# 15.1 The Nature of the Equilibrium State

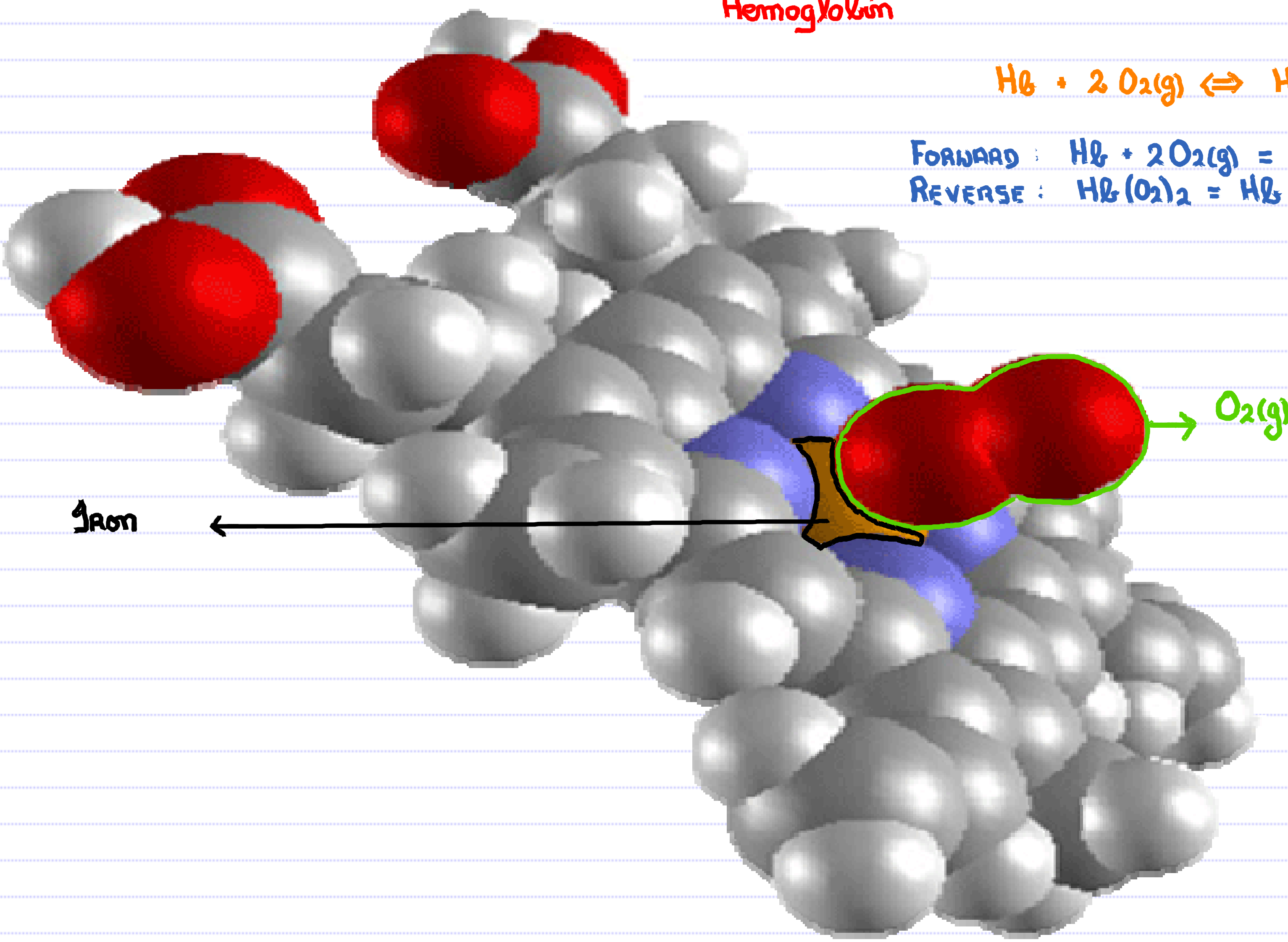
## The Equilibrium State

Hemoglobin

$Hb + 2\,O_{2}(g) \Leftrightarrow Hb(O_2)_2$

FORWARD : $Hb + 2O_2(g) = Hb(O_2)_2$

REVERSE : $Hb(O_2)_2 = Hb + 2O_2(g)$



## 15.1 The Nature of the Equilibrium State

### The Equilibrium State

$$Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$$

At Equilibrium : Initial Rate of forward Reaction = Initial Rate of the Reverse Reaction.

