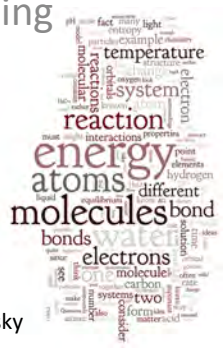
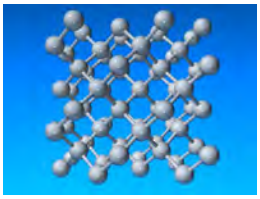
Ionic Bonding

- The limit of polar covalent bonding

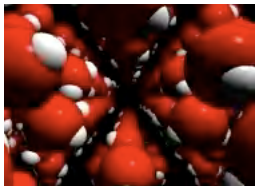


Chemistry, Life, the Universe & Everything – Cooper & Klymkowsky

What kinds of bonding do you know?

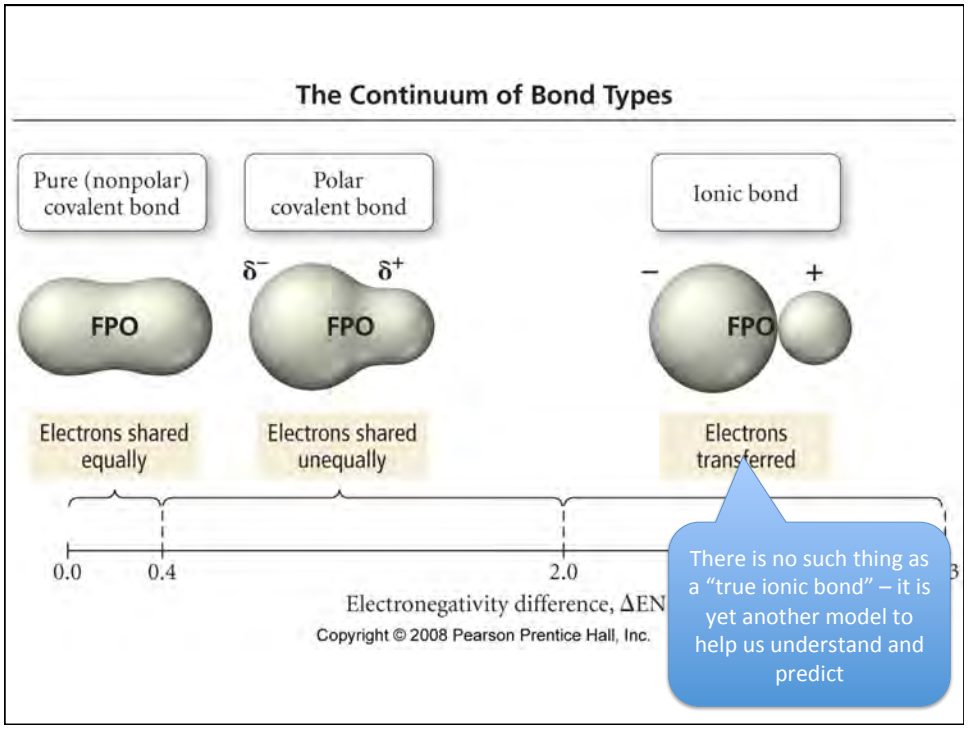


Diamond – covalent Network



Water – polar covalent Molecular (with intermolecular forces

Metallic



Questions

- What is an ion?
- What is an ionic compound?
- What is the difference between an ionic and a covalent bond?
- What kinds of compounds are likely to be ionic?

Recall:

- Diamond does not melt (and re-crystallize) – because covalent bonds are broken
- Water (and other molecular compounds) melt and re-crystallize – because the interactions between the molecules are broken on melting
- Sodium chloride melts and reforms – what implications does that have for the kind of bonding it has?

Other properties of NaCl

- V high melting and boiling points
- Conducts electricity when melted (but not in the solid – so not metallic)

Which is bigger?

- Na atom or Na^+ cation
- Cl atom or Cl^- anion

- Why?

Cations

- Positively charged
- Simple cations formed from metals losing electrons (ie elements with low electronegativity)
- **What is the relative size of the cation and atom? Why?**
- Smaller than corresponding atom
- Charge usually corresponds to loss of electrons back to "core" **but not because this is more stable –loss of electrons always requires energy**
- But highly charged ions form stronger bonds – which are more stable!

Anions

- Negatively charged
- Simple anions formed from non-metals gaining electrons (ie elements with high **electronegativity**
- **What is the relative size of the anion and atom? Why?**
- Larger than corresponding atom
- Charge usually corresponds to gain of electrons to the next filled (sub) shell ie noble gas configuration

