Threshold frequency calculator

Chapter 29 Particles and Waves: So far discussed are two behaviors of light: straight-line motion (Geometric optics) and wave-like behavior and interference (Wave Optics). In this chapter, we discuss the particle-like behavior of light. In fact, particle-like behavior is also associated with frequency and cannot be separated form from wave-like behavior. Max Planck formulated this theory that electrons orbit the nuclei of an atom, they receive energy from the environment in different forms. Typical forms: hot flashes, light waves, and collisions with other electrons and particles. The radius on which the electron orbits is a function of the electron K.E., and thus the speed of the electron. Recall K.E. = (1/2)Mv2. All electrons are also under Coulomb attraction force in the core given by F=ke2/r2. Furthermore, circular motion requires a centripetal force fc = Mv2/r. We know that this Coulomb force F, which provides the necessary centripetal force Fc electron spin. The above discussion makes it clear that in the simplest explanation, each electron takes a certain rotational radius depending on its energy or speed. When an electron receives extra energy, it has to change its orbit or rotational radius. You need to go into a larger orbit. The beam isn't just any ray. In such a transition, an empty track remains, which must be filled. You can charge the same electron or any other. The electron that fills the empty orbit must have the right energy, which is equal to the energy of the orbit. The electron that fills this orbit may contain too much energy to be eresed before it can fill that empty orbit. The excess energy emits from an electron is an energy burst, an energy package, an energy package or quantum energy, according to Max Planck. Excess energy is simply the energy difference between two different orbits. If an electron returns to a larger radiation orbit with Rm energy level Em a smaller beam orbit Rn at energy level En, it releases the quantum energy difference Em - En. Planck showed that this energy difference is proportional to the frequency of occurrence of the released quantum or energy package (f). The constant of proportionality is h, with a value of h = 6,626x10-34 J.s, which is called the Planck constant. The package or quantum energy is also called the photon.. In the electronvolt (h) is h = 4,14x10-15eV-sec. Plancks formula: Em - En = hf or ΔE = hf 1 example: Calculate (a) the energy of photons with a prevalence of 3,2x1014 Hz. (b) Find the appropriate wavelength and (c) express if they are in the visible range. Solution: (a) ΔE = hf; ΔE = (J.s)(3.2x1014 /s) = 2.12x10-19 J Note that 1eV = 1.6x10 -19 J . Our answer is a little more than 1eV. In fact, this (2.12 /1.6) = 1.3 eV. (b) c = f λ; λ = c / f; λ = (3,00x108m/s)/ (3,2x1014/s) = 9,4x10-7m = 940x10-9m = 940nm (c) The visible range is between 400 nm and 700 nm; This is not in the range. Infrared. Example 2: Calculate (a) the energy of all photons (in Joules) of ultraviolet light with a wavelength of 225 nm. (b) This energy is converted into an electron. Solution: (a) ΔE = hf = hc /λ; ΔE = (6,626x10-34 J.s)(3,00x108m/s) / 225x10-9m = 8,83x10-19 J. (b) Since 1eV = 1,6x10-19J; therefore ΔE = 5,5 eV. Photoelectric effect: The mechanism of operation of the photoelectric effect can be used to control the particle-like behaviour of light. The photocell may be made of a vacuum tube in which two metal plates or poles are fixed. The two plates are connected to two wires that come out of the sealed glass tube and are used to connect to other electronic components. For now, connect a photocell to just one galvanometer (sensitive ammeter), as shown in the figure below. One of the connectors (plates) of the pipe can be mounted obliquely so that the light coming from outside shines effectively on it. This side forms the negative pole. The other side collects or receives electrons and forms the positive pole. When light photons are placed towards the metal plate, it can be observed that the galvanometer in the circuit shows the passage of a current. When the light is off, the power stops. This shows that the impact of photons on a metal surface must release electrons from the outer outer skin of the outer outer layers of the metal oxide coating. Every energetic photon that collides with the metal surface emits an electron. This released electron has some speed