MEGA LECTURE

A-LEVEL CHEMISTRY

ASSESSMENT POINT 2

PAPER 2

(TOPICS 11, 16, 17, 18 and 19)

Answer all questions

Max 80 marks

Name ……
Mark ……../80 ……..% Grade ……

1. The manufacture of methanol can be achieved in two stages.

(a) In the first stage, methane and steam react according to the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +210 \text{ kJ mol}^{-1}$$

Discuss, with reasons, the effects of increasing separately the temperature and the pressure on the yield of the products and on the rate of this reaction.

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(6)
(Total 6 marks)

2. 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.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H^{\ominus} = -91 \text{ kJ mol}^{-1}$$

(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 dm^3.
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 .....
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Hydrogen .....
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(2)

(b) A different sample of synthesis gas was allowed to reach equilibrium in a similar container of volume 1.50 dm^3 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 .....
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Explanation .....
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(3)

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

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

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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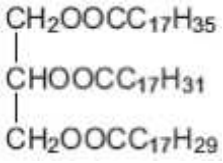
(1)

(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)

3. The initial rate of the reaction between the gases NO and H_2 was measured in a series of experiments at a constant temperature and the following rate equation was determined.

$$\text{rate} = k[NO]^2[H_2]$$

(a) Complete the table of data below for the reaction between NO and H_2

Experiment	Initial [NO] / mol dm^{-3}	Initial [H_2] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	3.0×10^{-3}	1.0×10^{-3}	1.8×10^{-5}

2	3.0×10^{-3}		7.2×10^{-5}
3	1.5×10^{-3}	1.0×10^{-3}	
4		0.50×10^{-3}	8.1×10^{-5}

(3)

(b) Using the data from experiment 1, calculate a value for the rate constant, *k*, and state its units.

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(3)
(Total 6 marks)

4. An experiment was carried out to determine the equilibrium constant, K_c, for the following reaction.

$$CH_3CH_2COOH + CH_3CH_2CH_2OH \rightleftharpoons CH_3CH_2COOCH_2CH_2CH_3 + H_2O$$

A student added measured volumes of propan-1-ol and propanoic acid to a conical flask. A measured volume of concentrated hydrochloric acid was added to the flask, which was then sealed.

After 1 week, the contents of the flask were poured into water and the solution was made up to a known volume.
This solution was titrated with standard sodium hydroxide solution.

(a) Explain how the student could determine the amount, in moles, of propan-1-ol added to the flask.

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(2)

(b) The titration described above gives the total amount of acid in the equilibrium mixture.
Explain how, by carrying out a further experiment, the student could determine the amount of propanoic acid in the equilibrium mixture.

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(2)

(c) In a repeat experiment, the student failed to seal the flask that contained the equilibrium mixture.

Explain why this error would lead to the student obtaining an incorrect value for the equilibrium constant K_c

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(2)
(Total 6 marks)

5. Outline a mechanism for the reaction of $CH_3CH_2CH_2CHO$ with HCN and name the product.

Mechanism

Name of product .....
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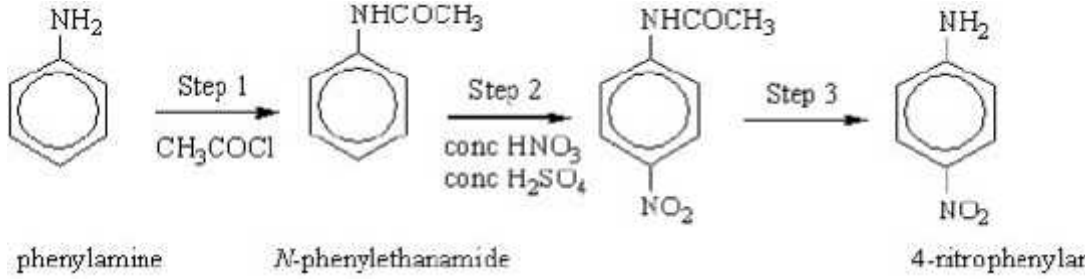
(5)
(Total 5 marks)

6. Synthetic dyes can be manufactured starting from compounds such as 4-nitrophenylamine.

A synthesis of 4-nitrophenylamine starting from phenylamine is shown below.



(a) equation for formation of *N*-phenylethanamide in Step 1 of the synthesis is shown below.

$$2C_6H_5NH_2 + CH_3COCl \rightarrow \underset{N\text{-phenylethanamide}}{C_6H_5NHCOCH_3} + C_6H_5NH_3Cl$$

(i) Calculate the % atom economy for the production of *N*-phenylethanamide
(M_r = 135.0).

