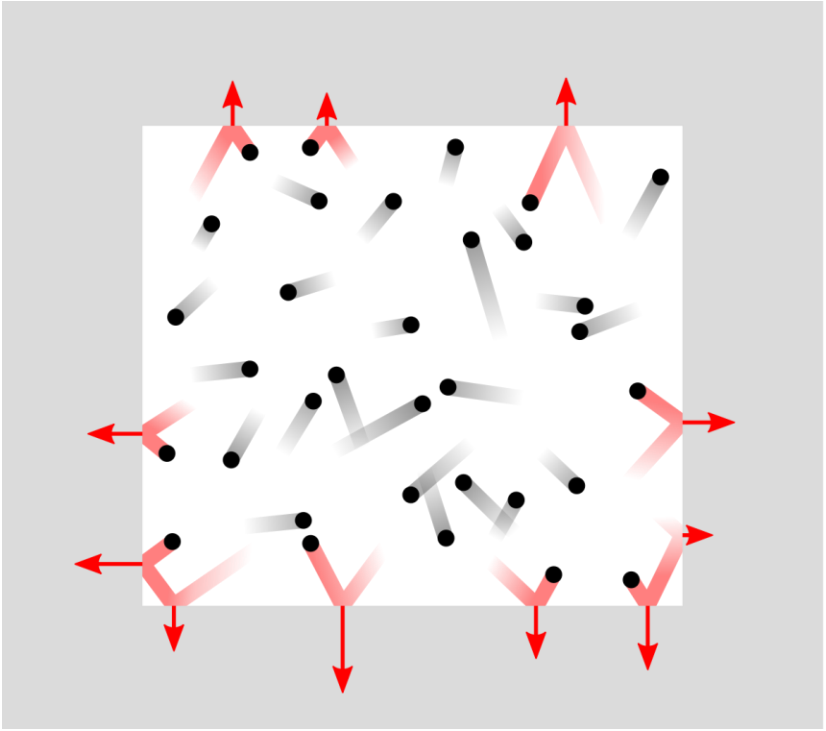
Imperial College London

Pressure

Ideal Gas Laws

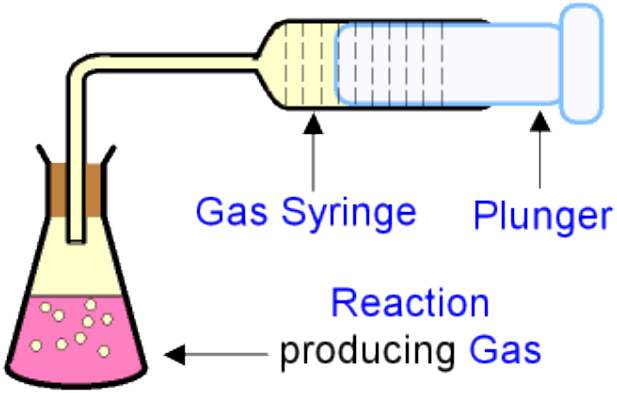


Measures of gases

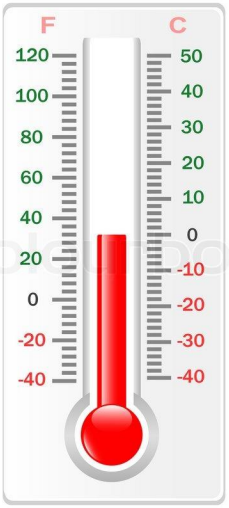
Imperial College London

- Pressure – How?

- Volume – How?



- Temperature – How?
  - Water freezes at?
  - Water boils at?

