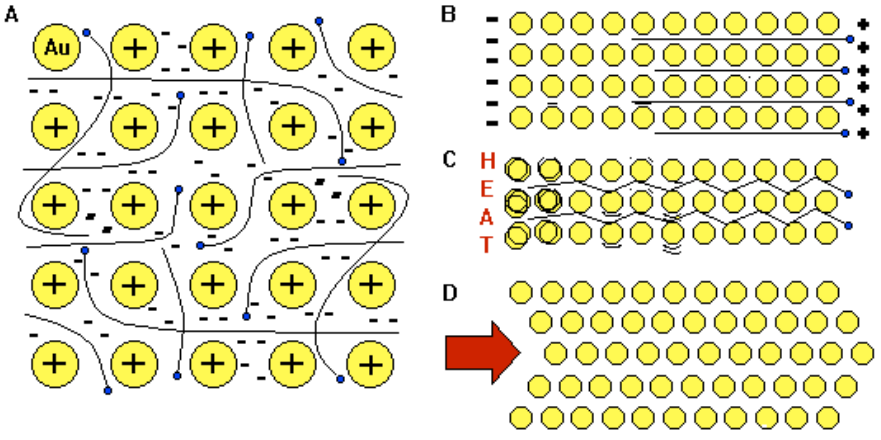
Properties of Ionic and Covalent Compounds

Remember...properties of metals are a result of the characteristics of metallic bonds.



https://www.uwgb.edu/dutchs/EarthSC202Notes/minerals.htm

What are the properties of covalent compounds?

Properties of Covalent Compounds

- Can be any state of matter (solid, liquid, gas)
- Lower melting points
- Don't conduct electricity
- Low solubility (some)

What are the properties of ionic compounds?

Properties of Ionic Compounds

- Crystalline solids-crystal lattice
- Solids at room temperature
- High melting point
- Hard, brittle
- Conducts electricity when in liquid state or when dissolved in water
- High solubility

Copper sulfate

http://en.wikipedia.org/wiki/Salt_%28chemistry%29

NaCl (Sodium Chloride

http://en.wikipedia.org/wiki/File:6158M-barite2.jpg

Ionic compounds conduct electricity

- For a material to conduct an electric current, there must be charged particles that can move.
- Ionic compounds in a liquid state or dissolved in water can conduct electricity
  - > Ions are free to move
- An aqueous solution of an ionic compound that conducts electricity is called an **electrolyte**.

Ionic bonds are very strong

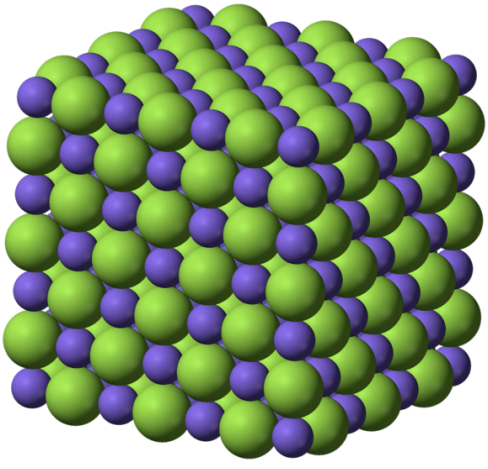
- Ionic bonds are very strong so lots of energy is needed to break them apart.
- Therefore, ionic compounds have very high melting points and boiling points.

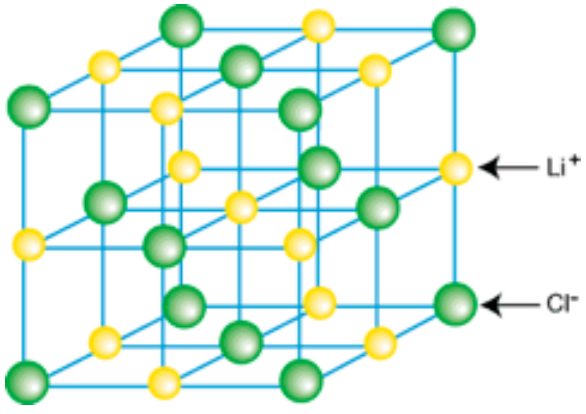
Compound	Melting Point (°C)	Boiling Point (°C)
NaI	660	1304
KBr	734	1435
NaBr	747	1390
$CaCl_2$	782	>1600
NaCl	801	1413
MgO	2852	3600

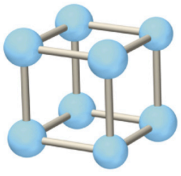
http://highered.mcgraw-hill.com/sites/007874637x/student_view0/chapter7/section2/self_check_quizzes.html

Crystal Lattice

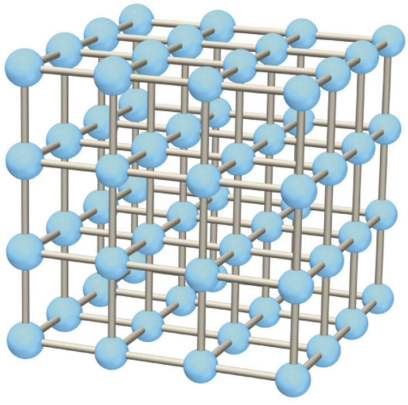
- Ionic Compounds form crystals.
- Positive and negative ions are packed into a regular, repeating pattern that balances the attraction and repulsion between ions.
  - > Positive and negative ions are attracted to each other, repelled by same charge
- This results in a **crystal lattice:** a 3-dimensional geometric arrangement of particles.
  - > Each positive ion is surrounded by negative ions
  - > Each negative ion is surrounded by positive ions





