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} $^{units}/_{mol}$
$32.00^oF = 0.000^oC = 273.15K$
Density of Water = $1.000\ ^g/_{mL}$
$R = 0.08206\ ^{L\bullet atm}/_{mol\bullet K} = 8.314\ ^J/_{mol\bullet K}$
$PV=nRT$
$\Delta T_{fp/bp} = k_{fp/bp}\bullet m\bullet i$
For water: $k_{fp} = -1.86\ ^{oC}/_m$
$k_{bp} = 0.512\ ^{oC}/_m$
$P_1 = X_1P_1^o$
$\Pi = MRTi$
$C_1V_1 = C_2V_2$
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 $1/[A]_t = kt + 1/[A]_o$
$k = Ae^{-Ea/RT}$

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

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

$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{conjugate acid}]}\right)$$

$E_{cell} = E^o_{cell} - {}^{RT}/_{nF}\ ln Q$
$E^o_{cell} = {}^{RT}/_{nF}\ ln K^o$
$K^o = e\hat{}(\ ^{nF}/_{RT}\ E^o_{cell})$
$F = 96485\ ^J/_{V\bullet mol\ of\ electrons}$
$\Delta G^o = \Delta H^o_{system} - T\Delta S^o_{system}$
$\Delta G^o = -nFE^o_{cell} = -RT ln K^o$
$\Delta G = \Delta G^o + RT ln Q$
$F = 96485\ ^C/_{mol\ electrons}$
1A = 1 C / sec

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. (5pts per question)

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

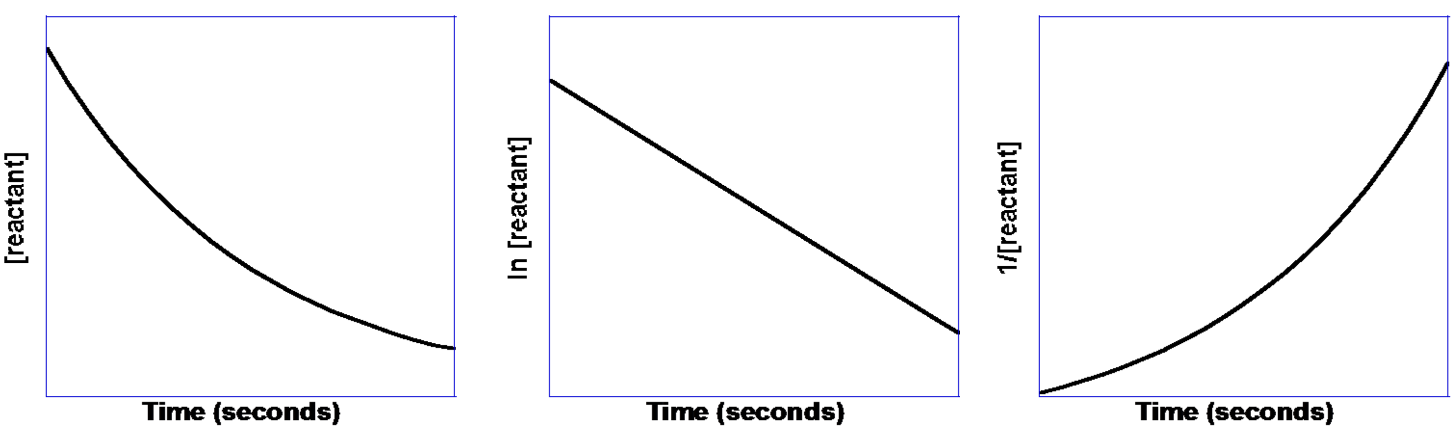
2. For the generic equation:

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

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

3. If the rate of a reaction increases by a factor of 4 when the initial concentration of reactant “A” is increased by a factor of 2, the reaction must be:
   a. 0th order with respect to $[A]_o$
   b. 1st order with respect to $[A]_o$
   c. 2nd order overall
   d. 2nd order with respect to $[A]_o$
   e. The order of the reaction depends on the balanced chemical equation

4. 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.



