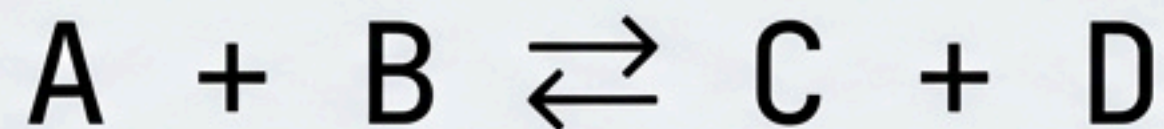


UNIT 6.3 / CHEMICAL EQUILIBRIUM

Law of Chemical Equilibrium

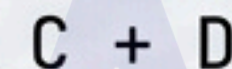
A structural breakdown of the equilibrium constant (K_c) and the mathematical rules that govern reversible reactions.

The Anatomy of a Reversible Reaction



Reactants

Initially high concentration. Deplete over time as the forward reaction occurs.

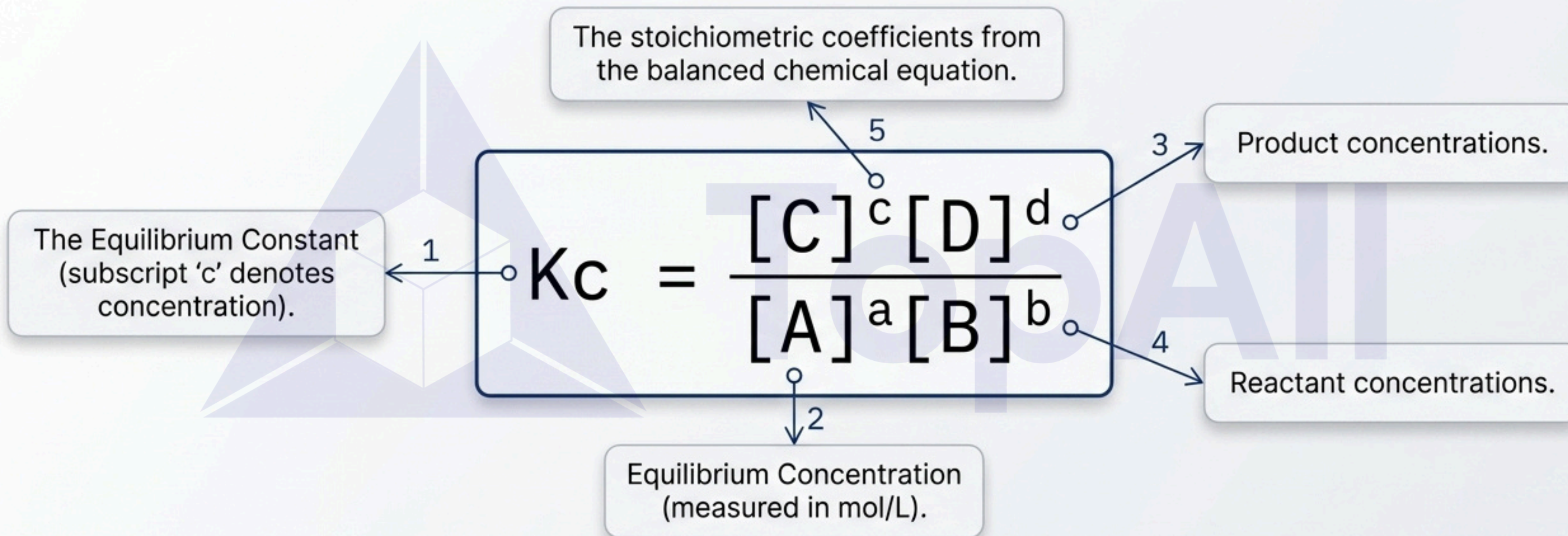


Products

Initially zero concentration. Accumulate over time as the reverse reaction kicks in.

Dynamic Equilibrium: The stage where the rate of the forward reaction perfectly equals the rate of the reverse reaction. Concentrations become visibly constant, though molecular activity continues.

The Equilibrium Constant (K_c)



At a given temperature, the ratio of product concentrations to reactant concentrations (raised to their specific powers) yields a constant value.

Finding the True Constant: $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$

If we measure concentrations of H_2 , I_2 , and HI across six different experiments at 731K, how do we find the mathematical relationship?

Trial Expression



✗ Fluctuates widely

Simply **dividing products** by reactants does not yield a constant number across different starting concentrations.

