Exam. # 2 of Physical Chemistry for Energy Science
Department of Nuclear Engineering, Seoul National University
11/21/01 Wednesday PM 2:30-4:30
Two hour, closed book, formula booklet, one spike sheet allowed

1. (15) For the ammonia production process with the following reaction;
   $(1/2)\ N_2 + (3/2)\ H_2 = NH_3$
   one mole of nitrogen and three moles of hydrogen are inserted into a reaction chamber and completely reacted at one atmosphere.
   (a) Determine heat of reaction for the above reaction, if reacted isothermally at room temperature
   (b) Determine adiabatic flame temperature, assuming all specific heat at room temperature apply for the entire range.

2. (10) For a pure substance, describe the followings
   (a) procedure to construct its phase diagram for the first order transition.
   (b) the second order transition.

3. (10) Starting from the condition that chemical potential of phase α and β are equal for a pure substance, show that;
   $dP/dT = \Delta H_m^{\alpha\beta}/(T^{\alpha\beta}\Delta V^{\alpha\beta})$
   where $\Delta H_m^{\alpha\beta}$ is the latent heat for the phase transformation.

4. (10) Using $dA = -SdT - PdV + \gamma dA + \mu dn$,
   show that the condition for a liquid drop and its vapor at equilibrium is;
   $\mu^v = \mu^l + 2\gamma M/\rho r$
   where γ, M, ρ and r are surface tension, molar mass, density and the radius of droplet, respectively.

5. (15) For an ideal gas,

   (a) Show that the molar internal energy can be determined from the following relationship:

$U-U_o=RT^2(\partial \ln z/\partial T)$,
where U_o is U at 0 K.

(b) A gas container containing 10 moles of the gas has a pressure of 1 atm. at room temperatture. The translational partition function is given for a molecule, as follows;

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

Then, derive a statistical expression for total internal energy

6. (15) Atoms in a single crystal are found to have vibration energy states that are separated by a constant difference, ε_o.

(a) Show that the partition function of the material is;

$$z = 1/[(1-\exp(-\varepsilon_o/kT)]$$

(b) For the material described above, average energy per atom is measured to be a ε_o at a temperature T_a. Show that;

$$T_a=(\varepsilon_o/k) / \ln[1+(1/a)]$$

7. (10) A real gas has a constant fugacity coeffient of 0.9.

(a) Determine its PVT relationship.

(b) What kind of force can make the above non-ideal behavior?

8. (15) Five moles of CO and ten moles of O2 gases isothermally reacted to create CO2 at one atm. and room temperature.

(a) What is the heat of reaction?

(b) What is the extent of reaction.

(b) How will the equilibrium change if temperature is increased?

END (Two pages, 8 problem sets)