EXAM 2 (CHEMISTRY 112 UIC(SUMMER 2006)

NAME: PRINT: KEY SIGN_____

MULTIPLE CHOICE SECTION

3Points Per Problem 3 x 25 =75 Points

1) Which of the following is (are) characteristic of gases?
[A] high compressibility
[B] relatively large distances between molecules
[C] formation of homogeneous mixtures, regardless of the natures of nonreacting gas components
[D] all of these
[E] none of these

2) A balloon originally had a volume of 4.39 L at 44°C and a pressure of 729 torr. To what temperature must the balloon be cooled to reduce its volume to 3.78 L if the pressure is constant? *SHOW WORK*
[A] 51.1°C [B] 38°C [C] 95.2°C [D] 0°C [E] 273°C

$\frac{4.39}{317} = \frac{3.78}{x}$ $x = 273K \Rightarrow 0°C$

3) Which one of the following decreases as the strength of the attractive intermolecular forces increases?
[A] The heat of vaporization
[B] The vapor pressure of a liquid.
[C] The sublimation temperature of a solid.
[D] The extent of deviations from the ideal gas law.
[B] The normal boiling temperature

4) Order the intermolecular forces (dipole-dipole, London Dispersion, ionic, and hydrogen-bonding) from weakest to strongest.

[A] dipole-dipole, London Dispersion, ionic, and hydrogen-bonding
[B] dipole-dipole, ionic, London Dispersion, and hydrogen-bonding
[C] London Dispersion, dipole-dipole, hydrogen-bonding, ionic
[D] London Dispersion, ionic, dipole-dipole, and hydrogen-bonding
[E] hydrogen-bonding, dipole-dipole, London Dispersion, and ionic

5) Which of the following should have the lowest boiling point?

[A] H_2O [B] Na_2S [C] N_2 [D] HF [E] NH_3

6) On a relative basis, the weaker the intermolecular forces in a substance,
[A] the greater its vapor pressure at a particular temperature.
[B] the higher its melting point.
[C] the more it deviates from ideal gas behavior.
[D] the greater its heat of vaporization.
[E] none of these

7) Which of the following is the correct order of boiling points for KNO_3, CH_3OH, C_2H_6, Ne?
[A] $Ne < C_2H_6 < CH_3OH < KNO_3$
[B] $Ne < C_2H_6 < KNO_3 < CH_3OH$
[C] $C_2H_6 < Ne < CH_3OH < KNO_3$
[D] $KNO_3 < CH_3OH < C_2H_6 < Ne$
[E] $Ne < CH_3OH < C_2H_6 < KNO_3$

8) Which of the following concentration measures will change in value as the temperature of a solution changes?
[A] molarity [B] mass percent [C] molality [D] mole fraction [E] all of these

9) The freezing point of helium is -270°C. The freezing point of xenon is -112°C. Both of these are in the noble gas family. Which of the following statements is supported by these data?

[A] The London dispersion forces between the helium molecules are less than the London dispersion forces between the xenon molecules.
[B] Helium and xenon form highly polar molecules.
[C] The London dispersion forces between the helium molecules are greater than the London dispersion between the xenon molecules.
[D] As the molecular weight of the noble gas increases, the freezing point decreases.
[E] none of these

10) How much energy is needed to convert 3.555 moles of ice at 0.00°C to water at 75.0°C? *SHOW WORK*

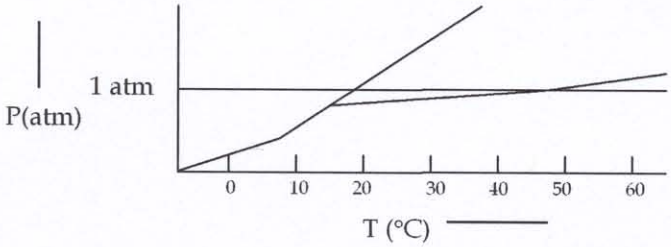
specific heat (ice) = 2.10 J / (g°C)
specific heat (water) = 4.18 J / g(g°C)
heat of fusion = 333 J / g
heat of vaporization = 2258 J / g