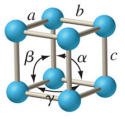


(a)

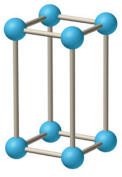


(b)

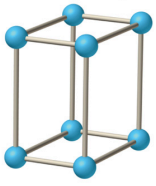
http://chemistry.umeche.maine.edu/~amar/spring2012/crystal.html



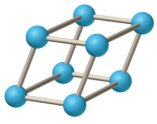
Simple cubic
$a = b = c$
$\alpha = \beta = \gamma = 90^\circ$



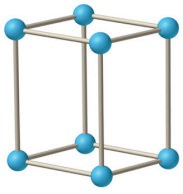
Tetragonal
$a = b \neq c$
$\alpha = \beta = \gamma = 90^\circ$



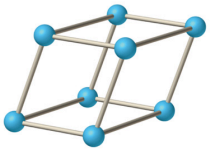
Orthorhombic
$a \neq b \neq c$
$\alpha = \beta = \gamma = 90^\circ$



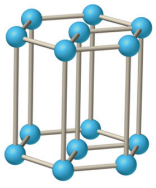
Rhombohedral
$a = b = c$
$\alpha = \beta = \gamma \neq 90^\circ$



Monoclinic
$a \neq b \neq c$
$\gamma \neq \alpha = \beta = 90^\circ$



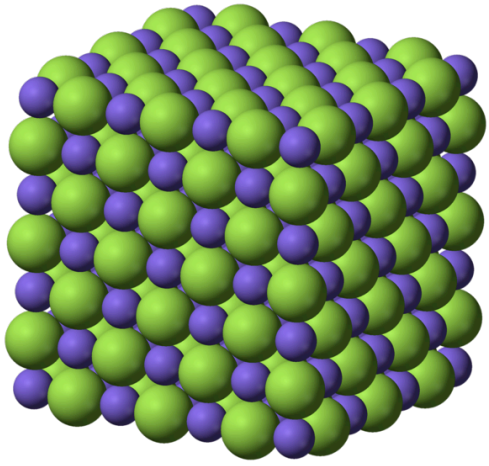
Triclinic
$a \neq b \neq c$
$\alpha \neq \beta \neq \gamma \neq 90^\circ$



Hexagonal
$a = b \neq c$
$\alpha = \beta = 90^\circ, \gamma = 120^\circ$

When an external force is applied to a crystal (you hit it with a hammer), it causes the crystal to crack

- The force repositions the like-charged particles next to each other
- Repulsive force cracks crystal

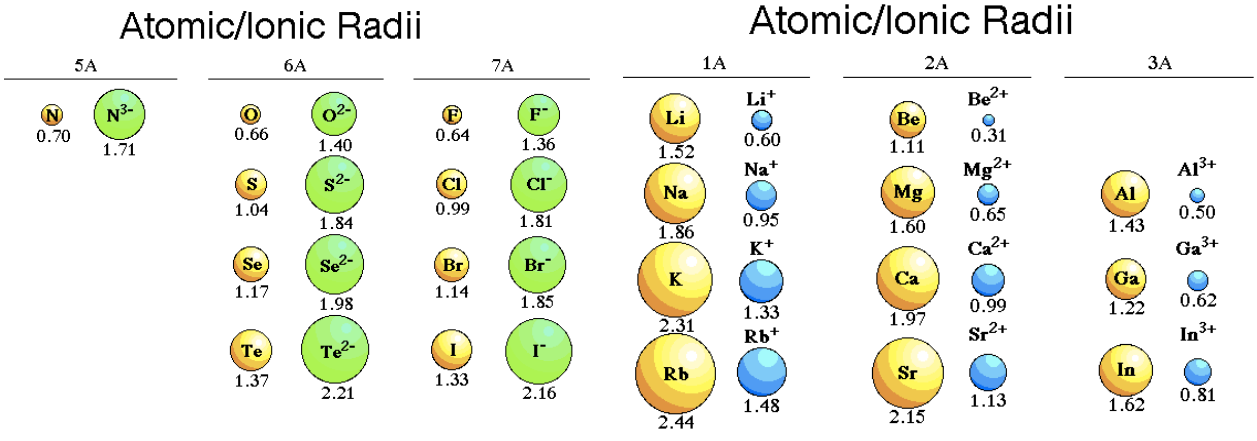


Energy of ionic bonds

- **Lattice energy:** energy needed to break apart one mole of an ionic compound.
  - > The greater lattice energy is, the stronger the force of attraction
- Lattice energy is greater for small ions, and greater charges (remember Coulomb's law?)

Remember periodic trends: **ionic radius**.

- Cations are always smaller than their neutral atom
- Anions are always bigger than their neutral atom
- Moving down a group: ionic radii increases
- Moving across a period: ionic radii of cations decreases, ionic radii of anions decreases



Example 1: Which of the following has a greater lattice energy?

NaCl or LiCl? Why?

KF or KCl? Why?

$MgCl_2$ or NaCl? Why?

Lattice Energies for Some Ionic Compounds

Compound	Lattice Energy (kJ/mol)	Compound	Lattice Energy (kJ/mol)
LiF	1030	$MgCl_2$	2326
LiCl	834	$SrCl_2$	2127
LiI	730		
NaF	910	MgO	3795
NaCl	788	CaO	3414
NaBr	732	SrO	3217
NaI	682		
KF	808	ScN	7547
KCl	701		
KBr	671		
CsCl	657		
CsI	600		

Example 2

Which compound has greater lattice energy? Why?

- KI or KBr? $SrCl_2$ or AgCl?

Order the following compounds from lowest to highest melting point.

- KI, KCl, KBr, KF