CheggSolutions - Thegdp

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## Chemistry Topic: Chemical Equilibrium

### Given Information:

Equilibrium constant $K = 1.4 \times 10^{-9}$

Initial concentration of $[A] = 0.24$ mol/L

Initial concentration of $[B] = 0.36$ mol/L

### Reaction:

$3A(g) + B(g) \rightleftharpoons C(g) + 2D(g)$

### Step-by-Step Solution:

**1. Introduction and Given Information:**

This problem involves finding the equilibrium concentrations of reactants and products in a chemical reaction. The equilibrium concentration is determined by the initial concentrations and the equilibrium constant.

**2. Write the expression for the equilibrium constant (K):**

$$K = \frac{[C][D]^2}{[A]^3[B]}$$

At equilibrium, the concentrations can be described using the change in concentrations from their initial values. Let's define the change as $x$:

$$\text{Change in [A]} = -3x \quad \text{Change in [B]} = -x \quad \text{Change in [C]} = +x \quad \text{Change in [D]} = +2x$$

**3. Express the equilibrium concentrations in terms of $x$:**

$$[A] = 0.24 - 3x \quad [B] = 0.36 - x \quad [C] = x \quad [D] = 2x$$

**4. Substitute these expressions into the equilibrium constant expression:**

$$K = 1.4 \times 10^{-9} = \frac{x(2x)^2}{(0.24 - 3x)^3(0.36 - x)}$$

**5. Simplify the expression:**

$$1.4 \times 10^{-9} = \frac{4x^3}{(0.24 - 3x)^3(0.36 - x)}$$

**6. Assume that $K$ is very small:**

Given the small value of $K$, the reaction tends heavily to the reactants' side. So, the changes in concentrations $3x$ and $x$ will be very small compared to the initial concentrations.

Thus,

$$[A] \approx 0.24 \text{ (since } x \text{ is negligible)} \quad [B] \approx 0.36 \text{ (since } x \text{ is negligible)}$$

**7. Solve for $x$:**

Substitute these approximate values back into the simplified form to solve for $x$:

$$1.4 \times 10^{-9} = \frac{4x^3}{(0.24)^3(0.36)}$$

Solving for $x^3$:

$$4x^3 = 1.4 \times 10^{-9} \times (0.24)^3 \times 0.36 \quad x^3 = \frac{1.4 \times 10^{-9} \times 0.013824 \times 0.36}{4}$$
$$x^3 = \frac{6.991 \times 10^{-12}}{4} \quad x^3 = 1.74775 \times 10^{-12}$$
$$x = \sqrt[3]{1.74775 \times 10^{-12}} \quad x \approx 1.2 \times 10^{-4} \text{ mol/L}$$

**8. Final Equilibrium Concentrations:**
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$$[C] = x \approx 1.2 \times 10^{-4} \, \text{mol/L}$$
$$[D] = 2x \approx 2 \times 1.2 \times 10^{-4} = 2.4 \times 10^{-4} \, \text{mol/L}$$
$$[A] = 0.24 - 3x \approx 0.24 - 3 \times 1.2 \times 10^{-4} \approx 0.23964 \, \text{mol/L}$$
$$[B] = 0.36 - x \approx 0.36 - 1.2 \times 10^{-4} \approx 0.35988 \, \text{mol/L}$$

Final Solution:

[A] ≈ 0.23964 mol/L

[B] ≈ 0.35988 mol/L

[C] ≈ 1.2×10^{-4} mol/L

[D] ≈ 2.4×10^{-4} mol/L

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