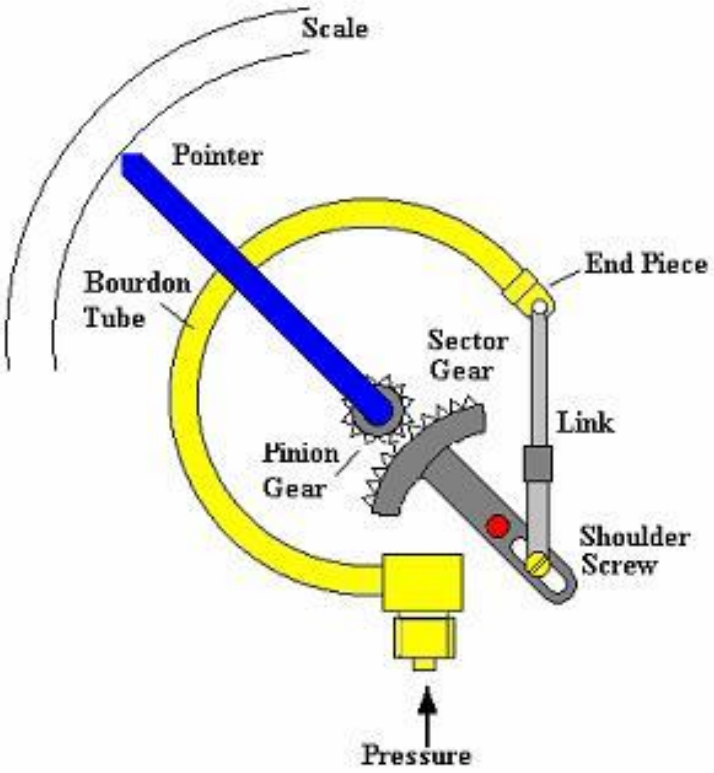


- These measures also apply to solids and liquids

How does it work?

Imperial College London

- Pressure Gauge (bourdon tube)
- Many other types

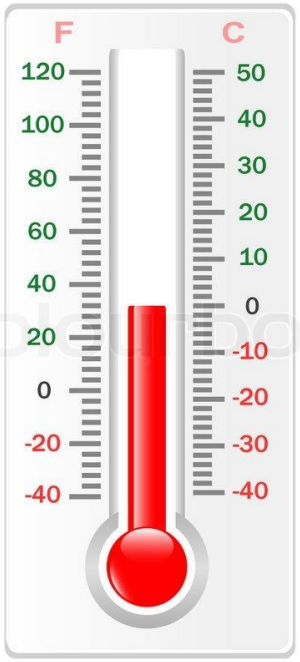


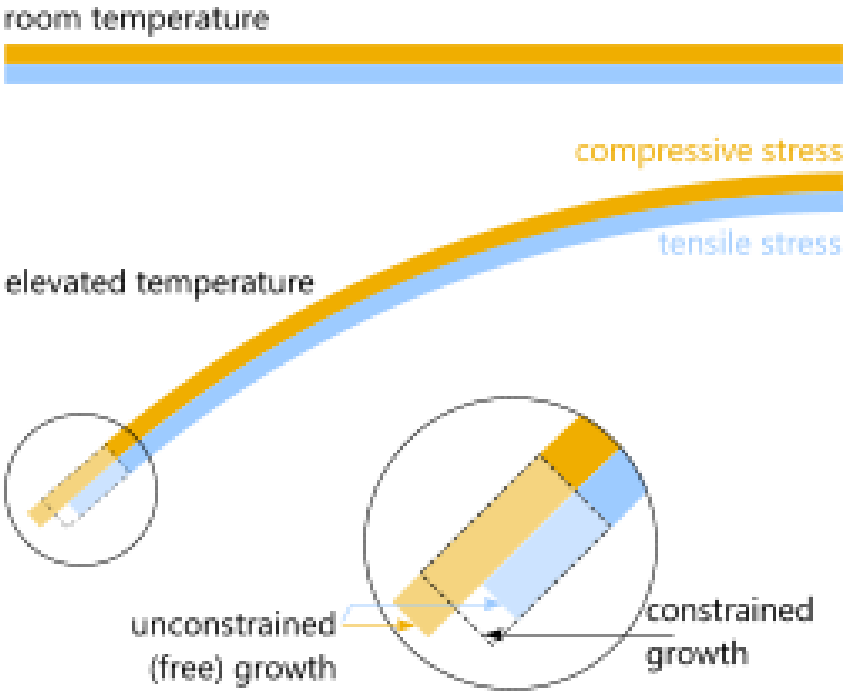
Section through the tube

How does it work?

