Name: ____

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 = $6.022\times10^{23}\ ^{\text{units}}/_{\text{mol}}$
$32.00^{o}F = 0.000^{o}C = 273.15K$
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: $k_{fp} = -1.86\ ^{oC}/_{m}$
$k_{bp} = 0.512\ ^{oC}/_{m}$
$P_1 = X_1P_1^{o}$
$\Pi = cRTi$
$C_1V_1 = C_2V_2$

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

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

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

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 (6pts each): Circle the letter of the most correct response.

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

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

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

4. All of the following concentration units require that you use the molar mass of the solute except:
   a. Molarity
   b. Mass percent
   c. Mole fraction
   d. Normality
   e. Molality

5. When dissolving a solid in a liquid:
   a. Formation of solvent-solute interactions is endothermic
   b. The boiling point of the solution will be lower 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 lower than that of the pure solvent

6. Carbon tetrabromide (CBr_4) has a higher boiling point than carbon tetrafluoride (CF_4) because:
   a. The bonds in CF_4 are polar but the bonds in CBr_4 are not
   b. CBr_4 has a higher molecular weight than CF_4
   c. CF_4 is a polar molecule but CBr_4 is not
   d. CF_4 has stronger intermolecular forces than CBr_4
   e. CF_4 is a gas at room temperature

Score

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

Sodium phosphate is Na_3PO_4,

$$M = \left(\frac{\left(\frac{\text{grams solute}}{\text{formula mass of solute}}\right)}{\text{L of solution}}\right) = \left(\frac{\left(\frac{21.918\text{g}}{163.940\,\text{g/mol}}\right)}{400.0\text{mL}\left(\frac{1\text{L}}{1000\text{mL}}\right)}\right) = 0.3342\text{M}$$

8. You have prepared a solution by dissolving 12.537g of ammonium perchlorate in 100.0g of water. What is the *molality* of this solution? (12pts)

Ammonium perchlorate is NH_4ClO_4,

$$m = \left(\frac{\left(\frac{\text{grams solute}}{\text{formula mass of solute}}\right)}{\text{kg of solvent}}\right) = \left(\frac{\left(\frac{12.537\text{g}}{117.488\,\text{g/mol}}\right)}{100.0\text{g}\left(\frac{1\text{kg}}{1000\text{g}}\right)}\right) = 1.067\text{m}$$

9. You have prepared a solution by diluting 15.00mL of a 1.268M aqueous solution of iron(II) sulfate to a total volume of 125.0mL. What is the *molarity* of this solution? (12pts)

For dilutions, use $C_1V_1 = C_2V_2$

$$(1.268\text{M})(15.00\text{mL}) = C_2(125.0\text{mL})$$
$$C_2 = 0.1522\text{M}$$

10. What is the boiling point of a solution made by dissolving 26.734g of sodium nitrate in 200.0g of water?

Sodium nitrate is $NaNO_3$, and forms 2 particles in solution, so the change in T_{bp} is:

$$\Delta T_{bp} = (k_{bpe})\left(\frac{\left(\frac{\text{grams solute}}{\text{formula mass of solute}}\right)}{\text{kg of solvent}}\right)\left(\frac{\text{mols particles}}{\text{mol solute}}\right) = \left(0.512\,\tfrac{°\text{C}}{\text{m}}\right)\left(\frac{\left(\frac{26.734\text{g}}{84.994\,\text{g/mol}}\right)}{0.2000\text{kg } H_2O}\right)(2) = 1.61°\text{C}$$

Pure water boils at 100°C, so the boiling point of this solution should be (100°C + 1.61°C) = 101.61°C

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

Since all of the solutes are being dissolved in the same amount of water, the amount of boiling point elevation depends upon the number of particles each solute contributes to the solution.
0.4mols $Mg_3(PO_4)_2$ → 5 mols of particles per mol of solute → (5)(0.4) = 2.0mols of solute particles
0.6mols NaCl → 2 mols of particles per mol of solute → (2)(0.6) = 1.2mols of solute particles
0.7mols $(NH_4)_3PO_4$ → 4 mols of particles per mol of solute → (4)(0.7) = 2.8mols of solute particles
0.5mols $Ca(NO_3)_2$ → 3 mols of particles per mol of solute → (3)(0.5) = 1.5mols of solute particles

Highest: 0.7mols $(NH_4)_3PO_4)_2$ > 0.4mols $Mg_3(PO_4)_2$ > 0.5mols $Ca(NO_3)_2$ > 0.6mols NaCl : Lowest B.P.

Score

12. How much energy is required to heat 1.285kg of water from 65.29ºC to 115.62ºC? {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)

Heating liquid water from 65.29°C to 100°C	(4.184 $^{J}/_{g\bullet°C}$)(1285g)(34.71°C) = 186600J
Phase change liquid to gas	(1285g / 18.015$^{g}/_{mol}$)(40.7$^{kJ}/_{mol}$)(1000 $^{J}/_{kJ}$) = 2903000J
Heating steam from 100°C to 115.62°C	(2.01 $^{J}/_{g\bullet°C}$)(1285g)(15.62°C) = 40300J
Total	3129900J

It's equally acceptable to report this problem in kilojoules.

13. Some salts have enough covalent bond character that they do not completely dissociate when dissolved in water. You have performed an experiment in which you have made a solution by dissolving 29.531g of bismuth(III) chloride in 150.00mL of water. The observed freezing point of this solution is –2.32ºC. Which of the following equations is most consistent with your observed freezing point? Explain your answer with explicit calculations. (25pts)

$$BiCl_3(s) \rightarrow Bi^{3+}(aq) + 3\,Cl^-(aq)$$
$$BiCl_3(s) \rightarrow [BiCl]^{2+}(aq) + 2\,Cl^-(aq)$$
$$BiCl_3(s) \rightarrow [BiCl_2]^{+}(aq) + Cl^-(aq)$$
$$BiCl_3(s) \rightarrow BiCl_3(aq)$$

$$\Delta T_{fp} = (k_{fpd})\left(\frac{\left(\frac{\text{grams BiCl}_3}{{}^{g}\!/_{mol}\ \text{BiCl}_3}\right)}{\text{kg of solvent}}\right)\left(\frac{\text{mols of particles}}{\text{mol of BiCl}_3}\right) = 2.32°C = (1.86\ {}^{°C}\!/_{m})\left(\frac{\left(\frac{29.531}{315.339\ {}^{g}\!/_{mol}}\right)}{0.15000\text{kg H}_2\text{O}}\right)(x)$$

Since x = 1.998, dissolving a mol of $BiCl_3$ will yield 2 mols of particles, so the third equation most consistent with the observed freezing point.

Score