3.9 Separation of Solution & Mixtures
Chromatography
3.10 Solubility

- Chromatography
- Fractional Distillation
- Factors Affecting Solubility

Factors Affecting Solubility

Structure

- Like dissolves Like
  - *polar dissolves polar; non-polar dissolves non-polar*
  - *miscible - soluble in all proportions*

Temperature

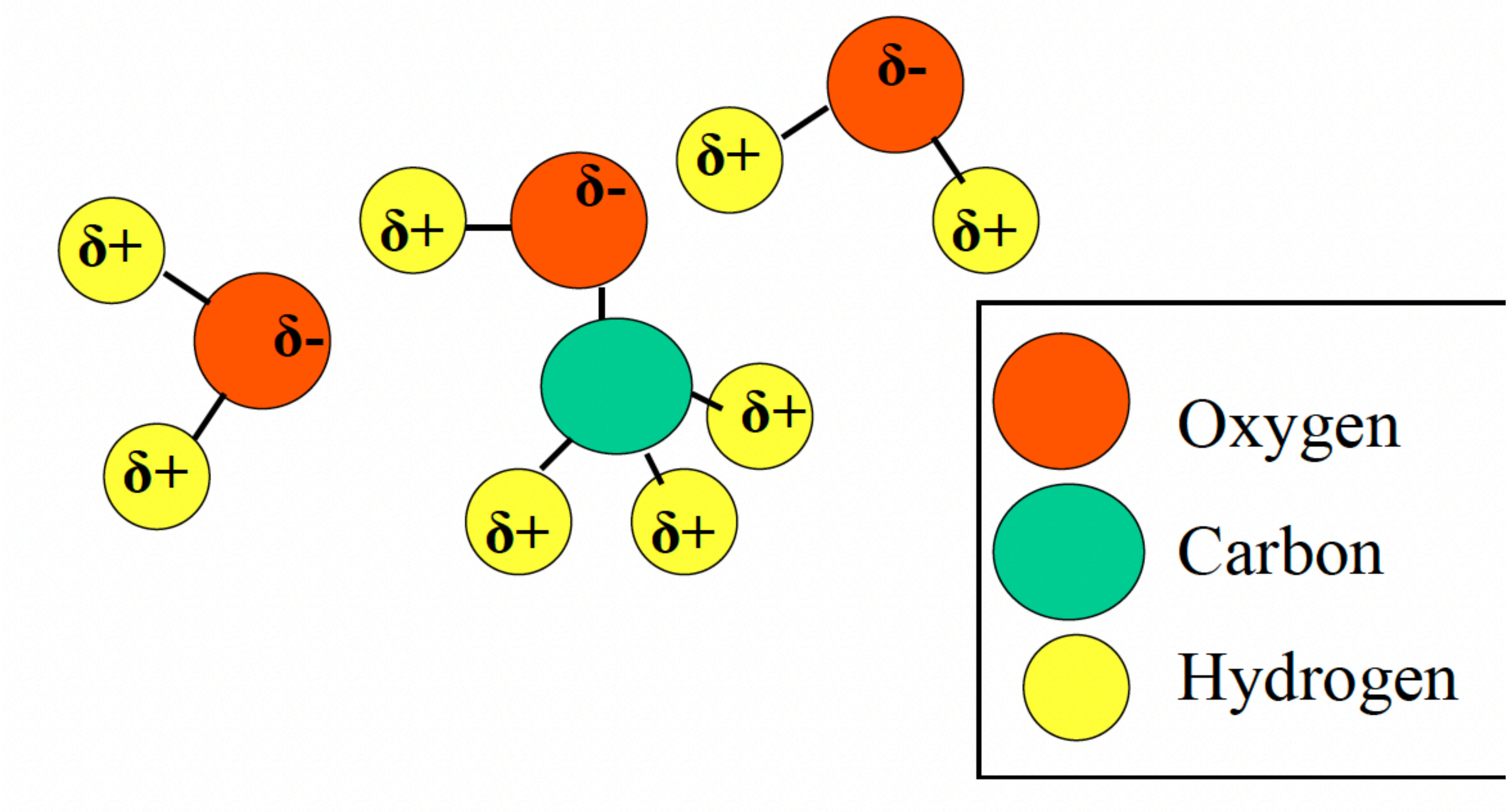
- different rules for different types of solutions

Pressure

- applies to Gas-Liquid solutions

Like Dissolves Like

Polar Molecules Dissolve in Polar Solvents (H_2O / MeOH)



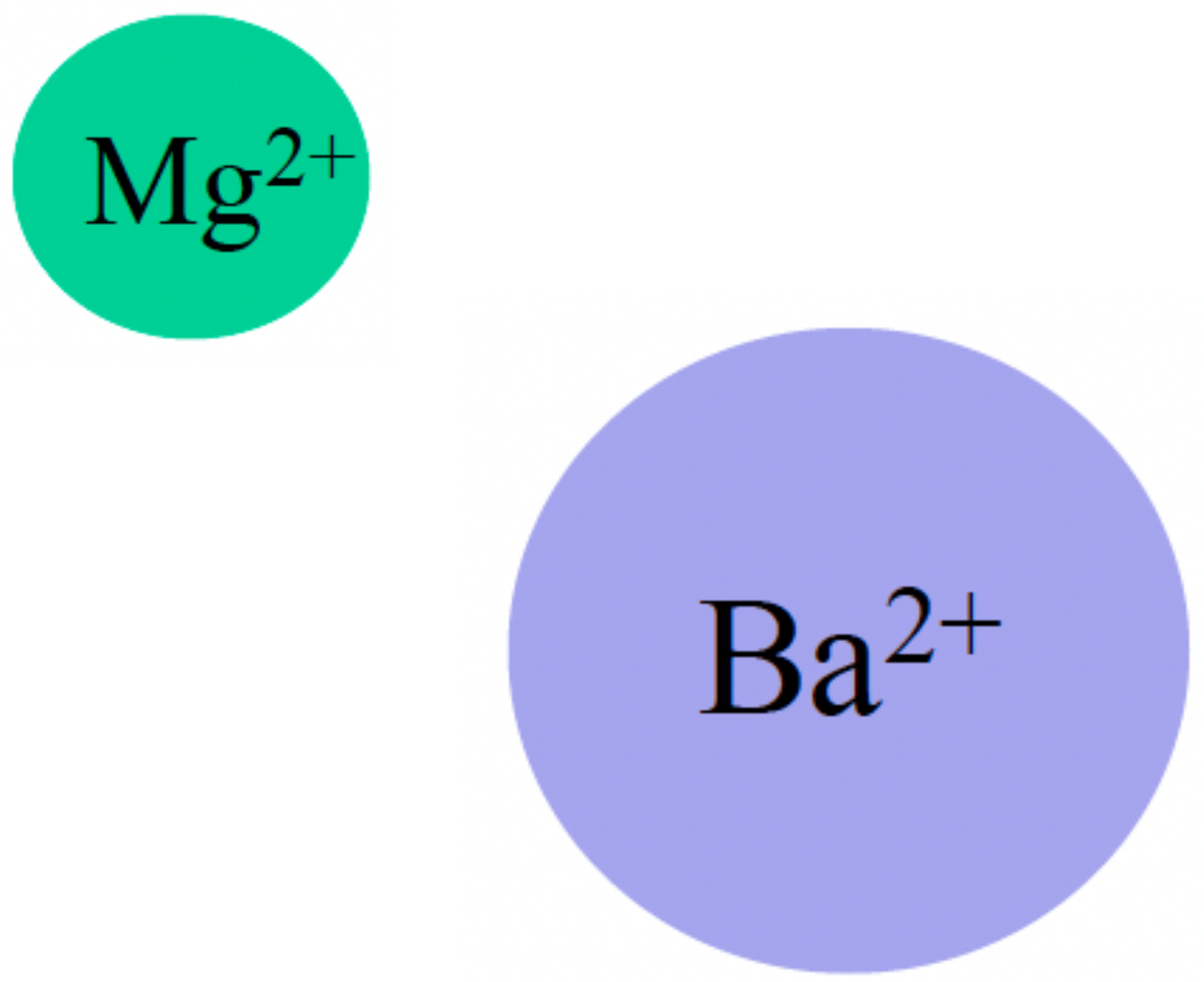
Ion-Dipole & Coulomb's Law

$$F = k\frac{Q_1Q_2}{d^2}$$

- Some ionic compounds do not dissolve in water.
- Solubility can be explained through Coulomb's Law
- If cation-anion attractions are stronger than ion-dipole attractions, the compound will not be soluble.
- **Ionic compounds do not dissolve in non-polar solvents, as non-polar solvents do not carry permanent dipoles.**