and therefore some K.E. = 1/2Mv2. The atoms of the outer surface, which have lost electrons, make up for their electron deficiencies from the internal layer atoms of metal oxide. This filling process transmits the wire and galvanometer from layer to layer to pole labeled Positive. The positive end pulls the emitted electrons out of the negative end through the vacuum tube and the circuit completes itself. This process happens very quickly. As soon as the light hits the metal plate, the circuit is on. As soon as the light's off, the circuit goes out. Figure 1 The conclusion of the above experiment is that light photons act as particles and kick electrons out of their orbits. That explains the particle-like behavior of light. Photoelectric Effect Formula: The energy required to just download an electron off a metal surface called the work function is that of the metal and can be seen in Wo. If the energy incident photon on the metal surface hf, and the kinetic energy of the released electron K.E., you can write the next energy balance of a photocell. hf = Wo + K.E. According to the equation, hf has to be bigger than Wo to release an electron. Since h is constant; therefore, the f must be high enough to make the photon effective. There is a limit to the frequency under which nothing happens. This limit is when the event's photon frequency is just enough to release an electron. Such a released electron has K.E. = 0. At a limiting frequency called threshold frequency, the kinetic energy of the released electron is zero. Setting KE = 0 and replacing f fth, we get: h fth = Wo or fth = Wo / h. The above formula specifies the threshold frequency, fth . Example 3: The working function of the sheet metal in a photocell is 1.73 eV. The wavelength of the incident photons is 366nm. Find the frequency of photons, (b) the e.e. of the electrons released, and (c) the threshold frequency and wavelength of this photocell. Solution: (a) c = fλ; f = c/λ = (3,00x108m/s) / (366x10-9m) = 8,20x1014 Hz (b) hf = W0 + K.E. ; K.E. = hf - W0 K.E. = (4.14x10-15eV)(8.20x1014 /s) - 1.73eV = 1.66eV (c) fth = W0 / h ; fth = 1.73 eV / (4.14x10-15eV) = 4.18x1014 Hz δth = c / fth ; λth = (3,00x108m/s) / (4,18x1014 Hz) = 718nm Wave-particle duality: According to De Broglie, each moving momentum can be associated with an equivalent wavelength for Mv particles, δ describes its wave motion behavior so that de Broglie wavelength, where δ is the so-called de Broglie wavelength. Example 4: Calculate the DeBroglie wavelength associated with the movement of the electron orbiting the hydrogen atom at a speed of 6,56x106 m/s. Solution: Λ = h/Mv can be used to write the following: δ = (6,626x10-34 Js) / [(9,108x10-31kg)(6,56x106 m/s)] = 1,11x10-10m. Chapter 29 Test Yourself 1: 1) Energy of the photon of light according to Max Planck's formula (a) E = 1/2Mv2. (b) E = hf. (c) E = Mgh. 2) Planck constant, h, (a) 6,6262x10-34 J.sec. (b) 4,14x10-15 eV.sec. (c) both & b. click here. 3) An electron orbiting the nuclei of an atom can be energized by receiving (a) a heat wave. (b) the collision of another subatom particle. c) by hitting a photon. (d) both a, b, & c. 4) If the electron is certificated in any way, it (a) requires a higher radius of rotation. (b) a smaller radius of rotation. (c) remains on the same track but rotates faster. click here. 5) If you have an empty orbit, you will be filled with an electron (a) into a lower orbit. (b) take a higher trajectory. Radius. (b) a faster moving electron. (c) greater energy. (d) a, b and c. 7) The extra energy of an electron in a higher orbit is released in the form of a photon (small package or energy shot) as soon as the electron fills a lower orbit. (a) True (b) False click here. 8) Excess energy (a) is the energy difference e2-E1 between higher and lower orbits. (b) the energy of each electron anyway. (c) both & b. 9) Photon mass (a) zero. (b) 1/2 of the mass of the electron. (c) neither a nor b. 10) Each photon carries a certain amount of energy. You can use an Einstein formula (E = Mc2) and calculate the equivalent mass of a photon. (a) True (b) False click here. 11) The higher the energy of the photon (a) the higher the speed. (b) the higher the speed. (c) the higher the frequency. (d) b, c, & d. 12) The higher the energy of the photon, the lower the wavelength. (a) True (b) False 13) The formula for the speed of waves (v = fλ) is only visible