What charge do you expect on

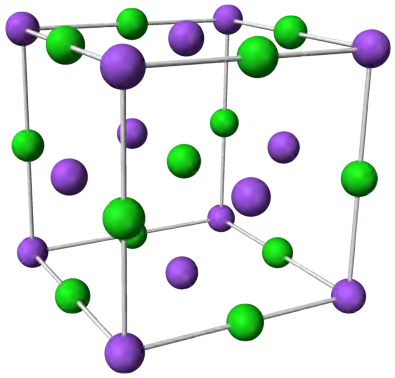
- K
- Mg
- Al
- S
- N
- Br
- Fe

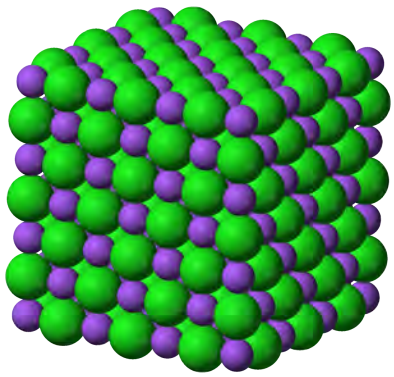
Elements That Form Ions with Predictable Charges

	1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1	Li^+														N^{3-}	O^{2-}	F^-	
2	Na^+	Mg^{2+}											Al^{3+}			S^{2-}	Cl^-	
3	K^+	Ca^{2+}														Se^{2-}	Br^-	
4	Rb^+	Sr^{2+}														Te^{2-}	I^-	
5	Cs^+	Ba^{2+}																

Transition metal ions always form a 2+ (and usually some others as well

Sodium Chloride





Ionic compounds:

- Metal plus non-metal eg NaCl
- Metals form cations, non-metals form anions
- Each ion typically achieves noble gas configuration **– this is a trade-off between energy required to gain or lose electrons, and stabilization of the system when ionic bonds are formed**
- Ionic compounds are neutral

What is the formula for the compounds formed between these ions?

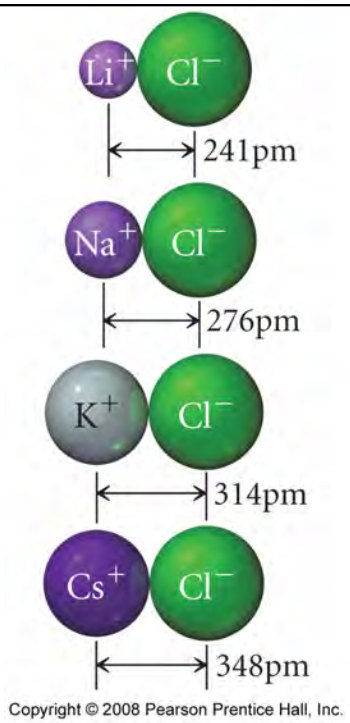
- Na^+ and Cl–
- Mg2+ and O2–
- Al3+ and O2–
- Mg and N
- Ca and Br
- Cs and S

Lattice Energy

- Energy released when an ionic lattice forms from ions in the gas phase
- $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$
- Force of attraction = constant (q^+q^-/r^2)
- Potential Energy = constant (q^+q^-/r)
- More charge – stronger attraction
- Larger ions – smaller attraction

Which has highest lattice energy?

Which has the highest melting point?



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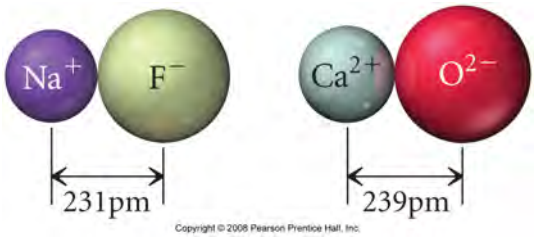

Which has highest lattice energy?

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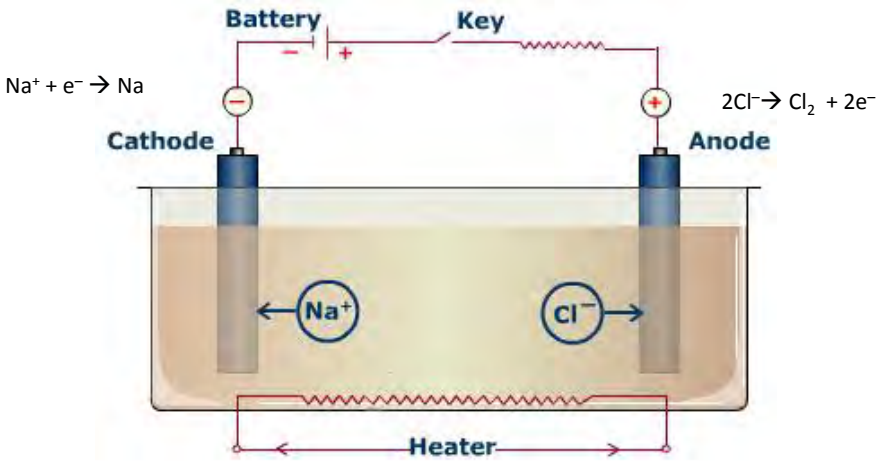
Electrolysis of NaCl



The charge is carried through the melt by IONS

Questions

- Why doesn't solid table salt conduct electricity?
- Why does molten table salt conduct electricity?
- Why do you think the melting point of table salt is so high? (it is over 800 °C)
- Why don't metals tend to gain electrons?
- Why don't non-metals lose electrons?
- What do you think happens to the size of a sodium atom when it loses an electron to become Na^+? Why?
- What do you think happens to the size of a chlorine atom when it gains an electron and becomes Cl^-? Why?