Ion-Dipole & Coulomb's Law

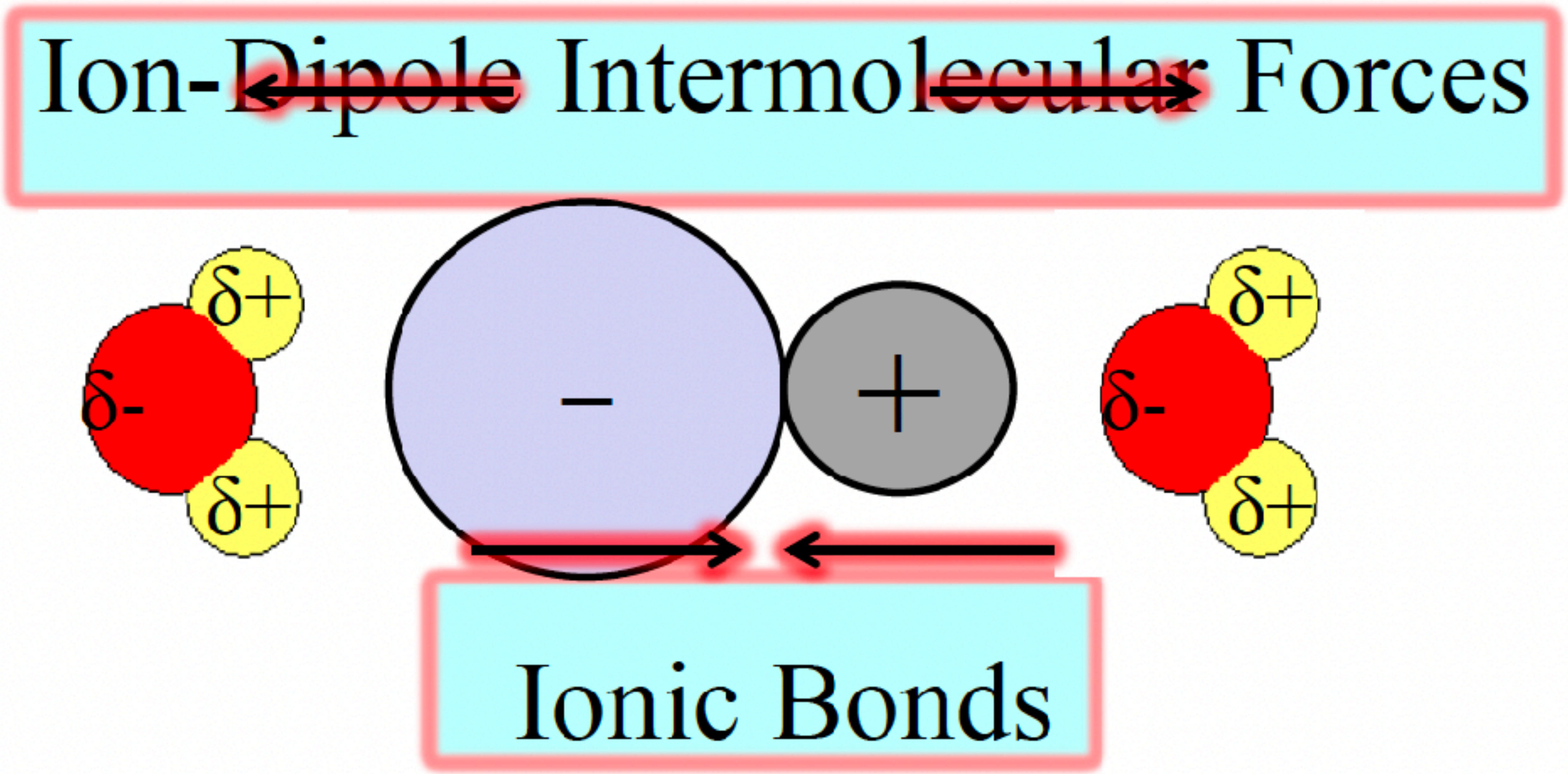
$$F = k\frac{Q_1Q_2}{d^2}$$



- $Mg(OH)_2$ is not soluble in water…
- but $Ba(OH)_2$ is soluble in water.

The forces of attraction between ions in $Mg(OH)_2$ are stronger than those in $Ba(OH)_2$.

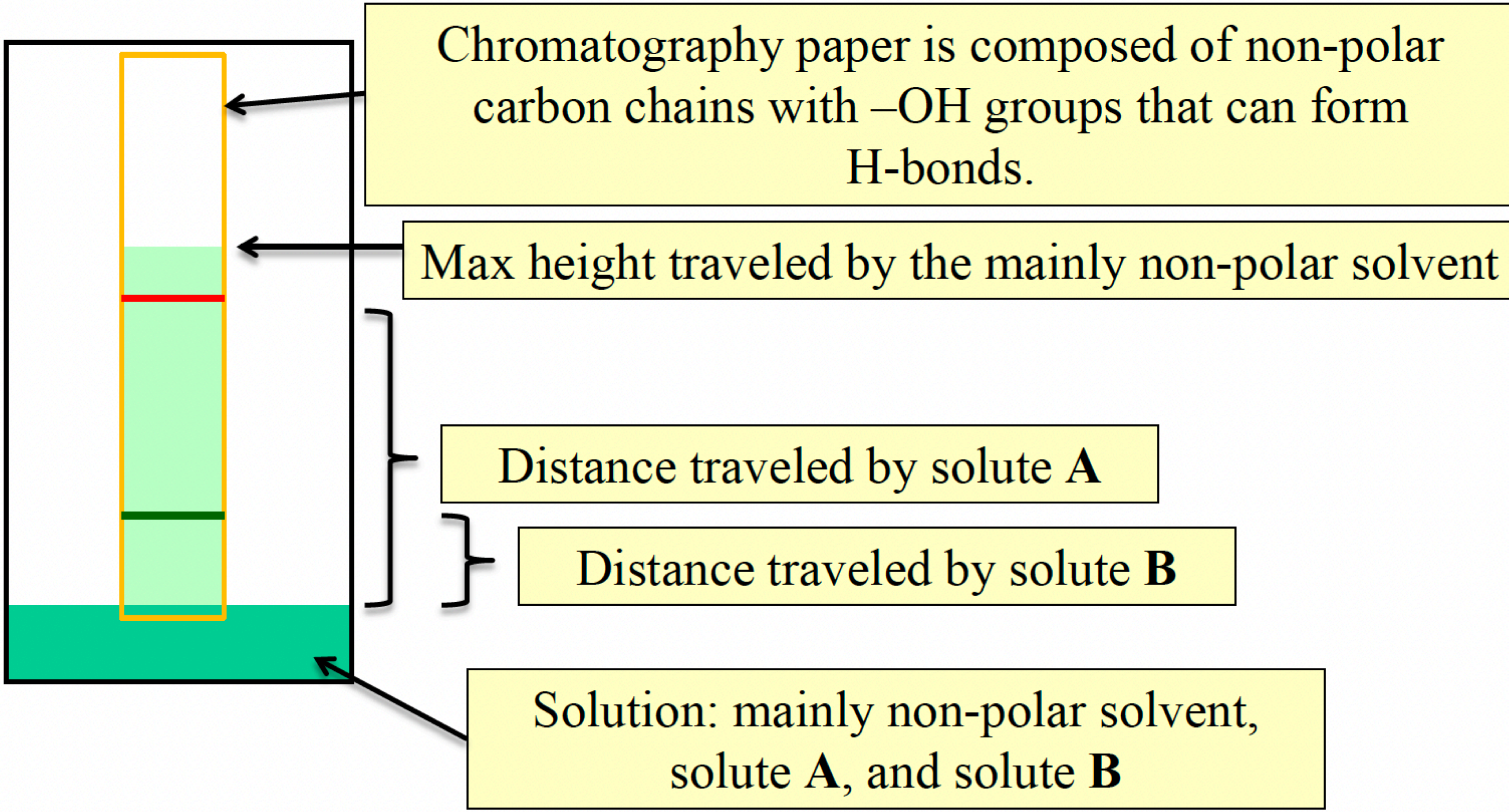
Ion-Dipole vs. Ionic Bonds



Two forces work against one another through Coulomb's Law. One of the forces will be stronger than the other.

$Mg(OH)_2$ is not soluble in water and $Ba(OH)_2$ is, because, for the alkaline earth metal hydroxides, forces of attraction from ionic bonds decrease more rapidly than the ion-dipole intermolecular forces when moving down the group.

