Liquids and Solids

Unit 8

Module 3

Module Concepts

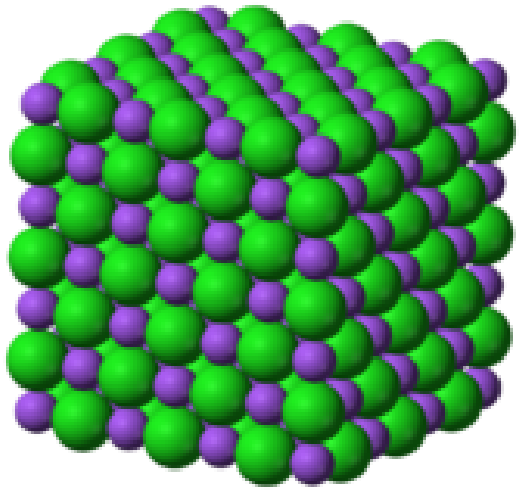
- Amorphous vs. Crystalline Solids
- Types of Crystalline Solids
- Periodic Table Stair-step
- Electrical Conductivity

Solids

- Recall that solids are also considered to be a "condensed" form of matter. Solids form as atoms or molecules slow down (i.e. lose kinetic energy) and pack tightly together as attractive forces form between particles.

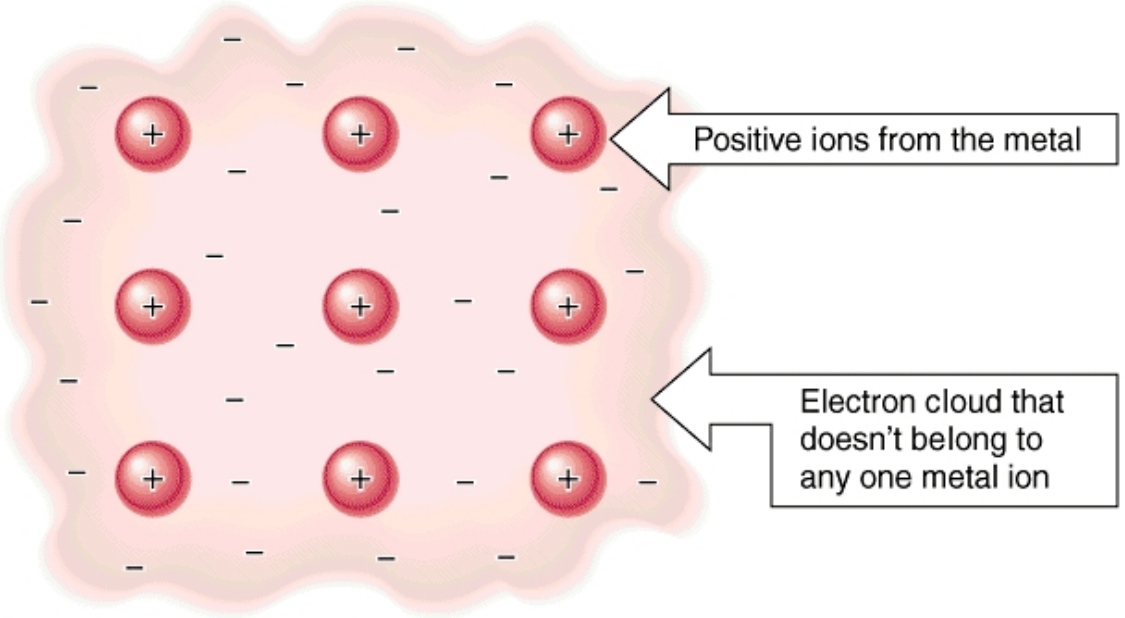
Terms Used to Describe Solids

- *Crystalline* - Most solids in nature are crystalline solids. Crystalline solids have particles which exist in a very highly ordered, repeating pattern. All ionic solids, like table salt (NaCl) are crystalline solids. There are *four* types of crystalline solids.

