Light and Matter

Planck's equation

$$f = \frac{c}{\lambda}, \quad E = hf = \frac{hc}{\lambda} = \rho c$$

$$h = 6.63 \times 10^{-34}\,\text{Js} = 4.14 \times 10^{-15}\,\text{eVs}$$

$$1\,\text{eV} = 1.6 \times 10^{-19}\,\text{J}$$

Force of electrons

$$F = \frac{2P_{\text{in}}}{c}$$

$$\text{photons per second} = \frac{\text{total energy}}{\text{energy per photon}} = \frac{P_{\text{in}}\lambda}{hc} = \frac{P_{\text{in}}}{hf}$$

Photoelectric effect

- V_{supply} does not affect photocurrent
- $V_{\text{sup}} > 0$: e- attracted to collector anode
- $V_{\text{sup}} < 0$: attracted to illuminated cathode, $I \to 0$
- v of e- depends on ionisation energy (shell)
- max current depends on intensity

Threshold frequency f_0

- minimum f for photoelectrons to be ejected
- x-intercept of frequency vs E_K graph
- if $f < f_0$, no photoelectrons are detected

Work function ϕ

- minimum E required to release photoelectrons
- magnitude of y-intercept of frequency vs E_K graph
- ϕ is determined by strength of bonding

$$\phi = hf_0$$

Kinetic energy

$$E_{\text{k-max}} = hf - \phi$$

voltage in circuit or stopping voltage = max E_K in eV
equal to x-intercept of volts vs current graph (in eV)

Stopping potential (V for minimum I)

$$V = h_{\text{eV}}(f - f_0)$$

principle

an e- requires hitting it with a photon, but this causes ρ to be transferred to electron, moving

$$\sigma\rho\sigma x = \frac{h}{4\pi}$$

ality

hotoelectric effect
photocurrent
tween incidence and ejection
n medium

ectric effect
tron release $\propto$ intensity
ne photon releases one electron
ons interact. interference pattern still appears when a dim light source is used so that only
pass at a time

vity

De Broglie's theory

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

$$\rho = \frac{hf}{c} = \frac{h}{\lambda} = mv, \quad E = \rho c$$

- cannot confirm with double-slit (slit $< r_{\text{proton}}$)
- confirmed by similar e- and x-ray diff patterns

X-ray and electron interaction

- e- is only stable if $mvr = n\frac{h}{2\pi}$ where $n \in \mathbb{Z}$
- rearranging this, $2\pi r = n\frac{h}{mv} = n\lambda$ (circumference)
- if $2\pi r \neq n\frac{h}{mv}$, no standing wave
- if e- = x-ray diff patterns, $E_{\text{e-}} = \frac{\rho^2}{2m} = (\frac{h}{\lambda})^2 \div 2m$
- calculating h: $\lambda = \frac{h}{\rho}$

Spectral analysis

- $\Delta E = hf = \frac{hc}{\lambda}$ between ground / excited state
- E and f of photon: $E_2 - E_1 = hf = \frac{hc}{\lambda}$
- Ionisation energy - min E required to remove e-
- EMR is absorbed/emitted when $E_{\text{K-in}} = \Delta E_{\text{shells}}$ (i.e. $\lambda = \frac{hc}{\Delta E_{\text{shells}}}$)