Arab Academy for Science & Technology & Maritime Transport

(AASTMT – Cairo Branch)

College of Engineering & technology

Electronics & Communication Engineering Department

Course : Solid State Electronics

Course Code : EC210

Instructors : Dr. Mostafa Fedawy, Eng. Mohamed Al-azamy

Sheet (3)

Wave Particle Duality

Physical Constants:

Charge of electron (e) =1.6×10^{-19} C

Mass of electron (m_e) = 9.1×10^{-31} kg

Mass of proton (m_p) = 1.672×10^{-27} kg

Plank's constant (h) = 6.63×10^{-34} J.s

Speed of light (C) = 3×10^{8} m/s

Put (T) for the true statement or (F) for the false statement:

1. The photoelectric experiment proves that waves behave as particles.
2. If the work function of a metal is eφ, electrons in this metal need an energy more than or equal eφ to be removed from the surface of the metal.
3. According to quantum theory, increasing the frequency of light used in a photoelectric experiment causes the kinetic energy of electrons ejected to decrease.
4. In a photoelectric experiment: according to quantum theory, if the intensity of light used is increased, the kinetic energy of photoelectrons is not affected.
5. If the intensity of light used in a photoelectric experiment is arbitrarily increased, photoelectric current can be produced regardless of the frequency of light used.
6. In a photoelectric experiment: the work function of the metal used is 2 eV. The kinetic energy of photoelectrons can be more than 2 eV.
7. If the wavelength of light is increased, the energy of photons of this light will increase.

Choose the correct answer justifying your choice:

1. When photons with energy of 10 eV are incident on a surface, the ejected electrons have energies up to 4 eV. If photon energy is 20 eV, the energy of ejected electrons will be up to

(a) 4 eV (b) 10 eV

(c) 14 eV (d) 20 eV

(e) 16 eV

2. A material with a photoelectric threshold frequency of f_o is illuminated with light of frequency f = 1.5 f_o. The maximum kinetic energy of the photoelectrons ejected is

(a) h f_o (b) 3.5 h f_o

(c) 2.5 h fo (d) 1.5 h f_o

(e) 0.5 h f_o

3. Light of frequency f incident on a given metal produces photoelectrons with a maximum kinetic energy K. If light of frequency f /2, is incident on the same metal, the maximum kinetic energy will be

(a) 0 (b) less than K/2

(c) K/2 (d) more than K/2

(e) ∞

4. The diagram shows the graphs of the stopping potential as a function of the frequency of the incident light for photoelectric experiments performed on three different materials. Rank the materials according to the values of their work functions, from least to greatest.

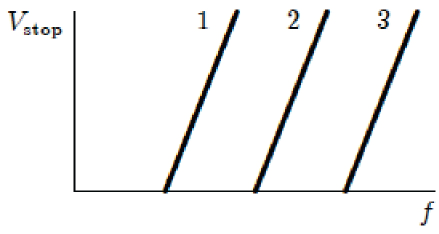
(a) 1, 2, 3

(b) 3, 2, 1

(c) 2, 3, 1

(d) 2, 1, 3

(e) 1, 3, 2



Solve the following Problems:

[1] Light of wavelength 200 nm is incident on a cadmium surface. A stopping voltage of magnitude 2.15 V is required to reduce the photocurrent to zero.

(a) What is the work function of the cadmium?

(b) If the incident light of wavelength 250 nm and intensity 150 watt/cm^2, the area of the cadmium cathode is 4 cm^2, calculate the number of the incident photons per second.

(c) Does a radiation of wavelength 290 nm eject electrons from the cadmium surface? If yes, calculate the maximum speed of the emitted electron.

[2] The photo-electric work function of potassium is 2 e.V. If the light having a wavelength of 350 nm falls on potassium, find:

(a) The kinetic energy of the most energetic electrons

(b) The stopping potential (V_s)

(c) The velocities of these electrons

(d) If the wavelength is changed to 348 nm, calculate the change in stopping potential.

[3] When a beam of light of 500 nm was incident on the cathode of a photocell, a photocurrent of 1 mA was measured. If the power content of the beam is 30 mW, find the quantum efficiency of the photocathode to light of this wavelength. Calculate the long-wave threshold for photoemission if the emitter has a work function of 2.1 eV.

(Quantum efficiency = number of emitted electrons / number of incident photons)