Chemistry 141 Name

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Exam 4 May 17, 2012

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|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 30 |
| Page 5 |  | 6 |
| Page 4 |  | 16 |
| Page 5 |  | 20 |
| Page 6 |  | 11 |
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| Page 8 |  | 8 |
| Extra credit |  | 5 |
| Total |  | 107 |
| 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+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=*i*X1\*Ptotal

C = q/ΔT

w=dxF

E = IR

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

F = 9.65 x 104 C

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 = 1.381 x 10-23 J/K

K = oC + 273.16

Kw = 1.0 x 10-14M2

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. Place the following compounds in order of **increasing** strength of intermolecular forces.

CH4 CH3CH2CH3 CH3CH3

* 1. CH3CH2CH3 < CH4 < CH3CH3
  2. CH3CH2CH3 < CH3CH3 < CH4
  3. CH3CH3 < CH4 < CH3CH2CH3
  4. CH4 < CH3CH2CH3 < CH3CH3
  5. CH4 < CH3CH3 < CH3CH2CH3

1. Which of the following statements is TRUE?
   1. Vapor pressure increases with temperature.
   2. Hydrogen bonds are stronger than covalent bonds.
   3. Intermolecular forces hold the atoms in molecules together.
   4. Dispersion forces are generally stronger than dipole-dipole forces.
   5. None of the above are true.
2. Which substance below has the strongest intermolecular forces?
   1. BY2, ΔHvap= 26.7 kJ/mol
   2. C3X2, ΔHvap= 36.4 kJ/mol
   3. DX2, ΔHvap= 23.3 kJ/mol
   4. A2X, ΔHvap= 39.6 kJ/mol
   5. EY3, ΔHvap= 21.5 kJ/mol
3. Identify triple point.
   1. The temperature, pressure, and density for a gas.
   2. The temperature at which the boiling point equals the melting point.
   3. The temperature and pressure where liquid, solid, and gas are equally stable and are in equilibrium.
   4. The temperature that is unique for a substance.
   5. The temperature at which the solid and liquid co-exist.
4. The normal boiling point for H2Se is higher than the normal boiling point for H2S . This can be explained by
   1. larger dipole-dipole forces for H2Se .
   2. larger dispersion forces for H2Se .
   3. larger hydrogen-bond forces for H2Se .
   4. larger dipole-dipole forces, larger dispersion forces, and larger hydrogen-bond forces for H2Se .
5. Give the reason that antifreeze is added to a car radiator.
   1. The freezing point is lowered and the boiling point is elevated.
   2. The freezing point is elevated and the boiling point is lowered.
   3. The freezing point and the boiling point are elevated.
   4. The freezing point and the boiling point are lowered.
   5. None of the above.
6. Choose the solvent below that would show the greatest boiling point elevation when used to make a 0.10 *m* nonelectrolyte solution.
   1. CCl4, Kb = 29.9°C/m
   2. C6H6, Kb = 5.12°C/m
   3. CH3CH2OCH2CH3, Kb = 1.79°C/m
   4. CH3CH2OH, Kb = 1.99°C/m
   5. CHCl3, Kb = 4.70°C/m
7. A solution is formed at room temperature by vigorously dissolving enough of the solid solute so that some solid remains at the bottom of the solution. Which statement below is TRUE?
   1. The solution is considered unsaturated.
   2. The solution is considered supersaturated.
   3. The solution is considered saturated.
   4. The solution would be considered unsaturated if it were cooled a bit to increase the solubility of the solid.
   5. None of the above are true.
8. Give the direction of the reaction, if K >> 1.
   1. The forward reaction is favored.
   2. The reverse reaction is favored.
   3. Neither direction is favored.
   4. If the temperature is raised, then the forward reaction is favored.
   5. If the temperature is raised, then the reverse reaction is favored.
9. In which of the following reactions will Kc = Kp?
   1. 4 NH3(g) + 3 O2(g) ⇌ 2 N2(g) + 6 H2O(g)
   2. SO3(g) + NO(g) ⇌ SO2(g) + NO2(g)
   3. 2 N2(g) + O2(g) ⇌ 2 N2O(g)
   4. 2 SO2(g) + O2(g) ⇌ 2 SO3(g)
   5. None of the above reactions have Kc = Kp.
10. Consider the following reaction at equilibrium. What effect will adding more H2S have on the system?

2 H2S(g) + 3 O2(g) ⇌ 2 H2O(g) + 2 SO2(g)

* 1. The reaction will shift to the left.
  2. No change will be observed.
  3. The equilibrium constant will decrease.
  4. The equilibrium constant will increase.
  5. The reaction will shift in the direction of products.

1. Place the following solutions in order of **increasing** osmotic pressure.

I. 0.15 M C2H6O2 II. 0.15 M MgCl2 III. 0.15 M NaCl

* 1. III < I < II
  2. II < III < I
  3. I < II < III
  4. II < I < III
  5. I < III < II

1. Consider the following reaction at equilibrium. What effect will adding some C have on the system?

CO2(g) + C(graphite) ⇌ 2 CO(g)

* 1. No effect will be observed since C is not included in the equilibrium expression.
  2. The equilibrium constant will decrease.
  3. The reaction will shift to the left in the direction of reactants.
  4. The equilibrium constant will increase.
  5. The reaction will shift to the right in the direction of products.

