17 • Chemical Equilibria

B L U F F E R ' S G U I D E

1. $aA + bB + \ldots \rightleftharpoons rR + sS + \ldots$

   $$K_c = \frac{[R]^r[S]^s \cdots}{[A]^a[B]^b \cdots}$$

   and for gases:

   $$K_p = \frac{(P_R)^r (P_S)^s}{(P_A)^a (P_B)^b}$$

2. K > 1 **products** favored
   K < 1 **reactants** favored

3. Excluded: solids; pure liquids; water (in aqueous solutions) because their [ ]'s do not change.

4. Convert from K_c to K_p
   $K_p = K_c(RT)^{\Delta n}$
   where Δn = moles of gaseous product – moles of gaseous reactant.

5. Typical question: Given K_c and the starting concentrations of reactants, find concentrations of products at equilibrium.

   Example: K_c for acetic acid = 1.8×10^{-5}. What is the equilibrium concentration of $[H^+]$ in a 0.100 M solution of the acid?

6. Equilibrium constant for a **reverse** reaction = $1/K$ the value of the forward reaction.

7. Equilibrium constant for a doubled reaction = K^2.

8. When using Hess's Law:
   $K_{overall} = K_1 \times K_2$

9. Le Châtelier's Principle: effect of changes in concentration, pressure, & temperature. Equilibrium always "shifts" away from what you add. "Stress" means too much or too little: chemical, heat, or room.

10. If **out** of equilibrium: Calculate the reaction quotient (Q) similar to the way an equilibrium constant would be found. If:
    Q < K **forward** reaction occurs to reach equilibrium
    Q > K **reverse** reaction occurs to reach equilibrium

11. Problem solving:

- Set up problems using the "magic box" (or ICE box) C = "change" or Δ.
  Example: $A \rightleftharpoons B + C$

	A	**B**	**C**
initial	5.0 M	0 M	0 M
Δ			
equilibrium			

  "Δ" row ***only*** follows the stoichiometry of the equation.

- Learn when to make an approximation (needed for multiple choice questions!) 5% rule usually works when value of K is 10^3 smaller than value of known concentrations.

  Example: $A \rightleftharpoons B + C$
  $K = 3.0 \times 10^{-6}$
  if [A] = 5.0M initially; find [C] at equilibrium.

- If greater than 5% use the quadratic equation: (not usual on the ACS exam)
  $ax^2 + bx + c = 0$

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

- Another easy to solve situation is the perfect squares situation.
  Example: $H_2 + I_2 \rightleftharpoons 2HI$ $K = 3.5 \times 10^2$
  Calculate [HI] when $[H_2] = [I_2] = 0.10$ M

Based on a handout by William Bond, Snohomish HS