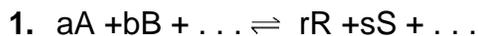


**Equilibrium: A Dynamic Process**

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 =  $1.8 \times 10^{-5}$ .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 equilb.
  - "Shift left"
- If  $K > Q$ 
  - Numerator too small  
Denominator too large
  - Not enough products  
Too many reactants
  - Forward rxn is favored to reach equilb.
  - "Shift right."

**9. ICE Box**Example:  $A \rightleftharpoons 2B + C$ 

	<b>A</b>	<b>B</b>	<b>C</b>
<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 [ ]<sub>initial</sub>
  - $x$  must be  $\leq 5\%$  of the [ ]<sub>initial</sub>
  - 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/>