1. A solution containing less than the equilibrium amount of solvent is called \_\_\_\_\_\_\_\_.
   1. a solute
   2. a supersaturated solution
   3. a saturated solution.
   4. an unsaturated solution
   5. a solvent
2. Consider the following reaction at equilibrium. What effect will reducing the volume of the reaction mixture have on the system?

CuS(s) + O2(g) ⇌ Cu(s) + SO2(g)

* 1. The equilibrium constant will decrease.
  2. No effect will be observed.
  3. The reaction will shift to the right in the direction of products.
  4. The equilibrium constant will increase.
  5. The reaction will shift to the left in the direction of reactants.

Problems (85 points)

1. (6 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: Br2 or I2

I2 will have the higher boiling point because it has a higher molar mass (more electrons so more polarizable) and will have stronger intermolecular forces.

* 1. higher vapor pressure at 25oC:  or 

Propanol will have the higher vapor pressure.

Glycerol will have the lower vapor pressure because it can hydrogen bond better than propanol.

1. (16 points) Swainsonine, C8H15NO3 (173.21 g/mol), a neurotoxin is the active ingredient in loco weed, a family of pea which grow across the American west. Cattle and horses will often eat the loco weed and begin to stagger around, thus the name. Swainsonine is dissolved in benzene, C6H6, to make 8.67% solution which has a density of 0.715 g/mL at 20oC. Calculate
   1. The molarity of swainsonine
   2. The molality of swainsonine
   3. The mole fraction of swainsonine
   4. The vapor pressure of the solution (vapor pressure benzene at 20oC = 114 torr)

Or

Psolution = 114 torr – 5 torr = 109 torr

1. (5 points) If you lived in Alaska, which of the following natural gases would you keep in an outdoor storage tank in winter, methane (CH4), propane (C3H8), or butane (C4H10)? Explain your reasoning.

I would choose methane because it has the weakest intermolecular forces and therefore will have the highest freezing point. It is the gas that is the least likely to freeze in the winter!

1. (5 points) Ammonia is both a donor and an acceptor of hydrogen in hydrogen bond formation. Draw a diagram showing the hydrogen bonding of an ammonia (NH3) molecule with two other ammonia molecules.



1. (10 points)A solution of 2.60 g of a compound having the empirical formula C6H5P dissolved in 25.0 g of benzene is observed to freeze at 4.3oC. Calculate the molar mass of the solute and its molecular formula. (Normal freezing point benzene is 5.5oC and Kf is 5.12oC/m)

Molar mass = ≈ 430 g/mol so molecular formula is 4X empirical formula.

1. (6 points) Write the equilibrium expression for the following reactions
   1. Fe2O3(s) + 3 CO(g) ⮀ 2 Fe(l) + 3 CO2 (g) Kc =
   2. MgCO3(s) ⮀ MgO(s) + CO2(g) Kp =
2. (5 points) Given the following reaction,

2 SO3(g) ⮀ 2 SO2(g) + O2(g) ΔHo = +197 kJ

predict the direction of the shift and whether the number of moles of SO3 will increase, decrease, or stay the same when each of the following changes are made to a system at equilibrium.

* 1. Oxygen gas is added.

Shift right, less SO3

* 1. The pressure is increased by decreasing the volume of the reaction container.

Shift left, more SO3

* 1. The temperature is decreased.

Shift left, more SO3

* 1. Gaseous sulfur dioxide is removed.

Shift left, more SO3

* 1. Gaseous sulfur trioxide is added.

Shift right, more SO3

1. (16 points) Pure nitrosyl chloride (NOCl) gas was heated to 240oC in a 1.00 L container. The initial pressure of NOCl was 0.88 atm and the final pressure was 0.64 atm.

2 NOCl(g) ⮀ 2 NO(g) + Cl2(g)

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 NOCl(g) | ⮀ | 2 NO(g) | + | Cl2(g) |
| I | 0.88 atm |  | 0 atm |  | 0 atm |
|  | − 2x |  | + 2x |  | + x |
| E | 0.88 atm – 2x  = 0.64 atm  x=0.12 atm |  | 2x atm  = 0.24 atm |  | x M  = 0.12 atm |

* 1. What is the value of Kc at 240oC?
  2. Calculate the value of Kp for the reaction

6 NO(g) + 3 Cl2(g) ⮀ 6 NOCl(g) at 240oC.

* 1. If 5.00 mol of NOCl, 1.00 mol NO, and 1.00 mol Cl2 were introduced into a 3.00 L reaction vessel at 240oC, would the 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) Given the reaction Br2(g) + I2(g)  2 IBr(g) with Kc=322 at 350K. If the initial concentrations of Br2 and I2 at 350 K are both 1.35 M, what are the concentrations of IBr, Br2, and I2 when the reaction mixture reaches equilibrium?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Br2(g) | + | I2(g) |  | 2 IBr(g) |
| I | 1.35 M |  | 1.35 M |  | 0 M |
|  | -x |  | -x |  | +2x |
| E | 1.35M-x |  | 1.35M-x |  | 2x |

[Br2] = [I2] = 1.35 M – 1.21 M = 0.14 M

[IBr] = 2(1.21 M) = 2.42 M