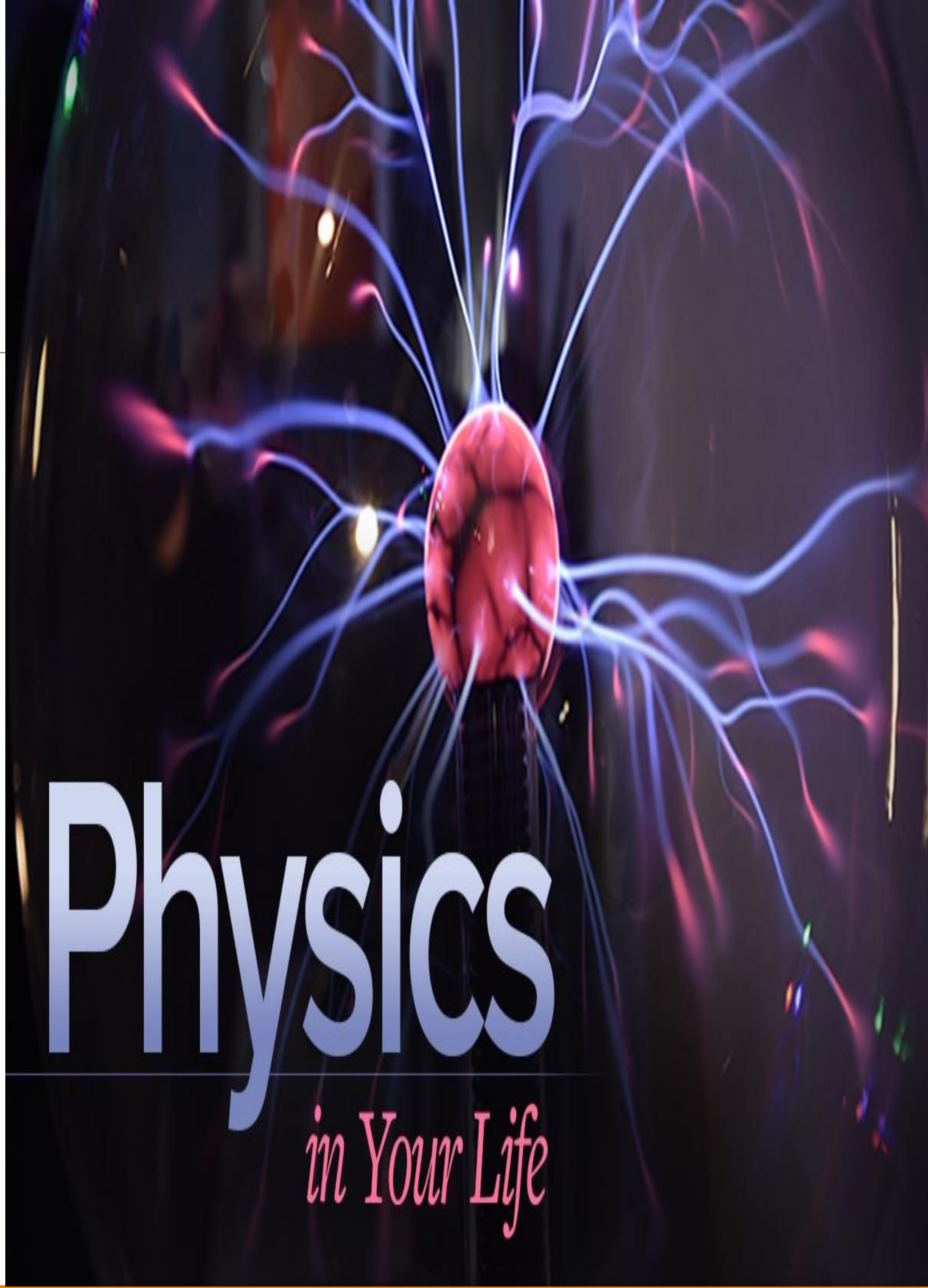
PHYS 102- ATOMIC PHYSICS

At the beginning of the semester, I said we shall consider three major topics:

