# WORKSHEET: CHEMICAL EQUILIBRIUM

Name ____________________
Last First

**FOR ALL EQUILIBRIUM PROBLEMS, YOU MUST:**

1) **Write all equilibrium equations**
2) **Write all equilibrium concentrations**
3) **Write all equilibrium expressions**

**SET A:**

1. a) What is the equilibrium constant expression for the reaction:

$3\ Fe(s) + 4\ H_2O\ (g) \rightleftharpoons Fe_3O_4\ (s) + 4\ H_2\ (g)$ **Ans:** $[H_2]^4/[H_2O]^4$

b) The equilibrium constant, $K_c$, for the reaction:

$2\ NOCl\ (g) \rightleftharpoons 2\ NO\ (g) + Cl_2\ (g)$ is $2.4 \times 10^{-7}$

What is the equilibrium constant, $K_c$, for the reaction:

$1/3\ Cl_2\ (g) + 2/3\ NO\ (g) \rightleftharpoons 2/3\ NOCl\ (g)$

**Ans:** $1.6 \times 10^2$

c) Given the following equilibrium equations and their corresponding equilibrium constants:

$2\ CO_2\ (g) + H_2O\ (g) \rightleftharpoons 2\ O_2\ (g) + CH_2CO\ (g)$ Kc = $6.1 \times 10^8$

$CH_4\ (g) + 2\ O_2\ (g) \rightleftharpoons CO_2\ (g) + 2\ H_2O\ (g)$ Kc = $1.2 \times 10^{14}$

Find $K_c$ for the reaction: $CH_4\ (g) + CO_2\ (g) \rightleftharpoons CH_2CO\ (g) + H_2O\ (g)$

Setup:

**Ans:** $7.3 \times 10^{22}$

2. A mixture of 9.22 moles of **A**, 10.11 moles of **B**, and 27.83 moles of **C** is placed in a one-liter container at a certain temperature. The reaction is allowed to reach equilibrium. At equilibrium the number of moles of **B** is 18.32. Calculate the equilibrium constant for the reaction:

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

**Ans:** 0.832

3. a. At a certain temperature, $K_c$ is $4.13 \times 10^{-2}$ for the equilibrium:

$$2\ IBr\ (g) \rightleftharpoons I_2\ (g) + Br_2\ (g)$$

Assume that equilibrium is established at the above temperature by adding only IBr (g) to the reaction flask. What are the concentrations of $I_2$ (g) and $Br_2$ (g) in equilibrium with 0.0124 moles/liter of IBr(g) ?

Setup:

**Ans:** $2.52 \times 10^{-3}$ M

b. What was the **initial** concentration of IBr before equilibrium was established?

Setup:

**Ans:** 0.0174

4. 0.924 mole of **A** (g) is placed in a 1.00 liter container at 700 °C, where it is 38.8 % dissociated when equilibrium was established.

$$3\ \mathbf{A}\ \mathbf{(g)} \rightleftharpoons 5\ \mathbf{B}\ \mathbf{(g)} + 2\ \mathbf{C}\ (g)$$

What is the value of the equilibrium constant, $K_c$, at the same temperature?

Setup:

**Ans:** 0.0241

5. The equilibrium constant for the reaction:

$$2\ NO\ (g) \rightleftharpoons N_2\ (g) + O_2\ (g)$$

is $2.60 \times 10^{-3}$ at 1100 °C. If 0.820 mole of NO (g) and 0.223 mole **each** of $N_2$ (g) and $O_2$ (g) are mixed in a 1.00 liter container at 1100 ℃, what are the concentrations of NO (g), $N_2$(g), and $O_2$ (g) at equilibrium?

Setup:

**Ans:** [NO]= 1.15 M
[$N_2$] = 0.058 M
[$Cl_2$]= 0.058 M

## SET B :

1. A mixture of 1.16 mole of **A**, 1.35 mole of **B** and 0.641 mole of **C** is placed in a one-liter container at a certain temperature. The reaction was allowed to reach equilibrium. At equilibrium. the number of moles of **A** is 1.95. Calculate the equilibrium constant, $K_c$, for the reaction:

$$2\ \mathbf{A}\ (g) \rightleftharpoons 2\ \mathbf{B}\ (g) + \mathbf{C}\ (g)$$

Setup:

**Ans:** 0.020

2. 0.822 mole of $SO_3$ (g) is placed in a 1.00 liter container at 600 K. 36.7 % of the $SO_3$ (g) are decomposed when equilibrium is established.

$$2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g)$$

What is the value of the equilibrium constant , $K_c$, at the same temperature?

