

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 $-\infty$ to ∞ .

- (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 N_2 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 temperature.

- (a) translational partition function is given as;

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

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).

$\langle v_x^2 \rangle = \int_{-\infty}^{\infty} v_x^2 F(v_x) dv_x$

5.02

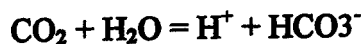
$L = P \cdot T$

$\langle v_x^2 \rangle = \dots$

3.

3.2.1.1200
 2.5×10^{-30}
 5.2×10^{-30}

4. Dissolved CO₂ gas undergoes ionization in water, as follows;



If unionized CO₂ 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

$$\text{limiting law; } \log \gamma_{\pm} = -z_+z_-(0.5116) \sqrt{I}$$

- (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: $\text{PbSO}_4 = \text{Pb}^{+2} + \text{SO}_4^{-2}$

- (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

$$\text{limiting law; } \log \gamma_{\pm} = -z_+z_-(0.5116) \sqrt{I}$$

- (c) 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