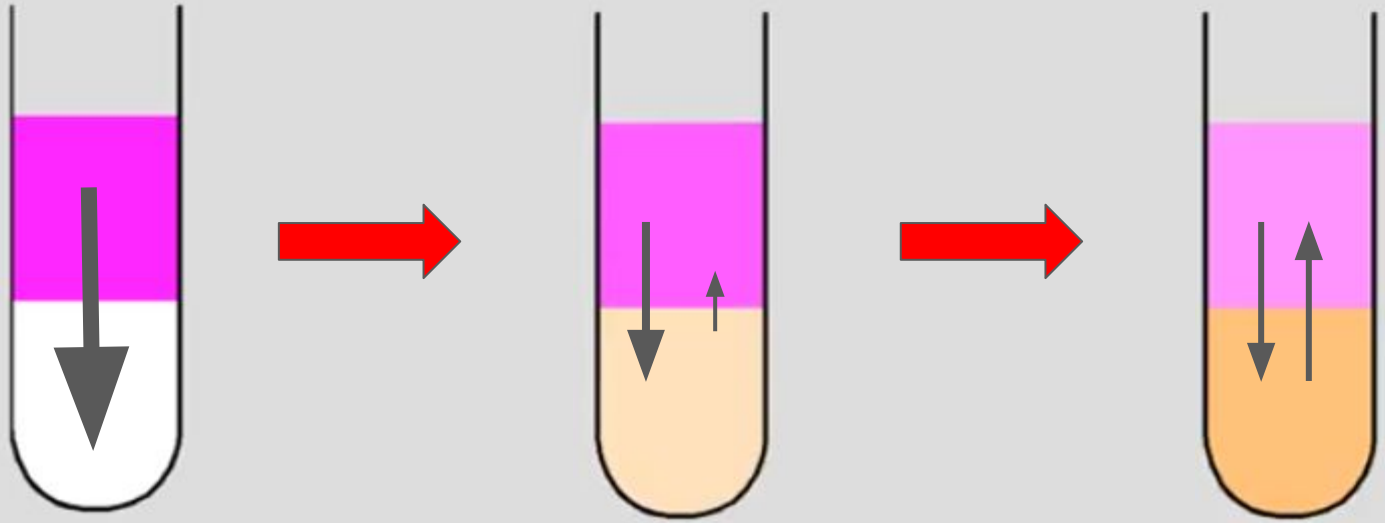
Lesson 1

Dynamic Equilibrium

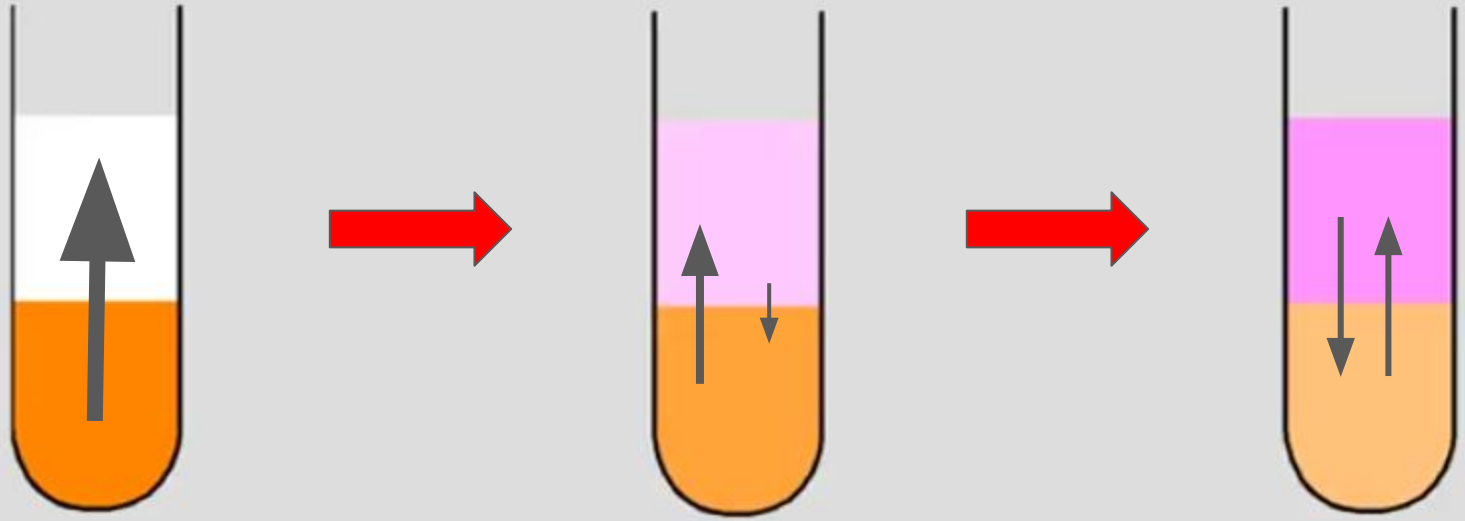
Learning Goals

- ❏ I will be able to explain the concepts of dynamic equilibrium and how the concept applies to various physical and chemical equilibria.
- ❏ I will be able to write the equilibrium law expression for various equilibria, and relate the magnitude of an equilibrium constant to the position of a system at equilibrium.

