Lesson 34: Photoelectric Effect Graphs

Like many other topics in science, the results of the photoelectric effect can be better understood if the results are presented in a graph. It is important to be able to interpret these graphs correctly.

- The following graph is a typical example of how the photoelectric effect will be shown to you.
  - Realize that some parts can be changed, and although this will change the graph (like flipping it around), the same essential information is there.
- The **vertical axis** is labeled as **energy**.
  - If we're in the positive values, we're basically looking at the kinetic energy the electron has as it zips around.
  - A negative energy value is how much energy it is lacking to be able to break off the metal it starts on.
- The **horizontal axis** is the **frequency** of the light striking the metal.

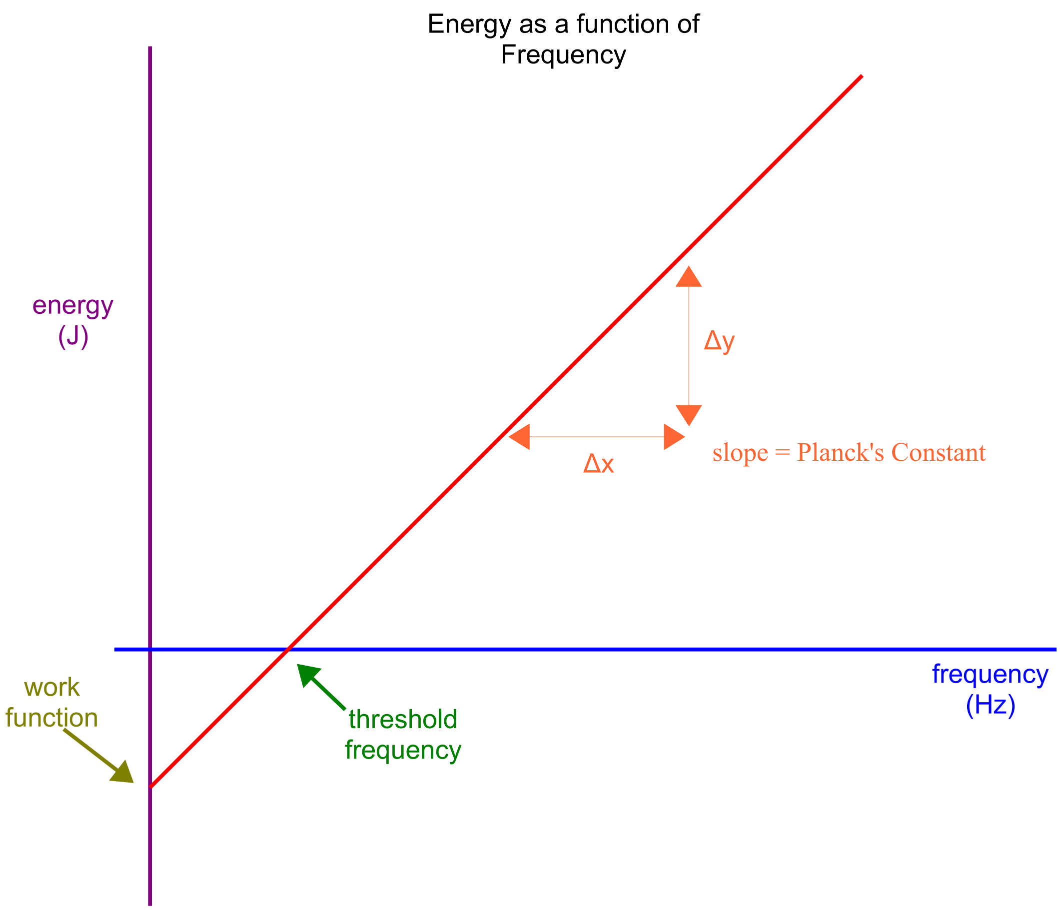


Illustration 1: Energy as a function of Frequency

Threshold Frequency

The x-intercept is the threshold frequency of the material. This makes sense, since the electron will have zero kinetic energy when it has received a photon at the threshold frequency. The electron has just enough energy to be knocked off the surface, but that's it!

Work Function

The y-intercept is the work function of the material. For any frequency less than the threshold frequency, it's like the electron is in a deep hole. As the frequency goes from zero to higher values, the electron is lifted higher out of the hole, until finally at its threshold frequency it's out. When there are no photons hitting it (frequency = 0 Hz), it is completely attached to the material. This is why they appear as negative values on the graph.

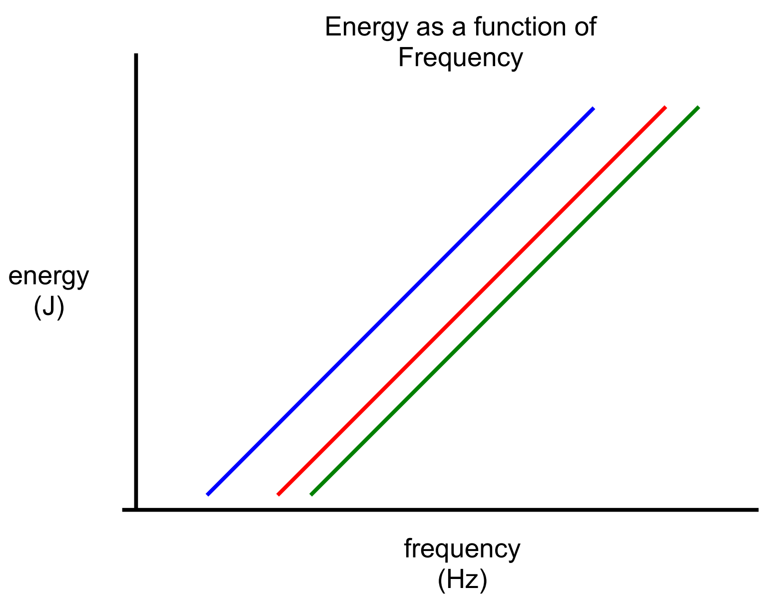
Planck's Constant

If you look at the values you would use to calculate the slope of the line (Δx and Δy), you'll notice that the "rise over run" would be a change in energy over a change in frequency. Look at the formula E = hf and solve for energy over frequency… what do you get?

$$E = hf \qquad h = \frac{E}{f} \quad \text{and} \quad slope = \frac{\Delta y}{\Delta x} = \frac{rise}{run} \qquad slope = \frac{E}{f}$$

So the slope of the graph will ***always*** be Planck's constant.

Example 1: The following graph shows the effect of shining different frequencies of light on three different metals. The metals and their work functions are copper (4.70eV), calcium (2.90eV), and selenium (5.11eV). **Identify** which line represents each metal.



From the formula for work function ($W = hf_o$) we know that the bigger the work function, the bigger the threshold frequency. Therefore, the lines are...

calcium (2.90eV)
copper (4.70eV)
selenium (5.11eV)

You can even relate the photoelectric effect formula to the formula for a straight line graph if it helps you remember what the three parts of the graph represent.

$$y = mx + b$$
$$E_{kmax} = hf + -W$$
$$hf = E_{kmax} + W$$

- The **y axis** is E_{kmax}
- The **slope** (**m**) is **Planck's Constant** (**h**)
- The **x axis** is the **frequency**
- The **y intercept** is the **work function** (**W**)

Homework

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