[A] 20.7 kJ [B] 10.1 kJ [C] 41.4 kJ [D] 65.8 kJ [E] 31.4 kJ

$(333)(64) + (4.18)(64)(75)$
$41,376\ J = 41.4\ kJ$

11) The triple point of CO_2 is at 5.2 atm and 57°C. Under atmospheric conditions present in a typical cold winter night in a Boulder, Colorado, laboratory (P = 630 torr, T = -15°C), solid CO_2 will:
[A] melt. [B] sublime. [C] boil. [D] remain solid. [E] none of these

12) Shown is a phase diagram for compound X. At 25□C and 1 atm X will exist as a:



[A] gas. [B] liquid. [C] solid. [D] gas/liquid at equilibrium. [E] gas/solid at equilibrium.

13) A 3.140 molal solution of NaCl is prepared. How many grams of NaCl are present in a sample containing 3.000 kg of water?

[A] 314.0 g [B] 755.0 g [C] 550.5 g [D] 942.0 g [E] none of these (a-d)

$3.14 \times 3 \times 58.45 = 550.6\ g$

14) A correct statement of Henry's law is:

[A] the concentration of a gas in a solution is proportional to pressure.
[B] the concentration of a gas in solution is independent of pressure.
[C] the concentration of a gas in solution is directly proportional to the mole fraction of solvent.
[D] the concentration of a gas in solution is inversely proportional to temperature.
[E] two of the above

15) A particular 10.0-L container will explode if the internal pressure exceeds 50.0 atm. What is the largest mass of He that can be inserted into the container at 19.0°C? *SHOW WORK*

[A] 20.9 g [B] 0.824 g [C] 1.28 x 103 g [D] 83.5 g [E] 6.849 g

$$\frac{(50)(10)(4)}{0.0821 \times 292} = 83.4$$

16) At 40°C, heptane has a vapor pressure of 92.0 torr and octane has a vapor pressure of 31.2 torr. Assuming ideal behavior, what is the vapor pressure of a solution that contains twice as many moles of heptane as octane? *SHOW WORK*

[A] 61.6 torr [B] 71.7 torr [C] 51.5 torr [D] 76.8 torr [E] none of these

$$\frac{1}{3}(31.2) + \frac{2}{3}(92.0) = 71.9$$

Raoult's Law + Partial Pressure

17) What is the boiling point change for a solution containing 0.328 moles of naphthalene (a nonvolatile, nonionizing compound) in 250. g of liquid benzene? (K_b = 2.53°C/m for benzene) *SHOW WORK*

[A] 3.32°C [B] 1.93°C [C] 4.31°C [D] 7.41°C

$$\frac{0.328 \text{ mole}}{0.25 \text{ kg}} \Rightarrow \text{molality} \times 2.53 = \Delta T = 3.3$$

18) In order to calculate the freezing point depression for a solvent contaminated with a non-volatile solute, the minimum information one must know is:

[A] the molality (of the solute).
[B] the molality (of the solute) and the freezing point depression constant of the solvent.
[C] the same quantities as in b plus the freezing point of the pure solvent.
[D] all of the quantities in c plus the molecular weight of the solute.
[E] all of the quantities in c plus the weight of the solvent.

19) Determine the mass of a nonvolatile, nonionizing compound that must be added to 3.00 kg of water to lower the freezing point to -1.3°C. The molar mass of the compound is 50.0 g/mol and the K_f for water is 1.86°C kg/mol. *SHOW WORK*

[A] 162 g [B] 14 g [C] 105 g [D] 22 g [E] 72 g

$$\frac{(50)(1.3)(3.0)}{1.86} = 104.8$$

20) Consider pure water separated from an aqueous sugar solution by a semipermeable membrane, which allows water to pass freely but not sugar. After some time has passed, the concentration of sugar solution:

[A] will have increased
[B] might have increased or decreased depending on other factors.
[C] will have decreased.
[D] will not have changed.
[E] will be the same on both sides of the membrane

20) Optional AT 373C Normal boiling pt of water Partial Pressure = 760 torr= 1atm.

