

## 〈Summary of Thermodynamics〉

Enthalpy

$$H = U + pV \quad (0.1)$$

Gibbs energy = Maximum non-expansion work

$$G = H - TS \quad (0.2)$$

Gibbs energy change of a closed system (in the absence of non-expansion work)

$$\left(\frac{\partial G}{\partial p}\right)_T = V \quad (0.3)$$

$$\left(\frac{\partial G}{\partial T}\right)_p = -S \quad (0.4)$$

Chemical potential of a pure substance = molar Gibbs energy

$$\mu = \left(\frac{\partial G}{\partial n}\right)_{p,T} = G_m \quad (0.5)$$

Chemical potential of an ideal gas A at a partial pressure  $p_A$  [from (0.3)]

$$\mu_A = \mu_A^\circ + RT \ln\left(\frac{p_A}{p^\circ}\right) \quad (0.6)$$

$\mu_A^\circ$ : chemical potential at the standard pressure  $p^\circ$  ( $\equiv 1$  bar)

Chemical potential of B in an ideal solution of molality  $b_B$  [from (0.3) & Raoult's law]

$$\mu_B = \mu_B^\circ + RT \ln\left(\frac{b_B}{b^\circ}\right) \quad (0.7)$$

$\mu_B^\circ$ : chemical potential at the standard molality  $b^\circ$  ( $\equiv 1$  mol kg<sup>-1</sup>)

Chemical potential of A in an ideal solution of mole fraction  $x_A$  [from (0.3) & Raoult's law]

$$\mu_A = \mu_A^* + RT \ln x_A \quad (0.8)$$

$\mu_A^*$ : chemical potential of a pure substrate A

Chemical potential of an incompressible liquid or solid C at a pressure  $p$  [from (0.3)]

$$\mu_C = \mu_C^\circ + V_m(p - p^\circ) \quad (0.9)$$

$\mu_C^\circ$ : chemical potential at the standard pressure  $p^\circ$  ( $\equiv 1$  bar)

## 〈Thermodynamic Data Source〉

The sources of the thermodynamic data appearing in exercises are as follows:

(no source shown) "Atkins' Physical Chemistry, 8th Ed.," P. W. Atkins and J. de Paula, Oxford Univ. Press (2006).

[JANAF] "JANAF Thermochemical Tables, 3rd Ed.," M. W. Chase, Jr., *et al.* *J. Phys. Chem. Ref. Data* **14**, Supplement 1 (1985).

## 〈Averaged Atomic Weights〉

H: 1.008	C: 12.01	N: 14.01	O: 16.00	F: 19.00	Na: 22.99	Mg: 24.31
Al: 26.98	Si: 28.09	P: 30.97	S: 32.06	Cl: 35.45	K: 39.10	Ca: 40.08

## 〈Schedule〉

[1] June 13 (Wed) 8:40~

[2] June 18 (Mon) 13:00~

[3] June 20 (Wed) 8:40~

[4] June 15 (Mon) 13:00~ [Problem-1] Due Date: July 9 (until the end of the class)

# The paper (report) must be submitted until the due date.

# Submissions via e-mail will not be accepted.