You can see Boyle's Law

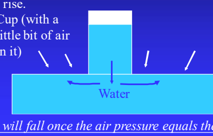
- If you fill a cup with water under the water level, turn it upside down and pick it up.
- This will (attempt to) increase the volume inside the cup.
- Which will decrease the pressure.
- The outside pressure will push in allowing you to pick up the water against gravity.
- as long as you don't raise the cup over the water line

Water in a cup

Gravity wants to pull the water in the cup down, which would make the water level rise.

However, if it fell it the volume of the air bubble would increase decreasing the pressure inside the cup

Air pressure pushes on the surface of the water not allowing the water level to rise.



The water will fall once the air pressure equals the pressure (weight divided by area) of the water being lifted.

Barometer

- Pressure can be measured with a barometer.
- Which works just like the cup but with mercury.

There is not an infinite amount of mercury that can be suspended.

Only until its pressure equals the outside air pressure. Once it falls a little you can measure it.

And you simply measure how high the mercury can be held.

This is inches of Hg or mm Hg (torr). This is how pressure is reported on the news

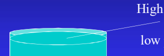
mm of Hg are also called torr after the inventor of the barometer Evangelista Torricelli

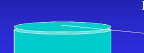
If it is so dangerous why use mercury?

- Mercury is very dense, so you don't need that tall of a tube to make it so it will start to fall.
- A little smaller than a meter will pretty much always fall a little under normal conditions.
- If you used water it would have to be over 10 m high to get it to fall a little.
- Standard pressure is 760 torr or 29.9 in Hg

Modern Barometers

- Digital Barometers and barometers with a dial use a sensor on a sealed drum.
- The top of the drum is flexible.
- Sealed inside the drum is air at a known (calibrated) pressure.
- Higher outside pressure caves the drum in.
- Lower outside pressure bows the drum out.





Heating things make them expand…

- and cooling makes them contract.
- This is noticeably true with gases.
- This is the ***Charles' Law***
- ~The volume of a gas is directly proportional to the temperature of that gas.
- $V \alpha T$; $V/T = k$
- $\frac{V_i}{T_i} = \frac{V_f}{T_f}$

Charles' Law

- If you have 6.7 L of a gas at 298 K, what volume will it occupy at 0° C?
- $\frac{V_i}{T_i} = \frac{V_f}{T_f}$

Charles' Law

- If you have 6.7 L of a gas at 298 K, what volume will it occupy at 0° C?
- $\frac{V_i}{T_i} = \frac{V_f}{T_f}$
- 6.7 L / (298 K) = V / (273 K)
- C + 273 = K
- *Temp must be in Kelvin because zero would make it undefined!
- V = 6.1 L

Charles' Law

- If you have .731 L of a gas at 318 K, what temperature will it be if it occupies 1.34 L?
- $\frac{V_i}{T_i} = \frac{V_f}{T_f}$

Charles' Law

- If you have .731 L of a gas at 318 K, what temperature will it be if it occupies 1.34 L?
- $\frac{V_i}{T_i} = \frac{V_f}{T_f}$
- .731 L / (318 K) = 1.34 L / T
- *Those who do the math without writing it down first commonly make mistakes.
- T = 583 K

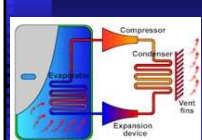
Gay-Lussac's Law

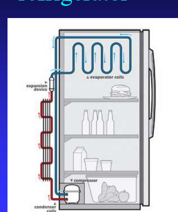
- The pressure of a gas is directly proportional to its temperature.
- T/P = T/P
- This is why an aerosol can or a tire feels cooler when air is released.
- It is also how a diesel engine ignites the fuel. It compresses it until it ignites.

Refrigeration/Air Conditioning

- Refrigeration and air conditioning work using these principles.
- WE CANNOT MAKE COLD AIR!!
- We can only separate cold air from hot air.
- AC works by compressing air at one point (causing it to heat up) and decompressing at another, causing it to cool down.

AC refrigerator





Combined Gas Law

- This is made by combining Charles' and Boyle's Law.
- $\frac{V_i P_i}{T_i} = \frac{V_f P_f}{T_f}$
- Temperature has to be in Kelvin (so it can never be 0)
- Volume and pressure can be in any unit as long as it is the same on both sides.

Problem

- If a gas occupies 22.7 mL at 31° C and 109 kPa, what volume will it take up at 17°C and 153 kPa?
- VP/T = VP/T

Problem

- If a gas occupies 22.7 mL at 31^{o} C and 109 kPa, what volume will it take up at 17^{o}C and 153 kPa?
- VP/T = VP/T
- 22.7 mL (109 kPa)/304 K = V 153 kPa / 290 K
- V= 15.4 mL