OGUN DIGICLASS

CLASS: SECONDARY SCHOOL

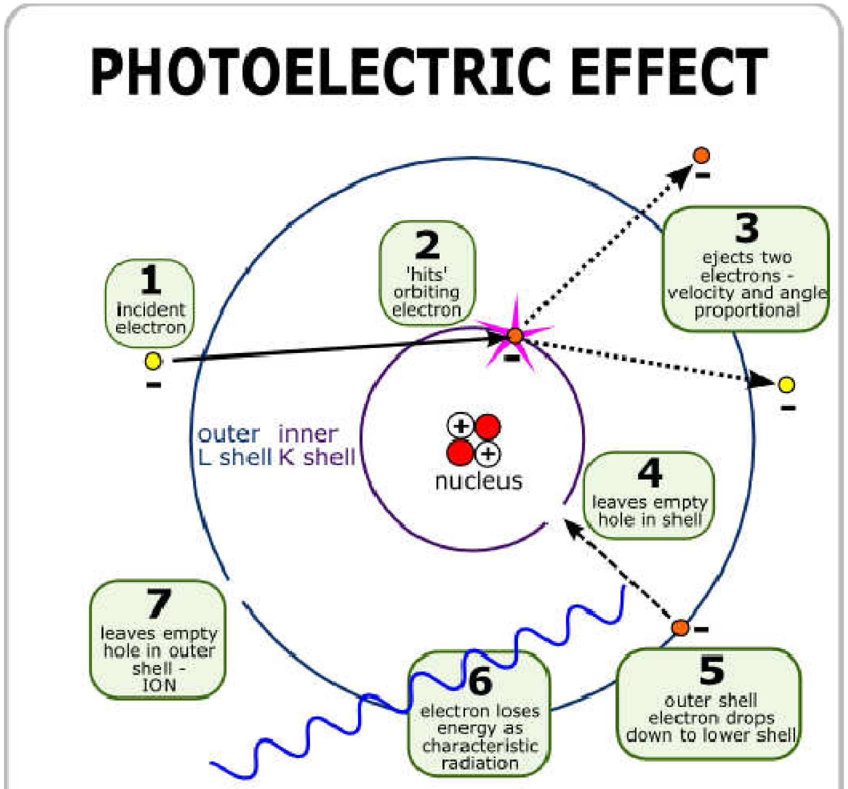
SUBJECT: PHYSICS

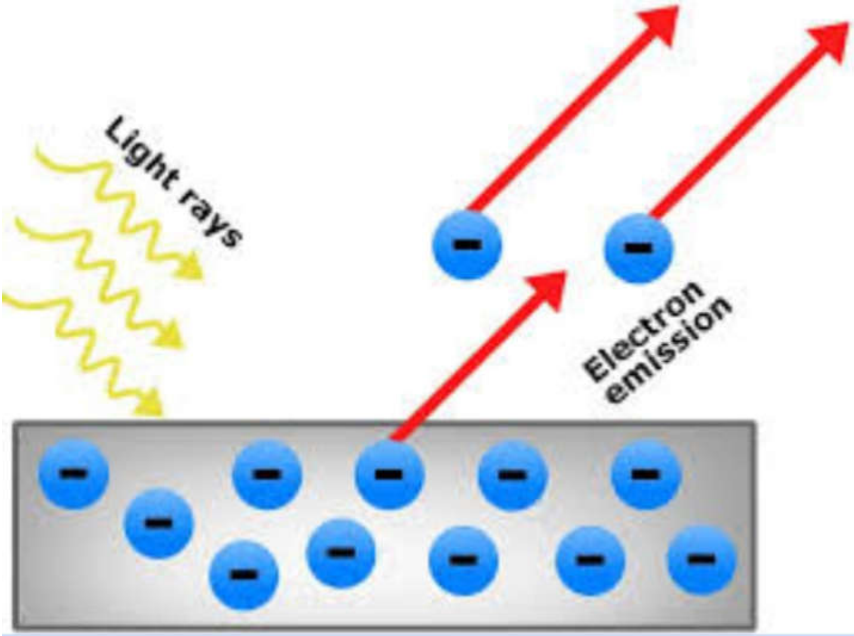
TOPIC: Photoelectric Effect

Learning objective

- Use of photon concept to explain the ejection of electrons in the photoelectric effect
- Solve simple problems involving threshold frequency, work function and Planck's constant.

