- Mar 27 Ch 4
- Mar 29 Ch 5 Q 7

- Apr 3 Ch 5 (Review)
- Apr 5 **Exam 2** (Ch 3, 4, and 5) (HW 7 originally due)

- Apr 10 Ch 5 HW 7 actually due here!!
- Apr 12 Ch 7 Q 8

- Apr 17 Ch 7
- Apr 19 Ch 7 Q 9, HW 8

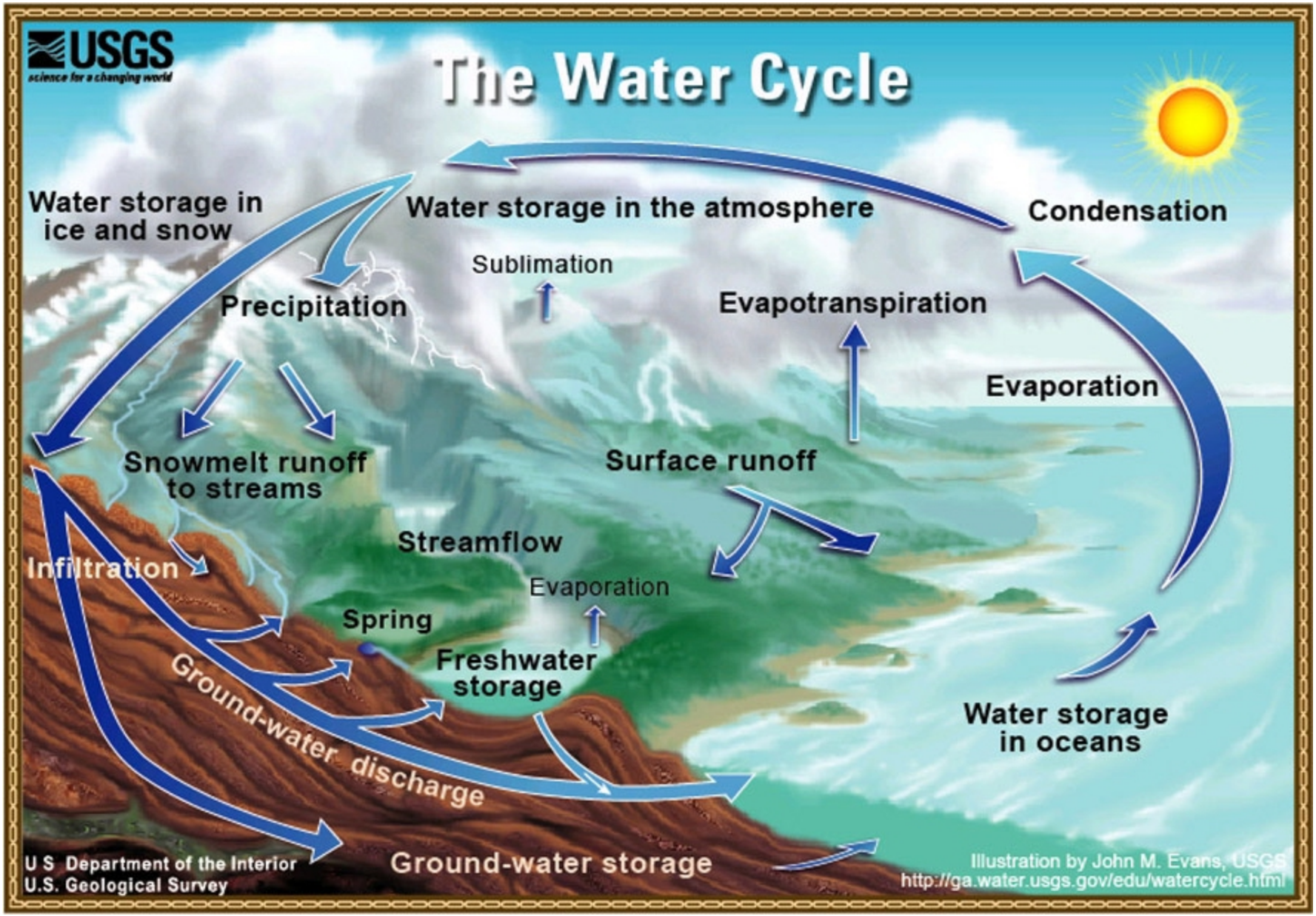
- Apr 24 Ch 8
- Apr 26 Ch 8 Letter due

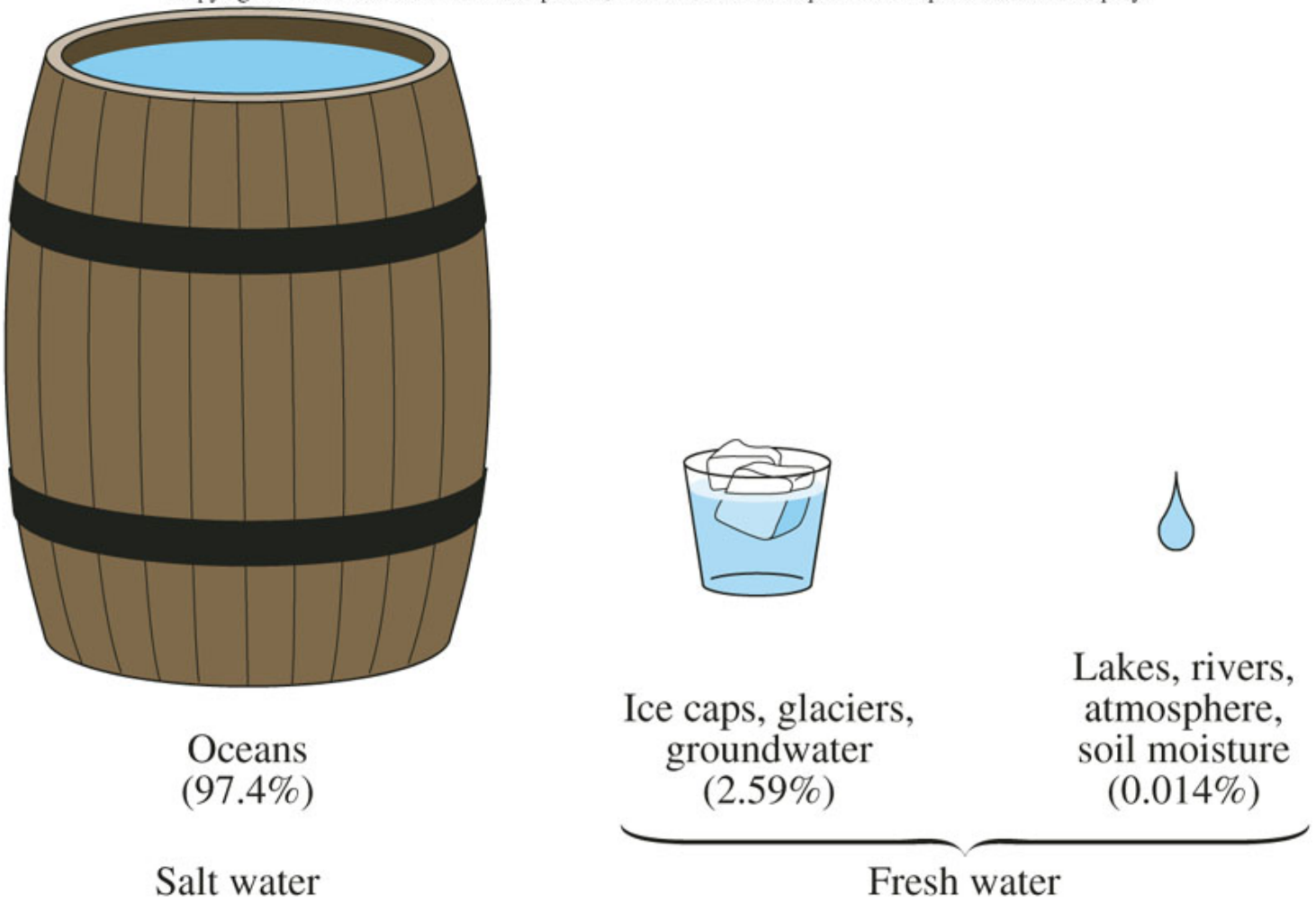
- May 1 Ch 8
- May 3 ? Q 10, HW 9

- May 8 ?
- May 10 **Exam 3** (Ch 5, 7, 8...?) HW 10

- May 15 Review and Wrap-up

Where does water come from?





