

Pledge and signature:

KEY

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1. (15) Consider the reaction, $N_2 + 3 H_2 \rightleftharpoons 2 NH_3$ (where all components are gases).

(a) Write the reaction equilibrium condition in a closed system. (Be specific for this reaction.)

$$\sum \nu_i \mu_i = 0 \Rightarrow \mu(N_2) + 3\mu(H_2) = 2\mu(NH_3)$$

(b) Suppose that initially a reaction vessel contains just 5.80 mol N_2 and 6.20 mol NH_3 . At a later time 6.50 mol of N_2 is present. How much of each of the other components is present, and what is the extent of reaction ξ ?

$$\Delta n_{N_2} = 0.70 \text{ mol} \Rightarrow \Delta n_{H_2} = 3 \times 0.70 \text{ mol} = 2.10 \text{ mol}$$

$$\text{and } \Delta n_{NH_3} = -2 \times 0.70 \text{ mol} = -1.40 \text{ mol}$$

$$\hookrightarrow H_2 = 2.10 \text{ mol} ; NH_3 = 4.80 \text{ mol}$$

$$\Delta n_i = \nu_i \xi \rightarrow \xi = -0.70 \text{ mol}$$

(c) Suppose the reaction is rewritten, $NH_3 \rightleftharpoons \frac{1}{2} N_2 + \frac{3}{2} H_2$. Repeat the calculations of (b) for the same initial and final amounts of N_2 and NH_3 .

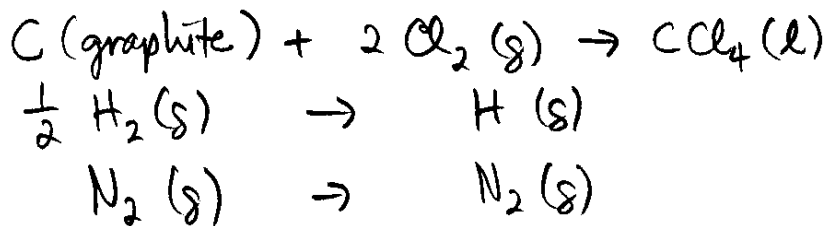
same final amounts of all 3 components.

$$\text{Consider } N_2. \Delta n_i = 0.70 \text{ mol} = \xi \nu = \xi \left(\frac{1}{2}\right)$$

$$\hookrightarrow \xi = 1.40 \text{ mol}$$

2. (7) For each of the following — $CCl_4(l)$, $H(g)$, $N_2(g)$ —

(a) Write the reaction of formation from reference-form elements at room T .



(b) Is $\Delta H_f^\circ = 0$ for any of these at $50^\circ C$? If so, which ones?

yes — $N_2(g)$

3. (4) For each of the following closed systems, write the conditions for material equilibrium between phases:

(a) ice in equilibrium with liquid water. $\mu[H_2O(s)] = \mu[H_2O(l)]$

(b) ice in equilibrium with an aqueous solution of sucrose.

$$\mu[H_2O(s)] = \mu[H_2O(soln)] \quad \left\{ + \mu[\text{sucrose}(soln)] = \mu[\text{sucrose}(ice)] \right.$$

(c) a two-phase system of ether and water, with each phase saturated with the other component.

$$\mu[H_2O(aq)] = \mu[H_2O(eth)] ; \mu[ether(aq)] = \mu[ether(eth)]$$