Chromatography & Solubility



Chromatography & Solubility

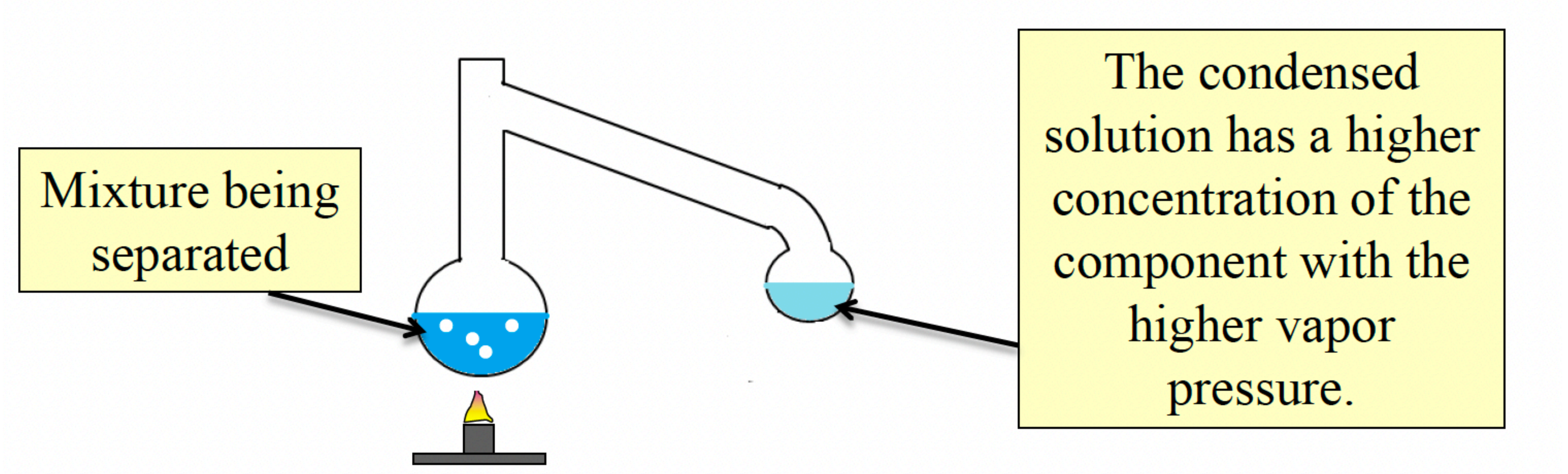
- The stationary phase is the chromatography paper, and the mobile phase is the solvent used.
- As the solvent moves up the piece of paper it carries with it solute particles.
- The distances that the different solute particles travel up the paper depend on their relative attractions for the moving solvent and the stationary paper.

Chromatography & Solubility

- Solute particles that can form H-bonds at several locations along their structures will not travel very far up the paper, as the molecules in the paper contain many –OH groups.
- Solute particles that are mostly non-polar will have weak attractions for the paper and relatively strong attractions for the mainly non-polar solute.

Fractional Distillation

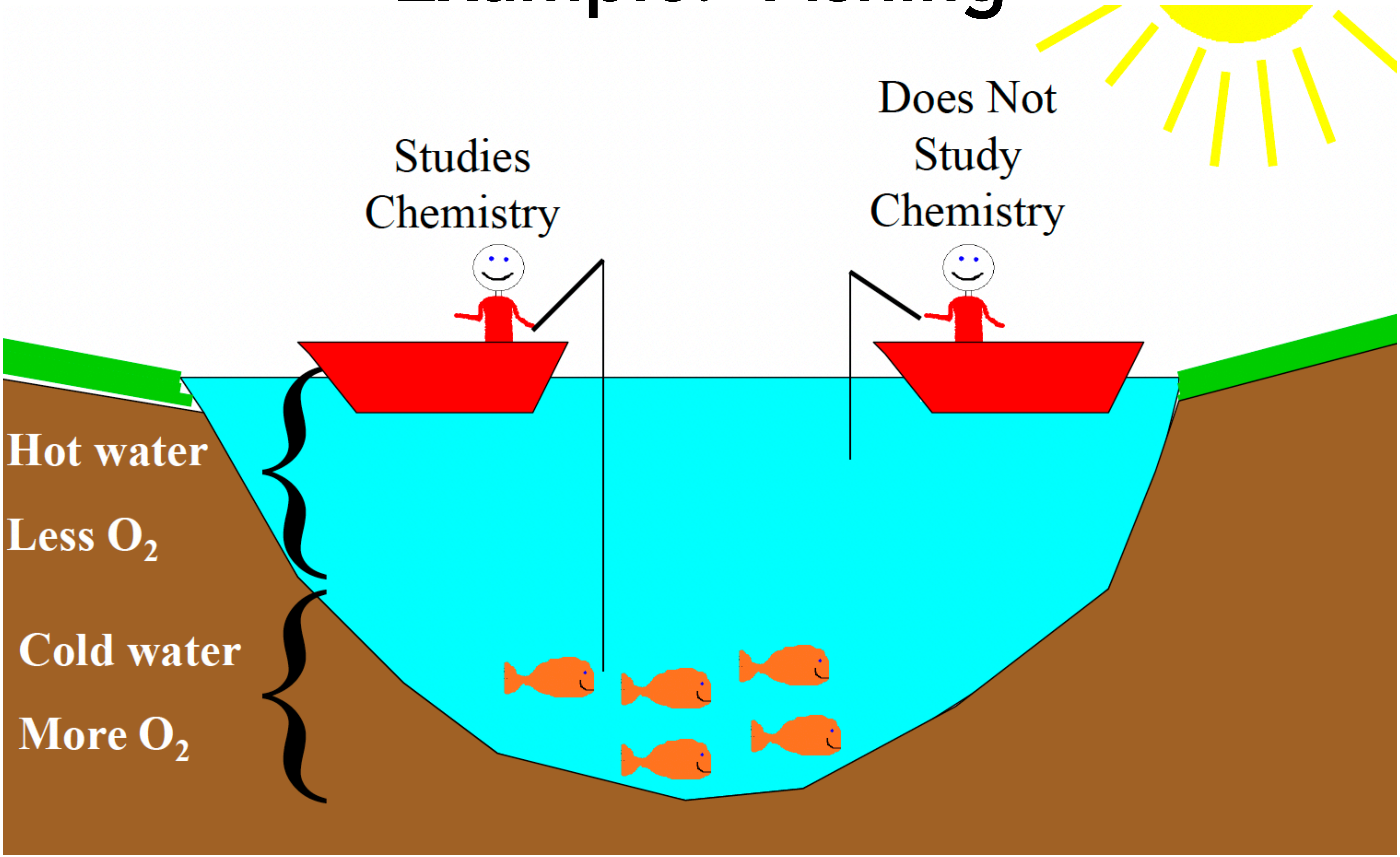
- The separation of volatile liquids in a liquid-liquid solution on the basis of boiling points.
- if the cycle of boiling and condensing is repeated enough times, complete purification of the more volatile substance can be achieved.



Gas Solubility & Temperature

- The solubility of most gases decreases as temperature increases.
  - Gases tend to have weak intermolecular forces.
  - As the kinetic energy of particles within a solution increases, aqueous particles break free from these weak attractions and re-enter the gas phase.

