CHEMDU · COMMUNITY CHEMISTRY · LEVEL 1

LECTURE 9

Kinetics & Equilibrium

Fast vs. Slow — Why Food Spoils, Why Medicine Works, and When to Throw It Out

■ Duration: 50 minutes

Lecture script · with hooks, segments, demos, and key takeaways

Hook (opening 3 minutes)

Teacher holds up (or shows photos of):

A glass of milk with a expiration date

A whole vs. crushed Alka-Seltzer tablet

A refrigerator (showing cold temperature)

A pressure cooker

Teacher says: "Milk left on the counter spoils in hours. Milk in the fridge lasts a week. Crushed Alka-Seltzer fizzes faster than a whole tablet. A pressure cooker cooks food in half the time.

Why? Same chemistry — different speeds.

- Today's question: What controls how fast a reaction happens — and how can you use that knowledge to keep food safe and medicine effective? *

By the end of this session, you will be able to:

Name four things that make chemical reactions faster or slower

Explain why you should never leave cooked rice out overnight

Understand why crushing medicine makes it work faster (and when that's dangerous)"

SEGMENT 1: What Is Kinetics? (6 minutes)

Teacher says: "Let's start with the word kinetics (kih-NET-iks).

Kinetics is the study of how fast chemical reactions happen. Some reactions are fast (explosions, fizzing). Some are slow (rust, food spoiling).

Everyday example: A match lights in a split second (fast). An iron fence takes years to rust (slow). Both are chemical reactions — just at different speeds.

Teacher continues: "Why do some reactions happen fast and others slow? It depends on four things:

Factor	What It Means	Speeds Up or Slows Down?
Temperature	How hot or cold it is	Hotter = faster; colder = slower
Concentration	How much chemical is in a liquid	More = faster; less = slower
Surface area	How much of a solid is exposed	More exposed = faster; less = slower
Catalyst	A helper that speeds things up without being used up	Adds a catalyst = faster

Memorization trick:

Hotter = faster. Colder = slower.

More = faster. Less = slower.

Smaller pieces = faster. Big chunks = slower.

Quick poll (show hands): "Raise your hand if you've ever seen sugar dissolve faster in hot coffee than in iced coffee."

Teacher: "You already know kinetics. Hot coffee = faster dissolving. That's temperature at work."

SEGMENT 2: Factor #1 — Temperature (6 minutes)

Teacher says: "The most important factor for everyday life is temperature.

Higher temperature = molecules move faster. They crash into each other more often and with more energy. More crashes = faster reaction.

Everyday examples:

Cold (Slow)	Hot (Fast)
Milk in fridge — lasts a week	Milk on counter — spoils in hours
Butter in fridge — solid	Butter in hot pan — melts instantly
Ice cube — melts slowly	Ice cube in hot water — melts fast
Bacteria grow slowly in fridge	Bacteria grow fast at room temperature

Safety application — food spoilage (2 minutes):

Teacher: "Bacteria are living things that perform chemical reactions to grow and multiply. Those reactions are temperature-sensitive. Warm temperatures speed up bacterial reactions. Cold temperatures slow them down.

Food	Safe in Fridge (40°F / 4°C)	Safe on Counter (70°F / 21°C)
Cooked rice	3-4 days	2 hours (then dangerous)
Cooked meat	3-4 days	2 hours
Dairy (milk, yogurt)	Until expiration date	2 hours
Leftover pizza	3-4 days	2 hours

The "2-hour rule":

Perishable food left at room temperature for more than 2 hours should be thrown out. Bacteria grow fast enough to make you sick.

Partner talk (1 minute): "Tell your partner: You cook dinner at 6 PM. You forget to put the leftovers in the fridge until 10 PM. Is the food safe to eat tomorrow?"

Answer: No — food has been at room temperature for 4 hours, more than the 2-hour limit. Throw it out.

Key safety rule (repeat together): "When in doubt, throw it out. Two hours on the counter is the limit."

SEGMENT 3: Factor #2 — Concentration (6 minutes)

Teacher says: "The second factor is concentration (kon-sen-TRAY-shun).

Concentration means how much of a chemical is in a given amount of liquid. Higher concentration = more molecules in the same space = more crashes = faster reaction.

Everyday examples:

Low Concentration (Slow)	High Concentration (Fast)
Weak lemonade (1 scoop powder)	Strong lemonade (3 scoops powder)
Diluted bleach (safe for cleaning)	Full-strength bleach (burns faster)
Small amount of medicine	Large dose of medicine (faster effect — but dangerous)
Small amount of bacteria in food	Large amount of bacteria in food (gets you sick faster)

Safety application — medicine dosing (2 minutes):

Teacher: "Higher concentration of medicine means faster and stronger effects. That's why you must measure medicine exactly.

Scenario	Safe	Dangerous
Child's liquid medicine	Measure with the dosing tool (low concentration for child's weight)	Using a kitchen spoon (too much = higher concentration = overdose risk)
Adult pain reliever	1-2 pills as directed	4+ pills = higher concentration in blood = liver damage risk

Quick poll (show hands): "Raise your hand if you've ever thought 'if one pill is good, two pills must be better.'"

