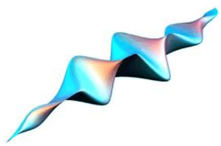
Chapter 29 - Particle Physics

Photon = particle of light energy

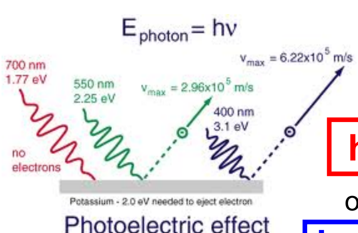
- Given off in "packets" of h
- h = Plank's constant = 6.626 x 10 $^{-34}$ Js



Energy of one photon = Ep = hf

Photoelectric Effect

- photon of light knocks out electron from a metal plate
- need minimum f (energy) to dislodge (Depends on metal)
- **W_o (Φ_o) = hf_o = work function** = min energy..photons BELOW this f WILL not dislodge electron
- Extra energy turns into KE = faster current



$hf = K_{max} + W_o$

or EQ sheet writes

$hc/\lambda = \Phi_o + K_{max}$

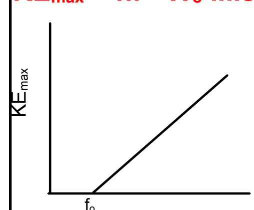
phet.colorado.edu/en/simulation/photoelectric

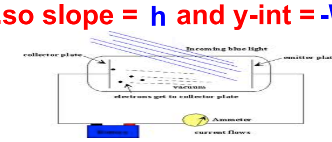
~~$hf =$~~

$KE_{max} = hf - \phi$

$y = mx + b$

$KE_{max} = hf - W_o$ ....so slope = h and y-int = $-W_o$





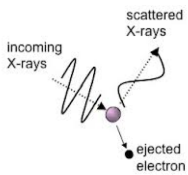
Stopping Voltage (V_o) = Energy to make electrons stop...pushes opposite direction

Remember W = KE

so **$eV_o = KE_{max}$**

Compton Effect and Photon Momentum

- Light waves can "collide" with electrons so as to CHANGE their frequency
- Like momentum collision
- higher f x-ray before....lower f x-ray after...since momentum is conserved....some momentum is transferred to the dislodged electron



$p_{\lambda 1} = p_p + p_\lambda$ ------conservation of momentum

From ch 28.... $E_p = mc^2$

From ch 29...$E_p = hf$

so... $p = mv = mc^2/c = hf/c = h/\lambda$

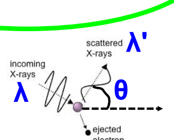
this means light has momentum!!!!

$$p = h/\lambda$$ → Compton wavelength

Compton Equation

$\lambda_e = h/mc = 2.43 \times 10^{-12}$ m
= Compton wavelength of an electron

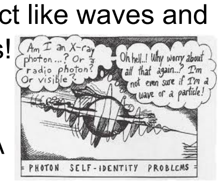
$$\lambda' - \lambda = (h/mc)(1 - \cos\theta)$$



note $\lambda' < \lambda$ because LOSES energy/ momentum

Wave-particle duality theory-

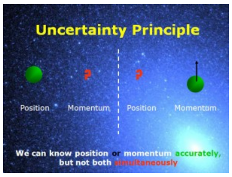
This means particles can act like waves and waves can act like particles!



wave as particle ⇒ $p = h/\lambda$

particle as wave = **deBroglie wavelength**

⇒ $$\lambda = h/p$$




"But you can't go through life applying Heisenberg's Uncertainty Principle to everything."

Newtonian Physics	Quantum Mechanics
Large Particles	Small Particles
v <<< c	v ≈ c
opening > λ	opening ≤ λ
Newton's Laws	Schrödenger EQ's

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$$

Second derivative with respect to x; Schrodinger Wave Function; Position; Energy; Potential Energy

Heisenberg's Uncertainty principle

- can't observe a particle without interacting and changing something about particle
- uncertainty in momentum OR position OR energy OR time

$\Delta p_y \Delta y \geq h/2\pi$

$\Delta E \Delta t \geq h/2\pi$

p_y = momentum in y direction
y = position in y direction
E = Energy t = time