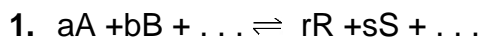


Equilibrium: A Dynamic Process

Inspired by Paul Groves

A BLUFFER'S GUIDE

Law of Mass Action:

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

and for gases:

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

2. $K > 1$ Products Favored
 $K < 1$ Reactant Favored

3. Excluded: solids, liquids including water in aqueous solutions.
 Why: because their []'s don't change

4. Convert K_c to K_p
 $K_p = K_c(RT)^{\Delta n}$
 Where $\Delta n =$
 mol of (g) products – mol of (g) reactants

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. Relationship between modifying a chemical equation and the value of K
- Reverse a rxn = $1/K_{\text{forward}}$
 - Multiplying by a number "n" = K^n
 - Adding rxns = $K_{\text{overall}} = K_1 \times K_2 \times \dots$

7. Le Chatelier's Principle: effect of changes in concentration, pressure and temperature. Equilibrium always "shifts" away from what you add and towards what you remove. "Stress" means too much or too little: chemical, heat, or volume.

8. If NOT at equilibrium (or you don't know if at equilibrium or not): Calculate Q , the reaction quotient.

- Set up the same way as if calculating K
- If $K < Q$
 - Numerator too large
 - Denominator too small
 - Too many products
 - Not enough reactants
 - Reverse rxn is favored to reach equil.
 - "Shift left"
- If $K > Q$
 - Numerator too small
 - Denominator too large
 - Not enough products
 - Too many reactants
 - Forward rxn is favored to reach equil.
 - "Shift right."

9. ICE BoxExample: $A \rightleftharpoons 2B + C$

| | A | B | C |
|--------------------|----------|----------|----------|
| <i>initial</i> | 5.0 M | 0 M | 0 M |
| <i>change</i> | -x | +2x | +x |
| <i>equilibrium</i> | 5.0-x | 2x | x |

"C" row follows the stoichiometry of the rxn

10. The 5% rule allows us to approximate
- K must be < 1
 - Usually able to be used if K is at least 1000 times smaller than []_{initial}
 - x must be $\leq 5\%$ of the []_{initial}
 - If 5% rule doesn't work then use quadratic equation (*not often seen on AP Exam*)

$$ax^2 + bx + c = 0$$

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

11. "Perfect Squares" are another way math is sometimes simplified.
 $3 \times 10^{-6} = (x)(x) / 0.1$ take $\sqrt{\quad}$ of both sides
 and you get $1.73 \times 10^{-3} = x / 0.316$ now solving for x is super easy.

Based on a handout by William Bond, Snohomish HS

Good for solving quadratic, cubic, etc for ICE Tables if no graphing calculator

<https://www.mathpapa.com/equation-solver/>