Q1. Carbon monoxide and hydrogen are used in the manufacture of methanol. An equilibrium is established according to the following equation.

$$CO(g) + 2H_2(g) \underset{}{\overset{\text{Cu catalyst}}{\rightleftharpoons}} CH_3OH(g) \qquad \Delta H = -9l \text{ kJ mol}^{-1}$$

(a) Give **two** features of a reaction at equilibrium.

Feature 1 .....

.....

Feature 2 .....

.....

(2)

(b) Explain why an increase in temperature causes a decrease in the equilibrium yield of methanol.

.....

.....

.....

(2)

(c) (i) State what is meant by the term *catalyst*.

.....

.....

(1)

(ii) State the effect, if any, of the copper catalyst on the position of this equilibrium at a fixed temperature.

.....

(1)

(d) Two methods are used to produce carbon monoxide from natural gas. Equations for these two methods are shown below.

Method 1 $CH_4 + H_2O \rightarrow 2CO + 3H_2$

Method 2 $CH_4 + CO_2 \rightarrow 2CO + 2H_2$

The manufacture of methanol from these sources of carbon monoxide has been described as carbon neutral.

(i) .....

.....

.....

.....

(1)

(ii) Show how combining the equations from these two methods can lead to the 1:2 mol ratio of carbon monoxide to hydrogen required for this synthesis of methanol.

.....

.....

.....

(1)
(Total 8 marks)

Q2. Many naturally-occurring organic compounds can be converted into other useful products.

(a) Glucose, $C_6H_{12}O_6$, can be fermented to make ethanol, which can then be dehydrated to make the unsaturated compound, ethane.

(i) Write an equation for the fermentation of glucose to form ethanol.

.....

(ii) Identify a catalyst for the dehydration of ethanol to form ethene. Write an equation for this reaction.

Catalyst .....

Equation .....

(3)

(b) Vegetable oils, which contain unsaturated compounds, are used to make margarine. Identify a catalyst and a reagent for converting a vegetable oil into margarine.

Catalyst .....

Reagent .....

(2)

(c) Oleic acid can be obtained from vegetable oils. Oleic acid is an example of an unsaturated compound.

$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$

oleic acid

(i) Deduce the molecular formula and the empirical formula of oleic acid.

Molecular formula .....

Empirical formula .....

(ii) State what is meant by the term *unsaturated*.

.....

(iii) Identify a reagent for a simple chemical test to show that oleic acid is unsaturated. State what you would observe when oleic acid reacts with this reagent.

Reagent ….....

Observation with oleic acid …….....

.....

(5)
(Total 10 marks)

Q3. (a) Ethanol can be manufactured by the direct hydration of ethene and by the fermentation of sugars.

(i) State what is meant by the term *hydration.*

.....

(ii) Give **one** advantage and **one** disadvantage of manufacturing ethanol by fermentation rather than by hydration.

Do **not** include energy consumption or cost.

Advantage .....

.....

Disadvantage .....

.....

(3)

(b) Ethanol can be oxidised to an aldehyde and to a carboxylic acid.

(i) Draw the structure of this aldehyde and of this carboxylic acid.

Structure of aldehyde *Structure of carboxylic acid*

(ii) Give a suitable reagent and reaction conditions for the oxidation of ethanol to form the carboxylic acid as the major product.

Reagent .....

Conditions .....

.....

(5)

(c) (i) Draw the structure of an alcohol containing four carbon atoms which is resistant to oxidation.

(ii) Draw the structure of an alcohol containing four carbon atoms which can be oxidised to a ketone.

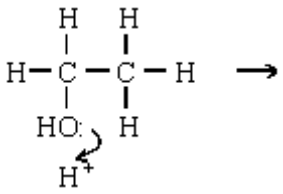
(2)

(d) In the presence of a catalyst, ethanol can be dehydrated to ethene.

(i) Give a suitable catalyst for use in this reaction.

.....

(ii) Complete the mechanism for this dehydration reaction.



(5)
(Total 15 marks)

Q4. Glucose can be used as a source of ethanol. Ethanol can be burned as a fuel or can be converted into ethene.

$C_6H_{12}O_6 \rightarrow CH_3CH_2OH \rightarrow H_2C=CH_2$

glucose ethanol ethene

(a) Name the types of reaction illustrated by the two reactions above.

Glucose to ethanol .....

Ethanol to ethene .....

(2)

(b) (i) State what must be added to an aqueous solution of glucose so that ethanol is formed.

.....

(ii) Identify a suitable catalyst for the conversion of ethanol into ethene.

.....

(2)

(c) (i) State the class of alcohols to which ethanol belongs.

.....

(ii) Give **one** advantage of using ethanol as a fuel compared with using a petroleum fraction.

.....

(2)

(d) Most of the ethene used by industry is produced when ethane is heated to 900°C in the absence of air. Write an equation for this reaction.

.....

(1)

(e) Name the type of polymerisation which occurs when ethene is converted into poly(ethene).

.....

(1)

(Total 8 marks)