

# IMF Evaluation Information Page

## Search Terms:

- Intermolecular forces; IMFs; Induced dipole; London Dispersion Forces; Dipole-dipole; Hydrogen bonding; Noncovalent interactions

## Broad definition of what we are considering

We are considering electrostatic attractive forces BETWEEN species. This generally means between two separate molecules or between two separate parts of a molecule but could be between a molecule and an ion. This includes how these interactions are formed as well as how the relative charges/partial charges on the species and the distance between species affect the strength of the electrostatic attraction (Coulomb's law).

***To meet the concept of interest: Video must either describe HOW IMFs are formed OR explicitly connect physical properties of substances to TYPES and RELATIVE STRENGTHS of IMFs.***

***Videos designed to just answer a very narrow question (e.g., which substance would have a bp closest to that of Ar?) are not ones we will do a full evaluation of.***

***Videos where IMFS are mentioned and explained but the focus is not IMFs, e.g., a video focused on the physical properties of water are not ones we are going to evaluate.***

## Johnstone's Triangle Elements

| Element                   | Examples                                                                                                                                                                                                                                                                                                                     |
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| Macroscopic               | Visible phenomena - differences in physical properties of substances: molecular compounds in different phases at Room temp - sugar vs hexane; differences in mp or bp - water vs. ethane; differences in viscosity - water vs. glycerol; for BP, specific examples and values are often expected if only briefly addressed   |
| Symbolic                  | Chemical formulas of substances; Potential energy well diagram; graphical representation of relative strength of forces; Coulomb's Law; using arrows to show dipole moments; Dashed lines between molecules representing IMFs; Lewis structures of molecules - showing three or more LS interacting counts as particulate    |
| Particulate               | Particle representations of molecules oriented appropriately for electrostatic interactions OR that illustrates something like increase surface contact (for LDFs); Bohr or QM type model showing unequal distribution of electrons. Showing unequal distribution of electrons in atoms for LDFs is included in particulate. |
| 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 macroscopic example of things that are miscible or immiscible and then show the particle interactions between the miscible and immiscible components.                                     |

## Core Ideas

| Core Idea Elements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| Electrostatic Bonding & Interactions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Energy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Atomic/Molecular Structure & Properties                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Attractive and repulsive electrostatic forces govern noncovalent and bonding (covalent and ionic) interactions between atoms and molecules. The strength of these forces depends on the magnitude of the charges involved and the distances between them.</p> <p><b>Video needs to include:</b><br/>Intermolecular forces (attractive noncovalent interactions) exist between atoms/molecules due to instantaneous, induced, and permanent dipoles. <b>AND</b> <i>The strength of the attraction depends on the size of the dipole. (Needs to have this last part!)</i></p> <p><b>Difference between this and CMR Option 1 is that for CMR video must include HOW the dipoles (permanent or temporary) are formed.</b></p> | <p>Kinetic and potential energy changes occur when atoms and molecules interact. Energy is released to the surroundings when attractive noncovalent interactions form, and conversely, energy is required to overcome noncovalent interactions.</p> <p><b>Video is likely to include:</b><br/>Energy is required to overcome intermolecular attractions between molecules to change phase from solid to liquid to gas and conversely is released to surroundings when molecular compounds change phase from gas to liquid to solid. Discussion of phase changes is not required though.</p> | <p>The macroscopic physical and chemical properties of a substance are determined by the three-dimensional structure, the distribution of electron density, and the nature and extent of noncovalent interactions between the particles.</p> <p><b>Video needs to include:</b> Physical properties of molecular compounds can be explained based on the type(s) and strength(s) of IMFs that exist between particles. <b>AND</b> Describe how a change to the strength of the IMF will influence the physical property (e.g. as IMF strength increases, boiling point will increase.)</p> |

