Name: _____

Chemistry 210 Exam 2

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = 6.022×10^{23} $^{\text{units}}/_{\text{mol}}$
$32.00^{\circ}F = 0.000^{\circ}C = 273.15K$
Density of Water = $1.000^{\text{g}}/_{\text{mL}}$
$R = 0.08206$ $^{\text{L•atm}}/_{\text{mol•K}} = 8.314$ $^{\text{J}}/_{\text{mol•K}}$
$PV=nRT$
$\Delta T_{fp/bp} = k_{fp/bp} \bullet m \bullet i$
For water, $k_{fp} = -1.86^{\circ C}/_{m}$; $k_{bp} = 0.52^{\circ C}/_{m}$
$P_1 = X_1 P_1^{\circ}$
$P = cRTi$
$C_1V_1 = C_2V_2$
Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Integrated Rate Laws:

0^{th} order	$[A]_t = -kt + [A]_o$
1^{st} order	$\ln[A]_t = -kt + \ln[A]_o$
2^{nd} order	$1/[A]_t = kt + 1/[A]_o$

$$k = Ae^{-Ea/RT}$$

$$\ln(k) = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	89 **Ac** 227.03	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114		116		

58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.94	70 **Yb** 173.04	71 **Lu** 174.97
90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (258)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Score

Multiple Choice: Circle the letter of the most correct response. (6pts. per question)

1. Which of the following does ***not*** affect the rate of a reaction?
   a. The frequency of collisions between reacting particles
   b. The coefficients of the reactants in the balanced equation
   c. The temperature of the system
   d. The orientation of colliding particles
   e. The energy of collisions between reacting particles

2. For the generic equation:

   $$aA + bB \rightarrow cC + dD$$

   Which of the following is a correct expression of the rate of the reaction:
   a. $-\frac{1}{a}\frac{\Delta[A]}{\Delta t}$
   b. $-\frac{1}{b}\frac{\Delta[B]}{\Delta t}$
   c. $k[A]^a[B]^b$
   d. $\frac{1}{d}\frac{\Delta[D]}{\Delta t}$
   e. $k[C]^c[D]^d$

   There should have been only 1 correct response, this question was discarded.

3. For the generic equation

   $$aA(g) + bB(g) \leftrightarrows cC(g) + dD(g)$$

   The value of the equilibrium constant, K_c:
   a. Must be measured, it cannot be derived from the balanced equation
   b. Is equal to $k[A]^a[B]^b$
   c. Is equal to $([A]^a[B]^b)/([C]^c[D]^d)$
   d. Is not affected by temperature
   e. Is equal to $([C]^c[D]^d)/([A]^a[B]^b)$

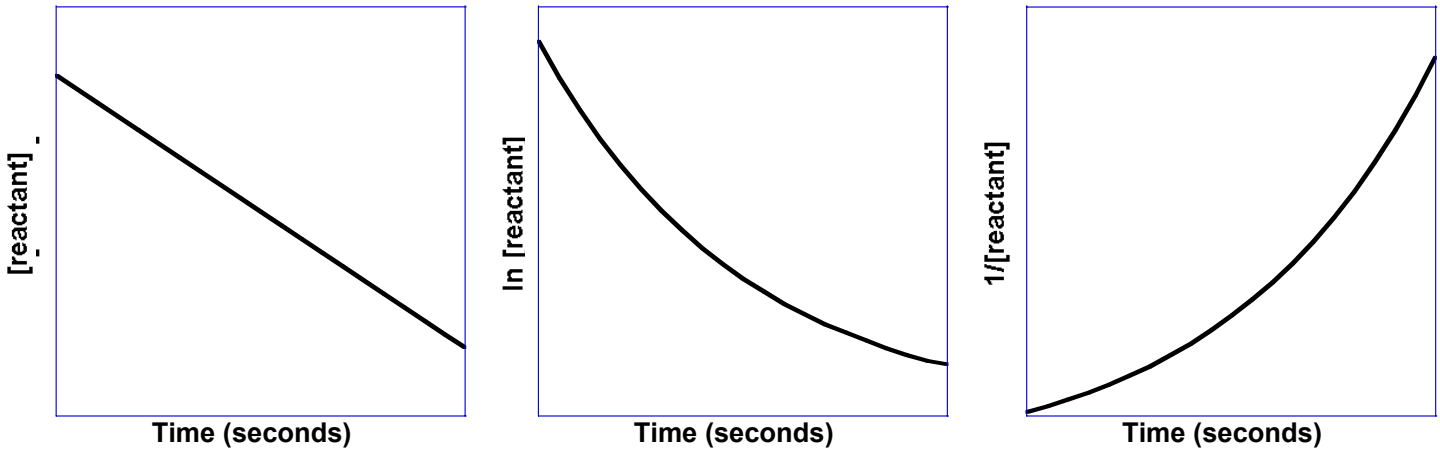
4. If the rate of a reaction increases by a factor if 4 when the initial concentration of reactant "A" is increased by a factor of 4, the reaction must be:
   a. 2nd order overall
   b. 4th order with respect to [A]o
   c. 1st order with respect to[A]o
   d. 2nd order with respect to [A]o
   e. The order of the reaction depends on the balanced chemical equation

