Name:______________

(4 points)

Chemistry 114
Third Hour Exam

Remember- Show all work for partial credit

1 (12 points) Butadiene react to from a dimers according to the equation:

$2\ C_4H_6(g) \rightarrow C_8H_{12}(g)$

The following data were collected for this reaction at 25^0C:

$[C_4H_6]$ (mol/L)	Time (s)
.01	0
.00476	1800
.00313	3600
.00241	5200

A. If you thought this was a second order reaction, what would you plot (X and Y) to prove it was second order? How would you get the k of the reaction from this plot?

Plot 1/[ ] as Y vs. t as X; the slope of the line = k

B. If you thought this was a first order reaction, what would you plot (X and Y) to prove it was first order? How would you get the k of the reaction from this plot?

Plot ln[ ] as Y vs. t as X; the slope of the line = -k

C. If you thought this was a zero order reaction, what would you plot (on X and Y) to prove it was zero order? How would you get the k of the reaction from this plot?

Plot [ ] as Y vs. t as X; the slope of the line = -k

2. (12 points) I have a second order reaction that has a half-life of 20 minutes when my reactant concentration is 0.400 M.

A. What does the term half-life mean?

The half-time of the reaction is how long it takes the concentration of the reactant to decrease by 1/2.

B. What is the k of this reaction?

For a second order reaction $t_{1/2} = 1/[A]_0k$; 20 min = 1/0.4(X); X=1/20(.40)

X=.125l/mol·min

C. If the initial reactant concentration is 0.400M, how long will it take until the reaction is 95% complete

if 95% complete, then only 5% or reactant remains

$[\text{reactant}]_{95\%}$ 0.4 (.05) = .02 Mol/l

For second order $1/[\ ]_t = 1/[\ ]_0 + kt$

1/.02 =1/.4 +.125X

50 = 2.5 + .125X

50-2.5 = .125X

47.5=.125X

47.5/.125 =X; X=380 min

3. (12 points) In the collision model for reaction kinetics we relate the k of a reaction to several other parameters in the equation:

$$k = zpe^{-E_a/RT}$$

Briefly state what the collision model is, then tell me what each symbol in the above equation is and how it relates to the collision theory.

The collision theory states that the rate of a reaction (k) is proportional to the number of collisions that take place times a steric factor, times a factor that accounts for the energy in a collision

k = the rate of a reaction
z= number of collisions
p = orientation of collision or steric factor
e = the exponential function
E_a is the activation energy or minimum E needed for a reaction
R = 8.314 J/K·mol (The gas constant)
T = temperature in K

4. (12 points) Define the following terms:

Inhibitor - A material that slows the rate of a reaction.

Homogeneous equilibrium-
An equilibrium in which all substance are in the same phase.

Frequency factor
The factor A in the Arrenhius equation: $k=Ae^{-Ea/RT}$. With our current collision model of kinetics it is equal to the number of collisions times the steric factor

A bimolecular step
An elementary step in a reaction in which two compounds or elements must collide for a reaction to occur.

A pseudo-second-order reaction
A rate constant that appears to be second order because one or more other reactants were at such a high concentration that their concentrations did not change significantly over the course of the reaction, so they were essential constants in the reaction rate calculation.

The Reaction quotient (Q)
The quotient you get when you plug your current set of conditions (that may not be at equilibrium) into the equilibrium expression.

5. (12 points) Write equilibrium expressions for the following reactions:

$2HF(g) \rightarrow H_2(g) + F_2(g)$

$K = [H_2][F_2]/[HF]^2$

$2KOH(aq) + Fe(NO_3)_2(aq) \rightarrow Fe(OH)_2(s) + 2KNO_3(aq)$

If you use the above equation: $[KNO_3]^2/[KOH]^2[Fe(NO_3)_2]$

Its actually more correct to go to the net ionic equation so you eliminate the spectator ions that don't contribute to the equilibrium

$Fe^{2+}(aq) + 2OH^{-}(aq) \rightleftharpoons Fe(OH)_2(s)$

Now $K = [Fe^{2+}][OH^{-}]^2$

The precipitation reaction of silver nitrate with magnesium chloride.

Molecular equations: $2AgNO_3(aq) + MgCl_2(aq) \rightleftharpoons 2AgCl(s) + Mg(NO_3)_2(aq)$

Net Ionic: $Ag^{+}(aq) + Cl^{-}(aq) \rightleftharpoons AgCl(s)$

$K=[Ag^{+}][Cl^{-}]$

6. (12 points) When the reaction: $N_2(g) + 3Cl_2(g) \rightleftharpoons 2NCl_3(g)$ is at equilibrium, the concentration of NCl_3 is .19M, the concentration of N_2 is .014M and the concentration of Cl_2 is .0043M .

A What is the K_c for this reaction?

$K_C=[NCl_3]^2/[N_2][Cl_2]^3 = .19^2/(.014)(.0043)^3$

$=3.24x10^7$

B. Assuming the temperature is 350 K, what is K_P for this reaction?

$K_P=K_C(RT)^{\Delta n}$; $\Delta n=2-(3+1)= -2$

$K_P=3.24x10^7(0.08206\cdot 350)^{-2}$

$=3.92x10^4$

C. What is K_C for the reaction $2N_2(g) + 6Cl_2(g) \rightleftharpoons 4NCl_3(g)$?

$2N_2(g) + 6Cl_2(g) \rightleftharpoons 4NCl_3(g) = 2(N_2(g) + 3Cl_2(g) \rightleftharpoons 2NCl_3(g)\ N_2(g) + 3Cl_2(g) \rightleftharpoons 2NCl_3(g))$

$K_{new}= K_{old^2}$

$=(3.24x10^7)^2$

$=1.05x10^{15}$

7. (12 points) The reaction $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$ has a K_c of 2.4×10^3.

A. Which of the following systems are at equilibrium?

B. For any system that is not at equilibrium tell me if more products will form as it comes to equilibrium, or if product will disappear is it come to equilibrium.

[NO]	$[N_2]$	$[O_2]$	At Equilibrium? (Y/N)	Product will **form** or **disappear**?
.016	.310	2.00	Y	
.020	.800	.570	N	Form
.024	2.00	2.60	N	Disappear

(Use this space for calculations)

Q_1=2·.310/(.016)^2=2,422 ; Q≅K;at equilibrium

Q_2=.570·.310/(.02)^2=1,140; Q<K; not enough products; products will form

Q_3=2.00·2.60/(.024)^2=9028;Q>K; too many products; products will disappear

8. (12 points) At a particular temperature 8.0 mol of SO_3 is placed in a 1.0 L container where the SO_3 dissociates by the reaction

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

At equilibrium 2.0 mol of SO_2 is present. Calculate K for this reaction.

	$2SO_3(g) \rightleftharpoons$	$2SO_2(g)$ +	$O_2(g)$
Initial	8	0	0
Change	?	2	?

From stoichiometry
2 mole SO_2 x (1 mole O_2)/2 mole SO_2)=1 mole O_2
2 mole SO_2 x (2 mole SO_3)/2 mole SO_2)=2 mole SO_3

	$2SO_3(g) \rightleftharpoons$	$2SO_2(g)$ +	$O_2(g)$
Initial	8	0	0
Change	-2	+2	+1
Equilibrium	6	2	1

$K = 2^2 \cdot 1/6^2 = .111$