21) Find the quantity of a gas in moles if 6.38 L at 358°C has a pressure of 955 torr.
[A] 207 mol [B] 0.155 mol [C] 6.45 mol [D] 0.285 mol [E] 0.273 mol

$\left(\frac{955}{760}\right)(6.38L) = n(.0821)(631)$ $n = 0.155$

22) A quantity of N2 gas originally held at 3.80 atm pressure in a 1.00-L container at 26°C is transferred to a 10.0-L container at 20°C. A quantity of O2 gas originally at 4.75 atm and 26°C in a 5.00-L container is transferred to this same container. What is the total pressure in the new container? *SHOW WORK*
[A] 2.52 atm [B] 3.80 atm [C] 2.76 atm [D] 2.70 atm [E] 8.55 atm

$(3.8)(1) = n_1 \times .0821 \times 299$ $n_1 = 0.155$ moles
$(4.75)(5) = n_2 \times 0.0821 \times 299$ $n_2 = 0.9674$ mole

$n_T = 1.1229$

$P(10) = 1.1229 \times .0821 \times 293$ $P = 2$

23) Calculate the molar mass of a gas if 4.40 g occupies 3.50 L at 560. torr and 41°C. *SHOW WORK*
[A] 28.2 g/mol [B]44.0 g/mol [C] 10.0 g/mol [D] 32.4 g/mol [E] 5.74 g/mol

$$M = \frac{44 \times 0.0821 \times 314}{\left(\frac{560}{760}\right) \times 3.5} = 43.98$$

24) Which of the following samples of gas would occupy the greatest volume at standard temperature and pressure (STP)?
[A] one gram of helium
[B] one gram of laughing gas (N_2O)
[C] one gram of propane fuel (C_3H_8)
[D] one gram of air
[E] Because of the standard molar volume, each of these 1-g samples would occupy the same volume.

25) Calculate the density of H_2S gas at 0.122 atm and 25.0°C. (MW(H_2S)= 34.08) *SHOW WORK*
[A] 0.185 g/L [B] 5.88 g/L [C] 2.03 g/L [D] 4.99 x 10-3 g/L [E] 0.170 g/L

$$P = \frac{nRT}{V} \rightarrow \rho = \frac{P \cdot MW}{R \cdot T}$$

$$\rho = \frac{0.122 \times 34.08}{0.0821 \times 298} = 0.169 \text{ g/L}$$

FREE RESPONSE SECTION
CHOICE EIGHT(8) of 10 Problems 5 Points Each x 8 = **40 points**

1) Show the Lewis Dot Structures; VSEPR geometries (structure/angles); and Hybridization for central atoms for the following Molecules/Ions

CO_2

sp

linear (2 domains) 180°

NH_3

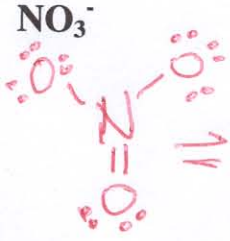
sp3 (4 dom

107° (less tha

distorted tet

trigonal pyra

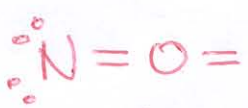
NO_3^-



⇌ 2 other resonant Structures

sp2 (trigonal Planar) 3 domains

N_2O



Sp

Linear 2 dom

2) What is the level of hybridization for the Carbon atoms in:

Benzene (C_6H_6) — *All sp2*

Acetylene C_2H_2 — *Both sp*

Propane $CH_3CH_2CH_3$ — *All sp3*

Allene (H_2C — *sp2—sp—s*

3) Consider the Combustion of Ethanol:

$C_2H_5OH_{(gas)} + 3\ O_{2(gas)} = 2\ CO_{2(gas)} + 3\ H_2O_{(gas)}$ ΔH = -1277.1 kJ/mol

Using the Bond Enthalpies:

O=O	495 kJ	C-C	348 kJ
C=O	799 kJ	OH	463 kJ
C-H	413 kJ	C-O	358 kJ

Determine the above ΔH_{rxn} for the combustion of Ethanol . Why is it different from above Enthalpy determined by experimental data.