Water is the “Universal Solvent”

- **Solvent** – a substance capable of dissolving other substances
- **Solute** – the substance(s) that dissolves in a solvent
- **Solution** – the resulting homogeneous mixture of uniform composition
- ***Aqueous* Solution** – solutions in which water is the solvent

Table 5.1 Importance of Water as a Solvent

In our bodies:

- Blood plasma is an aqueous solution containing a variety of life-supporting substances.
- Inhaled oxygen dissolves in blood plasma in the lungs allowing O_2 to combine with hemoglobin.
- Blood plasma carries dissolved CO_2 to the lungs to be exhaled.
- Blood plasma transports nutrients into all the cells and organs.
- Water helps to maintain a chemical balance by carrying wastes away.

In the environment:

- Water can transport toxic substances into, within, and out of living organisms.
- Water-soluble toxic substances, such as some pesticides, lead ions, and mercury ions, can be widely distributed.
- Water may reduce the concentrations of pollutants to safe levels by dilution or by carrying them away (or both).
- Rainwater carries substances, including those responsible for acid rain, from the atmosphere down to Earth.

Ways to Describe Concentration

- Weight Percent = $\frac{grams\ of\ \ solute}{grams\ of\ \ water} \times 100\%$
- 1 ppm = 1mg solute / L of water
- 1 ppb = 1μg/L
- Molarity: $M = \frac{moles\ of\ \ solute}{liters\ of\ \ solution}$

- The concentration of the solution we made by dissolving 17 g of NaNO3 in enough water to make 1 L of solution is:

0.20 M $NaNO_3$

0.20 M Na^+

0.20 M NO_3^-

1.7 wt % $NaNO_3$

4,600 ppm Na^+

12,400 ppm NO_3^-

This separation of ions in water is what we mean when we say “dissolve”

Electronegativity – a measure of an atom's attraction for the electrons it shares in a covalent bond.

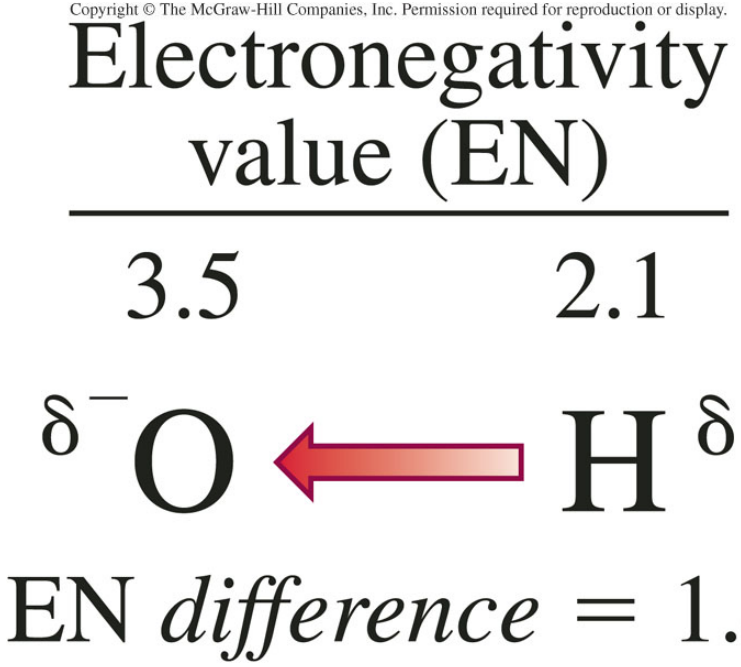
Table 5.4 Electronegativity Values, Arranged by Group Number

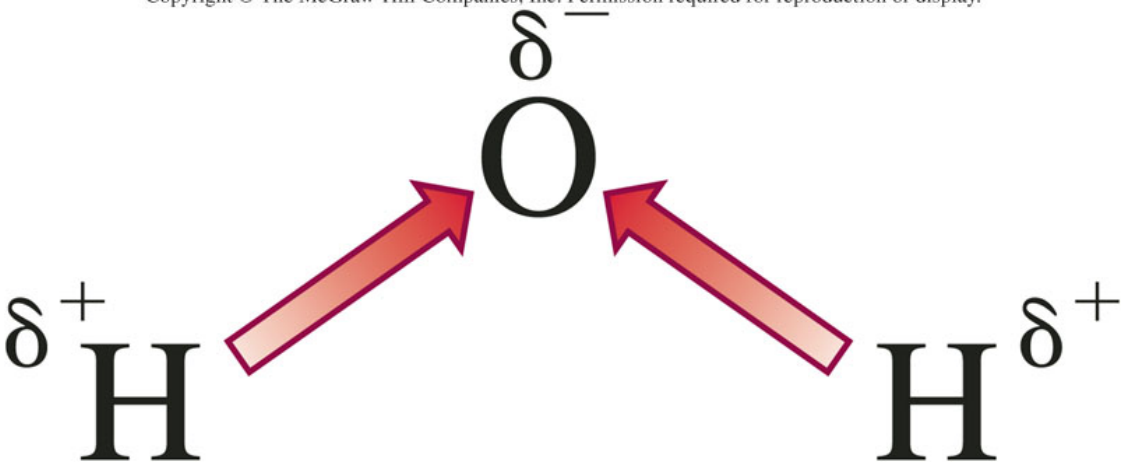
1A	2A	3A	4A	5A	6A	7A	8A
H							He
2.1							—
Li	Be	B	C	N	O	F	Ne
1.0	1.5	2.0	2.5	3.0	3.5	4.0	—
Na	Mg	Al	Si	P	S	Cl	Ar
0.9	1.2	1.5	1.8	2.1	2.5	3.0	—

Water is “Polar”

The bonds in water SHARE the electrons, but the electrons are not shared equally.