1) Optics

2) Electromagnetism

3) Atomic Physics

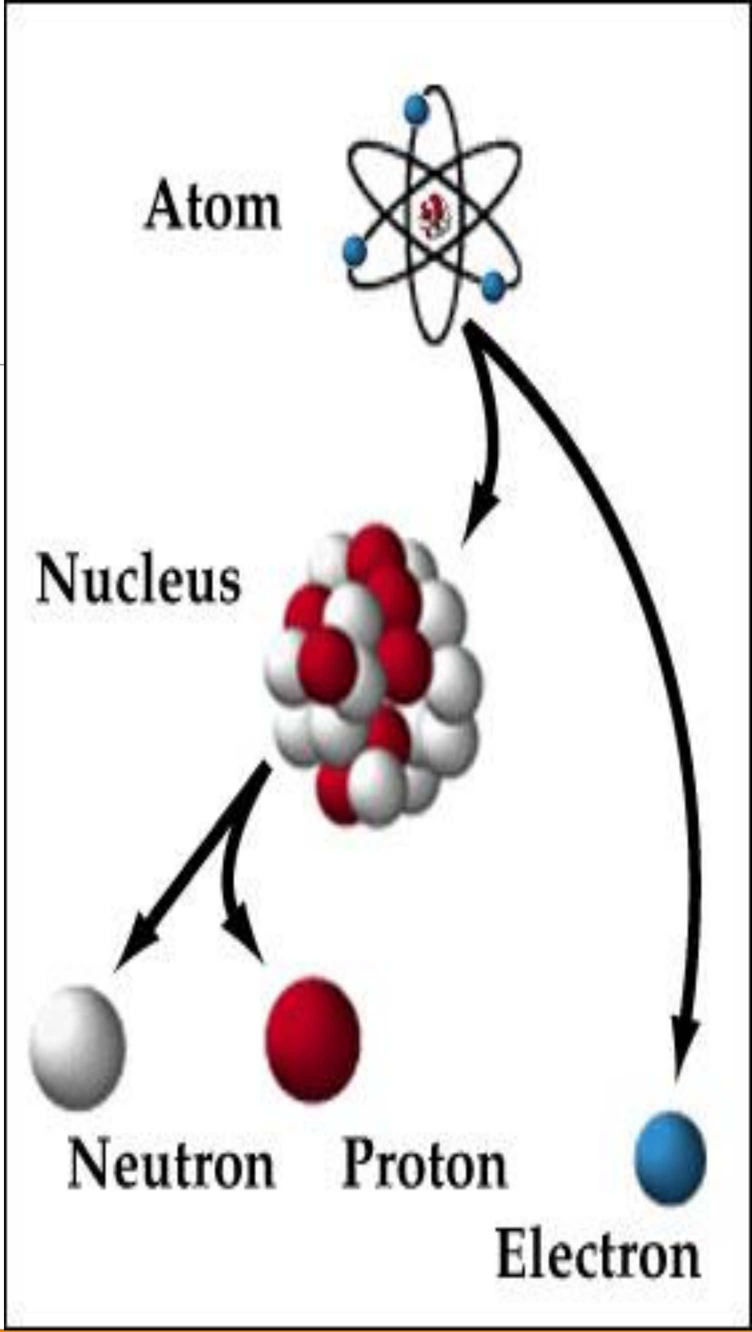


PHYS 102- ATOMIC PHYSICS

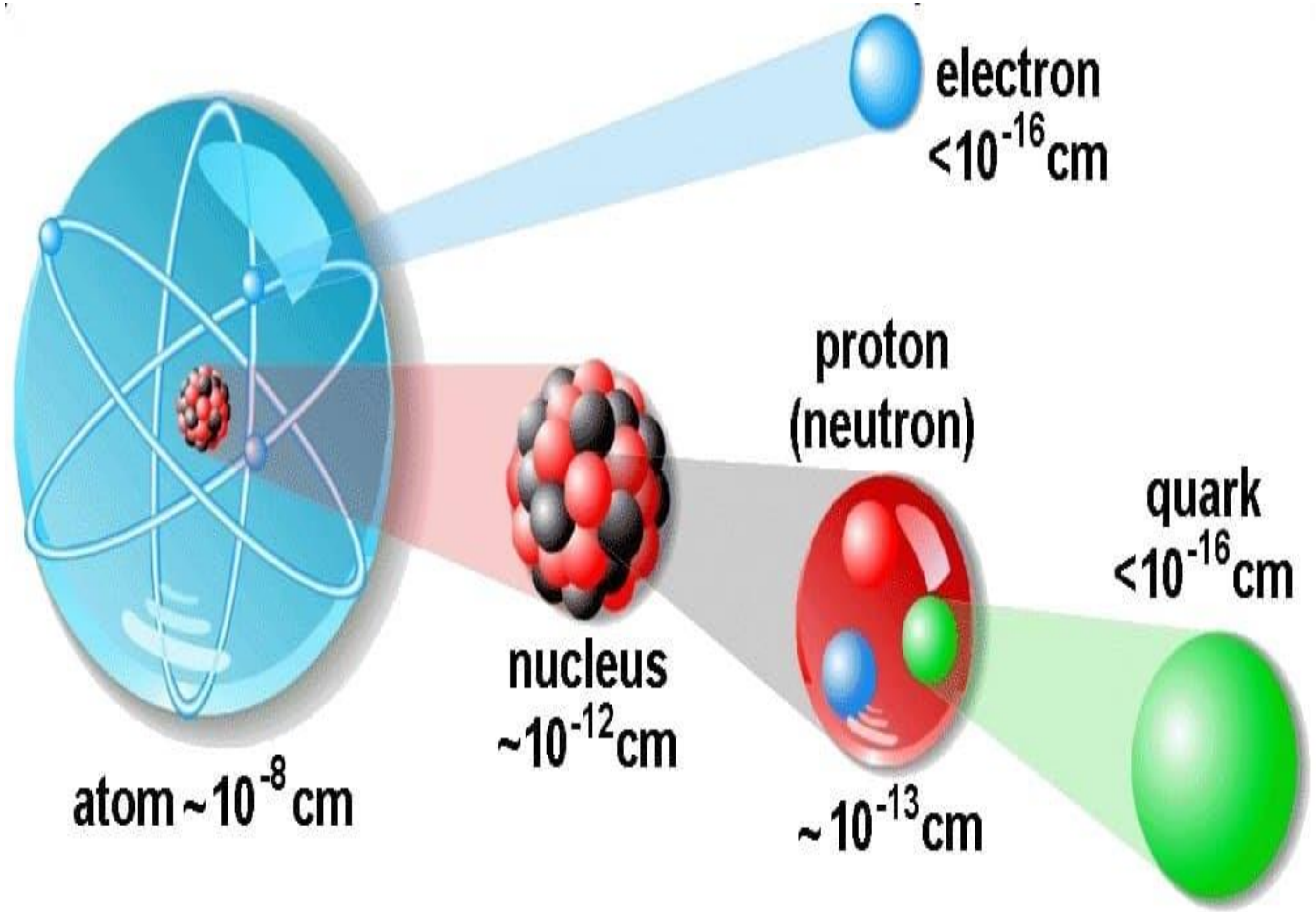
Lesson Goals:

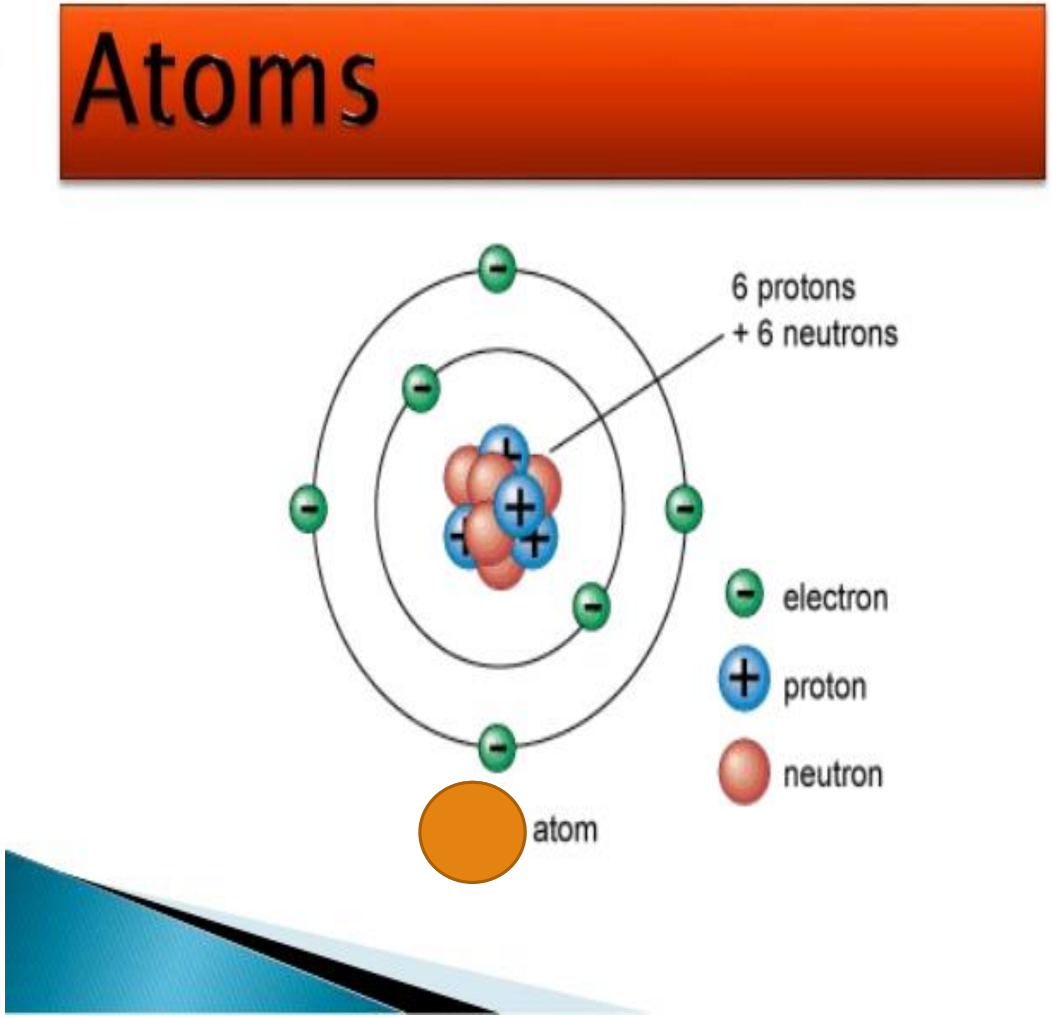
I strongly believe that at the end of this class, all of you should understand-:

1) Photons and Photo-Electric Effects
2) Radioactivity
3) The fundamental equation of radioactive decay
4) Half Life and Mean Life
5) Atomic Nucleus
6) Binding Energy