$$I_{2(hexane)} + I^-_{(aq)} \rightleftharpoons I_3^-{}_{(aq)}$$

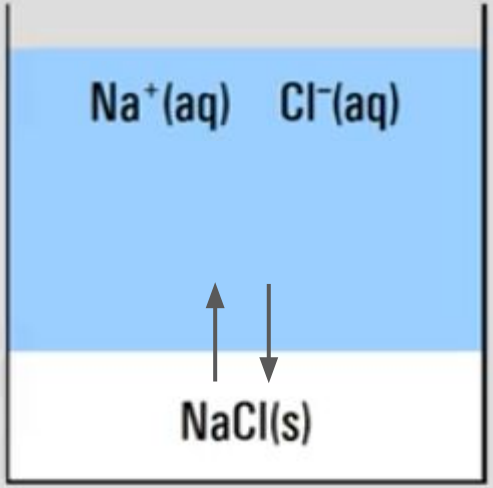


$$I_{2(hexane)} + I^-_{(aq)} \rightleftharpoons I_3^-{}_{(aq)}$$



SOLUBILITY EQUILIBRIA

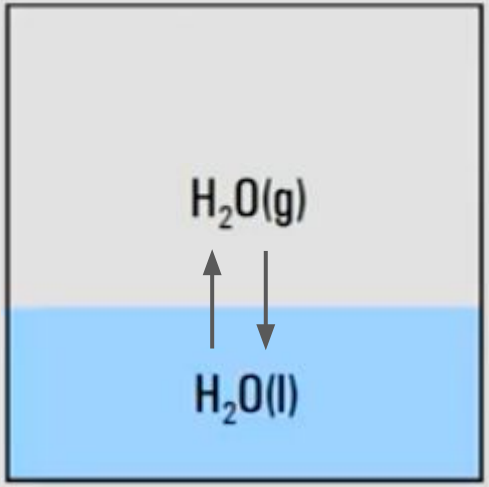
. . . is a dynamic equilibrium between solid solute and dissolved solute in a saturated solution



