Lecture 38

Mon: Dec 2 → Do poll of favorite physics video.

→ D2L Survey

→ Show this.

Weds: Dec 4 → * HW by 5pm

* Includes one more video.

Atomic spectra

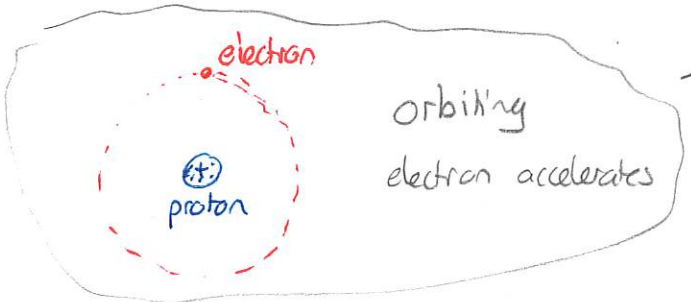
A gas of atoms can be excited so that it emits light. The light can be split into its constituent colors and, for a given material, this will display a series of particular distinct lines → this is the emission spectrum of the material. These spectra had been investigated since the early to middle 1800s and the question was to explain:

1) why there are only particular spectral lines and not a continuum for a given material.

2) why the particular spectral lines are the way the are for a given material, e.g. why hydrogen has the particular red, blue and violet lines.

DEMO: Hydrogen spectrum lines. McGuanie + Simon

The classical explanation would be:



→ Accelerating charge produces electromagnetic radiation with frequency matching that of the orbital frequency

This gets certain details completely incorrect!

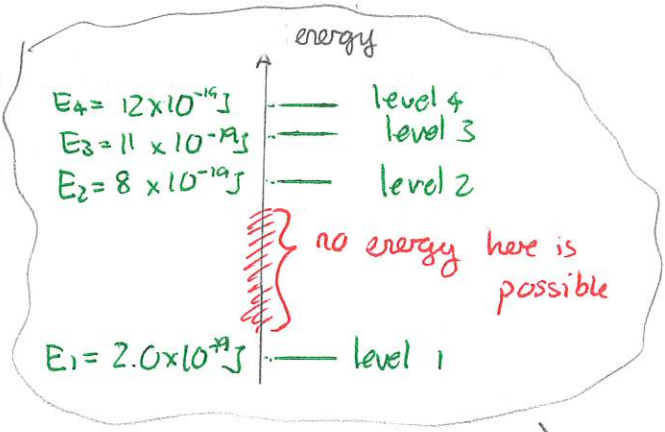
DEMO: Models of hydrogen atom – Classical solar system

Quantum theory explanation

A correct explanation eventually emerged from quantum theory. The ingredients are:

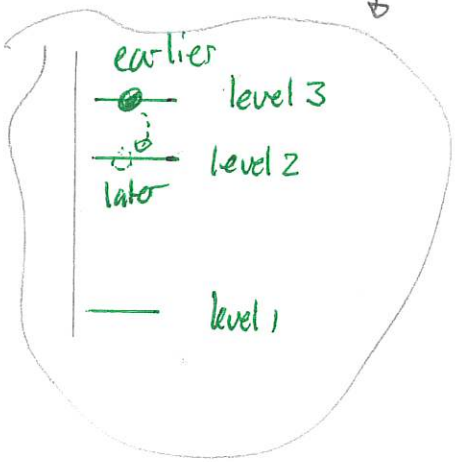
① Any atom or molecule can only take certain discrete energies.

The arrangement of these energies depends on the particular atom or molecule.



② The system will emit one photon if it drops from a higher to lower energy level. Then

energy of emitted photon = change in energy of atom/molecule.

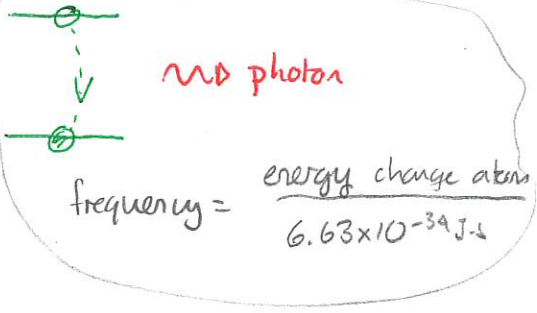


Quiz1 40% – 80%

③ The frequency of any emitted photon is determined using

$$\text{energy photon} = 6.63 \times 10^{-34}\ \text{J.s} \times \text{freq}$$

$$\Rightarrow \text{frequency} = \frac{\text{energy photon}}{6.63 \times 10^{-34}\ \text{Js}}$$



Quiz2 80%

This indicates that

If the possible energy levels for the atom/molecule are discrete then the atom/molecule can only emit electromagnetic radiation in a discrete spectrum.

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1 Artificial atom emission spectrum

An artificial atom has three energy levels as illustrated. The atom is initially in the level 3 and it then makes a jump to level 1.

Level 3 —— 11.0×10^{-19} J

Level 2 —— 7.0×10^{-19} J

Level 1 —— 2.0×10^{-19} J

a) Determine the decrease in the atom's energy.

b) Determine the frequency of the emitted light.

c) Determine the wavelength of the emitted light.

Answer: a) energy decrease = earlier energy − later energy.

$= 11.0 \times 10^{-19}\,J - 2.0 \times 10^{-19}\,J$

$= 9.0 \times 10^{-19}\,J$

b) frequency $= \frac{\text{energy photon}}{6.63 \times 10^{-34}\,J\cdot s} = \frac{\text{energy lost by atom}}{6.63 \times 10^{-34}\,J\cdot s}$

$= \frac{9.0 \times 10^{-19}\,J}{6.63 \times 10^{-34}\,J\cdot s} = 1.36 \times 10^{15}\,Hz$

c) wavelength $= \frac{\text{speed light}}{\text{freq}} = \frac{3.0 \times 10^{8}\,m/s}{}$

$= 2.2 \times 10^{-7}\,m$

$= 220\,nm.$