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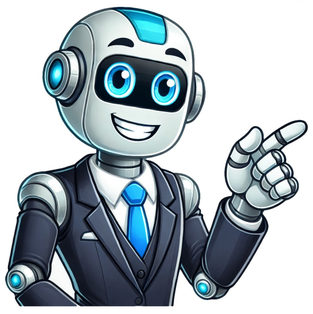

It was in 1887 when Heinrich Hertz was conducting experiments to prove Maxwell's electromagnetic theory of light, that he noticed a phenomenon which is strange. Hertz generally used a gap of spark - two sharp electrodes that are placed at a distance which is small so that spark of electricity can be generated that is to detect the presence of waves which electromagnetic. To get an even closer look he placed it in a box that was dark and found that the length of the spark was reduced. When he used a box of glass then the spark length increased and when he replaced it with a box of quartz the length of the spark increased further. This was the observation which was the first of the effects of photoelectric.A year later we can say that Wilhelm Hallwachs generally confirmed these results and showed that light which was the UV light on a Zinc plate that is connected to a battery generated a current that is because of electron emission. J.J. Thompson in 1898 found that the amount of current varies with the frequency and intensity of the radiation that is used.Later in 1908, Lenard Observed that the kinetic energy of electrons which are emitted increased with the frequency of radiation that is used. This could not be explained as the theory of Maxwell's electromagnetic which Hertz proved correct, predicted that the energy which is kinetic should be only dependent on light intensity and not on the frequency.The resolution which we have discussed would only come a few years later that too from famous scientist Einstein when he would provide an explanation to the Photoelectric Effect.Hertz Lenard Observations(Image will be uploaded soon)To test the hypothesis of Maxwell's Hertz that is used, an oscillator which is made of polished brass knobs that each one is connected to an induction coil and separated by a tiny gap that is over which sparks could leap. To confirm this whole thing that we have discussed, Hertz made a simple receiver of looped wire. Its ends are separated by a tiny gap as we will notice this. The receiver present was placed several yards from the oscillator. Hertz reasoned that if Maxwell's had the predictions which were said to be correct, electromagnetic waves would be transmitted during each series of sparks that would induce a current which is in the loop that would send the sparks that too across the gap. This generally occurred when Hertz turned on the oscillator and the transmission of electromagnetic waves. Hertz also noted that a conductor which is electrical reflects the waves and that they can be focused that too by a lens that through. The phenomenon of photoelectric emission was discovered in the year 1887 by Heinrich Hertz during the electromagnetic wave experiments. He generally observed that when the light falls on a surface of a metal, some of the electrons that are near the surface absorb energy which is enough from the incident radiation to overcome the attraction which is of the positive ions which are in the material of the surface.Hertz and Lenard's Observations of the Photoelectric EffectThis observation that we have seen that is related to the effect which is photoelectric and how this effect is proven by two scientists is one of the experiments that was conducted in 1887 by Heinrich Hertz to prove the theory of electromagnetic light when he observed strange phenomena as he placed two electrodes at a very small distance. So we can say here that an electric spark can be generated and he used a spark gap to apply this experiment so that he can easily observe the presence of waves which are electromagnetic. The same which we can say is the case with Lenard as he observed the kinetic energy of electrons which are emitted and then increased with the radiation that is used. Both of their experiments show the different types of samples or we can say that the experiment to prove the same thing but they all were given signals and only when this was confirmed and proven by Einstein.(Image will be uploaded soon)Every metal that we have learnt consists of certain minimum frequency which is of incident radiation below which no photoelectrons are emitted or are not able to emit this type of frequency is known as the threshold frequency.The increasing frequency of the beam which is incident keep the number of photons that are fired and this would increase the number of electrons that are emitted but the kinetic energy of the electrons which are emitted would not be affected by the number of photons that are present in the beam but the kinetic energy of the electrons which are emitted would be affected by the frequency of the light but we can say that it is generally provided with the light frequency that is to be fixed at a point.