So, let's look at the *ATOM!*





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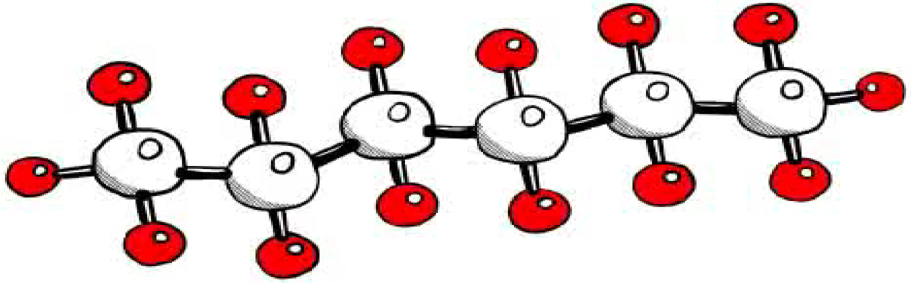
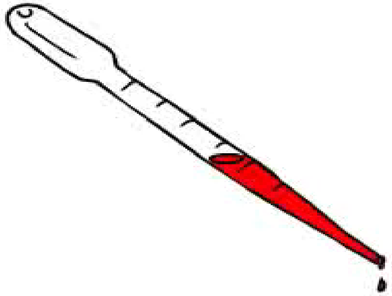
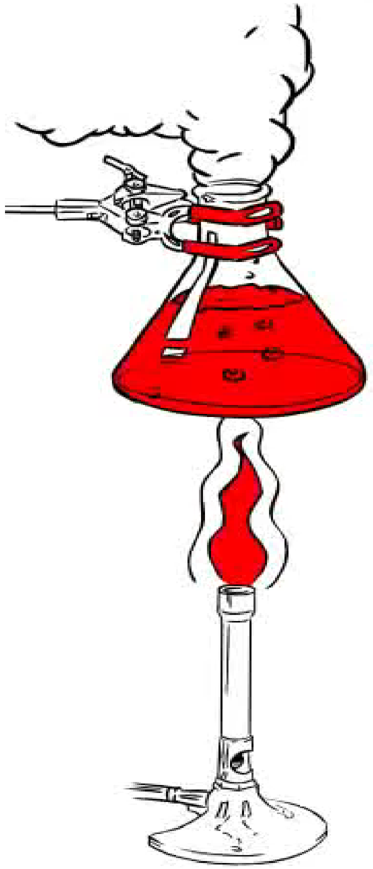
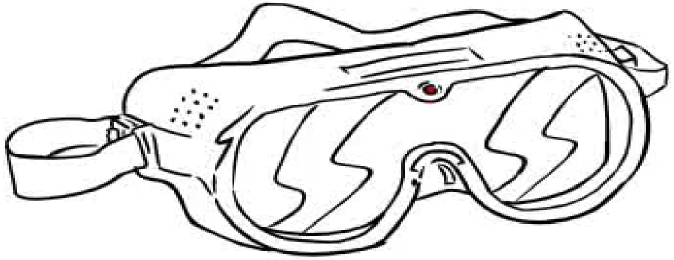
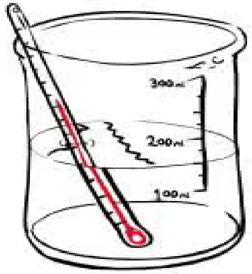