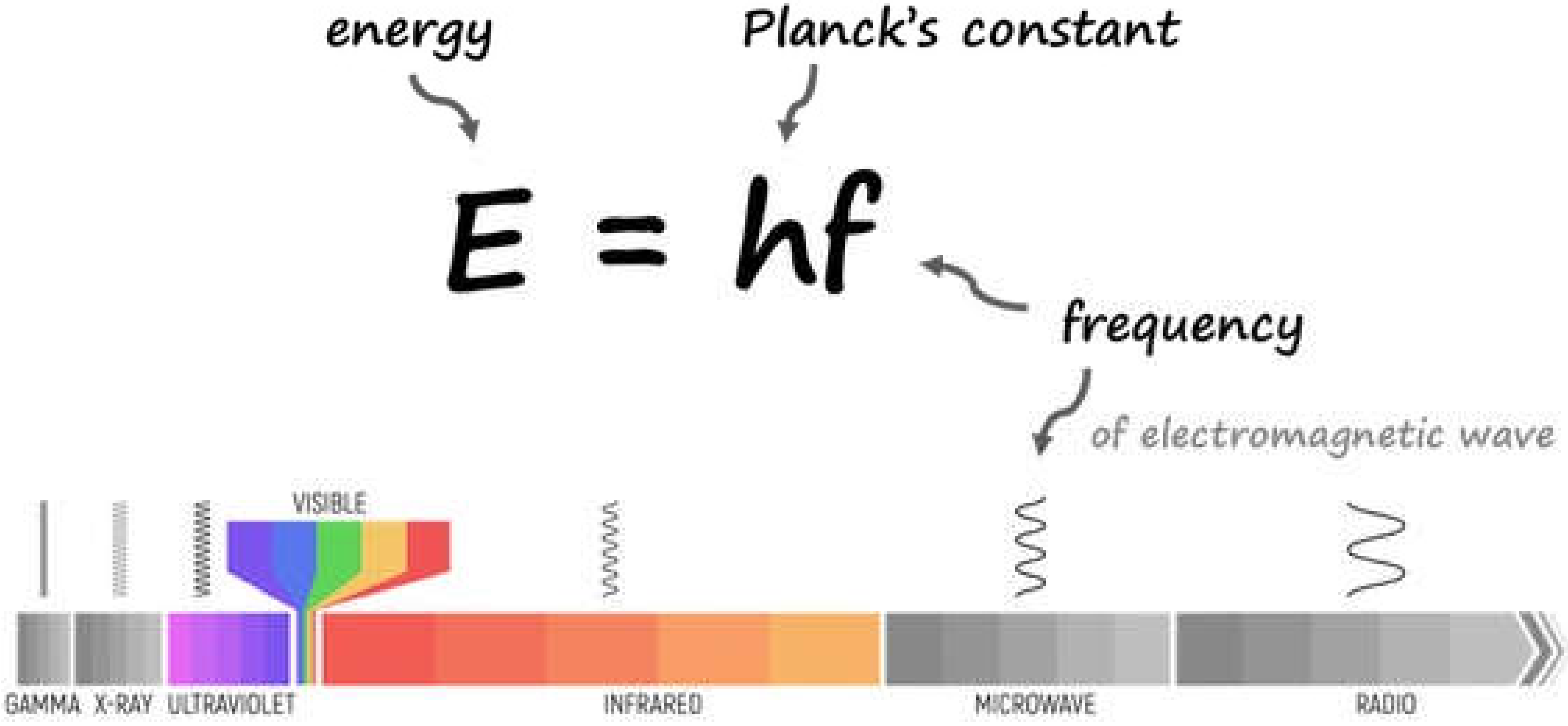
The Photoelectric Effect





A photo is the energy possessed by light.