1 (C-C) + 5(C-H) + 1(C-O) + 1(O-H) + 3(O=O) - { 4(C=O) +6(O-H) }

4719-5974 = -1255 kJ/mol Difference doe to the use of AVERAGE bond energies

Problem 4 Use the Activity Table below:

TABLE 4.5 Activity Series of Metals in Aqueous Solution

Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
Calcium	$Ca(s) \longrightarrow Ca^{2+}(aq) + 2e^-$
Sodium	$Na(s) \longrightarrow Na^+(aq) + e^-$
Magnesium	$Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$
Aluminum	$Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$
Manganese	$Mn(s) \longrightarrow Mn^{2+}(aq) + 2e^-$
Zinc	$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
Chromium	$Cr(s) \longrightarrow Cr^{3+}(aq) + 3e^-$
Iron	$Fe(s) \longrightarrow Fe^{2+}(aq) + 2e^-$
Cobalt	$Co(s) \longrightarrow Co^{2+}(aq) + 2e^-$
Nickel	$Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^-$
Tin	$Sn(s) \longrightarrow Sn^{2+}(aq) + 2e^-$
Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^-$
Hydrogen	$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$
Copper	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Silver	$Ag(s) \longrightarrow Ag^+(aq) + e^-$
Mercury	$Hg(l) \longrightarrow Hg^{2+}(aq) + 2e^-$
Platinum	$Pt(s) \longrightarrow Pt^{2+}(aq) + 2e^-$
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Ease of oxidation increases

a) List THREE METALS that WILL react BOTH Acid as well as with $ZnCl_2$

Mn and Above

b) List THREE METALS CATIONS that w react with Zinc Metal

Mn and Above

5) The Born-Haber Cycle looks at the formation of a salt from its elements, e.g. NaCl(s) from Na(s) and Cl_2(g) using Hess's Law. There are five(5) steps to the overall formation of NaCl(s)

$Na(s) + 0.5Cl_2(g) \rightarrow NaCl(s)$ $\Delta H°_f = -410.9$ kJ/mol

Fill in the missing Process and Thermodynamic Influence

Process	Endothermic/Exothermic
$Na_{(s)} => Na_{(gas)}$	*Endothermic*
$1/2Cl_{2(g)} \rightarrow Cl_{(g)}$	*Endothermic*
$e^- + Cl_g \rightarrow Cl^-$	*Exothermic*
$Na(g) \rightarrow Na^+(g) + e$	*Endothermic*
$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$	*Exothermic*

6) The following gases are added to a 5.0 L container: 3 moles of CS_2, 3 moles Br_2. These gases react as follows:

$$CS_2\,(g) + 3Br_2\,(g) \Leftrightarrow CBr_4\,(g) + S_2Br_2\,(g)$$

At equilibrium, the container contains 0.3 moles of S_2Br_2. . [Remember to balance]

	CS_2 mol/L	Br_2 mol/ L	CBr_4 mol/ L	S_2Br_2 mol/L
Initial	*0.6*	*0.6*	*0*	*0*
Change	*-x*	*-3x*	*x*	*x*
Equilibrium	*0.54*	*0.42*	*0.06*	*0.06*

a) What will be the equilibrium concentrations for all components.
b) Calculate the equilibrium constant, K_c, for this reaction.

$$[0.06][0.06] / \{ [0.54][0.42]^3 \} = 0.09$$

7) At 120°C. K_c is 2.98×10^{-2} for the reaction

$$4NOBr\,(g) + 3O_2\,(g) \Leftrightarrow 2N_2O_5\,(g) + 2Br_2\,(g)$$

In a given experiment, 2.0 mol of each reactant and product is introduced into a 500 ml container. **[Remember to balance]**

a. What is the equilibrium constant for the REVERSE reaction?
b. Is the reaction at equilibrium? Show a calculation to justify.
c. If not in what direction should the reaction proceed and WHY?
d. (**SETUP ONLY** how you would reach equilibrium if necessary)

