CHEMDU · COMMUNITY CHEMISTRY · LEVEL 1

LECTURE 10

Gas Laws

Why Tires Bulge in Summer, Why Chip Bags Puff Up on Planes, and Why You Should Never Heat a Sealed Can

■ Duration: 50 minutes

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

Hook (opening 3 minutes)

Teacher holds up (or shows photos of):

A car tire (bulging in summer heat)

A sealed bag of chips from an airplane (puffed up)

An aerosol can (hairspray, deodorant) with a "do not incinerate" warning

A hot air balloon

Teacher says: "You check your tire pressure in winter. It's fine. You check again in summer. It's too high. You didn't add air. Where did the extra pressure come from?

You open a bag of chips on an airplane. It looks like it's going to explode. You open the same bag on the ground. It's normal. Why?

- Today's question: How do temperature, pressure, and volume affect gases — and why does that matter for your safety? *

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

Explain why tires bulge in summer and why you should check pressure when tires are cold

Understand why a sealed aerosol can explodes if heated

Know why scuba divers can't hold their breath while ascending"

SEGMENT 1: What Is a Gas? (5 minutes)

Teacher says: "Let's start with what a gas is.

A gas is a state of matter where particles are far apart, moving fast, and not stuck together. Gases have no fixed shape and no fixed volume — they expand to fill any container.

Everyday examples you already know: *

Gas	Where You Find It	What It Does
Oxygen (O■)	Air (21% of the air you breathe)	Keeps you alive
Nitrogen (N■)	Air (78% of the air you breathe)	Dilutes oxygen — safe
Carbon dioxide (CO■)	Soda, dry ice, air you breathe out	Makes soda fizzy
Helium (He)	Balloons	Floats — lighter than air
Propane (C■H■)	Gas grills, camping stoves	Burns for heat

Teacher continues: "Gases behave differently than solids or liquids. Three things affect a gas:

Property	What It Means	Units We'll Use
Pressure (P)	How hard the gas is pushing on its container	PSI (pounds per square inch, for tires)
Volume (V)	How much space the gas takes up	Liters, cubic feet, or bag size
Temperature (T)	How hot or cold the gas is	°F or °C (Fahrenheit or Celsius)

Memorization trick:

Pressure = pushing force

Volume = space taken

Temperature = how fast gas particles are moving

Phvsical action:

> *"Pretend your hands are gas particles. Spread them far apart — that's low pressure. Push them close together — that's high pressure."*

SEGMENT 2: Gas Law #1 — Temperature and Volume (Charles's Law) (8 minutes)

Teacher says: "The first gas law is Charles's Law (CHAR-lez Law).

Charles's Law says: When pressure stays the same, increasing temperature makes a gas expand (take up more volume). Decreasing temperature makes a gas shrink (take up less volume).

Everyday example — hot air balloon: "A hot air balloon has a burner that heats the air inside the balloon. Heated air expands (takes up more space). The same number of air particles now need more room, so the balloon inflates. The expanded air is lighter than the cool air outside — so the balloon floats up."

Show this simple relationship:

text

Temperature UP → Volume UP (gas expands)

Temperature DOWN → Volume DOWN (gas shrinks)

Everyday examples you already know: *

Situation	What Happens	Why (Charles's Law)
Sealed chip bag on an airplane	Bag puffs up (expands)	Air pressure in the plane is lower at altitude. But temperature also changes. The bag expands.

Situation	What Happens	Why (Charles's Law)
Tire in summer vs. winter	Tire pressure increases in summer	Warm air expands inside the tire → higher pressure
Basketball in cold garage	Ball feels flat	Cold air shrinks inside → lower pressure
Hot air balloon	Balloon rises	Heated air expands → becomes lighter than cool air

Partner talk (1 minute): "Tell your partner: You leave a sealed plastic water bottle in a hot car. When you come back, the bottle is bulging. Why?"

Answer: Charles's Law — the air inside got hot, expanded, and pushed on the bottle walls.

Safety application — never heat a sealed container (2 minutes):

Teacher: "If you heat a sealed container, the gas inside expands. If it can't expand because the container is sealed, pressure builds up. If pressure gets too high, the container can explode.

Container	Safe?	Why?
Aerosol can (hairspray, deodorant)	NEVER heat	Gas expands → pressure builds → can explode like a bomb
Sealed soda can	NEVER heat	Can burst — hot soda + pressure = explosion risk
Pressure cooker	Safe — has a pressure release valve	Valve lets extra pressure escape
Car tire	Check when cold — driving heats tires	Driving increases temperature → pressure rises → possible blowout if overinflated

Safety rule (repeat together): "Never heat a sealed aerosol can. Never leave one in a hot car. Never throw one in a fire."

SEGMENT 3: Gas Law #2 — Pressure and Volume (Boyle's Law) (8 minutes)

Teacher says: "The second gas law is Boyle's Law (BOY-ulz Law).

Boyle's Law says: When temperature stays the same, increasing pressure makes a gas take up less volume (squeeze it). Decreasing pressure makes a gas take up more volume (expand).