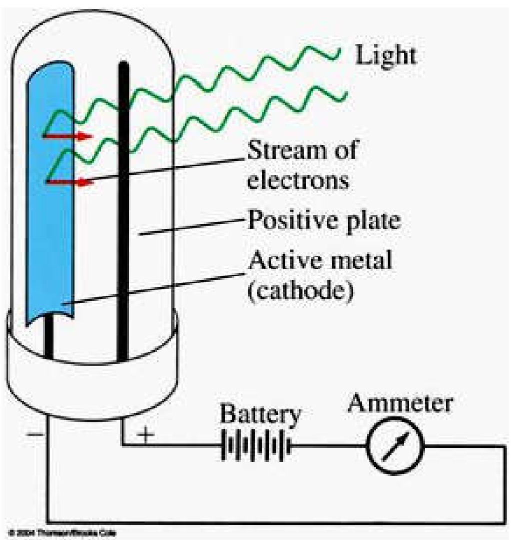
It is given as E = hf



Photoelectron is the electron emitted from the surface of the metal when light (UV) falls on it.

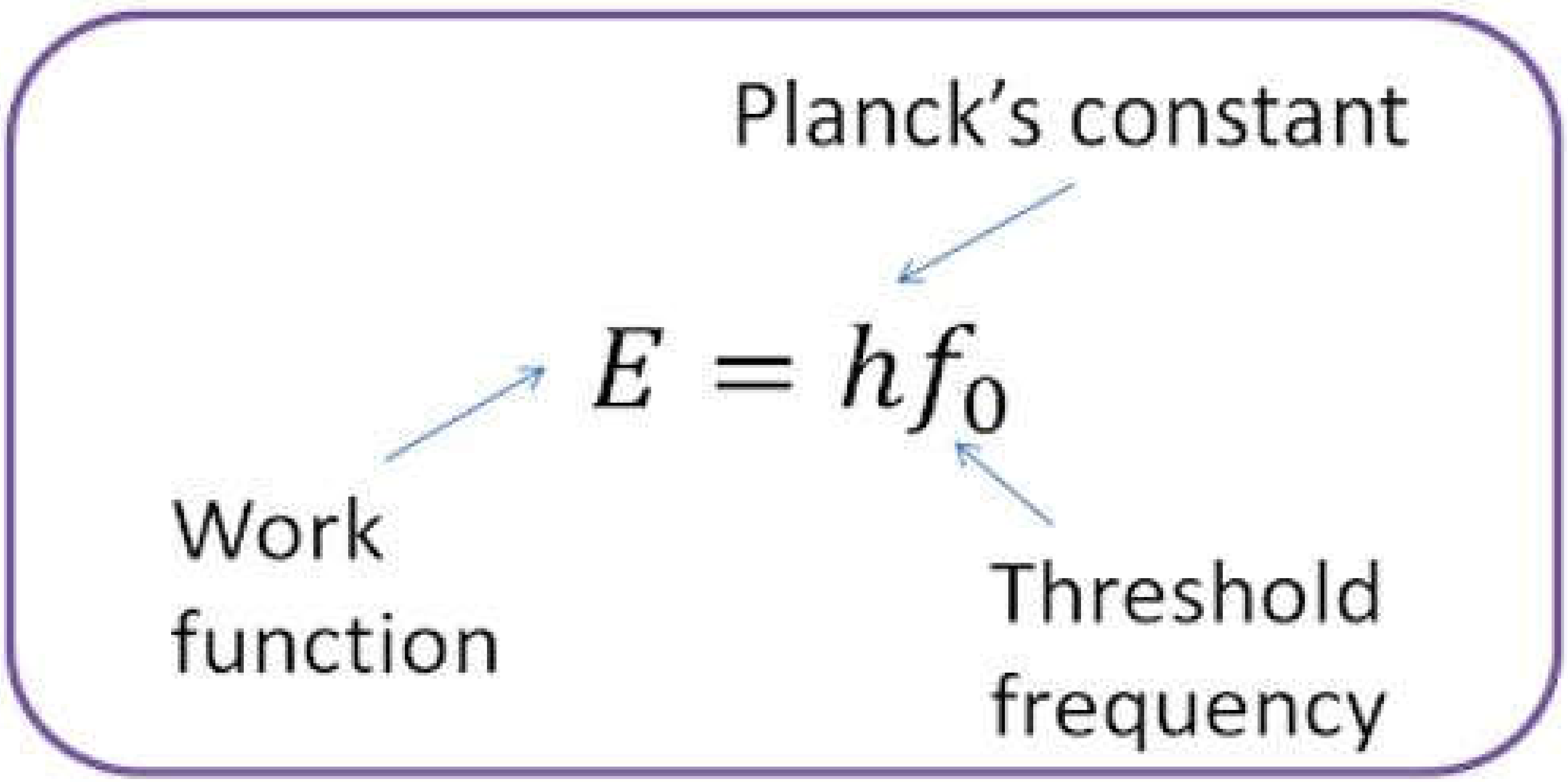
The phenomenon is called photoelectric effect