(Image will be uploaded soon)In a subject like physics, kinetic energy is the energy that is possessed by an object which is moving or by its motion. In other words, we can say that it can be defined as work which is required by a body which is to accelerate from its actual position to the position it wants to reach and the body which keeps this kinetic energy until and unless it changes its speed. Same goes with the case of accelerating the body which is from moving at a speed that is to divert itself towards the rating part. It is said that the energy that generally occurs in many forms which include energy which is chemical or we can also say the thermal energy and the electromagnetic energy that includes nuclear energy and rest energy and many more can be added to this category. Thus, kinetic energy can be seen in a moving object and also in the resting one. PHOTO ELECTRIC EFFECT Hertz, Hallwachs and Lenard's observation Hertz observation Maxwell's theory of electromagnetism predicted the existence of electromagnetic waves and concluded that light itself is just an electromagnetic wave. Then the experimentalists tried to generate and detect electromagnetic waves through various experiments. In 1887, Heinrich Hertz first became successful in generating and detecting electromagnetic waves with his high voltage induction coil to cause a spark discharge between two metallic spheres (we have learnt this in Unit 5 of XII standard physics). When a spark is formed, the charges will oscillate back and forth rapidly and the electromagnetic waves are produced. The electromagnetic waves that produced were detected by a detector that has a copper wire bent in the shape of a circle. (Ahuja) The apparatus consists of two metallic plates A and C placed in an evacuated quartz bulb. The galvanometer G and battery B are connected in the circuit. In order to improve the visibility of the spark, Hertz made many attempts and finally noticed an important thing that small detector sparks become more vigorous when then it was reposed to ultraviolet light. The reason for this behaviour of the spark was not known at that time and it was found that it is due to the photoelectric emission. Whenever ultraviolet light is incident on the metallic sphere, the electrons on the outer surface are emitted which caused the spark to be more vigorous. It is interesting to note that the experiment of Hertz confirmed that light is an electromagnetic wave. But the same experiment also produced the first evidence for particle nature of light. Hallwachs' observation In 1888, Wilhelm Hallwachs, a German physicist, confirmed that the strange behaviour of the spark is due to the action of ultraviolet light with his simple experiment. A clean circular plate of zinc is mounted on an insulating stand and is attached to a gold leaf electroscope by a wire. When the uncharged zinc plate is irradiated by ultraviolet light from an arc lamp, it becomes positively charged and the leaves will open as shown in Figure 7.6(a). Further, if the negatively charged zinc plate is exposed to ultraviolet light, the leaves will close as the charges leaked away quickly (Figure 7.6(b)). If the plate is positively charged, it becomes more positive upon UV rays irradiation and the leaves will open further (Figure 7.6(c)). From these observations, he concluded that negatively charged electrons were emitted from the zinc plate under the action of ultraviolet light. Lenard's observation In 1902, Lenard studied this electron emission phenomenon in detail. His simple experimental setup is as shown in Figure 7.7. The apparatus consists of two metallic plates A and C placed in an evacuated quartz bulb. The galvanometer G and battery B are connected in the circuit. When ultraviolet light is incident on the negative plate C, an electric current flows in the circuit that is indicated by the deflection in the galvanometer. On other hand, if the positive plate is irradiated by the ultraviolet light, no current is observed in the circuit. From these observations, it is concluded that the negative plate causes electron emission from the surface of the plate. Photoelectric effect The ejection of electrons from a metal plate when illuminated by light or any other electromagnetic radiation of suitable wavelength (or frequency) is called photoelectric effect. Although these electrons are not different from all other electrons, it is customary to call them as photoelectrons and the corresponding current as photoelectric current or photo current. Metals like cadmium, zinc, magnesium etc show photoelectric emission for ultraviolet light while some alkali metals lithium, sodium, caesium respond well even to larger wavelength radiation like visible light. The materials which eject photoelectrons upon irradiation of electromagnetic wave of suitable wavelength are called photosensitive materials. Download the Testbook APP & Get Pass Pro Max FREE for 7 Days10,000+ Mock TestsRankers Test Series & more!Download App Now The phenomenon of photoelectric emission was discovered in 1887 by Heinrich Hertz, during his electromagnetic wave experiments. In his experimental investigation on the production of electromagnetic waves by means of spark discharge, Hertz observed that high voltage sparks across the detector loop were enhanced when the emitter was illuminated by light from another spark. Further, he observed that the sparks were longer when the emitter was kept in a dark box. Hallwachs and Philipp Lenard in their researches investigated the phenomenon of photoelectric emission in detail during 1886-1902. Lenard