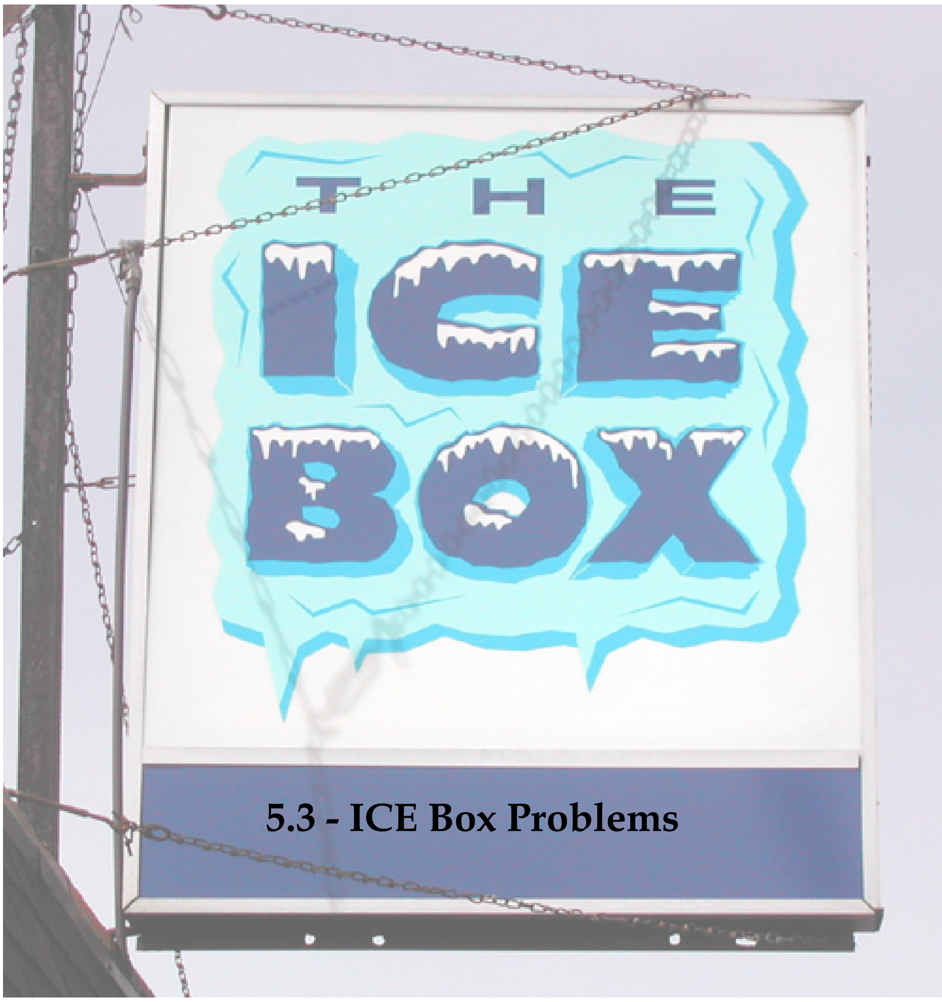
5.3 - ICE Box Problems



As we already know, a chemical equation tells us several pieces of information.

$$H_2 + I_2 \leftrightarrow 2HI$$

This equation tells us how the number of molecules or moles of each substance relate to each other by looking at the balancing coefficients.

The balancing coefficients also tell us how the concentration of each substance changes as a reaction goes on.

For example, if $[H_2]$ changes by x mols/L, then $[I_2]$ changes by x mols/L, and [HI] changes by 2x mols/L.

However, $[H_2]$ and $[I_2]$ are decreasing while [HI] is increasing. Thus, we say that $\Delta[H_2] = \Delta[I_2] = -x$, and the $\Delta[HI] = 2x$.

Note that the negatives mean decrease (or losing) and a positive value means gaining.

