

Bonding Evaluation Information Page

Search Terms

- Chemical bonding
- Ionic bonding
- Ionic bonding, energy, stability
- Why do atoms form bonds?
- Polar and nonpolar covalent bonding
- Covalent bonding and electrostatic attraction
- Covalent bonding and physical properties
- Bonding, potential energy
- Strength and length of covalent bonds
- Potential energy diagrams

Broad definition of what we are considering

We are considering the formation of bonds from either free atoms or from elements. This would include the formation of ionic or molecular covalent compounds from elements or explaining why bonds form. This boundary is set to limit the video sampling. Other kinds of electrostatic attractions (e.g., IMFs) will be investigated as separate topics.

Johnstone's Triangle Elements

Element	Examples
Macroscopic	Visible phenomena - difference in chemical properties for ionic and covalent compounds, physical properties (mp, bp, density, etc.). Must be a specific example - e.g., NaCl has a mp of 801 C as compared with sugar with a mp of 186 C, can't just generally say "ionic compounds generally have high melting points"
Symbolic	A chemical equation that shows a chemical reaction that involves changes in bonding, but some videos may show a graph of change of concentrations of reactants and products as the reaction proceeds and how reactants get converted into products. This may also include representations that involve the elemental abbreviations (e.g. C, H) changing bonds (going from C-C to C=C). Lewis structure representations that show ion formation and attraction between ions (ionic bonding) or electron sharing (covalent bonding). PE well graph.
Particulate	Particle representations of ionic and covalent compounds (ionic lattice vs. molecules). Showing interactions between two particles (i.e. relating that to Potential Energy)
Connection between levels	Videos should make explicit connections between two or more levels for this to be coded as present. For example, they could show a particle level diagram for an ionic lattice and connect that to physical properties of ionic compounds.

Core Ideas

Core Idea Elements		
Electrostatic Bonding & Interactions	Energy	Atomic/Molecular Structure & Properties
Attractive and repulsive electrostatic forces govern bonding (covalent and ionic) interactions between atoms. The attraction arises between oppositely charged ions (ionic) or protons of one atom and the valence electrons of the other atom (covalent). Notes: If the video talks about both ionic and covalent bonds, it must address electrostatics for both types of bonding to get coded as having this CI. The strength of the attractive forces depends on the magnitude of the charges involved and the distances between them (Coulomb's law). <i>This last part is NOT required for the video to be coded with this CI.</i>	Key idea: The driving force for bond formation is forming compounds that are lower in energy (more stable). In the formation of a chemical bond there is a decrease in chemical potential energy. Conversely, energy is required to break bonds. This may often be represented with a potential energy well diagram. Note: The formation of bonds results in a release of kinetic energy to the surroundings. <i>This is NOT required for the video to be coded with this CI.</i>	The macroscopic physical and chemical properties of a substance are determined by the nature and extent of interactions between the particles that make up that substance. Note: Must explain how bonding results in these different properties.

Scientific Practices

We expect that the most common practices will be:

- constructing explanations and engaging in argumentation from evidence (e.g. answers one of the causal mechanistic reasoning questions)
- Developing and Using Models (e.g. using a potential well diagram or explaining molecular properties based on drawing of particulate level interactions)
- Analyzing and Interpreting Data (e.g. looking at specific data about physical properties)
- Using Mathematical and Computational Thinking (e.g. using Coulomb's Law to explain relative strengths of ionic interactions)

Scientific Practices Criteria (must satisfy all criteria)	
SP 1: Asking Questions	
☐	Instruction presents an event, observation, phenomenon, data, scenario, or model.
☐	Instruction has instructor/students <i>generate</i> an empirically testable question about the given event, observation, phenomenon, data, scenario, or model. (Question cannot be rhetorical or simply a part of instruction; rather it must be a <i>process of generating</i> a testable question.

SP 2: Developing and Using Models

- ☐ Instruction presents an event, observation, or phenomenon for instructor/students to explain or make a prediction about.
- ☐ Instruction presents a representation or asks instructor/students to construct a representation.
- ☐ Instruction has instructor/students explain or make a prediction about the event, observation, or phenomenon.
- ☐ Instruction has instructor/students provide the reasoning that links the representation to their explanation or prediction.

SP 3: Planning Investigations

- ☐ Instruction poses a scientific question, claim, or hypothesis to be investigated.
- ☐ Instruction has instructor/students describe or design an investigation, or identify the observations required to answer the question or test the claim or hypothesis.
- ☐ Instruction has instructor/students justify how their description, design, or observations can be used to answer the question or test the claim or hypothesis.

SP 4: Analyzing and Interpreting Data

- ☐ Instruction presents a scientific question, claim, or hypothesis to be investigated.
- ☐ Instruction provides a representation of data (table, graph, or list of observations) used to answer the question or test the claim or hypothesis.
- ☐ Instruction provides an analysis of the data or asks instructor/students to analyze the data.
- ☐ Instruction has instructor/students interpret the results or assess the validity of the conclusions in the context of the scientific question, claim, or hypothesis.

