Chemistry 141 Name KEY

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Exam 4 May 20, 2010

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| --- | --- | --- |
|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 30 |
| Page 3 |  | 8 |
| Page 4 |  | 17 |
| Page 5 |  | 20 |
| Page 6 |  | 14 |
| Page 6 |  | 12 |
| Page 7 |  | 8 |
| Extra credit |  | 5 |
| Total |  | 114 |
| 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

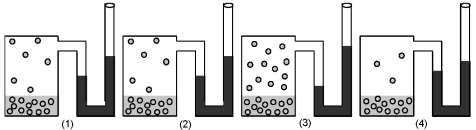
Kw = 1.0 x 10-14M2

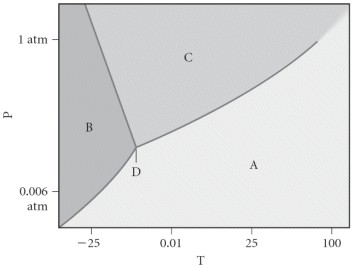
mass electron = 9.109 x 10-31 kg

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 (20 points)

1. Which of the following compounds exhibits hydrogen bonding?
   1. CH3Cl
   2. H3C-O-CH3
   3. HI
   4. NH3
2. 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.
3. When a liquid is heated at its boiling point, the
   1. temperature of the liquid remains the same as long as any liquid is present.
   2. covalent bonds are broken, allowing vaporization to occur.
   3. temperature of the liquid increases.
   4. temperature of the vapor phase increases.
4. Molecules of a liquid can pass into the vapor phase only if the
   1. vapor pressure of the liquid is high.
   2. molecules have sufficient kinetic energy to overcome the intermolecular forces in the liquid.
   3. temperature of the liquid is near its boiling point.
   4. liquid has little surface tension.
5.  If figure (1) represents the vapor pressure of water at 25oC, which figure represents the vapor pressure of water at 45oC?
   1. Figure (2)
   2. Figure (3)
   3. Figure (4)
6. Assign the appropriate labels to the phase diagram shown below.



* 1. A = liquid, B = solid, C = gas, D = critical point
  2. A = gas, B = solid, C = liquid, D = triple point
  3. A = gas, B = liquid, C = solid, D = critical point
  4. A = solid, B = gas, C = liquid, D = supercritical fluid
  5. A = liquid, B = gas, C = solid, D = triple point

1. Which substance below has the strongest intermolecular forces?
   1. A2X, Hvap = 39.6 kJ/mol
   2. BY2, Hvap = 26.7 kJ/mol
   3. C3X2, Hvap = 36.4 kJ/mol
   4. DX2, Hvap = 23.3 kJ/mol
   5. EY3, Hvap = 21.5 kJ/mol
2. For a liquid solution made by dissolving a solid or a gas in a liquid, the
   1. liquid is the solvent.
   2. liquid is the solute.
   3. solute is the component present in the greatest amount.
   4. solvent is the component present in the greatest amount.
3. For which case would Δ*Hsoln* be expected to be negative?
   1. if solute-solvent interactions are much greater than solvent-solvent and solute-solute interactions
   2. if solvent-solvent interactions are much greater than solute-solvent and solute-solute interactions
   3. if solute-solute interactions are much greater than solvent-solvent and solute-solvent interactions
   4. if solute-solvent interactions are the same as solvent-solvent and solute-solute interactions
4. Molality is defined as moles of solute per
   1. kilogram of solvent.
   2. liter of solution.
   3. total moles present.
   4. mole of solvent.
5. The solubility of gaseous solutes in liquid solvents is greater when the
   1. external pressure over the solution is increased.
   2. partial pressure of the solvent is increased.
   3. partial pressure of the gas above the solution is increased.
   4. external pressure is decreased.
6. Choose the aqueous solution that has the highest boiling point. These are all solutions of nonvolatile solutes and you should assume ideal van't Hoff factors where applicable.
   1. 0.100 *m* AlCl3
   2. 0.100 *m* NaCl
   3. 0.100 *m* MgCl2
   4. 0.100 *m* C6H12O6
   5. They all have the same boiling point.
7. Which of the following statements are TRUE?
   1. Dynamic equilibrium occurs when the rate of the forward reaction equals the rate of the reverse reaction.
   2. The equilibrium constant for the forward reaction is equal to the equilibrium constant for the reverse reaction.
   3. A reaction quotient (Q) larger than the equilibrium constant (K) means that the reaction will favor the production of more products.
   4. Dynamic equilibrium indicates that the amount of reactants and products are equal.
   5. All of the above are true.
8. In which of the following reactions will Kc = Kp?
   1. H2*(g)* + I2*(g)*  2 HI*(g)*
   2. CH4*(g)* + H2O*(g)* CO*(g)* + 3 H2*(g)*
   3. N2O4*(g)* 2 NO2*(g)*
   4. CO*(g)* + 2 H2*(g)* CH3OH*(g)*
   5. N2*(g)* + 3 H2*(g)* 2 NH3*(g)*
9. A solution is formed at room temperature by 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.

Problems (85 points)

1. (4 points) Skin swabbed with alcohol is cooled to below room temperature, even though the alcohol is at room temperature. Explain this observation.

As the alcohol evaporates from the skin it requires energy to overcome the heat of vaporization of the alcohol. This heat is taken from the skin, thus cooling it.

1. (4 points) Why isn't pentanol (CH3CH2CH2CH2CH2OH) very soluble in water?