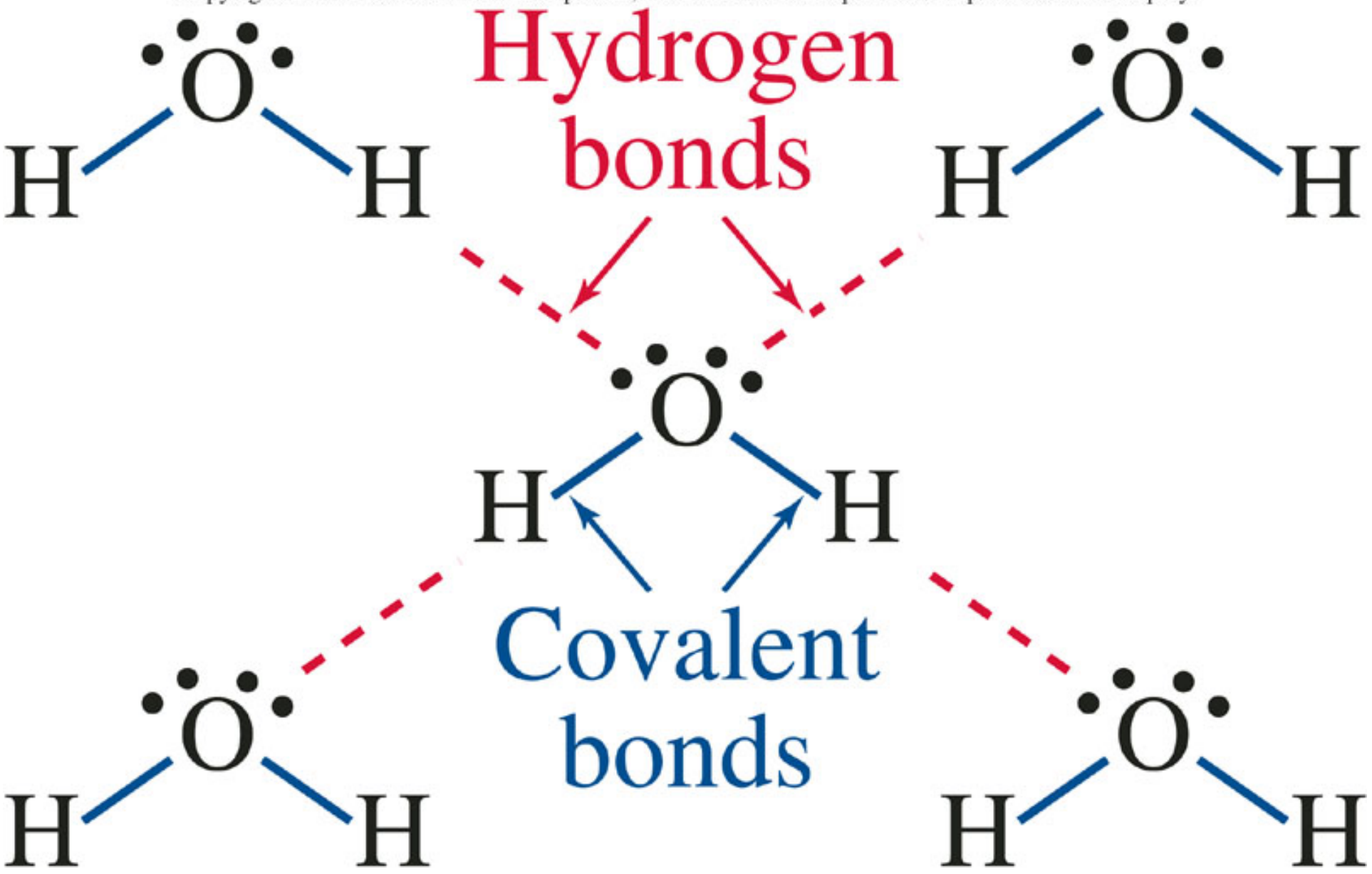
The O-H bond is a **polar covalent bond**

