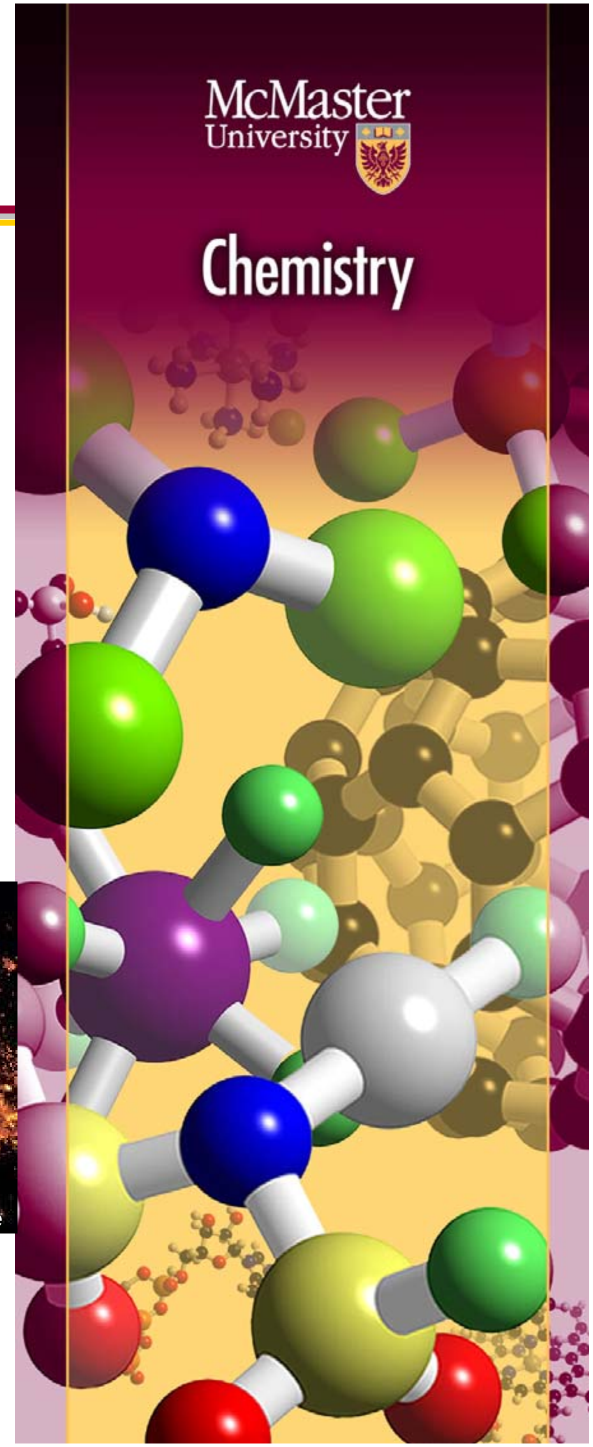
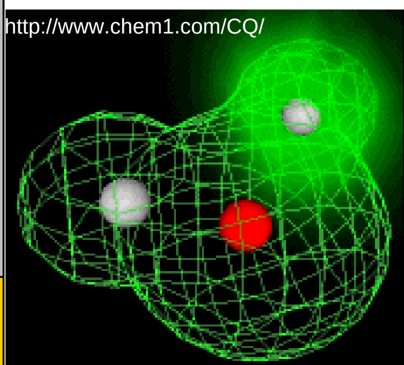
CHEM 1A03: Intro. Chemistry I



Water & Aqueous Chemistry

Ch.5: Reactions in Aqueous Solutions


http://www.chem1.com/CQ/


http://visibleearth.nasa.gov/view_rec.php?id=2429


http://en.wikipedia.org/wiki/Iron_blast_furnace


http://en.wikipedia.org/wiki/Thermite


http://www.scienceinafrica.co.za/2004/july/fluoride.htm

Water: A Vital Natural Resource!

Significance of Water: Energy, Health & Environment

"No single measure would do more to reduce disease and save lives in the developing world than bringing safe water & adequate sanitation to all."

UN Secretary-General Kofi Annan, 2003 International Year of Freshwater

"Water is probably the only natural resource to touch all aspects of human civilization —from agricultural and industrial development to the cultural & religious values embedded in society."

Koichiro Matsuura, Director-General, UNESCO

epartment of Chemistry

Water: An Enigmatic Medium!

http://visibleearth.nasa.gov/view_rec.php?id=2429

Unique Macroscopic Properties Essential to Life

1. Unusually high boiling point (b.p.) of liquid water at STP:
   bp = 100ºC at 1 atm (Sea level) → T,P-dependent

2. Density of ice (0.92 g/mL) **<** liquid water (1 g/mL) at 0ºC:
   Ice expands with freezing: Lower packing density

en.wikipedia.org/wiki/Iceberg

3. High specific heat capacity of water (74 J/mol·K at STP):
   Absorbs thermal heat for storage/distribution/release

4. Water dissolves a variety of solutes as a solvent:
   Strong solvation properties for most polar molecules/ions

en.wikipedia.org/wiki/Snowflak

41 Anomalies of Water: http://www.lsbu.ac.uk/water/anmlies.html

iClicker Question #1

Which intermolecular force accounts for water's unusual high b.p.?

