MEGA LECTURE

A-LEVEL CHEMISTRY

ASSESSMENT POINT 1

PAPER 2

(TOPICS 11, 16 and 17)

Answer all questions

Max 80 marks

Name ……
Mark ……../80 ……..% Grade ……

1. Gases **A** and **B** react as shown in the following equation.

$$2\mathbf{A}(g) + \mathbf{B}(g) \rightarrow \mathbf{C}(g) + \mathbf{D}(g)$$

The initial rate of the reaction was measured in a series of experiments at a constant temperature. The following rate equation was determined.

$$\text{rate} = k[\mathbf{A}]^2$$

An incomplete table of data for the reaction between **A** and **B** is shown in the table.

Experiment	Initial [A] / mol dm^{-3}	Initial [B] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	4.2×10^{-3}	2.8×10^{-3}	3.3×10^{-5}
2	7.9×10^{-3}	2.8×10^{-3}	
3		5.6×10^{-3}	1.8×10^{-4}

(a) Use the data from Experiment **1** to calculate a value for the rate constant, *k*, at this temperature.
Deduce the units of *k*.

Calculation .....
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Units .....
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(3)

(b) Use your value of *k* from (a) to complete the table for the reaction

between **A** and **B**.
(If you have been unable to calculate an answer for (a), you may assume a value of 2.3. This is **not** the correct answer.)

(2)

(c) The reaction is zero order with respect to **B**.

State the significance of this zero order for the mechanism of the reaction.

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(1)
(Total 6 marks)

2. (a) Compound **A**, $HCOOCH_2CH_2CH_3$, is an ester. Name this ester and write an equation for its reaction with aqueous sodium hydroxide.

Name

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Equation .....
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(2)

(b) The initial rate of reaction between ester **A** and aqueous sodium hydroxide was measured in a series of experiments at a constant temperature. The data obtained are shown below.

Experiment	Initial concentration of NaOH / mol dm^{-3}	Initial concentration of **A** / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.040	0.030	4.0×10^{-4}
2	0.040	0.045	6.0×10^{-4}
3	0.060	0.045	9.0×10^{-4}
4	0.120	0.060	to be calculated

Use the data in the table to deduce the order of reaction with respect

to **A** and the order of reaction with respect to NaOH. Hence calculate the initial rate of reaction in Experiment 4.

Order with respect to

A .....

Order with respect to

NaOH .....

Initial rate in Experiment

4 .....

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(3)

(c) In a further experiment at a different temperature, the initial rate of reaction was found to be 9.0×10^{-3} mol dm^{-3} s^{-1} when the initial concentration of **A** was 0.020 mol dm^{-3} and the initial concentration of NaOH was 2.00 mol dm^{-3}.
Under these new conditions with the much higher concentration of sodium hydroxide, the reaction is first order with respect to **A** and appears to be zero order with respect to sodium hydroxide.

(i) Write a rate equation for the reaction under these new conditions.

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(ii) Calculate a value for the rate constant under these new conditions and state its units.

Calculation .....
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Units .....
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(iii) Suggest why the order of reaction with respect to sodium hydroxide appears to be zero under these new conditions.

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(6)
(Total 11 marks)

3. (a) The data in the following table were obtained in two experiments about the rate of the reaction between substances **B** and **C** at a constant temperature.

Experiment	Initial concentration of **B** / mol dm^{-3}	Initial concentration of **C** / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	4.2×10^{-2}	2.6×10^{-2}	8.4×10^{-5}
2	6.3×10^{-2}	7.8×10^{-2}	To be calculated

The rate equation for this reaction is known to be

rate = k[**B**]^2[**C**]

(i) Use the data from Experiment **1** to calculate a value for the rate constant k at this temperature and deduce its units.

Calculation .....
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Units .....
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(3)

(ii) Calculate a value for the initial rate in Experiment **2**.

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(1)

(b) The data in the following table were obtained in a series of experiments about the rate of the reaction between substances **D** and **E** at a constant temperature.

Experiment	Initial concentration of **D** / mol dm $^{-3}$	Initial concentration of **E** / mol dm $^{-3}$	Initial rate /mol dm $^{-3}$ s $^{-1}$
3	0.13	0.23	0.26×10^{-3}
4	0.39	0.23	2.34×10^{-3}
5	0.78	0.46	9.36×10^{-3}

(i) Deduce the order of reaction with respect to **D**.

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(1)

(ii) Deduce the order of reaction with respect to **E**.

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(1)

(c) The compound $(CH_3)_3CBr$ reacts with aqueous sodium hydroxide as shown in the following equation.

$$(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$$

This reaction was found to be first order with respect to $(CH_3)_3CBr$ but zero order with respect to hydroxide ions.

The following two-step process was suggested.

Step **1** $(CH_3)_3CBr \rightarrow (CH_3)_3C^+ + Br^-$

Step **2** $(CH_3)_3C^+ + OH^- \longrightarrow (CH_3)_3COH$

(i) Deduce the rate-determining step in this two-step process.

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(1)

(ii) Outline a mechanism for this step using a curly arrow.

