

# Equilibrium Calculations Practice I

- Suppose that 2.00 mol of HI in a 1.00 L flask at 425 °C react to produce H<sub>2</sub> and I<sub>2</sub>. When equilibrium is reached the concentration of H<sub>2</sub> and I<sub>2</sub> are determined each to be 0.214 mol/L. What is the equilibrium constant?
- For the reaction: 
$$\text{N}_{2(g)} + 3 \text{H}_{2(g)} \rightleftharpoons 2 \text{NH}_{3(g)}$$
If the initial [N<sub>2</sub>] = 0.32 M, and the initial [H<sub>2</sub>] = 0.60 M. At equilibrium [H<sub>2</sub>] = 0.30 M What is K<sub>c</sub>?
- For the reaction: 
$$\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2 \text{HI}_{(g)}$$
K<sub>c</sub> = 55.6. If the initial [H<sub>2</sub>] = 0.200 M, and the initial [I<sub>2</sub>] = 0.200 M, what is the equilibrium [HI]?
- For the reaction: 
$$\text{H}_{2(g)} + \text{CO}_{2(g)} \rightleftharpoons \text{H}_2\text{O}_{(g)} + \text{CO}_{(g)}$$
K<sub>c</sub> = 0.771. If 0.0100 mol each of CO<sub>2</sub> and H<sub>2(g)</sub> are mixed in a 1.0 L container, what are the concentration of all the substances at equilibrium?
- K<sub>c</sub> = 64 for the reaction: 
$$\text{N}_{2(g)} + 3 \text{H}_{2(g)} \rightleftharpoons 2 \text{NH}_{3(g)}$$
At a certain temperature. Suppose it was found that an equilibrium mixture of these gases contained 0.360 M NH<sub>3</sub> and 0.0192 M N<sub>2</sub>. What was the concentration of H<sub>2</sub> in the mixture?
- At a certain temperature K<sub>c</sub> = 0.18 for the equilibrium:
$$\text{PCl}_{3(g)} + \text{Cl}_{2(g)} \rightleftharpoons \text{PCl}_{5(g)}$$
Suppose the reaction vessel at this temperature contained these gases at the following concentrations:  
[PCl<sub>3</sub>] = 0.0420 M    [Cl<sub>2</sub>] = 0.0240 M,    [PCl<sub>5</sub>] = 0.00500 M
  - Is the system at equilibrium?
  - If not, which direction will the equilibrium have to proceed in order to attain equilibrium?
- For the following reaction: 
$$\text{CH}_{4(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{(g)} + 3 \text{H}_{2(g)}$$
At 1500 °C, the equilibrium mixture of these gases is:  
[CO] = 0.300 mol dm<sup>-3</sup>    [H<sub>2</sub>] = 0.800 mol dm<sup>-3</sup>    [CH<sub>4</sub>] = 0.400 mol dm<sup>-3</sup>  
At 1500 °C, K<sub>c</sub> = 5.67, what is the equilibrium concentration of H<sub>2</sub>O<sub>(g)</sub>?
- For the reaction: 
$$\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_{2(g)}$$
K<sub>c</sub> = 4.06 at 500 °C, and the initial concentration of both CO<sub>(g)</sub>, and of H<sub>2</sub>O<sub>(g)</sub> is 0.100 mol dm<sup>-3</sup>. Determine the equilibrium concentration of all the reactants and products at this temperature.
- In an equilibrium mixture of the reaction: 
$$\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$$
at 250 °C in a 2.0 dm<sup>3</sup> vessel, there is 0.15 mol of PCl<sub>3</sub> and 0.090 mol of Cl<sub>2</sub>.  
K<sub>c</sub> = 0.19 mol dm<sup>-3</sup> at 250 °C.
  - Calculate the amount of PCl<sub>5</sub> present at equilibrium.
  - Calculate the mass of PCl<sub>5</sub> present at equilibrium.