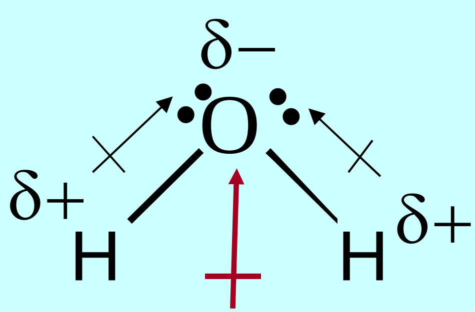
(a) Ion-dipole

(b) Dipole-dipole

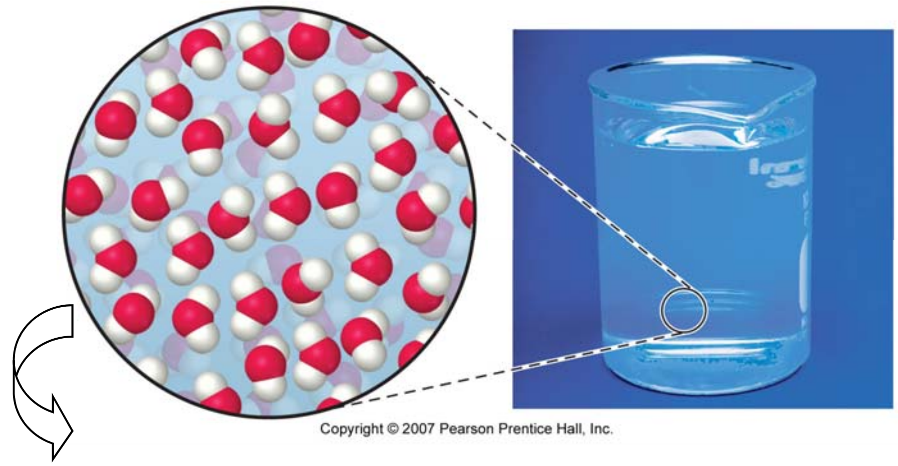
(c) H-bonding

(d) Van der Waals

(e) none of the above



Molecular Dipole



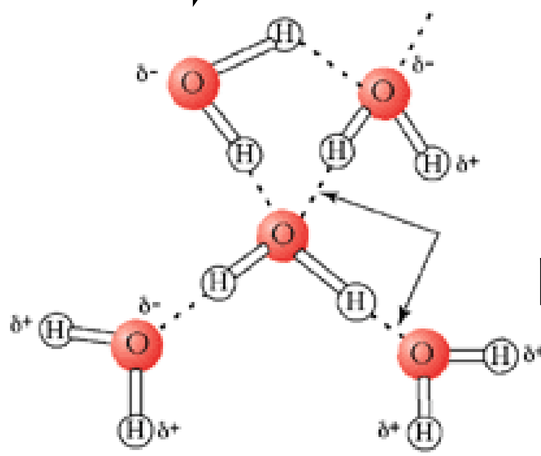


Fig. 5-1a, p. 152 (143, 9th ed.)

Hydrogen bonds: possible because

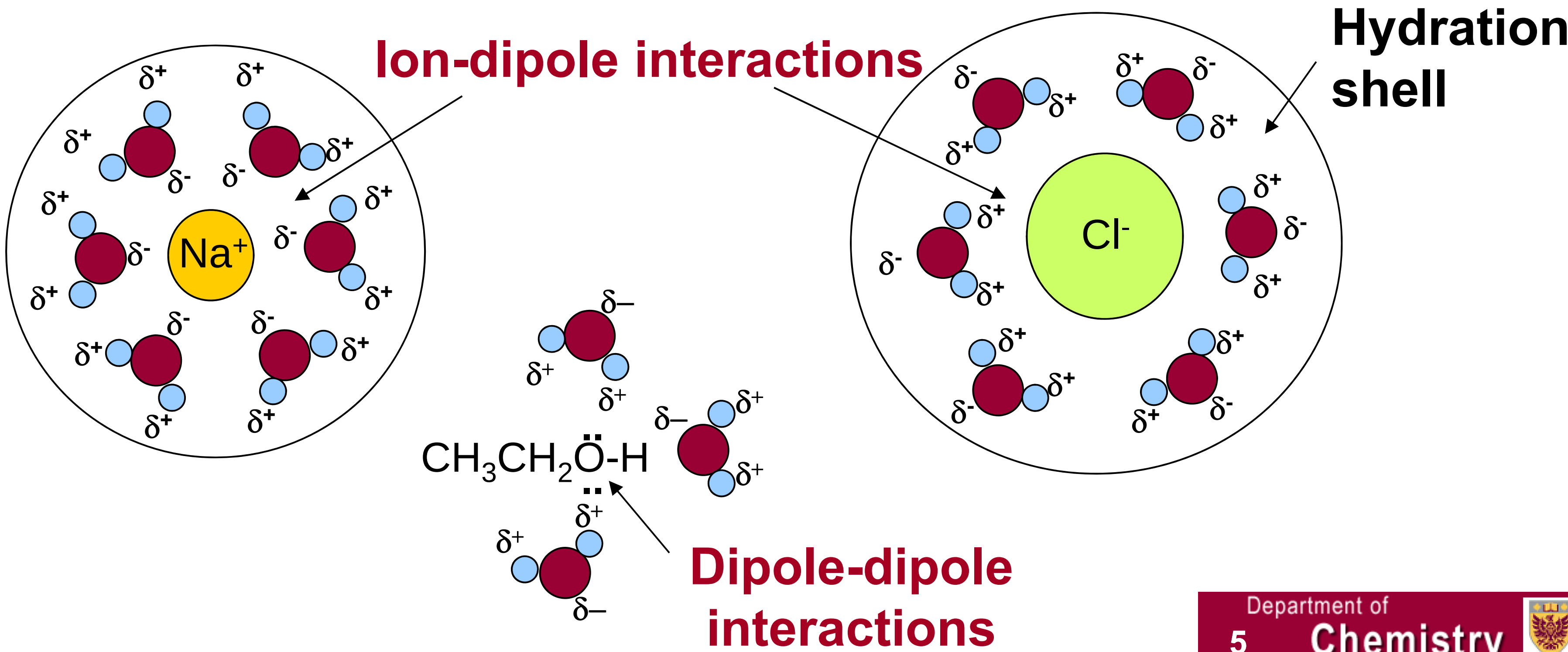
of water's extreme polarity

Solute Solvation by Water

- Solubilization of polar/ionic solutes: Hydration
- Energetically favorable H_2O-solute interactions:

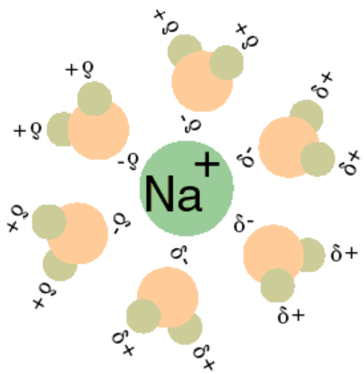
  H-bonding (dipole-dipole) with solutes (O-H, N-H , C=O)