$$NaCl(s) \rightleftharpoons Na^+(aq) + Cl^-(aq)$$

PHASE EQUILIBRIA

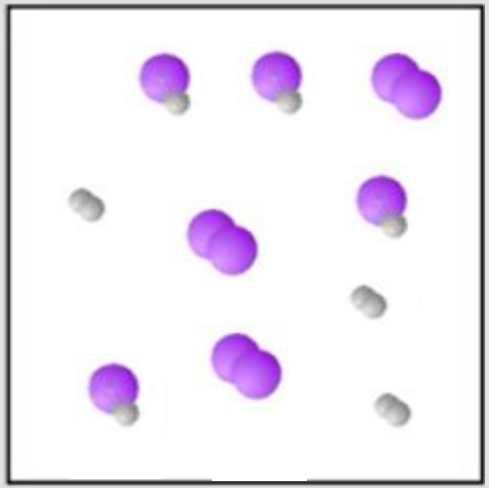
. . . is a dynamic equilibrium between two phases (solid, liquid, gas) of the same substance.



$$H_2O(l) \rightleftharpoons H_2O(g)$$

CHEMICAL EQUILIBRIA

. . . is a dynamic equilibrium between reactants and products in a chemical reaction.

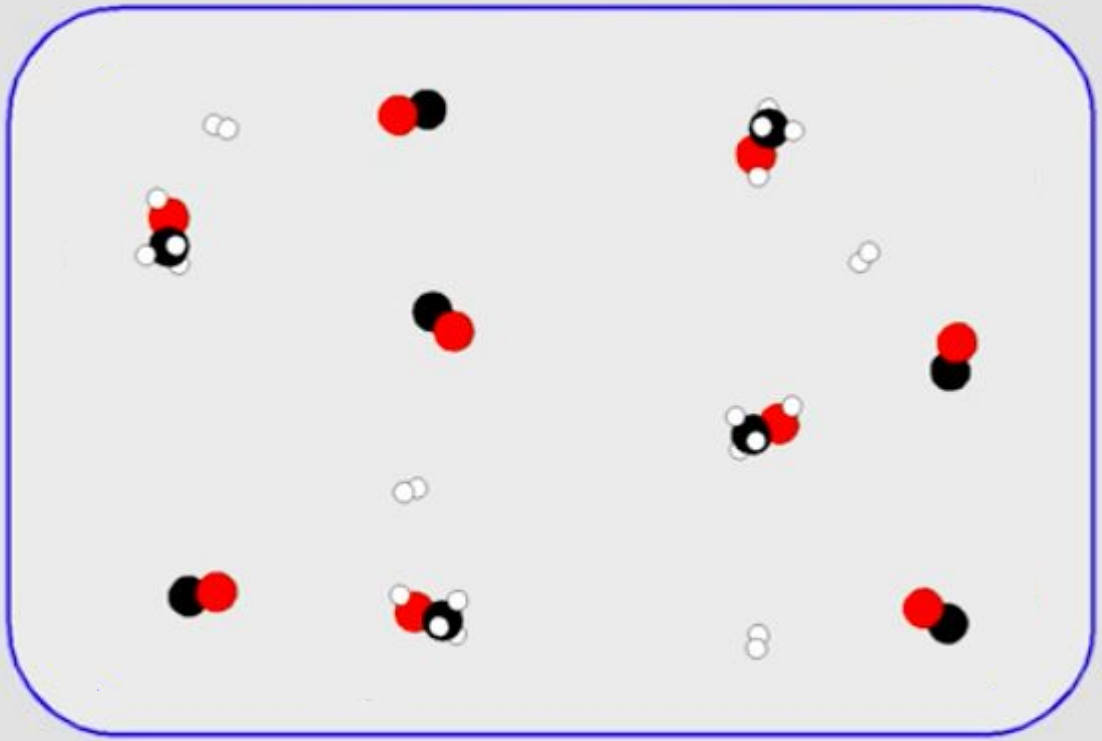


$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$$

- At equilibrium, the forward and reverse reactions continue but their rates are equal — thus, the concentrations of the reactants and products do not change.
- Equilibrium can be achieved only in a closed system.

EQUILIBRIUM CONSTANT

$$CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g)$$



$$CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g)$$

Initial and equilibrium concentrations (mol/L) at 483 K.