observed that when ultraviolet radiations were allowed to fall on the emitter plate of an evacuated glass tube enclosing two electrodes (metal plates), current flows in the circuit. As soon as the ultraviolet radiations were stopped, the current flow also stopped. These observations indicate that when ultraviolet radiations fall on the emitter plate(cathode), electrons are ejected from it which are attracted towards the positive plate(anode). The electrons flow through the evacuated glass tube, resulting in the current flow. Thus, light falling on the surface of the emitter causes the current in the external circuit. Hallwach in 1888, undertook the study further and connected a negatively charged zinc plate to an electroscope. An electroscope is an early scientific instrument used to detect the presence of electric charge on a body. It detects charge by the movement of a test object due to the Coulomb electrostatic force on it. He observes that the zinc plate lost its charge when it was illuminated by UV light. Further, the uncharged zinc plate became +ve by charged when it was irradiated by UV light. +ve charge on a +ively charged zinc plate was found to be further enhanced when it was illuminated by UV light. From these all observations, he concluded that -ve ly charged particles were emitted from the zinc plate under the action of UV light. After the discovery of the electron in 1897, it became evident that the incident light causes electrons to be emitted from the emitter plate. Hallwachs and Lenard also observed that when UV light fell on the emitter plate, no electrons were emitted at all. When the frequency of the incident light was smaller than a certain minimum value, called the "threshold frequency". This minimum frequency depends on the nature of the material of the emitter plate. It was found that certain metals like zinc, cadmium, magnesium etc responded only to UV light. However, some alkali metals such as lithium, sodium, potassium, caesium and rubidium are sensitive even to visible light. The electrons emitted are known as photoelectrons and this phenomenon is called the photoelectric effect. IMPORTANT LINKS OF DUAL NATURE OF RADIATION AND MATTER Introduction Electron Emission Photoelectric Effect Experimental Study of Photoelectric Effect Photoelectric Effect and Wave Theory of Light Einstein's Photoelectric Equation: Energy Quantum of Radiation Particle Nature of Light: The Photon Wave Nature of Matter Davisson and Germer Experiment The photoelectric effect is the phenomenon in which the particles, which are electrically charged, are released from a material's surface when they absorb electromagnetic radiation. The photoelectric effect is generally described using the example of a metal plate on which light falls. However, the energy source can be of different types such as infrared, visible, UV light, X-rays, etc. Moreover, the material needn't specifically be solid. It can be a liquid or a gas as well. The photoelectric effect plays a significant role in the formulation of modern physics due to the convoluted questions it raises related to the nature of light. This article will explain Hertz's observation of the photoelectric effect. Moreover, it will also explain Lenard's observation of the photoelectric effect.Furthermore, it will also explain the applications of the photoelectric effect.Hertz's observation of the photoelectric effectHeinrich Rudolf Hertz, a German physicist, discovered the photoelectric effect in 1887. According to Hertz's observation of the photoelectric effect, when a UV light falls on two metal electrodes with a voltage applied across them, the light generates sparks more quickly. He also hypothesized that the spark's intensity in the spark gap, which is the result of the electrons being ejected, depends on the frequency of the light. Hertz's observation was confirmed by Wilhelm Hallwachs in 1887. Hertz's Experimental Setup Philipp Lenard, a student of Hertz, took these observations further. In the early 1900s, he conducted detailed experiments to study the photoelectric effect. Lenard used a variety of light sources and metals and measured the energy of the ejected electrons. He found that the energy of the photoelectrons was independent of the intensity of the light but depended on the light's frequency. This was a puzzling result because, according to classical wave theory, the energy should have increased with the light's intensity. Lenard's observations are contained in the following three observations. The kinetic energy of the ejected electrons increases with the frequency of the incident light. This work showed that light has both wave-like and particle-like properties. Einstein's Photoelectric Equation and Laws of Photoelectric Effect Einstein's work showed that light has both wave-like and particle-like properties. This was a revolutionary concept at the time because it challenged the classical wave theory of light. The equation explains how photons can transfer their energy to electrons in a manner that causing those electrons to be ejected. This is the actual "photoelectric effect." It introduces the concept of a threshold frequency, which is the minimum frequency such