The Photoelectric Effect



- Light can strike the surface of some metals causing an electron to be ejected
  - No matter how brightly the light shines, electrons are ejected only if the light has sufficient energy (sufficiently short wavelength)
  - After the necessary energy is reached, the current (# electrons emitted per second) increases as the intensity (brightness) of the light increases
  - The current, however, does not depend on the wavelength

Electrons are only emitted if you have a high enough frequency, this is known as the threshold frequency f and is different for every metal.
Increasing the intensity of the light does not increase the K.E. of the emitted electrons but rather the number of electrons emitted



What are we saying

Without a large enough ball it doesn't matter how much energy you use when you throw it at the coconut you're not going to knock it off

If instead you use a large enough ball you can use very little energy to knock the coconut off

What else can be observed

If the frequency is above the threshold frequency then electrons can receive the energy from just one photon and do not accumulate energy as would be expected from wave theory.

The kinetic energy relies on the frequency not intensity of light

The left over energy from the frequency of the light through conservation of energy goes into the kinetic energy of the electron.

More on conservation of energy

- If energy must be conserved how can we turn that into an equation?

$E = hf$ and $E = W + E_{k(max)}$ where E is the photon energy , W is the work function and $E_{k(max)}$ is the maximum kinetic energy.

Therefore $E_{k(max)} = hf - W$

We can then calculate the speed v of the electron : since $E_k = \frac{1}{2}mv^2$

$$V = \sqrt{\frac{2(hf - W)}{m}}$$

Work function W is the minimum energy required to liberate/eject an electron from a metal’s surface.

$$W = hf$$

EXAMPLE

If a photoemission surface has threshold wavelength of 0.65μm. Calculate

(i) its threshold frequency

(ii) the maximum speed of the electron emitted by violet light of wavelength 0.4μm.($h = 6.6 \times 10^{\ \ 4}$J, $v = 3 \times 10\ $ m/s)

SOLUTION

(i)threshold frequency f = v/ = 3x10 / 0.65 x 10

= 4.62 x 10^{14}Hz

(ii) the maximum speed of the electron emitted by violet light of wavelength K.E = hf - W

= hv/ - hv/

= [(6.6 x 10^{4} x 3x10)/0.4 x 10] - [(6.6 x 10^{4} x 3x10)/0.65 x 10]

= (4.95 x 10^{1}) - (3.09 x 10^{1})

= 1.90 x 10^{1} J

Applications of Photoelectric Emission

- Photometers
- Burglar alarms
- Automatic doors
- Television cameras
- Sound production from film tracks
- Solar cell
- Fire alarm

ASSIGNMENT

Plotting E = W+ $\boldsymbol{E_{k(max)}}$

The photoelectric effect has been investigated for zinc. Calculate a value for h, W and the frequency at which electrons will start being emitted with the following data.

Wavelength (nm)	E_k (eV)
200	1.8875
100	8.075
50	20.45
20	57.575
10	119.45

Steps

1. Convert nm to frequency
2. Convert eV to J (1eV = 1.6 x 10^{1} J)
3. Plot frequency on x axis and Kinetic energy on y axis
4. Intercept of x axis is the threshold frequency
5. Intercept of y axis is W
6. Gradient is h