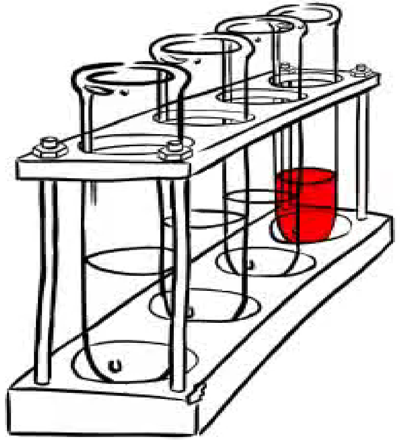




Parts of an atom





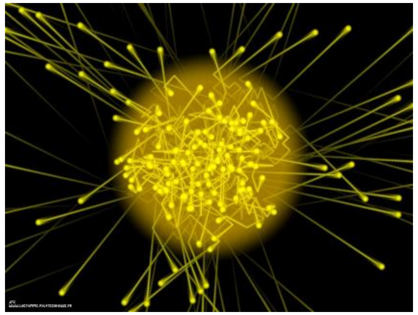


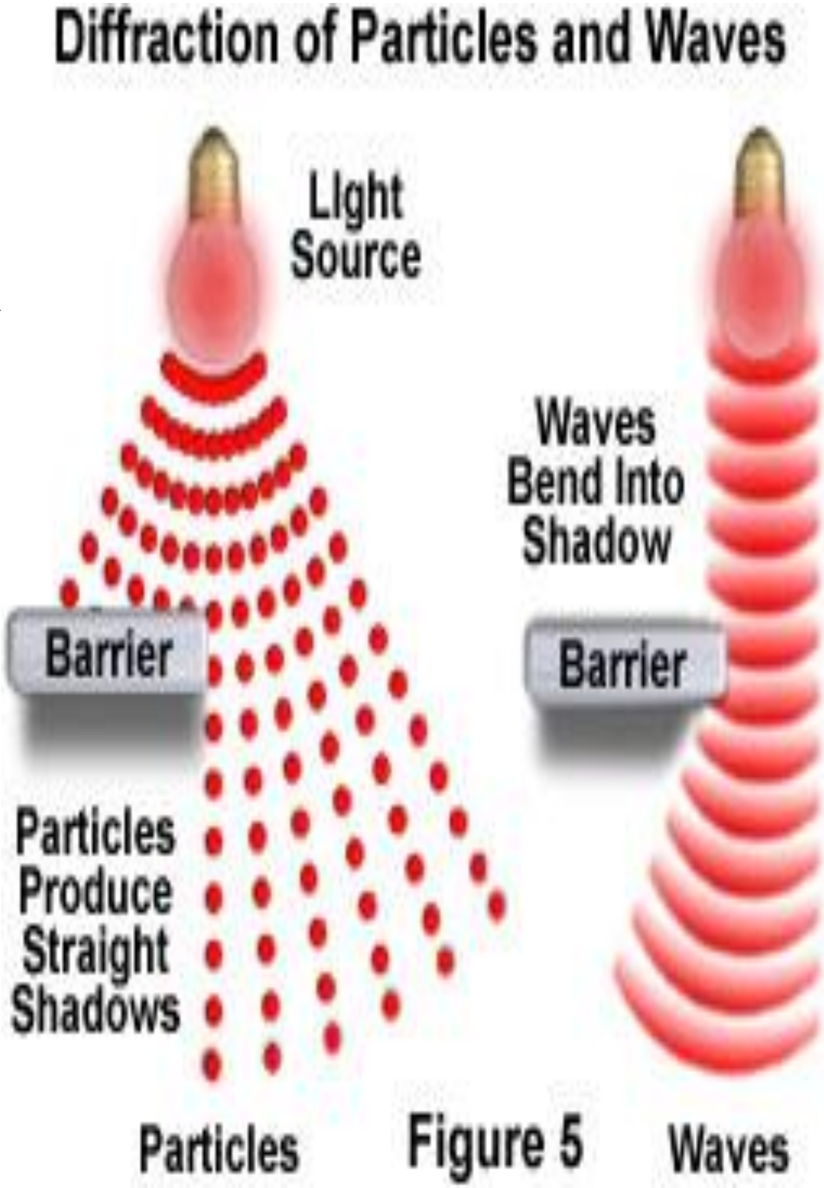
PHYS 102- PHOTONS

Electromagnetic radiation, including light have a dual nature.

Albert Einstein proposed that EMR is emitted and absorbed in particle like packages of definite energy called **photons.**

<u>**Photons:**</u> They are discrete packet of energy (also called light quanta).





PHYS 102- PHOTONS

From Classical Mechanics, all electromagnetic waves have:

a) frequency that varies linearly with the speed.

b) frequency that varies inversely with the wavelength.

$\boldsymbol{f = \frac{c}{\lambda}}$ c = speed of light in vacuum λ = wavelength of electromagnetic wave

Einstein (1879-1955) later proposed that energy of a photon is dependent on its frequency.

Also, Max Planck later explained the properties of black-body radiation (in which photon lie) and the universal constant used to measure that property is called the **Planck's constant (*h*).**

$\boldsymbol{h = 6.626 \times 10^{-34}\, J.s}$

To convert to eV.s, where 1 eV $= 1.602 \times 10^{-19} C$

$\boldsymbol{h = 4.136 \times 10^{-15}\, eV.s}$

PHYS 102- PHOTONS

$\boldsymbol{E = hf}$ **-----**Energy of Photon

Recall that $\boldsymbol{f = \frac{c}{\lambda}}$

Hence, $\boldsymbol{E = h\frac{c}{\lambda}}$ ------- [Equa. 1]

Equation 1, explains the energy of an individual photon and it is measured in **Joules**.

