

Kinetics Information Page

Search Terms:

- Reaction kinetics
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- Factors affecting reaction rate
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- Reaction rate examples
- Collision theory in kinetics
- Activation energy in reactions
- Reaction mechanisms

Broad definition of what we are considering

- We are considering primarily the conceptual understanding of reaction kinetics in chemical systems. This includes how reaction rates are influenced by various factors, the **interpretation of rate laws***, and the mechanisms of reactions. We are not focused on videos that exclusively solve mathematical problems involving reaction rates without addressing the conceptual aspects OR videos that just address collision theory and do not address any aspects of reaction rates.
***Note: Interpretation of rate laws connecting order to collisions and/or mechanism. It is not enough to say that you can only get the coefficients from the mechanism, there needs to be an explanation of how the coefficients are derived from the mechanism.**

Johnstone's Triangle Elements

Element	Examples
Macroscopic	Visual examples of chemical reactions with different rates (e.g., slow rusting of iron vs. fast combustion of gasoline, color changing reactions). Demonstrations of factors affecting reaction rates (e.g., temperature, concentration, catalysts). <i>Note: Just showing a picture of things with different surface areas and saying that the one with more surface area will react faster falls under verbal only.</i>
Symbolic	Chemical equations showing reaction rates (e.g., rate laws). Graphs or diagrams illustrating reaction rates (e.g., concentration vs. time graphs). Reaction energy diagrams Equations involving reaction kinetics (e.g., $\text{rate} = k[\text{A}]^n[\text{B}]^m$).
Particulate	Particle depictions showing collisions between reactant molecules. Illustrations of transition states and intermediates at the particulate level. [not observed]

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 a fast reaction and connect it to particle diagrams showing collisions and symbolic representations of rate laws.
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Core Ideas

Core Idea Elements	
Change and Stability in Chemical Systems	Energy
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: Factors such as temperature, reactant concentration, and catalysts can influence the rate of chemical reactions by changing the frequency and/or energy of collisions. OR Many chemical processes involve multiple steps and the overall rate of the process is governed by the slowest step. <i>This should involve a specific example where it is shown how the different steps being slow are carried to the impact on the rates.</i>	Energy changes are either the cause or the consequence of change in chemical systems, which can be considered on different scales and can be accounted for by the conservation of the total energy of the system of interest and the surroundings. Video needs to include: For particles to react to form products, they must collide with sufficient energy to overcome the activation energy barrier. AND - Catalysts speed up a reaction by lowering the activation energy of a reaction. OR - Increasing temperature increases the average energy of the particles and number of collisions with enough energy to react.
Particulate Nature of Matter	Electrostatic Bonding and Interactions
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: Reactions proceed through collisions between particles. For a reaction to occur, individual particles must collide with the correct orientation and sufficient energy to react. Factors that directly alter the number of successful collisions will change the rate of a reaction. <i>(needs to explicitly mention both orientation and energy to meet this)</i>	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. Video needs to include: Chemical reactions require the input of sufficient energy to break bonds between atoms in the reactants (or achieve the transition state which is a partial breaking and forming of bonds). This should be linked to specific bonds within a reaction.

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 is the effect of temperature on the rate of a reaction?** (Linked to Energy)

- **How:** At higher temperatures, reactant molecules have more kinetic energy, leading to more frequent and energetic collisions. [Both more frequent and energy required]
- **Why:** Increased kinetic energy means that a greater proportion of collisions have enough energy to overcome the activation energy barrier, resulting in a higher reaction rate.

Option 2: What is the effect of a catalyst on the rate of a reaction? (Linked to Energy)

- **How:** Catalysts provide an alternative reaction pathway with a lower activation energy, allowing reactant molecules to convert into products more easily.
- **Why:** By lowering the activation energy, catalysts increase the number of successful collisions, thereby speeding up the reaction without being consumed in the process.

Option 3: What is the effect of concentration on the rate of a reaction? (Linked with Particulate Nature of Matter)

- **How:** Higher concentrations of reactants lead to more frequent collisions between reactant molecules.
- **Why:** Increased collision frequency means that more reactant molecules can have the opportunity to interact and form products, resulting in a higher reaction rate.

Note: Needs to be talking about this in terms of a reaction. Saying that increasing concentration/pressure means more particles per unit area, thus more collisions and faster reaction without talking about collisions between reactants or talking about a specific reaction does not meet this.

Option 4: What is the effect of surface area on the rate of a reaction? (Linked with Particulate Nature of Matter)

- **How:** More surface area of solid reactants lead to more spots for collisions between reactant molecules.
- **Why:** Increased collision frequency means that more reactant molecules can have the opportunity to interact and form products, resulting in a higher reaction rate.

Option 5: What causes a reaction to be fast or slow? (Linked with Energy and Bonding/Electrostatics)

- **How:** The rate of a chemical reaction is affected by the activation energy - amount of energy that particles need to collide with for a reaction to occur. Reactions with higher activation energies occur more slowly.

- **Why:** For a reaction to occur, bonds have to break. Stronger bonds require more energy to break so reactions that involve breaking stronger bonds are slower.

Option 6: What determines the rate of a chemical reaction? (Linked to Change/Stability and Energy)

- **How:** The rate of a chemical reaction is determined by the slowest step in the reaction mechanism.
- **Why:** The slowest step in a mechanism has the highest total energy of any transition state throughout the process of converting reactants to products. Achieving this energy state will be least likely due to the higher required energy which will therefore limit how quickly products can be formed.

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 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

Topics:

- Reaction coordinate diagram. Need to have and use a little.

Captions

- Videos with full on-screen captions (that can not be removed) are considered “low” for multimedia when considering text usage.

Self-Assessment

- Self-assessment needs to be relevant to the general conceptual idea, and there needs to be enough pause or verbal suggestion to imply to a watcher they should take time to answer the question.