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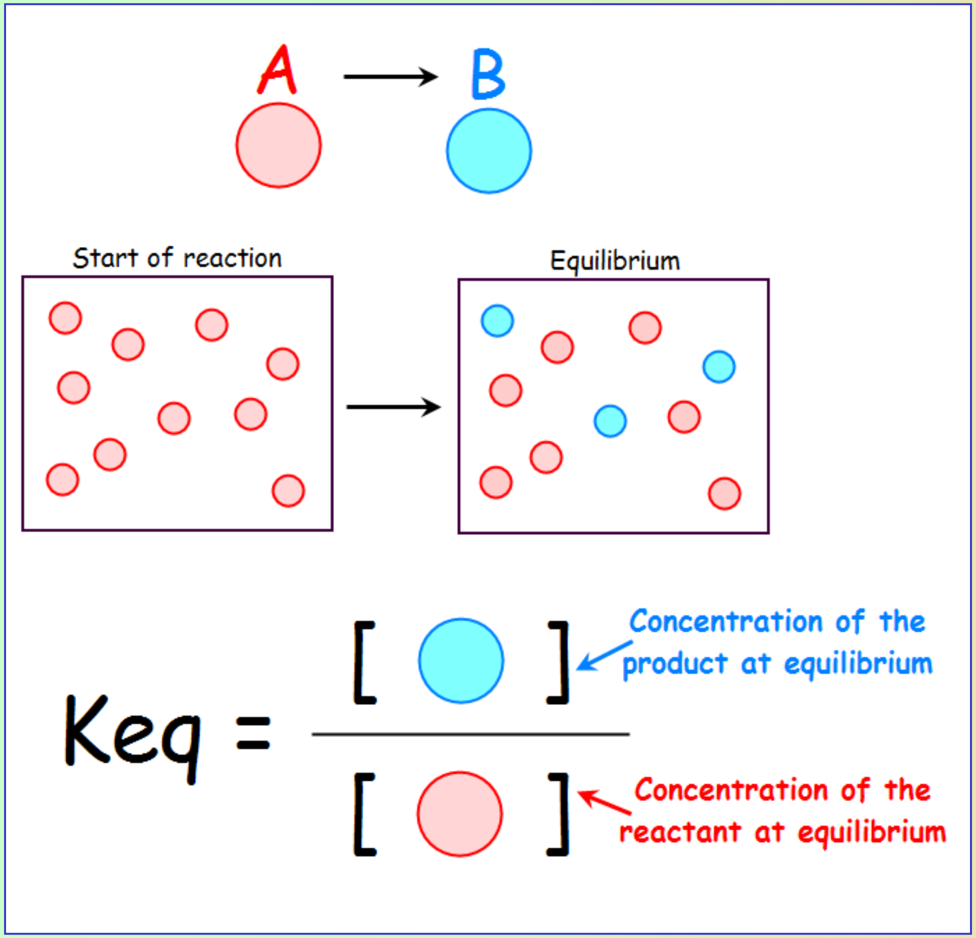
The position of equilibrium: the constant K_{eq}



Equilibrium constant K_{eq}

To quantify the position at which a particular reaction will come to equilibrium, chemists use a quantity known as **equilibrium constant**, Keq.

The general definition of dynamic chemical equilibrium is

$$\boxed{\text{Forward rate} = \text{Reverse rate}}$$

Therefore, when our simple one-step reaction is at equilibrium, we may write:

$$\boxed{k_f\ [A] = k_r\ [B]}$$

Since k_f and k_r are constants we can rearrange the expression to get the equilibrium constant:

$$\boxed{Keq = \frac{k_f}{k_r} = \frac{[B]}{[A]}}$$

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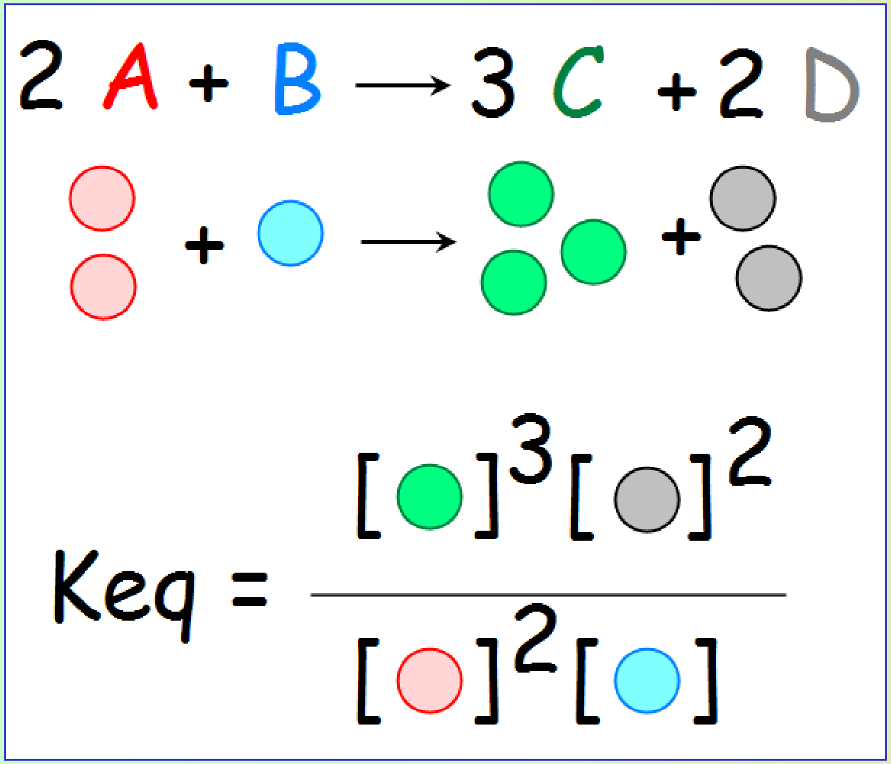