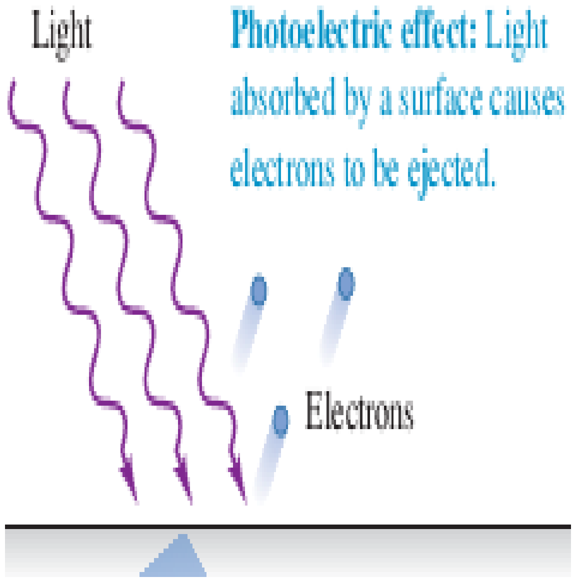
PHYS 102- PHOTOELECTRIC EFFECT

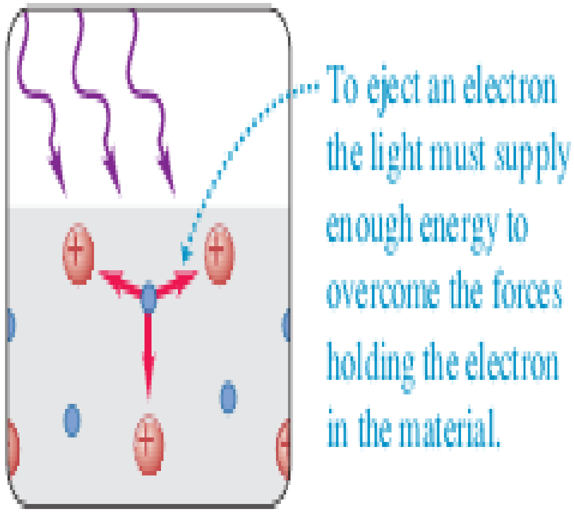
When EMR is incident on the surface of a certain metal, electrons may be ejected.

A photon energy (hf) penetrates the material and it is absorbed by an electron.

If the energy is high, electron will be raised to the surface and it will be ejected with a kinetic energy $\frac{1}{2}mv^2$.

The electron itself must now acquire a minimum energy that will allow it to escape from the surface of the metal. This is called work function **ø. This is equal to the energy of the incident.**





PHYS 102- PHOTOELECTRIC EFFECT

The Einstein's Photoelectric equation is given as:

Energy of the incident radiation = work function + maximum kinetic energy of the electron

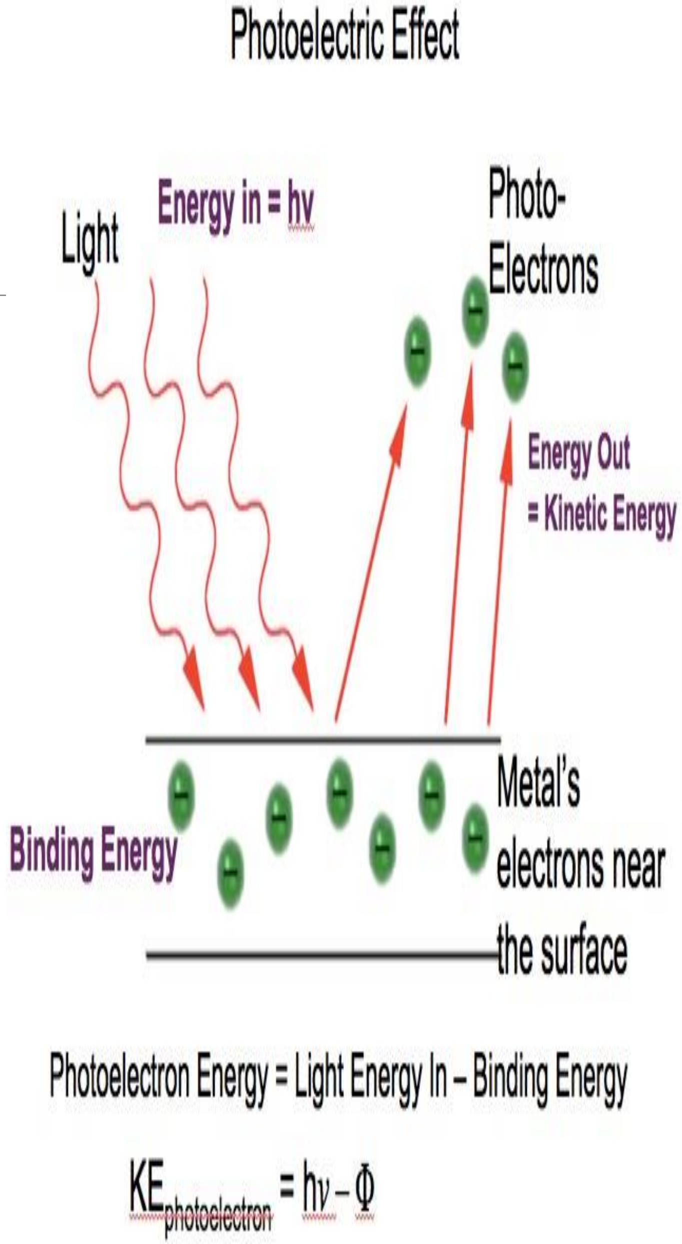
$$E(hf) = \emptyset + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = hf - \emptyset$$

<u>Stopping Potential</u>: Potential difference that must be applied to stop the motion of the ejected electron.

$$V_s e = \frac{1}{2}mv^2$$

$$V_s e = hf - \emptyset$$



PHYS 102- PHOTON - MOMENTUM

What is momentum? :- It refers to the quantity of motion that an object has.

