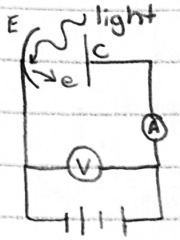
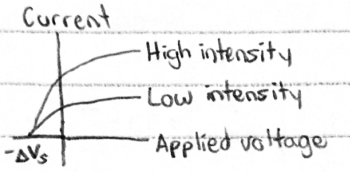
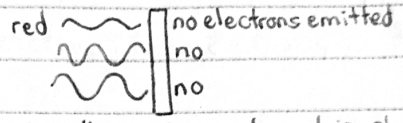
Quantum Mechanics PH112

Quantum theory - describes physics on a microscopic / atomic scale

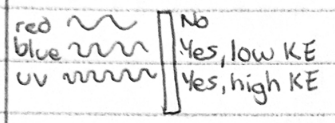
Photoelectric effect - when light is incident on certain metallic surfaces, electrons are emitted from the surface







Wave theory does not explain photoelectric effect

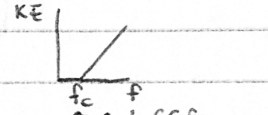


Small $\lambda \rightarrow$ high ν

Light consists of a beam of small particals that is directly proportional to frequency

$E_{ph} = \underbrace{hf}_{\text{Planck's constant} = 6.6\times10^{-34}\ Js} = E_{binding} + KE_{el}$

$KE_{el} = E_{ph} - \Phi = hf - \underbrace{\Phi}_{\text{work function}}$ $\quad KE \sim hf$



Cutoff frequency $= \frac{\Phi}{h}$

Example #1

$v = 4.6\times10^5$ m/s

$\lambda = 625$ nm $= 6.25\times10^{-7}$ m

$\Phi = ?$ $f_c = ?$

$KE = hf - \Phi$ $\quad \Phi = hf - KE$

$hf = 6.6\times10^{-34}(4.8\times10^{14}) = 3.2\times10^{-19}$ J

$c = \lambda f$ $\quad f = \frac{c}{\lambda} = \frac{3\times10^8}{6.25\times10^{-7}} = 4.8\times10^{14}$ Hz

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.1\times10^{-31})(4.6\times10^5)^2 = 9.6\times10^{-20}$ J

$\Phi = 3.2\times10^{-19} - 9.6\times10^{-20} = \boxed{2.2\times10^{-19}\ J} = 1.4$ eV

$f_c = \frac{\Phi}{h} = \frac{2.2\times10^{-19}}{6.6\times10^{-34}} = \boxed{3.3\times10^{14}\ Hz}$

$1\ eV = 1.6\times10^{-19}$ J

Photocell - current produced when light of high frequency falls on the cell

A beam of light behaves like a wave

A single photon behaves like a particle