Imperial College London

- Thermometer (liquid/gas)
- Thermometer (bi-metallic)
- Many other types

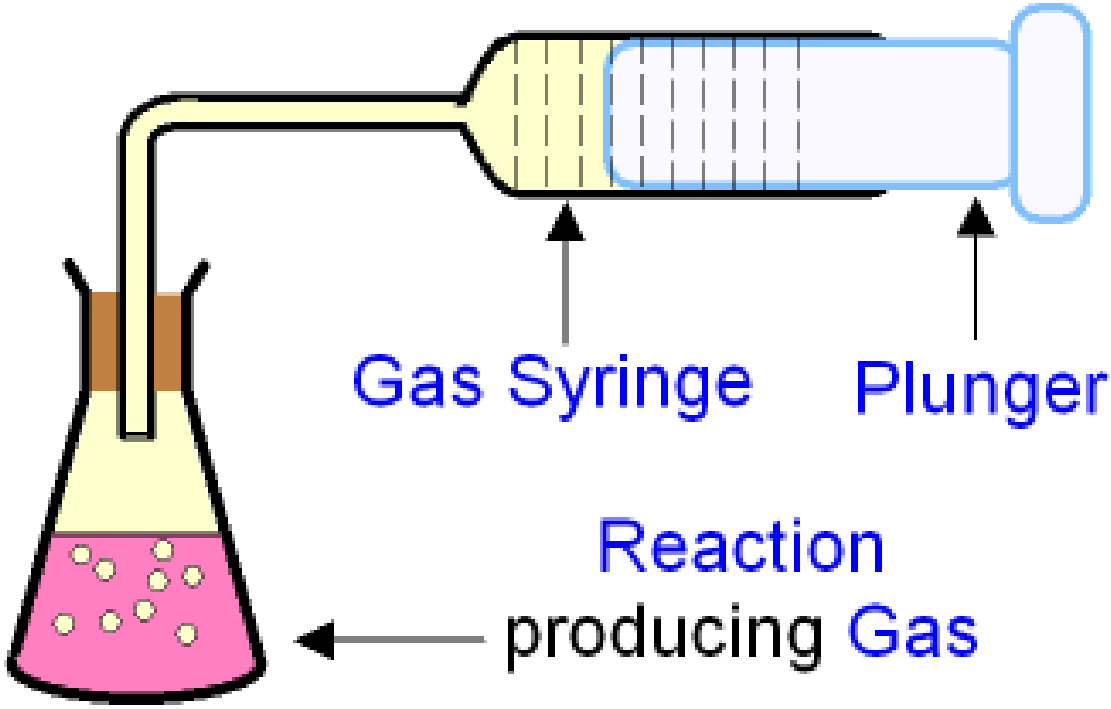




How does it work?

Imperial College London

- Gas syringe (gas displacement)



Ideal Gas Relationships

Imperial College London

- Are pressure, volume, temperature related?
  - What is your intuition?
- Why?

Boyle's Law Practical

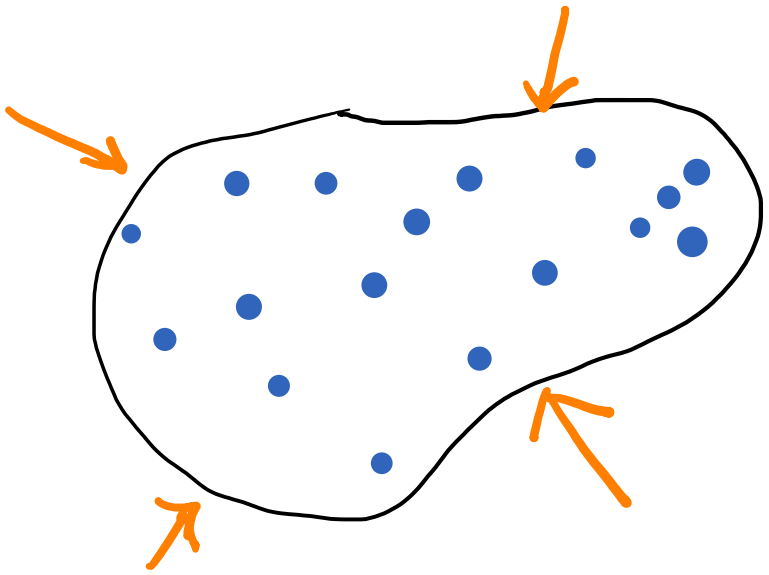
Imperial College London

- Materials
  - Gas Syringe
  - Pressure Sensor
  - Data Logger
- Results
  - Record all parameters
  - Plot data
  - Change one variable

Boyle's Law

Imperial College London

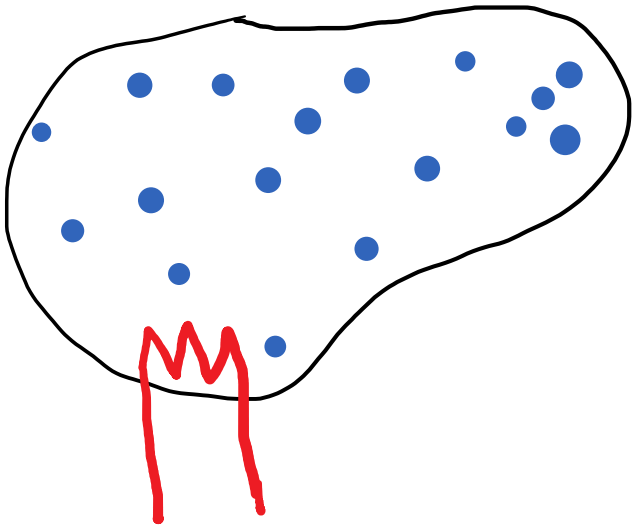
- Robert Boyle (1627-1691)
- Boyle's Law: *The pressure (P) of a closed vessel is inversely proportional (k) to the change in (V)*
- Mathematically: $\mathrm{PV} = \mathrm{k}$