Show this simple relationship:

text

Pressure UP → Volume DOWN (gas gets squeezed)

Pressure DOWN → Volume UP (gas expands)

Everyday example — a syringe: "Think of a syringe (without the needle). Pull the plunger back. You increase the volume inside. The pressure goes down. Air rushes in to fill the space. Push the plunger in. You decrease the volume. The pressure goes up. Air pushes out."

Everyday examples you already know: *

Situation	What Happens	Why (Boyle's Law)
Squeezing a balloon	Balloon bulges out on the sides	You increase pressure on one spot → gas moves to lower pressure area
Bicycle pump	Pushing plunger forces air into the tire	Decreasing volume = increasing pressure = air moves out
Marshmallow in a syringe	Pull plunger → marshmallow expands	Lower pressure → gas inside marshmallow expands
Deep-sea diving	Pressure increases as you go deeper	Volume of air in your lungs decreases

> Partner talk (1 minute): "Tell your partner: You squeeze a plastic water bottle with your hand. The bottle gets smaller. What happens to the pressure inside?"

Answer: Pressure increases (Boyle's Law — volume down = pressure up).

Safety application — scuba diving and lung overexpansion (2 minutes):

Teacher: "This is life-saving knowledge for scuba divers.

Depth	Pressure	What Happens to Air in Lungs
Surface (0 feet)	1 atmosphere (normal pressure)	Normal lung volume
33 feet underwater	2 atmospheres (double pressure)	Air in lungs is squeezed to half its normal volume
66 feet underwater	3 atmospheres (triple pressure)	Air in lungs is squeezed to one-third volume

The danger: "If a diver takes a deep breath at 66 feet (high pressure) and then swims straight up to the surface without exhaling, the air in their lungs expands rapidly. The lungs can overexpand and rupture. This is called lung overexpansion injury — it can kill you.

The rule: Never hold your breath while scuba diving. Breathe normally and continuously."

> Quick poll (show hands): "Raise your hand if you've ever been scuba diving or thought about trying it."

Teacher: "Now you know the most important safety rule: never hold your breath underwater while diving with scuba gear."

SEGMENT 4: Gas Law #3 — Pressure and Temperature (Gay-Lussac's Law) (8 minutes)

Teacher says: "The third gas law is Gay-Lussac's Law (gay-loo-SAKS Law).

Gay-Lussac's Law says: When volume stays the same (container doesn't change size), increasing temperature increases pressure. Decreasing temperature decreases pressure.

Show this simple relationship:

text

Temperature UP → Pressure UP (if container is sealed)

Temperature DOWN → Pressure DOWN (if container is sealed)

Everyday examples you already know: *

Situation	What Happens	Why (Gay-Lussac's Law)
Car tire in summer	Tire pressure goes up	Hot air expands → pushes harder on tire walls
Car tire in winter	Tire pressure goes down (low pressure warning light)	Cold air shrinks → pushes less
Aerosol can in hot car	Can bulges — could explode	Gas inside gets hot → pressure increases → can bursts
Pressure cooker	Pressure builds up as temperature rises	Sealed container + heat = higher pressure (cooks food faster)

Teacher continues: "This is why your car's tire pressure monitoring system (TPMS) light often comes on in the morning when it's cold. The air inside the tires is cold → lower pressure. As you drive, tires warm up → pressure returns to normal."

Safety application — checking tire pressure (2 minutes):

When to Check	Why
When tires are COLD (before driving more than 1 mile)	Cold pressure is the correct pressure. Driving heats tires and increases pressure temporarily.
In the morning	Best time — tires haven't been heated by driving or sun
At least once a month	Tires naturally lose pressure over time (about 1-2 PSI per month)

What to do if your low pressure light comes on:

Check pressure with a tire gauge when tires are cold

Add air to reach the recommended PSI (listed on a sticker inside the driver's door)

If pressure drops again quickly, you may have a leak or a nail in the tire

Safety rule (repeat together): "Check tire pressure cold. Once a month. Before long trips."

Phvsical action:

> *"Pretend you're using a tire pressure gauge (push onto valve stem, look at reading)."*

SEGMENT 5: Bringing It All Together — The Three Gas Laws (6 minutes)

Teacher says: "Let's review all three gas laws with one simple table."

Show this table (read aloud and discuss):

Law Name	What Changes	What Stays the Same	Relationship	Everyday Example
Charles's Law	Temperature ↔ Volume	Pressure	Hot = bigger volume; Cold = smaller volume	Hot air balloon, chip bag on plane
Boyle's Law	Pressure ↔ Volume	Temperature	Squeeze = smaller volume; Expand = lower pressure	Syringe, bicycle pump, diving
Gay-Lussac's Law	Temperature ↔ Pressure	Volume	Hot = higher pressure; Cold = lower pressure	Car tire summer vs. winter, aerosol can

Memorization trick:

Charles: Temperature changes Volume (both change)

Boyle: Pressure changes Volume (opposite directions)

Gay-Lussac: Temperature changes Pressure (both change together)

Partner talk (2 minutes): "Tell your partner the name of each law and one example:

Charles's Law example? (Hot air balloon)

Boyle's Law example? (Syringe, diving)

Gay-Lussac's Law example? (Car tire summer vs. winter)"

SEGMENT 6: The "Gas Law in Real Life" Quiz (6 minutes)

Teacher says: "Let's test your knowledge with real situations. I'll describe something. You tell me which gas law applies."