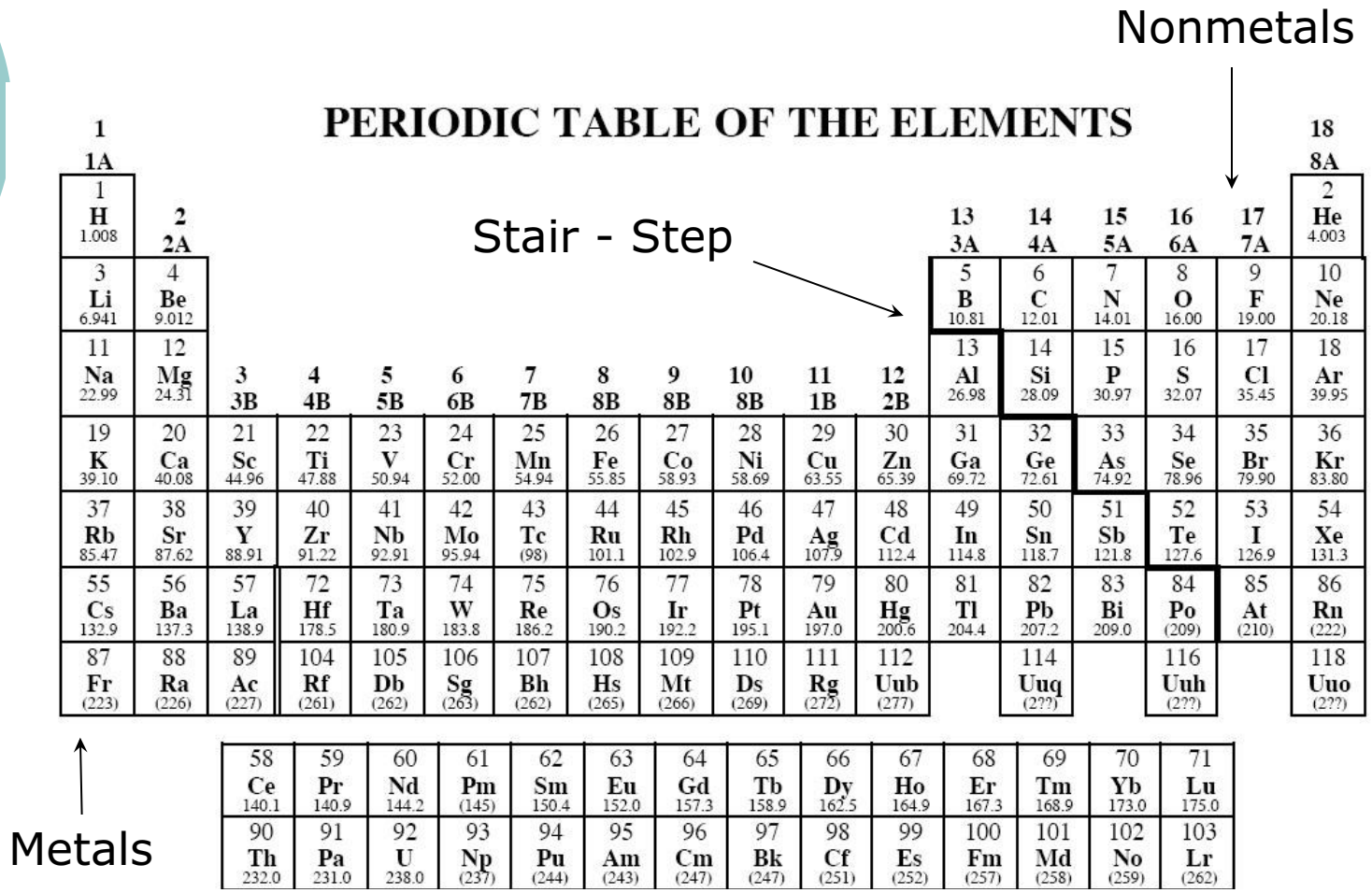


Types of Crystalline Solids

- Metallic – consists only of tightly packed metal atoms. (Metals are those elements to the left of the "stair-step" of the periodic table.)
  - These solids are good conductors of heat and electricity due to the "sea of electrons" bonding model.



Periodic Table – Visualizing the Stair-Step



1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.008	2 2A																2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Uub (277)		114 Uuq (???)		116 Uuh (???)		118 Uuo (???)

