ACTIVITY/WORKSHOP on KINETICS & EQUILIBRIUM. NAME:_____

1. Consider the following data obtained at 300 K for the following reaction:

$$2NO_2(g) + O_3(g) \rightarrow N_2O_5(g) + O_2(g)$$

Experiment	Initial $[NO_2]$ (M)	Initial $[O_3]$ (M)	Initial Rate (M/s)
1	0.65	0.80	2.61×10^4
2	1.10	0.80	4.40×10^4
3	1.70	1.55	1.32×10^5

A. Determine the rate law for this reaction.

B. Calculate the value of the rate constant, making sure to include the proper units.

C. How is the average rate of appearance of N_2O_5 (g) related to the average rate of disappearance of NO_2 (g)? If the rate of disappearance of NO_2 (g) is 3.71×10^5 M/s, what is the value of the rate of appearance of N_2O_5 (g)?

2. Consider the following reaction along with pertinent kinetic data shown below:

$$BrO_3^-(aq) + 9I^-(aq) + 6H^+(aq) \rightarrow 3I_3^-(aq) + Br^-(aq) + 3H_2O(l)$$

$[BrO_3^-]_o$	$[I^-]_o$	$[H^+]_o$	Initial Rate
0.10 M	0.10 M	0.10 M	3.00×10^{-4} M/s
0.18 M	0.14 M	0.10 M	7.56×10^{-4} M/s
0.18 M	0.10 M	0.10 M	5.40×10^{-4} M/s
0.18 M	0.31 M	0.20 M	1.67×10^{-3} M/s
0.55M	0.35M	0.05M	?

A. Determine the rate law for this reaction.

B. What is the value of the rate constant for the first set of data? Make sure to include the proper units!

C. What would be the initial rate for row 5?

3. The rate constant for the second-order reaction between CH_3CH_2Br and OH^- in water is 2.8×10^{-4} L mol^{-1} s^{-1} at 35.0°C. The value of the rate constant for this same reaction is 1.4×10^{-3} L mol^{-1} s^{-1} at 50.0°C. Determine the energy of activation for this process.

4. Soil near the Rocky Flats Nuclear Processing Facility in Colorado was found to be contaminated with radioactive plutonium-239, which has a half-life of 2.4×10^4 years. The soil was loaded into drums for storage. How many years must pass before the radioactivity drops to 20% of its initial value assuming first-order kinetics?

5. In the reaction $3ClO^-(aq) \rightarrow 2Cl^-(aq) + ClO_3^-(aq)$, the rate of formation of Cl^- is 3.6 mol L^-1 s^{-1}. What is the rate of reaction of ClO^-?

6. Butadiene can undergo the following reaction to form a dimer (two butadiene molecules hooked together):

$$2C_4H_8(g) \rightarrow C_8H_{16}(g)$$

The reaction is second-order with a half-life of 5.92×10^{-2} s at a given temperature.

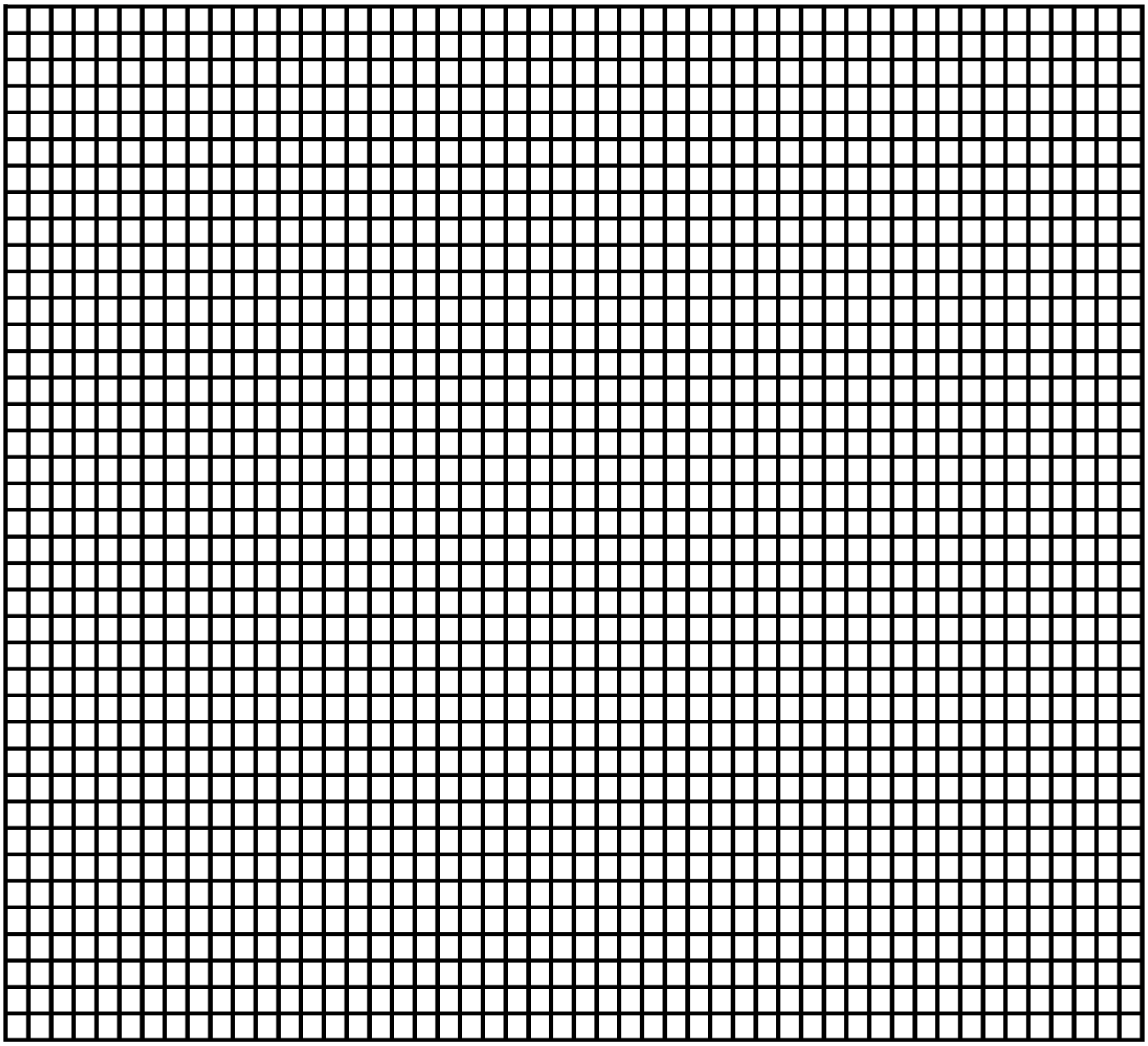
a) If the initial concentration of C_4H_8 is 0.50 M, what is the rate constant for the reaction?

