

Q1. The reactions of molecules containing the chlorine atom are often affected by other functional groups in the molecule.

Consider the reaction of $\text{CH}_3\text{CH}_2\text{COCl}$ and of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ with ammonia.

(a) For the reaction of $\text{CH}_3\text{CH}_2\text{COCl}$ with ammonia, name and outline the mechanism and name the organic product.

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(b) For the reaction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ with an **excess** of ammonia, name and outline the

mechanism and name the organic product.

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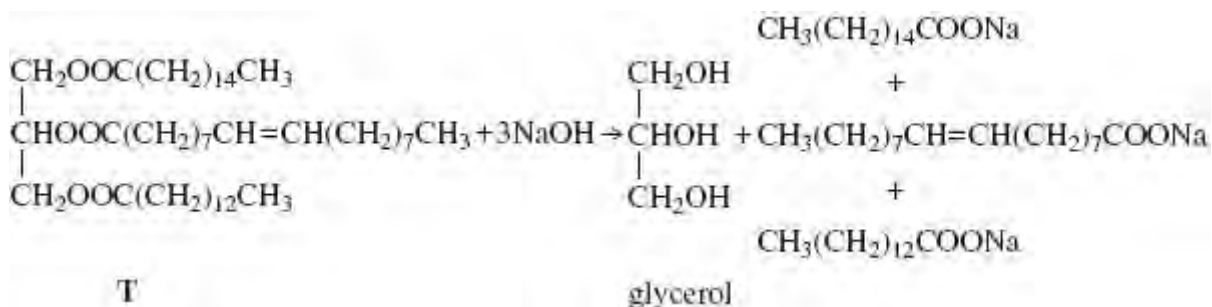
- (c) Suggest **one** reason why chlorobenzene (C₆H₅Cl) does **not** react with ammonia under normal conditions.

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(1)
 (Total 13 marks)

- Q2.** The triester, **T**, shown below is found in palm oil. When **T** is heated with an excess of sodium hydroxide solution, the alcohol glycerol is formed together with a mixture of three other products as shown in the following equation.



- (a) (i) Give the IUPAC name for glycerol.

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(1)

- (ii) Give a use for the mixture of sodium salts formed in this reaction.

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(1)

- (b) When **T** is heated with an excess of methanol, glycerol is formed together with a

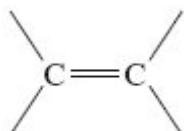
mixture of methyl esters.

- (i) Give a use for this mixture of methyl esters.

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(1)

- (ii) One of the methyl esters in the mixture has the IUPAC name methyl (*Z*)-octadec-9-enoate. Draw **two** hydrogen atoms on the diagram below to illustrate the meaning of the letter *Z* in the name of this ester.



(1)

- (iii) One of the other methyl esters in the mixture has the formula $\text{CH}_3(\text{CH}_2)_{12}\text{COOCH}_3$. Write an equation for the complete combustion of one molecule of this ester.

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(1)

(Total 5 marks)

Q3.(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)

- Q4.** (a) Write an equation for the formation of methyl propanoate, $\text{CH}_3\text{CH}_2\text{COOCH}_3$, from methanol and propanoic acid.

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(1)

- (b) Name and outline a mechanism for the reaction between methanol and propanoyl chloride to form methyl propanoate.

Name of mechanism

Mechanism

(5)

- (c) Propanoic anhydride could be used instead of propanoyl chloride in the preparation of methyl propanoate from methanol. Draw the structure of propanoic anhydride.

(1)

- (d) (i) Give **one** advantage of the use of propanoyl chloride instead of propanoic acid in the laboratory preparation of methyl propanoate from methanol.

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- (ii) Give **one** advantage of the use of propanoic anhydride instead of propanoyl chloride in the industrial manufacture of methyl propanoate from methanol.

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(2)

- (e) An ester contains a benzene ring. The mass spectrum of this ester shows a molecular ion peak at $m/z = 136$.

- (i) Deduce the molecular formula of this ester.

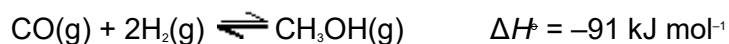
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(ii) Draw **two** possible structures for this ester.

(3)
(Total 12 marks)

Q5. Synthesis gas is a mixture of carbon monoxide and hydrogen. Methanol can be manufactured from synthesis gas in a reversible reaction as shown by the following equation.



(a) A sample of synthesis gas containing 0.240 mol of carbon monoxide and 0.380 mol of hydrogen was sealed together with a catalyst in a container of volume 1.50 dm³. When equilibrium was established at temperature T_1 the equilibrium mixture contained 0.170 mol of carbon monoxide.

Calculate the amount, in moles, of methanol and the amount, in moles, of hydrogen in the equilibrium mixture.

Methanol

Hydrogen

(2)

(b) A different sample of synthesis gas was allowed to reach equilibrium in a similar container of volume 1.50 dm³ at temperature T_1 .

At equilibrium, the mixture contained 0.210 mol of carbon monoxide, 0.275 mol of

hydrogen and 0.0820 mol of methanol.

- (i) Write an expression for the equilibrium constant K_c for this reaction.

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(1)

- (ii) Calculate a value for K_c for the reaction at temperature T_1 and state its units.

Calculation

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Units

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(4)

- (iii) State the effect, if any, on the value of K_c of adding more hydrogen to the equilibrium mixture.

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(1)

- (c) The temperature of the mixture in part (b) was changed to T_2 and the mixture was left to reach a new equilibrium position. At this new temperature the equilibrium concentration of methanol had increased.

Deduce which of T_1 or T_2 is the higher temperature and explain your answer.

Higher temperature

Explanation

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(3)

- (d) The following reaction has been suggested as an alternative method for the production of methanol.



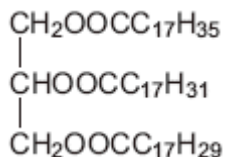
The hydrogen used in this method is obtained from the electrolysis of water.

Suggest **one** possible environmental disadvantage of the production of hydrogen by electrolysis.

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(1)

- (e) One industrial use of methanol is in the production of biodiesel from vegetable oils such as



Give the formula of **one** compound in biodiesel that is formed by the reaction of methanol with the vegetable oil shown above.

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(1)

(Total 13 marks)