light in photons, c = fλ. (b) only in the case of photons with no visible light. c) E&2 M waves, of which visible light is part. click here. Problem: A student calculated a frequency of 4.8x1016 Hz for a certain type of X-ray and a wavelength of 7.0 nm. 14) Use the equation v = fλ and calculate the v to see if the student's calculations are correct. (a) Correct (b) Bad 15. (b) 3,36x1017 m/s. (c) neither a nor b. click here. 16) The reason why the answer is article 14(1) is that the Commission is not in a good way. (a) True (b) False 17) In the photoelectric effect (a) electrons collide and photons are released. (b) photons collide and electrons are released. neither a nor b. click here. 18) In a photocell, the plate receiving the photons (a) will be negative. (b) positive. (c) neutral. 19) The reason why released (energized) electrons do not return to their shells is that their (a) energies are more than sufficient for orbits. (c) outer shells that have lost electrons will remain in loss forever. (d) the following shall be inserted after the first paragraph of Article 10 (1) (b) (click here. 20) When light occurs on the metal plate of a photocell, the other pole of the cell becomes positive. This is because (a) photons carry negative charges. (b) the other pole loses electrons to replace the lost electrons of the sheet metal through an external wire connected to the sheet metal. (c) both the information referred to in Article 21(b) and (b); in the vacuum of the cell. (b) accelerate to the other pole because the other pole is positive. (c) neither a nor b. 22) Negative current in the external conductor of the photocell (a) zero. (b) from the sheet metal. (c) towards the negative plate. click here. 23) In a photocell, the photon energy of the event is (a) 1/2Mv2. (b) hf. (c) Oh. 24) In a photocell, the working function of the sheet metal (a) 1/2Mv2. (b) hf. (c) Oh. 25) The energy of each electron released in a photocell is (a) 1/2Mv2. (b) hf. (c) Oh. click here. 26) The photon frequency of the 5.00 eV incident is (a) 1,21x10-15Hz. (b) 1,21x1015 Hz. (c) 2,21x1015 Hz. 27) The energy of an ultraviolet photon with a frequency of 3,44x1015Hz is hf, 14,2 eV. (b) 2,27x10-18J. (c) a & b. 28) When 3,7 eV photons occur on a metal with a working function of 1,7 eV, the energy of each electron released is (a) 2,0eV. (b) 5.4eV. (c) 6.3eV. click here. 29) 4.7 eV photons event is a 1.7 eV working function metal. The energy of each electron released is (a) 4.8x10-19J. (b) 3.0eV. (c) both & b. 30) 3.7 eV photons are a 1.7 eV working metal. The speed of each electron released is (a) 8.4x10-5m/s. (b) 8,4x10 5 m/s. (c) 8,4x10-15 m/s. click here. 31) A speed of 8.4x10-5m/s is not reasonable for a moving electron, as (a) electrons always move at the speed of light. (b) this speed has a speed of -5, which is very close to zero, like shutting down. (c) neither a nor b. 32) If the average speed of electrons emitted by photoelectric action is 9,0x105 m/s and the energy of the inset photons is on average 4,0eV, the working function of the metal shall be (a) 1,3eV. (b) 1,1 eV. (c) 1,7 eV. click here. 33) The wavelength associated with proton movement at 6,2x106 m/s is (a) 6,4x10-14m. (b) 9,4x10-14 m. (c) 4,9x10-14m. 34) The diameter of the hydrogen atom (where it is about the electronic cloud) is 0.1nm or 10-10m called Angstrom. The hydrogen atom's core has a diameter of up to 100,000 times smaller or 10-15m so-called Femtometer (fm). The wavelength associated with the moving proton shall be as 33. (b) 64fm. (c) 640fm. click here. Problems: 1) Calculate (a) the energy of photons with a frequency of 6,40x1014 Hz. (b) Find the appropriate wavelength and (c) express if they are in the visible range. 2) Calculate (a) the energy (in Joule) of each photon of ultraviolet light with a wavelength of 107 nm. (b) This energy is converted into an electron. 3) The working function of the sheet metal is a photocell 2.07eV. The wavelength of the incident photons is 236nm. Find the frequency of photons(a), b) of each one(c) the e.e., (d) velocity of the electrons released, and (e) the threshold frequency and wavelength of this photocell. 4) Calculate the Wavelength DeBroglie, which is related to the movement of an electron with a speed of (a) 1,31x107 m/s. Answers: 1) 2.65eV, 469nm, Yes 2) 1.86x10-18J, 12eV 3) 1.27x1015Hz, 5.26eV, 3.19eV, 1.1x106m/s, 5.00x1014Hz, 600.nm 4) 0.556Å 0.556