  +/- ion-dipole forces



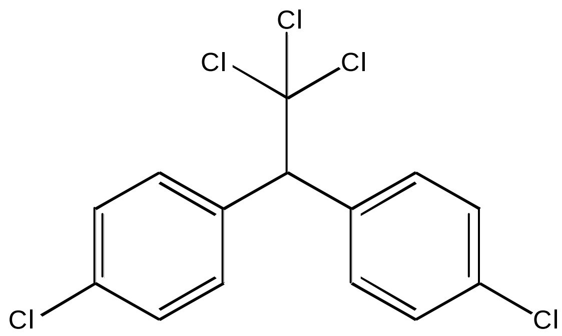
Properties of Water Vital for Molecular Behaviour

Ion Hydration, Sodium Pumps & Ion Transport



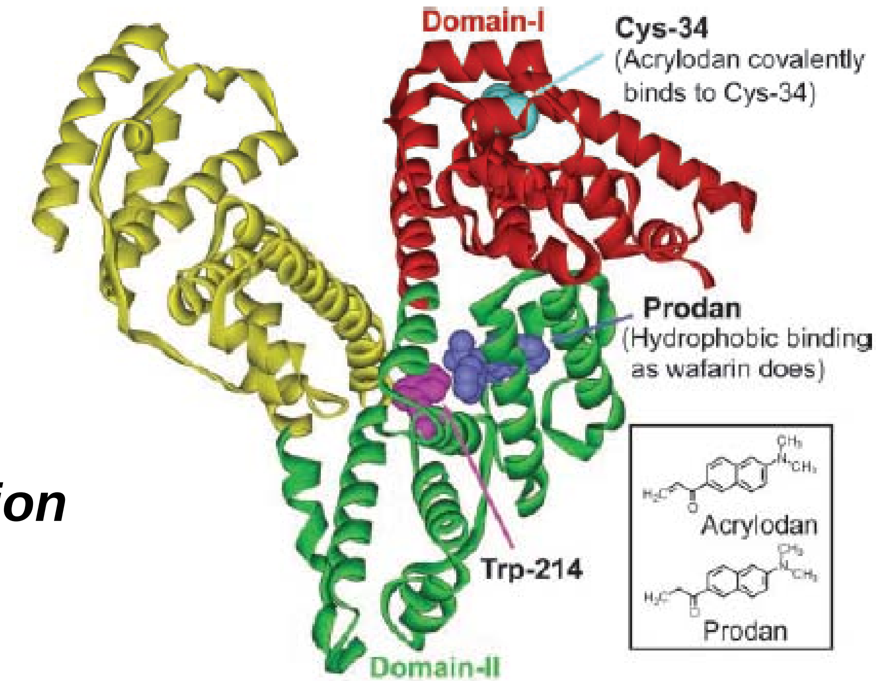
Sodium Ion

Solubility, Toxicity & Bioaccumulation



Dichlorodiphenyl-trichloroethane (DDT)

Protein Folding, Activity & Drug Binding



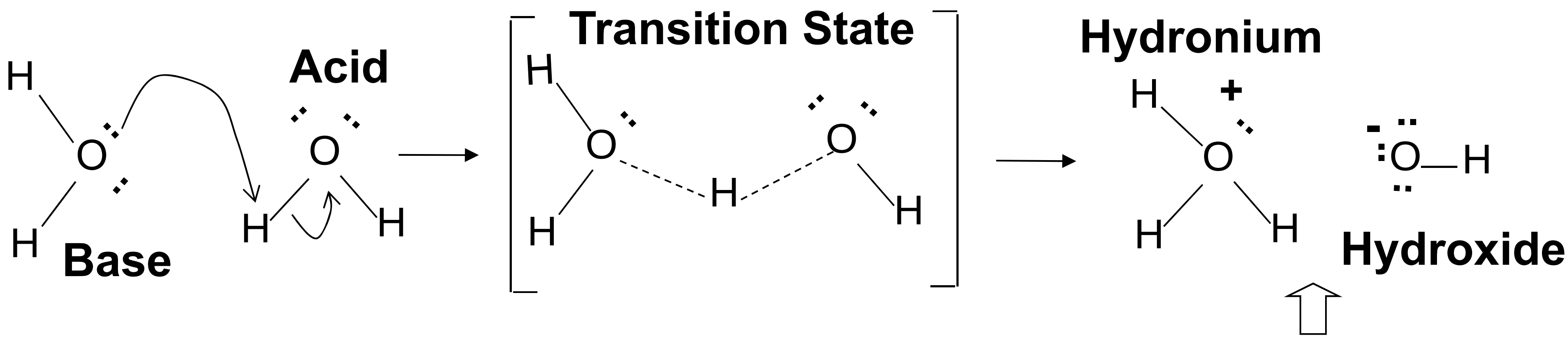
Human Serum Albumin (HSA)

Auto-ionization of Water

- Water auto-ionization: Water is amphoteric & conductive

$$2H_2O\,(l) \underset{}{\overset{K_w}{\rightleftharpoons}} H_3O^+\,(aq) + OH^-\,(aq)$$

Water acts as acid & base with itself!