$$k_f [Fe^{3+}][SCN^-] = k_R [FeSCN^{2+}]$$

$$\frac{k_f}{k_R} = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$$

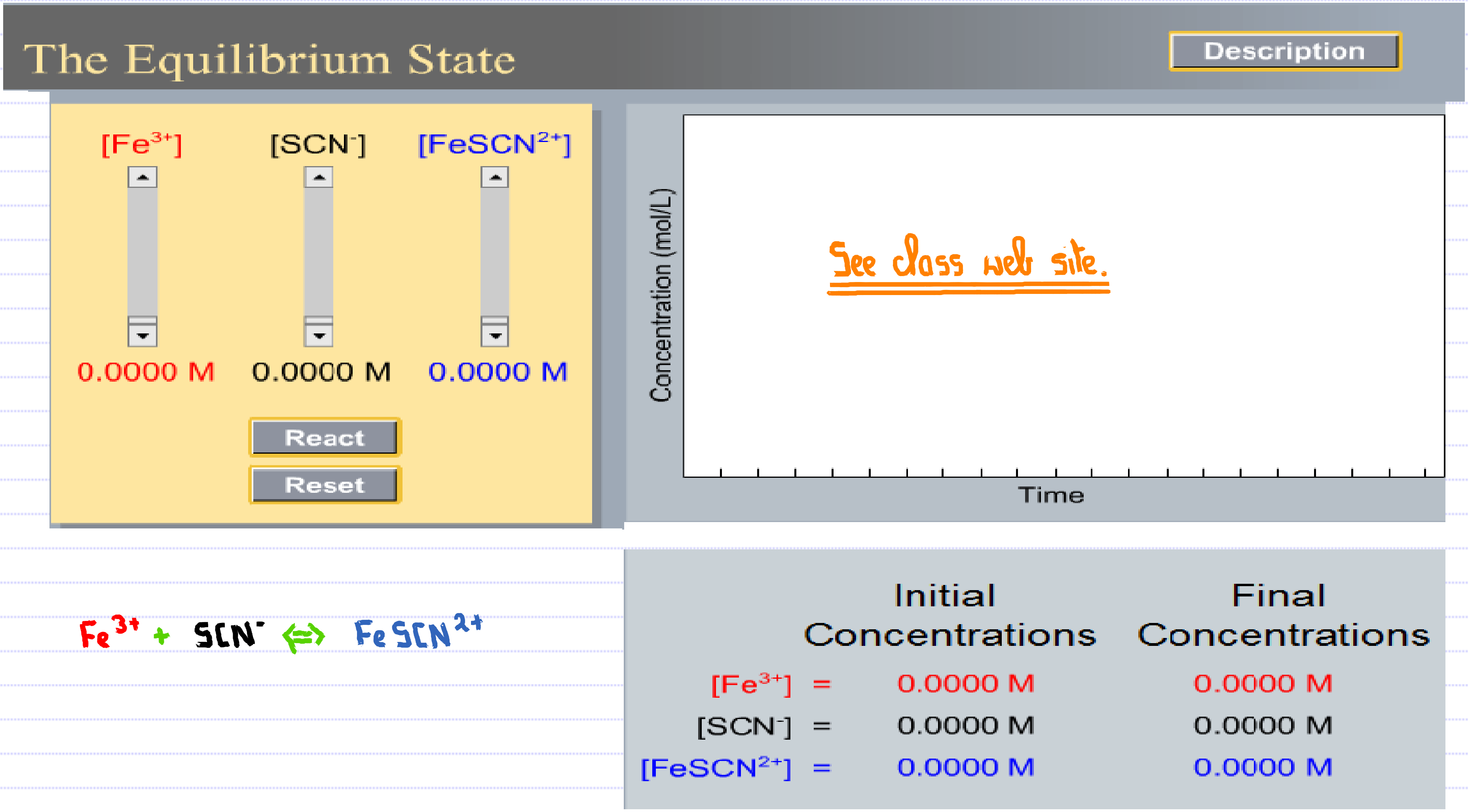
$\frac{k_f}{k_R}$ → Constant.

$$\frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]} = \text{Constant} = K$$

