AS LEVEL CHEMISTRY

TOPIC 9 –ANALYSIS OF ORGANIC COMPOUNDS

ASSESSED HOMEWORK

Answer all questions

Max 80 marks

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

1. Explain how infrared spectroscopy can be used to show that an aldehyde is definitely pentanal.

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(Total 2 marks)

2. A chemist discovered four unlabelled bottles of liquid, each of which contained a different pure organic compound. The compounds were known to be propan-1-ol, propanal, propanoic acid and 1-chloropropane.

Describe four **different** test-tube reactions, one for each compound, that could be used to identify the four organic compounds.
Your answer should include the name of the organic compound, the reagent(s) used and the expected observation for each test.

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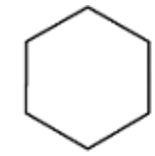
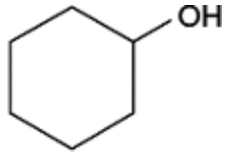
(8)
(Total 8 marks)

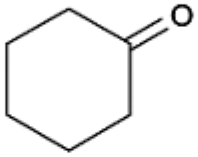
3. Consider the five cyclic compounds, **A**, **B**, **C**, **D** and **E**.



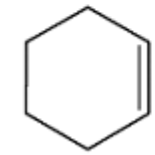
cyclohexane
A



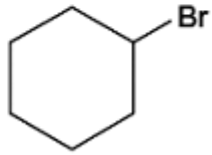
cyclohexanol
B



cyclohexanone
C



cyclohexene
D

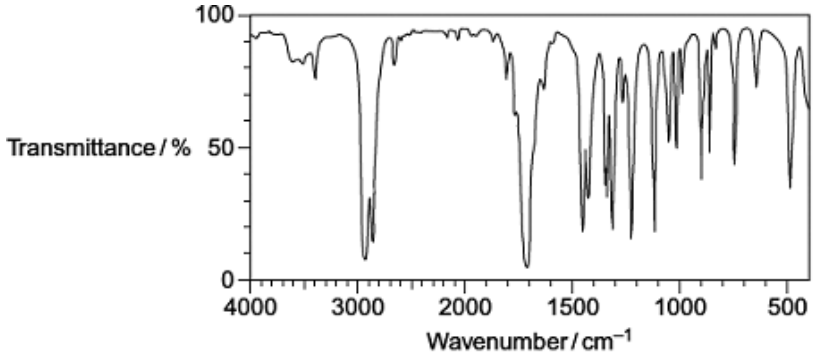


bromocyclohexane
E

(a) The infrared spectra of compounds **A**, **B**, **C** and **D** are shown below.

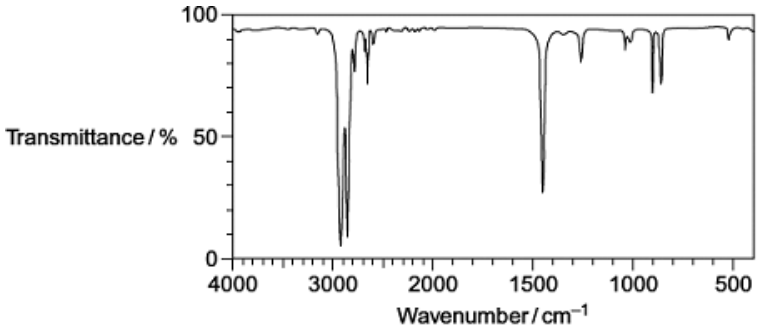
Write the correct letter, **A**, **B**, **C** or **D**, in the box next to each spectrum. You may find it helpful to refer to **Table 1** on the Data Sheet.

(i)



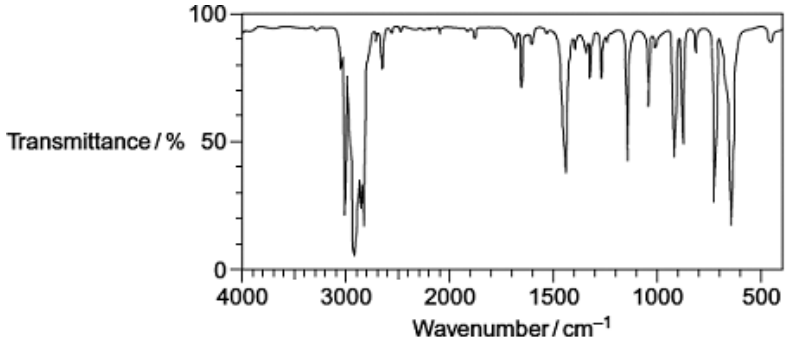
(1)

(ii)