Electrolytes

$$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}\ (25^{\circ}C)$$

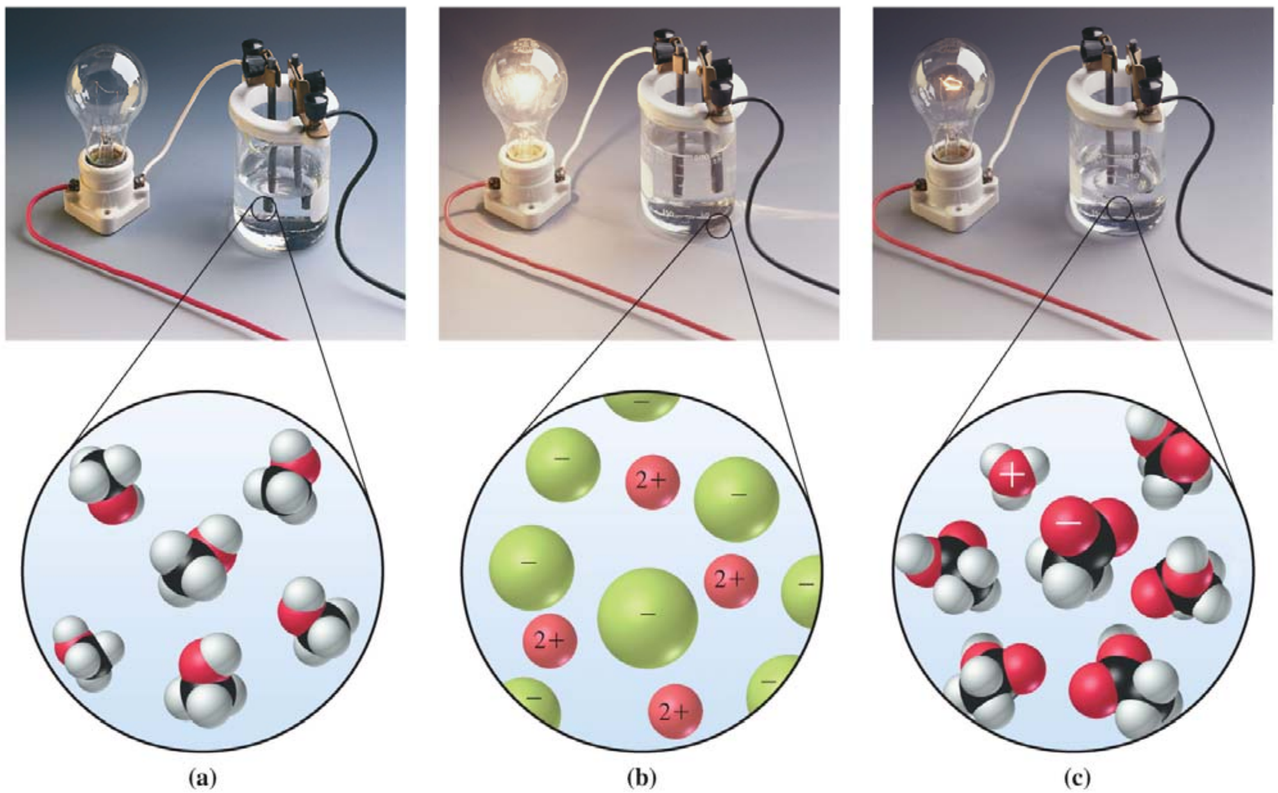
Why isn't $[H_2O]$ included in equilibrium expression?

Purified De-ionized Water:

pH = $-\log[H_3O^+] = 7.0$
Low conductivity since $[H_3O^+]$ & $[OH^-] = 0.1\ \mu M$

Solute Properties & Electrolytes

Non-electrolyte | **Strong electrolyte** | **Weak electrolyte**



Neutral molecule | **Fully charged ions** | **Partially ionized molecule**

Degree of ionization of an electrolyte in aqueous solution!

Fig. 5-3, p. 152-155 (143- 146, 9th ed.)

Solutes as Electrolytes

1. Strong electrolyte (Ionic)

Sodium Chloride:

$NaCl(aq) \longrightarrow Na^{+}(aq) + Cl^{-}(aq)$

Intravenous supply of electrolytes

2. Weak electrolyte (Weakly Ionic)

Preservative/Sour

Acetic Acid: Vinegar (5-8% w)

Conductive ions

$$CH_3COOH\ (aq) + H_2O\ (l) \underset{}{\overset{pK_a = 4.8}{\rightleftharpoons}} CH_3COO^-\ (aq) + H_3O^+\ (aq)$$

3. Non-electrolyte (Neutral)

Ethanol: Vodka (> 40% v)

Spirit, Depressant & Diuretic

CH_3CH_2OH **pK_a = 16 → *No ionization***

iClicker Question #2

Which of the following would be the strongest conductor of electricity?

(a) NaBr (aq, 1M)

(b) CH_3OH (l)

(c) CH_3COOH (aq, 1M)

(d) $(NH_4)_2SO_4$ (aq, 1M)

(e) H_2O (l)

Major Types of Aqueous Chemical Reactions

- **1. Solubility or Precipitation Reactions: (ion transfer)** **Lab 2**

$$Cu(NO_3)_2(aq) \;+\; 2\,NaOH(aq) \rightleftharpoons Cu(OH)_2(s) \;+\; 2\,NaNO_3(aq)$$

- **2. Reduction-Oxidation (Redox) Reactions: (electron transfer)**

$$Zn\,(s) \;+\; Cu^{2+}\,(aq) \rightleftharpoons Zn^{2+}\,(aq) \;+\; Cu\,(s)$$

Lab 2

- **3. Acid-Base Reactions: (proton transfer)**

$$CH_3COOH\,(aq) + H_2O\,(l) \rightleftharpoons CH_3COO^-\,(aq) \;+\; H_3O^+\,(aq)$$

K is a measure of extent of chemical reaction & transformation!

Solubility: Qualitative Guidelines

TABLE 5.1 Solubility Guidelines for Common Ionic Solids

Follow the lower-numbered guideline when two guidelines are in conflict. This leads to the correct prediction in most cases.

1. Salts of group 1 cations (with some exceptions for Li^+) and the NH_4^+ cation are soluble.
2. Nitrates, acetates, and perchlorates are soluble.
3. Salts of silver, lead, and mercury(I) are insoluble.
4. Chlorides, bromides, and iodides are soluble.
5. Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of group 2 cations and hydroxides of Ca^{2+}, Sr^{2+}, and Ba^{2+} are slightly soluble).
6. Sulfates are soluble except for those of calcium, strontium, and barium.

