CHE 112 - Practice Exam 2 - Chapter 17 and 13 - ver 1 Score: ____/100

Name: ____________________ Class: ________________ Date: ________________

You may use your prepared spreadsheet on the exam. Before leaving the exam, show your spreadsheet to the instructor. Then email the spreadsheet and confirm that your instructor received it.

[8 pt] 1. Answer the following questions about the reaction: $NH_4^+(aq) + NO_2^-(aq) \longrightarrow N_2(g) + 2H_2O(l)$

Experiment	$[NH_4^+]$ (M)	$[NO_2^-]$ (M)	Rate (M/s)
1	1.25	3.25	1.91×10^4
2	4.0	3.25	6.13×10^4
3	4.0	1.75	1.78×10^4

(a) What is the rate law?
(b) What is the value of the rate constant?
(c) What is the reaction rate when both reactant concentrations are 1.86 M?

(1) rate=$k[A]^1[B]^2$
(2) 1.45×10^3 M^{-2} s^{-1}
(3) $9.33\times^3$M/s

[6 pt] 2. The rearrangement of methyl isonitrile (CH_3NC) is a first-order reaction with rate constant $5.11 \times 10^{-5} s^{-}1$ at 472 K. The initial concentration of CH_3NC is 0.0340 M.

(a) What is the molarity after 2.00 hours? Explain. 2(a) **0.0235 M**

(b) How many minutes does it take for the concentration of CH_3NC to drop to 0.0300M? Explain. 2(b) **40.8 min**

McMurry 12.51

[6 pt] 3. At elevated temperature nitrous oxide decomposes according to the following equation: $2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$. Given the following data is the reaction 0th, 1st or 2nd order? What is the value of the rate constant?

Time (min)	0	60	90	120	180
[N_2O] M	0.250	0.218	0.204	0.190	0.166

1 - Zero Order: Time vs Conc
2 - First Order: Time vs ln(Conc)
3 - Second Order: Time vs 1/Conc

First order has best curve fit.
k = -slope = - (-2.3×10^3 = 2.3×10^3/min

[6 pt] 4. Given the following data determine the Activation Energy (kJ/mol) for the following reaction by plotting the Arrhenius Equation. Show your graph to the instructor and email it after the exam. 4. **14.5 kJ/mol**

Temp (℃)	k ($M^{-1}s^{-1}$)]
15.0	6.40×10^3
35.0	4.32×10^3
60.0	2.82×10^3
80.0	2.10×10^3

y = 1744x + 2.7081
14.5 kJ/mol

[6 pt] 5. Given an initial reaction with k = 8.50×10^3 s^{-1} at 250. K is heated to 350. K where the rate constant is measured as 7.75×10^5 s^{-1}, calculate the activation energy in kJ/mol. Explain. 5. **32.8 kJ/mol**

see spreadsheet

Kinetics and Equilibrium

[6 pt] 6. In collision theory what three factors determine the value of the rate constant of a reaction? Explain why/how each effects the rate constant.

(a) Collision Frequency

Molecules must collide/make contact between them in order to react. Therefore the more collisions the more likely a reaction is to occur. This also explains some of the temperature dependence of reactions, higher temperature

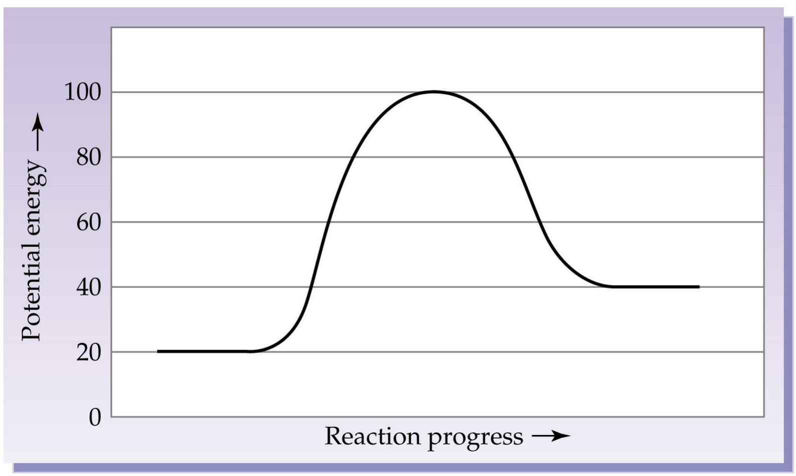
(b) Collision Energy

In order for molecules to react they must collide with enough energy to break/make bonds and overcome the Activation Energy.

(c) Orientation or Stearic

In order for molecules to react they must collide with the correct orientation to break/make the correct bonds

[7 pt] 7. The potential energy profile for the one-step reaction: $AB + CD \longrightarrow AC + BD$ is shown below. The energies are in kJ/mol relative to an arbitrary zero energy level. Label (1) the activation energy (E_A), (2) ΔE, (3) reactants, (4) products and (5) transition state and (6) draw an additional line representing the what a catalyzed reaction would look like. Is the reaction endothermic or exothermic?



mcmurry 12.108
The reaction is **endothermic** the products are higher in energy then the reactants.