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

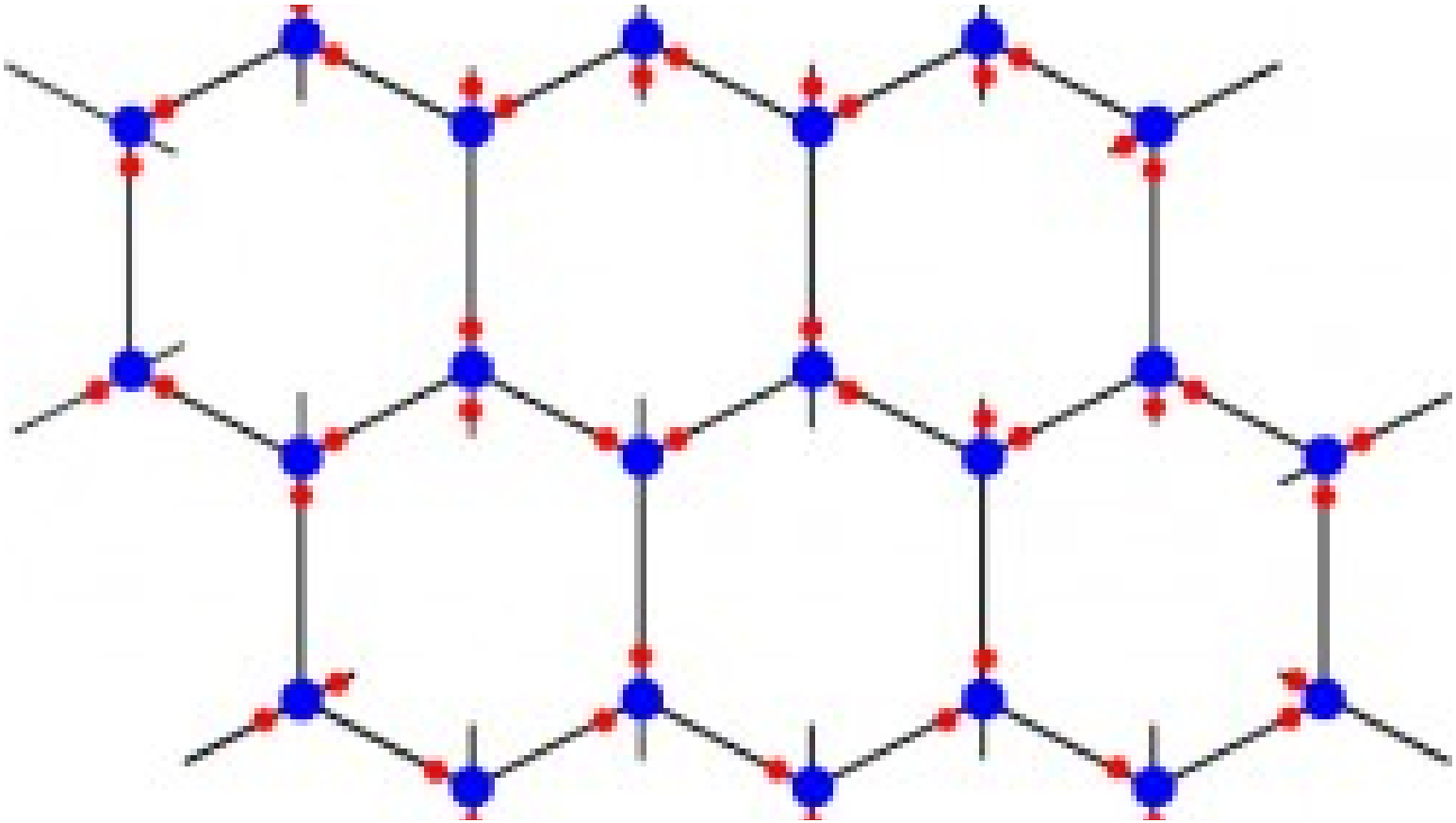
Metallic Crystalline Solids – Cont'd

- The "sea of electrons" refers to the mobility of valence electrons from one metal atom to another because of how loosely they are attracted to the atomic nucleus due to large atomic size. This movement of electrons from one metal atom to another results in mobile charged particles, which allow the flow of heat and electric currents. Example: Any metal from the periodic table, such as silver.

Types of Crystalline Solids – Cont'd

- *Molecular* – consists of covalent molecules which consist exclusively of nonmetal atoms.
  - Covalent molecules are made up of nonmetals bonded to one another through the sharing of electrons. (Nonmetals are those elements to the right of the "stair step" in the periodic table.) These molecules are held together by weak attractive forces like hydrogen bonding. These solids do not have the ability to conduct heat or electricity in any state of matter. They generally have low melting points. Examples: sugar ($C_{12}H_{22}O_{11}$) and ice (H_2O)