Equilibrium constant K_{eq}

For a general equation of this type

$$a\,A + b\,B \rightleftarrows c\,C + d\,D$$

(where A and B are reactants
C and D are products and
a, b, c and d are the coefficients of the balanced equation)

the expression of the equilibrium constant is:

$$Keq = \frac{[C]^c\ [D]^d}{[A]^a\ [B]^b}$$

This constant can be applied as long as the temperature doesn’t change.

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Exercise

Consider the reaction

$$H_2\ (g) + I_2\ (g) \rightleftarrows 2\ HI\ (g)$$

At the start of the reaction, the number of moles of both reactants is 0.2 mol and there is no product inside the vessel. The volume of the vessel is 2 L.

At 427 ºC, in the equilibrium, the number of moles of each reactant is 0.042 mol.

Determine the equilibrium constant.

Solution

The number or moles in equilibrium is:

	H_2 (g) +	I_2 (g) ⇄	2 HI (g)
start	0.2 mol	0.2 mol	0
change	-x	-x	2x
------			
equilibrium	0.2 - x	0.2 - x	2x

0.2 - x = 0.042 → x = 0.158

$$Keq = \frac{[HI]^2}{[H_2]\ [I_2]} = \frac{\left[\frac{0.316\ mol}{2\ L}\right]^2}{\left[\frac{0.042\ mol}{2\ L}\right]\left[\frac{0.042\ mol}{2\ L}\right]}$$

Keq = 56.6

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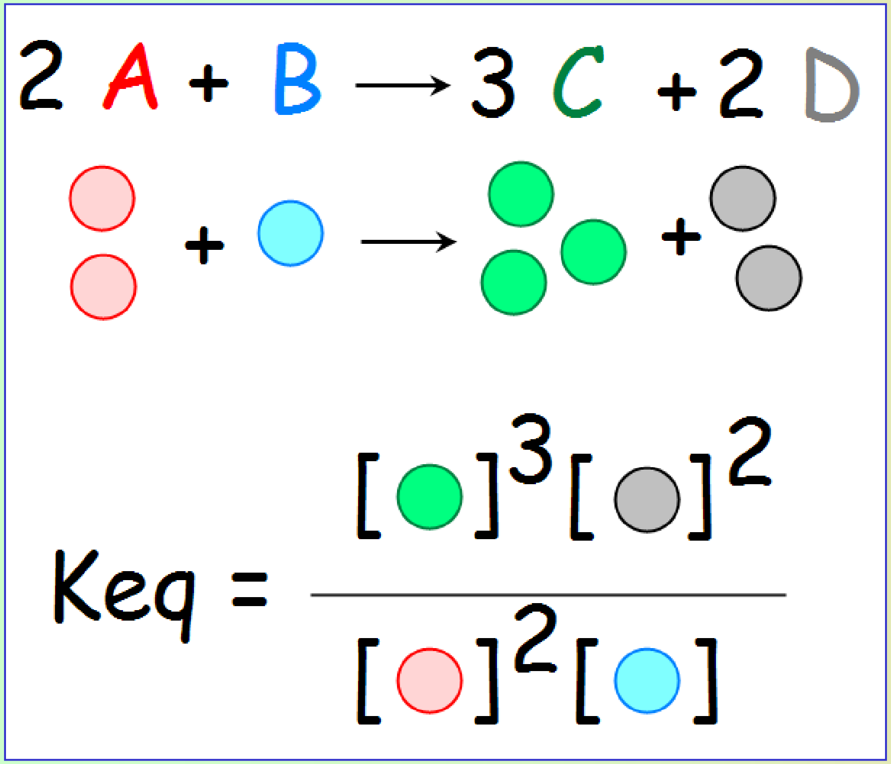

Equilibrium constant K_{eq}

When the numerator is much larger than the denominator

$$\boxed{\frac{[\text{products}]}{[\text{reactants}]} > 1}$$

the products will be in larger proportion and when the denominator is larger

$$\boxed{\frac{[\text{products}]}{[\text{reactants}]} < 1}$$

there will be more reactants than products.