	CO	H_2	CH_3OH
TRIAL 1			
Initial concentration	0.100	0.100	0.000
Equilibrium concentration	0.0911	0.0822	0.00892
TRIAL 2			
Initial concentration	0.000	0.000	0.100
Equilibrium concentration	0.0753	0.151	0.0247
TRIAL 3			
Initial concentration	0.100	0.100	0.100
Equilibrium concentration	0.138	0.176	0.0620

$$CO(g) + 2\,H_2(g) \rightleftharpoons CH_3OH(g)$$

	EQUILIBRIUM LAW EXPRESSION				EQUILIBRIUM CONSTANT
TRIAL 1	$\frac{[CH_3OH]}{[CO]\,[H_2]^2}$	=	$\frac{0.00892}{(0.0911)\,(0.0822)^2}$	=	14.5
TRIAL 2	$\frac{[CH_3OH]}{[CO]\,[H_2]^2}$	=	$\frac{0.0247}{(0.0753)\,(0.151)^2}$	=	14.4
TRIAL 3	$\frac{[CH_3OH]}{[CO]\,[H_2]^2}$	=	$\frac{0.0620}{(0.138)\,(0.176)^2}$	=	14.5

$$a\,A + b\,B \rightleftharpoons g\,G + h\,H$$

$$K = \frac{[G]^g\,[H]^h}{[A]^a\,[B]^b}$$

EQUILIBRIUM CONSTANT

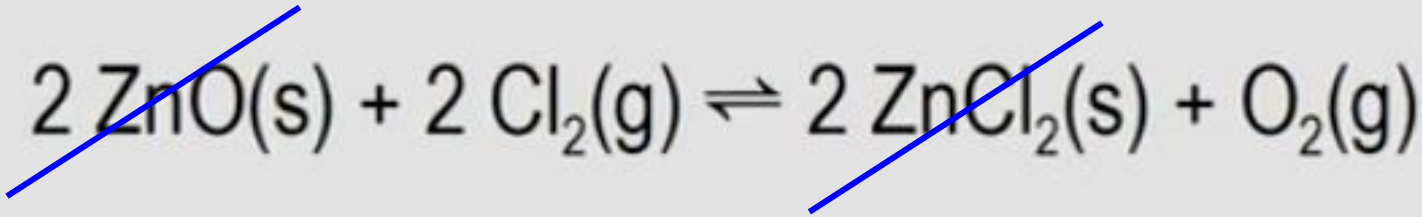
EQUILIBRIUM LAW EXPRESSION

[ ] = molar concentration

Examples

$$N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)$$

$$K = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$$



$$K = \frac{[O_2]}{[Cl_2]^2}$$

- Pure liquids and solids are not included in the equilibrium law expression.

$$MgF_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\,F^-(aq)$$

$$K = \frac{[Mg^{2+}]\,[F^-]^2}{1}$$

- Pure liquids and solids are not included in the equilibrium law expression.

$$N_2H_4(aq) + H_2O(l) \rightleftharpoons N_2H_5^+(aq) + OH^-(aq)$$

$$K = \frac{[N_2H_5^+]\,[OH^-]}{[N_2H_4]}$$

- Pure liquids and solids are not included in the equilibrium law expression.

$$a\,A + b\,B \rightleftharpoons g\,G + h\,H$$

$$K = \frac{[G]^g\,[H]^h}{[A]^a\,[B]^b}$$

- The products are favoured if K>>1.
- The reactants are favoured if K<<1.
- For a given chemical reaction, the equilibrium constant depends only on the temperature of the system.

Success Criteria

- ❑ I can explain the concept of dynamic equilibrium and how the concept applies to various physical and chemical equilibria.

- ❑ I can write the equilibrium law expression for various equilibria, and relate the magnitude of an equilibrium constant to the position of a system at equilibrium.

PRACTICE:

- Page 428 #1, 2
- Page 436 #1, 5ab, 6abc.