

CHEMICAL EQUILIBRIUM B PROBLEMS

Name KEY  
Period \_\_\_\_\_

- 1) A mixture of 0.10 moles of NO, 0.050 moles of H<sub>2</sub>, and 0.10 moles of H<sub>2</sub>O is placed in a 1.0-liter vessel at 300 K. The following equilibrium is established:



At equilibrium, [NO] = 0.062 M.

a. Calculate the equilibrium concentrations of H<sub>2</sub>, N<sub>2</sub>, and H<sub>2</sub>O.

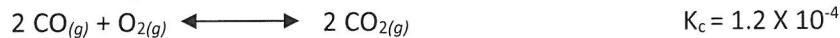
b. Calculate K<sub>c</sub>.

| NO                                       | H <sub>2</sub> | N <sub>2</sub> | H <sub>2</sub> O |
|--|----------------|----------------|------------------|
| I 0.1M                                   | .05M           | 0M             | .1M              |
| C -1.062<br>= .038<br>(2x)               | - .038<br>(2x) | + .019 (x)     | + .058 (2x)      |
| E .062M<br>= .012M<br>= .019M<br>= .138M |                |                |                  |

$$K_c = \frac{(0.019)^1 \cdot (0.138)^2}{(0.062)^2 \cdot (0.012)^2} = 653.7$$

$$K_c = \frac{[\text{N}_2]^1 \cdot [\text{H}_2\text{O}]^2}{[\text{NO}]^2 \cdot [\text{H}_2]^2}$$

- 2) From the following equation:



$$K_c = 1.2 \times 10^{-4}$$

Calculate the concentrations of all the species if 0.30 moles of CO and 0.30 moles of O<sub>2</sub> are reacted in a 1.0-liter container.

| CO                | O <sub>2</sub> | CO <sub>2</sub> |
|-------------------|----------------|-----------------|
| I .30M            | .30M           | 0M              |
| C -2x             | -x             | +2x             |
| E .3-2x<br>= .3-x | 2x             |                 |

$$K_c = 1.2 \times 10^{-4} = \frac{(2x)^2}{(0.3-2x)^2 \cdot (0.3-x)} \rightarrow 1.2 \times 10^{-4} = \frac{4x^2}{(0.3)^2 \cdot (0.3-x)} \rightarrow 1.2 \times 10^{-4} = \frac{4x^2}{0.027} \\ \text{SMALL, DISREGARD X CHANGE}$$

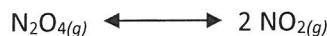
$$3.24 \times 10^{-6} = 4x^2$$

$$x^2 = 8.1 \times 10^{-7}$$

$$x = 9 \times 10^{-4}$$

$$\begin{aligned} \text{CO} &\rightarrow 0.3-2x = 0.298 \text{M} \\ \text{O}_2 &\rightarrow 0.3-x = 0.299 \text{M} \\ \text{CO}_2 &\rightarrow 2x = 1.8 \times 10^{-3} \text{M} \end{aligned}$$

- 3) A flask is charged with 1.50 atm of N<sub>2</sub>O<sub>4</sub> and 1.00 atm NO<sub>2</sub> at 25°C, and the following equilibrium is achieved:



After equilibrium is reached, the partial pressure of NO<sub>2</sub> is 0.512 atm.

a. What is the equilibrium partial pressure of N<sub>2</sub>O<sub>4</sub>?

b. Calculate the value of K<sub>p</sub> for the reaction.

| N <sub>2</sub> O <sub>4</sub> | NO <sub>2</sub>                    |
|-------------------------------|------------------------------------|
| I 1.5                         | 1.00                               |
| C 2.488<br>.244 (x)           | 1.512<br>= -488 (2x)               |
| E 1.5+.244<br>= 1.744 atm     | .512 atm<br>PROVIDED IN<br>PROBLEM |

$$K_p = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.512)^2}{1.744} = 0.150$$

- 4) At  $2000^{\circ}\text{C}$ , the equilibrium constant for the reaction



$$K_c = 2.4 \times 10^3$$

If the initial concentration of NO is  $0.200 \text{ M}$ , what are the equilibrium concentrations on NO, N<sub>2</sub> and O<sub>2</sub>?

|   | NO     | N <sub>2</sub> | O <sub>2</sub> |
|---|--------|----------------|----------------|
| I | 0.200  | 0              | 0              |
| C | -2x    | +x             | +x             |
| E | 0.2-2x | x              | x              |

$K_c$  IS LARGE, SO  
CANNOT DISREGARD  
VALUE OF  $x$ !

$$2.4 \times 10^3 = \frac{(x)^1 \cdot (x)^1}{(0.2-2x)^2}$$

$$2.4 \times 10^3 = \frac{x^2}{(0.2-2x)^2}$$

$$\sqrt{2.4 \times 10^3} = \frac{x}{0.2-2x} \rightarrow 9.8 - 9.8x = x \rightarrow 9.8 = 9.8x \rightarrow x = 0.99$$

- 5) For the equilibrium:



At  $400 \text{ K}$ ,  $K_c = 7.0$ . If  $0.30 \text{ mol}$  of Br<sub>2</sub> and  $0.30 \text{ mol}$  Cl<sub>2</sub> are introduced into a  $1.0 \text{ L}$  container at  $400 \text{ K}$ , what will be the equilibrium concentrations of Br<sub>2</sub>, Cl<sub>2</sub>, and BrCl?

|   | Br <sub>2</sub> | Cl <sub>2</sub> | BrCl <sub>2</sub> |
|---|-----------------|-----------------|-------------------|
| I | 0.3M            | 0.3M            | 0                 |
| C | -x              | -x              | +2x               |
| E | 0.3-x           | 0.3-x           | 2x                |

$$K_c = 7 = \frac{(2x)^2}{(0.3-x)(0.3-x)}$$

$$\sqrt{7} = \frac{2x}{(0.3-x)} \rightarrow 0.7\sqrt{7} - 2.65x = 2x \rightarrow 0.7\sqrt{7} = 4.65x \rightarrow x = 0.17$$

- 6) At  $218^{\circ}\text{C}$ ,  $K_c = 1.2 \times 10^{-4}$  for the equilibrium:



Calculate the equilibrium concentrations of NH<sub>3</sub> and H<sub>2</sub>S if a sample of solid NH<sub>4</sub>HS is placed in a closed vessel and decomposes until equilibrium is reached.

|                                   | NH <sub>3</sub> | H <sub>2</sub> S |
|-----------------------------------|-----------------|------------------|
| NH <sub>4</sub> HS <sub>(s)</sub> | 0               | 0                |
| NON-FACTOR<br>SINCE IT IS SOLID!  | x               | x                |
|                                   | x               | x                |

$$K_c = [\text{NH}_3]^1 \cdot [\text{H}_2\text{S}]^1$$

$$1.2 \times 10^{-4} = [x]^1 \cdot [x]^1$$

$$x = 0.011 \text{ M}$$

$$\boxed{[\text{NO}] \rightarrow 2x = 0.198 \text{ M}}$$

$$\boxed{[\text{N}_2] \rightarrow x = 0.099 \text{ M}}$$

$$\boxed{[\text{O}_2] \rightarrow x = 0.099 \text{ M}}$$