McQuarrie

Chapter 1

(A)

(1) Blackbody radiation

- Perfect absorber & emitter of light at all frequencies

(2) photoelectric effect

(3) Hydrogen line spectra.

1800s

Rayleigh - Jeans law

depends on Temperature

square of frequency.

$$\rho_\nu(T)\,d\nu = \frac{8\pi k_B T}{c^3}\nu^2\,d\nu$$

as heat increase in frequency the radiant energy density keeps on increasing & increasing.

frequency

$\frac{1}{\lambda}$ → Amount of light. ⇒ This failure is known as ultraviolet catastrophy.

* Classically, energy is a continuum range of values

Max-Plank solved this (1900s) by comming up with Quantum Assumption

Plank's constant

$E = nh\nu$ → energy can only take integer values

integer

i.e the space in between energy level.

* Quantum assumption is that we have discrete energy levels with spacing.

Now the new Equation

frequency version

$$\rho_\nu(T)\,d\nu = \frac{8\pi h}{c^3}\frac{d\nu}{e^{h\nu/k_BT}-1}$$

$h \approx 6.626\times10^{-34}\ \text{J}\cdot\text{s}$

$$\rho_\lambda(T)\,d\lambda = \frac{8\pi hc}{\lambda^5}\times\frac{d\lambda}{e^{hc/\lambda k_BT}-1}$$

$$\lambda_{max}T = \frac{hc}{4.965k_B}$$

$\lambda_{max}T = 2.90\times10^{-3}\ \text{m}\cdot\text{K}$

meters

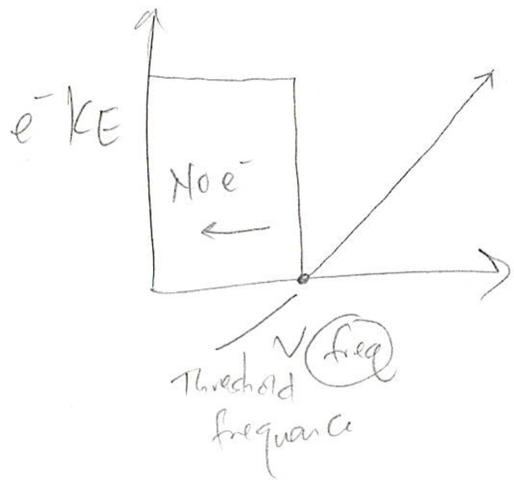
③ Photoelectric Effect · Light — EM radiation, that's why it reacts with e^-

① piece of metal
② shine the light on it
③ under the right conditions photon can be emitted.

Experimentally speaking

* frequency determines the color of the light.

*



Albert einsteign → Nobel prize in Photoelectric Effect.

* Light comes in quanta → called photons

$E = h\nu$

By Conservation of Energy

$KE = h\nu - \phi$ — eV

photon energy

- work function of the metal
- Amount of light required to remove an electron from the metal.

Quantum - discrete amount of Energy.

eV - amount of energy an electron gain when moving in 1V potential.

$1eV = (1.602 \times 10^{-19} C) \times (1V)$

$= 1.602 \times 10^{-19}$ Joules

* To get any e^- $h\nu > \phi$

Same values of h for both Black Body radiation

(1c) Hydrogen Atomic Spectra

$\lambda = \frac{h}{p}$ $\frac{kg \cdot m^2}{s^2} \cdot s$ / $\frac{kg\, m}{s}$

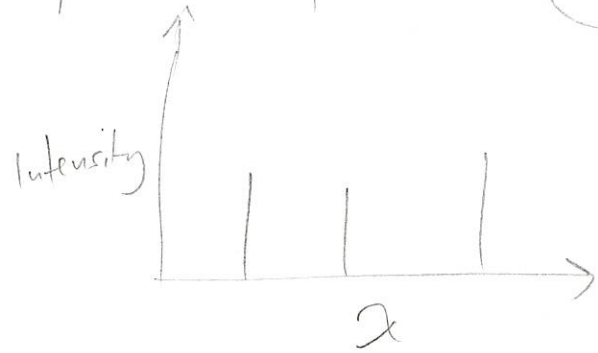
- place hydrogen in a tube and ~~place~~ electricity
- Excitation
- Emission of light.