SP 5: Using Mathematics and Computational Thinking

- ☐ Instruction presents an event, observation, or phenomenon.
Instruction has instructor/students perform a calculation or statistical test, generate a mathematical representation, or demonstrate a relationship between parameters.
- ☐ Instruction has instructor/students give a consequence or an interpretation in words, diagrams, symbols, or graphs of their mathematical results while demonstrating reasoning in the context of the given event, observation, or phenomenon.

SP 6: Constructing Explanations and Engaging in Argument from Evidence

- ☐ Instruction presents an event, observation, or phenomenon.
- ☐ Instruction presents or asks instructor/students to make a claim based on the given event, observation, or phenomenon.
- ☐ Instruction has instructor/students provide scientific principles or evidence (data or observations) to support the claim.
- ☐ Instruction has instructor/students provide reasoning about why the scientific principles or evidence support the claim.

SP 7: Evaluating Information

- ☐ Instruction provides an excerpt from a conversation, article, student solution, or other communication that makes one or more assertions.
- ☐ Instruction presents a conclusion about the validity of the assertion(s) made or asks instructor/students to make a conclusion about the validity of the assertion(s), or reconcile multiple assertions with each other.
- ☐ Instruction has instructor/students provide reasoning to support their conclusion(s) about the validity of the assertion(s) or reconciliation with data, observations, or scientific principles.

Causal Mechanistic Reasoning

What drives the formation of bonds between atoms?

How:

- Both ionic and covalent bonds form as a result of electrostatic attractions between oppositely charged particles.
- Ionic bonding: electrostatic attractions between oppositely charged ions (ions formed from the gain or loss of electrons). **Important note: ionic bonding is NOT a transfer of electrons.**
- Covalent bonding: electrostatic attraction between nucleus of one atom and the valence electrons of another atom results in “sharing” of electrons between the two atoms. More accurate analogy may be a “tug of war” between two atoms for the valence electrons.

Why:

- Energy changes are associated with (and potentially drive) chemical reactions. Spontaneous reactions will result in a net decrease in energy.
 - For covalent bonds, this means that the new bonds formed by sharing result in a lower energy state than having two non-interacting atoms.
 - For ionic bonds, the electrostatic interactions between the newly formed ions are stronger than the original interactions between the atoms within the elemental compound. OR The formation of ionic bonds releases a great deal of energy (strong attractions) which compensates for the energy required to form ions.
 - For molecular compounds, the formation of new bonds are stronger than the bonds present in the elemental form.

Must have both parts!

What determines the Relative Strengths of Ionic Bonds?

How:

- Ionic bonds are formed by the electrostatic attractions between oppositely charged ions (ions formed from the gain or loss of electrons). Important note: ionic bonding is NOT a transfer of electrons.
- The strength of the ionic bond depends on the size and charge on the ions

Why:

- Coulomb's Law ($F \propto Q_1 Q_2 / D^2$) relates the strength of attraction between oppositely charged particles to size of charges and distance between them
- Higher charges and smaller distances between charges result in stronger attractions which means stronger bonds

Must have both parts!

What is the relationship between different types of bonds and physical properties? (molecular vs. covalent networks, or ionic)

How:

- Different kinds of compounds can be classified or identified based on physical properties (can be implicit).
- Physical properties depend on the strength of attractive forces between individual particles in the substance OR the types of particles that make up the substance.

Why:

- Network solids require the breaking of covalent bonds, but in the case of molecular compounds, you are only breaking IMFs which are notably weaker and can be disrupted at much lower temperatures. Thus mp/bp of network compounds are generally very high whereas molecular compounds have lower mp and bps.
- Mp/bp of ionic compounds are generally high due to strong electrostatic attractions between oppositely charged ions; conductivity of liquids and solutions because ions are free to move; brittle because when you bend like charged ions get close together and will repel; solubility of many in water as water is polar and positive end of water can surround negative ions etc.
- **Does not need to explain all of these but generally needs to explain some well.**

Must have both parts!

Multimedia Principles

Multimedia learning as knowledge construction: The goal of multimedia presentations is not only to present information but also to provide guidance for how to process the presented information – that is, for determining what to pay attention to, how to mentally organize it, and how to relate it to prior knowledge. We will categorize the videos along each of the following criteria (High and Low should be mutually exclusive.)

High	Low
• Video almost exclusively involves <u>meaningful and relevant</u> images and verbal components <u>AND images are explained for a novice learner</u> • Text on screen is minimal (ex. Only brief bullet points or keywords if text is used) • Content is all relevant to the topic and learning (no music, unhelpful animations, graphics, etc.) • Contains elements that meaningfully support student organizing content or identify key ideas (introductory organizer, section heading, summary, guiding questions/topic (for short, focused video only) Key Question: Could a novice learner clearly understand what they should take away from the video? Yes=high.	• Large segments of video presented just verbally and not pictorially (ex. just the instructor talking, or just written words) OR images presented are not relevant to learning or explained. If images are clearly incorrect or misleading it should be low. • Contains full sentences of written text that are also narrated (<i>e.g., several bullet points or sentences on one screen OR full sentences of text on many screens</i>) • Contains extraneous content, music, graphics, animations, background changes, sounds, or just too much stuff on the screen at one time - anything that detracts attention from core content • Does not contain any elements that meaningfully help learners organize content or identify key ideas (e.g., no introductory organizer, section headings, video segments, summary, guiding question/topic (for short focused videos only)