Gay-Lussac's Law

Imperial College London

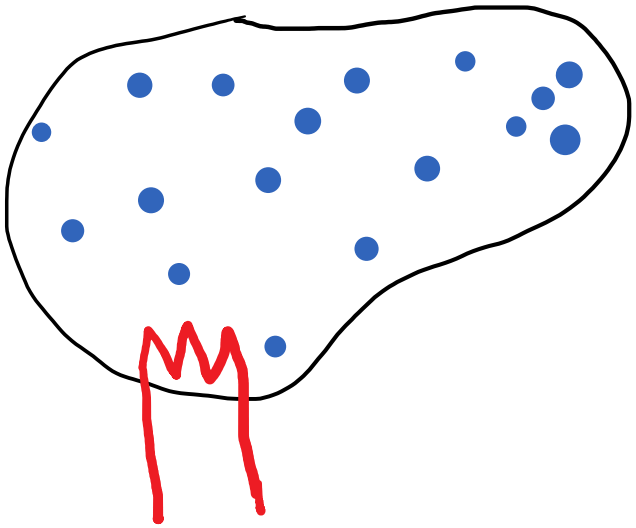
- Joseph Louis Gay-Lussac (1778-1850)
- Gay-Lussac Law: *The pressure (P) of a closed vessel is directly proportional (k) to its temperature (T)*
- Mathematically: $\frac{P}{T} = k$



Charles' Law

Imperial College London

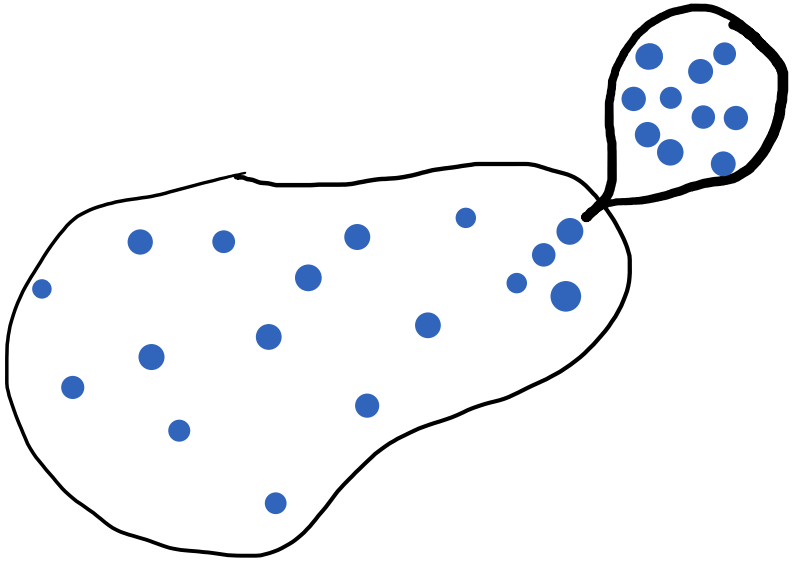
- Jacques Charles (1746-1823)
- Charles Law: *The volume (V) of a gas is directly proportional (k) to its temperature (T)*
- Mathematically: $\frac{V}{T} = k$