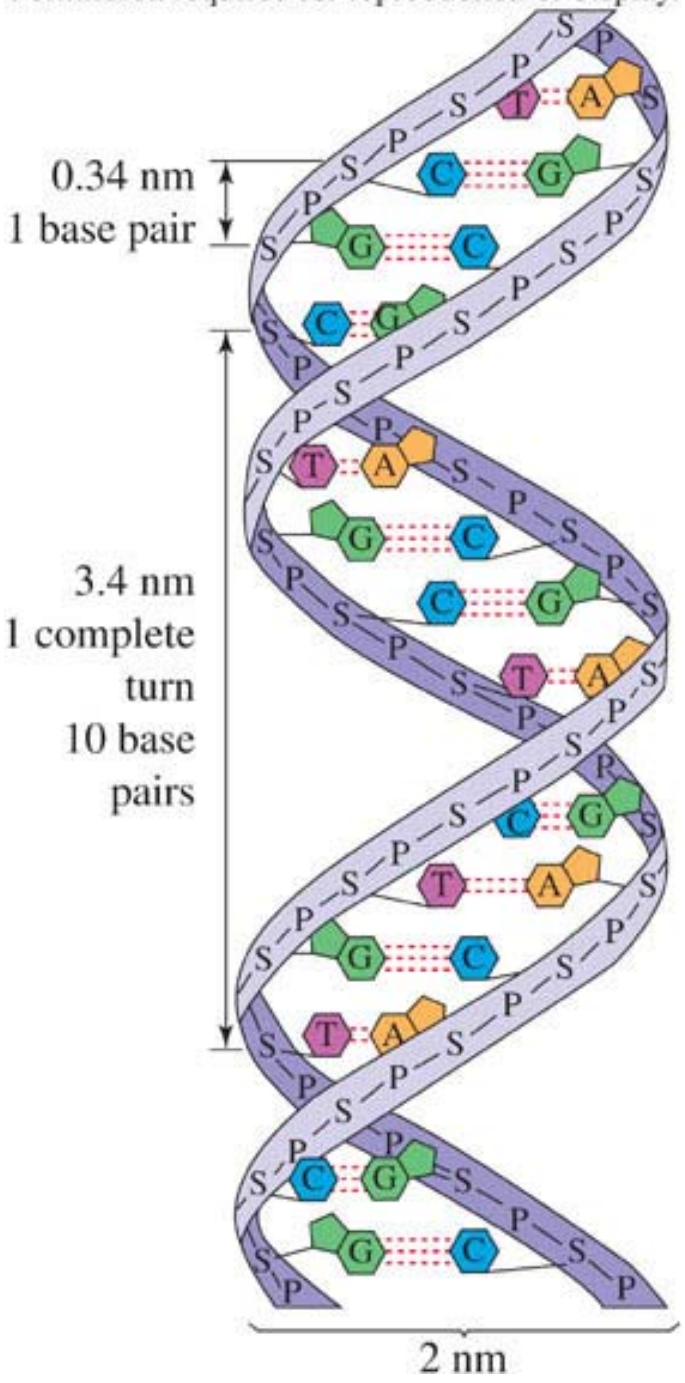




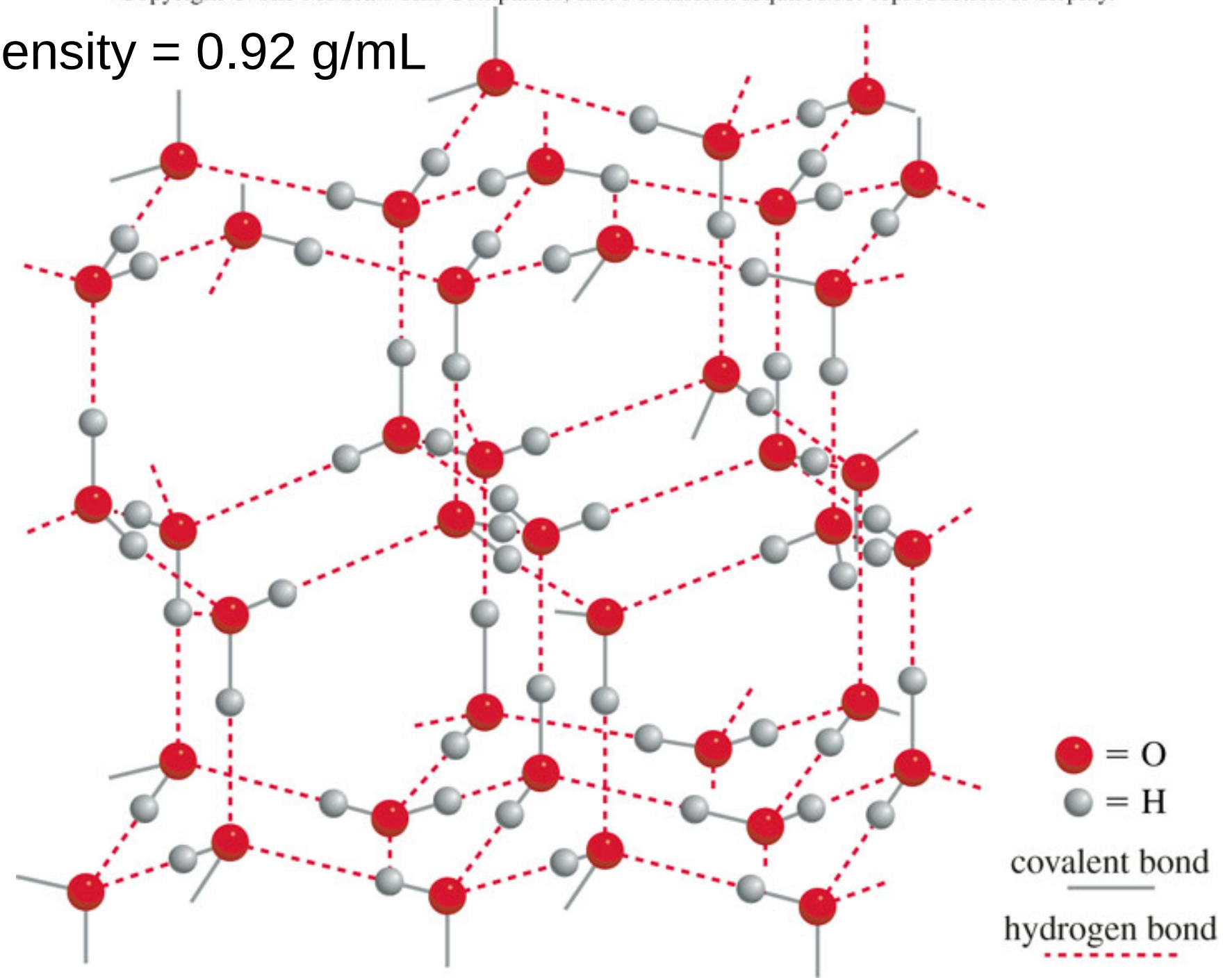
Forces of Attraction

- Electrostatic Interaction – the attraction between opposite charges
- Intramolecular forces – forces that exist within a single molecule
  - Polar bonds
- Intermolecular forces – interactions between two or more molecules
  - Hydrogen-bonding

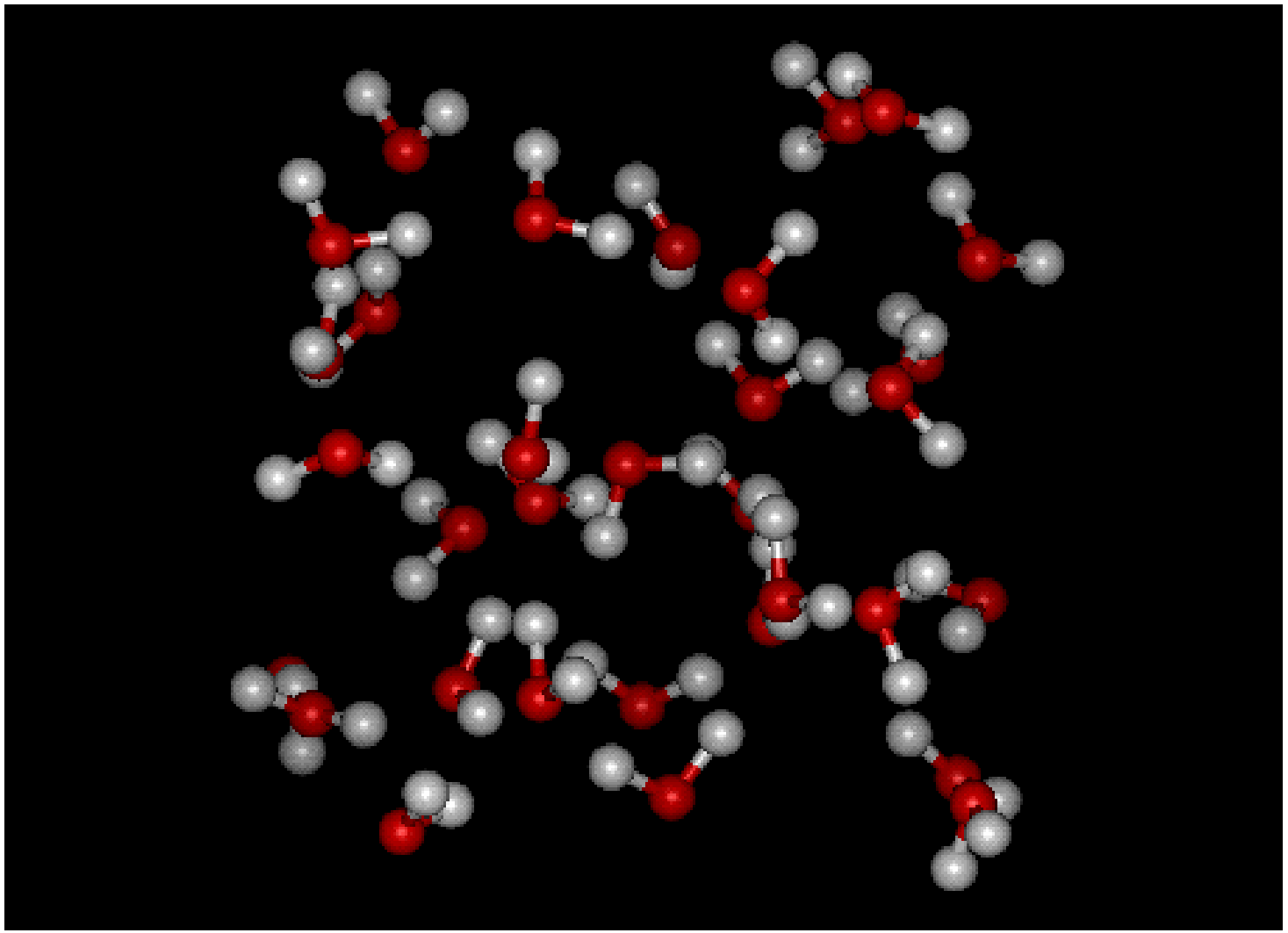




Density = 0.92 g/mL



Density = 1.00 g/mL



Specific Heat of Water

- Specific Heat – the quantity of heat that must be absorbed by a substance to increase the temperature of one gram by one degree Celsius
- Unusually high for liquid water

$$4.884\frac{J}{g\cdot {}^{o}C} \quad or \quad 1.00\frac{cal}{g\cdot {}^{o}C}$$

- Why? Because water's hydrogen bonds resist the additional motion that comes with increased T

Specific Heat of Water

- Consequences of this high specific heat?
  - Very efficient coolant: excess heat energy is transferred to water without changing the water's temperature
  - Helps to drive weather patterns and determine local climate
  - May serve to mediate global warming, which is one of the large uncertainties in the experts' models

