AP® CHEMISTRY
2008 SCORING GUIDELINES (Form B)

Question 1

Answer the following questions regarding the decomposition of arsenic pentafluoride, $AsF_5(g)$.

(a) A 55.8 g sample of $AsF_5(g)$ is introduced into an evacuated 10.5 L container at 105°C.

(i) What is the initial molar concentration of $AsF_5(g)$ in the container?

$\text{mol } AsF_5 = 55.8 \text{ g } AsF_5 \times \frac{1 \text{ mol } AsF_5}{169.9 \text{ g } AsF_5} = 0.328 \text{ mol}$ $[AsF_5]_i = \frac{0.328 \text{ mol } AsF_5}{10.5 \text{ L}} = 0.0313\ M$	One point is earned for the correct molar mass. One point is earned for the correct concentration.

(ii) What is the initial pressure, in atmospheres, of the $AsF_5(g)$ in the container?

$PV = nRT$ $P = \frac{0.328 \text{ mol} \times 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1} \times 378 \text{ K}}{10.5 \text{ L}} = 0.969 \text{ atm}$	One point is earned for the correct substitution. One point is earned for the correct pressure.

At 105°C, $AsF_5(g)$ decomposes into $AsF_3(g)$ and $F_2(g)$ according to the following chemical equation.

$$AsF_5(g) \rightleftarrows AsF_3(g) + F_2(g)$$

(b) In terms of molar concentrations, write the equilibrium-constant expression for the decomposition of $AsF_5(g)$.

$K = \frac{[AsF_3]\,[F_2]}{[AsF_5]}$	One point is earned for the correct equation.

(c) When equilibrium is established, 27.7 percent of the original number of moles of $AsF_5(g)$ has decomposed.

(i) Calculate the molar concentration of $AsF_5(g)$ at equilibrium.

$100.0\% - 27.7\% = 72.3\%$ $[AsF_5] = 0.723 \times 0.0313\ M = 0.0226\ M$	One point is earned for the correct concentration.

Question 1 (continued)

(ii) Using molar concentrations, calculate the value of the equilibrium constant, K_{eq}, at 105°C.

$[AsF_3] = [F_2] = 0.277 \times [AsF_5]_i$ $= 0.277 \times 0.0313\ M = 0.00867\ M$ $K_{eq} = \frac{[AsF_3]\,[F_2]}{[AsF_5]} = \frac{[0.00867]\,[0.00867]}{[0.0226]} = 0.00333$	One point is earned for setting $[AsF_3] = [F_2]$. Note: the point is not earned if the student indicates that $[AsF_3] = [F_2] = [AsF_5]$. One point is earned for the correct calculation of $[AsF_3]$ and $[F_2]$. One point is earned for the correct calculation of K_{eq}.

(d) Calculate the mole fraction of $F_2(g)$ in the container at equilibrium.

mol $AsF_5 = 0.0226\ M \times 10.5$ L $= 0.237$ mol mol F_2 = mol $AsF_3 = 0.00867\ M \times 10.5$ L $= 0.0910$ mol mol fraction $F_2 = \frac{\text{mol } F_2}{\text{mol } F_2 + \text{mol } AsF_3 + \text{mol } AsF_5}$ $= \frac{0.0910}{0.0910 + 0.0910 + 0.237} = 0.217$ OR mol fraction $F_2 = \frac{0.00864}{0.00864 + 0.00864 + 0.0226} = 0.217$	One point is earned for the correct calculation of the mole fraction of $F_2(g)$.