Avogadro's Law

Imperial College London

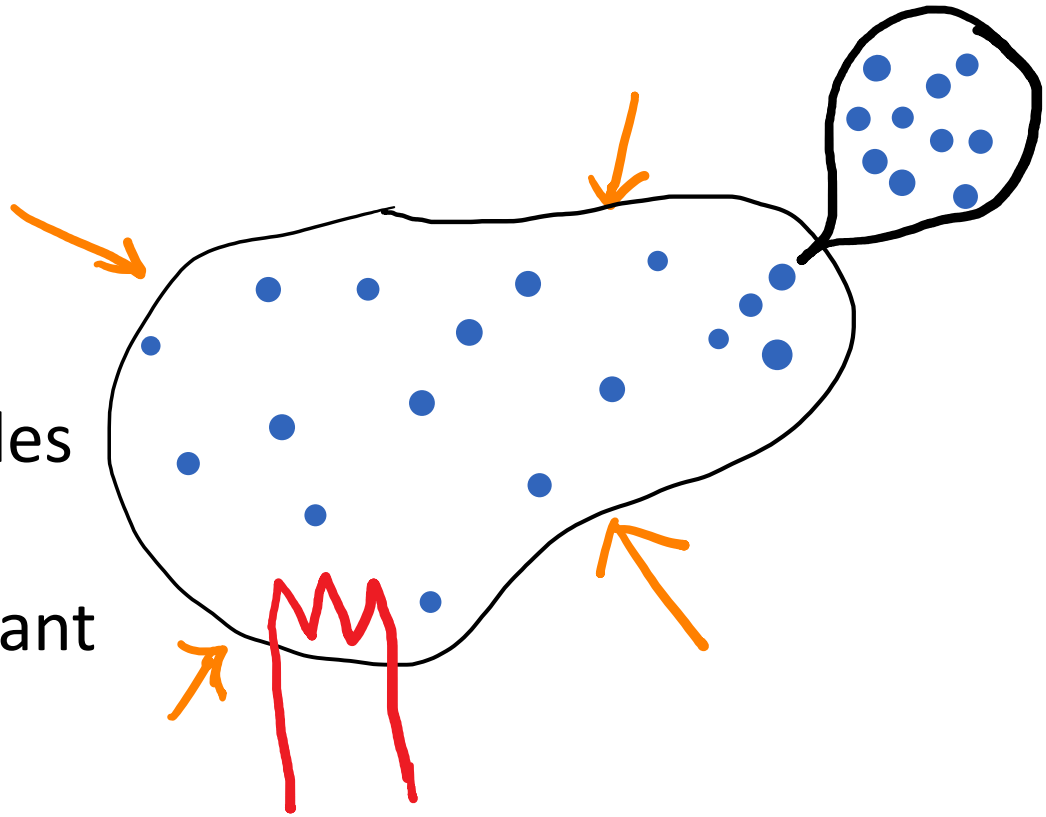
- Amadeo Avogadro (1776-1856)
- Avogadro's Law: *The volume (V) occupied by a gas is directly proportionally (k) to the number of molecules (n) of gas*
- Mathematically: $\frac{V}{n} = k$



Ideal Gas Law

Imperial College London

- $PV = nRT$
- P: pressure (kPa)
- V: Volume (L)
- n: number of molecules (mol)
- R: universal gas constant 8.314 kPa·L/mol/K
- T: temperature (K)



Charles' Law Practical

Imperial College London

- Materials
  - Flask with boiling water
  - Stopper
  - Cold water
- Results
  - Volume (hot)
  - Volume (cold)

Things worth considering

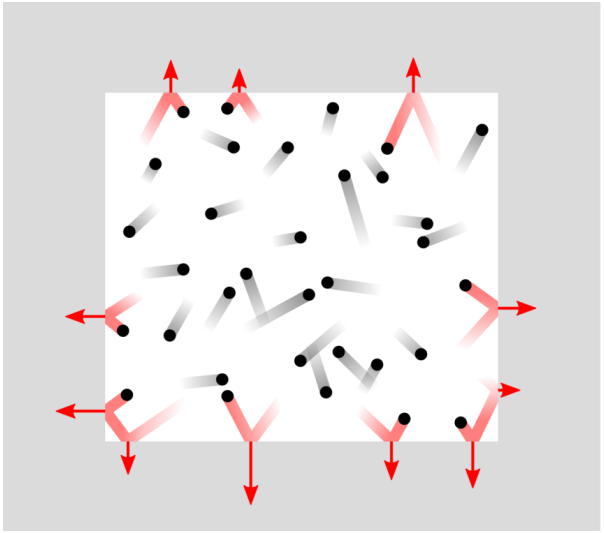
Imperial College London

- Observation based results/equations
- Why do these properties influence one another?
- What do these properties measure?

What are we measuring?

Imperial College London

- Volume
  - Displaced space
- Pressure
  - Average molecular collisions exerting force on container
  - More collisions = more force
- Temperature
  - Average kinetic energy of molecules
  - More temperature = faster



Questions worth asking

Imperial College London

- What is an ideal gas?
  - Theoretical property of gases
  - Important for simplifying many things in physics and mechanics
- Are they real?
  - N, O, H, CO2, and noble gases are mostly ideal gases
  - Gases are generally ideal in natural conditions (where the laws were derived)

Negative Pressure

Imperial College London

- Whoosh Bottle Video: https://www.youtube.com/watch?v=98Vkl1YnNFs
- Can we have negative pressure?
  - Pressure below atmospheric – yes
  - Negative – no
  - Vacuum – absence of matter and molecular collisions
- Atmospheric Pressure
  - 14.7 psi or 100 kPa
- What causes this?
- Reduce atmospheric pressure?

Manometer

Imperial College London

- Open tube is filled with water
- One end is caped and extra air is added…
- Air is removed from the capped end…