Name:______________

(4 points)

Chemistry 114
Third Hour Exam

Remember- Show all work for partial credit
All questions are worth 12 points

1. CCl_4 has a normal freezing point of -23.0°C and a K_f of 30°C·kg/mol. I have dissolved 5 grams benzene (Molar mass = 78.0) in 150 grams of CCl_4. What is the freezing point of this solution?

$\Delta T = K_f\, m$ (Not ionic so you don't need to worry about the Van't Hoff factor)

Moles benzene = 5 g/ (78 g/mole) = **.064 moles**

molality = moles/ kg solvent = .064 moles / .150 kg CCl_4 = **.427 m**

ΔT = .427 x 30 = 18.46 °C

Freezing point = -23 -18.46 = **-41.46 °C**

2. I am studying the reaction $BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(l) + 3H_2O(l)$

If the initial rate of appearance of H_2O is .008 mol/L·sec,

A, What is the initial rate of appearance of Br_2?

.008 mole H_2O/L·sec x 3 mole Br_2/3 mole H_2O = .008 mol Br_2 /L·sec

B. What is the initial rate of disappearance of BrO_3^-?

.008 mole H_2O/L·sec x 1 mole BrO_3 / 3mole H_2O = .00267 mol BrO_3^- /L·sec

C. What is the initial rate of disappearance of Br^-?

.008 mole H_2O/L·sec x 5 mole Br^- / 3mole H_2O = .00133 mol Br^- /L·sec

3. I am studying the reaction: A + B → C
Given the following data of concentration and rates:

[A](M)	[B](M)	rate (mol/L·sec)
.06	.06	$2.76x10^{-4}$
.06	0.1	$4.04x10^{-4}$
0.1	0.1	$6.74x10^{-4}$

Find the order parameters and the rate constant for this reaction. When you have found these numbers write the rate law for this reaction.

Dividing equation 2 by equation 1

$$\frac{4.04x10^{-4}}{2.76x10^{-4}} = \frac{k[A]^x[B]^y}{k[A]^x[B]^y} = \frac{k[.06]^x[.1]^y}{k[.06]^x[.06]^y}$$

$$1.46 = \left(\frac{.1}{.06}\right)^y ; = 1.66^y$$

$$\ln(1.46) = y\ln(1.66)$$

$$.3784 = y(.5068); y = .3784/.5068 = .747$$

Dividing equation 3 by equation 2

$$\frac{6.47x10^{-4}}{4.04x10^{-4}} = \frac{k[A]^x[B]^y}{k[A]^x[B]^y} = \frac{k[.1]^x[.1]^y}{k[.06]^x[.1]^y}$$

$$1.67 = \left(\frac{.1}{.06}\right)^x ; = 1.66^x$$

$$\ln(1.67) = x\ln(1.66)$$

$$.513 = y(.507); y = .513/.507 = 1.01 \approx 1$$

Using the last equation:
$6.47x10^{-4} = k(1.)^1(.1)^{.747}$; $k = 6.47x10^{-4} / ((1.)^1(.1)^{.747}) = .0376$
rate = .0376 $[A]^1$ $[B]^{.747}$

4. I have a second order reaction that has a rate constant of $6.14x10^{-2}$ L/mol·sec. If my initial reactant concentration is .01M, how long does it take until the reaction is 90% complete?

For the reaction to be 90 % complete, only 10 % of the reactant can remain so
[ ] = .01(.1) = .001

Plugging these values into the second order rate equation:

$$\frac{1}{.001} = 6.14x10^{-2}t + \frac{1}{.01}$$

$$1000 = 6.14x10^{-2}t + 100$$

$$900 = 6.14x10^{-2}t; t = 900 / 6.14x10^{-2} = 14{,}658 \text{ seconds}$$

5. Give the equations for the half-life of a
zero order reaction

$$t_{1/2} = \frac{[A_o]}{2k}$$

first order reaction

$$t_{1/2} = \frac{.693}{k}$$

second order reaction

$$t_{1/2} = \frac{1}{k[A_o]}$$

6.Define the following terms
Homogeneous catalyst
A catalyst that is in the same phase as the reactants and products.

steric factor
The steric factor is p in the equation $k=zpe^{-Ea/RT}$ and reflects the fraction of collisions that are actually in the correct orientation to result in a chemical reaction.

elementary step
In a reaction mechanism an elementary step is a reaction whose rate law can be written directly from the molecularliy of the reaction.

half-life of a reaction
The time it takes for one half of the reactant to change to product in a given reaction.

rate constant (in a differential rate law equation)
k in the equation rate = $k[A]^n$. It is a proportionality constant that reflects the how a rate is proportional to the concentration term.

7. If a reaction with an activation energy of 20 kJ/mol has a k of $3x10^{-5}\ s^{-1}$ at 20° C, what is the k of the reaction at 100°C?

20 °C = 293 K

100 °C = 373 K

$$\ln\left(\frac{K_1}{K_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{3x10^{-5}}{X}\right) = \frac{20000}{8.314}\left(\frac{1}{373} - \frac{1}{293}\right)$$

$$\ln\left(\frac{3x10^{-5}}{X}\right) = 2406(.002681 - .003413)$$

$$\ln\left(\frac{3x10^{-5}}{X}\right) = -1.761$$

$$\frac{3x10^{-5}}{X} = e^{-1.761} = 172$$

$$X = 3x10^{-5}/.172 = 1.74x10^{-4}$$

8. I am studying the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2\ NH_3(g)$

A. (For Bryan L.) What is the equilibrium expression for this reaction?

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

B. (For me) If the K_C for the above reaction is $6.0x10^{-2}$, what is the K_C for the reaction

$NH_3(g) \rightleftharpoons ½\ N_2(g) + 3/2\ H_2(g)$

First, reverse the above reaction to $2\ NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

$K_{reverse} = 1/K_{forward} = 1/6.0x10^{-2} = 16.67$

Now multiply by ½

½ x $(2\ NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g))$ = $NH_3(g) \rightleftharpoons ½\ N_2(g) + 3/2\ H_2(g)$

$K_{new} = K_{Old}^{\ ½}$ = sqrt(16.67) = 4.076

C. (Also for me)

What is K_P for the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2\ NH_3(g)$ if T = 200K?

$K_P = K_C(RT)^{\Delta n}$; Δn= 2-4 = -2

$K_P = 6.0x10^{-2}\ (.08206\ x\ 200)^{-2} = 2.23x10^{-4}$