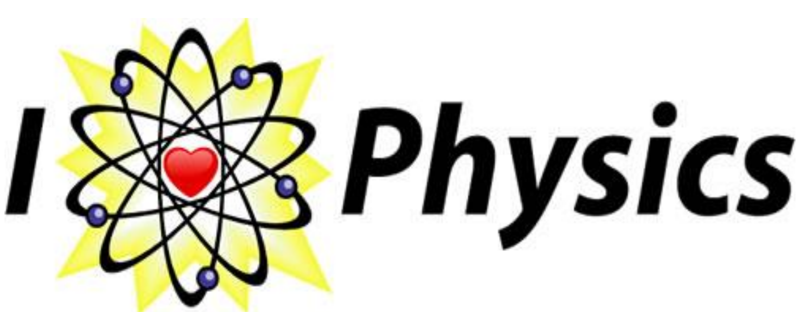
مركز أم الامارات

Grade 12 General / physics

Trimester 3 / Academic Year 2019-2020



The Kinetic energy of photoelectric electrons

1- How to find the kinetic energy of the photoelectric electrons?

The kinetic energy of an ejected electron is equal to the difference between the incident photon energy (hf) and the energy of a photon with the threshold frequency (hf_0).

$$KE = hf - hf_0$$

- **Note1**: (hf_0) is the minimum energy needed to free the most weakly bound electron from the metal. It is called also the work function of a metal.
- **Note2**: When a photon of frequency f_0 is incident on a metal, the energy of the photon is enough to release an electron but not enough to provide the electron with any kinetic energy.

The kinetic energy of the photoelectric electrons	
1	$KE = E - W$
2	$KE = hf - hf_0$
3	$KE = \frac{1240}{\lambda} - \frac{1240}{\lambda_0}$
4	$KE = -e.\Delta V_0$ This will be explained later
5	$KE = \frac{1}{2}m.v^2$

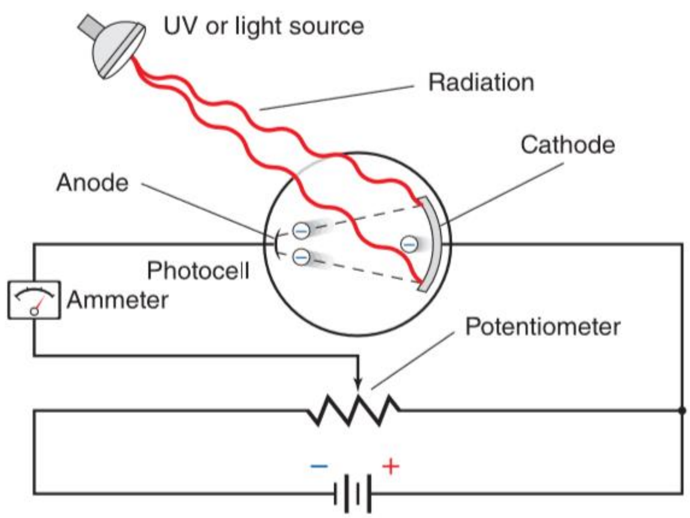
The ejected electrons have differing kinetic energies, so they have differing velocities

2- Two photons each of them has an energy less than the work function of a metal, but the sum of their energies is higher than the work function. If these two photons fall on the surface of that metal, are they able to free the most weakly bound electron from the metal?

No, because one photon interacts with one electron, an electron cannot simply store energy from low frequency photons until it collects enough energy to break free

Testing the photon theory

1- This experiment support Einstein's photon theory:



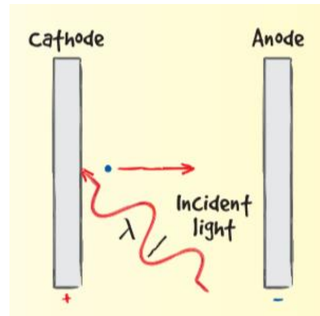
At a certain potential difference, called the stopping potential, the current stops because no electrons ejected from the cathode have enough kinetic energy to reach the anode. At the stopping potential, the electrons' kinetic energy at the cathode equals the work done by the electric field to stop them ($W = KE = -e\Delta V_0$)

2- Name on of the photoelectric effect applications.

The photoelectric detectors in the digital camera.

Applications

1- **The stopping potential difference of a certain photocell is 4.0 V. How much kinetic energy does the incident light give the electrons**?



2- An electron has an energy of 2.3 eV. What is the kinetic energy of the electron in joules?

3- What is the kinetic energy in eV of an electron with a velocity of 6.2×10^{6} m/s?

4- The stopping potential for a photoelectric cell is 5.7 V. Calculate the maximum kinetic energy of the emitted photoelectrons in eV.

5- The stopping potential for a photoelectric cell is 5.1 V. How much kinetic energy does the incident light give the electrons in joules?

6- The maximum kinetic energy of emitted photoelectrons in a photoelectric cell is 7.5×10^{-19} J. What is the stopping potential?

7- A photocell uses a sodium cathode. Sodium has a threshold wavelength of 526 nm.

