

**W1-2-60-1-6**

**JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY**

**UNIVERSITY EXAMINATIONS 2014/2015**

**YEAR II SEMESTER I EXAMINATION FOR THE BACHELOR OF SCIENCE IN BIOTECHNOLOGY**

**HBB 2204: CHEMICAL KINETICS IN BIOENGINEERING**

**DATE: APRIL, 2015 TIME: 2 HOURS**

**INSTRUCTIONS: Answer Question ONE (Compulsory) and any TWO other questions**

**Question One**

a) Explain what is meant by rate of reaction. [1 mark]

b) Consider the reaction



Suppose that at particular moment during the reaction, N2O5 is being formed at a rate

of 0.048ms-1 .

1. Write the rate expression in terms of the disappearance of the reactants NO2 and O2 and the appearance of the product N2O5. [3 marks]
2. What is the overall rate? [2 marks]
3. At what rate is O2 reacting. [2 marks]
4. At what rate is NO2 reacting [2 marks]

c) The reaction of nitric oxide with hydrogen at 1280oC is



From, the following data collected at this temperature, determine;

1. the rate raw [10 marks]
2. the rate constant [3 marks]
3. the rate of reaction when [NO]=13.0 x 10-3m and [H2]=6.0 x10-3M [2 marks]

Data

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment | [NO] (M) | [H2] (M) | Initial rate (ms-1) |
| 1 | 10.0x10-3 | 2.0x10-3 | 5.0x10-5 |
| 2 | 10.0x10-3 | 4.0x10-3 | 10.0x10-5 |
| 3 | 14.0x10-3 | 2.0x10-3 | 9.8x10-5 |

d) The decomposition of ethane (C2H6) to methyl radicals is first order reaction with a rate constant of 5.36 x 10-4s-1 at 700oC



Calculate the half-life of the reaction in minutes. [5 marks]

**Question Two (20 Marks)**

a) Discuss the effect of temperature of the rate of reaction. [4 marks]

b) Rate constants for the decomposition of acetaldehyde



were measure at five different temperatures as shown in the table below.

|  |  |
| --- | --- |
| K() | T(K) |
| 0.011 | 700 |
| 0.035 | 730 |
| 0.105 | 760 |
| 0.343 | 790 |
| 0.789 | 810 |

Use this data to plot lnK versus  and determine the activation energy in (kJmol-1) for the reaction. (Note the reaction is  order in CH3CHO, so K has units of ).

[10 marks]

c) The gas phase decomposition of nitrous oxide (N2O) is believed to occur via two elementary steps.

Step 1 

Step 2 

Experimentally, the rate law is found to be rate

Rate = K[N2O]

1. Write the equation for the overall reactions [3 marks]
2. Identify the intermediates [2 marks]
3. What can you say about the relative rates of steps 1 and 2. [1 mark]

**Question Three (20 Marks)**

a) For the decomposition of acetone dicarboxylic acid K=2.46 x 10-5s-1 at 273k and

1.63 x 10-3S-1 at 303k. Calculate the energy of activation of the reaction. [5 marks]

b) If a first order reaction has an activation energy of 104500 Jmol-1 and pre-exponential factor A in the Arrhenius equation has a value of 5.0 x1013s1, at what temperature will the reaction have a half-life of:

1. 1 minute [4 marks]
2. 30 days [4 marks]

c) Show that for a first order reaction, the time required for 99.9% completion of the reaction is 10 times the time for 50% completion. [7 marks]

**Question Four (20 Marks)**

a) What is meant by a reaction of second order? [1 mark]

b) Starting with equal concentration of ethyl acetate and sodium hydroxide, the saponification of ethyl acetate was carried out. Same volume of the reaction mixture was withdrawn at different intervals of time and titrated with the same acid.

The following data were obtained:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time(min): | 0 | 5 | 15 | 25 |
| Acid used : | 16 | 10.24 | 6.13 | 4.32 |

Show that the reaction is of the second order. [9 marks]

c) A second order reaction in which the initial concentration of both the reactions are same is 25% complete in 600 sec. How long will it take for a reaction to go to 75% completion.

[10 marks]