"slightly soluble" = soluble

Soluble: Strong Electrolytes (K_{sp} >> 1)

$$KI\,(aq) \longrightarrow K^+\,(aq) + I^-\,(aq)$$

Insoluble: Weak Electrolytes (K_{sp} << 1)

$$CdCO_3\,(s) \rightleftharpoons Cd^{2+}\,(aq) + CO_3^{2-}\,(aq)$$

Table 5-1; p. 156-159 (146-149, 9th ed.)

Net Ionic Reaction

Precipitation of AgI (s)

$$AgNO_3\,(aq) + KI\,(aq) \longrightarrow AgI\,(s) + KNO_3\,(aq)$$

or

Total Ionic Equation

$$Ag^+\,(aq) + NO_3^-\,(aq) + K^+\,(aq) + I^-\,(aq) \longrightarrow AgI\,(s) + K^+\,(aq) + NO_3^-\,(aq)$$

Spectator Ions Derived from Strong Electrolytes

Net Ionic Equation

$$\boxed{Ag^+\,(aq) + I^-\,(aq) \longrightarrow AgI\,(s)}$$

p. 157 (147, 9th ed.)

Practice Exercise & Solution

Practice Question:

Determine the mass of KI needed to precipitate 0.1 mM of $AgNO_3$ in a 20 mL sample solution.

Balanced equation:
$AgNO_3$ (aq) + KI (aq) → AgI (s) + KNO_3(aq)

Moles of $AgNO_3$ present in solution:
$(1 \times 10^{-4}$ moles/L$) \times (2 \times 10^{-2}$ L$) = 2 \times 10^{-6}$ moles of $AgNO_3$

moles of KI = moles of $AgNO_3$, from the balanced reaction.

Mass of KI = 2×10^{-6} moles x 166.0 g/mol = 0.3 mg

Solubility & Precipitation: Demo#1

Solubility Product (defined by K_{sp})

$$AgI\,(s) \underset{}{\overset{K_{sp}}{\rightleftharpoons}} Ag^{+}\,(aq) + I^{-}\,(aq)$$

K_{sp} **= 8.3 x** 10^{-17}

Precipitation

$$Ag^{+}\,(aq) + I^{-}\,(aq) \overset{1/K_{sp}}{\rightleftharpoons} AgI\,(s)$$

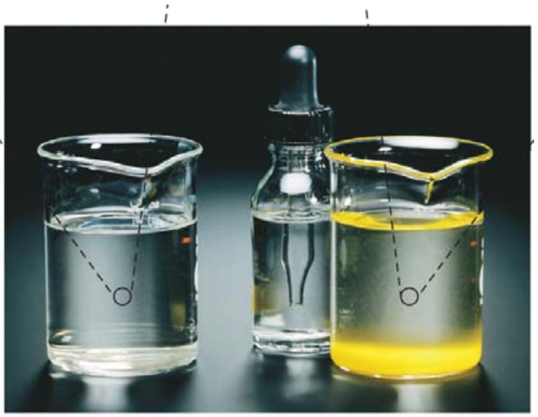
$K = 1/K_{sp} = 1.2 \times 10^{16}$

Fig. 5-7 (5-4 9th ed.)

Solubility & Precipitation: Demo#2

$$PbI_2\,(s) \overset{K_{sp}}{\rightleftharpoons} Pb^{2+}\,(aq) + 2I^-\,(aq) \qquad K_{sp} = 7.1 \times 10^{-9}$$

iClicker Question #3



What would be the impact of dissolving PbI_2 in a 1.0 M solution of $Pb(NO_3)_2$?

a. Increase the solubility

b. Decrease the solubility

c. No effect on equilibrium

Fig. 18-1, pg 752

Solubility Product for Salts: K_{sp}

- Measure of the intrinsic solubility of a salt in aqueous solution → Also temp., pH, ionic strength dependent; K_{sp} in pure water

- A low $K_{sp} << 1$ implies a sparingly soluble or highly insoluble salt

Which form of apatite is least soluble & most resistant to demineralization (tooth decay)?


en.wikipedia.org/wiki/Human_tooth

Hydroxylapatite

$$Ca_5(PO_4)_3OH\,(s) \overset{K_{sp}}{\rightleftharpoons} 5Ca^{2+}\,(aq) + 3PO_4^{3-}\,(aq) + OH^-\,(aq)$$

$$K_{sp} = [Ca^{2+}]^5\,[PO_4^{3-}]^3\,[OH^-] = 1.0 \times 10^{-36}$$

Fluorapatite

$$Ca_5(PO_4)_3F\,(s) \overset{K_{sp}}{\rightleftharpoons} 5Ca^{2+}\,(aq) + 3PO_4^{3-}\,(aq) + F^-\,(aq)$$

$$K_{sp} = [Ca^{2+}]^5\,[PO_4^{3-}]^3\,[F^-] = 1.0 \times 10^{-60}$$

Differential Solubility of Salts

Determine the Relative Decrease in Solubility of Fluorapatite vs. Hydroxylapatite

Hydroxylapatite:

$$Ca_5(PO_4)_3OH\ (s) \xrightleftharpoons{K_{sp}} 5Ca^{2+}\ (aq) + 3PO_4^{3-}\ (aq) + OH^-\ (aq)$$

$$K_{sp} = [Ca^{2+}]^5\ [PO_4^{3-}]^3\ [OH^-] = 1.0 \times 10^{-36}$$

Let x = $[OH^-]$ formed upon dissolution

$$K_{sp} = (5x)^5\ (3x)^3\ (x) = 84375\,x^9$$

$$x = [K_{sp}/84375]^{1/9} = 2.84 \times 10^{-5}\ M \longleftarrow$$

Molar solubility of hydroxylapatite

Differential Solubility of Salts...contd

Similarly, for Fluorapatite:

$$Ca_5(PO_4)_3F\ (s) \xrightleftharpoons{K_{sp}} 5Ca^{2+}\ (aq) + 3PO_4^{3-}\ (aq) + F^-\ (aq)$$

$$K_{sp} = [Ca^{2+}]^5\ [PO_4^{3-}]^3\ [F^-] = 1.0 \times 10^{-60}$$

Let x = $[F^-]$ formed upon dissolution

$$K_{sp} = (5x)^5\ (3x)^3\ (x) = 84375\,x^9$$

$$x = [K_{sp}/84375]^{1/9} = 6.11 \times 10^{-8}\ M$$

$$\frac{2.84 \times 10^{-5}\ M}{6.11 \times 10^{-8}\ M} = 460 \longleftarrow$$

Hydroxylapatite 460-fold <u>more</u> soluble than fluorapatite

Take Home Problem

What is the molar solubility of cobalt (II) hydroxide (K_{sp} = 1.6 x 10^{-15})?