(1)
(Total 8 marks)

4. (a) Addition reactions to both alkenes and carbonyl compounds can result in the formation of isomeric compounds.

(i) Choose an alkene with molecular formula C_4H_8 which reacts with HBr to form two structural isomers. Give the structures of these two isomers and name the type of structural isomerism shown.

Outline a mechanism for the formation of the major product.

(ii) Using HCN and a suitable carbonyl compound with molecular formula C_3H_6O, outline a mechanism for an addition reaction in which two isomers are produced.
Give the structures of the two isomers formed and state the type of isomerism shown.

(14)

(b) Explain why ethanoyl chloride reacts readily with nucleophiles.
Write an equation for one nucleophilic addition–elimination reaction of ethanoyl chloride.
(A mechanism is not required.)

(4)
(Total 18 marks)

5. (a) Name the compound $(CH_3)_2NH$

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(1)

(b) $(CH_3)_2NH$ can be formed by the reaction of an excess of CH_3NH_2 with

CH_3Br. Name and outline a mechanism for this reaction.

Name of mechanism .....

Mechanism

(5)

(c) Name the type of compound produced when a large excess of CH_3Br reacts with CH_3NH_2 Give a use for this type of compound.

Type of compound .....

Use .....

(2)

(d) Draw the structures of the two compounds formed in the reaction of CH_3NH_2 with ethanoic anhydride.

(2)
(Total 10 marks)

6. (a) A flask containing a mixture of 0.200 mol of ethanoic acid and 0.110 mol of ethanol was maintained at 25 °C until the following equilibrium had been established.

$$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

The ethanoic acid present at equilibrium required 72.5 cm^3 of a 1.50 mol dm^{-3} solution of sodium hydroxide for complete reaction.

(i) Calculate the value of the equilibrium constant, K_c, for this reaction at 25 °C.

(ii) The enthalpy change for this reaction is quite small. By reference to the number and type of bonds broken and made, explain how this might have been predicted

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(9)

(b) Aspirin can be prepared by acylation using either ethanoyl chloride or ethanoic anhydride, as represented by the equations shown below.

$CH_3COCl + HOC_6H_4COOH \rightarrow CH_3COOC_6H_4COOH + HCl$

$(CH_3CO)_2O + HOC_6H_4COOH \rightarrow CH_3COOC_6H_4COOH + CH_3COOH$

(i) By a consideration of the intermolecular forces involved, explain why the product HCl is a gas but the product CH_3COOH is a liquid at room temperature.

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(iii) Give **two** industrial advantages of using ethanoic anhydride rather than ethanoyl chloride in the manufacture of aspirin.

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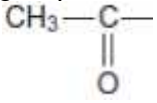
(4)
(Total 13 marks)

7. The triiodomethane reaction is often used as a test for aldehydes and ketones that contain the CH_3CO group shown.



The aldehyde or ketone is reacted with an alkaline solution of iodine. Triiodomethane (CHI_3) is formed as a precipitate. Compounds that contain a group that can be oxidised to the CH_3CO group will also give a positive result in this test.

(a) State, with a reason, whether or not ethanol will give a positive result in the triiodomethane reaction.

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(1)

(b) The equation for the reaction of ethanal with an alkaline solution of iodine is

$CH_3CHO + 3I_2 + 4NaOH \longrightarrow CHI_3 + HCOONa + 3NaI + 3H_2O$

In an experiment using this reaction, the yield of triiodomethane (CHI_3) obtained by a student was 83.2%.

Calculate the minimum mass of iodine that this student would have used to form 10.0 g of triiodomethane.
Give your answer to the appropriate precision.
Show your working.

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(5)

(c) Triiodomethane can be separated from the reaction mixture by filtration.
State **one** reason why the solid residue is then washed with water after the filtration.

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(1)

(d) State **one** reason, other than cost or availability, why water is suitable for washing this solid residue after the filtration.

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(1)
(Total 8 marks)

8. Salicylic acid, $C_6H_4(OH)COOH$, reacts with magnesium to produce magnesium salicylate and hydrogen.

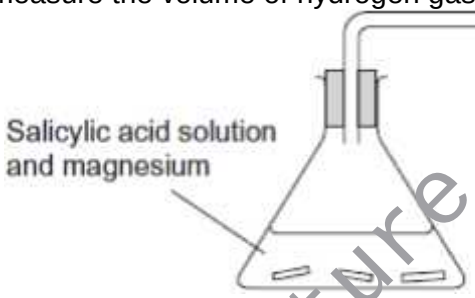
(a) Complete the equation for this reaction.

$C_6H_4(OH)COOH$

(1)

(b) In an alternative method for determining percentage purity, a student reacted a solution of salicylic acid with an excess of magnesium and collected the hydrogen gas that was released.

Complete the diagram below to show an apparatus that could be used to collect and measure the volume of hydrogen gas produced.



(1)
(Total 2 marks)

9. Ethanoic acid, propyl ethanoate and propan-1-ol are all colourless liquids. Esters do **not** give a positive result with any of the usual tests for functional groups.

State how you could use chemical tests to show the presence of ethanoic acid and propan-1-ol in a mixture of the acid, the alcohol and the ester.

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(Total 4 marks)