Chemistry 210 Exam 1

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•atm/mol•K = 8.314 J/mol•K
1atm = 760torr = 760mmHg = 101.325kPa
PV=nRT
$\Delta T_{fp/bp} = k_{fp/bp} \cdot m \cdot i$
For water: $k_{fp} = -1.86$ °C/m
$k_{bp} = 0.512$ °C/m
$P_1 = X_1 P_1^o$
$\Pi = MRTi$
$C_1V_1 = C_2V_2$

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

Integrated Rate Laws:
$\ln[A]_t = -kt + \ln[A]_o$
$1/[A]_t = kt + 1/[A]_o$
$[A]_t = -kt + [A]_o$
$k = Ae^{-Ea/RT}$
$$\ln(k) = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$
$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$
$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{conjugate acid}]}\right)$$

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

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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 (6pts each): Circle the letter of the most correct response.

1. Rank the 3 states of matter from lowest kinetic energy to highest kinetic energy.
   - ***a. Solid, liquid, gas***
   - b. Gas, solid, liquid
   - c. Liquid, gas, solid
   - d. Gas, liquid, solid
   - e. Solid, gas, liquid

2. When dissolving a solid in a liquid:
   - a. Formation of solvent-solute interactions is endothermic
   - ***b. The boiling point of the solution will be higher than that of the pure solvent***
   - c. Energy is released (exothermic) by breaking solvent-solvent and solute-solute interactions
   - d. The enthalpy of solution is always positive
   - e. The freezing point of the solution will be higher than that of the pure solvent

3. Which of the following statements is most correct about colligative properties of an ideal solution?
   - ***a. Colligative properties depend upon the number of solute particles, not on the identity of the solute particles.***
   - b. The presence of a solute raises the freezing point of a solution.
   - c. The presence of a solute lowers the boiling point of a solution.
   - d. The presence of a solute raises the vapor pressure of a solution.
   - e. These statements are all correct.

4. The volume of a gas:
   - a. Decreases as the temperature increases
   - b. Remains constant as the amount of gas is increased
   - c. Is always a constant
   - ***d. Decreases as the pressure increases***
   - ***e. Increases as the kinetic energy increases***

5. Under which of the following conditions is a gas ***least*** "ideal"?
   - a. Low temperature, low pressure
   - b. High temperature, low pressure
   - c. Room temperature, 25ºC
   - d. High temperature, high pressure
   - ***e. Low temperature, high pressure***

6. Which of the following is ***not*** a correct gas law relationship?
   - a. $PV = nRT$
   - b. $n_1T_1 = n_2T_2$
   - ***c.*** $V_1n_1 = V_2n_2$
   - d. $P_1V_1 = P_2V_2$
   - e. $P_1 / T_1 = P_2 / T_2$

Score

7. What is the volume of 1.648mols of ideal gas at 34.67°C and 2.81atm pressure? (12pts)

$$PV = nRT$$
$$(2.81atm)V = (1.648mols)(0.08206^{L\bullet atm}/_{mol\bullet K})(34.67+273.15K)$$
$$V = 14.8L$$

8. You have a 17.38L sample of gas at 41.29°C. What is the volume of this gas if the temperature is decreased to 14.82°C? (12pts)

$$V_1 / T_1 = V_2 / T_2$$
$$(17.38L) / (41.29+273.15K) = V_2 / (14.82+273.15K)$$
$$V = 15.92L$$

9. You have prepared a solution by dissolving 21.918g of magnesium bromide in enough water to make 400.0mL of solution. What is the *molarity* of this solution? (12pts)

$$(21.928g\ MgBr_2) / (184.113^{g}/_{mol}) / (0.4000L) = 0.2979M$$

10. What is the freezing point of a solution made by dissolving 26.734g of nickel(II) nitrate in 200.0g of water? (15pts)

$$(26.734g\ Ni(NO_3)_2) / (182.698^{g}/_{mol}) / (0.2000kg) = 0.7316m$$
$$\Delta T_{fp} = k_{fpd}\bullet m\bullet n = (1.86^{°C}/_{m})(0.7316m)(3) = 4.08°C$$
The freezing point of the solution is -4.08°C.

11. Each of the following solids is dissolved in separate beakers containing 500.0mL of water. Rank the solutions from highest freezing point to lowest freezing and explain your answer. (15pts)
   a. 0.4mols magnesium phosphate
   b. 0.5mols calcium nitrate
   c. 0.6mols sodium chloride
   d. 0.7mols ammonium phosphate

The change in a colligative property is dependent upon the number of solute particles. For each of the above: a → 5(0.4mol) = 2.0mols of particles; b → 3(0.5mol) = 1.5mols of particles; c → 2(0.6mol) = 1.2mols of particles; d → 4(0.7mol) = 2.8mols of particles;
Highest (least depressed) freezing point → c > b > a > d → Lowest (most depressed) freezing point

Score

12. How much energy is lost when cooling 750.0g of water from 37.25ºC to -11.92ºC? {C_s(ice) = 2.09 $^J/_{g.K}$; C_s(water) = 4.184 $^J/_{g.K}$; C_s(steam) = 2.01 $^J/_{g.K}$; ΔH_{fusion}(water) = 6.02 $^{kJ}/_{mol}$; $\Delta H_{vaporization}$(water) = 40.7 $^{kJ}/_{mol}$ } (25pts)

There are 3 processes taking place over this temperature range: 37.25°C→0°C = heat capacity of liquid water; at 0°C→enthalpy of fusion of water; 0°C→-11.92°C = heat capacity of solid water

$$(4.184\,^J/_{g\bullet K})(750.0g)(37.25K) = 116890J = 116.9kJ$$

$$(6.02\,^{kJ}/_{mol})(750.0g / 18.015\,^g/_{mol}) = 251kJ$$

$$(2.09\,^J/_{g\bullet K})(750.0g)(11.92K) = 18680J = 18.7kJ$$

Total energy lost = 116.9kJ + 251kJ + 18.7kJ = 387kJ

13. You have reacted 2.83g of aluminum metal with100.0mL of 3.07M HCl(aq) to produce hydrogen gas and aluminum chloride. How many liters of hydrogen gas can be produced at 38.27°C and 1.085atm? (25pts)

$$2\ Al(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2(g)$$

$$(2.83g\ Al)\left(\frac{1mol\ Al}{26.982g\ Al}\right)\left(\frac{3mols\ H_2}{2mols\ Al}\right)\left(\frac{(0.08206\frac{L\bullet atm}{mol\bullet K})(311.42K)}{1.085atm}\right) = 3.71L\ H_2(g)$$

$$(0.1000L\ HCl(aq))\left(\frac{3.07mols\ HCl}{1\ L\ HCl(aq)}\right)\left(\frac{3mols\ H_2}{6mols\ HCl}\right)\left(\frac{(0.08206\frac{L\bullet atm}{mol\bullet K})(311.42K)}{1.085atm}\right) = 3.62L\ H_2(g)$$

HCl(aq) is the limiting reagent, 3.62L of H_2(g) can be produced by this combination.

Score