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(ii) In a process where 10.0 kg of phenylamine are used, the yield of *N*-phenylethanamide obtained is 5.38 kg.

Calculate the percentage yield of *N*-phenylethanamide.

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(iii) Comment on your answers to parts (i) and (ii) with reference to the commercial viability of the process.

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(7)

(b) Name and outline a mechanism for the reaction in Step 1.

Name of mechanism……

Mechanism:

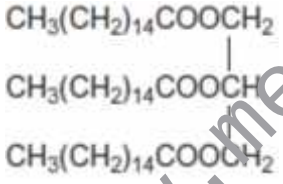
(5)

(c) The mechanism of Step 2 involves attack by an electrophile. Write an equation showing the formation of the electrophile. Outline a mechanism for the reaction of this electrophile with benzene.

(4)
(Total 16 marks)

7. The slowing down of chemical processes is important in food storage. Over time, fats may become rancid. This involves the formation of compounds that have unpleasant odours and flavours within the food.
Hydrolysis of fats is one way in which rancid flavours are formed. Fats break down to long-chain carboxylic (fatty) acids and glycerol.

(a) Complete the right-hand side of the equation below to show how hydrolysis affects the molecule of fat shown.



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+ $3H_2O$ 3 ..... + ...

(2)

(b) Other than by cooling, suggest **one** method that would decrease the rate of hydrolysis of fats.

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(1)

(c) Food can also acquire unpleasant flavours when the fatty acids, produced by hydrolysis of fats, are oxidised by air. This oxidation occurs by a free-radical mechanism.
Chemicals called anti-oxidants can be added to food to slow down the oxidation.
Suggest why anti-oxidants are **not** regarded as catalysts.

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(2)

(d) A student investigated the extent of hydrolysis in an old sample of the fat in part (a).
The carboxylic acid extracted from a 2.78 g sample of this fat (M_r = 806.0) reacted with 24.5 cm^3 of a 0.150 mol dm^{-3} solution of NaOH.
Calculate the percentage of the fat that had hydrolysed.
Show your working.

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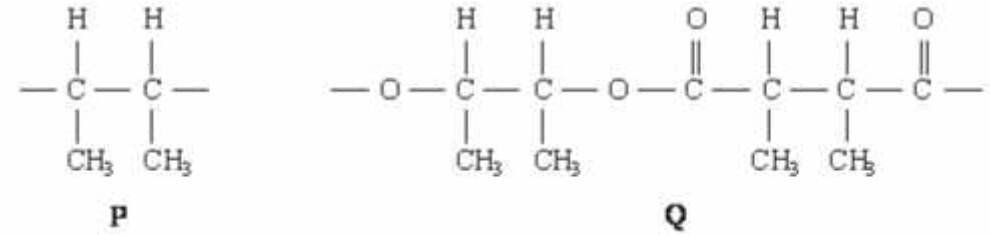
(4)
(Total 9 marks)

8. (a) The repeating units of two polymers, **P** and **Q**, are shown below.



P **Q**

(i) Draw the structure of the monomer used to form polymer **P**. Name the type of polymerisation involved.

Structure of monomer

Type of polymerisation .....

(ii) Draw the structures of **two** compounds which react together to form polymer **Q**. Name these **two** compounds and name the type of polymerisation involved.

Structure of compound 1

Name of compound 1 .....

Structure of compound 2

Name of compound 2 .....

Type of polymerisation .....

(iii) Identify a compound which, in aqueous solution, will break down polymer **Q** but not polymer **P**.

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(8)

(b) Draw the structures of the **two** dipeptides which can form when one of the amino acids shown below reacts with the other.

Structure 1 *Structure 2*

(2)

(c) Propylamine, $CH_3CH_2CH_2NH_2$, can be formed either by nucleophilic substitution or by reduction.

(i) Draw the structure of a compound which can undergo nucleophilic substitution to form propylamine.

(ii) Draw the structure of the nitrile which can be reduced to form propylamine.

(iii) State and explain which of the two routes to propylamine, by nucleophilic substitution or by reduction, gives the less pure product. Draw the structure of a compound formed as an impurity.

Route giving the less pure product .....

Explanation ....

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Structure of an impurity

(5)
(Total 15 marks)

9. (a) During the preparation of aspirin, it is necessary to filter the crude product under reduced pressure.

Draw a diagram to show the apparatus you would use to filter the crude product under reduced pressure. (Do **not** include the vacuum pump.)

(2)

(b) You are provided with a small sample of pure aspirin in a melting point tube. Describe briefly how you would determine an accurate value for the melting point of aspirin.

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(2)
(Total 4 marks)