

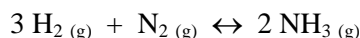
AP CHEMISTRY

TOPIC 6: EQUILIBRIUM, PART C

Day 66:

- Heterogeneous Equilibria
- Reaction Quotient
- Applications of the Equilibrium Constant
- Calculating Equilibrium Pressures

1. The equilibrium constant is $0.0900 M^{-2}$ at 25°C for the reaction:



For which of the following sets of conditions is the system at equilibrium (Show all work)? For those which are not at equilibrium, in which direction will the system shift?

a) a 1.0-L flask contains 1.0 mol of NH_3 , 1.0 mol N_2 , and 0.10 mol H_2 .

Answers:

$$Q = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3[\text{N}_2]} = \frac{\left(\frac{1.0 \text{ mol}}{1 \text{ L}}\right)^2}{\left(\frac{0.10 \text{ mol}}{1 \text{ L}}\right)^3 \left(\frac{1.0 \text{ mol}}{1 \text{ L}}\right)} = 1.0 \times 10^3 \frac{\text{L}^2}{\text{mol}^2}$$

$Q > K$

Shift to the Left
to form Reactants

b) a 2.0-L flask contains 0.84 mol of NH_3 , 0.80 mol N_2 , and 0.98 mol H_2 .

Answers:

$$Q = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3[\text{N}_2]} = \frac{\left(\frac{0.84 \text{ mol}}{2 \text{ L}}\right)^2}{\left(\frac{0.98 \text{ mol}}{2 \text{ L}}\right)^3 \left(\frac{0.80 \text{ mol}}{2 \text{ L}}\right)} = 3.8 \frac{\text{L}^2}{\text{mol}^2}$$

$Q > K$

Shift to the Left
to form Reactants

c) a 3.0-L flask contains 0.25 mol of NH_3 , 0.56 mol N_2 , and 0.0010 mol H_2 .

Answers:

$$Q = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3[\text{N}_2]} = \frac{\left(\frac{0.25 \text{ mol}}{3 \text{ L}}\right)^2}{\left(\frac{0.0010 \text{ mol}}{3 \text{ L}}\right)^3 \left(\frac{0.56 \text{ mol}}{3 \text{ L}}\right)} = 1.0 \times 10^9 \frac{\text{L}^2}{\text{mol}^2}$$

$Q > K$

Shift to the Left
to form Reactants

d) $P_{\text{H}_2} = 1.33 \text{ atm}$, $P_{\text{N}_2} = 2.10 \text{ atm}$, $P_{\text{NH}_3} = 0.25 \text{ atm}$ (K_p is 13.35 atm^{-2} at 25°C for the reaction)

Answers:

$$Q = \frac{(P_{\text{NH}_3})^2}{(P_{\text{H}_2})^3(P_{\text{N}_2})} = \frac{(0.25 \text{ atm})^2}{(1.33 \text{ atm})^3(2.10 \text{ atm})} = 0.013 \frac{1}{\text{atm}^2}$$

$Q < K$

Shift to the Right
to form Reactants

e) $P_{\text{H}_2} = 200. \text{ torr}$, $P_{\text{N}_2} = 49.8 \text{ torr}$, $P_{\text{NH}_3} = 21.0 \text{ torr}$ (K_p is 13.35 atm^{-2} at 25°C for the reaction)

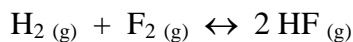
Answers:

$$Q = \frac{(P_{\text{NH}_3})^2}{(P_{\text{H}_2})^3(P_{\text{N}_2})} = \frac{\left(\frac{21.0 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}\right)^2}{\left(\frac{200. \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}\right)^3 \left(\frac{49.8 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}\right)} = 0.639 \frac{1}{\text{atm}^2}$$

$Q < K$

Shift to the Right
to form Products

2. The equilibrium constant for the reaction



has the value 2.1×10^3 at a particular temperature. When the system is analyzed at equilibrium at this temperature, the concentrations of $\text{H}_2(\text{g})$ and $\text{F}_2(\text{g})$ are both found to be 0.0021 M . What is the concentration of $\text{HF}(\text{g})$ in the equilibrium system under these conditions?

Answers:

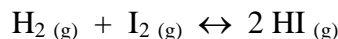
$$K = \frac{[\text{HF}]^2}{[\text{H}_2][\text{F}_2]} = 2.1 \times 10^3 \quad ; \quad [\text{HF}]^2 = (2.1 \times 10^3)[\text{H}_2][\text{F}_2]$$

$$[\text{HF}]^2 = (2.1 \times 10^3) \left(0.0021 \frac{\text{mol}}{\text{L}} \right) \left(0.0021 \frac{\text{mol}}{\text{L}} \right) = 9.261 \times 10^{-3} \frac{\text{mol}^2}{\text{L}^2}$$

$$\sqrt{[\text{HF}]^2} = \sqrt{9.261 \times 10^{-3} \frac{\text{mol}^2}{\text{L}^2}}$$

$$[\text{HF}] = 0.096 \frac{\text{mol}}{\text{L}}$$

3. The reaction



has a $K_p = 45.9$ at 763 K . A particular equilibrium mixture at that temperature contains gaseous HI at a partial pressure of 4.00 atm and hydrogen gas at a partial pressure of 0.200 atm . What is the partial pressure of I_2 ?

Answers:

$$K_p = \frac{(P_{\text{HI}})^2}{(P_{\text{H}_2})(P_{\text{I}_2})} = 45.9 \quad ; \quad \cancel{K_p = \frac{(P_{\text{HI}})^2}{(P_{\text{H}_2})(P_{\text{I}_2})}}$$

$$P_{\text{I}_2} = \frac{(P_{\text{HI}})^2}{(K_p)(P_{\text{H}_2})} = \frac{(4.00 \text{ atm})^2}{(45.9)(0.200 \text{ atm})} = 1.74 \text{ atm}$$