Chemistry 141 Name

Dr. Cary Willard

Exam 4 May 22, 2013

|  |  |  |
| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 3 multiple choice |  | 30 |
| Page 5 |  | 13 |
| Page 6 |  | 18 |
| Page 7 |  | 13 |
| Page 8 |  | 16 |
| Page 9 |  | 8 |
| Page 10 |  | 12 |
| Total |  | 110 |
| Percent Score |  | 100 |

Note: All work must be shown to receive credit. On calculation problems show answer with the correct number of significant figures using scientific notation if necessary.

Chemistry Formulas and Constants



Formulas

Kinetic energy = ½ mv2

w = −PΔV

Ptotal = P1+P2+P3+…

ΔG = ΔH - TΔS

PV = nRT

P1=*i*X1∙Ptotal

C = q/ΔT

ΔGo = -nFEo

ΔG = - RTlnK

E = mc2

Ba(Na)2 = fruit

HΨ=EΨ

Amp = C/sec

π= *i*MRT

E = hν = hc/λ

M1V1 = M2V2

Ptotal = P1 + P2 + P3 + …

M = mol/L

m = mol/kg solvent

Xi = moli/ moltotal

ΔTb = *i*(kb)(m)

ΔTf = *i*(kf)(m)

Psoln = (Psolv)(Xsolv)

pH = -log [H3O+]

pOH = -log[OH-]

[H3O+][OH-]= 1.0x10-14M2

pH+pOH = 14



Constants

1 angstrom = 10-8 cm

h = 6.626 x 10-34 J sec

c= 2.9979 x 108 m/sec

e = 1.602 x 10-19 C

NA = 6.022 x 1023/mol

K = oC + 273.16

Kw = 1.0 x 10-14M2

Kf water = 1.86oC/m

Kb water = 0.512oC/m

Kf benzene = 5.12oC/m

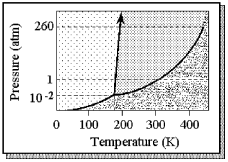
Kb benzene = 2.53oC/m

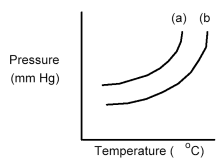
mass electron = 9.109 x 10-31 kg

R = 0.0821 L atm/mol K= 8.314 J/K mol= 1.987 cal.mol K= 62.4 L torr/mol K

Standard Temperature and Pressure = 0oC and 1 atm

Multiple Choice (30 points)

1. Which is expected to have the largest dispersion forces?
   1. C2H6
   2. CO2
   3. C8H18
   4. N2
2. Which of the following compounds has the highest boiling point?
   1. H3C-O-CH3
   2. HOCH2CH2OH
   3. CH3CH2CH2CH3
   4. CH3CH2OH
3. In liquid methanol, CH3OH which intermolecular forces are present?
   1. Dispersion, hydrogen bonding and dipole-dipole forces are present.
   2. Only dipole-dipole and ion-dipole forces are present.
   3. Only hydrogen bonding forces are present.
   4. Only dispersion and dipole-dipole forces are present.
4. The normal boiling point for HBr is higher than the normal boiling point for HCl. This can be explained by
   1. larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for HBr.
   2. larger dispersion forces for HBr.
   3. larger hydrogen-bond forces for HBr.
   4. larger dipole-dipole forces for HBr.
5. When a liquid is heated at its boiling point, the
   1. covalent bonds are broken, allowing vaporization to occur.
   2. temperature of the liquid increases.
   3. temperature of the vapor phase increases.
   4. temperature of the liquid remains the same as long as any liquid is present.
6. The magnitude of the heats of vaporization, fusion and sublimation of a substance reflect the
   1. strength of the covalent bonds between atoms in each molecule of the substance.
   2. strength of the intermolecular forces of the substance.
   3. density of the substance.
   4. magnitudes of the boiling and melting points of the substance.
7. The phase diagram of a substance is shown to the right. The approximate normal boiling point of this substance is
   1. 180 K.
   2. 300 K.
   3. 190 K.
   4. 430 K.
8. The rubbing alcohol sold in drug stores often is composed of 70% isopropyl alcohol and 30% water. In this solution
   1. isopropyl alcohol is the solvent.
   2. water is the solvent.
   3. both water and isopropyl alcohol are solvents.
   4. neither water nor isopropyl alcohol is a solvent.
9. Which of the following statements is **true** for a supersaturated solution?
   1. The solute in the solution is at equilibrium with undissolved solute.
   2. A supersaturated solution is more than 50% solute by mass.
   3. The solution contains more than the equilibrium amount of solute.
   4. The solution is stable and the solute will not precipitate.
10. In general, as the temperature increases, the solubility of gases in water \_\_\_\_\_\_\_\_ and the solubility of most solids in water \_\_\_\_\_\_\_\_.
    1. decreases, increases
    2. increases, decreases
    3. decreases, decreases
    4. increases, increases
11. Red blood cells are placed into pure water. Which of the following statements is true?
    1. The osmotic pressure inside the cells equals the osmotic pressure outside.
    2. Water molecules flow out of the red blood cells, causing them to collapse.
    3. The osmotic pressure of the cell contents increases, causing the cells to burst.
    4. Water flows into the red blood cells, causing them to swell and burst.

