

Name:

Date:

Chemistry 12: Lesson 9 - Equilibrium Equilibrium Calculations Part 2

a)

Example 4: Predicting which way a reaction will shift

$K_{eq} = 49$ for $2 \text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2 \text{NO}_2(g)$. If 2.0 mol of $\text{NO}(g)$, 0.20 mol of $\text{O}_2(g)$ and 0.40 mol of $\text{NO}_2(g)$ are put into a 2.0 L bulb **which way will the reaction shift** in order to reach equilibrium?

****When making predictions you need to calculate the Reaction Quotient (Q), this is to see where about your [Product]:[Reactant] ratio is compared to where it should be at equilibrium****

Tral
Keq

Expressions for Q are the same as your equilibrium constant.

STEP 1: Write out the equilibrium expression

$$K_{eq} = \frac{[\text{NO}_2]^2}{[\text{O}_2][\text{NO}]^2}$$

$$C = \frac{n}{V}$$

STEP 2: Calculate all starting concentrations

$$[\text{NO}]_{\text{start}} = \frac{2.0 \text{ mol}}{2.0 \text{ L}}$$

$$[\text{O}_2]_{\text{start}} = \frac{0.2 \text{ mol}}{2.0 \text{ L}}$$

$$[\text{NO}_2] = \frac{0.4 \text{ mol}}{2.0 \text{ L}}$$

$$[\text{NO}]_{\text{start}} = 1.0 \text{ M}$$

$$[\text{O}_2]_{\text{start}} = 0.10 \text{ M}$$

$$[\text{NO}_2] = 0.20 \text{ M}$$

STEP 3: Solve for Q

$$Q = \frac{[\text{NO}_2]_{\text{start}}^2}{[\text{NO}]_{\text{start}}^2 [\text{O}_2]_{\text{start}}}$$

$$= \frac{(0.20)^2}{(1.0)^2 (0.1)}$$

$$Q = 0.40$$

STEP 4: Make a prediction

$$Q = 0.40$$

$$Q < K_{eq}$$



$$K_{eq} = 49$$

$$K_{eq} = \frac{\text{P} \uparrow}{\text{R}}$$

Q needs to increase to reach eq.
 $\therefore \uparrow$ Products so shift to products (right)

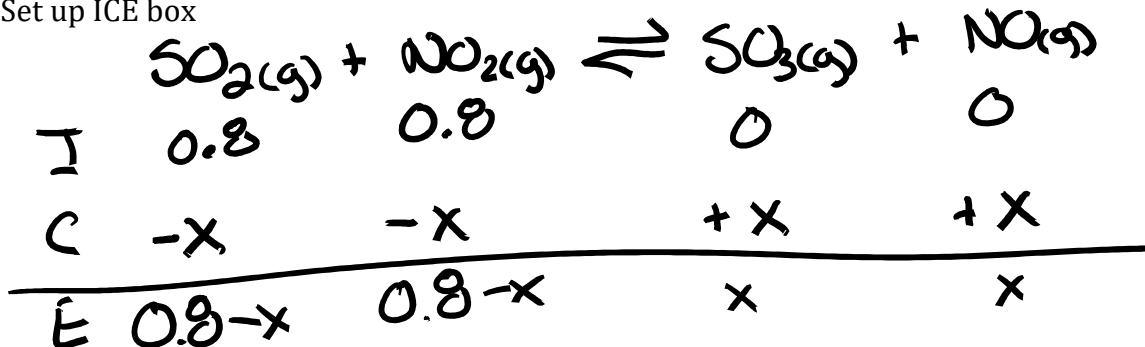
Example 5: Finding all concentrations at equilibrium

$K_{eq} = 3.5$ for $SO_2(g) + NO_2(g) \leftrightarrow SO_3(g) + NO(g)$. If 4.0 mol of $SO_2(g)$ and 4.0 mol of $NO_2(g)$ are placed in a 5.0 L bulb and allowed to come to equilibrium, what concentration of all species will exist at equilibrium?

STEP 1: Write out the equilibrium expression

$$K_{eq} = \frac{[SO_3][NO]}{[NO_2][SO_2]} \quad \left| \quad [SO_2]_i = \frac{4 \text{ mol}}{5} = 0.8 \quad [NO_2] = \frac{4}{5} = 0.8\right.$$

STEP 2: Set up ICE box



STEP 3: Solve

$$K_{eq} = 3.5 = \frac{(x)(x)}{(0.8-x)(0.8-x)}$$

$$\sqrt{3.5} = \frac{x}{0.8-x}$$

$$1.87 = \frac{x}{0.8-x}$$

$$1.87(0.8-x) = x$$

$$1.496 - 1.87x = x$$
$$+1.87x \quad +1.87x$$

$$\frac{1.496}{2.87} = \frac{2.87x}{2.87}$$

$$0.521 M = x$$

$$[SO_3][NO] = 0.521 M$$

$$[SO_2] = [NO_2] = 0.8 - x$$
$$= 0.8 - 0.521$$
$$= 0.28 M$$

EXAMPLE 6: A shift back to equilibrium

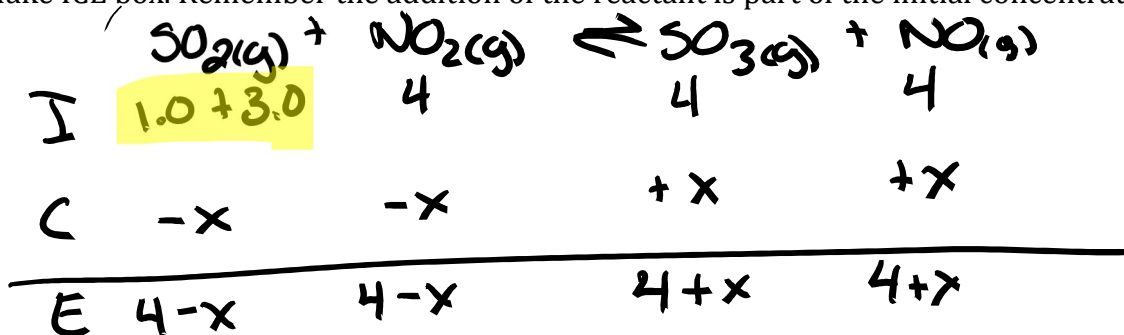
A 1.0 L reaction vessel contained 1.0 mol of SO_2 , 4.0 mol of NO_2 , 4.0 mol of SO_3 and 4.0 mol of NO at equilibrium according to $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g})$. If 3.0 mol of SO_2 is added to the mixture, what will be the new concentration of NO when equilibrium is re-attained

STEP 1: Find K_{eq} for the reaction

$$K_{\text{eq}} = \frac{[\text{SO}_3][\text{NO}]}{[\text{SO}_2][\text{NO}_2]}$$

$$K_{\text{eq}} = \frac{(4)(4)}{(1)(4)} = 4$$

STEP 2: Make ICE box. Remember the addition of the reactant is part of the initial concentration.



STEP 3: Solve

$$K_{\text{eq}} = 4.0 = \frac{(4+x)^2}{(4-x)^2}$$

$$x = 1.33$$

$$\begin{aligned} [\text{NO}] &= 4 + x \\ &= 5.33 \text{ M} \end{aligned}$$