Aqueous Solutions

- Nonelectrolyte – solutions that do not conduct electricity
- Electrolyte – solutions that conduct electricity
  - Ions – electrically charges species that carry current in aqueous solution
    - Cation – positively charged
    - Anion – negatively charged

(a) Distilled water

(b) Sugar water

(c) Salt water

Table 5.5 Comparison of a Sodium Atom with a Sodium Ion

Sodium Atom		Sodium Ion	
$Na\cdot$	Na 11 protons 11 electrons *Net* charge: zero	Na^+	Na 11 protons 10 electrons *Net* charge: 1+

Table 5.6 Comparison of a Chlorine Atom with a Chloride Ion

Chlorine Atom		Chloride Ion	
$:\dot{\underset{\cdot\cdot}{Cl}}\cdot$	Cl 17 protons 17 electrons *Net* charge: zero	$:\underset{\cdot\cdot}{Cl}:^-$	Cl^- 17 protons 18 electrons *Net* charge: 1−

Ionic Solids

- Metal cation and non-metal anion
- Solids DO NOT conduct electricity
- But Ions dissociate in solution, forming Electrolytic Solutions

$$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$$

$$KI(s) \xrightarrow{H_2O} K^+(aq) + I^-(aq)$$

$$MgCl_2(s) \xrightarrow{H_2O} Mg^{2+}(aq) + 2Cl^-(aq)$$

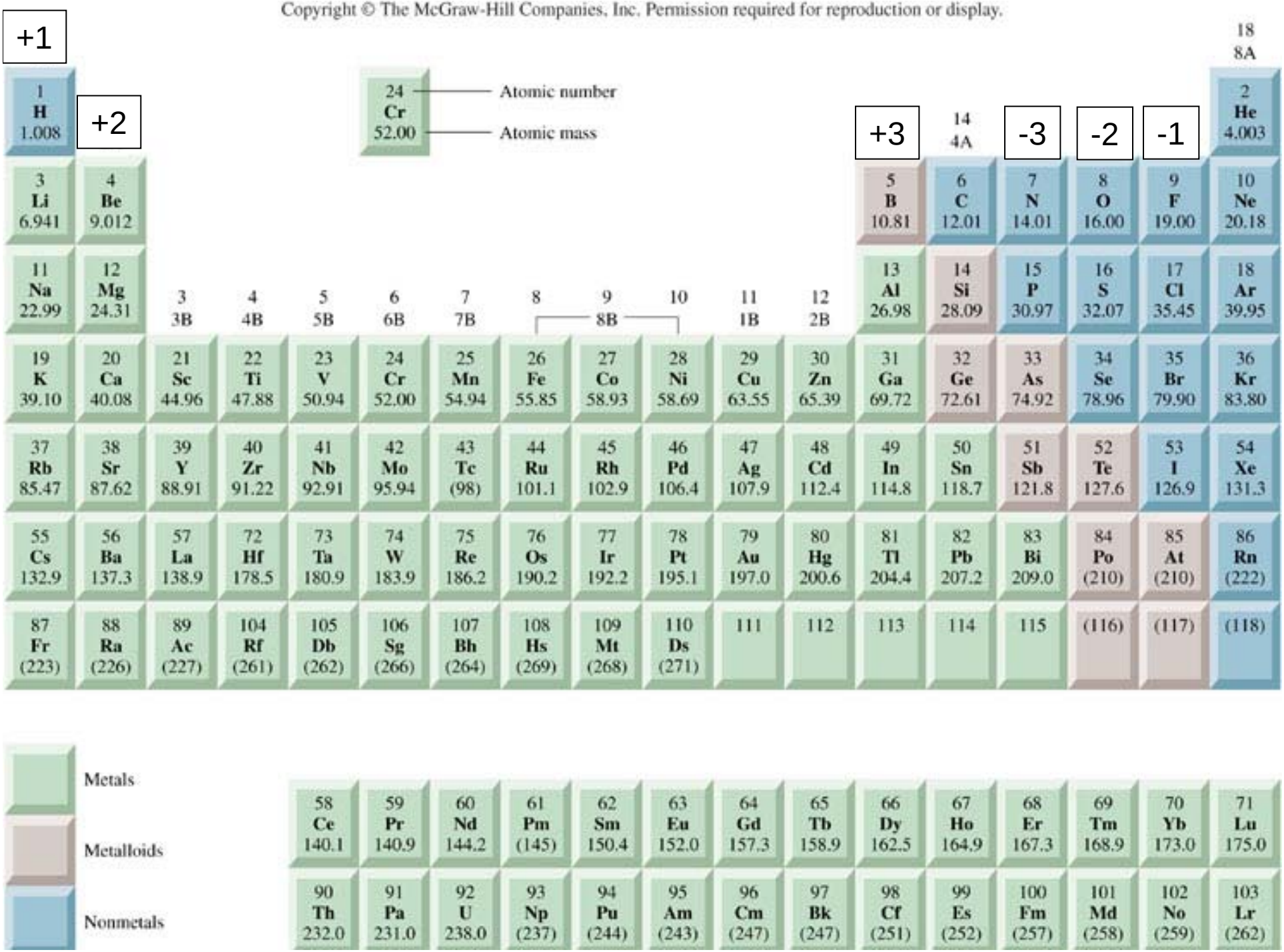
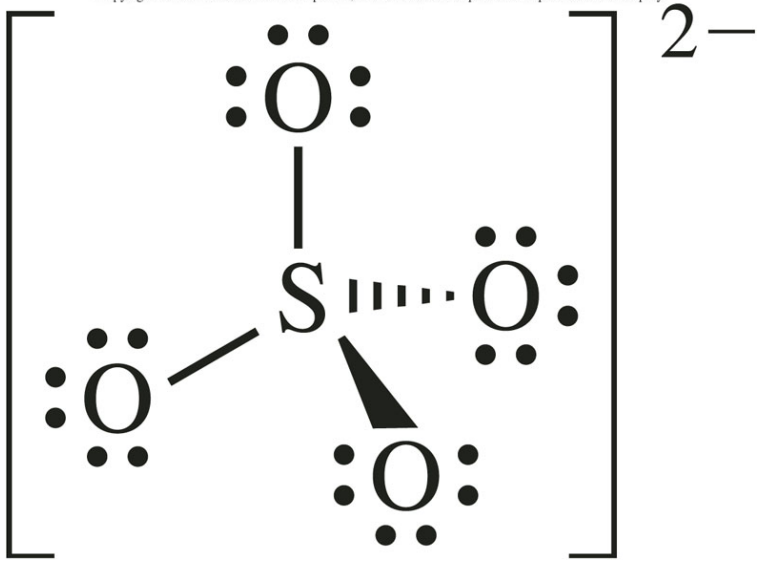


Table 5.7 Common Polyatomic Ions

Name	Formula	Name	Formula
acetate	$C_2H_3O_2^-$	nitrite	NO_2^-
bicarbonate*	HCO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	sulfate	SO_4^{2-}
hydroxide	OH^-	sulfite	SO_3^{2-}
hypochlorite	OCl^-	ammonium	NH_4^+
nitrate	NO_3^-		

* Also called the hydrogen carbonate ion.

