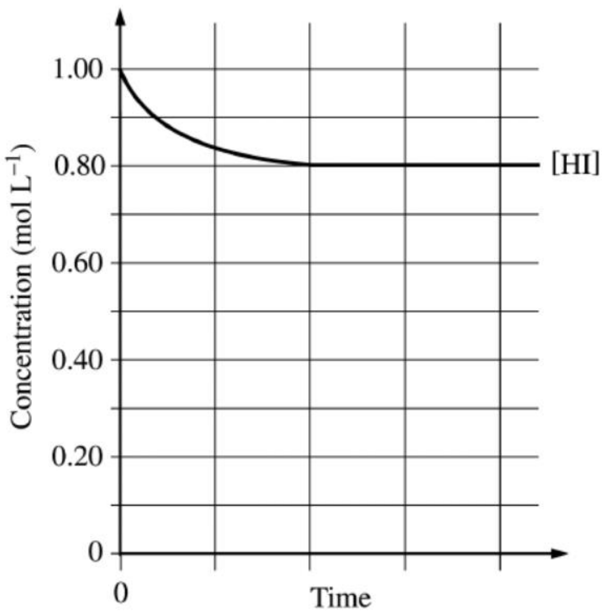
2003B

$$2\ HI(g) \leftrightarrows H_2(g) + I_2(g)$$

After a 1.0 mole sample of HI(*g*) is placed into an evacuated 1.0 L container at 700. K, the reaction represented above occurs. The concentration of HI(*g*) as a function of time is shown below.

(a) Write the expression for the equilibrium constant, *Kc* , for the reaction.



(b) What is [HI] at equilibrium?

(c) Determine the equilibrium concentrations of $H_2(g)$ and $I_2(g)$.

(d) On the graph above, make a sketch that shows how the concentration of $H_2(g)$ changes as a function of time.

(e) Calculate the value of the following equilibrium constants at 700. K.

(i) K_c

(ii) K_p

(f) At 1,000 K, the value of *Kc* for the reaction is 2.6×10^{-2}. In an experiment, 0.75 mole of HI(*g*), 0.10 mole of $H_2(g)$, and 0.50 mole of $I_2(g)$ are placed in a 1.0 L container and allowed to reach equilibrium at 1,000 K. Determine whether the equilibrium concentration of HI(*g*) will be greater than, equal to, or less than the initial concentration of HI(*g*). Justify your answer.

$K_c = \dfrac{[H_2][I_2]}{[HI]^2}$	1 point for correct expression

From the graph, $[HI]_{eq}$ is 0.80 M	1 point for equilibrium [HI]

$2\ HI(g) \rightarrow H_2(g) + I_2(g)$ I: 1.0 M, 0, 0 C: –0.20 M, +0.10 M, +0.10 M E: 0.80 M, 0.10 M, 0.10 M $[I_2] = [H_2] = 0.10\ M$	1 point for stoichiometric relationship between HI reacting and $H_2(g)$ or $I_2(g)$ forming 1 point for $[H_2]_{eq}$ and $[I_2]_{eq}$

From the graph, $[H_2]_{eq}$ is 0.10 M The curve should have the following characteristics: - start at 0 M; - increase to 0.1 M; - reach equilibrium at the same time [HI] reaches equilibrium	1 point for any two characteristics 2 points for all three characteristics

$K_c = \dfrac{[H_2][I_2]}{[HI]^2} = \dfrac{[0.10][0.10]}{[0.80]^2} = 0.016$	1 point for correct substitution (must agree with parts (b) and (c))

$Q = \dfrac{[H_2][I_2]}{[HI]^2} = \dfrac{[0.10][0.50]}{[0.75]^2} = 8.9 \times 10^{-2}$ $K_c = 2.6 \times 10^{-2}$ $Q > K_c$ To establish equilibrium, the numerator must decrease and the denominator must increase. Therefore, [HI] will increase.	1 point for calculating Q and comparing to K_c 1 point for predicting correct change in [HI]

2008B

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?

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

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 $AsF_5(g)$.

(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.

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

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

$\text{mol AsF}_5 = 55.8 \text{ g AsF}_5 \times \dfrac{1 \text{ mol AsF}_5}{169.9 \text{ g AsF}_5} = 0.328 \text{ mol}$ $[\text{AsF}_5]_i = \dfrac{0.328 \text{ mol AsF}_5}{10.5 \text{ L}} = 0.0313\ M$	One point is earned for the correct molar mass. One point is earned for the correct concentration.

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

$K = \dfrac{[\text{AsF}_3][\text{F}_2]}{[\text{AsF}_5]}$	One point is earned for the correct equation.

$100.0\% - 27.7\% = 72.3\%$ $[\text{AsF}_5] = 0.723 \times 0.0313\ M = 0.0226\ M$	One point is earned for the correct concentration.

i]	AsF_5	⇌	AsF_3 +	F_2
I	0.0313		0	0
+C	−x		+x	+x
E	0.0226		0.00867	0.00867

$[\text{AsF}_3] = [\text{F}_2] = 0.277 \times [\text{AsF}_5]_i$ $= 0.277 \times 0.0313\ M = 0.00867\ M$ $K_{eq} = \dfrac{[\text{AsF}_3][\text{F}_2]}{[\text{AsF}_5]} = \dfrac{[0.00867][0.00867]}{[0.0226]} = 0.00333$	One point is earned for setting $[\text{AsF}_3] = [\text{F}_2]$. Note: the point is not earned if the student indicates that $[\text{AsF}_3] = [\text{F}_2] = [\text{AsF}_5]$. One point is earned for the correct calculation of $[\text{AsF}_3]$ and $[\text{F}_2]$. One point is earned for the correct calculation of K_{eq}.

$\text{mol AsF}_5 = 0.0226\ M \times 10.5 \text{ L} = 0.237 \text{ mol}$ $\text{mol F}_2 = \text{mol AsF}_3 = 0.00867\ M \times 10.5 \text{ L} = 0.0910 \text{ mol}$ $\text{mol fraction F}_2 = \dfrac{\text{mol F}_2}{\text{mol F}_2 + \text{mol AsF}_3 + \text{mol AsF}_5}$ $= \dfrac{0.0910}{0.0910 + 0.0910 + 0.237} = 0.217$ OR $\text{mol fraction F}_2 = \dfrac{0.00864}{0.00864 + 0.00864 + 0.0226} = 0.217$	One point is earned for the correct calculation of the mole fraction of $\text{F}_2(g)$.