

1. Define the "equation of state". What is its importance in thermodynamic study?

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2. People always predicts a chemical reaction by using  $G$  (Gibbs energy) whether it will take place or take place spontaneously. Explain why  $G$  is more commonly used than other thermodynamic units such as  $A$ ,  $U$ ,  $S$ ,  $H$ , etc.? Also explain  $G$  is a function of pressure and temperature.

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3. One mole of a perfect gas is expanded isothermally and reversibly at  $0^\circ\text{C}$  from 1 to  $1/10$  bar. Calculate (a)  $W$ , (b)  $q$ , (c)  $H$ , (d)  $G$ , and (e)  $S$  for the gas. One mole of a perfect gas in 22.8L is allowed to expand irreversibly into an evacuated vessel such that the final total volume is 228L. Calculate (f)  $W$ , (g)  $q$ , (h)  $H$ , (i)  $G$ , and (j)  $S$  for the gas.

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4. Carbon has two allotropes, graphite and diamond. At  $25^\circ\text{C}$  and 1.013 bar pressure, graphite is the stable form. Calculate the pressure which must be applied to graphite at  $25^\circ\text{C}$  in order to bring about its transformation to diamond.

Given:

$$H_{298}(\text{graphite}) - H_{298}(\text{diamond}) = -1900\text{J/mole}$$

$$S_{298}(\text{graphite}) = 5.73\text{J/K mole}$$

$$S_{298}(\text{diamond}) = 2.43\text{J/K mole}$$

The density of graphite at  $25^\circ\text{C}$  is  $2.22\text{g/cm}^3$

The density of diamond at  $25^\circ\text{C}$  is  $3.515\text{g/cm}^3$

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5. The work done by a nonideal gas which obeys the equation of state

$$PV = RT(1 + BP)$$

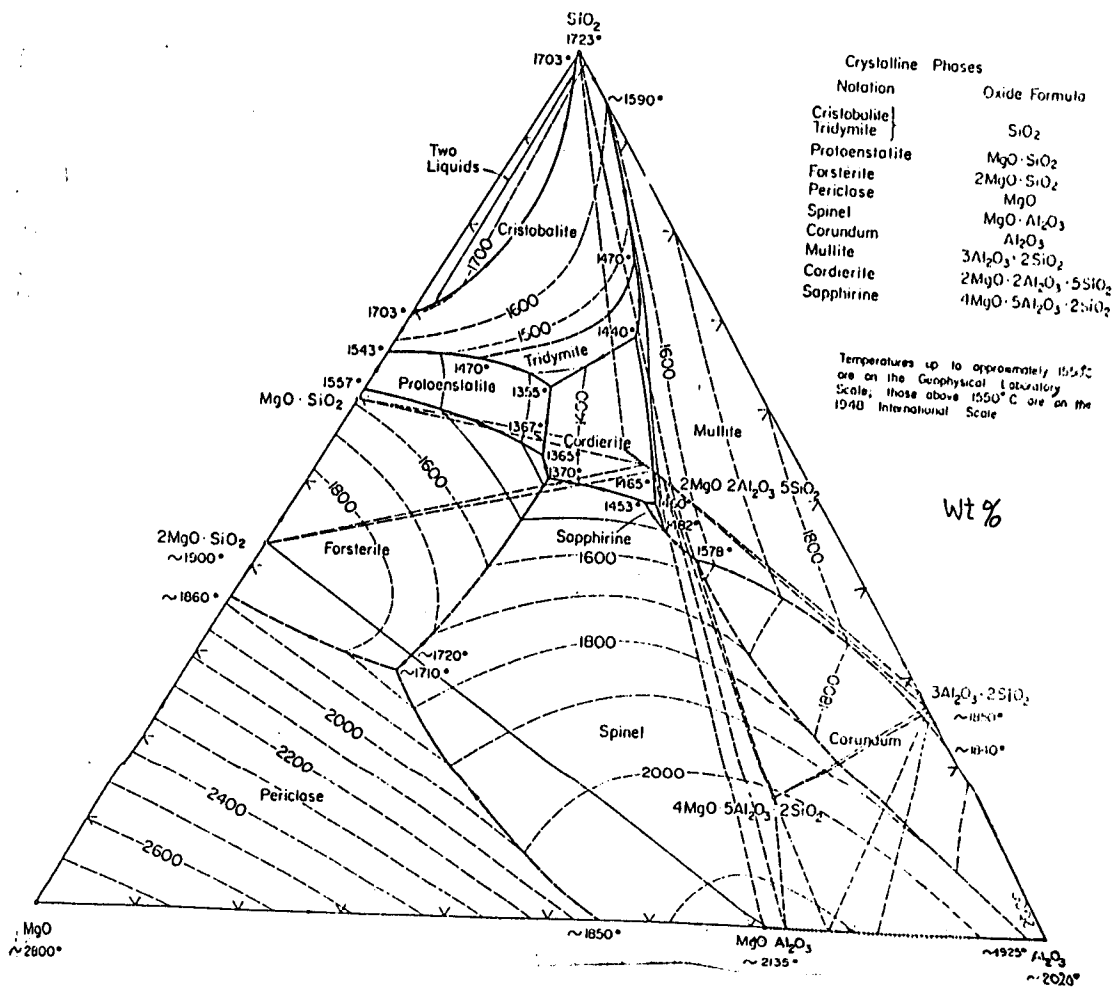
in a reversible, isothermal expansion from  $P_1$  to  $P_2$  is same as that done when an ideal gas is reversibly and isothermally expanded from  $P_1$  to  $P_2$ , but the work done by the nonideal gas in a reversible expansion from  $V_1$  to  $V_2$  is greater than that done when an ideal gas is reversibly and isothermally expanded from  $V_1$  to  $V_2$ . Prove it and explain why this so.

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6. Show that the process  $\text{H}_2\text{O}(l, -5^\circ\text{C}) = \text{H}_2\text{O}(cr, -5^\circ\text{C})$  is a spontaneous process in an isolated system containing in addition to the water a thermostat at  $-5^\circ\text{C}$ . The heat of fusion of water is  $333.5\text{J/g}$  at  $0^\circ\text{C}$ , and the specific heats for water and ice may be taken as  $4.2\text{J/K g}$  and  $2.1\text{J/K g}$ , respectively.

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根據下面  $MgO-Al_2O_3-SiO_2$  系相圖 解答下列(7)至(11)題。50%



- (7) 堇青石 (cordierite) 和假藍寶石 (sapphirine) 兩結晶相 (crystalline phase) 的安定上限 (upper limit of stability) 是幾度? 超出此上限溫度時, 兩結晶相各自會發生什麼變化?
- (8) 為  $MgO-Al_2O_3-SiO_2$  系做一個  $1500^\circ C$  之等溫切面 (isothermal section).
- (9)  $MgO-Al_2O_3-SiO_2$  系中有那幾個 ternary invariant points 是 reaction points? 敘述這些 reaction points 之性質。
- (10) 把等重量的 鎂橄欖石 (forsterite) 和 金剛玉 (corundum) 的 權重

粉末均勻混合後，加熱至幾度時才會開始有液相出現？加熱至幾度以上才會完全熔融？在  $1000^{\circ}\text{C}$  時會有那幾相 (phase) 平衡共存？在  $1600^{\circ}\text{C}$  時，會有那幾相平衡共存？

- (11)  $\text{MgO}-\text{Al}_2\text{O}_3-\text{SiO}_2$  系中有沒有液體不溶混 (liquid immiscibility) 的現象？若有，兩液相可以平衡共存的最低溫度是幾度？