Every particle that has an energy E must have a momentum.

Momentum is a product of mass and velocity of an object. $\boldsymbol{p = mv}$

Note: Photon have zero rest mass, hence the energy of the momentum is given as:

$$\boldsymbol{E = pc}$$

$$\boldsymbol{p = \frac{E}{c} = \frac{energy\ of\ photon}{speed\ of\ light}}$$

Recall that: $\boldsymbol{E = hf = h\frac{c}{\lambda}}$

$$\boldsymbol{p = \frac{h}{\lambda}}\ (kg.m/s)$$

WORK PROBLEMS

1] Show that the Photons in a 1240 nm infrared beam have energies of 1.0eV.

2] To break a chemical bond in the molecules of human skin, which causes a sunburn, a photon energy of about 2.50eV is required. To what wavelength does this correspond? Also the type of photon that causes a sunburn is…….?

3] Calculate the frequency and wavelength of photons having an energy of a) 1.80eV and b) 2.5keV.

4] A laser pointer with a power output of 5.0mW emits a red light with wavelength (λ= 650nm). a) What is the magnitude of the momentum of each photon? b) How many photon does it emits per second?

5] The work function of sodium metal is 2.3eV. What is the longest wavelength light that can cause photoelectric emission from sodium?

ANSWERS

1] E = $1.602 \times 10^{-19} J = 1\ eV$

2] a) Wavelength is 354nm

b) Type of photon that causes sunburn is Ultraviolet

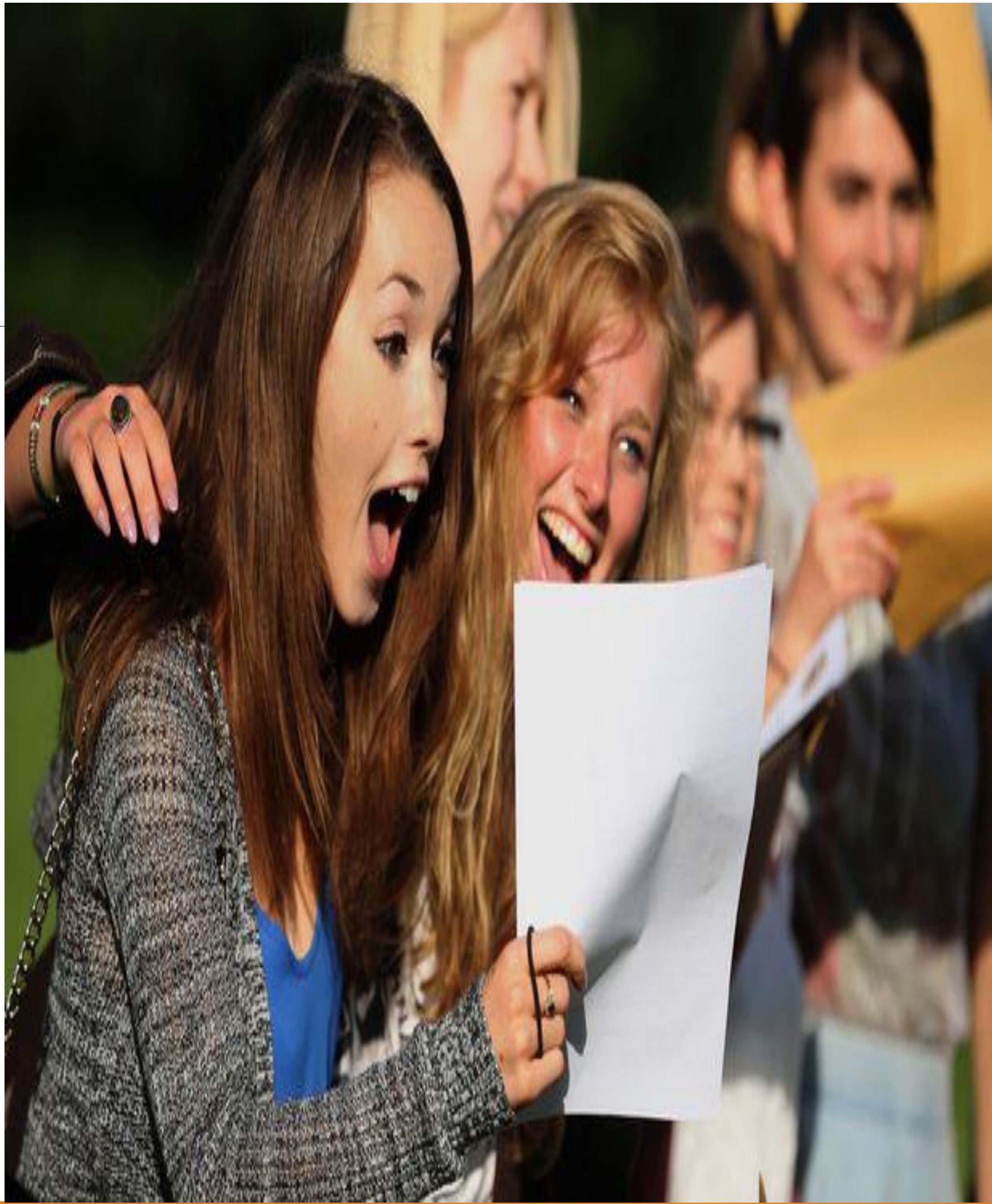
3] a) For 1.80eV: f = $4.35 \times 10^{14}\mathrm{Hz}$, $\lambda = 6.89 \times 10^{-7} m$

b) For 2.50keV: f = $6.04 \times 10^{17}\mathrm{Hz}$, $\lambda = 4.96 \times 10^{-10} m$