a. 6.1 x 10^{-6}

b. 9.3 x 10^{-6}

c. 8.7 x 10^{-6}

d. 7.4 x 10^{-6}

e. 1.1 x 10^{-6}

Application: Low Cost Defluoridation Method

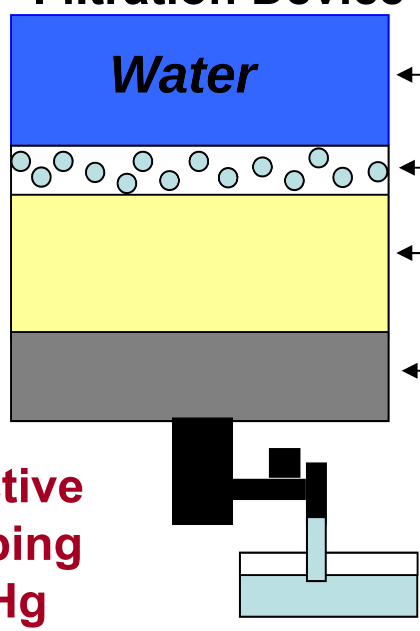
- Inexpensive, renewable and low cost method needed for defluoridation of drinking water in villages of developing countries

- Ion-exchange process uses charred animal bone that is pulverized, filtered & washed for defluoridation via F^- adsorption

$$Ca_5(PO_4)_3OH\ (s) + F^-\ (aq) \underset{}{\overset{K_{ex}}{\rightleftharpoons}} Ca_5(PO_4)_3F\ (s) + OH^-\ (aq)$$

Ion-exchange Mechanism

Filtration Device



Fluoridated Water

Rock/Pebble Layer

Charred Bone Layer

Charcoal/C

Treated Water

Regenerated with NaOH & H_2O wash

Also effective for adsorbing Pb, As, Hg

http://www.scienceinafrica.co.za/2004/july/fluoride.htm

Q vs K_{sp}: Practice Question

Precipitation of PbS (s): Lead Contamination

$$PbS\,(s) \overset{K_{sp}}{\rightleftharpoons} Pb^{2+}\,(aq) + S^{2-}\,(aq)$$

$$K_{sp} = [Pb^{2+}][S^{2-}] = 3.0 \times 10^{-29}$$

Will a precipitate form if 0.50 mL of 10 μM of K_2S is mixed with 250 mL of 0.10 μM $Pb(NO_3)_2$?

$$K_2S\,(aq) + Pb(NO_3)_2\,(aq) \rightleftharpoons 2KNO_3\,(aq) + PbS\,(s)$$

Initial Concentration of K_2S After Mixing Solutions:

= (1x10^{-5} mol/L*5x10^{-4} L) / 2.505x10^{-1} L

= 1.996 x 10^{-8} M

Initial Concentration of $Pb(NO_3)_2$ After Mixing Solutions:

= (1x10^{-7} mol/L*2.50x10^{-1} L) / 2.505x10^{-1} L

= 9.980 x 10^{-8} M

$Q = [Pb^{2+}][S^{2-}] = (9.98 \times 10^{-8})(1.996 \times 10^{-8}) = 2.0 \times 10^{-15} >> K_{sp}$

Therefore, precipitate of PbS (s) will form!

iClicker Questions #4 & #5

What is the value for Q_{sp} if 0.500 mL of 1.50M $BaCl_2$ is mixed with 0.600 mL of 0.20M NaOH?

a. 8.1×10^{-3}

b. 7.7×10^{-3}

c. 2.3×10^{-3}

d. 9.1×10^{-2}

e. 7.4×10^{-2}

If the K_{sp} for $Ba(OH)_2$ is 5×10^{-3}, will a precipitate form?

a. Yes

b. No

Take Home Problem

Which of the following reactions will result in formation of a precipitate?

(i) $\mathbf{2}\,NaOH\,(aq) + MgCl_2\,(aq) \longrightarrow Mg(OH)_2\,(s) + 2NaCl\,(aq)$

(ii) $BaS\,(aq) + CuSO_4\,(aq) \longrightarrow CuS\,(s) + BaSO_4\,(s)$

(iii) $(NH_4)_2SO_4\,(aq) + ZnCl_2\,(aq) \longrightarrow ZnSO_4\,(aq) + 2NH_4Cl\,(aq)$

(A) **i**

(B) **ii**

(C) **iii**

(D) **i and ii**

(E) **ii and iii**

Note that precipitation reactions involve an ion-exchange process without changes in oxidation state of any species

Ch 5-2, p. 159 (p. 149, 0th ed.)

Reduction-Oxidation Reactions (Redox)

- A redox reaction can be identified by changes in oxidation numbers (O.N.) in the reactants and products
- The reducing agent loses electrons and is oxidized
- The oxidizing agent gains electrons and is reduced

Example (Lab 2):

LEO says GER or OIL RIG

$$Zn(s) + 2\,HCl(aq) \longrightarrow H_2(g) + ZnCl_2(aq)$$

O.N. 0 +1 -1 0 +2 -1

Zn(s) is oxidized (loses 2 e^-)

Zn is the reducing agent

H^+(aq) is reduced (each H^+ gains 1 e^-)

H^+ is the oxidizing agent

Concept Check: Oxidation States of Nitrogen

N Biogeochemical Cycle

Compound or ion	Oxidation state
NO_3^-	
N_2O_4	
NO_2^-	
NO	
N_2O	
N_2	
NH_2OH	
N_2H_4	
NH_3	

