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} $^{units}/_{mol}$

$32.00^\circ F = 0.000^\circ C = 273.15 K$

Density of Water = $1.000^g/_{mL}$

$R = 0.08206$ $^{L \cdot atm}/_{mol \cdot K} = 8.314$ $^J/_{mol \cdot K}$

$PV = nRT$

$\Delta T_{fp/bp} = k_{fp/bp} \cdot m \cdot i$

For water: $k_{fp} = -1.86\,^{\circ C}/_m$

              $k_{bp} = 0.512\,^{\circ C}/_m$

$P_1 = X_1 P_1^\circ$

$\Pi = MRTi$

$C_1 V_1 = C_2 V_2$

Quadratic formula:

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

Integrated Rate Laws:

$$\ln[A]_t = -kt + \ln[A]_o$$

$$1/[A]_t = kt + 1/[A]_o$$

$$[A]_t = -kt + [A]_o$$

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

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

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

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

$E_{cell} = E^\circ_{cell} - {^{RT}/_{nF}}\,lnQ$

$E^\circ_{cell} = {^{RT}/_{nF}}\,lnK^\circ$

$K^\circ = e^{\wedge}({^{nF}/_{RT}}\,E^\circ_{cell})$

$F = 96485$ $^J/_{V \cdot mol\ of\ electrons}$

$\Delta G^\circ = \Delta H^\circ_{system} - T\Delta S^\circ_{system}$

$\Delta G^\circ = -nFE^\circ_{cell} = -RTlnK^\circ$

$\Delta G = \Delta G^\circ + RTlnQ$

$F = 96485$ $^C/_{mol\ electrons}$

$1A = 1\ C / sec$

1																		2
H 1.0079																		**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 frequency of collisions between reacting particles
   b. The orientation of colliding particles
   c. The coefficients of the reactants in the balanced equation
   d. The temperature of the system
   e. The energy of collisions between reacting particles

2. 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 $k[A]^a[B]^b$
   c. Is equal to $([A]^a[B]^b)/([C]^c[D]^d)$
   d. Is equal to $([C]^c[D]^d)/([A]^a[B]^b)$
   e. Must be measured, it cannot be derived from the balanced equation

3. If the rate of a reaction increases by a factor if 9 when the initial concentration of reactant "A" is increased by a factor of 9, 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. 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 activation energy for a reaction
   c. The presence of a catalyst does not change the mechanism of a reaction
   d. The concentration of a catalyst cannot appear in the rate law for a reaction
   e. The presence of a catalyst changes the energy of the products and reactants in a reaction

5. 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 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

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

Score

Problems: Show your work.

7. A reaction is found to be first order with respect to reactant A and second order with respect to reactant B. If $[A]_o = 0.168M$, $[B]_o = 0.761M$ and $k = 8.51 \times 10^{-2}\ M^{-2}sec^{-1}$, what is the initial rate of the reaction? (10pts)
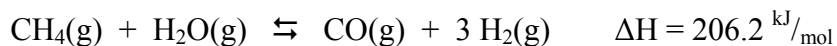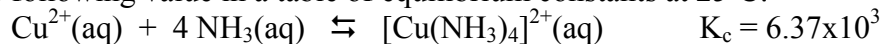
8. For the reaction:
$$CH_4(g)\ +\ H_2O(g)\ \rightleftarrows\ CO(g)\ +\ 3\ H_2(g) \qquad \Delta H = 206.2\ ^{kJ}/_{mol}$$
The equilibrium concentrations are observed: $[CO]_{eq} = 1.16M$, $[H_2]_{eq} = 0.961M$, $[CH_4]_{eq} = 9.94 \times 10^{-3}\ M$, $[H_2O]_{eq} = 4.46 \times 10^{-4}\ M$. What is the equilibrium constant for this reaction? (10pts)

9. A reaction is found to be second order with respect to nitrate ion, a reactant. If $[NO_3^-]_o = 5.68M$ and $k = 2.91 \times 10^{-4}\ M^{-1}sec^{-1}$, what will the concentration be after 12 minutes have passed? (10pts)

