Chemical bonding & structure

Ionic bonding and structure
Covalent bonding
Covalent structures
Intermolecular forces
Metallic bonding

Ms. Thompson - SL Chemistry
Wooster High School

Topic 4.5
Metallic bonding

- A metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons.
- The strength of an metallic bond depends on the charge of the ions and the radius of the metal ion.
- Alloys usually contain more than one metal and have enhanced properties.

Metallic bonding

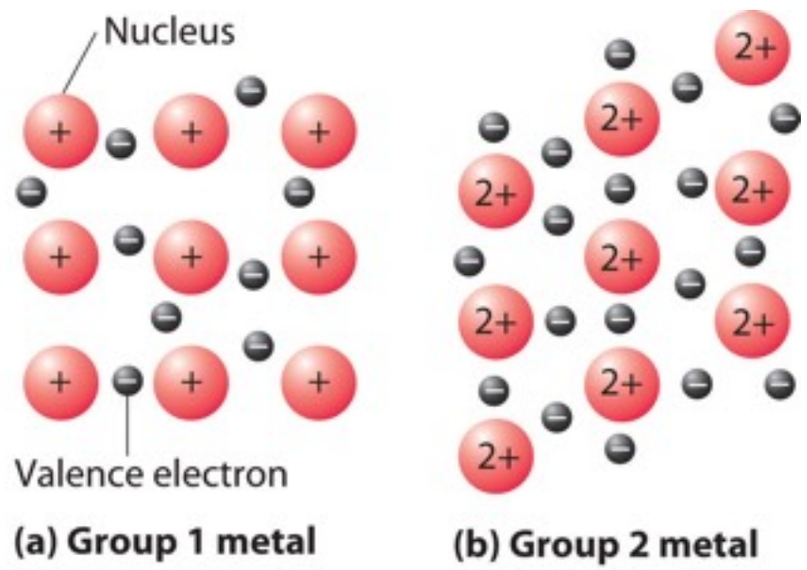
Nature of science

- Use theories to explain natural phenomena - the properties of metals are different from covalent and ionic substances and this is due to the formation of non-directional bonds with a "sea" of delocalized electrons.

Metallic bonding

Metallic bonding

- **Metals:**
  - Lie to the left of the stepped line on the periodic table
  - Have low ionization energies, so valence electrons can be de-localized throughout the metal.
  - Regular giant lattice structure that consists of positive ions (cations) surrounded by a "sea" of delocalized electrons.
- A **metallic bond** is the electrostatic attraction between a lattice of positive ions and delocalized electrons.



Metallic bonding

Metallic bonding

- **Delocalized electrons** are free to move throughout the crystalline lattice structure - not bound to a metal's nucleus
- Strength of metallic bonds depends on three factors:
  - Number of valence electrons that become delocalized
  - The charge of the metal ion
  - The ionic radius of the metallic positive ion (cation)

Metallic bonding

Alloys

- An ally is a mixture of that consist either of two or more metals or in metal combined with other alloying elements composed of non-metals.
  - i.e. cast iron consists of the metal iron and the non-metal carbon
- Have enhanced properties:
  - Strength, hardness, and durability

Alloy	Composition	Uses
brass	copper and zinc	door handles, window fittings, screws
steel	iron, carbon, and other metals such as tungsten	bridges and buildings
dental amalgam	mercury, silver, and tin	used by dentist for teeth fillings

Metallic bonding

Electric conductivity in malleability in metals

- **Electrical conductivity**
  - Good conductors of electricity due to mobile delocalized electrons
  - When potential is applied to metal, electrons move through metallic structure
  - Impurities in metal can restrict movement of electrons - creates resistance
  - Copper in electrical wiring must have a high degree of purity
- **Malleability**
  - the ability of a solid to be pounded or hammered into a sheet or other shape without breaking
  - Positive ions can slide past one another - leads to rearrangement of shape
  - Metallic bonds do not have defined direction (**non-directional** - act in every direction)

Metallic bonding

Melting point trends in metals

- Metallic bonds are strong and have high melting points
- Alkaline earth metals have higher melting points then alkali metals
  - This is due to the greater number of delocalized electrons found in the alkaline earth metals
  - i.e. Calcium and potassium
  - Calcium has two delocalized electrons whereas potassium only has one - electrostatic attraction between positive ions and delocalized electrons will be greater in calcium
  - Ca^{2+} forms 2+ ions and K^{+} forms 1+ ions - electrostatic attraction between positive ions and delocalized electrons will also be greater in calcium
  - Ca^{2+} atomic radius = 100pm and K^{+} atomic radius = 138pm which means delocalized electrons will be more strongly attracted to Ca^{2+} ion.

Metal	Melting point / °C
potassium (K)	63.5
calcium (Ca)	842

Metallic bonding

Melting point trends in metals

- Trend in melting point can also be observed on descending group 1, the alkali metals
- The **ionic radius** (responsible for varied melting point) increases going down a group and the melting point will decrease with decreasing strength of the attractive forces of the nucleus to the valence electrons

Metal	**Ionic radius of M^+ / pm**	**Melting point / °C**
Lithium (Li)	76	180.5
Sodium (Na)	102	97.8
Potassium (K)	138	63.5
Rubidium (Rb)	152	39.3
Caesium (Cs)	167	28.5

Metallic bonding

Properties of alloys in terms of non-directional bonding

- Alloys can have a number of improved properties compared to the parent metallic element:
  - Greater strength
  - Greater resistance to corrosion
  - Enhanced magnetic properties
  - Greater **ductility** (a mechanical property that allows a metal to deform under tensile stress, for example being able to stretch the metal into a wire)
- Adding a small amount of an alloying element can dramatically change properties of an alloy
  - The addition of an alloying element can disturb the network of positive ions and therefore making the metal stronger

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Metallic bonding

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- ➡The strength of an metallic bond depends on the charge of the ions and the radius of the metal ion.
- ➡Alloys usually contain more than one metal and have enhanced properties.