4] a) p = $1.02 \times 10^{-27} kg.m/s$

b) $1.63 \times 10^{16} photon/s$

5] $\lambda = 5.39 \times 10^{-7} m$



BIBLIOGRAPHY

1) Sears and Zemansky's University Physics with Modern Physics. 14th Edition: Hugh D. Young. Roger A. Freedman

2) Schaum's Outlines College Physics. 11th Edition: Eugene Hecht.

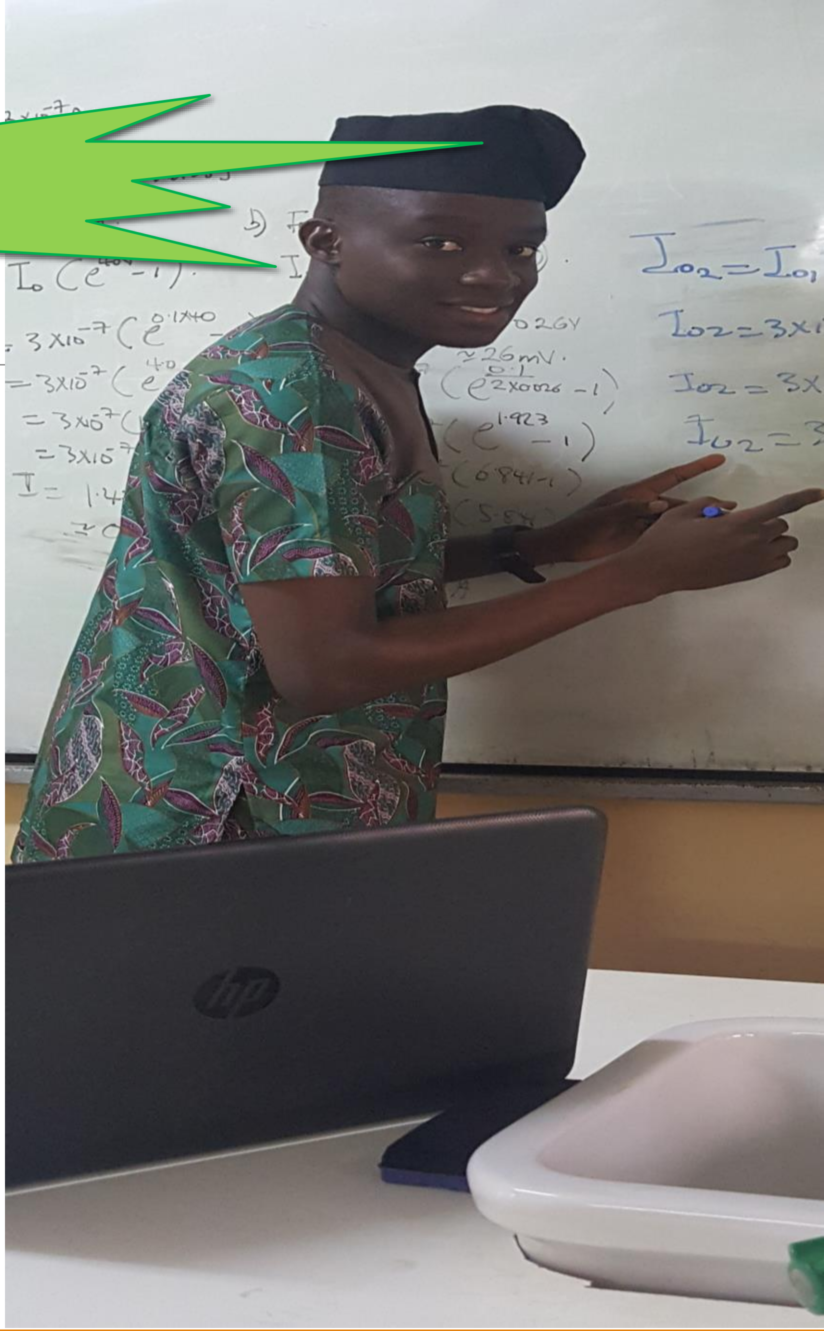
3) University Physics. Volume 2. Poh Liong Young, M.W. Anyakoha, P.N. Okeke

4) The Physics for University and Colleges. Volume 1. Kehinde Daniel and Opadele Abayomi

QUESTION TIME?????????????????

About Lecturer:

Opadele A.E is a physics enthusiast with special interest in Medical Physics. He loves to present the complex theories in physics in seemingly simple approach for effectual understanding.



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