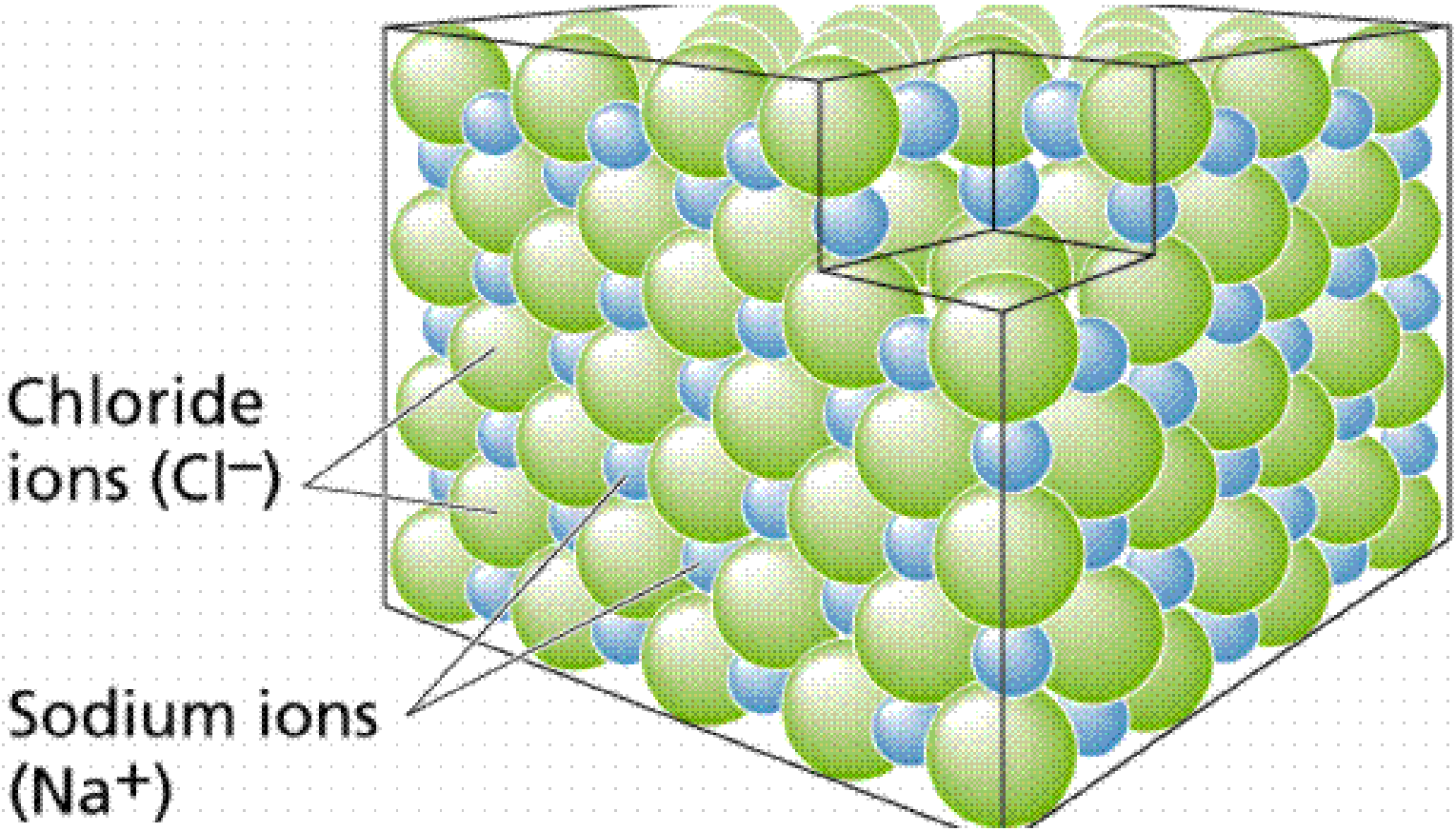
Molecular Crystalline Solid - Ice



Types of Crystalline Solids – Cont'd

- *Ionic Crystalline Solids* – consists of ionic compounds.
  - Ionic compounds are generally made up of a combination of *metals and nonmetals* (elements from BOTH sides of the stair-step) bonded to one another by an *attraction between oppositely charged particles*. These oppositely charged particles are held together in a tightly packed crystal lattice, a rigid 3D structure resembling a molecular cage.