Example: Fishing

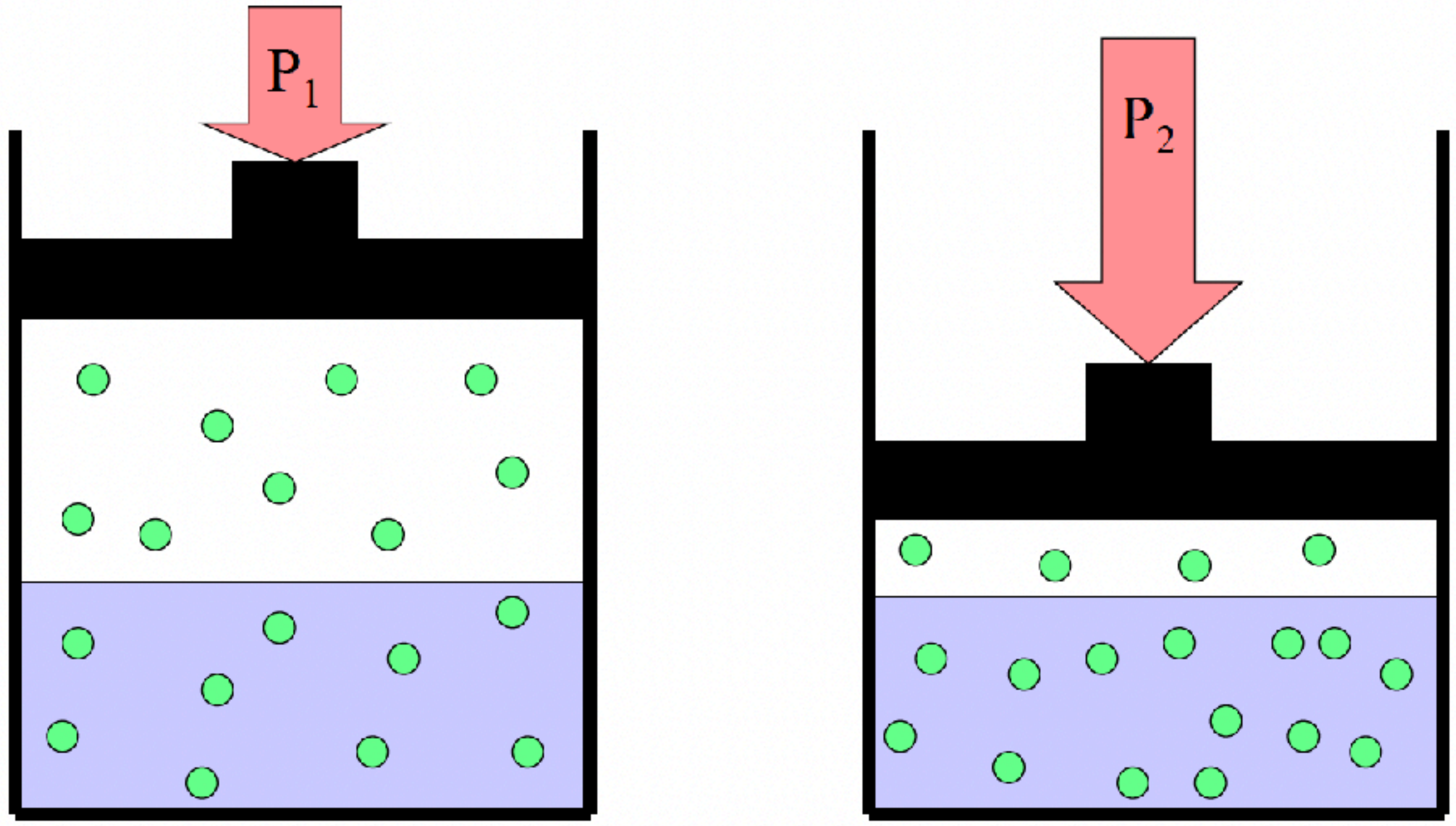


Beverages & Pollution

- Warm carbonated drinks go flat faster than cold carbonated beverages.
- Thermal Pollution
  - during many industrial processes, water is pumped out of lakes or rivers and used to cool equipment, gases or other liquids
  - heat flows into this water
  - it is then returned to the lake or river that it came from
  - the temperature of that bod of water increases and the concentration of dissolved oxygen decreases…fish can die.

Gas Solubility & Pressure

- Henry's Law: solubility is directly proportional to the the pressure of the gas above the solution.



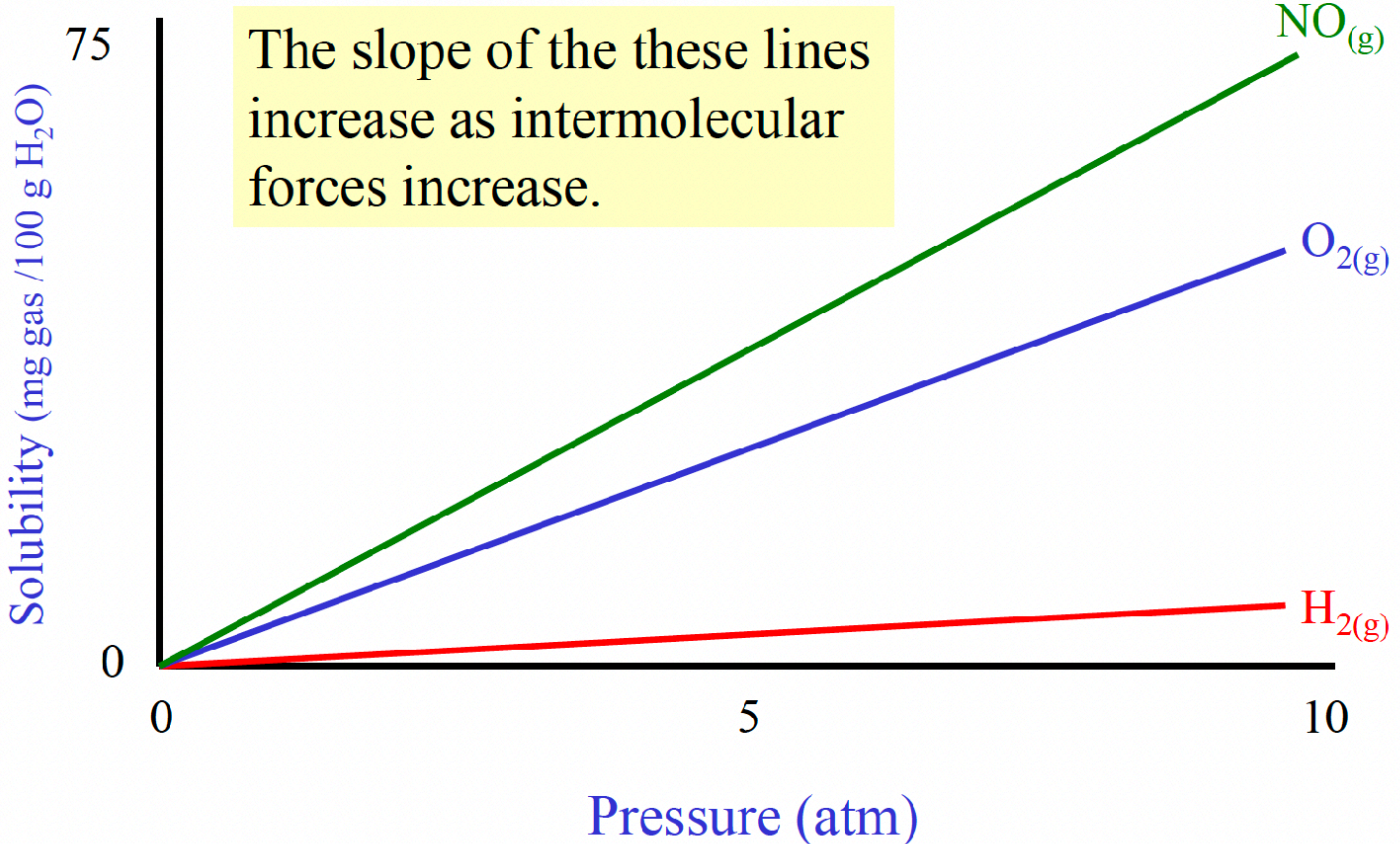
$A_{(g)} \rightleftharpoons A_{(aq)}$

When P_A is small, [A] in the solution is low.

$A_{(g)} \rightleftharpoons A_{(aq)}$

When P_A is large, [A] in the solution is high.

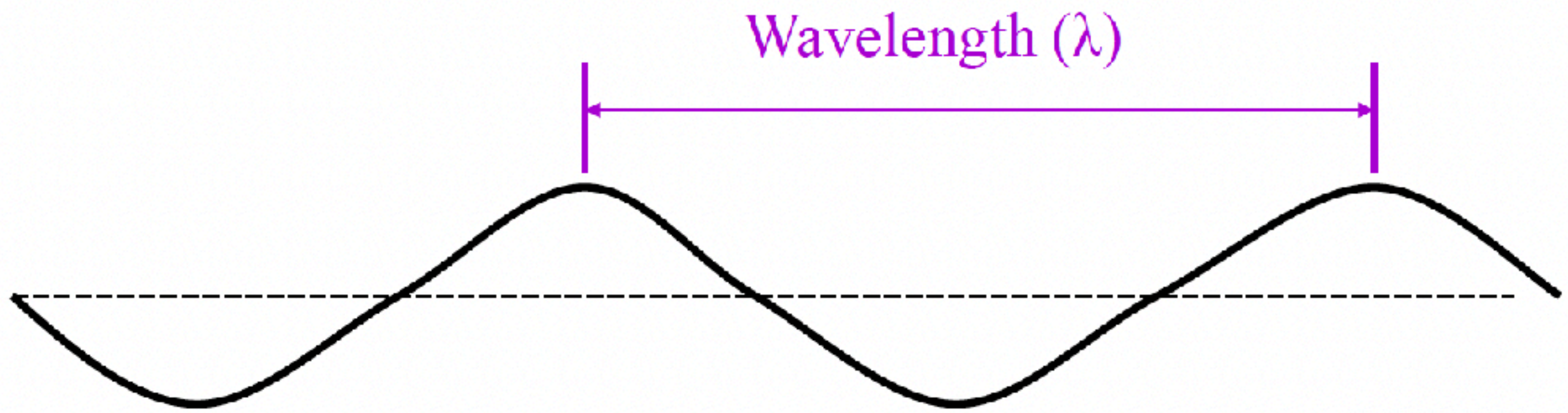
Gas Solubility & Pressure



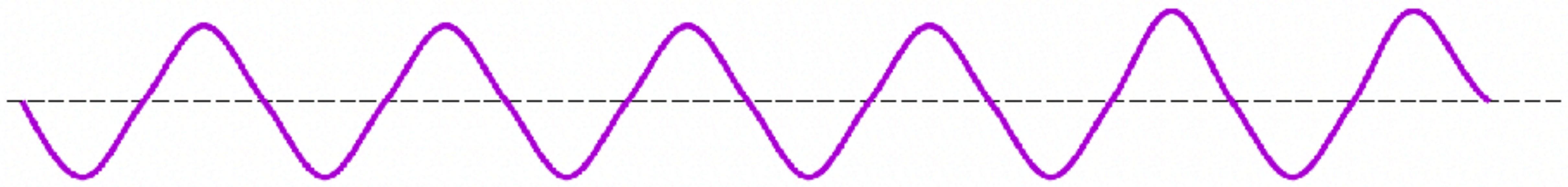
3.12 Photoelectric Effect

- Waves & Light
- Quantum Theory
- Electromagnetic Spectrum
- Atomic Emission Spectra