? Is this true ... don't take my word for it ! ... experiment

## 15.2 The Equilibrium Constant, K

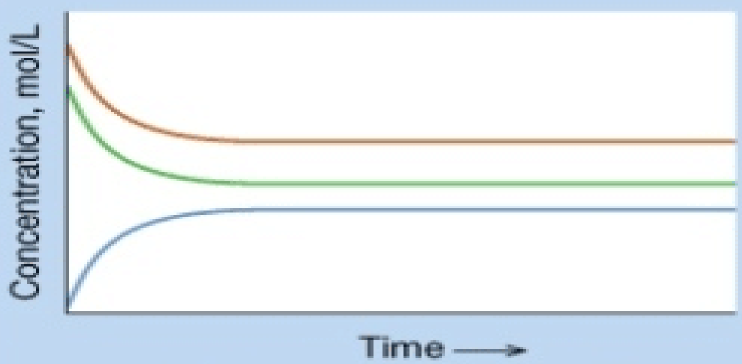
### The Equilibrium State




$Fe^{3+} + SCN^{-} \rightleftharpoons FeSCN^{2+}$

## 15.2 The Equilibrium Constant, K

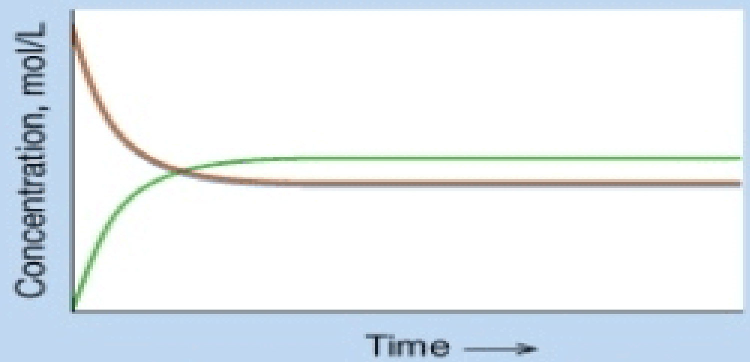
### Equilibrium Constants




| Initial concentrations | Final concentrations |
|---|---|
| $[Fe^{3+}] = 0.00900$ M | $5.63 \times 10^{-3}$ M |
| $[SCN^-] = 0.00760$ M | $4.23 \times 10^{-3}$ M |
| $[FeSCN^{2+}] = 0.00000$ M | $3.37 \times 10^{-3}$ M |

$Fe^{3+}$ and $SCN^-$

$$K = \frac{[0.00337]}{[0.00563][0.00423]} = 142$$




| Initial concentrations | Final concentrations |
|---|---|
| $[Fe^{3+}] = 0.00000$ M | $5.18 \times 10^{-3}$ M |
| $[SCN^-] = 0.00000$ M | $5.18 \times 10^{-3}$ M |
| $[FeSCN^{2+}] = 0.00900$ M | $3.82 \times 10^{-3}$ M |

$Fe^{3+}$ and $SCN^{2+}$

$$K = \frac{[0.00382]}{[0.00518][0.00518]} = 142$$

In general : $aA + bB \Leftrightarrow cC + dD$

$$K = \frac{[\text{PRODUCTS}]}{[\text{REACTANTS}]} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

## 15.2 The Equilibrium Constant, K

### Equilibrium Constants – Meaning of the Magnitude of K

K : K >> 1 ; K << 1 ; K ≈ 1

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K >> 1

$I_2(g) + Cl_2(g) \Leftrightarrow 2\ ICl(g)$ $K = 2.1 \times 10^5$ @ 25°C

Product-favored reaction.

@ Equilibrium :- very little $I_2(g)$ and $Cl_2(g)$ remaining.

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K << 1

$CH_3CO_2H(aq) + H_2O(l) \Leftrightarrow CH_3CO_2^- + H_3O^+$ $K = 1.8 \times 10^{-5}$ @ 25°C

Reactant-favored reaction.

@ Equilibrium :- very little $CH_3CO_2^-$ and $H_3O^+$ produced.

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K ≈ 1

$2\ NO_2(g) \Leftrightarrow N_2O_4(g)$ $K = 1.4$ @ 25°C

@ Equilibrium :- significant amounts of $NO_2(g)$ and $N_2O_4(g)$ present.