Chem12 Equilibrium Calculations-60

If a system is not at equilibrium and we know the initial concentrations of the products and reactants and the equilibrium constant, we can find the equilibrium concentrations of all species.

e.g. for the reaction : $H_2(g) + Cl_2(g) <-> 2HCl(g)$

$K_{eq} = 42$, at a certain temperature. If the initial concentrations of the gases are known we can find the equilibrium concentrations. An example is given below.

Experimentally we have for the above reaction at the same T :

	$H_2(g)$	+	$Cl_2(g)$	<->	$2HCl(g)$
Initial concentrations	+0.300 M		+0.300 M		+0.000 M
Change in conc.	-0.229 M		-0.229 M		+0.458 M
Eq. concentrations	+0.071 M		+0.071 M		+0.458 M

In this example we start with O.300 mol/L concentrations of $H_2(g)$ and $Cl_2(g)$ in a closed container. The conditions are not at equilibrium but there is a shift toward equilibrium as $H_2(g)$ and $Cl_2(g)$ molecules collide and form HCl(g) molecules. We can calculate $K_{trial} = 0.00$ which is a sort of preliminary $K_{eq.}$ There must be a shift to the right since K_{eq} must equal 42. For every mole of each reactant that is lost, two moles of product are formed. The numbers above were measured experimentally. We find that $K_{eq} = 42$, as it should since it is a constant as long as the temperature doesn't change.

If we know the equilibrium concentrations of the reactants and products, we can find K_{eq}. If we know K_{eq} and there is an equilibrium shift in which the concentration of the reactants and products changes, we can find the new equilibrium concentrations of the reactants and products.

e.g. for the reaction : $CO(g) + H_2O(g) <-> H_2(g) + CO_2(g)$ $K_{eq} = 0.80$
If we have initially $[CO] = 2.0$ M and $[H_2O] = 2.0$ M, find the equilibrium concentrations of all species.

	$CO(g)$	+	$H_2O(g)$	<->	$H_2(g)$	CO_2
start	2.0		2.0		0.0	0.0
change	-X		-X		+X	+X
eq.	2.0-X		2.0-X		+X	+X

Since $K_{eq} = 0.80$, we have : $K_{eq} = \frac{[X][X]}{[2.0-X][2.0-X]} = 0.80$

Solving for X we find X = 0.95 M. The equilibrium concentrations can now be found. $[CO(g)] = 1.1$ M, $[H_2O(g)] = 1.1$ M, $[H_2] = 0.95$ M, and $[CO_2] = 0.95$ M.

Exercises.

1) Given : $CO_2(g) + H_2(g) <-> CO(g) + H_2O(g)$, At equilibrium the concentrations are : $[CO_2(g)] = 0.648$ M, $[H_2(g)] = 0.148$ M, $[CO(g)] = 0.352$ M, and $[H_2O(g)] = 0.352$ M. Find K_{eq}.

2) In a 2.0 L container at equilibrium, it is determined that there are 0.20 mol $H_2(g)$, 0.10 mol $Cl_2(g)$, and 0.90 mol HCl. Find K_{eq} for the reaction : $H_2(g) + Cl_2(g) <-> 2HCl(g)$

3) Given the reaction : $2SeO_2(g) + O_2(g) <-> 2SeO_3(g)$, with $K_{eq} = 3.6 \times 10^{-2}$ at 260°C. If $[SeO_2] = 0.45$ M and $[O_2] = 0.70$ M, at equilibrium, find $[SeO_3]$.

4) What happens to the equilibrium concentration of SeO_3 in the reaction above if a catalyst is added?

5) Given the reaction : $PCl_5(g) <-> PCl_3(g) + Cl_2(g)$ $K_{eq} = 2.2$
At a certain point we find : $[PCl_5] = 0.15$ M, $[PCl_3] = 0.096$ M, $[Cl_2] = 2.4$ M. Show that the system is not at equilibrium. Which way will it shift? (Hint, find K_{trial} and compare with K_{eq})

6) Given the reaction : $N_2(g) + 3H_2(g) <-> 2NH_3(g)$ and initial concentrations of $N_2 = 2.0$ M, and $H_2 = 1.0$ M, find K_{eq} if the equilibrium concentration of $H_2 = 0.40$.

7) Given the reaction : $NH_4HS(s) <-> NH_3(g) + H_2S(g)$ If 1.00 mole of NH_4HS is placed in a 1.00 L container and a reaction established, we find the equilibrium concentration of NH_3 = 0.040 M. Find $K_{eq.}$

8) Given the reaction : A + B <-> C + D with K_{eq} = 0.250
If the initial concentrations of all reactants and products is 2.00 M, find the equilibrium concentrations (in mol/L) of the reactants and products.

9) Given the reaction : $2HI(g) <-> H_2(g) + I_2(g)$ with K_{eq} = 0.0184, find the equilibrium concentrations (in mol/L) of all species, if initially there is only 0.100 M of HI(g).

Answers : 1) 1.29, 2) 41, 3) 0.071, 4) nothing, 5) $K_{trial} = 1.5 < 2.2$, therefore, shift is to the right., 6) 1.4, 7) 0.0016, 8) 2.67, 2.67, 1.33, 1.33, 9) 0.0787, 0.0107, 0.0107.