Components of a Wave



High Frequency Wave



Frequency (ν)– the number of times a wave repeats itself per second

$$c = \lambda \nu$$

Speed of light

3×10^8 m/s

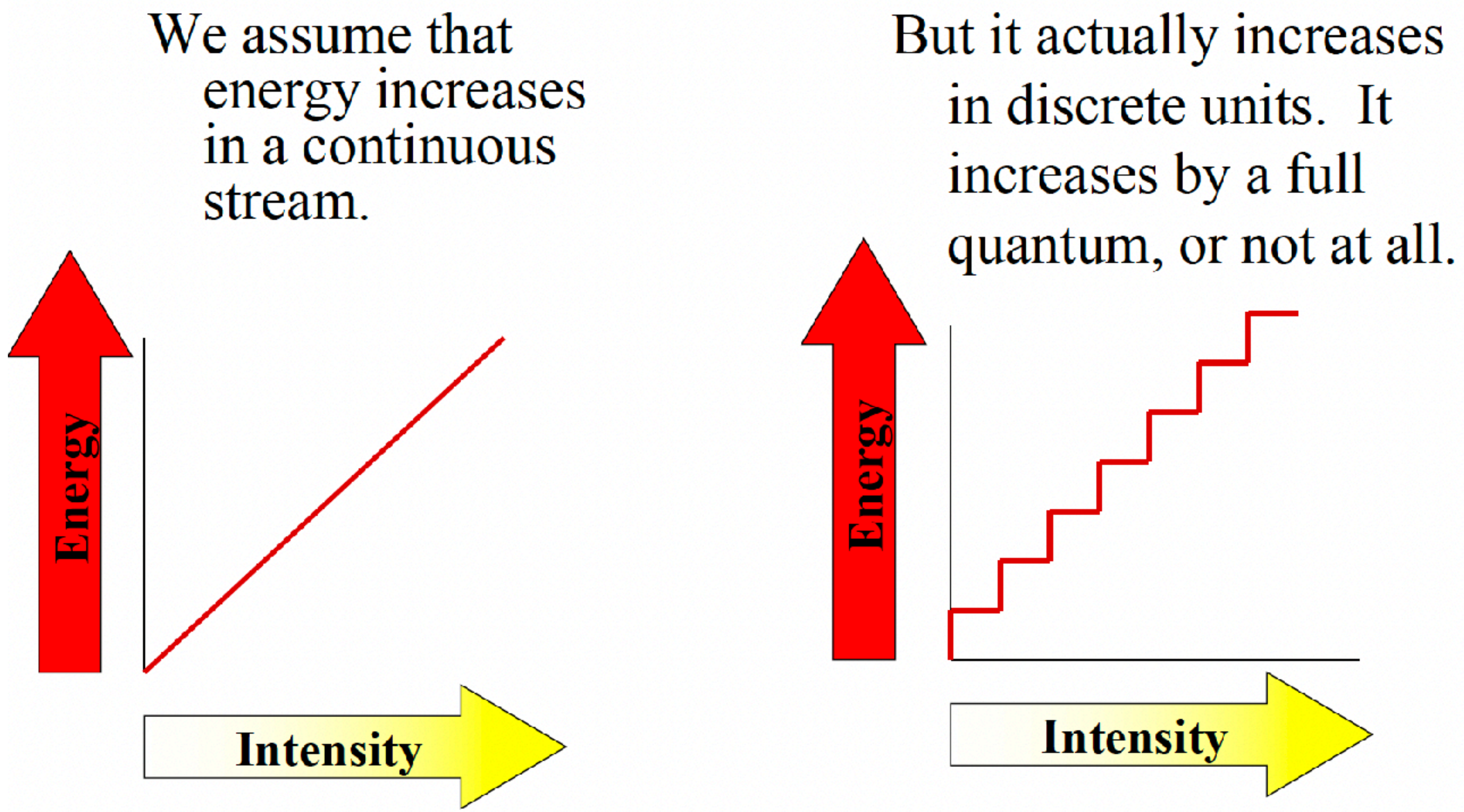
Wavelength (m)

Frequency (s^{-1} or Hz)

Example: Find the frequency of a green light that has a wavelength of 545 nm.

Quantum Theory & Planck

- Max Planck (1900) - hypothesized that the energy radiated from a heated object, such as a lightbulb filament, is emitted in discrete units or **quanta**.



Planck & Einstein

Energy per Quantum (J)

Frequency (s^{-1})

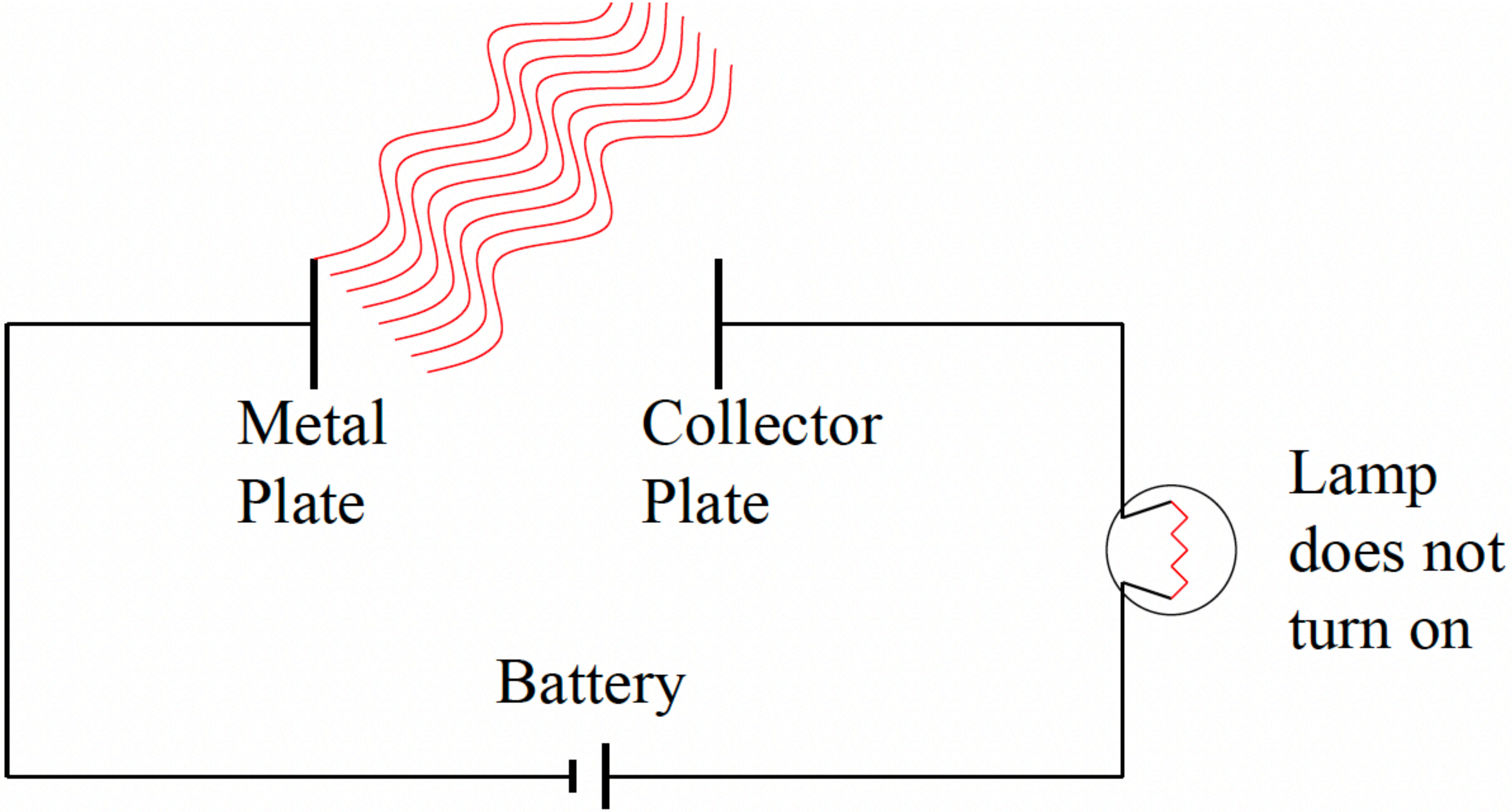
$$E = h\nu$$

Planck's Constant

(6.63×10^{-34} Js)