Even though the pentanol molecule contains a hydrogen bonding portion, the bulk of the molecule is nonpolar and only exhibits dispersion forces. The majority of this molecule will not hydrogen bond to water molecules, making it difficult to dissolve.

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.
   1. higher boiling point: CH3CH2-O-CH2CH3 or CH2CH2CH2CH2-OH

The butanol has the higher boiling point.

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

* 1. higher vapor pressure at 25oC: SO2 or CO2

CO2 will have the higher vapor pressure.

SO2 has a higher molar mass and stronger dispersion forces. Additionally it is a bent molecule giving it a permanent dipole. This means that it will have stronger intermolecular forces and a higher vapor pressure.

* 1. highest viscosity Br2 or I2

The iodine has the higher viscosity.

Iodine has the higher viscosity because it has more electrons making it more polarizable. The more polarizable molecule will have the greatest dispersion forces and therefore the molecules will stick together more tightly making the substance more viscous.

1. (8 points) Vitamin B1 is a water soluble vitamin necessary to prevent beriberi, a disease of the nervous system. What is the molecular mass of vitamin B1 if a 35.00 mg sample dissolved in 10.00 g of water depresses the freezing point by 0.0193oC. (Kf = 1.86 K/m).
2. (20 points) Galactose, C6H12O6, is a naturally occurring sugar found in milk (it is a part of the disaccharide lactose). A 1.427 m solution of galactose in water has a density of 1.3832 g/mL at 20oC. (vapor pressure of pure water at 20oC = 17.5 torr) Calculate
   1. The mass percent galactose
   2. The mole fraction of galactose
   3. The molarity of galactose
   4. The osmotic pressure of the solution at 20oC
   5. The vapor pressure (in torr) of the solution at 20oC.
3. (8 points) Methanol (CH3OH) is manufactured by the reaction of carbon monoxide with hydrogen in the presence of a ZnO/Cr2O3 catalyst:

 Ho = −91 kJ

For each of the following changes indicate whether the reaction shifts to the right (🡪), shifts to the left (🡨), or no shift (NC). Then answer the question regarding the shift with increases (🡩) decreases (🡫) no change (NC) or unable to determine (?)..

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Change to system | Shift (Circle one) | Question | Change |
|  | Remove CO(g) | 🡪 🡨 NC | Concentration of CO | 🡩 🡫 NC ? |
|  | Raise temperature | 🡪 🡨 NC | Concentration of H2 | 🡩 🡫 NC ? |
|  | Reduce volume | 🡪 🡨 NC | Concentration of CH3OH | 🡩 🡫 NC ? |
|  | Add ZnO/Cr2O3 | 🡪 🡨 NC | Rate reverse reaction | 🡩 🡫 NC ? |

Mol of H2

1. (6 points) Write the equilibrium expressions for the following reactions
   1. 4 NH3*(g)* + 3 O2*(g)* 🡨🡪 2 N2*(g)* + 6 H2O*(g)*
   2. 2 Au2O3*(s)* 🡨🡪 4 Au*(s)* + 3 O2*(g)*
2. (12 points) When 1.50 mol of CO2 is heated in a 20.0 L container at 600 K, the equilibrium concentration of CO is 7.34 x 10-3 M. The equilibrium reaction is

2 CO2*(g)*  2 CO*(g)* + O2*(g)*

* 1. What are the equilibrium concentrations of CO2 and O2?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2 CO2(g) |  | 2 CO(g) | + | O2(g) |
| I | 0.0750 M |  | 0 mol |  | 0 M |
|  | -2x |  | +2x |  | + x |
| E | 0.0750 M-2x  =(0.075 – 2(.00367))M  =0.0677 M |  | 2x mol  = 0.00734 M  x=3.67 x 10-3 M |  | x = 0.00367 |

* 1. What is the value of Kc at 600K?
  2. What is the value of Kp in atm at 600K?
  3. What is the value of Kp for the reaction at 600 K?

4 CO*(g)* + 2 O2*(g)* 4 CO2*(g)*

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 0.955 M, what are the concentrations of IBr, Br2, and I2 when the reaction mixture reaches equilibrium?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Br2(g) | + | I2(g) |  | 2 IBr(g) |
| I | 0.955 M |  | 0.955 M |  | 0 M |
|  | -x |  | -x |  | +2x |
| E | 0.955M-x |  | 0.955M-x |  | 2x |

[N2] = [O2] = 0.955 M – 0.859 M = 0.096 M

[NO] = 2(0.859 M) = 1.72 M

Extra Credit (5 points)

A 2.000 g sample of the weak acid HA (molar mass = 138.0 g/mol) is dissolved in 500.0 grams of water. The freezing point of the resulting solution is -0.106oC. Calculate the value of Ka for this acid. Assume molarity equals molality for this solution. (Kf = 1.86 K/m).

(Hint: For an acid dissociating HA🡸🡺 H+1 + A-1, Ka = [H+1][A-1]/[HA])

True molality of solution

Effective molality of solution

Ratio of effective molality to actual molality or van’t hoff value

Equilibrium calculations

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | HA(aq) |  | H+(aq) | + | A– (aq) |
| I | 0.0435 M |  | 0 M |  | 0 M |
|  | -x |  | +x |  | +x |
| E | 0.0435-x |  | x M |  | x M |
|  | =0.0300 M |  | =0.0135 M |  | = 0.0135M |

Total effective molality = sum of molalities of all species

= (0.0435 – x)+(x) + (x) = 0.0570 M

x=0.0135 M