b) If the initial concentration of C_4H_8 is 0.010 M, what will be the concentration of C_4H_8 after 3.6×10^2 s?

7. You gather the following data showing the effect of temperature on the rate constant of a reaction:

Temperature (K)	Rate Constant (s^{-1})
300	0.0134
310	0.0407
320	00.114
330	00.303
340	00.757

Determine the value of the energy of activation (E_a) and the Arrhenius frequency factor (A) for this reaction.



8. Consider the following proposed reaction mechanism:

$$ClO^- + H_2O \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} HClO + OH^- \qquad \text{FAST}$$

$$HClO + I^- \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} HIO + Cl^- \qquad \text{FAST}$$

$$HIO + OH^- \xrightarrow{k_3} IO^- + H_2O \qquad \text{SLOW}$$

A. Determine the rate law for this given mechanism.
B. What is the overall reaction for this process?
C. List any intermediate(s) present in the mechanism, if any.
D. List any catalyst(s) present in the mechanism, if any.
E. Draw the appropriate reaction profile energy diagram for this mechanism, making sure to label all the appropriate components.
F. How does a catalyst affect the rate of a reaction? Briefly explain AND *clearly* illustrate on your proposed reaction profile energy diagram.

9. At 400 °C, the equilibrium constant $K_p = 3.1 \times 10^4$ for the following equilibrium reaction:

$$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$$

What is the value of K_c at this temperature?

10. The initial concentrations of nitrogen and hydrogen are 0.010 M and 0.020 M, respectively, for the Haber Process in the synthesis of ammonia. The mixture is heated to a temperature at which $K_c = 0.11$. What is the equilibrium composition of the mixture?

11. Given the following information,

$$HF(aq) \leftrightarrow H^+(aq) + F^-(aq) \qquad K_1 = 6.8 \times 10^{-4}$$

$$H_2C_2O_4(aq) \leftrightarrow 2H^+(aq) + C_2O_4^{2-}(aq) \qquad K_2 = 3.8 \times 10^{-6}$$

Determine the value of the equilibrium constant for the following reaction:

$$2HF(aq) + C_2O_4^{2-}(aq) \leftrightarrow 2F^-(aq) + H_2C_2O_4(aq)$$

12. At 448 °C, the equilibrium constant $K_p = 51$ for the following reaction:

$$H_2(g) + I_2(g) \leftrightarrow 2HI(g)$$

Predict in which direction the system will shift to establish equilibrium at the given temperature when 0.020 mol of HI, 0.010 mol of H_2, and 0.030 mol of I_2 are present in a 2.00-L container.

13. At 2000 °C, the equilibrium constant for the reaction $2NO(g) \leftrightarrow N_2(g) + O_2(g)$ is $K_p = 2400$. If the initial partial pressure of NO is 37.3 atm, what are the equilibrium partial pressures of NO, N_2, and O_2?

14. At 25 °C, $K_c = 0.090$ for the reaction $H_2O(g) + Cl_2O(g) \leftrightarrow 2HOCl(g)$. Calculate the concentrations of all species at equilibrium if 1.0 g of H_2O and 2.0 g of Cl_2O are mixed in a 1.0 L flask.

15. The K_c of hydroxyapatite, $Ca_5(PO_4)_3OH$, is 6.8×10^{-37}. Calculate the concentration of phosphate ion in pure water. $Ca_5(PO_4)_3OH(s) \leftrightarrow 5Ca^{+2}(aq) + 3PO_4^{-3}(aq) + OH^-(aq)$

16. $6CO_2(g) + 6H_2O(l) \leftrightarrow C_6H_{12}O_6(s) + 6O_2(g)$ $\Delta H° = 2816$ kJ

How is the equilibrium yield of $C_6H_{12}O_6$ affected by:

A. increasing the pressure of CO_2 _____

B. increasing temperature _____

C. removing CO_2 _____

D. decreasing the total pressure _____

E. removing part of the $C_6H_{12}O_6$ _____

F. adding a catalyst _____