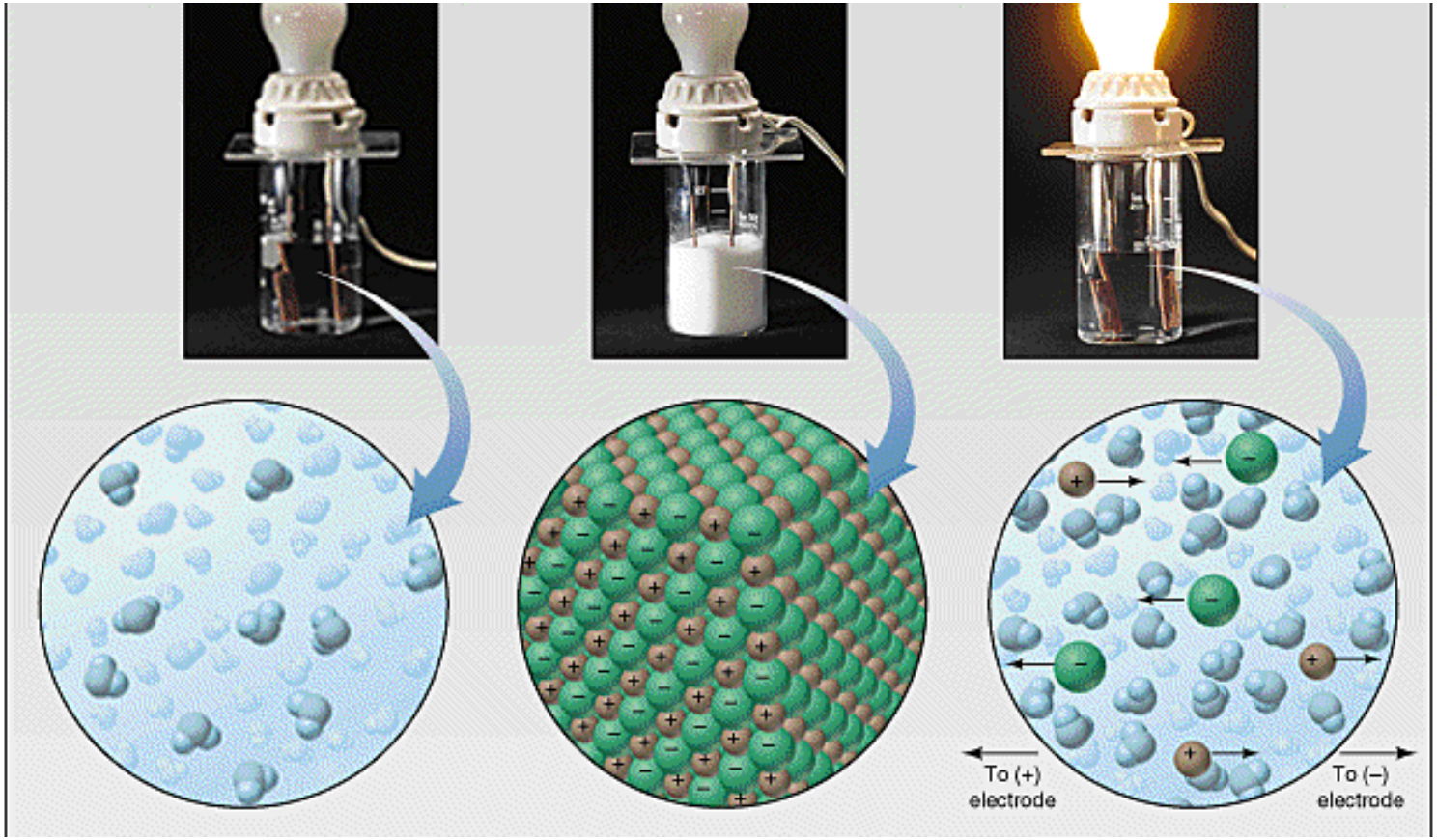
Ionic Crystalline Solids - Salt



Ionic Crystalline Solids

These solids **cannot** conduct electricity in the solid state, but if melted or dissolved, the crystal lattice holding oppositely charged particles together breaks down, allowing these charged particles to gain mobility. The movement of these charged particles allows these substances to conduct electricity in the molten or dissolved state.