5. For a first order reaction:
   a. The slope of the integrated rate law plot is equal to k
   b. The intercept of the integrated rate law plot is equal to the initial concentration
   c. The slope of the integrated rate law plot is equal to $(-E_a/R)$
   d. The intercept of the integrated rate law is equal to the *ln* of the initial concentration
   e. The slope of the integrated rate law is equal to the frequency factor, A.

6. Which of the following is ***true*** regarding catalysts and catalyzed reactions?
   a. The presence of a catalyst changes the equilibrium constant for a reaction
   b. The presence of a catalyst changes the energy of the products and reactants in a reaction
   c. The presence of a catalyst changes the activation energy for a reaction
   d. The presence of a catalyst does not change the mechanism of a reaction
   e. The concentration of a catalyst cannot appear in the rate law for a reaction

Score

Name: _____



7. The reaction represented by the plots above:
   a. Is zero order
   b. Is first order
   c. Is second order
   d. Is third order
   e. The order can't be determined by these graphs

8. Which of the following is ***false*** regarding equilibrium?
   a. The concentrations of products and reactants does not change once the reaction has reached equilibrium
   b. Equilibrium can be shifted by changing pressure or temperature
   c. The forward and reverse reactions stop when a system reaches equilibrium
   d. The rates of the forward and reverse reactions are equal
   e. Equilibrium concentrations do not depend upon whether you approach equilibrium from the left or the right

9. Which of the following is ***false*** regarding reaction mechanisms?
   a. The steps of the mechanism can contain chemical species that do not appear in the overall correctly balanced chemical equation
   b. The observed rate law is equal to the sum of the rate laws from all steps
   c. Catalysts can appear in the steps of a mechanism
   d. A mechanism must be composed of elementary reactions
   e. The observed rate law must agree with the rate law of the slowest step

10. Which of the following statements is ***false*** regarding the reaction quotient, Q?
    a. It tells the direction that the reaction must shift to reach equilibrium
    b. If $Q > K_c$, the system needs to shift toward the reactants to reach equilibrium
    c. If $Q = K_c$, the system is at equilibrium
    d. If $Q < K_c$, the system needs to shift toward the reactants to reach equilibrium
    e. It has the same mathematical form as the equilibrium constant

Score

Multiple Choice Calculations: (12pts each)

11. A reaction is found to be first order with respect to reactant A and second order with respect to reactant B. If $[A]_o = 0.318M$, $[B]_o = 0.934M$ and $k = 5.49x10^{-5}\ M^{-2}sec^{-1}$, what is the initial rate of the reaction?
    a. $1.98x10^{-4}\ {}^{M}/_{sec}$
    b. $1.85x10^{-4}\ {}^{M}/_{sec}$
    c. $1.63x10^{-5}\ {}^{M}/_{sec}$
    d. $1.52x10^{-5}\ {}^{M}/_{sec}$
    e. $5.19x10^{-6}\ {}^{M}/_{sec}$

12. For the reaction:
    $$CH_4(g) + H_2O(g) \leftrightarrows CO(g) + 3\ H_2(g) \qquad \Delta H = 206.2\ {}^{kJ}/_{mol}$$
    The equilibrium concentrations have been found to be $[CO]_{eq} = 2.22M$, $[H_2]_{eq} = 1.81M$, $[CH_4]_{eq} = 8.81x10^{-5}$ M, $[H_2O]_{eq} = 1.53x10^{-2}$ M. What is the equilibrium constant?
    a. $1.02x10^{-7}$
    b. 388
    c. $2.98x10^{6}$
    d. $8.94x10^{6}$
    e. $9.77x10^{6}$

13. A reaction is found to be second order with respect to fluoride ion, a reactant. If $[F^-]_o = 2.19M$ and $k = 1.16x10^{-2}\ M^{-1}sec^{-1}$, what will the concentration be after 12 minutes have passed?
    a. 8.81 M
    b. 1.68 M
    c. 0.596 M
    d. 0.127 M
    e. 0.114 M