- In polyatomic ions the charge is spread out over the entire ion.



$$NaNO_3(s) \xrightarrow{H_2O} Na^+(aq) + NO_3^-(aq)$$

$$K_2CO_3(s) \xrightarrow{H_2O} 2K^+(aq) + CO_3^{2-}(aq)$$

$$MgSO_4(s) \xrightarrow{H_2O} Mg^{2+}(aq) + SO_4^{2-}(aq)$$

$$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$$

Ionic Compounds

- Chemical Formulas – must be neutral so charges must cancel out.

Na (+1) + Cl (-1) make NaCl

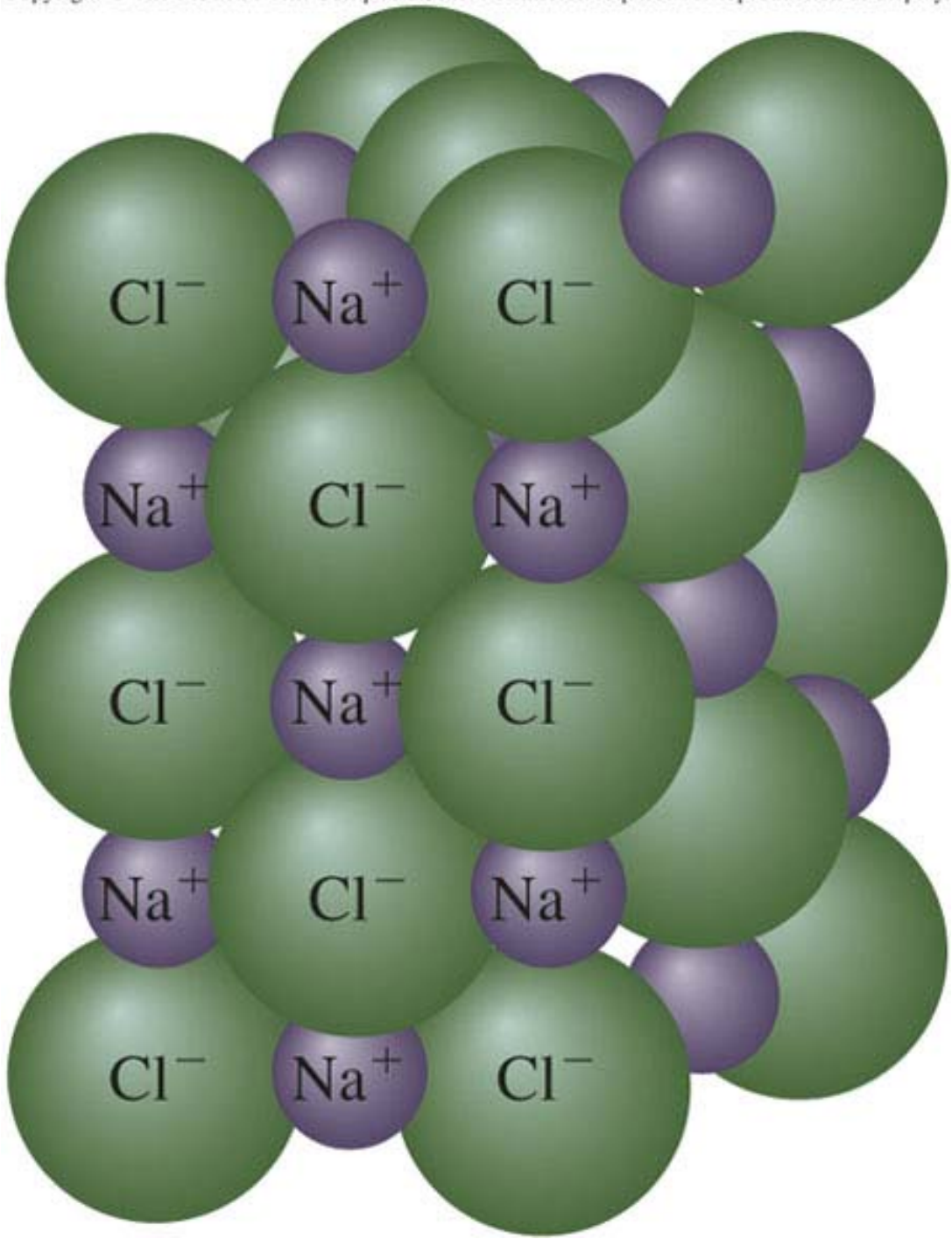
Ca (2+) & Br (-1) make $CaBr_2$

Li (+1) & S (-2) make Li_2S

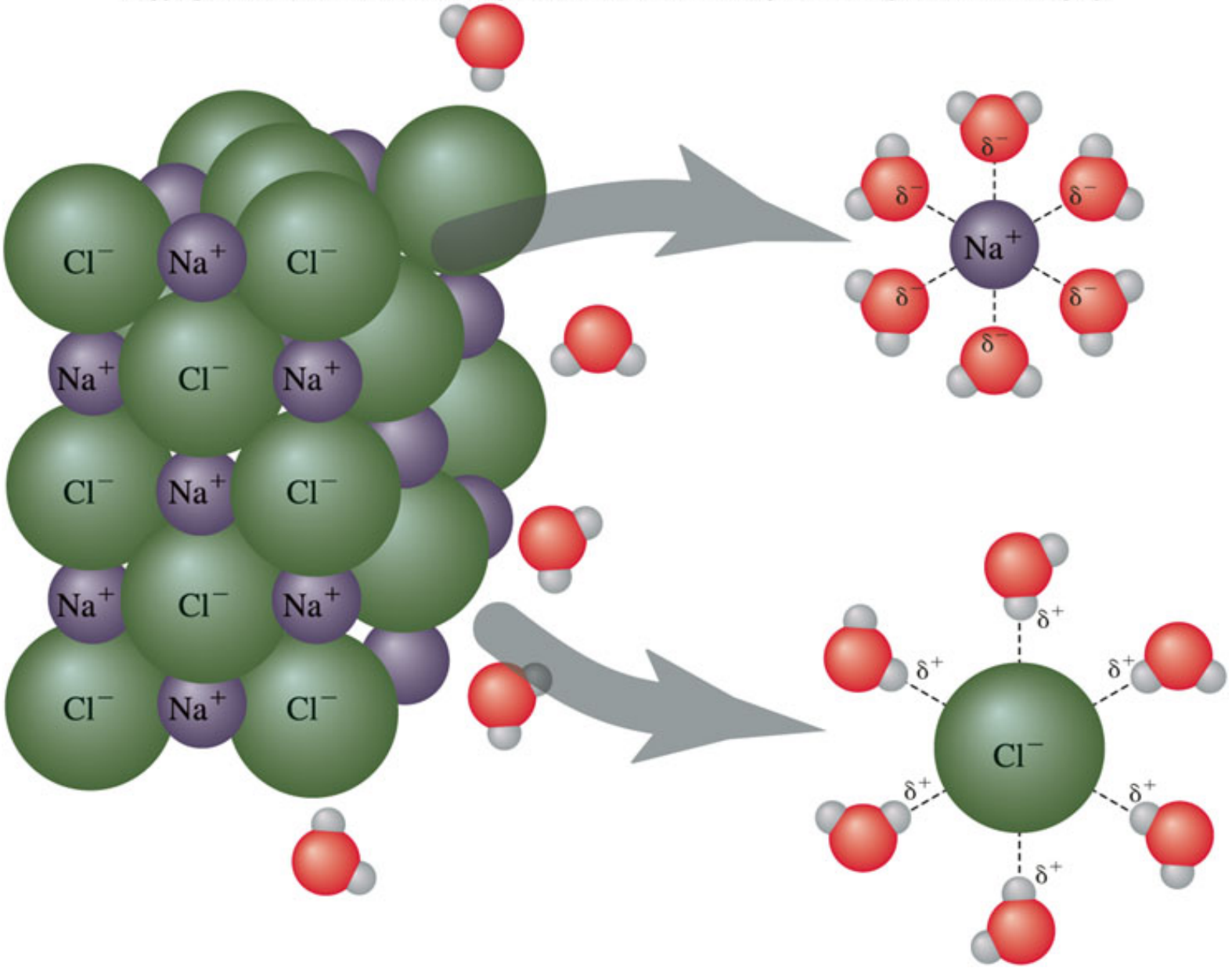
Al (+3) & O (-2) make Al_2O_3

Table 5.8 Writing the Formula for an Ionic Compound

Aluminum Cation	Sulfate Anion	Aluminum Sulfate
Al^{3+}	SO_4^{2-}	
Al^{3+}	SO_4^{2-}	$Al_2(SO_4)_3$
	SO_4^{2-}	
$2(+3) = +6$	$3(-2) = -6$	Electrically neutral



