Final Exam. for Physical Chemistry for Energy Science
Department of Nuclear Engineering, Seoul National University
12/17/02 Tuesday PM 7:00-10:00
Three hour, closed book, one spike sheet allowed

1. For ideal gas molecules with Maxwell velocity distribution;

$$F(v_x)dv_x = [m/(2\pi kT)]^{1/2} \exp(-mv_x^2/2kT)\, v_x^2\, dv_x$$

Where the velocity ranges from –infinity to infinity.

(a) Show that the mean square momentum $\langle (mv_x)^2 \rangle = mkT$ using the integration rule. Note that v_x is the velocity in x-direction.

(b) Show that the variance of velocity becomes kT/m

(c) Derive the expression on pressure determined as function of speed, number density and mass of molecules

(d) Using the Maxwell distribution, determine the mole fraction of N2 molecules having the velocity in the range of 300.0 to 300.1 m/sec.

2. A gas container containing 10 mole of Ne gas has a pressure of 100 atm. at room temperatture.

(a) translational partition function is given as;

$$z_{trans} = (2\pi mk)^{3/2} V/h^3$$

determine the value of translational partition function for Ne gas

(b) Determine molar internal energy of Ne.

3. Equation of state(EOS) is needed for many engineering applications.

(a) How will you determine phase diagram of plutonium by experiment?

(b) If only microgram of Pu is available for experiment (note that IAEA has complicated control system on pure Pu), how can you determine EOS of Pu-gas ?

(c) What are other properties you can extract from the experiment in (b).

4. Dissolved CO_2 gas undergoes ionization in water, as follows;

$$CO_2 + H_2O = H^+ + HCO3^-$$

If unionized CO_2 has a concentration of 0.01 mole/kg in water and all the fugacity coefficients are 0.9, what is pH of the solution?

5. The freezing point of water is depressed by 0.21 C with 0.11 mol/kg of HCOOH.

(a) Determine the degree of dissociation.

(b) Determine the change in Standard Gibbs Free Energy with ionization.

6. HCl solution with an initial concentration of 0.01 m is diluted to 0.001 m.

(a) determine the mean ionic activity coefficient by using Debye-Hueckel limiting law; $\log \gamma_{\pm} = - z_+ z_- (0.5116) \sqrt{I}$

(b) determine activity of solution before and after the dilution.

(c) What is the change in the chemical potential by dilution?

7. For a saturated solution of: $PbSO4 = Pb^{+2} + SO4^{-2}$

(a) The solubility of the salt is given as 1.5×10^{-4} mole/l. Determine ionic strength of the solution.

(b) Determine the mean ionic activity coefficient using Debye-Hueckel limiting law; $\log \gamma_{\pm} = - z_+ z_- (0.5116) \sqrt{I}$

(d) Determine the Gibbs free energy change of the reaction.

8. Show that P+F=C+2

9. The activity of CH3OH and water is 0.254 and 0.717 respectively, when the mole fraction of CH3OH is 0.1499. If the water activity is changed to 0.710 at the mole fraction of CH3OH of 0.1501, what is the new activity of CH3OH?

10. Why all the colligative properties depend only on concentration, regardless of the types of chemical solutes especially at low concentration?

END