Trial Expression



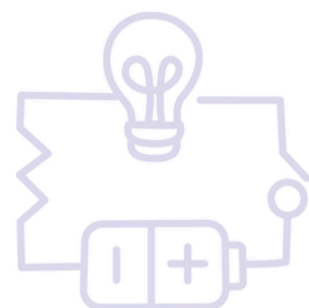
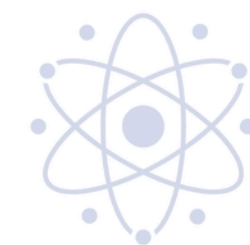
✓ Constant Value

Raising the product to the **power of 2** (its stoichiometric coefficient) yields **exactly the same constant (x)** in all six experiments.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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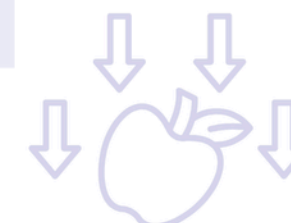
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- » Track Your Performance Smarter



Why Coefficients Become Powers

Step 1 (The Chemistry)



The reaction produces 2 moles of HI. Structurally, this means the products are HI + HI.

Step 2 (The Math)

$$\text{Numerator} = [\text{HI}] \times [\text{HI}]$$

In the Law of Mass Action, we multiply the concentrations of all individual product molecules.

Step 3 (The Simplification)

$$[\text{HI}]^2$$

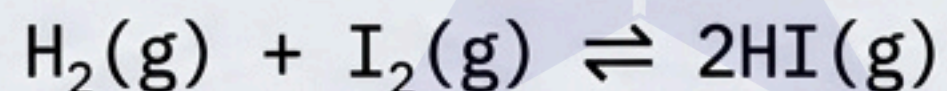
$[\text{HI}] \times [\text{HI}]$ mathematically simplifies to $[\text{HI}]^2$.

General Rule

A coefficient a in front of molecule A (aA) means A appears a times in the reaction. Multiplying its concentration a times yields $[A]^a$.

Reversing the Reaction Direction

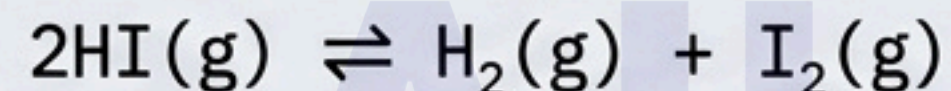
Forward Reaction



$$K_c = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = x$$



Reverse Reaction



$$K'_c = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2} = \frac{1}{x}$$

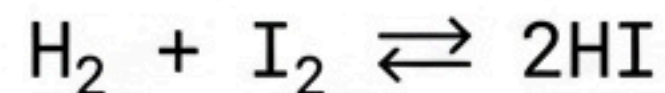
$$K'_c = 1 / K_c$$

The equilibrium constant for a reverse reaction is the exact inverse (reciprocal) of the forward reaction's constant.

Changing Stoichiometric Coefficients

Tier 1

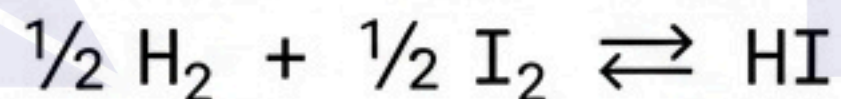
Base Equation

 K_c

Action:
Multiply the
entire equation
by 1/2.

Tier 2

Halved Equation



$$K_c'' = \frac{[\text{HI}]}{[\text{H}_2]^{\frac{1}{2}}[\text{I}_2]^{\frac{1}{2}}}$$

Multiplying an equation by a factor n raises the equilibrium constant to the power of n .

$$K_c'' = (K_c)^n$$

(In this example, $n = 1/2$, so $K_c'' = \sqrt{K_c}$)

Diagnostic Guide: Reading K_c

What K_c Tells Us

The Ratio

The exact mathematical ratio of product and reactant concentrations at equilibrium.

The Extent of Reaction

$K_c > 10^3 \rightarrow$ Products heavily dominate (reaction goes nearly to completion).

$K_c < 10^{-3} \rightarrow$ Reactants heavily dominate (reaction barely proceeds).



What K_c Does NOT Tell Us

The Rate / Speed

K_c contains zero information about how fast equilibrium is reached. A reaction with a massive K_c might still take years to occur without a catalyst.

Thermodynamics $\neq$ Kinetics.

K_c dictates the destination, not the speed of the journey.



You've Learned the Theory.

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