Water Solutions of Ionic Compounds



Not all ionic compounds are soluble

Table 5.9 **Generalizations About the Solubility of Ionic Compounds in Water**

All **sodium, potassium,** and **ammonium** (NH_4^+) compounds are soluble.
All **nitrates** are soluble.
Most **chlorides** are soluble (except silver, some mercury, and lead chlorides).
Most **sulfates** are soluble (except strontium, barium, and lead sulfate).
Most **carbonates** are insoluble* (except those with Group 1A or NH_4^+ cations).
Most **hydroxides** and **oxides** are insoluble (except those with Group 1A or NH_4^+ cations).
Most **sulfides** are insoluble (except those with Group 1A or NH_4^+ cations).

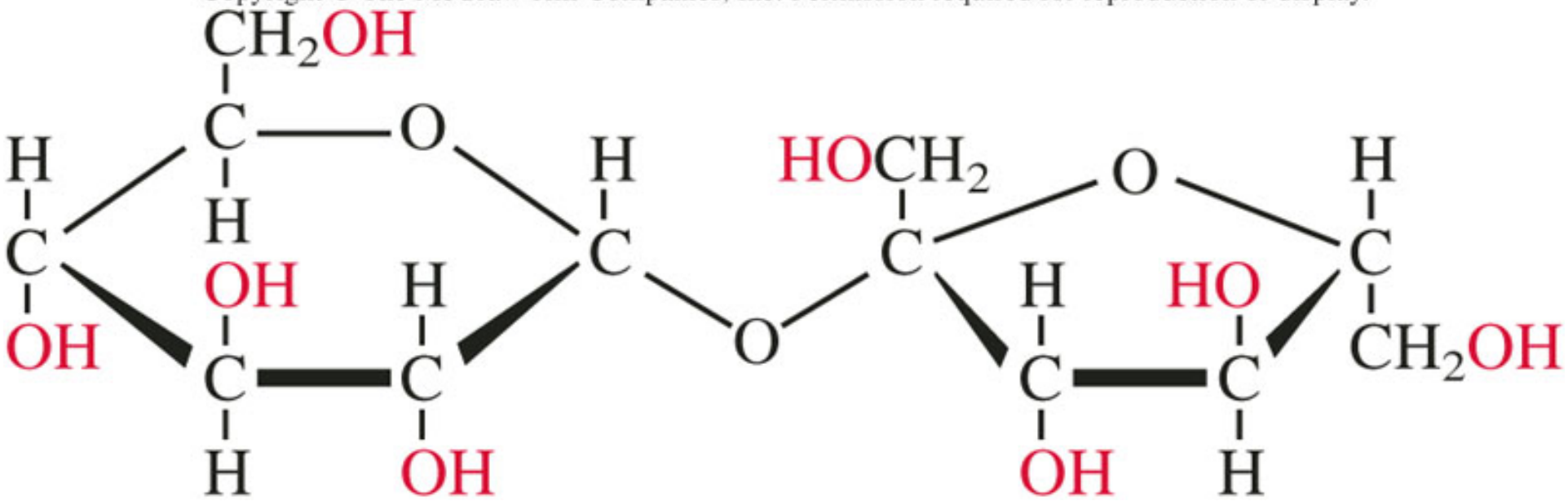
* "Insoluble" means that the compounds have extremely low solubility in water (less than 0.01 M). All ionic compounds have at least a very small solubility in water.

Table 5.10 Environmental Consequences of Solubility

Source	Ions	Solubility and Consequences
Salt deposits	sodium and potassium halides*	These salts are soluble. Over time, they dissolve from the land and wash into the sea. Thus, oceans are salty and sea water cannot be used for drinking without expensive purification.
Agricultural fertilizers	nitrates	All nitrates are soluble. The runoff from fertilized fields carries nitrates into surface and groundwater. Nitrates are toxic, especially for infants.
Metal ores	sulfides and oxides	Most sulfides and oxides are insoluble. Minerals containing iron, copper, and zinc are often sulfides and oxides. If these minerals had been soluble in water, they would have been washed out to sea long ago.
Mining waste	mercury, lead	Most mercury and lead compounds are insoluble. They are leached slowly from waste piles into rivers and lakes where they contaminate water supplies.

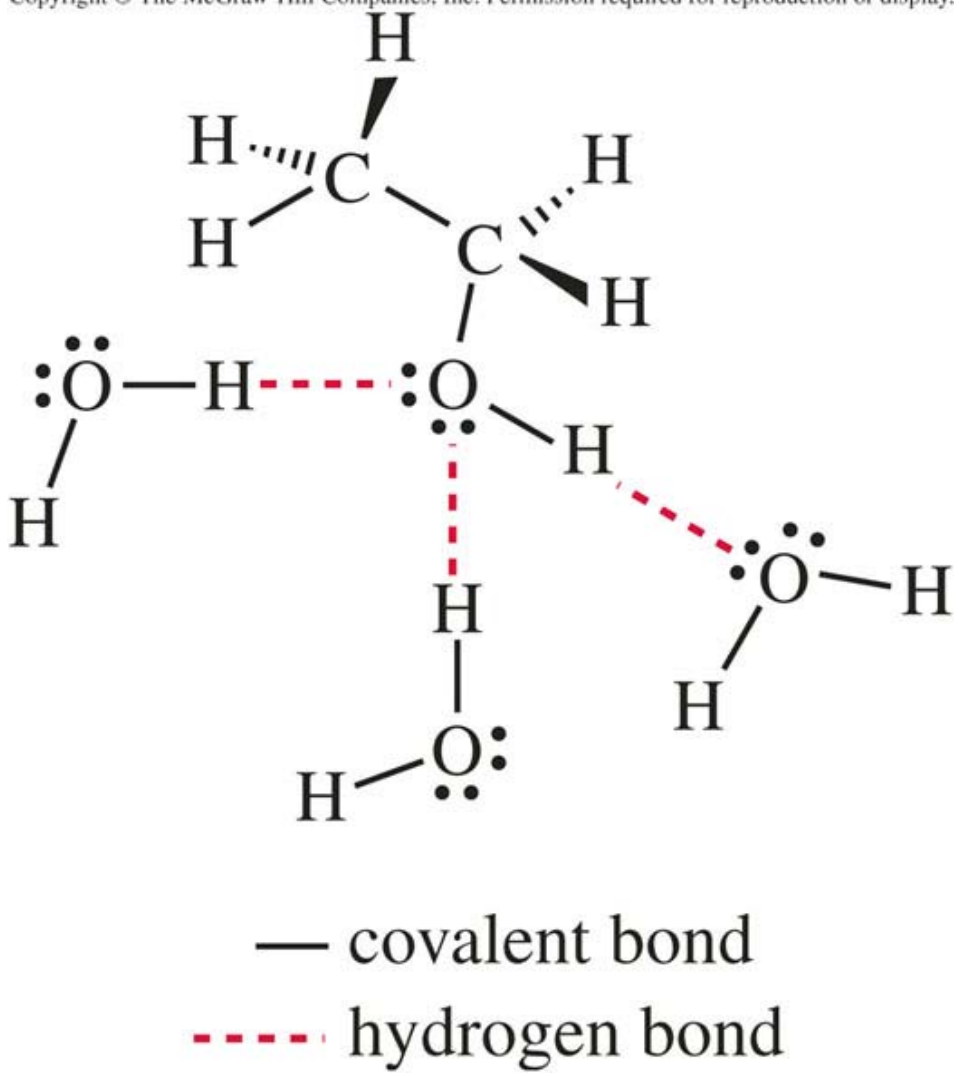
* Halides are the anions in Group 7, such as Cl^- and I^-.

