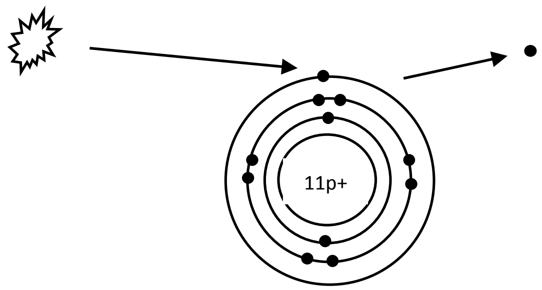
Photoelectric Effect

Note: The pHet simulation (Photoelectric Effect) is very helpful here.

Red light does NOT initiate the photoelectric Effect (PE effect) with sodium no matter how intense the light but blue light DOES initiate the photoelectric effect. Let's start with this idea.



This electron has kinetic energy!

I have drawn a sodium atom using the Bohr-Rutherford method. In the 3rd, outermost orbit is 1 electron. If a photon of blue light interacts with this 1 electron, it will free it from the atom. The electron is electrostatically attracted to the +ve nucleus so it will take work to remove this electron. The outermost electron is the easiest to free as it is the most loosely attached and requires the least amount of work to detach it.

 = photon of blue light

Photons and electrons interact in a 1:1 ratio. That is 1 photon interacts with 1 electron. If the photon does NOT have enough energy to do the work to free the electron, then it stays with the sodium nucleus. This is what happens with red light. The red photons never have enough energy to do the work necessary to free the outer electron from the nucleus so it stays put. No current is observed because no electrons are freed.

Basic formula:

$$E_\lambda = W_o + E_k$$

Kinetic energy of freed electron

$E_k = \frac{1}{2} mv^2$

You need mass of electron! (kg)

Energy of the photon.

Planck's formulas

$E = hc/\lambda$

$E = hf$

Work Function

This is how much work it takes to release an outer electron. It is determined experimentally and you have charts to look up values.

Each metal has its own unique work function.

To make this formula work, Energy and Work must be in Joules!!

But scientists often use electronvolts (eV) for such small amounts. Be able to convert! 1 eV = 1.6×10^{-19} Joules

Example question:

Q: A metal has a known work function of 2.3 eV and it is illuminated with orange light of wavelength 632 nm. Will you observe the photoelectric effect?

A: If Eλ > Wo then you will see PE effect.

$E\lambda = hc/\lambda = (6.626 \times 10^{-34})(3 \times 10^{8})/632 \times 10^{-9} = 3.15 \times 10^{-19}$ Joules

NOTICE → nm converted to meters in formula!

Now convert Joules to eV to compre Eλ to Wo

3.15×10^{-19} ~~Joules~~ x 1 eV/1.6×10^{-19} ~~Joules~~ = 1.9 eV

Eλ (1.9 ev) is less than Wo (2.3 eV) so NO photoelectric effect.

Q: What is the longest wavelength that would produce the PE effect?

A: Shorter wavelengths have more energy so this question is asking for the 'cut off' frequency. That is, the lowest energy/longest wavelength that would have enough energy to rip off an electron.

$E_\lambda = W_o + E_k$ Set Ek = 0 because you just want to free the electron with no left over energy for Ek.

$E_\lambda = W_o$

$hc/\lambda = 3.68 \times 10^{-19}$ Joules $(2.3 \text{ eV}) \times (1.6 \times 10^{-19} \text{ J}/ 1\text{eV}) = 3.68 \times 10^{-19}$ J

$\lambda = 5.40 \times 10^{-7}$ m

The longest wavelength that would create the PE effect would be 540 nm