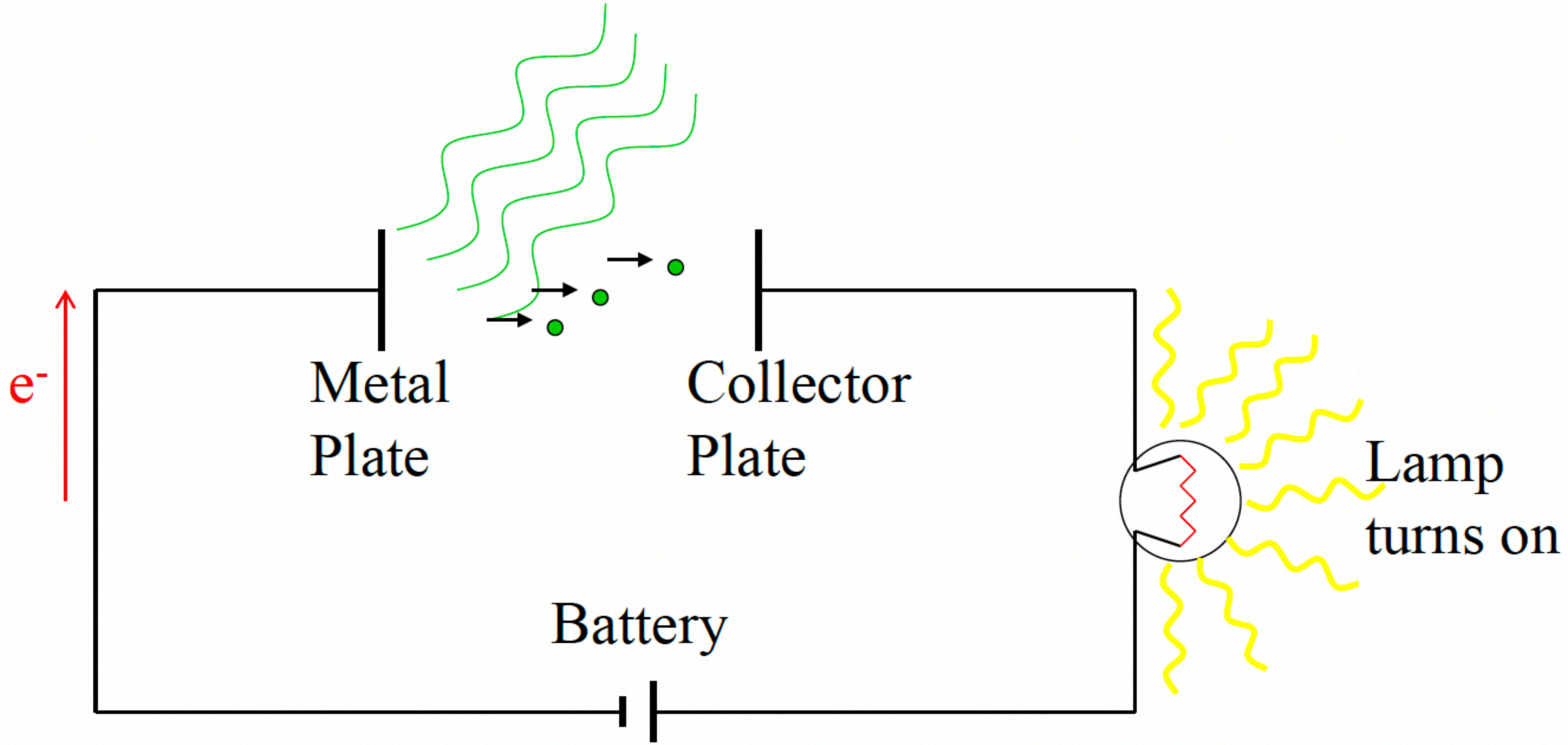
The Photoelectric Effect

- 1st Fact: Highly intense, low frequency light does not eject any electrons, even if it shines on the surface for several days.



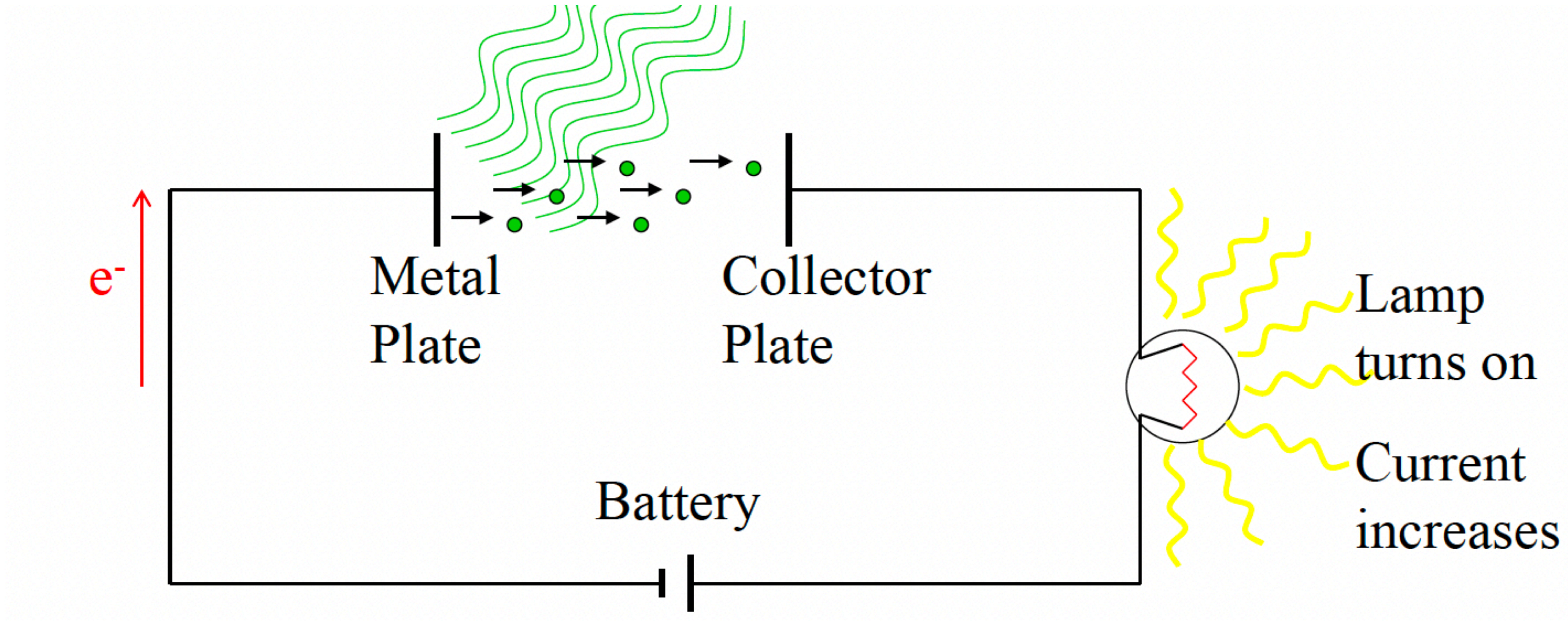
The Photoelectric Effect

- 2nd Fact: When the threshold frequency is reached, electrons are ejected immediately.