## Equilibrium Calculations II

1.  $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g})$
- a) At equilibrium  $[\text{SO}_2] = 4.1 \text{ M}$ ,  $[\text{NO}] = 0.5 \text{ M}$ ,  $[\text{SO}_3] = 3.0$ ,  $[\text{NO}_2] = 0.5 \text{ M}$  Calculate K.
- b) In another experiment, 8.00 mol of  $\text{SO}_2$  and 4.00 mol of  $\text{NO}_2$  are placed in a 2.00 L flask and are allowed to reach equilibrium, and the concentration of  $\text{SO}_3$  at equilibrium is 0.4 mol. Calculate K.
- a)  $\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons \text{C}(\text{g}) + \text{D}(\text{g})$
- b) 0.80 mol of A and 0.80 mol of B are placed in a 1.0 L flask and react until equilibrium is reached. Analysis reveals that 0.60 mol of both C and D are present. Calculate the equilibrium concentrations of A, B, C, and D, and then calculate K.
- c) In another experiment, the initial concentrations of A and B are 2.0 M and 2.0 M respectively. Calculate the equilibrium concentrations of A, B, C and D.
3.  $\text{A}(\text{g}) + \text{B}(\text{g}) \rightleftharpoons \text{C}(\text{g}) + \text{D}(\text{g}) \quad K = 4.0$   
If the initial concentrations of A and B are 0.4 M and 0.4 M respectively. Calculate the equilibrium concentration of all relevant compounds.
4. At the temperature of 660 K, the reaction:  
 $\text{SO}_2(\text{g}) + \text{NO}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g}) + \text{NO}(\text{g}) \quad K = 85.0$   
A reaction flask at 660 K contains gases at the following concentrations:  
 $[\text{SO}_2] = 0.0025 \text{ M}$ ,  $[\text{NO}_2] = 0.0035 \text{ M}$ ,  $[\text{NO}] = 0.025 \text{ M}$ ,  $[\text{SO}_3] = 0.0400 \text{ M}$
- a) Is the system at equilibrium?  
b) If not which direction will the reaction have to go to attain equilibrium?
5. Calculate the equilibrium concentration of  $\text{NH}_3$  for the reaction:  
 $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$   
The equilibrium concentrations for the reactants are  $[\text{N}_2] = 0.45 \text{ M}$  and  $[\text{H}_2] = 1.10 \text{ M}$ , K is  $1.7 \times 10^{-2}$ .
6. At 373 K, the following reaction has an equilibrium constant,  $K = 2.2 \times 10^{-10}$   
 $\text{COCl}_2(\text{s}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$   
If 1.00 mol of phosgene,  $\text{COCl}_2$ , is placed in a 10.0 L flask, calculate the concentration of carbon monoxide, CO, at equilibrium.
7. At 1000 °C, for the reaction:  $2 \text{H}_2\text{O}(\text{g}) \rightleftharpoons 2 \text{H}_2(\text{g}) + \text{O}_2(\text{g})$   
 $K_c = 7.32 \times 10^{-18} \text{ mol dm}^{-3}$ , what will be the  $[\text{H}_2(\text{g})]$  at equilibrium if 1.00 mol of  $\text{H}_2\text{O}(\text{g})$  are placed in a 10.0 L vessel?
8. For the equilibrium:  $2 \text{HBr}(\text{g}) \rightleftharpoons \text{Br}_2(\text{g}) + \text{H}_2(\text{g})$   
 $K_c = 0.190 \text{ mol dm}^{-3}$  at 250 °C. 2.085g of  $\text{HBr}(\text{g})$  was heated to 250 °C in a sealed container of 500 cm<sup>3</sup> capacity and maintained at this temperature until equilibrium was established. Calculate the concentration of the reactants and the products.
9. In an experiment for the following equilibrium system at 25 °C :  
 $\text{CH}_3\text{COOH}(\text{l}) + \text{C}_2\text{H}_5\text{OH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5(\text{l}) + \text{H}_2\text{O}(\text{l}); \quad K_c = 4.00$   
The equilibrium concentrations are determined to be:  
 $[\text{CH}_3\text{COOH}] = 0.330 \text{ mol}$ ,  $[\text{CH}_3\text{COOC}_2\text{H}_5] = 0.660 \text{ mol}$ ,  $[\text{H}_2\text{O}] = 0.660 \text{ mol}$   
What amount of  $\text{C}_2\text{H}_5\text{OH}$  is present at 25 °C?