14. You have found the following value in a table of equilibrium constants at 25ºC:
    $$Cu^{2+}(aq) + 4\ NH_3(aq) \leftrightarrows [Cu(NH_3)_4]^{2+}(aq) \qquad K_c = 1.7x10^{-13}$$
    What is the equilibrium constant for the reaction:
    $$2\ [Cu(NH_3)_4]^{2+}(aq) \leftrightarrows 2\ Cu^{2+}(aq) + 8\ NH_3(aq)$$
    a. $3.5x10^{25}$
    b. $5.9x10^{12}$
    c. $2.9x10^{12}$
    d. $3.4x10^{-13}$
    e. $2.9x10^{-26}$

Score

Chem 210 – Exam 2a *Name:* _____
Spring 2008

Problems: (21pts each)

15. For the reaction:

$$Pb^{2+}(aq) + 4\ OH^-(aq) \rightarrow [Pb(OH)_4]^{2-}(aq)$$

You have collected the following data at 16.93ºC:

Experiment	$[Pb^{2+}]_o$	$[OH^-]_o$	$Rate_{observed}$
1	0.267 M	1.621 M	$1.16\text{x}10^{-2}\ ^{M}/_{sec}$
2	0.267 M	3.242 M	$2.32\text{x}10^{-2}\ ^{M}/_{sec}$
3	0.801 M	1.621 M	$3.48\text{x}10^{-2}\ ^{M}/_{sec}$

What are the rate law and the value of the rate law constant, k, for this reaction?
If you redo Experiment 2 at 34.26ºC, the rate is $7.53\text{x}10^{-2}\ ^{M}/_{sec}$. What is the activation energy for this reaction?

Comparing runs 1 and 2, $[OH^-]_o$ doubles, rate doubles, the rxn is 1st order with respect to $[OH^-]_o$
Comparing runs 1 and 3, $[Pb^{2+}]_o$ triples, rate triples, the rxn is 1st order with respect to $[Pb^{2+}]_o$

$$Rate_o = k\,[Pb^{2+}]_o[OH^-]_o$$

Plugging in values to solve for k:

$$k = \frac{Rate_0}{[Pb^{2+}]_0[OH^-]_0} = \frac{1.16\text{x}10^{-2}\ \frac{M}{sec}}{(0.267M)(1.621M)} = 2.68\text{x}10^{-2}\ \frac{1}{M\bullet sec}$$

At 34.26ºC, the rate law *expression* remains the same, but the value of k changes. Plugging in the new conditions:

$$k = \frac{Rate_0}{[Pb^{2+}]_0[OH^-]_0} = \frac{7.53\text{x}10^{-2}\ \frac{M}{sec}}{(0.267M)(3.242M)} = 8.70\text{x}10^{-2}\ \frac{1}{M\bullet sec}$$

Plugging in to the comparative form of the Arrhenius equation:

$$\ln\left(\frac{2.68\text{x}10^{-2}\ \frac{1}{M\bullet sec}}{8.70\text{x}10^{-2}\ \frac{1}{M\bullet sec}}\right) = \frac{E_a}{8.314\ ^{J}/_{mol\bullet K}}\left(\frac{1}{307.41K} - \frac{1}{290.08K}\right) \rightarrow E_a = 50.4\ ^{kJ}/_{mol}$$

16. When 3.512g of nitrogen dioxide {$NO_2(g)$} and 4.913g of chlorine gas {$Cl_2(g)$} are sealed together in a 2.000L vessel, they reach equilibrium with nitrogen trichloride {$NCl_3(g)$} and oxygen {$O_2(g)$}. If the equilibrium concentration of $Cl_2(g)$ is found to be $3.124\text{x}10^{-4}$ M:
    a. What are the equilibrium concentrations of all products and reactants?
    b. What is the value of K_c?
    c. Is the reaction Product-favored or reactant-favored?

	$2\ NO_2(g)$	$+\ 3\ Cl_2(g) \leftrightarrow$	$2\ NCl_3(g)$	$+\ 2\ O_2(g)$
Initial	$3.512g/46.005\ ^{g}/_{mol}/2.000L$	$4.913g/70.906\ ^{g}/_{mol}/2.000L$		
	$3.817\text{x}10^{-2}$ M	$3.464\text{x}10^{-2}$ M	0	0
Δ	-2x	-3x	+2x	+2x
@ Eq	$(3.817\text{x}10^{-2} - 2x)$M	$(3.464\text{x}10^{-2} - 3x)$M	2x M	2x M
	$1.523\text{x}10^{-2}$ M	$3.124\text{x}10^{-4}$ M	$2.289\text{x}10^{-2}$ M	$2.289\text{x}10^{-2}$ M

$$K_c = \frac{[NCl_3]_{eq}^2[O_2]_{eq}^2}{[NO_2]_{eq}^2[Cl_2]_{eq}^3}$$

$K_c = 3.881\text{x}10^7$, product-favored