$\boxed{J = \frac{kg \cdot m^2}{s^2}}$

$\lambda = \frac{h}{p}$ h → planks constant, p – momentum

$CV = $ joules

Hydrogen atomic spectrum



⇒ hydrogen only emits light at very specific frequencies

⇒ Reidberg formula: $\tilde{\nu} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$ where $n_2 > n_1$

Integer n shows up. $\frac{1}{\lambda}$ σ σ^*

(d) Chapter 1: De Broglie Postulate – matter can also behave like wave.

* light as both light & particle.

Particle → Photoelectric effect

Wave → Light deffraction.

$\lambda = \frac{h}{mv}$

(e) Electron Diffraction →

Coulomb's law ⇒ ① $f = \frac{e^2}{4\pi \varepsilon_0 r^2}$

force of attraction

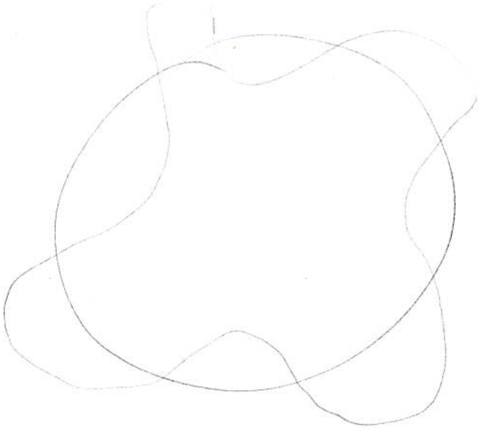
distance between charge.

* ① and ② have to balance each other.

– force that keeps e^- from collapsing is centifugal force

② $f = \frac{m_e v^2}{r}$ mass, velocity square

$$* \quad \therefore \frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{M_e v^2}{r}$$. Bohr assumes radius is fixed



Circumference

$2\pi r = n\lambda \quad n = 1, 2, 3$.

$\lambda = \frac{h}{mv} \qquad 2\pi r = n\left(\frac{h}{mv}\right)$

mass of e^-

$m = M_e$

$mv\,2\pi r = nh$

$\frac{h}{2\pi} = \hbar$

$M_e v 2\pi r = nh$

$M_e v r = \frac{nh}{2\pi} = n\hbar \longrightarrow$ Angular momentum

angular momentum comes in ~~Q~~ integer $\hbar$

You can't have a fraction.

$\therefore$ Angular momentum is also Quantized.

→ So what is the velocity of the electron?

$v = \frac{n\hbar}{M_e r}$

$\frac{e^2}{4\pi\varepsilon_0 r^2} = M_e v = \frac{M_e\left(\frac{n\hbar}{M_e r}\right)}{r}$

Solve for r; $r = \frac{4\pi\varepsilon_0 \hbar^2 n^2}{M_e e^2}$

This shows that orbits are Quantized.

$n = 1$

$r = a_0 = 5.29 \times 10^{-11}\,m$

Energy

$= KE + \underline{PE}$ Potential energy is Coulomb potential

$\frac{1}{2} M_e V^2$

$$KE + PE = \frac{1}{2} M_e V^2 - \underbrace{\frac{e^2}{4\pi \varepsilon_0 r}}_{\text{Because } e^- \text{ going away from nucleus.}}$$

$$E = -\frac{M_e e^4}{8 \varepsilon_0^2 h^2 n^2}$$ ∴ Energy is also Quantized.

$$\Delta E = h\nu = \underbrace{\frac{M_e e^4}{8 \varepsilon_0^2 h^2}}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Rydberg Constant

$R_H = 109680 \text{ cm}^{-1}$

Bohrs Model doesn't Predict the — That's why Bohr Model is not Correct but right for H

- H atom in a magnetic field
- Fails for He
- Violates uncertainty Principle

$\Delta x \Delta p \geq \frac{\hbar}{2}$