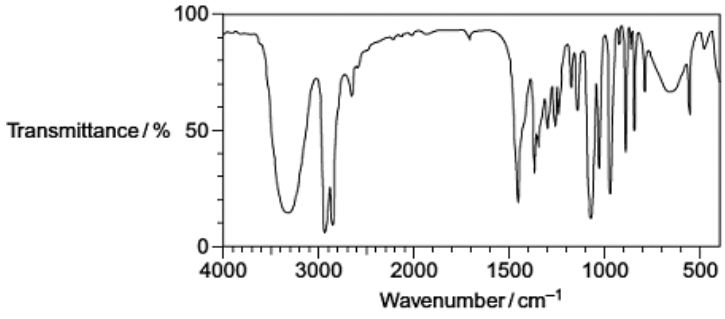
(1)

(iii)



(1)

(iv)



(1)

(b) A simple chemical test can be used to distinguish between cyclohexane (**A**) and cyclohexene (**D**).
Give a reagent for this test and state what you would observe with each compound.

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(3)

(c) Cyclohexanol (**B**) can be converted into cyclohexanone (**C**).

Give a reagent or combination of reagents that can be used for this reaction and state the type of reaction.

State the class of alcohols to which cyclohexanol belongs.

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(d) Cyclohexane (**A**) can be converted into bromocyclohexane (**E**) by a reaction that is similar to the reaction of methane either with chlorine or with bromine.

Name and outline a mechanism for the reaction of methane (CH_4) with bromine to form bromomethane (CH_3Br). Give **one** condition for this reaction to occur.
Write an equation for each step in your mechanism.

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(5)
(Total 15 marks)

4. Pure hydrogen peroxide is a colourless liquid with a boiling point of 150 °C. Hydrogen peroxide was originally produced commercially in a two-stage process. In the first stage barium was heated in air to form barium peroxide. In the second stage barium peroxide was added to aqueous nitric acid. The equations for the reactions are shown below.

Stage **1** $Ba(s) + O_2(g) \longrightarrow BaO_2(s)$

Stage **2** $BaO_2(s) + 2HNO_3(aq) \longrightarrow H_2O_2(aq) + Ba(NO_3)_2(aq)$

(a) Suggest **one** method of separating hydrogen peroxide from the reaction mixture in Stage **2**.

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(1)

(b) Apart from cost, suggest **one** reason why nitric acid was eventually replaced by sulfuric acid in Stage **2**.

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(1)

(c) Suggest **one** reason why infrared spectroscopy could **not** be used to indicate the presence of a small amount of water in hydrogen peroxide.

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(1)

(Total 3 marks)

5. Butan-2-ol can be oxidised by acidified potassium dichromate(VI) to form butanone as shown by the following equation.

$$CH_3CH_2CH(OH)CH_3 + [O] \rightarrow CH_3CH_2COCH_3 + H_2O$$

(a) State the class of alcohol to which butan-2-ol belongs.

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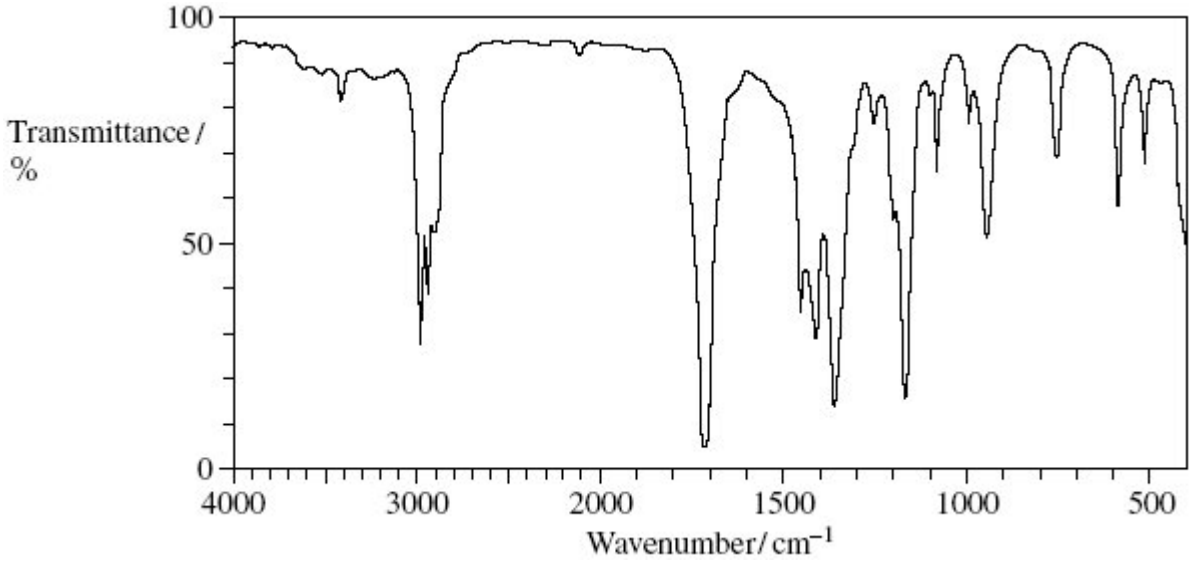
(1)

(b) The infrared spectrum shown below is either that of butan-2-ol or that of butanone.



