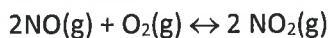


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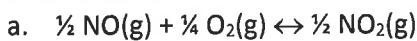
K_{eq} and ICE Problems Worksheet

1. Calculate the equilibrium constant, K_{eq}, for the following reaction at 25°C, if [NO]_{eq} = 0.106 M, [O₂]_{eq} = 0.122 M and [NO₂]_{eq} = 0.129 M.

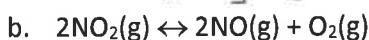


$$K_{\text{eq}} = \frac{[\text{NO}_2]}{[\text{NO}]^2[\text{O}_2]} = \frac{(0.129)^2}{(0.106)^2(0.122)} = \boxed{12.1}$$

2. Given the balanced equation and the value for K_{eq} from #1, calculate new value of K_{eq} for the following:



$$K_{\text{eq}} = \frac{[\text{NO}_2]^{1/2}}{[\text{NO}]^{1/2}[\text{O}_2]^{1/4}} = \frac{(0.129)^{1/2}}{(0.106)^{1/2}(0.122)^{1/4}} = \boxed{1.87}$$

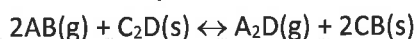


$$K_{\text{eq}} = \frac{[\text{NO}]^2[\text{O}_2]}{[\text{NO}_2]^2} = \frac{(0.106)^2(0.122)}{(0.129)^2} = \boxed{0.0824}$$



$$K_{\text{eq}} = \frac{[\text{NO}][\text{O}_2]^{1/2}}{[\text{NO}_2]} = \frac{(0.106)(0.122)^{1/2}}{(0.129)} = \boxed{0.287}$$

3. Find the equilibrium constant, K_{eq}, for the following equilibrium. The initial concentrations of AB and A₂D are 0.30 M before they are mixed and when equilibrium is reached, the equilibrium concentration of A₂D is 0.20 M. Use an ICE table for your calculation.



I	0.30	X	0.30	X
C	+0.20	X	-0.10	X
E	0.50	X	0.20	X

$$K_{\text{eq}} = \frac{[\text{A}_2\text{D}]}{[\text{AB}]^2} = \frac{(0.20)}{(0.50)^2} = \boxed{0.80}$$

4. If 0.50 mol of NO₂ is placed in a 2.0L flask to create NO and O₂, calculate []_{eq} if K_{eq} = 1.2 × 10⁻⁵.

$$2\text{NO}_2 \rightleftharpoons 2\text{NO} + \text{O}_2$$

I	0.250	0	0
C	-2x	+2x	+x
E	0.250 -2x	2x	x

$$K_{\text{eq}} = \frac{[\text{NO}]^2[\text{O}_2]}{[\text{NO}_2]^2} = \frac{(2x)^2(x)}{(0.250 - 2x)^2}$$

$K_{\text{eq}} = 1.2 \times 10^{-5} \ll 0.250 = [\text{NO}_2]$, so is insignificant and can be ignored.

$$1.2 \times 10^{-5} = \frac{4x^3}{0.0625}$$

$$4x^3 = 7.5 \times 10^{-7}$$

$$x = 5.72 \times 10^{-3}$$

$$\boxed{\begin{aligned} [\text{NO}_2] &= 0.24 \text{ M} \\ [\text{NO}] &= 0.011 \text{ M} \\ [\text{O}_2] &= 0.0057 \text{ M} \end{aligned}}$$

Answers:

1. K_{eq} = 12.1; 2. a. K_{eq} = 1.87, b. K_{eq} = 0.0826, K_{eq} = 0.287; 3. K_{eq} = 0.80;
4. [O₂]_{eq} = 0.0057 M, [NO]_{eq} = 0.0114 M, [NO₂]_{eq} = 0.24 M

5. For the system, if we start with 0.100 mol/L of CO_2 and H_2 , what are the concentrations of the reactants and products at equilibrium given that $K_{\text{eq}} = 0.64$ at 900K?

$$\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \leftrightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$$

I	0.100	0.100	0	0
C	-x	-x	+x	+x
E	0.100 - x	0.100 - x	x	x

$$K_{\text{eq}} = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{CO}_2][\text{H}_2]}$$

$$\sqrt{0.64} = \frac{(x^2)}{\sqrt{(0.100-x)^2}}$$

$$0.80 = \frac{x}{0.100-x}$$

$$0.080 - 0.80x = x$$

$$1.80x = 0.080$$

$$x = 0.0444$$

$$[\text{CO}] = [\text{H}_2\text{O}] = 0.0444 \text{ M}$$

$$[\text{CO}_2] = [\text{H}_2] = 0.0556 \text{ M}$$

6. For the system, if we start with 0.010 mol/L of H_2 and I_2 and 0.096 mol/L of HI , what are their concentrations at equilibrium given that $K_{\text{eq}} = 0.016$?