Situation	Which Gas Law?	Why?
A sealed bag of coffee beans puffs up when you drive from sea level to the mountains (lower air pressure)	Boyle's Law	Lower outside pressure → gas inside bag expands (volume up)
You leave a propane tank for your grill in the sun. The pressure gauge reads higher than when it was in the shade.	Gay-Lussac's Law	Temperature up → pressure up (volume is fixed — tank doesn't expand)
A child's helium balloon shrinks when you bring it inside from a hot car into an air-conditioned house.	Charles's Law	Temperature down → volume down (gas shrinks)
A scuba diver takes a balloon underwater at 33 feet. The balloon gets smaller.	Boyle's Law	Pressure up (underwater) → volume down (balloon squeezes)
An aerosol can has a warning: "Do not store above 120°F."	Gay-Lussac's Law	Heat increases pressure inside sealed can → explosion risk

Quick check (show of hands for each one):

Coffee beans at high altitude — raise hand if you think Boyle's Law (Yes)

Propane tank in sun — raise hand if you think Gay-Lussac's Law (Yes)

Helium balloon in cold room — raise hand if you think Charles's Law (Yes)

CLOSING — The 30-Second Challenge (3 minutes)

Teacher says: "Pair up. Person A: 30 seconds — explain why tire pressure is higher in summer than in winter (name the law). Person B: 30 seconds — explain why you should never heat a sealed aerosol can (name the law)."

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

You learned…	So you can…
Charles's Law — hotter = gas expands (volume up); colder = gas shrinks (volume down)	Understand why chip bags puff up on planes; why hot air balloons rise
Boyle's Law — squeeze = volume down, pressure up; expand = volume up, pressure down	Understand syringes, bicycle pumps, and why divers can't hold their breath
Gay-Lussac's Law — hotter sealed container = higher pressure; colder = lower pressure	Check tire pressure when cold; never heat aerosol cans
Never heat a sealed aerosol can	Prevent explosion — don't leave in hot car or throw in fire
Check tire pressure when tires are cold	Get accurate reading — driving heats tires and increases pressure temporarily

You learned…	So you can…
Scuba divers must never hold their breath	Prevent lung overexpansion injury (Boyle's Law — expanding air ruptures lungs)
Tire pressure drops in winter, rises in summer	Add air in winter; check more often when seasons change

Final line (preview of next week): "Next week: Nuclear Chemistry (Light Version) — why smoke detectors have radioactive material, why you should test your home for radon, and what to do if you see the trefoil symbol (■■). See you then."

SUPPLEMENTARY MATERIALS FOR LECTURE 10 (No Grade)

Resource	Source	Description	Link / Search Term
Video: "Gas Laws" (Boyle, Charles, Gay-Lussac)	Khan Academy	8-minute explanation with animations	Search "Khan Academy gas laws"
PhET "Gas Properties" simulation	University of Colorado	Interactive — pump gas molecules, change temperature, see pressure and volume change	Search "PhET gas properties"
Tire pressure safety	NHTSA / safercar.gov	Official guidance on checking tire pressure	Search "NHTSA tire pressure"
Scuba diving lung overexpansion	Divers Alert Network	Medical explanation of why holding breath underwater is dangerous	Search "DAN lung overexpansion"
Article: "The Science of Hot Air Balloons"	ACS ChemMatters	How Charles's Law makes balloons fly	Search "ChemMatters hot air balloon"

OPTIONAL "NO-PRESSURE" ASSIGNMENT

"Between now and next session, check the tire pressure on a car (yours, a family member's, or a friend's). Look at the sticker inside the driver's door — it tells you the recommended PSI. Check when tires are cold. Next time, tell us what you found."

DEFINITIONS SUMMARY FOR LECTURE 10 (Student Handout)

Term	Simple Definition	Everyday Example
Gas	State of matter where particles are far apart, moving fast, no fixed shape/volume	Air, oxygen, helium
Pressure	How hard gas is pushing on its container	PSI in car tires

Term	Simple Definition	Everyday Example
Volume	How much space gas takes up	Size of a balloon, bag of chips
Temperature	How hot or cold gas is (related to how fast particles move)	Hot car vs. cold garage
Charles's Law	Hotter = gas expands (volume up); colder = gas shrinks (volume down)	Hot air balloon, chip bag on plane
Boyle's Law	Squeeze = volume down, pressure up; expand = volume up, pressure down	Syringe, bicycle pump, scuba diving
Gay-Lussac's Law	Hotter sealed container = higher pressure; colder = lower pressure	Car tire summer vs. winter, aerosol can
Lung overexpansion injury	Lung damage caused by holding breath while ascending from deep water	Scuba divers must never hold their breath
Aerosol can	Sealed can containing gas under pressure	Hairspray, deodorant, spray paint