Teacher: "That's a common thought — but it's wrong. Higher concentration means faster reaction in your body. Too fast can damage your liver, kidneys, or stomach. Always follow the label."

SEGMENT 4: Factor #3 — Surface Area (6 minutes)

Teacher says: "The third factor is surface area (SUR-fess AIR-ee-uh).

Surface area is how much of a solid is exposed to its surroundings. Smaller pieces have more surface area than one big piece. More surface area = more places for the reaction to happen = faster reaction.

Everyday examples:

Large Pieces (Slow, less surface area)	Small Pieces (Fast, more surface area)
Whole Alka-Seltzer tablet (fizzes slowly)	Crushed Alka-Seltzer (fizzes instantly)
Large log on a campfire (burns slowly)	Small twigs and kindling (burn fast)
Bite-size food (digests slower)	Chewed food (digests faster)

Show this visual (draw or describe):

text

One sugar cube (1 piece) Same sugar crushed into powder

Surface area = 6 small sides Surface area = thousands of tiny particles

Dissolves slowly Dissolves instantly

Teacher continues: "This is why you chew your food. Your teeth increase surface area so your stomach can digest it faster.

Safety application — dust explosions (2 minutes):

Dust explosion: When fine dust (flour, sawdust, grain) is suspended in air, each tiny particle has lots of surface area. A spark can cause an explosion that burns everything instantly.

Material	As a solid (safe)	As dust (dangerous)
Flour	Safe in a bag	Flour dust in the air — can explode
Sawdust	Safe in a pile	Sawdust cloud — can explode
Grain	Safe in a silo	Grain dust — can explode

Teacher: "This is rare at home, but it happens in factories and grain elevators. Never throw flour or powdered sugar near an open flame — it can ignite."

Phvsical action:

"Pretend you're chewing food (crushing motion with teeth). That's increasing surface area for faster digestion."

"Pretend you're crushing a pill (using a spoon). That makes it work faster — but ask a doctor first. Some pills are designed to be slow."

SEGMENT 5: Factor #4 — Catalysts (6 minutes)

Teacher says: "The fourth factor is catalyst (KAT-uh-list).

A catalyst is something that speeds up a chemical reaction without being used up itself. It helps molecules crash together, but it doesn't change or disappear.

Everyday examples:

Catalyst	Where It Works	What It Does
Enzymes (in your body)	Your stomach, cells, liver	Break down food, build new cells
Catalytic converter	Your car's exhaust system	Turns toxic gases into less toxic gases
Manganese dioxide	Hydrogen peroxide (to make oxygen)	Speeds up decomposition of peroxide

Teacher continues: "The most important catalysts in your body are enzymes (EN-zimes).

Enzymes are protein catalysts that speed up chemical reactions in your body. Without enzymes, reactions would be too slow to keep you alive.

How fast are enzymes?

Without enzymes: Breaking down food could take weeks

With enzymes: Breaking down food takes hours

> Real-world example — lactose intolerance: "Lactose is a sugar in milk. Your body makes an enzyme called lactase (LAK-tase) to break it down. If your body doesn't make enough lactase, milk sugar stays undigested — that causes gas, bloating, and diarrhea. That's lactose intolerance."
>
> Quick poll (show hands): "Raise your hand if you or someone you know has lactose intolerance."

Teacher: "People with lactose intolerance can take a pill containing the enzyme lactase. That pill is a catalyst — it breaks down milk sugar so their body can digest it."

SEGMENT 6: What Is Equilibrium? (7 minutes)

> Teacher says: "Now let's talk about equilibrium (ee-kwih-LIB-ree-um).

Equilibrium is when a chemical reaction is happening in both directions at the same speed. Forward reaction and backward reaction cancel each other out. Nothing seems to change, even though reactions are still happening.

Everyday example — a soda bottle: "Inside a sealed soda bottle, carbon dioxide (CO■) is in the space above the liquid (gas) AND dissolved in the soda (liquid). Molecules move from gas to liquid and from liquid to gas at the same speed. That's equilibrium."

Show this visual (draw or describe):

text

Soda bottle:

Gas space (CO■) ←→ Liquid soda (CO■ dissolved)

↑ ↑

■■ molecules move ■■■

both directions at same speed

Teacher continues: "What happens when you open the bottle? You release the gas. Now the forward reaction (gas → liquid) and backward reaction (liquid → gas) are no longer balanced. CO■ comes out of the liquid quickly — that's the fizz."

Real-world example — your lungs: "Your blood carries oxygen (O■) and carbon dioxide (CO■). When you breathe in, oxygen enters your blood. When you breathe out, carbon dioxide leaves your blood. Your body maintains equilibrium so you have just the right amount of each gas."