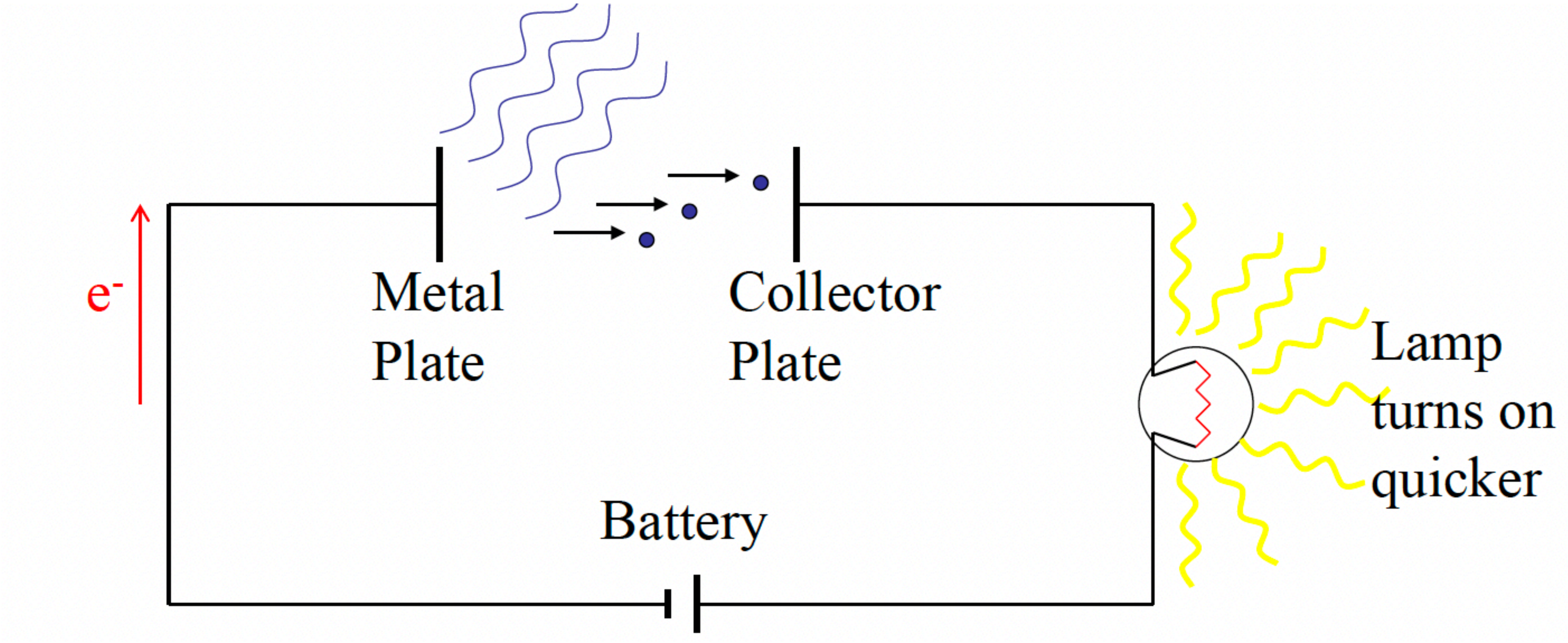
The Photoelectric Effect

- 3rd Fact: Increasing the intensity of the light at a frequency that will cause electrons to be ejected results in a higher ejection rate. However, all ejected electrons share the same velocity.



The Photoelectric Effect

- 4th Fact: Increasing the frequency of the light increases the velocity of the ejected electrons. However, all electrons share the same velocity.

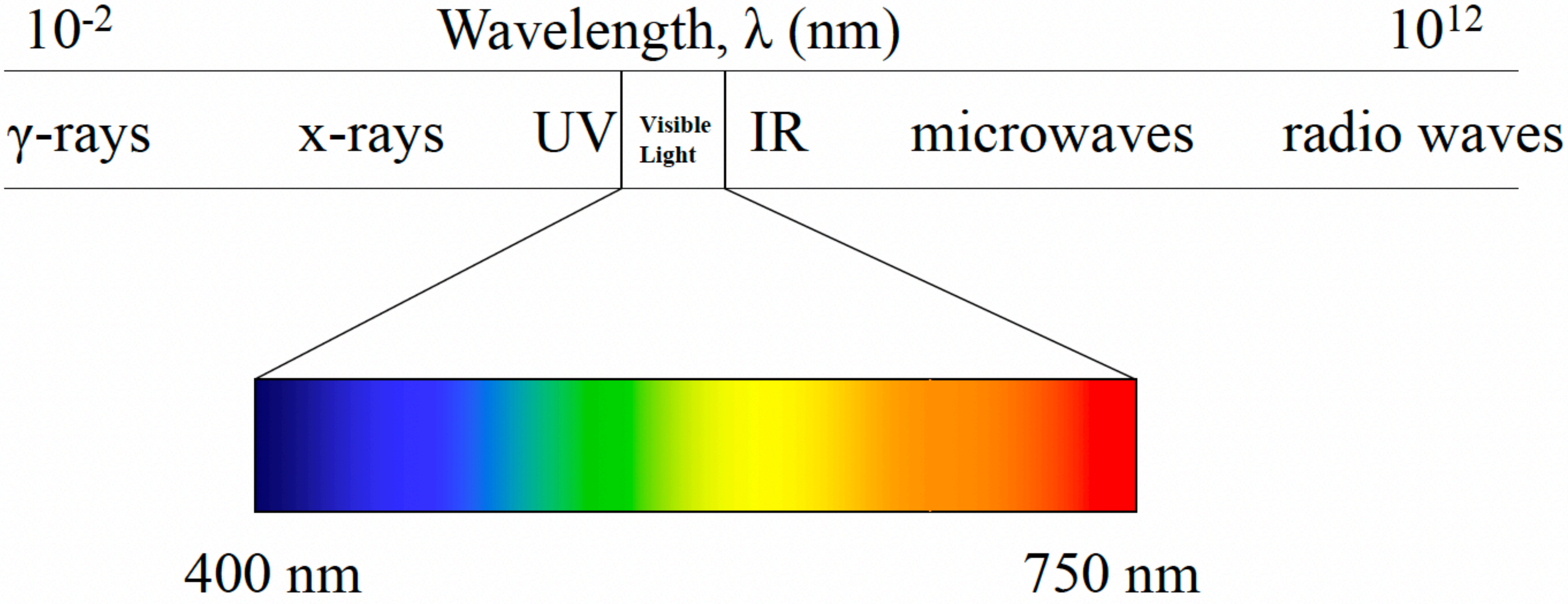


Einstein's Theory(1905)

- A beam of light is a stream of particles called photons.
- The energy of a photon is related to its frequency according to $E = h\nu$.
- The quantum of Planck is a particle - a photon.
- If the frequency of a photon is below a certain threshold, no electrons are ejected.
- If the frequency of the photon is at or above a certain threshold, its energy is transferred to the electron.
    - This causes the electron to overcome the forces of attraction holding it to the metal.
    - The electron absorbs the photon.

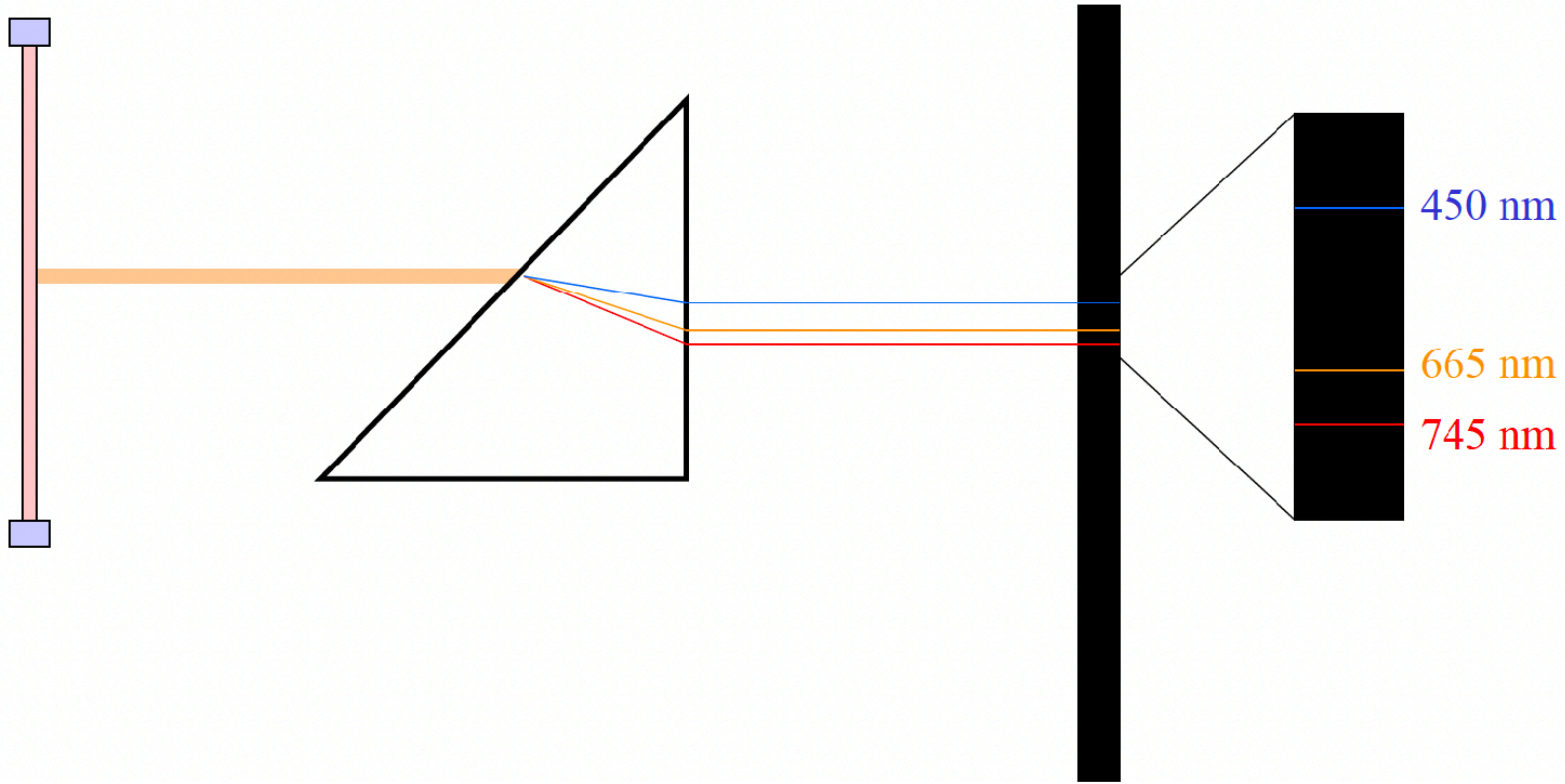
The Electromagnetic Spectrum - Continuous Spectrum of Light