## Scientific Practices

| Scientific Practices Criteria (must satisfy all criteria)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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| <p><b>SP 1: Asking Questions</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Instruction presents an event, observation, phenomenon, data, scenario, or model.</li> <li><input type="checkbox"/> 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.)</li> </ul>                                                                                                                                                            |
| <p><b>SP 2: Developing and Using Models</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Instruction presents an event, observation, or phenomenon for instructor/students to explain or make a prediction about.</li> <li><input type="checkbox"/> Instruction presents a representation or asks instructor/students to construct a representation.</li> <li><input type="checkbox"/> Instruction has instructor/students explain or make a prediction about the event, observation, or phenomenon.</li> <li><input type="checkbox"/> Instruction has instructor/students provide the reasoning that links the representation to their explanation or prediction.</li> </ul> |

**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

### Option 1: What governs the strength of attraction between molecules (IMFs)?

#### How:

- Molecules are attracted to each other based on the partial charges (temporary or permanent) that exist. Opposite charges attract. The strength of attraction depends on the size of the dipoles (e.g., LDFs tend to be weaker than D-D as instantaneous dipoles are weaker than permanent dipoles).

#### Why:

- Particles develop partial charges based on the distribution of electrons within a molecule. Unequal sharing or complete transfer of electrons leads to permanent charges (partial or full charges respectively). Temporary dipoles are formed due to an asymmetric distribution of electrons within an atom or molecule (either through random motion or in response to another atom/molecule/ion/or electrical field). This should be addressed for each IMF type presented.

**Must have both parts! For videos that just talk about one type of IMF (e.g., DD) just need to describe why for the relevant IMF type.**

### Option 2: What drives the formation of attractions between molecules (IMFs)?

#### How:

- The strength of IMFs is governed by the magnitude of the charges involved and the distance between the interacting species.

#### Why:

- The formation of attractive forces between species results in a lower potential energy state for the system and a corresponding release of energy to the surroundings, or conversely overcoming attractive forces requires energy. Stronger attractions release more energy when formed/require more energy to overcome.

**Must have both parts!**

### Option 3: What is the relationship between different types of IMFs and physical properties?

#### How:

- Physical properties depend on the strength of attractive forces between individual particles in the substance.

#### Why:

- Mp/bp will increase with increasing strength of IMFs, because more energy is required to overcome them.
- Viscosity will increase with increasing strength of IMFs, because more energy is required to allow the molecules to move past each other.
- Vapor pressure will decrease with increasing strength of IMFs, because less energy will be required to overcome them and get into the vapor phase.

**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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| <ul style="list-style-type: none"><li>• Video almost exclusively involves <b><u>meaningful and relevant</u></b> images and verbal components <b>AND <u>images are explained for a novice learner</u></b></li><li>• Text on screen is minimal (ex. Only brief bullet points or keywords if text is used)</li><li>• Content is all relevant to the topic and learning (no music, unhelpful animations, graphics, etc.)</li><li>• Contains elements that <b>meaningfully</b> support student organizing content or identify key ideas (introductory organizer, section heading, summary, guiding questions/topic (for short, focused video only) <b>Key Question: Could a novice learner clearly understand what they should take away from the video?</b> Yes=high.</li></ul> | <ul style="list-style-type: none"><li>• Large segments of video are 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</li><li>• 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 includes forced closed captioning</i>)</li><li>• Contains extraneous content, music, graphics, animations, background changes, sounds, or just too much stuff on the screen at one time - <b>anything that detracts attention from core content</b></li><li>• 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)</li></ul> |

## Misleading vs. Inaccuracies

- Several minor spelling issues is misleading, not inaccurate
- Note: common confusing issue
  - Some videos use the terms van der Waals forces and London dispersion forces interchangeably.
  - Official IUPAC definition for van der Waals forces: The attractive or repulsive forces between molecular entities (or between groups within the same molecular entity) other than those due to bond formation or to the electrostatic interaction of ions or of ionic groups with one another or with neutral molecules. The term includes: dipole–dipole, dipole-induced dipole and London (instantaneous induced dipole-induced dipole) forces. The term is sometimes used loosely for the totality of nonspecific attractive or repulsive intermolecular forces.
    - Source: PAC, 1994, 66, 1077. (Glossary of terms used in physical organic chemistry (IUPAC Recommendations 1994)) on page 1175 [Terms] [Paper]  
(<https://goldbook.iupac.org/terms/view/V06597#:~:text=https%3A%2F%2Fdoi.org%2F10.1351,bond>)