5. 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

Score

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

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

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 often be shifted by changing pressure or temperature
   c. The rates of the forward and reverse reactions are equal
   d. Equilibrium concentrations do not depend upon whether you approach equilibrium from the left or the right
   e. The forward and reverse reactions stop when a system reaches equilibrium

9. For the generic equation

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

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

10. Which of the following is ***true*** regarding equilibrium reactions?
    a. If $K < 0$, the reaction reaches equilibrium very quickly.
    b. If $K > 1$, the reaction is reactant-favored.
    c. If $K = 1$, the reaction has stopped.
    d. If $K > 1$, the reaction is product-favored.
    e. If K is very small, the limiting reactant is very nearly used up.

11. Considering the reaction given, all of the following stresses will shift the equilibrium to the right except:

    $$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g) \qquad \Delta H_{rxn} = 131\ ^{kJ}/_{mol}$$

    a. Removing carbon dioxide from the system
    b. Increasing the pressure on the system
    c. Adding carbon monoxide to the system
    d. Increasing the temperature of the system
    e. Removing hydrogen from the system

12. Which of the following statements is ***true*** regarding the reaction quotient, *Q*?
    a. It indicates how quickly a reaction will reach equilibrium
    b. If $Q > K_c$, the system needs to shift toward the reactants to reach equilibrium
    c. If $Q = K_c$, the reaction has stopped
    d. If $Q > K_c$, the system needs to shift toward the products to reach equilibrium
    e. It has the same mathematical form as the rate law expression

Score

Problems: Show your work.

13. A reaction is found to be second order with respect to reactant A and zero order with respect to reactant B. If $[A]_o$ = 0.538M, $[B]_o$ = 0.552M and k = 8.61×10^{-3} $M^{-1}sec^{-1}$, what is the initial rate of the reaction? (12pts)

14. For the reaction:

$$2\ CH_3OH(g)\ +\ 3\ F_2(g)\ \leftrightarrows\ 2\ CF_3OH(g)\ +\ 3\ H_2(g) \qquad \Delta H = -437.2\ {}^{kJ}/_{mol}$$

The equilibrium concentrations are observed: $[CH_3OH]_{eq}$ = 0.328M, $[F_2]_{eq}$ = 0.136M, $[CF_3OH]_{eq}$ = 5.91×10^{-2} M, $[H_2]_{eq}$ = 0.972 M. What is the equilibrium constant for this reaction? (12pts)

15. A reaction is found to be zero order with respect to carbonate ion, a reactant. If $[CO_3^{-2}]_o$ = 3.27M and k = 4.37×10^{-2} M•min^{-1}, how much time must pass before the concentration of carbonate ions falls to 8.67×10^{-3}M? (12pts)

16. You have found the following value in a table of equilibrium constants at 25ºC:

$$Fe^{3+}(aq)\ +\ 4\ Cl^-(aq)\ \leftrightarrows\ [FeCl_4]^{-1}(aq) \qquad K_c = 2.16 \times 10^5$$

What is the equilibrium constant for the following reaction? (12pts)

$$2\ [FeCl_4]^{-1}(aq)\ \leftrightarrows\ 2\ Fe^{3+}(aq)\ +\ 8\ Cl^-(aq)$$

Score

17. For the reaction:

$$2\ NO_2(g)\ +\ Br_2(aq)\ \rightarrow\ 2\ NOBr(g)\ +\ O_2(g)$$

You have collected the following data at 46.92ºC:

Experiment	$[NO_2]_o$	$[Br_2]_o$	$Rate_{observed}$
1	1.38 M	1.62 M	$1.37x10^{-2}\ ^{M}/_{min}$
2	2.76 M	1.62 M	$1.37x10^{-2}\ ^{M}/_{min}$
3	1.38 M	3.24 M	$5.48x10^{-2}\ ^{M}/_{min}$

What are the rate law and the value of the rate law constant, k, for this reaction?
If you redo Experiment 3 at 19.64ºC, the rate is $8.16x10^{-4}\ ^{M}/_{min}$. What is the activation energy for this reaction? (21pts)

18. When 0.276mols of sulfur dioxide {$SO_2(g)$} and 0.383mols of fluorine gas {$F_2(g)$} are sealed together in a 1.500L vessel, they reach equilibrium with thionyl fluoride {$SOF_2(g)$} and oxygen {$O_2(g)$}. The equilibrium concentration of $F_2(g)$ is found to be 0.234 M. (21pts)
    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?

Score