Score:_____ / 100 Name:Key

Exam 1 – Chapters 12 & 13

1. (6 pts) Calculate the rate of appearance for nitrogen dioxide if the rate disappearance of N_2O_5 is 0.75 M/s.

$$2\ N_2O_5\ (g) \rightarrow 4\ NO_2\ (g) + O_2\ (g)$$

1.5 M/s

2. Use the data of table to answer the following questions for the reaction:

$$H_2\ (g) + 2\ ICl\ (g) \rightarrow 2\ HCl\ (g) + I_2\ (g)$$

Experiment	Initial $[H_2]$, M	Initial [ICl], M	Rate, M/s
1	0.24	0.10	7.2×10^{-6}
2	0.12	0.10	3.6×10^{-6}
3	0.12	0.15	5.4×10^{-6}

a. (6 pts) What is the rate law? rate = k $[H_2][ICl]$
(show work here)

b. (3 pts) What is the overall order? _second

c. (3 pts) What is the value of the rate constant? k = 0.00030 $M^{-1}\ s^{-1}$
(show work here)

d. (3 pts) What is the rate when the concentrations are $[H_2]$ = 0.55 M and ICl = 0.43 M? 7.1×10^{-5} M s^{-1}
(show work here)

3. (6 pts) For ***EACH*** set of factors, circle the one that will increase the rate by increasing the number of successful collisions:

Set 1 a. Decreasing the temperature b. Increasing the temperature

Set 2 a. Increasing the [reactants] b. Increasing the [products]

Set 3 a. Decreasing the surface area of the reactants b. Increasing the surface area of the reactants

For extra credit (2 pts), suggest one more factor that will increase the number successful collisions:

_____

4. (12 pts) Complete the following table:

Reaction Order	Linear Graph	Units for the Rate Constant, *k*
2nd	**1/[A] versus time**	**$M^{-1} s^{-1}$**
zero	**[A] versus time**	**$M s^{-1}$**
first	**ln [A] vs. time**	**s^{-1}**

5. Consider the hypothetical chemical equation: $2B + C \rightarrow G$

The reaction mechanism is found to be

Step 1 : $A + B \rightarrow D$ (fast)

Step 2: $D \rightarrow C + A$ (fast)

Step 3: $B + 2C \rightarrow G$ (slow)

a. (6 pts) What is the rate law for the overall reaction? matches the slow step : rate = $k [B][C]^2$

b. (3 pts) Is there an intermediate? YES / NO If so, what is it? D

c. (3 pts) Is there a catalyst? YES / NO If so, what is it? A

d. (3 pts) What is the molecularity of step two? unimolecular

6. (8 pts) A particular reaction has a rate constant of 2.35×10^{-3} $M^{-1}s^{-1}$ at 35°C and an initial half-life of 338 seconds. What is the concentration of the reactant A after two half-lives have passed?

Solve second order kinetics equations (the units of k give away the order)

$338 s = 1/ (2.35 \times 10^{-3} M^{-1} s^{-1}[A])$ So [A] = 1.26 M

Solve the second equation for second order kinetic, except time, t, is 338 x 2 since 2 ½ lives have passed

$[A]_t = 0.43$ M

7. (6 pts) The conversion of oxygen gas to ozone gas is endothermic: $3 O_2 (g) \leftrightarrow 2 O_3 (g)$. What will happen to this system if the temperature is decreased.

a. The value of K_P will increase since the reaction shifts in the forward direction.

b. The value of K_P will decrease since the reaction shifts in the forward direction.

c. The value of K_P will increase since the reaction shifts in the reverse direction.

d. The value of K_P will decrease since the reaction shifts in the reverse direction.

c. The value of K_P is unaffected by temperature changes.

8. (6 pts) Write the equilibrium constant expression, K_C, for the reaction:

$$3 Fe (l) + 4 H_2O (g) \leftrightarrow Fe_3O_4 (s) + 4 H_2 (g)$$

aqueous and gases only $K_C = \frac{[H_2]^4}{[H_2O]^4}$

9. (6 pts) For the reaction $3\ F_2(g) + Cl_2(g) \leftrightarrow 2\ ClF_3(g)$, $K_P = 45.0$ at 300 K. What direction must the equilibrium shift in order for the reaction to reach equilibrium if the partial pressure of F_2 is 0.40 atm, the partial pressure of Cl_2 is 0.75 atm, and the partial pressure of ClF_3 is 0.25 atm? *(Show work to defend your answer)*

a. $Q_C > K_C$ so the reaction will shift in the forward direction towards products.

b. $Q_C > K_C$ so the reaction will shift in the reverse direction towards reactants.

c. $Q_C < K_C$ so the reaction will shift in the forward direction towards products.

d. $Q_C < K_C$ so the reaction will shift in the reverse direction towards reactants.

10. (8 pts) Ammonia is oxidized to nitric acid by the Ostwald process. The first step is represented by the following reaction $4\ NH_3(g) + 5\ O_2(g) \leftrightarrow 4\ NO(g) + 6\ H_2O(g)$ $\Delta H° = -905.6$ kJ
When 3.00 mol of ammonia and 2.50 mol of oxygen gas are placed in a 4.00 L container and allowed to come to equilibrium, the mixture is found to contain 1.75 mol of NO (g). What is the molarity of all species at equilibrium?

	NH_3	O_2	NO	H_2O
Initial	0.75 M	0.63 M		
Change	-4x	-5x	+4x	+6x
Equilibrium	0.75 – 4x	0.63 – 5x	4x	6x

At equilibrium, [NO] = 1.75 mol/4.00 L = 0.44M

Also at equilibrium, [NO] = 4x so 4x = 0.44m and x = 0.11 M

Equilibrium Molarity:

$[NH_3]_e = 0.31$ M

$[O_2]_e = 0.080$ M

$[NO]_e = 0.44$ M

$[H_2O]_e = 0.66$ M

11. (10 pts) Methanol (CH_3OH) is manufactured by the reaction of carbon monoxide with hydrogen in the presence of a ZnO/Cr_2O_3 catalyst:

$$CO(g) + 2\ H_2(g) \xleftrightarrow{ZnO/Cr_2O_3} CH_3OH(g) \qquad \Delta H° = -91.0 \text{ kJ}$$

Does the amount of ***methanol*** increase, decrease, or remain the same when an equilibrium mixture of reactants and products is subjected to the following changes?

a. The temperature is increased.	increase	decrease	no change
b. CO is added.	increase	decrease	no change
c. The volume is decreased.	increase	decrease	no change
d. Helium is added	increase	decrease	no change
e. The catalyst is removed.	increase	decrease	no change

Extra Credit (10 pts)

Consider the reaction C (s) + CO_2 (g) ↔ 2 CO (g) where K_C is 0.77 at 500. K. What is the equilibrium concentration of carbon dioxide gas when [C] = 0.55 M, [CO_2] = 0.65 M, and [CO] = 0.85 M? Show all work!

Answer: $[CO_2]_e$ = _____