A. Find the work function of sodium in eV.
B. If ultraviolet radiation with a wavelength of 348 nm falls on sodium, will the cathode discharge electrons? If so, what is the maximum energy of the ejected electrons in eV?

8- The threshold wavelength of zinc is 310 nm. Find the threshold frequency, in Hz, and the work function, in eV, of zinc.

9- The work function for cesium is 1.95 eV. What is the maximum kinetic energy, in eV, of photoelectrons ejected when 425-nm violet light falls on the cesium?

10- When a metal is illuminated with 193-nm ultraviolet radiation, electrons with kinetic energies of 3.5 eV are emitted. What is the work function of the metal?

11- Rely on the following figure to answer the questions.

A. What does the slop of the line represent?

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B. What does point A represent?

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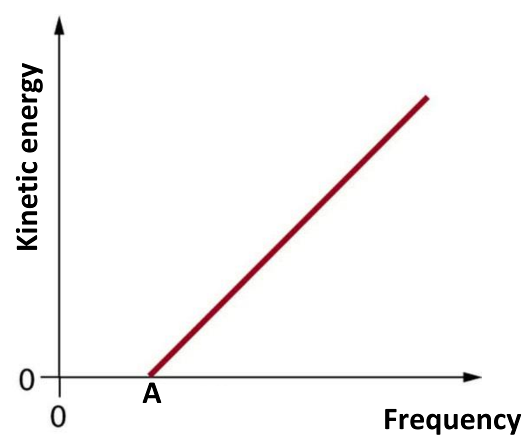


The Compton Effect

1- What are the properties of photons (as a particle)?

- ✓ The photon has kinetic energy even though it has no mass
- ✓ The photon has momentum (according to Einstein theory)

2- Write the equation of the photon momentum

$$p = \frac{hf}{c}$$

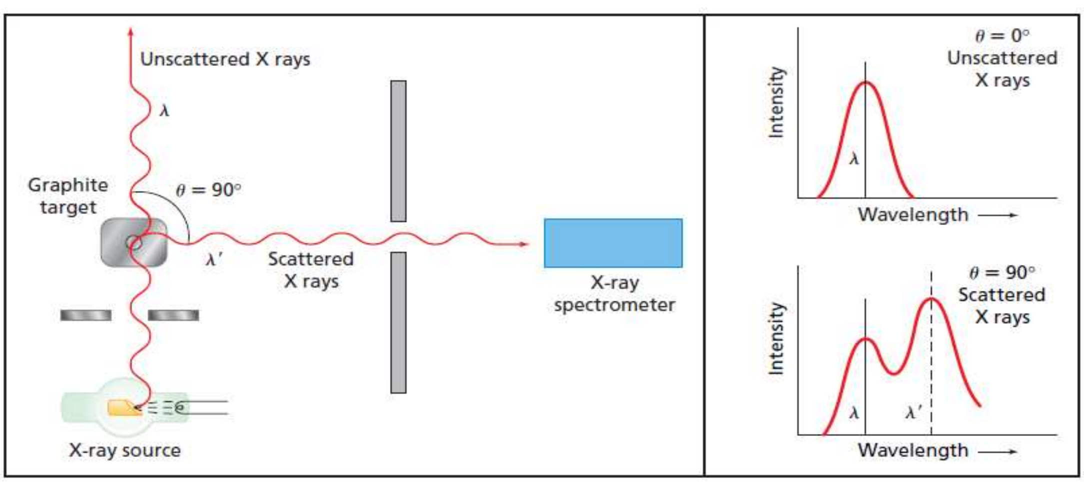
$$p = \frac{h}{\lambda}$$

3- What is the name of the scientist who validated Einstein's theory about the photon momentum?

Arthur Holly Compton.

4- Explain Compton experiment.

A. Compton directed X-rays of a known wavelength at a graphite target.
B. He measured the wavelengths of the X-rays scattered by the target.
C. He observed that some of the X-rays were scattered without change in wavelength, whereas others had a longer wavelength than that of the original radiation.
D. The energy of a photon is inversely proportional to its wavelength. The increase in wavelength that Compton observed, meant that the X-ray photons had lost both energy and momentum.
E. The result is (photon is a particle and has momentum)



5- Define Compton effect.

It is the shift in the energy of scattered photons

6- Photons and conservation of energy and momentum

Compton found that the energy and momentum gained by the ejected electrons equaled the energy and momentum lost by the photons. Thus, photons obey the laws of conservation of energy and momentum when they collide with other particles.

$$(P_{photon} + P_{electron})_{initial} = (P_{scattered\ photon} + P_{electron})_{final}$$

$$(E_{photon} + E_{electron})_{initial} = (E_{scattered\ photon} + E_{electron})_{final}$$

Applications

1- What is the momentum of violet light if its wavelength 4.0×10^2 nm?

2- What is the momentum of a violet light if its frequency $7.8\text{x}10^{14}$Hz?

3- An X-ray strikes a bone, collides with an electron, and scatters. How does the wavelength of the scattered X-ray compare to the wavelength of the incident X-ray?