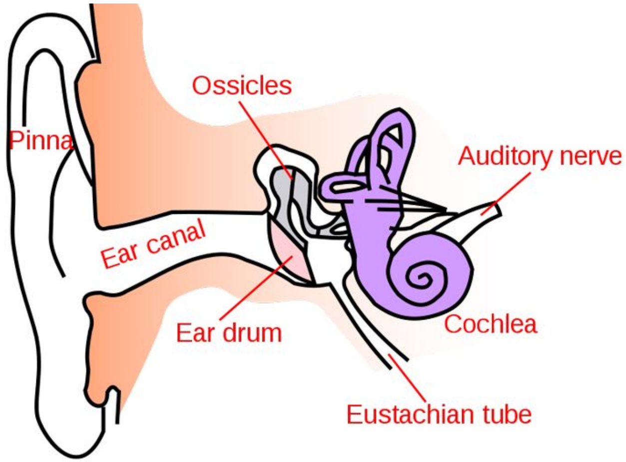
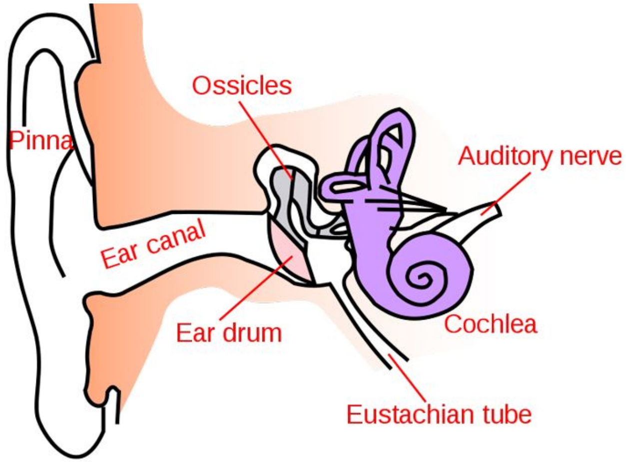
Real-World Application: Ears "Popping"

If you have ever traveled in an airplane or driven high up into the mountains, you've probably noticed that your ears sometimes need to "pop." This "popping" is caused by the same change in air pressure that "pops" the egg into and out of the bottle. Air pressure decreases as altitude increases, so as you go higher, the air pressure decreases, causing the air trapped in your inner ear to push your eardrums outward. Your body tries to regain equilibrium or balance by allowing some of the air in your inner ear to escape through the Eustachian tubes. When the tubes open, the pressure releases and you feel the "pop."



Real-World Application: Ears “Popping”

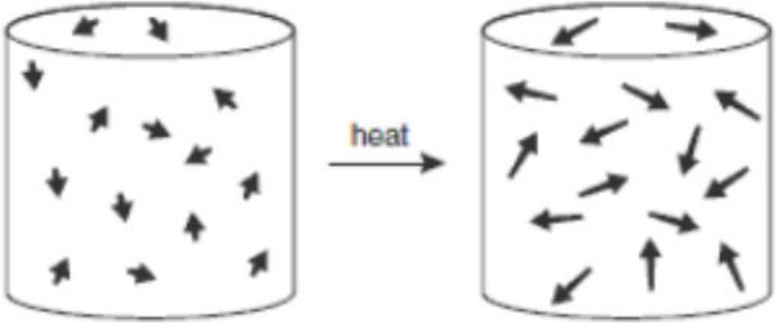
On the way back down to a lower altitude the air pressure increases. The extra pressure from the outside of the ear pushes the eardrums inward. Air moves in through the Eustachian tubes, the ears “pop,” and balance is restored. Many people don’t wait for this to happen on its own because the pressure imbalance can be uncomfortable. Instead, they just plug their noses, close their mouths, and pretend like they’re blowing their noses. Because the air from their lungs has nowhere to go, it is forced into the inner ear through the Eustachian tubes, causing their ears to “pop.”



https://www.stevespanglerscience.com/lab/experiments/egg-in-bottle/

Gay-Lussac's Law

- Looks at **relationship between pressure and temperature, with constant volume** and moles
- If temperature goes up, the gas molecules will move faster, colliding more with the walls of the container
- Pressure results from collisions between gas molecules and walls of container



Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

- ★ If T ↑, then P ↑ ………………….if T ↓, then P ↓
- ★ Temperature must be in Kelvin

Example Problem--Gay Lussac's Law

A can has a pressure of 1.0 atm at a temperature of 20° C. Determine the pressure when the temperature rises to 30° C.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Example Problem--Gay Lussac's Law

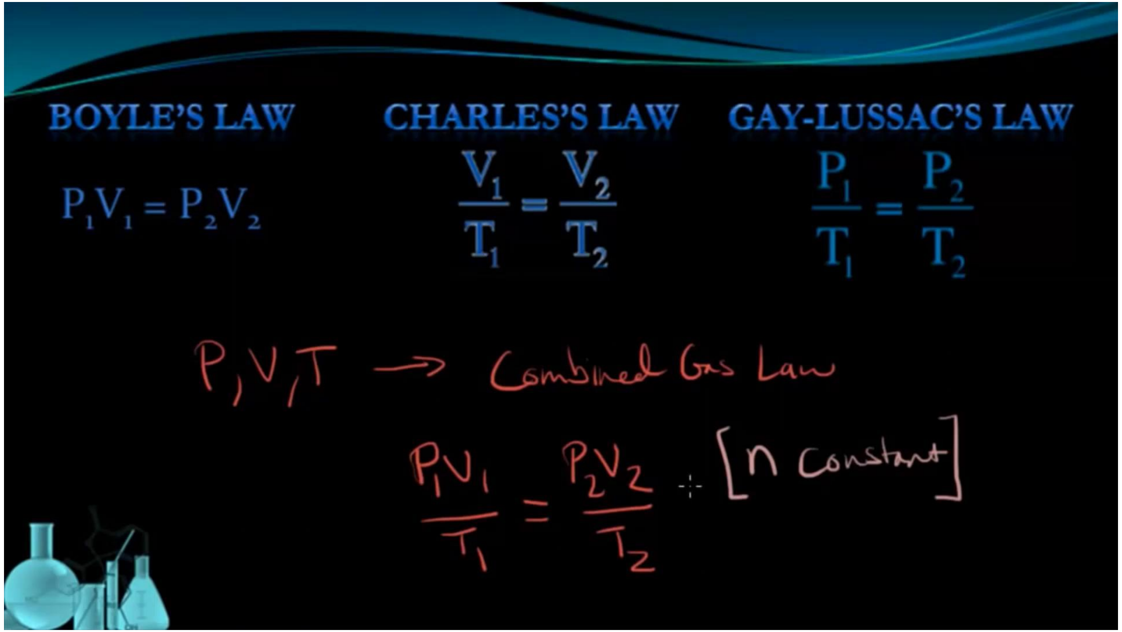
A can has a pressure of 1.0 atm at a temperature of 20° C. Determine the pressure when the temperature rises to 30° C.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

P_1 = 1.0 atm
T_1 = 20°C + 273.15 = 293.15 K
P_2 = ?
T_2 = 30°C + 273.15 = 303.15 K

P_2 = 1.02 atm

Combined Gas Law



Example Problem (combined law)

A 20-L container is filled with helium and the pressure is 150 atm and the temperature is 30° C. How many 5-L balloons can be filled when the temperature is 22° C and the atmospheric pressure is 1 atm?

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$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

P_1 = 150 atm
V_1 = 20 L
T_1 = 30°C + 273.15 = 303.15 K
P_2 = 1 atm
V_2 = ?
T_2 = 22°C + 273.15 = 295.15 K

Example Problem (combined law)

A 20-L container is filled with helium and the pressure is 150 atm and the temperature is 30° C. How many 5-L balloons can be filled when the temperature is 22° C and the atmospheric pressure is 1 atm?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{150 \times 20}{303.15} = \frac{1 \times V_2}{295.15}$$

$$\frac{3000}{303.15} = \frac{V_2}{295.15}$$

$3000(295.15) = V_2(303.15)$

$885450 = V_2(303.15)$

$V_2 = 2920$ L

2920 L/ 5 L per balloon = 584 balloons!

Real-World Application: “Deflategate”

- In 2015, the New England Patriots (an American Football team) were headed to the superbowl (again!)
- That same year, they were accused of purposefully under-inflating their footballs, in an important playoff game
- Are the Patriots to blame, or can the underinflation be explained by environmental factors?
- Scientists at Carnegie Mellon University, MIT, and other institutions tried to resolve the issue