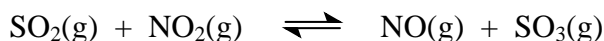


- Consider the following reaction.



At 460 °C this reaction has a value of  $K_c = 85.0$ . Suppose 0.100 mol of  $\text{SO}_2$ , 0.0600 mol of  $\text{NO}_2$ , 0.0800 mol of  $\text{NO}$  and 0.120 mol of  $\text{SO}_3$  are placed in a 10.0 L container at this temperature. What are the concentrations of all of the gases when the system reaches equilibrium?

**The initial concentrations are:**

$$[\text{SO}_2(\text{g})] = \text{number of moles} / \text{volume} = (0.100 \text{ mol}) / (10.0 \text{ L}) = 0.0100 \text{ M}$$

$$[\text{NO}_2(\text{g})] = (0.0600 \text{ mol}) / (10.0 \text{ L}) = 0.00600 \text{ M}$$

$$[\text{NO}(\text{g})] = (0.0800 \text{ mol}) / (10.0 \text{ L}) = 0.00800 \text{ M}$$

$$[\text{SO}_3(\text{g})] = (0.120 \text{ mol}) / (10.0 \text{ L}) = 0.0120 \text{ M}$$

**The reaction quotient can be used to predict the direction that the reaction will shift:**

$$Q = \frac{[\text{NO}(\text{g})][\text{SO}_3(\text{g})]}{[\text{SO}_2(\text{g})][\text{NO}_2(\text{g})]} = \frac{(0.0120)(0.00800)}{(0.0100)(0.00600)} = 1.6$$

As  $Q < K$ , the reaction will shift to the right – to increase the amount of products and decrease the amount of reactants. The reaction table is then:

	$\text{SO}_2(\text{g})$	$\text{NO}_2(\text{g})$	$\rightleftharpoons$	$\text{NO}(\text{g})$	$\text{SO}_3(\text{g})$
<b>initial</b>	<b>0.0100</b>	<b>0.00600</b>		<b>0.00800</b>	<b>0.0120</b>
<b>change</b>	<b>-x</b>	<b>-x</b>		<b>+x</b>	<b>+x</b>
<b>equilibrium</b>	<b>0.0100 - x</b>	<b>0.00600 - x</b>		<b>0.00800 + x</b>	<b>0.0120 + x</b>

Hence,

$$K = \frac{(0.00800+x)(0.0120+x)}{(0.0100-x)(0.00600-x)} = 85.0$$

$$85.0(x^2 - 0.01600x + 0.0000600) = x^2 + 0.02000x + 0.000096$$

$$84.0x^2 - 1.38x + 0.005004 = 0$$

Solving this quadratic equation gives  $x = 0.0054$  and  $0.011$ . The second root is not possible, as it leads to negative concentrations for the reactants.

Using  $x = 0.0054 \text{ M}$  gives,

$$[\text{SO}_2(\text{g})] = (0.0100 - 0.0054) \text{ M} = 0.00460 \text{ M}$$

$$[\text{NO}_2(\text{g})] = (0.00600 - 0.0054) \text{ M} = 0.000597 \text{ M}$$

$$[\text{NO}(\text{g})] = (0.00800 + 0.0054) \text{ M} = 0.0134 \text{ M}$$

$$[\text{SO}_3(\text{g})] = (0.0120 + 0.0054) \text{ M} = 0.0174 \text{ M}$$

$[\text{SO}_2(\text{g})] = 0.00460 \text{ M}$	$[\text{NO}_2(\text{g})] = 0.000597 \text{ M}$
$[\text{SO}_3(\text{g})] = 0.0174 \text{ M}$	$[\text{NO}(\text{g})] = 0.0134 \text{ M}$