$$2\text{HI}(\text{g}) \leftrightarrow \text{H}_2(\text{g}) + \text{I}_2(\text{g})$$

I	0.096	0.010	0.010
C	-x	+x	+x
E	0.096 - x	0.010 + x	0.010 + x

$$Q = \frac{(0.010)^2}{(0.096)^2} = 0.0010 \quad Q < K, \text{ so rxn shifts } \rightarrow$$

$$K_{\text{eq}} = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2}$$

$$\sqrt{0.016} = \frac{\sqrt{(0.010+x)^2}}{\sqrt{(0.096-x)^2}}$$

$$0.1265 = \frac{0.010+x}{0.096-x}$$

$$0.01265x = 0.010 + x$$

$$1.1265x = 0.00214$$

$$x = 0.0019$$

$$[\text{H}_2] = [\text{I}_2] = 0.012 \text{ M}$$

$$[\text{HI}] = 0.094 \text{ M}$$

7. At 650°C, the reaction below has a K_{eq} value of 0.771. If 2.00 mol of both hydrogen and carbon dioxide are placed in a 4.00 L container and allowed to react, what will be the equilibrium concentrations of all four gases?

$$\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \leftrightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$$

I	0.500	0.500	0	0
C	-x	-x	+x	+x
E	0.500 - x	0.500 - x	x	x

$$K_{\text{eq}} = \frac{[\text{CO}][\text{H}_2\text{O}]}{[\text{H}_2][\text{CO}_2]}$$

$$\sqrt{0.771} = \frac{\sqrt{x^2}}{\sqrt{(0.500-x)^2}}$$

$$0.8781 = \frac{x}{0.500-x}$$

$$0.4391 - 0.8781x = x$$

$$x = 0.234$$

$$[\text{CO}] = [\text{H}_2\text{O}] = 0.234 \text{ M}$$

$$[\text{H}_2] = [\text{CO}_2] = 0.266 \text{ M}$$

8. Carbonyl bromide, COBr_2 , can be formed by reacting CO with Br_2 . A mixture of 0.400 mol CO , 0.300 mol Br_2 , and 0.0200 mol COBr_2 is sealed in a 5.00L flask. Calculate equilibrium concentrations for all gases, given that the $K_{\text{eq}} = 0.680$.

$$\text{CO}(\text{g}) + \text{Br}_2(\text{g}) \leftrightarrow \text{COBr}_2(\text{g})$$

I	0.0800	0.0600	0.00400
C	+x	+x	-x
E	0.0800 + x	0.0600 + x	0.00400 - x

$$Q = \frac{(0.00400)}{(0.0800)(0.0600)} = 0.833 \quad Q > K, \text{ so rxn shifts } \leftarrow$$

$$K_{\text{eq}} = \frac{[\text{COBr}_2]}{[\text{CO}][\text{Br}_2]}$$

$$0.680 = \frac{(0.00400-x)}{(0.0600+x)(0.0800+x)}$$

$$x = 6.72 \times 10^{-4}$$

$$[\text{COBr}_2] = 0.00333 \text{ M}$$

$$[\text{CO}] = 0.0807 \text{ M}$$

$$[\text{Br}_2] = 0.0607 \text{ M}$$

$$0.680(0.004800 + 0.140x + x^2) = (0.00400 - x)$$

$$3.264 \times 10^{-3} + 0.0952x + 0.680x^2 = 0.00400 - x$$

$$0.680x^2 + 1.0952x - 7.36 \times 10^{-4} = 0$$

- Answers: 5. $[\text{CO}]_{\text{eq}} = [\text{H}_2\text{O}]_{\text{eq}} = 0.044 \text{ M}$, $[\text{CO}_2]_{\text{eq}} = [\text{H}_2]_{\text{eq}} = 0.056 \text{ M}$; 6. $[\text{HI}]_{\text{eq}} = 0.093 \text{ M}$, $[\text{H}_2]_{\text{eq}} = [\text{I}_2]_{\text{eq}} = 0.012 \text{ M}$;
7. $[\text{CO}]_{\text{eq}} = [\text{H}_2\text{O}]_{\text{eq}} = 0.234 \text{ M}$, $[\text{H}_2]_{\text{eq}} = [\text{CO}_2]_{\text{eq}} = 0.266 \text{ M}$; 8. $[\text{CO}]_{\text{eq}} = 0.0807 \text{ M}$, $[\text{Br}_2]_{\text{eq}} = 0.0607 \text{ M}$, $[\text{COBr}_2]_{\text{eq}} = 0.0033 \text{ M}$