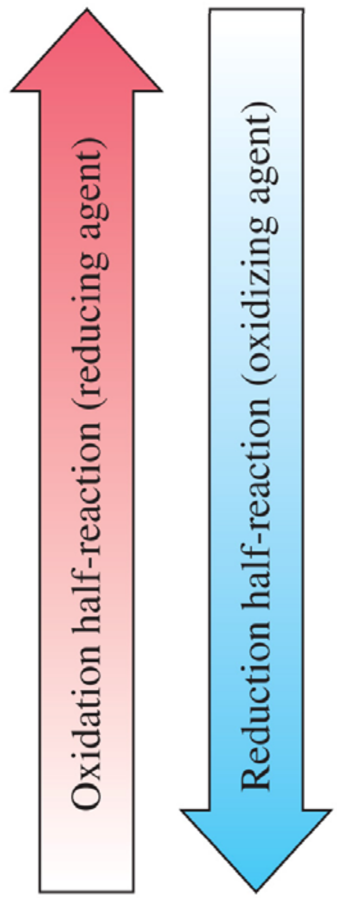


Fig. 5-15, p. 176 (5-9, p 162, 9th ed.)

iClicker Question #6

What is the oxidation number for phosphorous in Na_2HPO_4?

a. 0

b. +3

c. -2

d. +5

Redox Reactions

Thermite Reaction (or Goldschmidt reaction, 1893)

- A classic redox reaction involving hematite (rust) and aluminum for welding applications/pyrotechnics

Reducing agent

$$\underset{+3}{Fe_2O_3}\,(s) + \underset{0}{2Al}\,(s) \longrightarrow \underset{0}{2Fe}\,(l) + \underset{+3}{Al_2O_3}\,(s)$$

Oxidizing agent

$\Delta^\circ H < 0$; $T > 2{,}000$ K

Highly Exothermic!

Consider Half-Reactions

1. $Fe^{3+}\,(s) + 3e^- \longrightarrow Fe\,(l)$ Reduction (Gains e^-)
2. $Al\,(s) \longrightarrow Al^{3+}\,(s) + 3e^-$ Oxidation (Loses e^-)

A redox reaction is an electron transfer process!

http://www.youtube.com/watch?v=Yex063_Fblk

http://en.wikipedia.org/wiki/Thermite

iClicker Question #7

Identify the <u>oxidizing agent</u> in the following redox reaction:

$K_2Cr_2O_7$ (aq) + HI (aq) --> KI (aq) + CrI_3 (aq) + I_2 (s) + H_2O (l)

a. I^-

b. $Cr_2O_7^{2-}$

c. K^+

d. Cr^{3+}

e. H_2O

From the Iron Age to Post-Modern Age

Reduction of Iron Oxide

- Steel and related iron-based alloys are widely used in construction

- Smelting of iron ore in a blast furnace → Chemical reduction
method for iron (Fe) extraction; Feedstocks: C, Fe_2O_3, $CaCO_3$

$$\underset{0}{C}\,(s) + \tfrac{1}{2}\,O_2\,(g) \xrightarrow{\Delta H^\circ < 0}$$

$$\underset{+3}{Fe_2O_3}\,(s) + 3\,\underset{+2}{CO}\,(g) \longrightarrow \underset{0}{Fe}\,(l) + 3\,\underset{+4}{CO_2}\,(g)$$

$$Fe\,(l) \xrightarrow[\text{Slag}]{\text{Purify /Alloy}} \text{Steel \& Steel Alloys}$$

Fe_2O_3 (s)

http://en.wikipedia.org/wiki/Iron_ore

Fe (l)

http://en.wikipedia.org/wiki/Iron_blast_furnace

Stainless steel Fe (Cr, Ni)

http://en.wikipedia.org/wiki/Stainless_steel

Hamilton: Steel City

U. S. Steel Canada (Stelco) & ArcelorMittal Dofasco Inc.

Blast Furnace: Continuous Generation of Fe (l)

C, Fe_2O_3, $CaCO_3$

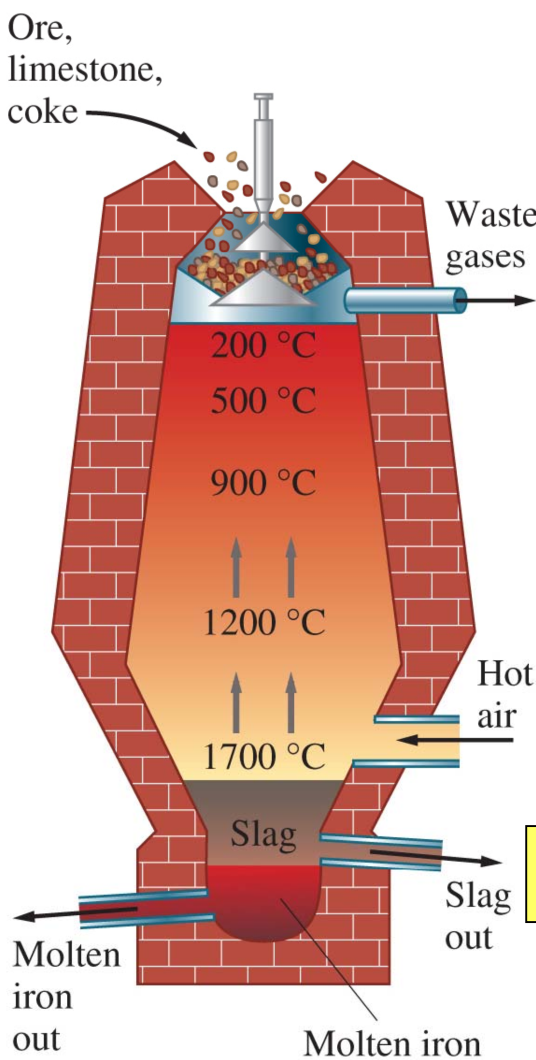


Fig 23-9 p. 1044 (Fig 23.8, pg 976, 9th ed.)

Waste Gases: CO_2, CO, SO_2, NO_x, H_2O

Scrubbing of waste gases needed to reduce emissions & lower energy costs!