Setup:

**Ans:** $5.05 \times 10^{-2}$

3. For the equilibrium:

$$2\ BrCl\ (g) \rightleftharpoons Br_2\ (g) + Cl_2\ (g)$$

at 205 °C, the equilibrium constant, $K_c$, is 0.143. If 1.34 moles **each** of $Br_2$ (g) and $Cl_2$ (g) are introduced in a container which has a volume of 11.0 liters and allowed to reach equilibrium at 205 °C, what would be the concentrations of $Br_2$ (g), $Cl_2$ (g), and BrCl (g) at equilibrium?

Setup:

**Ans:** $[Cl_2]$= 0.0529 M
$[Br_2]$= 0.0529 M
[BrCl] = 0.139 M

4. a. What is the numerical value of the equilibrium constant, $K_c$, for the reaction:

$$3\ N_2\ (g) + 3\ O_2\ (g) \rightleftharpoons 6\ NO\ (g)$$

if the equilibrium constant for the reaction:

$2\ NO\ (g) \rightleftharpoons N_2\ (g) + O_2\ (g)$ is $3.5 \times 10^{-6}$

Setup:

**Ans:** $2.3 \times 10^{16}$

b) What is the equilibrium constant expression for the reaction:

$$2\ Ni\ (s) + 2\ CO_2\ (g) \rightleftharpoons 2\ CO\ (g) + 2\ NiO\ (s)$$

**Ans:** K= $[CO]^2/[CO2]^2$

5. For the reaction:

$$2\ NO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ NO_3\ (g)$$

at 923 °C , $K_c$ is 42.5. If 0.0500 mole of $NO_2$ (g), 0.122 mole of $O_2$ (g) and 0.300 mole of $NO_3$ (g) are mixed in a 1.00 liter container at 923 °C, in what direction will the reaction proceed?(Show your calculation to prove that your answer is not a guess.)

Setup:

**Answer:** $Q_c$ > Kc (The reaction will proceed spontaneously to the left)

**SET C :**

1. For the equilibrium:

$$2\ NO\ (g) \rightleftharpoons N_2\ (g) + O_2\ (g)$$

at 300 K, the equilibrium constant, $K_c$, is 0.185. If 1.45 moles **each** of $N_2$ (g) and $O_2$ (g) are introduced in a container that has a volume of 6.00 liters and allowed to reach equilibrium at 300 K, what are the concentrations of $N_2$ (g ), $O_2$(g),and NO (g) at equilibrium?

Setup:

**Ans:** $[N_2]$= 0.112 M
$[O_2]$= 0.112 M
[NO]= 0.260 M

2. 1.87 mole of **A** (g) are placed in a 1.00 liter container at 700 K. 43.3 % of **A** (g) had decomposed when the reaction reached equilibrium .

$$2\ \mathbf{A}\,(g) \rightleftharpoons 3\ \mathbf{B}\ (g) + \mathbf{C}\ (g)$$

What is the value of the equilibrium constant, $K_c$, at the same temperature?

Setup:

**Ans:** 0.639

3. a. What is the equilibrium constant expression for the reaction:

$$2\ Fe\ (s) + 2\ NO_2\ (g) \rightleftharpoons 2\ NO\ (g) + 2\ FeO\ (s)$$

**Ans:** $K = [NO]^2/[NO_2]^2$

b. What is the numerical value of the equilibrium constant, $K_c$, for the reaction:

$$2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g)$$

if the equilibrium constant for the reaction given below is is $2.7 \times 10^{-3}$ ?

$$1/2\ O_2\ (g) + SO_2\ (g) \rightleftharpoons SO_3\ (g)$$

Setup:

**Ans:** $1.4 \times 10^5$

4. A mixture of 3.31 moles of **A**, 4.33 moles of **B**, and 5.95 moles of **C** is placed in a one-liter container at a certain temperature. The reaction was allowed to reach equilibrium. At equilibrium, the number of moles of **B** is 6.16 . Calculate the equilibrium constant, $K_c$, for the reaction:

$$\mathbf{A}\ (g) \rightleftharpoons 3\ \mathbf{B}\ (g) + 2\ \mathbf{C}\ g)$$

Setup:

**Ans:** $4.5 \times 10^3$

5. For the reaction:

$$2\ \mathbf{A}\ (g) \rightleftharpoons \mathbf{B}\ (g) + \mathbf{C}\ (g)$$

at 900 °C, $K_C$ is 1.40 x $10^{-3}$. If 0.780 mole of **A** (g) and 0.244 mole **each** of **B** (g) and **C** (g) are mixed in a 1.00 liter container at 900 °C, what are the concentrations of **A, B**, and **C** at equilibrium?

Setup:

**Ans:** [**A**]**=** 1.180 M
[**B**]= 0.044 M
[**C**]=0.044 M