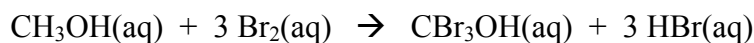10. You have found the following value in a table of equilibrium constants at 25ºC:
$$Cu^{2+}(aq)\ +\ 4\ NH_3(aq)\ \rightleftarrows\ [Cu(NH_3)_4]^{2+}(aq) \qquad K_c = 6.37 \times 10^3$$
What is the equilibrium constant for the following reaction? (10pts)
$$3\ [Cu(NH_3)_4]^{2+}(aq)\ \rightleftarrows\ 3\ Cu^{2+}(aq)\ +\ 12\ NH_3(aq)$$

Score
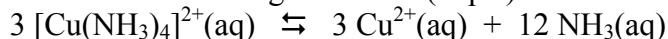
11. Methane (CH_4) reacts with oxygen to form carbon dioxide and water. Under some set of conditions at some point in time, you find that 6.115g of methane react every minute in a 500.0mL vessel. (15pts)
    a. What is the rate of methane consumption?
    b. What is the rate of oxygen consumption?
    c. What is the rate of carbon dioxide production?
    d. What is the rate of water production?
   e. What is the rate of the *reaction*?

12. For the reaction:
$$CH_3OH(aq) + 3\ Br_2(aq) \rightarrow CBr_3OH(aq) + 3\ HBr(aq)$$
You have collected the following data at 14.88ºC:

Experiment	$[CH_3OH]_o$	$[Br_2]_o$	$Rate_{observed}$
1	3.97 M	2.86 M	$3.49 \times 10^{-3}\ M/_{sec}$
2	7.94 M	2.86 M	$6.98 \times 10^{-3}\ M/_{sec}$
3	3.97 M	5.72 M	$6.98 \times 10^{-3}\ M/_{sec}$

What are the rate law and the value of the rate law constant, k, for this reaction?
If you redo Experiment 2 at 41.26ºC, the rate is $7.53 \times 10^{-2}\ M/_{sec}$. What is the activation energy for this reaction? (20pts)

Score

Name: _____

13. The graph at the right represents an uncatalyzed reaction, $E + F \rightarrow G + H$. Modify the graph to show what it would look like if a catalyst were used. Explain your modifications. (10pts)

Energy →

E + F

G + H

Reaction Coordinate →
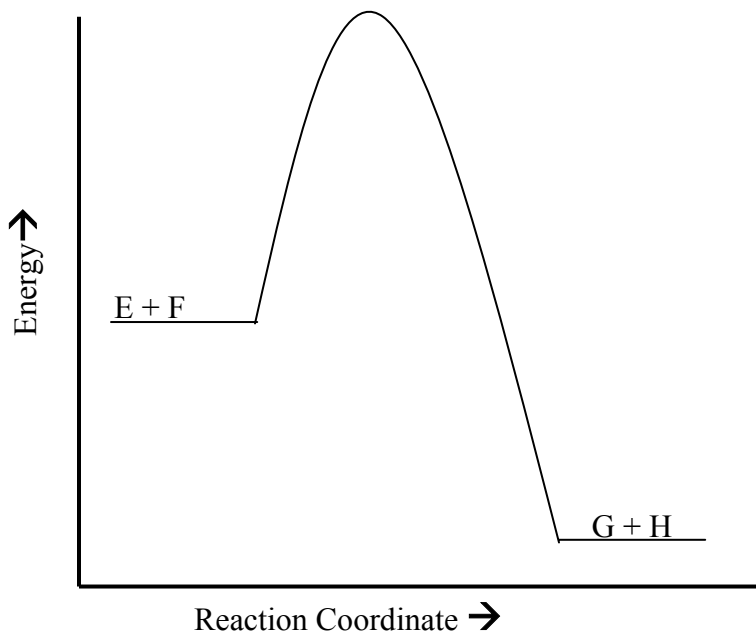
14. When 0.518mols of nitrogen dioxide $\{NO_2(g)\}$ and 0.815mols of chlorine gas $\{Cl_2(g)\}$ are sealed together in a 2.000L vessel, they reach equilibrium with nitrogen trichloride $\{NCl_3(g)\}$ and oxygen $\{O_2(g)\}$. The equilibrium concentration of $Cl_2(g)$ is found to be 0.316 M. (20pts)
   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

15. You have been studying the reaction series:

A → B → C

The first step (A → B) is exothermic, the second step (B → C) is endothermic, and the overall reaction (A → C) is exothermic. Draw qualitatively correct Reaction Coordinate/Energy diagrams for this series of reactions if: a) the first step is slow; b) the second step is slow. Label all axes and any other features of importance on the graphs. **(Your answer will include 2 separate graphs.)** (15pts)

Score