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Photoelectric effect - classical physics predicts that increased intensity of incident radiation will result in increased kinetic energy of the electrons coming off the metal. It also predicts a lag time between the light hitting the metal and electrons getting knocked off, but neither of these are observed. Instead, the kinetic energy of electrons depends only on the frequency of the incident radiation and the electrons are released instantaneously.

Black body radiation - classical physics predicts an equal amount of energy in an infinite number of modes so that a black body in thermal equilibrium will emit radiation with infinite power. Modern physics fixes up this situation by only allowing certain energies - those which are an integer multiple of the fundamental quantum of energy. Making this assumption makes theory fit experiment exactly if "h" (Planck's constant) is chosen carefully. This is also known as the "Ultraviolet Catastrophe".

Given

$$u(f,T)df = \frac{8\pi h f^3}{c^3}\left(\frac{1}{e^{hf/kT}-1}\right)df$$

derive $u(\lambda,T)d\lambda$.

Recall, for a general function $F(b)db = F(a)\left|\frac{da}{db}\right| db$ ← expressed in terms of b

In our case, $F = u$, $a = f$, $b = \lambda$.

$$u(\lambda,T)d\lambda = \underbrace{u(f,T)}\left|\frac{df}{d\lambda}\right| d\lambda$$

→ where this is expressed in terms of λ.

We are given $f = \frac{c}{\lambda} \Rightarrow \left|\frac{df}{d\lambda}\right| = \frac{c}{\lambda^2}$.

So, $$u(\lambda,T)d\lambda = \frac{8\pi h\left(\frac{c}{\lambda}\right)^3}{c^3}\left(\frac{1}{e^{hc/\lambda kT}-1}\right)\frac{c}{\lambda^2}\,d\lambda$$

$$= \boxed{\frac{8\pi hc}{\lambda^5}\left(\frac{1}{e^{hc/\lambda kT}-1}\right)d\lambda}$$

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$\varphi = 4.2eV$

What is the maximum wavelength/minimum frequency to remove an e^-?

We are given $KE = hf - \varphi$, and to find the minimum frequency we set $KE = 0$.

$$\Rightarrow hf = \varphi \Rightarrow f = \frac{\varphi}{h} = \frac{4.2eV}{4.136\times10^{-15} eVs} = \boxed{1.02\times10^{15} hz}$$

$$f = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{f} = \frac{3\times10^{8} m/s}{1.02\times10^{15} s^{-1}} = \boxed{2.95\times10^{-7} m}$$

Recall $KE = eV_s$. $\Rightarrow eV_s = hf - \varphi$

$$\Rightarrow V_s = \frac{hf - \varphi}{e} = \frac{(4.136\times10^{-15} eVs)\left(\frac{3\times10^{8} m/s}{200\times10^{-9} m}\right) - 4.2eV}{e}$$

$$= \boxed{2.00 V}$$