- Every wavelength of light is represented in the continuous spectrum.

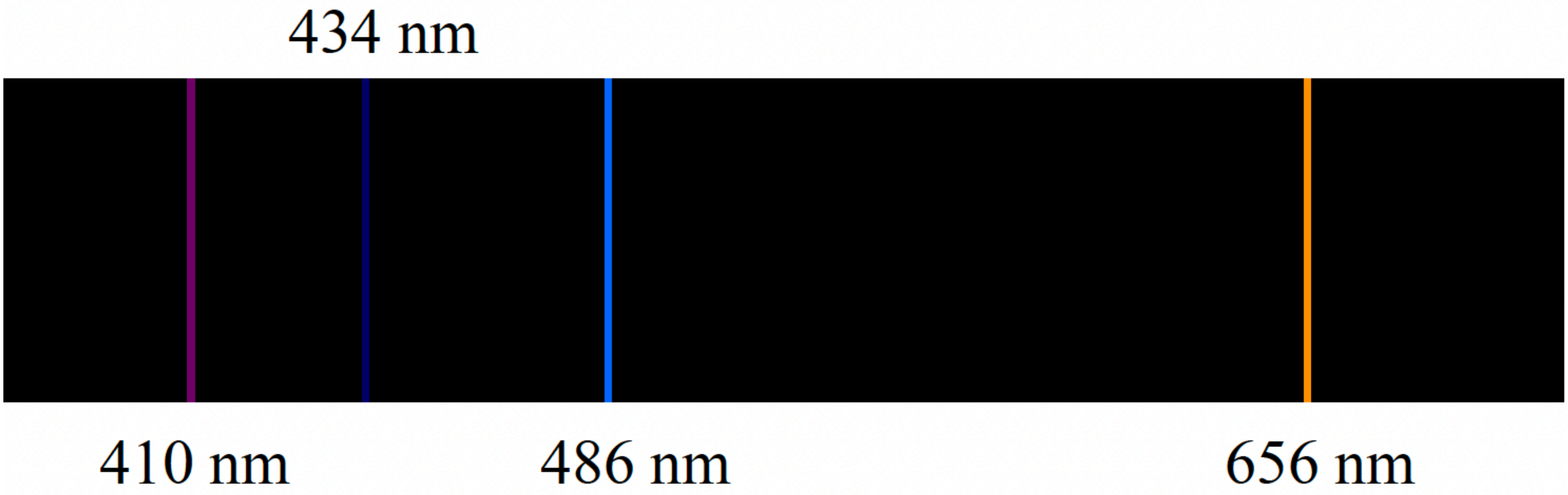


Atomic Emission Spectrum

- Every wavelength of light is represented in the continuous spectrum.



Hydrogen Emission Spectrum



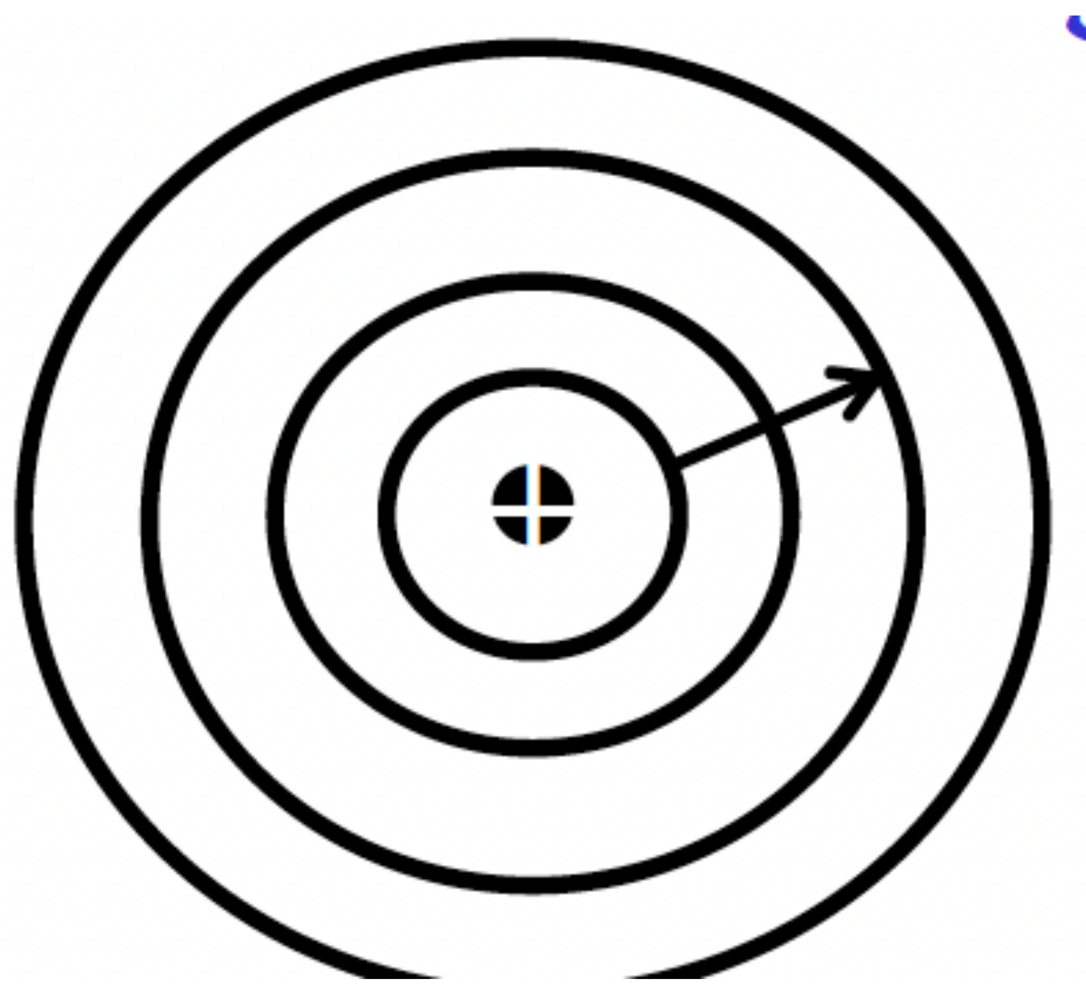
Why do we have different colors of light?

- As wavelength / frequency changes, color changes.
- But there is a duality to light:
  - It behaves like a wave AND it behaves like a particle (photon)
- As wavelength / frequency changes, the energy per photon changes.

$$E = h\nu$$

Why do atoms produce atomic light spectrums? (Absorption & Emission)

- When a photon is absorbed by an atom or molecule, an electron moves up one or more energy levels.
- The increase in energy is equal to the energy of the photon that was absorbed and equal to the difference in energy between the two energy levels.



Why do atoms produce atomic light spectrums? (Absorption & Emission)

- When a photon is emitted from an atom or molecule, an electron moves down one or more energy levels.
- The decrease in energy is equal to the energy of the photon that was released and also equal to the difference in energy between the two energy levels.