pent-1-ene.

[8 marks]

(b) All three isomers of C_5H_{10} contain the same functional group.

Draw the displayed formula of pent-1-ene.

Draw the structures of the pair of stereoisomers and give their full IUPAC names.

Explain the origin of the stereoisomerism shown.

[5 marks]

(c) The rates of hydrolysis of two chloroalkanes can be investigated by adding aqueous silver nitrate to the chloroalkanes. During the hydrolysis reactions, chloride ions are liberated slowly. Precipitates of silver chloride are formed.

Outline a method to compare the rate of hydrolysis of 1-chlorobutane with that of 2-chlorobutane. State how the method would ensure a fair test.

[4 marks]

[Total 17 marks]

5. Cement kilns were once one of the largest contributors to global pollution by nitrogen oxides.

(a) State how nitrogen oxides could be formed during the manufacture of Portland cement.

[1 mark]

(b) Sulfur dioxide is formed by the oxidation of sulfur compounds in the fuel used to heat the kiln. Sulfur dioxide can be removed by the minerals in the kiln.
Suggest why a kiln with a very fast air flow is likely to emit more sulfur dioxide than one with a slower air flow but otherwise operating under the same conditions.

[1 mark]

[Total 2 marks]

6. Standard enthalpy of combustion data can be used to calculate enthalpies of formation.

(a) State the meaning of the term standard enthalpy of combustion.

[3 marks]

(b) The equation corresponding to the enthalpy of formation of propan-1-ol is shown.

$$3C(s) + 4H_2(g) + \frac{1}{2}O_2(g) \longrightarrow CH_3CH_2CH_2OH(l)$$

Table 1 contains some standard enthalpy of combustion data.

Table 1

	C(s)	**$H_2(g)$**	**$CH_3CH_2CH_2OH(l)$**
$\Delta H_c^{\ominus}$ / kJ mol^{-1}	–394	–286	–2010

Use data from **Table 1** to calculate a value for the standard enthalpy of formation of propan-1-ol. Show your working.

[3 marks]

(c) An equation for the complete combustion of gaseous propan-1-ol is shown.

$$CH_3CH_2CH_2OH(g) + 4\tfrac{1}{2}O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g) \quad \Delta H = -1893 \text{ kJ mol}^{-1}$$

Table 2 shows some bond enthalpy data.

Table 2

	C–H	C–O	O–H	C=O	O=O
Bond enthalpy / kJ mol^{-1}	412	360	463	805	496

Use data from **Table 2** and the enthalpy change for this reaction to calculate a value for the bond enthalpy of a C–C bond in propan-1-ol.

[3 marks]

[Total 9 marks]

7. Haloalkanes are used as refrigerants, solvents and anaesthetics.

(a) Trichloromethane ($CHCl_3$) is a haloalkane that can be formed by heating a mixture of chloromethane (CH_3Cl) and chlorine.

(a) (i) Write an overall equation for the formation of trichloromethane by the reaction of chloromethane with chlorine.

[1 mark]

_____

(a) (ii) Name the mechanism for this formation of trichloromethane.

[1 mark]

_____

(a) (iii) Dichloromethane (CH_2Cl_2) is an intermediate in this formation of trichloromethane.

Write an equation for each of the following steps in the mechanism for the reaction of dichloromethane with chlorine.

[4 marks]

Initiation step

_____

First propagation step

_____

Second propagation step

_____

A termination step leading to the formation of a compound with formula $C_2H_2Cl_4$

_____

(b) Chlorotrifluoromethane ($CClF_3$) is used as a refrigerant, but is being phased out due to concerns about ozone depletion in the upper atmosphere.
In the upper atmosphere, $CClF_3$ decomposes in the presence of UV light forming a reactive intermediate that catalyses the decomposition of ozone.

(b) (i) Write an equation to show how $CClF_3$ decomposes to form the reactive intermediate.

[1 mark]

_____

(b) (ii) Write two equations to show how this reactive intermediate is involved in catalysing the decomposition of ozone.

[2 marks]

1 _____

2 _____

[Total 9 marks]