# Review Problems – Chemical Kinetics

1. For the reaction given below, what is the instantaneous rate for each of the reactants and products?

3 A + 2 B 🠆 4 C revise

2. Given the following experimental data, find the rate law and the rate constant for the reaction:



NO (g) + NO2 (g) + O2 (g) 🠆 N2O5 (g)

Run [NO]o , M [NO2]o , M [O2]o , M Initial Rate, Ms-1

1 0.10 M 0.10 M 0.10 M 2.1 x 10-2

2 0.20 M 0.10 M 0.10 M 4.2 x 10-2

3 0.20 M 0.30 M 0.20 M 1.26 x 10-1

4 0.10 M 0.10 M 0.20 M 2.1 x 10-2

3. The half-life of a radioisotope is found to be 4.55 minutes. If the decay follows first order kinetics, what percentage of isotope will remain after 2.00 hours?

4. The mechanism of a reaction is shown below.

a) What is the overall reaction?

b) Which compounds are intermediates?

c) Predict the rate law based on this mechanism.

d) What is the overall order of the reaction?

HOOH + I¯ 🠆 HOI + OH¯ (slow)

HOI + I¯ 🠆 I2 + OH¯ (fast)

2OH¯ + 2H3O+ 🠆 4 H2O (fast)

5. For the reaction A + B 🠆 C, the rate constant at 215 oC is 5.0 x 10-3 and the rate constant at 452o C is 1.2 x 10-1.

a) What is the activation energy in kJ/mol?

b) What is the rate constant at 100o C?

6. The following data was collected for the reaction

OH- + CH3COOCH2CH3→ CH3COO­- + CH3CH2OH

|  |  |  |
| --- | --- | --- |
| Time, min | [CH3COOCH2CH3] | [OH-] |
| 0 | 0.02000 | 0.02000 |
| 5 | 0.01280 | 0.01280 |
| 12 | 0.00766 | 0.00766 |
| 25 | 0.00540 | 0.00540 |
| 35 | 0.00426 | 0.00426 |
| 55 | 0.00289 | 0.00289 |
| 120 | 0.00137 | 0.00137 |

Determine the overall order of reaction and write the rate law. What are the units on k? You do not need to solve for k.

7. In the reaction N2O5 → N2O4 + 1/2O2, the N2O5 decomposes by a first order mechanism. At 298K, the half-life is 340 minutes. Find the value of the reaction rate constant. Calculate the number of minutes required for the reaction to proceed to 70% completion.

8. The rate of the reaction

OH- + CH3COOCH2CH3→ CH3COO­- + CH3CH2OH

Was measured at several temperatures and the following data were collected.

|  |  |
| --- | --- |
| Temperature (°C) | k (M-1s-1) |
| 15 | 0.0521 |
| 25 | 0.101 |
| 35 | 0.184 |
| 45 | 0.332 |

Using these data, construct a graph of ln k vs 1/T. Using your graph, determine the value of Ea.

9. Given the equation H2S+ Cl2 → S + 2H+ + 2Cl-, where the rate of reaction is first order in each reactant and the rate constant for the disappearance of H2S at 28°C is

3.5E-2 M-1s-1, find the rate of formation of Cl- when the concentration of H2S is 1.6E-4 M and the concentration of Cl2 is 0.070 M.

10. Consider the two-step mechanism for the low-temperature reaction between CO and NO2.

NO2 + NO2 → NO3 + NO (slow)

CO + NO3 → CO2 + NO2 (fast)

CO + NO2 → CO2 + NO

Obtain the rate law corresponding to this mechanism.

11. The reaction between nitric oxide and chlorine is believed to proceed via a two-step mechanism:

NO + Cl2 → NOCl2 (fast)

NOCl2 + NO →2NOCl (slow)

2NO + Cl2 → 2NOCl2

Write the overall rate law for this reaction. (No intermediates are allowed in the rate law)

12. In the first order decomposition of acetone at 500°C,

CH3OCH3 → product

it is found that the concentration of acetone is 0.0300 M after 200 min and 0.0200 M after 400 min. Calculate the rate constant, the half life, and the initial concentration.

13. The decomposition of nitrosyl chloride

NOCl→NO + 1/2 Cl2

is a second order reaction. If it takes 0.20 min to decompose 15% of a 0.300 M solution of nitrosyl chloride, what is k for the reaction?

14. For the decomposition of HI, the activation energy is 182 kJ/mol. The rate constant at 850°C is 0.0174 L/mol h. What is the rate constant at 700°C? At what temperature will the rate constant be 1/4 of what it is at 850°C?

15. On the graph below, label the **A**) activation energy, **B**)the change in energy of the reaction, **C**) the reactants, **D**) the products, **E**) the activated complex, and **F**) tell whether the reaction is exothermic or endothermic.

**Answers:**

1. don’t worry about this problem

2. Rate = k[NO] [NO2] k = 2.1 M-1s-1

3. k = 0.152 min-1 At = 1.15 x 10-6 % (not much!!)

4. a) Overall reaction: HOOH + 2 I¯ + 2 H3O+ 🠆 I2 + 4 H2O

b) Intermediates: OH¯ and HOI

c) Predicted mechanism: Rate = k [HOOH][I¯ ]

d) Overall order: 2nd order

5. a) 39.4 kJ/mol

b) 2.50 x 10-4 s-1

6. second order, L/mol●s

7. 2.04E-3, 590

8. 47.5 kJ/mol

9. 7.8 x 10-7 M/s

10. rate = k[NO2]2

11. rate = k[NO]2[Cl2]

12. 2.03x10-3 min-1, 342,0.0450

13. 2.9 L/mol●min

14. 8.61x10-4 L/mol h, 775°C

15. You’re on your own.