Identify the compound to which this infrared spectrum refers.

Explain your answer.

You may find it helpful to refer to the table of infrared absorption data on the back of the Periodic Table (**Table 1**).

Identity of the compound .....

Explanation .....

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(3)

(c) Draw the displayed formula of the alcohol C_4H_9OH which is resistant to oxidation by acidified potassium dichromate(VI).

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(1)
(Total 5 marks)

6. (a) Alcohols can be classed as primary, secondary or tertiary. Draw possible structures for a primary, a secondary and a tertiary alcohol which have the molecular formula C_4H_8O.
Which of the structures you have drawn cannot be oxidised by potassium dichromate in acid solution?

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(4)

(b) Explain what is meant by the fingerprint region of an infra-red spectrum. State how it is used to confirm the identity of organic molecules such as the primary, secondary and tertiary alcohols of molecular formula C_4H_8O.

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(2)

(c) Each of the parts below concerns a different pair of isomers. Deduce one possible structural formula for each of the species **A** to **F**. Use, where appropriate, the table of infra-red absorption data given on the data sheet.

(i) **A** and **B** have the molecular formula C_3H_8O. **A** has a broad absorption band at 3300 cm^{-1} in its infra-red spectrum, but **B** does not.

(ii) **C** and **D** have the molecular formula C_5H_{10}. **C** has a weak absorption band at 1650 cm^{-1} in its infra-red spectrum, but **D** does not.

(iii) **E** and **F** have the molecular formula C_3H_6O and both have strong absorption bands at about 1700 cm^{-1} in their infra-red spectra. **E** reacts with Tollens' reagent but **F** does not.

(6)
(Total 12 marks)

7. Suggest **one** reason why Tollens' reagent is used as the oxidising agent in the specific test for aldehydes rather than the less expensive acidified potassium dichromate(VI).

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(Total 1 mark)

8. Some alcohols can be oxidised by an acidified solution of potassium dichromate(VI). Aldehydes can be oxidised by Tollens' reagent or by Fehling's solution.

An unknown pure liquid **A** contains only a single alcohol.
Outline a simple procedure to allow you to determine whether **A** is a primary, a secondary or a tertiary alcohol.

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(Total 3 marks)

9. A sample of an alcohol was thought to be contaminated with an alkene. Give a reagent that could be used to confirm the presence of an alkene. State what you would observe.

Reagent .....

Observation .....

(Total 2 marks)

10. (a) Propanoic acid can be made from propan-1-ol by oxidation using acidified potassium dichromate(VI). Propanal is formed as an intermediate during this oxidation.

(i) State the colour of the chromium species after the potassium dichromate(VI) has reacted.

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(1)

(ii) Describe the experimental conditions and the practical method used to ensure that the acid is obtained in a high yield. Draw a diagram of the assembled apparatus you would use.

Conditions .....

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Apparatus

(4)

(iii) Describe the different experimental conditions necessary to produce propanal in high yield rather than propanoic acid.

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(2)

(b) Propan-1-ol is a volatile, flammable liquid.
Give **one** safety precaution that should be used during the reaction to minimise this hazard.

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(1)

(c) A student followed the progress of the oxidation of propan-1-ol to propanoic acid by extracting the organic compounds from one sample of reaction mixture.

(i) Give a chemical reagent which would enable the student to confirm the presence of propanal in the extracted compounds.
State what you would observe when propanal reacts with this reagent.

Reagent .....

Observation .....

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(2)

(ii) Give a chemical reagent that would enable the student to confirm the presence of propanoic acid in the extracted compounds.
State what you would observe when propanoic acid reacts with this reagent.

Reagent .....

Observation .....

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(2)

(d) Predict which **one** of the compounds, propan-1-ol, propanal and propanoic acid will have the highest boiling point. Explain your answer.

Prediction .....

Explanation .....

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(3)
(Total 15 marks)

11. A student read the following passage on the Internet.

> Haloalkanes contain a polar covalent bond. The carbon atom of the polar covalent bond can be attacked by nucleophiles. Nucleophilic attack enables haloalkanes to undergo substitution reactions.
> A nucleophilic substitution reaction occurs when a haloalkane undergoes hydrolysis; the rate of hydrolysis of the haloalkane is influenced by the carbon–halogen bond enthalpy.