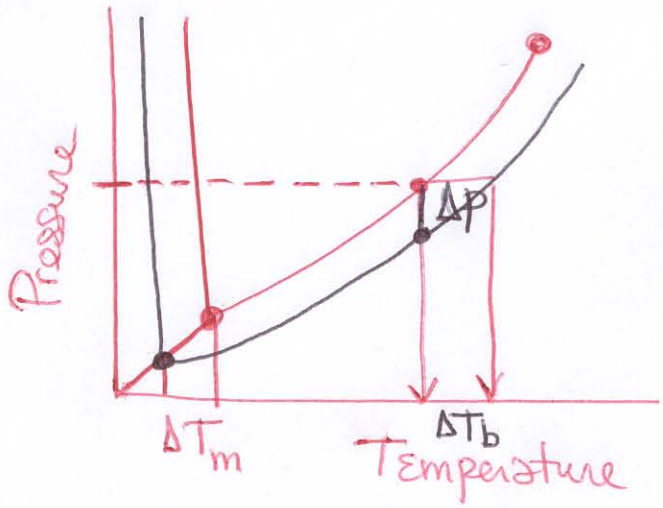
(a) $K'_{eq} = 1/K_{eq} = 1/2.98 \times 10^{-2}$

(b) $Q = \dfrac{[N_2O_5]^2[Br_2]^2}{[NOBr]^4[O_2]^3} = \dfrac{4^2 \cdot 4^2}{4^4 4^3} = 4^{-3} =$

(c) $Q = 0.0156 < 0.0298$ → too little product
Shift to RIGHT

(d) Solve $\dfrac{[4+2x]^2[4+2x]^2}{\quad} = 0.0298$

8) Draw a generalized Phase Diagram for water and utilize Raoult's Law to demonstrate how the change of partial pressure of water is influenced by the addition of a salt. Illustrate how one arrives at both freezing point depression and boiling point elevation. (You need to be very specific and detailed!!!!)



$\chi_{solvent} = \frac{n_{solvent}}{n_{solu} + n}$

$\Delta p = p^{\circ} - p'$

$p' = \chi_{solvent} \times p^{\circ}$

p° = pure vapor pressure

p' = reduced pressure with solute

9) A solution of hydrogen peroxide is 30.0% H_2O_2 by mass and has a density of 1.11 g/cm3. The molarity of the solution is: *SHOW WORK*

[A] 8.82 M [B] 9.79 M [C] 0.980 M [D] 7.94 M

30 grams H_2O_2 / 100 grams of solution

$\frac{30 \text{ grams } H_2O_2}{34} = 0.882 \text{ moles}$

100 grams of solution $\times \left(\frac{1 \text{ mL}}{1.11 \text{ g solution}}\right) = 0.90$

$\frac{0.8823 \text{ moles}}{0.90 \text{ L solution}} = \boxed{9.79 \text{ M}}$

Then; What is the molality of the above 30.0% H_2O_2 solution? *SHOW WORK*

$\frac{0.8823 \text{ moles}}{70 \text{ g of water}} \rightarrow \frac{0.8823 \text{ moles}}{0.70 \text{ kg water}} = \boxed{12.6 \text{ molal}}$

10) Balance the Following Equation:

Consider the Redox reaction in Acidic Environment:

As_2O_3 (*s*) + NO_3^- (*aq*) → H_3AsO_4 (*aq*) + NO (*g*)

What are the oxidation numbers of As in As_2O_3 and in H_3AsO_4

$As_2^{+3}O_3 \longrightarrow 2H_3As^{+5}O_4 + 4e$

What are the oxidation numbers of N in both NO_3^- and NO

$3e^- + N^{+5}O_3^- \longrightarrow N^{+2}O$

N (NO_3^-) is reduced in this reaction

As (As_2O_3) is oxidized in this reaction

As (As_2O_3) is the reducing agent

Write the half reaction for Arsenic and define the number of electrons transferred (gained/lost) [circle] *HINT Remember to balance As's*

$3(As_2O_3 \xrightarrow{4e} 2H_3AsO_4 + 4e)$

Write the half reaction for Nitrogen and define the number of electrons transferred (gained/lost) [circle]

$4(3e^- + NO_3^- \xrightarrow{3e} NO)$

Combine Reduction and Oxidation Reactions by multiplying each by appropriate number thus cancel electrons

$3As_2O_3 + 4NO_3^- \xrightarrow{12e} 6H_3AsO_4 + 4NO$

Add Waters to Mass Balance Oxygen

$7H_2O + \ldots$

Write final balanced equation with acid (H+) included to balance Hydrogens.

$4H^+ + 7H_2O + 3As_2O_3 + 4NO_3^- \xrightarrow{12e} 6H_3AsO_4 + 4N$