Chemistry 141 Name

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Exam 4 December 10, 2012

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|  | Points Earned | Points Possible |
| Page 1 multiple choice |  | 30 |
| Page 3 |  | 11 |
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| Page 5 |  | 16 |
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| Total |  | 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. Which of the following should have the largest dipole moment?
   1. KCl(*g*)
   2. H2(*g*)
   3. CO2(*g*)
   4. CH3F(*g*)
2. Which is expected to have the largest dispersion forces?
   1. C2H6
   2. CO2
   3. C8H18
   4. N2
3. When a narrow diameter glass tube is inserted into a body of water, water rises in the tube and its surface inside is concave upwards. Which statement, concerning the strength of the intermolecular forces between glass and water molecules compared to those between water molecules, is accurate?
   1. The forces of attraction between the glass and water are the same as those in water.
   2. The forces of attraction between the glass and water are weaker than those in water.
   3. Intermolecular forces are irrelevant to this situation.
   4. The forces of attraction between the glass and water are stronger than those in water.
4. 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.
5. 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.
6. A saturated solution is defined as
   1. a solution that is in equilibrium with both pure solvent and undissolved solute.
   2. a solution that is in equilibrium with pure solvent.
   3. a solution than is in equilibrium with undissolved solute.
   4. a concentrated solution.
7. 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.
8. Which concentration varies with temperature?
   1. molarity
   2. molality
   3. wt %
   4. mole fraction
9. 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.
10. 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
11. For which one of the following reactions will *Kc* = *Kp*?
    1. ZnO(*s*) + CO(*g*) Zn(*s*) + CO2(*g*)
    2. CO(*g*) + 2 H2(*g*) CH3OH(*g*)
    3. COCl2(*g*) CO(*g*) + Cl2(*g*)
    4. 2 O3(*g*) 3 O2(*g*)
12. 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. Iron oxide ores are reduced to iron metal by exothermic reaction with carbon monoxide:

FeO(s) + CO(g) ↔CO2(g).

Which of the following changes in condition will cause the equilibrium to shift to the right?

* 1. add CO2
  2. add FeO
  3. add CO
  4. raise the temperature

1. Which one of the following statements does **not** describe the equilibrium state?
   1. The rate of the forward reaction is equal to the rate of the reverse reaction.
   2. The concentration of the reactants and products reach a constant level.
   3. The concentration of the reactants is equal to the concentration of the products.
   4. Equilibrium is dynamic and there is no net conversion to reactants and products.
2. 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. (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 viscosity: CH3CH3 or CH3CH2F

CH3CH2F will have the have the higher viscosity because it is more polar due to the more electronegative fluorine atom. More polar means stronger intermolecular forces and a higher viscosity.

* 1. Higher boiling point: CH3CH2F or CH3CH2OH

CH3CH2OH will have the higher boiling point because it is able to hydrogen bond.

* 1. higher vapor pressure at 25oC: carbon tetrachloride, CCl4 or carbon tetraiodide, CI4.

The dispersion forces for carbon tetraiodide, CI4 are higher than for carbon tetrachloride, CCl4 meaning that it is harder to evaporate so its vapor pressure will be lower.

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. (8 points) A newly formulated substance has a normal boiling point of 425oC, a normal freezing point of 75oC, a triple point at 250 torr and 50oC, and a critical point at 3000 torr and 600oC. Draw a phase diagram for this substance, labeling the liquid, gas, and solid phases, the triple point, the critical point, and the supercritical fluid.

0

0

50

600

425

3000

760

250

75

Temperature (oC)

Pressure (torr)

solid

liquid

gas

Which is more dense for this substance, the liquid or the solid state? Explain how you arrived at this answer.

The solid is more dense because the liquid converts to a solid when pressure is applied

solid

1. (4 points) Explain why liquids, unlike gases are virtually incompressible.

In liquids the molecules are already touching each other so they are not able to get much closer. In gases there is lots of empty space.

1. (16 points) The umami taste of some foods is thought to be due to the presence of two amino acids, glutamate and aspartic acid. Sodium asparatate, Na2C4H5O4N (177.08 g/mol), is dissolved in water to make an 18.2% solution which has a density of 1.17 g/mL at 20oC. Calculate
   1. The molarity of sodium asparate
   2. The molality of sodium asparate
   3. The freezing point of the solution (Kf, H2O= 1.86oC/m)

The freezing point will be -2.34 oC

Actually would be -7.01 due to dissociation in solution! +2 bonus points if catch this!

* 1. The osmotic pressure (in torr) of the solution

1. (8 points) The stevia plant produces a variety of glycosides which is a natural non-caloric sweeteners. The empirical formula of one of these glycosides is C5H8O. To find its molecular formula, you dissolve 1.65 g in 25.0 g of chloroform, CH3Cl. The boiling point of the solution is 62.41oC. What is the molecular formula of this glycoside? (Normal boiling point chloroform is 61.70oC and Kb is +3.63oC/m)

Molar mass = 336 g/mol so molecular formula is 4X empirical formula.

1. (8 points) A solution of glucose in water has a vapor pressure of 15.9 torr at 25oC. The vapor pressure of pure water is 23.8 torr at 25oC and 71.9 torr at 45oC.
   1. What is the mole fraction of glucose in this solution?

Or

* 1. What would be the vapor pressure of this solution at 45oC?

Or

1. (16 points)Carbon tetrachloride can be produced by the following reaction:

CS2(g) + 3 Cl2(g) ⮀ S2Cl2(g) + CCl4(g) at 650K

8.34 mol of CS2 and 15.7 mol of Cl2 were placed in a 3.00 L flask and after equilibrium was achieved, the mixture contains 4.05 mol CCl4.

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | CS2(g) | + | 3 Cl2(g) | ⮀ | S2Cl2(g) | + | CCl4(g) |
| I | 2.78 M |  | 5.23 M |  | 0 M |  | 0 M |
|  | -x |  | -3x |  | + x |  | + x |
| E | 2.78 –x  = 2.78 – 1.35  =1.43 M |  | 5.23 – 3x  = 5.23 – 3(1.35) = 1.18 M |  | x M  = 1.35 M |  | x M  = 1.35 M |

* 1. What is the value of Kp at 650K?

Or

* 1. Calculate the value of Kc for the reaction

2S2Cl2(g) + 2 CCl4(g)⮀ 2CS2(g) + 6 Cl2(g) at 650 K

* 1. If 1.00 mol of S2Cl2, 1.00 mol CCl4, 2.00 mol CS2, and 2.00 mol Cl2 were introduced into a 3.00 L reaction vessel at 650K, 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 less than the value of K so the reaction would proceed in the forward direction.

1. (6 points) Write the equilibrium expressions for the following reactions
   1. 2 NO(g) + Br2(g) 🡨🡪 2 NOBr(g)
   2. NH4HS(s) 🡨🡪 NH3(g) + H2S(g)
2. (8 points) For the reaction CO(g) + H2O(g) ⇋ CO2(g) + H2(g), Kc = 23.2 at 600K. If 0.250 mol each of CO and H2O are introduced into a 1.00 L reaction vessel and equilibrium is established, how many moles each substance will be present?

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | CO(g) | + | H2O(g) | ⮀ | CO2(g) | + | H2(g) |
| I | 0.250 M M |  | 0.250 M |  | 0 M |  | 0 M |
|  | -x |  | -x |  | + x |  | + x |
| E | 0.250 –x |  | 0.250 – x |  | x M |  | x M |

[H2O]=[CO]= 0.250 M - 0.206 M = 0.043 M

[H2]=[CO2]= 0.206 M