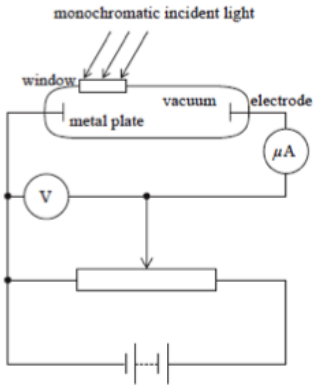
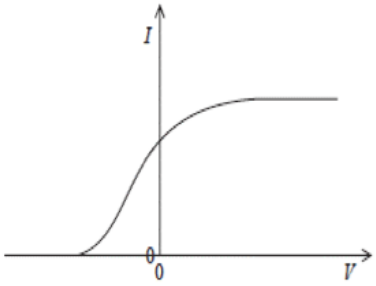
The apparatus shown is used to investigate the photo-electric effect. The potential difference V applied between the metal plates and electrode may be varied in magnitude and direction. In one particular experiment, the frequency and intensity of the light are held constant. The graph shows the variation with the potential difference of the current measured on the microammeter.

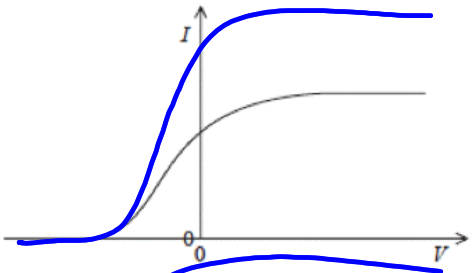




1. Discuss the features of the graph.
   a) current reaches a maximum value with positive potential difference
   b) current drops to zero with a negative potential difference = stopping potential

2. How would this graph change if the intensity of the light increased at the same frequency? Sketch it on the axes.

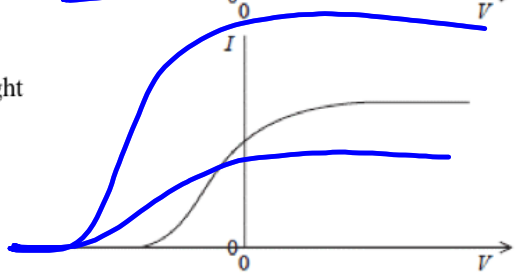
   Same V_s (same energy per photon = same E_{max}) – higher max current (more photons)



(if all photons already cause PE)

3. How would this graph change if the frequency of the light increased at the same intensity? Sketch it on the axes.

   More negative V_s (more energy) – lower max current (fewer photons so fewer electrons)



4. The potentiometer is adjusted to give the minimum voltage at which there is zero reading on the microammeter. State and explain what change, if any, will occur in the microammeter when

a) the intensity of the incident light is increased but the frequency remains unchanged.

No change – stopping potential depends on energy of each electron – no change in frequency so no change in photon energy so no change in electron energy

b) the frequency of the light is increased at a constant intensity.

· Reading increases from zero – photon energy increases so electron energy increases.

Matter Waves

Louis de Broglie (French physicist, 1892 – 1987) postulated in his doctoral dissertation that because light can have both wave and particle characteristics, perhaps all forms of matter have both characteristics.

De Broglie Hypothesis (1924):

All particles can behave like waves whose wavelength is given by $\lambda = \frac{h}{p}$

where h = Planck's constant and p = the momentum of the particle

Matter wave:

All moving particles have a "matter wave" associated with them whose wavelength is the de Broglie wavelength.

Wave-Particle Duality:

Both matter and radiation have a "dual nature".
They exhibit both particle and wave properties.

De Broglie wavelength

Sketch the relationship between speed and the de Broglie wavelength of a moving object