Beryllium (Be) will most likely form an ion with what charge?

a) -1  
b) -2  
c) +1  
d) +2
What would the chemical formula for magnesium fluoride (a salt of Mg and F) be?

a) MgF
b) Mg₂F
c) MgF₂
d) MgF₃
Ionic compounds are neutral (no net charge). What are the ionic charges in the following compounds?

- **NaCl**: $\text{Na}^{+1}$ and $\text{Cl}^{-1}$
- **KBr**: $\text{K}^{+1}$ and $\text{Br}^{-1}$
- **MgF}_2$: $\text{Mg}^{+2}$ and $\text{F}^{-1}$
- **Al}_2\text{O}_3$: $\text{Al}^{+3}$ and $\text{O}^{-2}$
Naming convention for salts

• The metal comes first with its name unchanged
• The nonmetal comes second, with the suffix “ide” appended
If aluminum and chlorine form a compound, what would the formula be?

A. AlO₂
B. Al₂O
C. Al₃O₂
D. Al₂O₃
Covalent Bonding

- What are non-metal bonds like?
  - covalent, polar, hydrogen bonds, dispersion
- How strong are they?
- Can this help explain trends in melting and boiling temperatures and in conductivity?

“To find the truth you have to try and you have to persist in trying. Sometimes it’s fun. Sometimes it’s hard or boring. But it’s always worth it…”

“The Creator of the Universe has implanted a message in every created thing. Geology, astronomy, physics – all science is really nothing more than an effort to read those messages.”

Henry Eyring
Today’s class

- Forces between atoms in molecules.
- Forces between molecules in a liquid or solid.

Covalent Bonding

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• Forces between atoms in molecules.
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non-metal bonds

• Many compounds used by our bodies are non-metals (water, oxygen, carbon dioxide, etc.)
• Liquids or gases at room temperature.
• Do not conduct electricity
What are Covalent Materials like?

• Generally have melting and boiling points in the intermediate to low range
• Poor conductors of heat and electricity
• May be solids, liquids, or gases
• Exist as molecules!
Electron sharing

- Chemistry worries about electrons in the largest unfilled orbitals
- Non-metals form molecules by sharing electrons to fill orbitals
- Produces “real” molecules

Non-metal bonds

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single, double, triple

• bond strength = energy required to separate atoms

![Diagram of ethane, ethylene, and acetylene with bond numbers](image)
Electronegativity

- Some atoms are not as good at sharing as others.
- Electronegativity: how strongly atoms attract electrons

- bond strength = energy required to separate atoms

bond strength
ethane \( \text{C}_2\text{H}_6 \) 348
ethylene \( \text{C}_2\text{H}_4 \) double 614
acetylene \( \text{C}_2\text{H}_2 \) triple 839
Electronegativity

- Some atoms are not as good at sharing as others.
- Electronegativity: how strongly atoms attract electrons

Polarity

- Polarity: from unequal electronegativity AND geometry
- NON-POLAR:
  - $\text{H}_2$  
  - $\text{O}_2$  
  - $\text{N}_2$

Electron density is largest between the molecules.
Also non-polar

- $\text{CO}_2$ combines atoms with unequal electronegativity.
- Non-polar by geometry

Polarity

- Polarity: from unequal electronegativity AND geometry
- NON-POLAR:
  - H$_2$
  - O$_2$
  - N$_2$

Electron density is largest between the molecules.
Also non-polar

- CO$_2$ combines atoms with unequal electronegativity.
- Non-polar by geometry

Polar Molecules

- Water is polar.
- The oxygen side of the molecule is more negative (greater electronegativity)
- The hydrogen side is more positive (smaller electronegativity).
The extreme: an ionic bond

- In covalent bonds, electronegativity is nearly the same
- For metal/non-metal bonds, electronegativity is strongly unequal: IONIC BONDS

Polar Molecules

- Water is polar.
- The oxygen side of the molecule is more negative (greater electronegativity)
- The hydrogen side is more positive (smaller electronegativity).
Forces between molecules: how do they compare?

Forces between molecules in a liquid:
- Dispersion forces: ~1 kJ mol⁻¹
- Dipole–dipole interactions: ~5–10 kJ mol⁻¹
- Hydrogen bonding: 30–150 kJ mol⁻¹

Force between atoms in a molecule:
- Covalent bonding: 200–900 kJ mol⁻¹
Melting and boiling temperatures: how do they compare?

- Nitrogen
- Oxygen
- Helium
- Water

**Dispersion forces**
- ~ 1 kJ mol\(^{-1}\)

**Dipole–dipole interactions**
- ~ 5–10 kJ mol\(^{-1}\)

**Hydrogen bonding**
- 30–150 kJ mol\(^{-1}\)

**Low melting temperature**

**Higher melting temperature**
What best explains the high freezing temperature of water?

A. Covalent bonds between the molecules
B. Hydrogen bonds between the molecules
C. Dispersion forces between the molecules
D. Attraction of the permanent dipole in one molecule to the dipole in another
How many electrons are shared between these two carbon atoms?

A. 2
B. 3
C. 6
D. 12
The forcing of electrons from oxygen atoms [O] to carbon atoms [C] (against the gradient) occurs in photosynthesis and makes food. The return of the electrons during cellular respiration releases the energy to power life.
Arrange S, Cl, F in order of increasing electronegativity.

A. S, Cl, F
B. Cl, F, S
C. F, Cl, S
D. F, S, Cl
Some examples: Nitrogen

- Strong covalent bonds.
- No dipole.
- Only weak dispersion forces for attraction between molecules.
- Good electrical insulator.
- Low melting and boiling temperatures.
Some examples: Carbon Dioxide

- Strong covalent bonds.
- No dipole.
- Only weak dispersion forces for attraction between molecules.
- Good electrical insulator.
- Low melting and boiling temperatures.
Some examples: Water

- Large dipole.
- Hydrogen bonding between molecules
- Higher melting and boiling temperatures.
- Can lose H⁺ to form an acid
- Excellent solvent

(polarity demo
pH demo)
Some examples: Glucose

- Large dipole.
- Hydrogen bonding between molecules
- “Sticky” likes to form crystals:
  2C sugar, 1C water, string, patience

- Higher melting and boiling temperatures.
- A carbohydrate ("carbon water")
Some examples: Carbon

**DIAMOND**
- Each carbon is attached to 4 other carbons
- Strong bonds between atoms: network
- Poor electrical conductor

**GRAPHITE**
- Strong bonds to 3 other carbons in a plane
- Weak bonds between planes
- Excellent lubricant (for your pinewood derby)
Molecular ions

- Think of a happy family of atoms that is missing a few electrons.
- They can’t share any more, so they go steal them.
Summary

- Covalent bonds occur in non-metals, when atoms share electrons and form molecules.
- Usually strong forces between atoms in molecules.
- Usually weak forces between molecules in a liquid or solid.
- Bond characteristics help determine properties of more complex systems (stay tuned…).