[8 pt] 8. The following two step mechanism has been suggested for the reaction methane and Chlorine gas:

Step 1: $NO_2Cl(g) \xrightarrow{k_1} NO_2(g) + Cl(g)$

Step 2: $Cl(g) + NO_2Cl \xrightarrow{k_2} NO_2(g) + Cl_2(g)$

(a) What is the overall reaction?

McMurry 12.74 $2NO_2Cl(g) \longrightarrow 2NO_2(g) + Cl_2(g)$

(b) What is the predicted rate law if the first step is much slower than the second step?

rate $= k_1[NO_2Cl]$

(c) Define the term: reaction intermediate. List any in the reaction.

Cl is a reaction intermediate because it is created and then destroyed.

(d) Define the term: catalyst. List any in the reaction.

Destroyed then created. Speed up a reaction. No catalysts in this question.

Kinetics and Equilibrium

[9 pt] 9. Write the equilibrium constant expression (K_c) for the following reactions. In addition state whether the reaction will favor the (R)eactants, (P)roducts or (B)oth if appreciable amounts of both will be present.

(a) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\quad K_c = 5.8 \times 10^{-2}$ at 425 K. $\quad$ 9(a) **Both**

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

(b) $NH_4SH(s) \longleftrightarrow NH_3(g) + H_2S(g)$ $\quad K_c = 5.8 \times 10^{-5}$ at -25 ℃. $\quad$ 9(b) **Reactants**

$$K_c = \frac{[NH_3][H_2S]}{1}$$

(c) $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\quad K_c = 1.25 \times 10^{25}$ at 35 °F. $\quad$ 9(c) **Products**

$$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

[4 pt] 10. For reaction in A (above), what is the value of K_p. $\quad$ 10. 4.76×10^{-5}

$$K_p = K_c(RT)^{\Delta n} = 5.8 \times 10^{-2}(0.0821 \times 425)^{-2} = 4.76 \times 10^{-5}$$

[5 pt] 11. Given the reaction: $H_2O(g) + CH_4(g) \longrightarrow CO(g) + 3H_2(g)$ is at 250 K and contains the following concentrations of reactants and products calculate K_c. $[H_2O] = 0.65$ M, $[CH_4] = 0.50$ M, $[CO] = 0.25$ M, $[H_2] = 0.40$ M. $\quad$ 11. **0.049**

$$K_c = \frac{[0.25][0.4]^3}{[0.65][0.5]} = 0.049$$

[6 pt] 12. At 25 ℃ the reaction $A + 2B \rightleftharpoons 2C$ has an equilibrium constant $K_{eq} = 1.85 \times 10^{-5}$. If the concentration of A, B, and C are 0.25 M, 0.5 M and 0.75 M respectively, is the reaction at equilibrium? Explain. If the reaction is not at equilibrium in which direction will the reaction proceed to reach equilibrium?

$$Q_c = \frac{[0.75]^2}{[0.25][0.5]^2} = 9$$

$K_c << Qc$ therefore proceeds towards Reactants.

Kinetics and Equilibrium

[2 pt] 13. What is Le Chateliers Principle?

When a stress is applied to a system at equilibrium the reaction seeks to remove the stress and reach a new equilibrium.

[15 pt] 14. Answer the following questions about the reaction below. The reaction is endothermic. Assume the system is at equilibrium.

$$2C_2H_6(s) + 7O_2(g) \rightleftharpoons 6H_2O(g) + 4CO_2(g)$$

Complete the following table. Indicate changes in concentration of each product and reactant by entering (I)ncrease, (D)ecrease, (N)o change, or a ? for insufficient information to determine.

Stress Applied:	Direction Reaction Shifted	$[C_2H_6]$	$[O_2]$	$[H_2O]$	$[CO_2]$
Add O_2	$\longrightarrow$	D	I	I	I
Remove CO_2	$\longrightarrow$	D	D	I	D
Increase Volume	$\longrightarrow$	D	D	I	I
Decrease Pressure	$\longrightarrow$	D	D	I	I
Increase Temperature	$\longleftarrow$	I	I	D	D

[6 pt] 15. At 25 ℃ the reaction $C_2H_4(g) + H_2(g) \longrightarrow C_2H_6(g)$ has an equilibrium constant $K_c = 0.98$. If the concentration of $C_2H_4 = 0.33$ M and $H_2 = 0.53$ M, what will the final equilibrium concentrations of all the reactants and products be? Explain.

https://chem.libretexts.org/Core/Physical_and_Theoretical_Chemistry/Equilibria/Chemical_Equilibria/Calculating_an_Equilibrium_Concentration

$C_2H_4 = 0.23$ M

$H_2 = 0.43$ M

$C_2H_6 = 0.098$ M