1. The diagram at the right shows a close-up view of the vapor pressure curves for a pure solvent and a solution containing a nonvolatile solute dissolved in this solvent. Which curve is the solvent and what happens to the vapor pressure when the solute is dissolved in the solvent?
   1. Curve (a) is the solvent and the vapor pressure increases.
   2. Curve (a) is the solvent and the vapor pressure decreases.
   3. Curve (b) is the solvent and the vapor pressure increases.
   4. Curve (b) is the solvent and the vapor pressure decreases.
2. A catalyst increases the rate of a chemical reaction by providing a lower-energy mechanism for the reaction. When this occurs, which one of the following is **not** affected?
   1. activation energy for the forward reaction
   2. activation energy for the reverse reaction
   3. rate of the reverse reaction
   4. equilibrium constant
3. A crude type of disappearing ink is based on the following endothermic equilibrium:

[Co(H2O)6]CL2 (*aq*) ↔ [CoCl2(H2O)4] (*aq*) + 2 H2O (*g*)

(colorless) (blue)

If the reactant solution is used to write on a piece of paper and the paper is allowed to partially dry, what can be done to bring out the colored handwriting?

* 1. add water
  2. put the paper in the oven
  3. put the paper in the freezer
  4. decrease the volume

1. Which statement is **true** for a reaction with *Kc* equal to 2.43 x 10-12?
   1. The reaction proceeds nearly all the way to completion.
   2. There are appreciable concentrations of both reactants and products.
   3. The reaction proceeds hardly at all towards completion.
   4. Increasing the temperature will not change the value of *Kc*.

Problems (85 points)

1. (9 points) In each group of substances, pick the one that has the given property. Justify your answer using descriptions of the types of intermolecular forces that are important as well as other factors determining liquid properties.
   1. higher boiling point: CH3CH3  or CH3CH2CH2CH2CH3

The pentane has the higher boiling point because it has more electrons making it more polarizable. The more polarizable molecule will have the greatest dispersion forces and therefore the highest boiling point.

* 1. higher vapor pressure at 25oC: CH3CH2CH3  or CH3OCH3

The pentane has the higher vapor pressure.

Both molecules have similar molar masses and similar dispersion forces, but the ether molecule is polar meaning that it will also have dipole-dipole interactions. This means that it will have stronger intermolecular forces and a lower vapor pressure.

* 1. highest viscosity CH3OCH3 or CH3CH2OH

Ethanol will have the higher viscosity.

Both molecules have similar dispersion forces and both are polar. The ethanol has the ability to form hydrogen bonds however which means that it will have the strongest intermolecular forces and the higher viscosity.

1. (4 points) The nonpolar hydrocarbon, C25H52, is a solid at room temperature. Its boiling point is greater than 400oC. Which has the stronger intermolecular forces, C25H52 or H2O? Explain. (Discuss the types of intermolecular forces present in each molecule in your answer.)

The hydrocarbon has only London dispersion forces whereas water has London dispersion forces, is polar, and can hydrogen bond. Although the water has very strong intermolecular forces due to its ability to hydrogen bond, the intermolecular forces on the hydrocarbon are greater as evidenced by its higher boiling point.