Safety application — deep-sea diving (the bends) (2 minutes):

Depth	Pressure	What Happens to Nitrogen in Blood	Risk
Surface	Normal pressure (1 atm)	Normal amount of nitrogen dissolved in blood	Safe
Deep underwater	High pressure (3+ atm)	More nitrogen dissolves in blood (equilibrium shifts)	Safe while down there
Rising too fast	Pressure drops quickly	Nitrogen comes out of blood as BUBBLES (like opening a soda)	Dangerous — can cause joint pain, paralysis, death

Teacher: "Divers must ascend slowly to let equilibrium happen gradually — so nitrogen comes out of blood slowly, not as bubbles. That's called decompression (dee-kom-PRESH-un)."

Partner talk (1 minute): "Tell your partner: Why do scuba divers rise slowly to the surface?"

Answer: To let dissolved nitrogen leave their blood slowly — otherwise, bubbles form (the bends), which is painful and dangerous.

SEGMENT 7: Bringing It All Together — The "Kinetics in Your Kitchen" Quiz (4 minutes)

Teacher says: "Let's test your knowledge with real kitchen situations. I'll describe a situation. You tell me which factor(s) are at work."

Situation	Which Factor? (Temperature / Concentration / Surface Area / Catalyst)	Why?
A pressure cooker cooks food faster	Temperature (higher pressure = higher boiling point = hotter)	Hotter = faster reactions
Crushed garlic has more flavor than whole garlic cloves	Surface area (crushing exposes more surface)	More exposed = faster release of flavor molecules
Your stomach uses enzymes to digest food	Catalyst (enzymes speed up digestion)	Without enzymes, digestion would take weeks
Leftover soup spoils faster in summer than in winter	Temperature (summer heat speeds bacterial growth)	Hotter = faster bacterial reactions
A small amount of bacteria in food vs. a large amount	Concentration (more bacteria = faster spoilage)	Higher concentration = faster reaction

Quick check (show of hands for each one): "Pressure cooker — show hands if you think it's temperature." (Yes) "Crushed garlic — show hands if you think it's surface area." (Yes)

CLOSING — The 30-Second Challenge (3 minutes)

Teacher says: "Pair up. Person A: 30 seconds — name the four factors that affect reaction speed, and give one example of each. Person B: 30 seconds — why should you never leave cooked rice on the counter for 4 hours?"

Final takeaway table (show on screen / read aloud):

You learned…	So you can…
Temperature — hotter = faster; colder = slower	Refrigerate leftovers within 2 hours
Concentration — more = faster; less = slower	Measure medicine exactly — more is NOT better
Surface area — smaller pieces = faster	Chew your food; crush medicine only if directed
Catalyst — speeds reactions without being used up	Understand enzymes (lactase for milk digestion)
Equilibrium — reactions happening both directions at same speed	Understand why scuba divers ascend slowly (the bends)
2-hour rule — perishable food at room temperature >2 hours = throw out	Prevent food poisoning
Dust explosions — fine dust in air can explode	Never throw flour or powdered sugar near a flame

Final line (preview of next week): "Next week: Gas Laws — why your tires bulge in summer, why a chip bag puffs up on an airplane, and why you should never heat a sealed aerosol can. See you then."

SUPPLEMENTARY MATERIALS FOR LECTURE 9 (No Grade)

Resource	Source	Description	Link / Search Term
Video: "Factors Affecting Reaction Rates"	Khan Academy	5-minute explanation	Search "Khan Academy reaction rates factors"
PhET "Reaction Rates" simulation	University of Colorado	Interactive — change temperature, concentration, surface area	Search "PhET reaction rates"
Food safety: 2-hour rule	USDA / Foodsafety.gov	Official guidelines for leftovers	Search "USDA 2 hour rule leftovers"
Article: "How Do Enzymes Work?"	ACS ChemMatters	Readable explanation of biological catalysts	Search "ChemMatters enzymes"
Decompression sickness (the bends)	Divers Alert Network	What happens and why divers ascend slowly	Search "DAN decompression sickness"

OPTIONAL "NO-PRESSURE" ASSIGNMENT

"Between now and next session, check your refrigerator. Find something with an expiration date or a 'refrigerate after opening' label. Next time, tell us: what is it, and why does cold temperature keep it safe longer?"

DEFINITIONS SUMMARY FOR LECTURE 9 (Student Handout)

Term	Simple Definition	Everyday Example
Kinetics	The study of how fast chemical reactions happen	Fast = match; slow = rust
Temperature	How hot or cold something is	Hot coffee dissolves sugar faster
Concentration	How much chemical is in a given amount of liquid	Strong lemonade (more powder) = faster taste
Surface area	How much of a solid is exposed	Crushed Alka-Seltzer fizzes faster
Catalyst	Something that speeds up a reaction without being used up	Enzymes in your stomach digest food
Enzymes	Protein catalysts in your body	Lactase breaks down milk sugar
Equilibrium	When forward and backward reactions happen at same speed	Sealed soda bottle — CO■ moves gas ↔ liquid
The bends	Nitrogen bubbles forming in blood when rising too fast from deep water	Scuba divers must ascend slowly
2-hour rule	Perishable food at room temperature for more than 2 hours should be thrown out	Leftovers forgotten on the counter