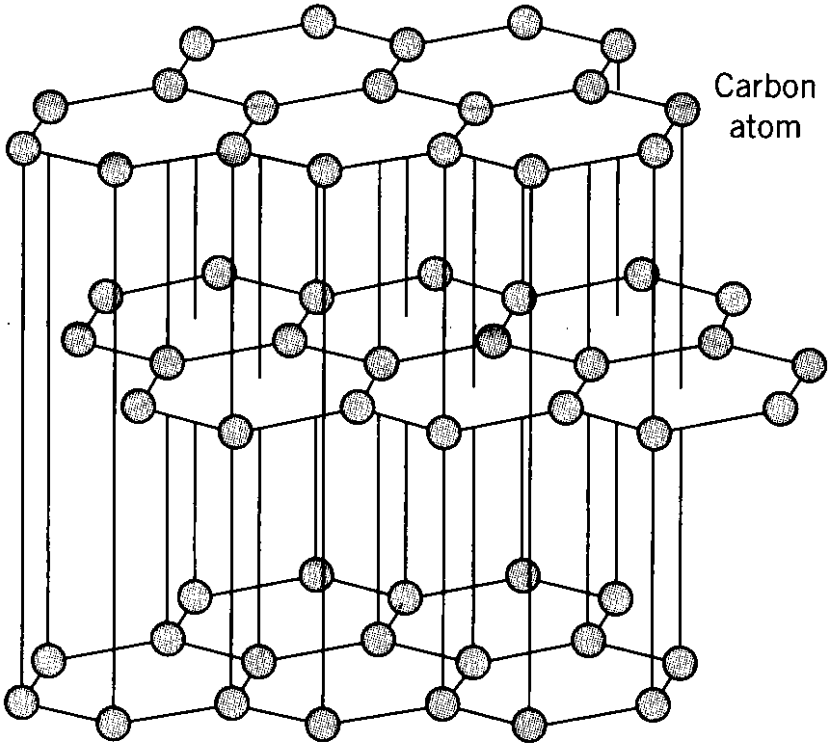
Conductivity of Ionic Compounds



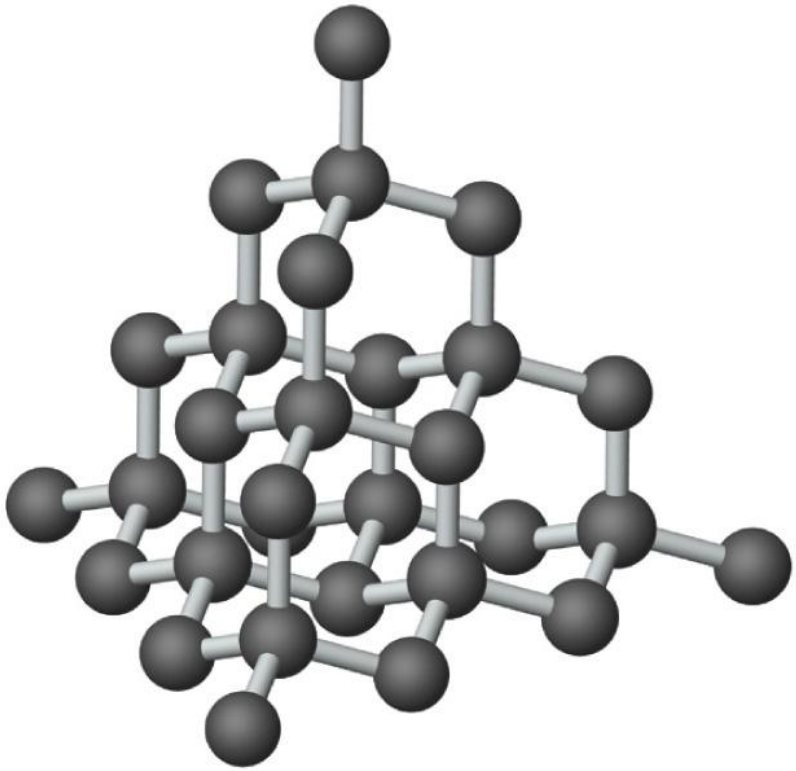
Types of Crystalline Solids – Cont'd

- *Covalent-Network Crystalline Solids*– a very special type of crystalline solid that consists of certain nonmetals that are covalently bonded to each other in an EXTREMELY rigid pattern. Examples of these special crystalline solids include diamond, quartz, and graphite.

Covalent Network Crystalline Solids



Carbon - graphite



Carbon - diamond

Amorphous Solids

- *Amorphous* - Solids whose particles do not exist in highly ordered, repeating patterns (i.e. irregular arrangement of particles). The word amorphous comes from the Greek word meaning "without form". Glass, rubber, and most plastics would be examples of amorphous solids.

Crystalline vs. Amorphous - Comparison

- In this graphic, look at how glass, an amorphous solid, has an irregular arrangement of particles compared to the very regular pattern seen in quartz, a crystalline solid.