

## Study Card: Using ICE Tables

### What is an ICE Table?

- A graphic organizer that relates initial and equilibrium [ ]s for a reversible reaction; very useful for solving equilibrium problems.
- Includes columns for each (g) and (aq) state reactant or product.
- Includes three rows in which concentrations are listed – initial [ ], equilibrium [ ], and the change in [ ]; equilibrium [ ] = initial [ ] + change in [ ].
- The change row reflects the stoichiometry of the reaction; can be + or -.

**I = Initial**  
**C = Change**  
**E = Equilibrium**

### Example #1:

Consider the reaction:  $\text{H}_2\text{O}(g) + \text{CO}(g) \rightleftharpoons \text{H}_2(g) + \text{CO}_2(g)$   
 Initially, reactant [ ]s are 1.20 M each. There are no products. At equilibrium,  $[\text{H}_2\text{O}] = 0.35$  M. Calculate the  $K_c$  value.

#### Solution:

Given information is in black in the ICE table. This is the starting point. Then complete the Change row with *x expressions*; the - means reacted away; the + means produced. See red entries.

	$\text{H}_2\text{O}$	$\text{CO}$	$\rightleftharpoons$	$\text{H}_2$	$\text{CO}_2$
Initial [ ]	1.20	1.20		0.00	0.00
Change in [ ]	-x	-x		+x	+x
Equilibrium [ ]	0.35	1.20 - x		x	x

Using  $\text{H}_2\text{O}$  column; x can be determined:  $0.35 = 1.20 - x \rightarrow x = 0.85$ . Now plug x into the expressions in Equilibrium row to determine the [ ] values of the remaining substances.

$$[\text{CO}] = 1.20 - x = 0.35 \text{ M}; \quad [\text{H}_2] = [\text{CO}_2] = x = 0.85 \text{ M}$$

Now substitute into the  $K_c$  equation to calculate  $K_c$ .  $\rightarrow K_c = (0.85 \cdot 0.85) / (0.35 \cdot 0.35) = 5.9$

### Example #2:

Consider:  $\text{N}_2\text{O}_4(g) \rightleftharpoons 2 \text{NO}_2(g)$   
 $K_p = 0.175$ . Initially, P of  $\text{N}_2\text{O}_4$  is 1.08 atm and P of  $\text{NO}_2$  is 2.42 atm. Determine the equilibrium partial pressures.

#### Solution:

Use an ICE Table to organize the solution:

	$\text{N}_2\text{O}_4$	$\rightleftharpoons$	$\text{NO}_2$
Initial P	1.08		2.42
Change in P	+x		-2x
Equilibrium P	1.08 + x		2.42 - 2x

Now substitute expressions for P into  $K_p$  equation. Solve for x; then use x to determine equilibrium pressures.

**Critical Step:** Determine Q, compare to  $K_p$  to determine the direction rxn proceeds.

$$Q = \frac{P_{\text{NO}_2}^2}{P_{\text{N}_2\text{O}_4}} = \frac{(2.42 \text{ atm})^2}{1.08 \text{ atm}} = 5.42$$

**Tricky Algebra:** Solving for x isn't easy. See our website for extensive details.

$$0.175 = \frac{P_{\text{NO}_2}^2}{P_{\text{N}_2\text{O}_4}} = \frac{(2.42 - 2x)^2}{1.08 + x}$$

$$x = 0.9145 \dots$$

$$P \text{ of } \text{N}_2\text{O}_4 = 1.08 + x = 1.99 \text{ atm}$$

$$P \text{ of } \text{NO}_2 = 2.42 - 2x = 0.59 \text{ atm}$$

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