Starting and Equilibrium Concentrations at 490°C for the Reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

	Concentrations (mol/dm³)									
	Experiment 1		Experiment 2		Experiment 3		Experiment 4		Experiment 5	
	At start	At equil.	At start	At equil.	At start	At equil.	At start	At equil.	At start	At equil.
H_2	1.00		0		0		0.600		0.800	
		0.228		0.114		0.171		0.245		0.090
I_2	1.00		0		0		0.400		1.200	
		0.228		0.114		0.171		0.045		0.490
HI	0		1.00		1.50		0		0	
		1.544		0.772		0.158		0.711		1.423

The mass-action expression for this reaction is

$$\frac{[HI]^2}{[H_2] \times [I_2]}$$

Substituting the equilibrium concentrations for Experiment 1, as given in Figure 18-5, into the mass-action expression gives

Exp. 1

$$\frac{(1.544)^2}{(0.228)\,(0.228)} = 45.9$$

When the equilibrium concentrations for the remaining four experiments are substituted into the mass-action expression, it turns out that the data for all five experiments produce the same numerical value:

Exp. 2

$$\frac{(0.772)^2}{(0.114)\,(0.114)} = 45.9$$

Exp. 3

$$\frac{(1.158)^2}{(0.171)\,(0.171)} = 45.9$$

Exp. 4

$$\frac{(0.711)^2}{(0.245)\,(0.045)} = 45.9$$

Exp. 5

$$\frac{(1.423)^2}{(0.090)\,(0.490)} = 45.9$$

The value of the mass-action expression for each of these experiments is 45.9. This means that no matter what the initial concentrations of the hydrogen, iodine, or hydrogen iodide, their concentrations will adjust themselves until, at equilibrium, they produce the constant 45.9 when substituted into the mass-action expression.

Thus, the mass-action expression for this system and other systems at equilibrium shows a constant numerical value. The mass-action expression, when set equal to a constant, is called the **equilibrium expression.** The constant itself is called the **equilibrium constant,** K_{eq}. In the example considered here,

The equilibrium expression is: $K_{eq} = \dfrac{[HI]^2}{[H_2] \times [I_2]}$

The equilibrium constant is: $K_{eq} = 45.9$

To sum up, at a particular temperature, the mass-action expression for a reversible reaction will be equal to a constant if the equilibrium concentrations of the reactants and products are used to evaluate the expression. This principle is called the **law of chemical equilibrium.**