(a) Explain the meaning of each of the following terms in the information given above.

(i) *nucleophile*

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(1)

(ii) *substitution,* as applied to nucleophilic substitution in a haloalkane

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(1)

(iii) *hydrolysis*

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(1)

(iv) *bond enthalpy,* as applied to a carbon–halogen bond.

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(1)

(b) Outline a mechanism for the nucleophilic substitution reaction in which 2-bromopropane ($CH_3CHBrCH_3$) reacts with potassium hydroxide to form propan-2-ol.

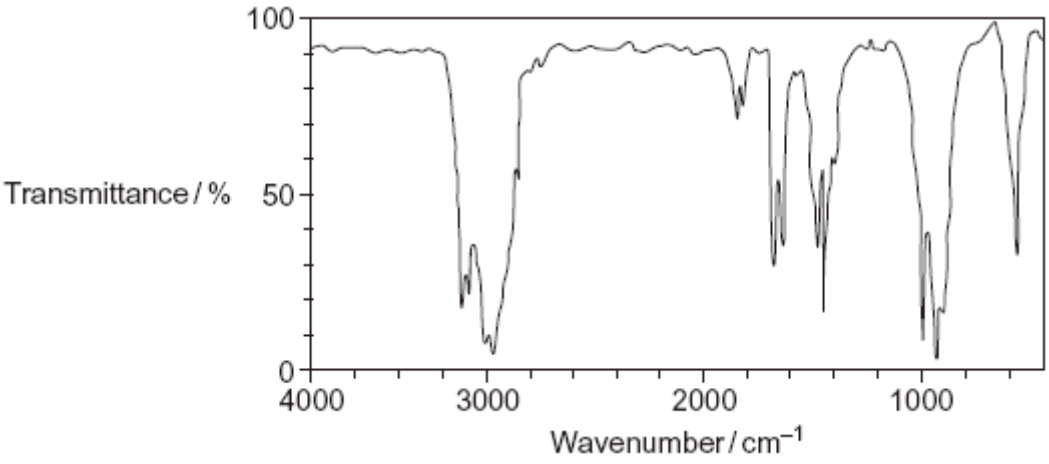
(2)

(c) Haloalkanes also undergo elimination reactions to produce alkenes.

(i) Outline a mechanism for the elimination reaction in which 2-bromopropane reacts with potassium hydroxide to form propene.

(3)

(ii) A student obtained the following infrared spectrum for the product from this elimination reaction.



Use information from the infrared spectrum to state and explain how the student deduced that the product was an alkene.
You may find it helpful to refer to **Table 1** on the Data Sheet.

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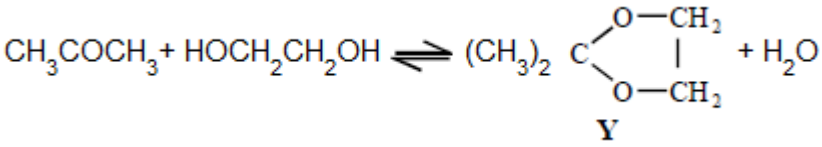
(2)
(Total 11 marks)

12. This question is about the reaction between propanone and an excess of ethane-1,2-diol, the equation for which is given below.



Y

In a typical procedure, a mixture of 1.00 g of propanone, 5.00 g of ethane-1,2-diol and 0.100 g of benzenesulphonic acid, $C_6H_5SO_3H$, is heated under reflux in an inert solvent. Benzenesulphonic acid is a strong acid.

The products would **not** have an absorption in the infra-red at

A 1050 cm^{-1}

B 1720 cm^{-1}

C 2950 cm^{-1}

D 3400 cm^{-1}

(Total 1 mark)

13. Which one of the following statements about but-2-enal, $CH_3CH=CHCHO$, is **not** true?

A It has stereoisomers.

B It shows a strong absorption in the infra-red at about 1700 cm^{-1}.

C It will turn an acidified solution of potassium dichromate(VI) green.

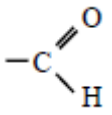
D It can be dehydrated by concentrated sulphuric acid.

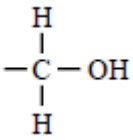
(Total 1 mark)

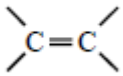
14. Certain chemical tests were performed on the pain-relief drug ibuprofen. The results of these tests are given in the table below.

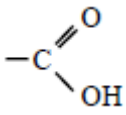
Test	**Result**
Aqueous sodium carbonate	Effervescence
Bromine water	Remained orange
Acidified potassium dichromate(VI) and heat	Remained orange
Fehling's solution and heat	Remained blue

Which one of the following functional groups do these results suggest that ibuprofen contains?

A 

B 

C 

D 

(Total 1 mark)