

Gas Laws Evaluation Information Page

Search Terms:

- Ideal gas law, Boyle's law, Charles's law, Avogadro's law, $PV=nRT$, combined gas law, ideal gas properties

Broad definition of what we are considering

We are considering primarily the conceptual understanding of how particulate motion gives rise to the relationships between volume, pressure, and temperature for samples of gases. It is fine to exclusively be addressing Ideal gases, without being explicit about the assumptions.

We will not code videos that just use the combined gas law ($PV=nRT$) or any of the individual relationships to solve mathematical problems without addressing any of the conceptual aspects.

Topic

- *Either single gas law or Ideal gas law, not both*
- *Conceptual followed by calculations for videos that start with conceptual and then follow with practice problems using the gas laws*
- *If mainly conceptual with a single short problem thrown in the middle DO NOT use Conceptual followed by calculations*

Johnstone's Triangle Elements

Element	Examples
Macroscopic	Visible phenomena - balloons changing sizes at different temperatures, anything showing how macroscopic physical properties (V, T, P) of gases change when another variable is adjusted. This can be particulate representations that show macroscopic properties (e.g., increasing the temperature of a gas causing an increase in volume. If illustrating the relationship between P and another variable, there must be some measure of pressure to be macroscopic.)
Symbolic	Graphs that show how variables are related (e.g., P and V). $PV=nRT$ or any other relationship equation. Other example, n with down arrow and V with down arrow to symbolically illustrate a relationship. ($P\downarrow V\uparrow$)
Particulate	Particle representations of molecules oriented within a gas sample, showing significant distance between molecules. May involve animation showing molecules moving, or drawing indicating movement. Could show that different gases freely mix.
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 particles within a drawing of a balloon or other gas containing container and how changing temperature affects volume.

However, to meet the connections criteria, there should be a verbal explanation.

Core Ideas

Core Idea Elements		
Change and Stability in Chemical Systems	Particulate Nature of Matter	Atomic/Molecular Structure & Properties
Energy and entropy changes, the rates of competing processes, and the balance between opposing forces govern the fate of chemical systems. Video needs to include: Gas behaviour/properties are governed by gas particle motion. AND Changing one variable (P, V, T, or n) causes changes in the particle motion which results in changes in other variables. - Examples: Decreasing volume, keeping T and n constant, causes the particles to push out on the wall more which increases the pressure - Decreasing the temperature, keeping V and n constant, causes particles to slow down resulting in fewer and less forceful collisions with the container walls thus decreasing the pressure <i>Just showing particle motion without explicitly talking about changes in motion DOES NOT meet this.</i> <i>Does not need to include discussion of particle collisions to meet CI but CMR DOES require discussion of particle collisions.</i>	Matter is comprised of individual particles and it is through interactions of these individual particles that materials exhibit their properties and undergo chemical reactions Video needs to include: A description of how Kinetic molecular theory can be used to explain the properties of gases (gas particles travel in straight lines until they hit other gas particles or the walls of the container, volume of particles is negligible compared to total volume, particles collide elastically, speed of particles is dependent on temperature, attractive forces between particles are negligible). This includes stating that the pressure of a gas arises from collisions of the particles with the walls of the container.	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. Video needs to include: Describes how the particulate nature (having volume and IMFs) causes real gases to deviate from the Ideal Gas Law predictions.

Scientific Practices

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

Must have both How and Why!

Option 1: What happens to one ideal gas property (P, V, T, n) when there is a change in another (assuming the others are kept constant)?

How:

- Correctly describes how the change in the first variable will change the particulate motion related to the second variable. For example:
 - increasing the volume of a container will require gas particles to travel farther before hitting a wall of the container, or
 - increasing temperature will cause molecules to move faster.

Why:

- Explanation should clearly articulate why that change will affect the second variable in the way that it does, based on the particulate collisions with the walls. For example:
 - the increased volume of the container will result in fewer collisions with the wall and thus a lower pressure, or
 - that the faster moving particles will have more collisions with the wall and greater force, which will increase the pressure (or in a flexible container, expand the size of the container until the internal and external pressures are equal.)
 - OR If pressure is constant, decreasing the temperature will result in fewer collisions with the walls causing the pressure inside to be less than the pressure outside which will in turn result in a decrease in volume until the external and internal pressures are again equal.

Option 2: What explains deviations from ideal gas behaviour (real gases)?

How:

- Real gases frequently do not meet the expectations for ideal gases, e.g., have pressures that are lower or higher than what would be predicted by the ideal gas law, because gas particles do possess some volume and exhibit some IMFs with other particles in the gas phase.

Why:

- Especially at high pressures (low volumes), the volume of real gases will decrease the “empty space” available to ideal gases which means that the predicted pressure will be lower than the actual pressure.

- Especially at low temperatures, the IMFs of real gases will cause molecules to sometimes stick together and decrease the effective number of particles in the systems. This means the predicted pressure will be higher than the actual pressure.

Must address both aspects of the why.

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 or definitions 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 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 • 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>) • 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)

Misleading vs. Inaccuracies

- Several minor spelling issues is misleading, not inaccurate