Chemistry 1210 Spring 2024 Test 1

Friday, February 2, 2024 Time: 1 hour 50 minutes

Name: _____ Student #: _____

*This test consists of **nine** pages of questions, the formula sheet, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **35.5** marks available. Good luck!*

1) **[9.5 marks total]** For the reaction

$3A + 2B \longrightarrow C + 6D$

The following data were collected:

Run	[A] (M)	[B] (M)	$\frac{\Delta[B]}{\Delta t}(\frac{M}{s})$
1	0.1	0.2	-5.091×10^{-5}
2	0.2	0.2	-1.440×10^{-4}
3	0.3	0.3	-3.240×10^{-4}

a) **[2 marks]** Determine the rate law for the reaction.

b) **[3 marks]** Determine the rate constant for the reaction. Include units.

c) **[1 mark]** What will be the value of $\frac{\Delta[D]}{\Delta t}$ (in M/s) in run 3?

d) **[2 marks]** This reaction cannot occur in a single step. Give two reasons why.

e) **[0.5 marks]** What is the overall order of the reaction kinetics?

f) **[1 mark]** What is the order of the reaction kinetics with respect to compound C? How do you know? (No marks for guessing. ☺)

2) **[10 marks total]** The following mechanism has been proposed for the decomposition of ozone in the atmosphere:

$$Cl\cdot + O_3 \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ClO\cdot + O_2 \quad \text{(fast)}$$

$$ClO\cdot + O_3 \xrightarrow{k_3} Cl\cdot + 2O_2 \quad \text{(slow)}$$

a) **[1 mark]** What is the overall reaction for the decomposition of ozone?

b) **[0.5 marks]** Are there any catalysts? If so, what are they?

c) **[0.5 marks]** Are there any reactive intermediates? If so, what are they?

d) **[1 mark]** If you add more ozone (O_3) to the reaction above, the rate will increase, but past a certain amount of added ozone the rate will not increase any more. Why? (No marks for guessing. ☺)

e) **[2 marks]** What rate law is predicted by the mechanism?

f) **[1 mark]** If the experimental rate law was determined to be rate = $k[O_3][O_2]^{-1}$, would the mechanism above be "good"? How do you know? (No marks for guessing. ☺)

g) **[4 marks]** Sketch (not necessarily to scale) the energy diagram for the mechanism above. On your graph, be sure to include:

i) **[0.5 marks]** Proper axes labels with appropriate units.
ii) **[2 marks]** The appropriate number of energy barriers.
iii) **[0.5 marks]** The appropriate relative heights for the energy barriers.
iv) **[0.5 marks]** A label for the forward activation energy for each step.
v) **[0.5 marks]** The proper relative energies of reactants and products for each step. Assume that both steps are exothermic.

3) **[2 marks]** For a certain reaction, a plot of lnk vs. 1/T was made. The y-intercept was found to be 21.4313, and the slope was -6013.62 K. Determine the rate constant for the reaction at 26.85°C, including units for the rate constant. Assume the reaction is first order.

4) **[2 marks]** A certain reaction runs 1.90909 times faster at 36.85°C than it does at 26.85°C. What is the energy of activation for the reaction? Give your answer in kJ/mol.

5) **[3 marks]** For a certain reaction a plot of $1/[A]_t$ vs. t resulted in a straight line with a slope of 0.25 $M^{-1}s^{-1}$ and a y-intercept of 10 M^{-1}. Find the half-life of the reaction.

6) **[2 marks]** The (radioactive) breakdown of elements follows first-order kinetics. One element that breaks down this way is Technitium-96, which has a half-life of 4.3 days. How many hours will it take for 10 percent of a sample of Technitium-96 to break down?

7) **[1 mark]** Write a reaction for which the equilibrium expression is $K = P_{CO2,e}$.

8) **[6 marks]** For the reaction:

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$ $\quad K_p = 9.4 \times 10^{88}$ at 250°C

a) Calculate K_c at 250°C

b) Calculate the value of K_p for the reaction

$2NO(g) + 3H_2O(l) \rightleftharpoons 2NH_3(g) + 2.5O_2(g)$

c) Given the additional reaction

$2H_2O(l) \rightleftharpoons 2H_2(g) + O_2(g)$ $\quad K_p = 9.8 \times 10^{-41}$ at 250°C

Calculate K_p for the reaction

$4NH_3(g) + 2O_2(g) \rightleftharpoons 4NO(g) + 6H_2(g)$