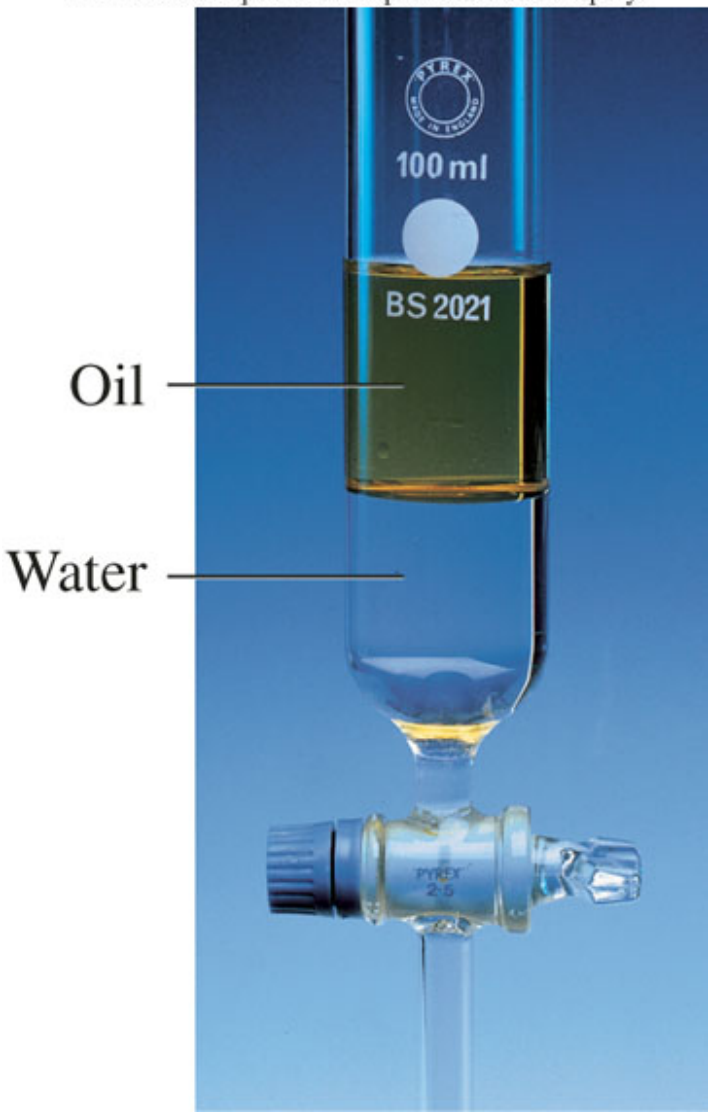
- What else will dissolve in water?
- If the intermolecular interactions between the solvent and the solute are comparable to the intermolecular interactions between the solute particles, the solute will dissolve
- Most Polar Compounds will dissolve in water



Like Dissolves Like

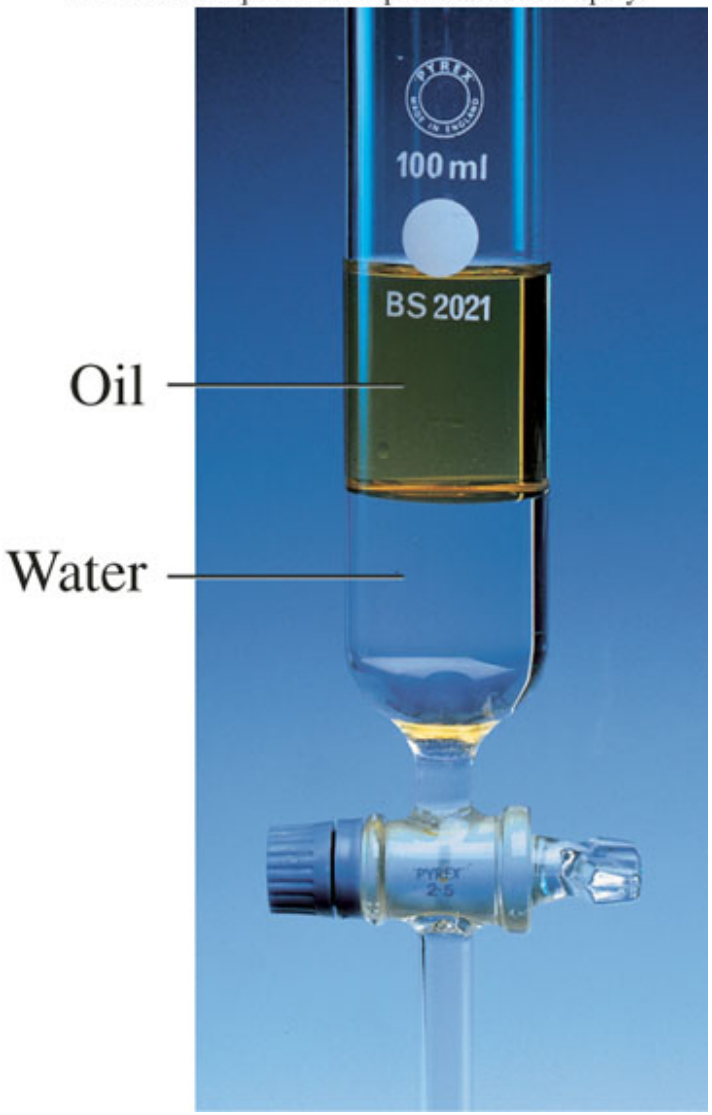
- Polar compounds
  - Ethanol
  - Methanol
  - Sugar
  - Ethylene Glycol
- Ionic compounds
  - salts





- Oils and Fats are nonpolar compounds and are insoluble in water

http://jchemed.chem.wisc.edu/JCESoft/CCA/samples/cca2like.html



- Dry cleaning
  - Perchlorinated ethylene (C_2Cl_4) is carcinogenic, and water soluble – which leads to environmental pollution
  - By designing detergents which are soluble in other solvents, such as liquid CO_2, the pollution can be mitigated

- “Lipophilic” compounds are **not** soluble in water, but **are** soluble in fats.
  - Nonpolar compounds
  - DDT
  - PCBs
  - Can bioaccumulate

- Hydrophilic compounds are **not** soluble in fats but **are** soluble in water