Steel: Fe < 1% C

Hot Air Injection

Slag (Silicates)

Pig Iron, Fe (l)
3 - 4 % C

Balancing Redox Reactions: Half-reactions

1. Deduce the oxidation numbers for all species → This will identify the oxidizing and reducing agents

2. Write reduction and oxidation skeleton half-reactions

3. Balance the redox atoms (usually not O, H unless they are participating in the redox chemistry)

4. Add the correct number of electrons to each half-reaction

5a. If acidic conditions: Balance O by adding H_2O then H by H^+

5b. If basic conditions: Balance as if in acidic conditions, then add OH^- to balance the H^+ (making water), then cancel the H_2O (or balance the negative charges by adding OH^-, then balance O & H by adding H_2O)

6. Check atoms and charges. Multiply half-reactions by a factor, if needed, to make the number of electrons transferred match.

7. Write the net redox reaction!

p 170-174 (p. 157-161, 9th ed.)

Balancing Redox Reactions: Acidic Conditions

Balance the following reaction under acidic conditions:

$$Fe^{2+}(aq) + MnO_4^-(aq) \rightarrow Fe^{3+}(aq) + Mn^{2+}(aq)$$

Half-cell Reactions:

Oxidation $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + \boxed{1e^-}$ **X 5**

Reduction $\overset{+7}{Mn}O_4^-(aq) + \boxed{5e^-} + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

Net Balanced Redox Reaction

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

p. 171-172 (157-158, 9th ed.)

Balancing Redox Reactions: Basic Conditions

Balance the following reaction under basic conditions:

$$SO_3^{2-}\,(aq) + MnO_4^-\,(aq) \rightarrow SO_4^{2-}\,(aq) + MnO_2\,(s)$$

Half-cell Reactions:

Oxidation $\overset{+4}{SO_3^{2-}}\,(aq) + H_2O\,(l) \rightarrow \overset{+6}{SO_4^{2-}}\,(aq) + 2e^- + 2H^+\,(aq)$ **X 3**

Reduction $\overset{+7}{MnO_4^-}\,(aq) + 3e^- + 4H^+\,(aq) \rightarrow \overset{+4}{MnO_2}\,(s) + 2H_2O\,(l)$ **X 2**

$$3SO_3^{2-}\,(aq) + 2MnO_4^-\,(aq) + 2H^+\,(aq) \rightarrow 3SO_4^{2-}\,(aq) + 2MnO_2\,(s) + H_2O\,(l)$$

Net Balanced Redox Reaction

$$3SO_3^{2-}\,(aq) + 2MnO_4^-\,(aq) + H_2O\,(l) \rightarrow 3SO_4^{2-}\,(aq) + 2MnO_2\,(s) + 2OH^-\,(aq)$$

p. 172-174 (158-160, 9th ed.)

iClicker Question #8

When the following is balanced in a basic solution:

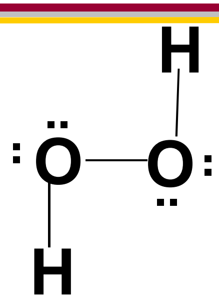
MnO_4^- (aq) + $C_2O_4^{2-}$ (aq) --> MnO_2(s) + CO_3^{2-}

The coefficient in front of CO_3^{2-} is:

a. 1
b. 2
c. 3
d. 4
e. 6

Disproportionation Reactions

Hydrogen Peroxide (H_2O_2)



- Reactive molecule because of weak O-O single bond
- One reactant (H_2O_2) acts as both reducing and oxidizing agent

$$2H_2O_2\,(aq) \longrightarrow 2H_2O\,(l) + O_2\,(g) \qquad \Delta H^\circ < 0$$

Half-Reactions

Oxidation $\quad \overset{-1}{H_2O_2}\,(aq) \rightarrow \overset{0}{O_2}\,(g) + 2e^- + 2H^+$

Reduction $\quad \overset{-1}{H_2O_2}\,(aq) + 2e^- + 2H^+ \rightarrow \overset{-2}{2H_2O}\,(l)$

$$2H_2O_2\,(aq) \longrightarrow 2H_2O\,(l) + O_2\,(g)$$

3% H_2O_2 as disinfectant

Topical antiseptic as H_2O_2 can oxidize microbes

p. 174 (p. 160, 9th ed.)

REDOX Chemical Reactions: Demo

- Observe and predict the outcome of these two reactions

Redox Chemical Reactions

1. $CuSO_4$ (aq) + Zn (s) $\longrightarrow$ Cu (s) + Zn^{2+} (aq)

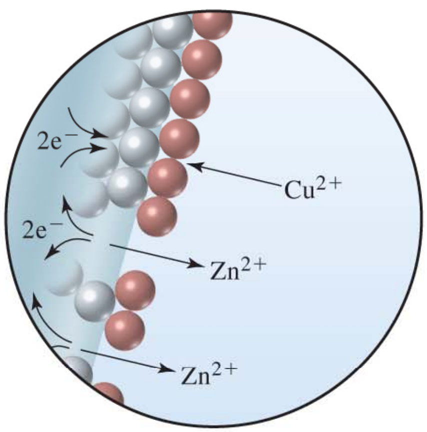
   As in Lab 2

2. $AgNO_3$ (aq) + Cu (s) $\longrightarrow$ Ag (s) + Cu^{2+} (aq)

Observations…

A Closer Look...

(a) (b) (c)



$$CuSO_4\ (aq)\ +\ Zn\ (s) \longrightarrow Cu\ (s)\ +\ Zn^{2+}\ (aq)$$

Fig 5-12, p. 167 (Fig 5-7, p. 155)

Acid-Base Reactions

- Involve proton (H^+) transfer (Bronsted-Lowry definition)

Example:

$$HCl(aq) + NaOH(aq) \longrightarrow H_2O(l) + NaCl(aq) \qquad \text{(Lab 1)}$$

Acid **Base (OH^-)**

H^+ donor **H^+ acceptor**

- The focus of an upcoming section (Ch 16)

p. 160-165; 177-181 (p. 149-153, 163-165, 9th ed.)