1. (18 points) A 3.179 M solution of glucose (C6H12O6) has a density of 1.381 g/mL at 25oC. Calculate
   1. the mass percent of glucose
   2. the mole fraction of glucose
   3. The molality of glucose
   4. The vapor pressure of water at 25oC is 23.8 torr. What is the vapor pressure of the glucose solution under these same conditions?
   5. What is the boiling point of the glucose solution?
   6. What is the osmotic pressure of the glucose solution at 20oC?
2. (7 points) A 10.0 g sample of p-dichlorobenzene, a component of mothballs, is dissolved in 80.0 g of benzene, C6H6. The freezing point of the solution is 1.20oC. The freezing point of pure benzene is 5.48oC.
   1. What is the approximate molar mass of p-dichlorobenzene?
   2. An elemental analysis of p-dichlorobenzene indicated that the empirical formula is C3H3Cl. What is the molecular formula of p-dichlorobenzene?

Molar mass = 150 g/mol so molecular formula is 2X empirical formula.

1. (6 points) Write the appropriate equilibrium constant for each of the following reactions.
   1. 2 C(s) + O2(g) ⇋ 2 CO(g) Kp =
   2. Br2(g) + 5 F2(g) ⇋ 2 BrF5(g) Kc =
2. (16 points) At a 275oC, 12.0 mol of SO3 is placed into a 3.0 L rigid container, and the SO3 dissociates by the reaction

2 SO3 (g) ⇋ 2 SO2(g) + O2(g)

At equilibrium, 3.0 mol of SO2 is present.

* 1. Determine the value of Kc for the reaction?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 SO3 (g) | ⮀ | 2 SO2(g) | + | O2(g) |
| I | 4.0 M |  | 0 M |  | 0 M |
| Δ | −2x |  | + 2x |  | + x |
| E | 4.0 − 2x  = 4.0 − 1.0  =3.0 M |  | 2x M  = 1.0 M |  | x M  = 0.50 M |

* 1. What is the value of Kp at 275oC?

Or

* 1. Calculate Kc for 2 O2(g) + 4 SO2(g) ⇋ 4 SO3(g)
  2. If 3.00 mol of SO3, 1.00 mol SO, and 2.00 mol O2 were introduced into a 3.00 L reaction vessel at 450K, would the original reaction proceed in the forward or the reverse direction. Calculate the Q value and explain how this predicts the answer to this question.

The value of Q is greater than the value of K so the reaction would proceed in the reverse direction.

1. (8 points) At 25oC, Kc = 0.145 for the following reaction in the solvent CCl4:

2BrCl(g) <==> Br2(g) + Cl2(g)

If the initial concentration of BrCl in the solution is 0.050 M, what will the equilibrium concentrations of Br2 and Cl2 be?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 BrCl(g) | ⮀ | Br2(g) | + | Cl2(g) |
| I | 0.050 M M |  | 0 M |  | 0 M |
|  | -2x |  | + x |  | + x |
| E | 0.050 –x M |  | x M |  | x M |

[Br2]=[Cl2]= 0.00068 M

[BrCl] = 0.050 M – 2(0.00068M) = 0.036 M

[BrCl] =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[Br2] = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

[Cl2] = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. (12 points) Answer the following questions based on the reaction

C(s) + 2 H2(g) <==> CH4(g) + heat

* 1. If H2 is added to the reaction vessel (circle the correct answer)
     1. The rate of the forward reaction will (increase, decrease, stay the same).
     2. The rate of the reverse reaction will (increase, decrease, stay the same).
     3. The pressure of CH4 will (increase, decrease, stay the same)
  2. If the total volume of the system is decreased (T remains constant) the equilibrium will shift to the (right, left, stay the same)
  3. If carbon is added to the reaction vessel the equilibrium will shift to the (right, left, stay the same)
  4. If the temperature is reduced
     1. The equilibrium will shift to the (right, left, stay the same)
     2. The value of K will (increase, decrease, stay the same)
  5. If a catalyst is added to the reaction vessel
     1. The equilibrium will shift to the (right, left, stay the same)
     2. The rate of the forward reaction will (increase, decrease, stay the same).
     3. The rate of the reverse reaction will (increase, decrease, stay the same).
  6. Show graphically how the concentrations of H2 and CH4 change when CH4 is added to the reaction vessel and when H2 is removed. 