This knowledge of changing concentrations is key for an **ICE box problem**. The ICE is an acronym for:

I - Initial concentration
C - Change in concentration
E - Equilibrium concentration

An ICE box problem deals with initial concentrations **not** at equilibrium. Time passes, and equilibrium is eventually reached with new concentrations kept in check by the equilibrium constant.

You can use an ICE box in any problem where you know some, but not all, equilibrium concentrations

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The following process can be used to solve an ICE box problem for a general reaction: A + B ↔ C

1. Balance the equation.
2. Set up the ICE box:

	[A]	[B]	[C]
[Initial]			
[Change]			
[Equilibrium]			

3. Use information from the question to plug values into the ICE box. It is the bottom row that we really want to use; the other rows in the table just help get us there

Some hints you may want to consider:

i. Initially, you should have no product for the forward reaction.

ii. Balanced coefficients (mole to mole ratios) can help you determine unknown values in the "C" column.

iii. E = I - C

Ex) Ammonia is created by the following process:

$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2\ NH_{3(g)}$

If the initially $[N_2]$ = 0.96 M and $[H_2]$ = 0.72 M, and at equilibrium $[NH_3]$ = 0.24 M what is the equilibrium constant?

[Inial]			
[Change]			
[Equilibrium]			

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iii. If K_{eq} is known, but you **do not** know [product] then let one of the changes in equilibrium equal x to solve for the missing concentrations at equilibrium.

Ex) Initially, for the reaction below, $[H_2] = [I_2] = 0.200$ M.

$$H_{2(g)} + I_{2(g)} \leftrightarrow 2HI_{(g)}$$

Calculate all three equilibrium concentrations if $K_{eq} = 64.0$.

[Inial]			
[Change]			
[Equilibrium]			

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This situation may involve the quadratic formula if you come across a quadratic equation of the for ax ^{2}+ bx + c:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Ex) Given this equation,

$PCl_{3(g)} + Cl_{2(g)} \leftrightarrow PCl_{5(g)}$

Calculate all three equilibrium concentrations if initially $[PCl_5]$ = 1.00 M and K_{eq} = 16.0.

[Inial]			
[Change]			
[Equilibrium]			

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5.3 – ICE Box Problems – Assignment

1. For the reaction
   $N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$
   The initial $[N_2]$ = 0.32 M and the initial $[H_2]$ = 0.66 M. At a certain temperature and pressure the equilibrium $[H_2]$ is found to be 0.30 M. What is K_{eq} under these circumstances?

[Initial]			
[Change]			
[Equilibrium]			

2. Suppose that 2.00 moles of HCl in a 1.00L glass flask slowly decomposes into H_2 and Cl_2. When equilibrium is reached, the concentrations of H_2 and Cl_2 are both 0.214 M. What is the K_{eq}?

[Initial]			
[Change]			
[Equilibrium]			

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3. Consider the equilibrium: $2N_2O(g) + O_2(g) \leftrightarrow 4NO(g)$
   3.00 moles of NO(g) are introduced into a 1.00-Liter evacuated flask. When the system comes to equilibrium, 1.00 mole of $N_2O(g)$ has formed. Determine the equilibrium concentrations of each substance. Calculate the K_c for the reaction based on these data.

[Initial]			
[Change]			
[Equilibrium]			

4. At some temperature, $K_{eq} = 33$ for the reaction $H_2 + I_2 \rightarrow 2HI$. If initially, $[H_2] = .0600$ M and $[I_2] = .0300$ M, what are all three equilibrium concentrations?

[Initial]			
[Change]			
[Equilibrium]			

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5. Graphite (solid carbon) and carbon dioxide are kept at constant pressure at 1000 K until the following reaction reaches equilibrium.

   $C_{(s)} + CO_{2(g)} \leftrightarrow 2CO_{(g)}$

   If $K_{eq} = 0.021$, calculate the equilibrium concentration of CO if the concentration of CO_2 was initially 0.012 M.

[Initial]			
[Change]			
[Equilibrium]			

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