Higher Grade Physics

Unit 2 : PARTICLES & WAVES

Wave Particle Duality

Photoelectric Emission

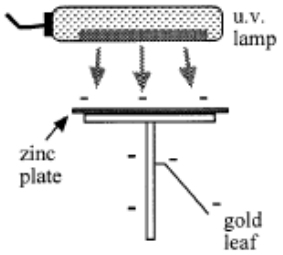
1. Green light has a wavelength of 546 nm.

   (a) Express this wavelength in metres (using scientific notation).
   (b) Calculate:
   (i) the frequency of these light waves
   (ii) the period of these light waves.

2. Ultraviolet radiation has a frequency of $2{\cdot}0 \times 10^{15}$ Hz.

   (a) Calculate the wavelength of this radiation.
   (b) Calculate the period of this radiation.

3. Radiation of frequency 5.0×10^{14} Hz can eject electrons from a metal surface.



   An ultraviolet lamp of frequency 5.4×10^{14} Hz then shines onto the cap of the electroscope.
   (a) Describe and explain what happens to the gold leaf.
   (b) Explain the effect each of the following changes has on the gold leaf of the negatively charged electroscope:
   (i) using a more intense ultraviolet lamp
   (ii) moving the ultra violet lamp further away from the cap
   (iii) shining red light onto the electroscope cap instead of u.v. radiation
   (iv) using a tin plate instead of the zinc plate and illuminated with u.v. radiation
   (v) charging the electroscope positively instead of negatively.

4. How much energy is possessed by a photon of frequency:
   (a) 4.28×10^{14} Hz (b) 7.50×10^{14} Hz (c) 5.00×10^{14} Hz ?

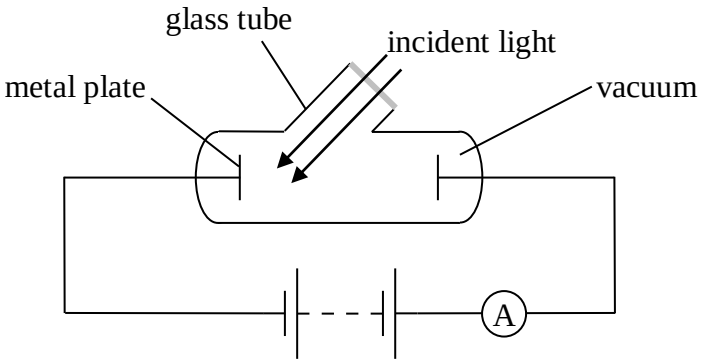
5. How much energy is possessed by a photon of wavelength :
   (a) 700 nm (b) 400 nm (c) 60.0 nm ?

6. What is the frequency of a photon with energy :
   (a) 5.30×10^{-20} J (b) 2.80×10^{-19} J (c) 9.65×10^{-19} J ?

7. What is the wavelength of a photon with energy :
   (a) 1.66×10^{-19} J (b) 3.62×10^{-19} J (c) 7.96×10^{-19} J ?

8. Which, if any, of the photons in question 7 are photons of visible light ?

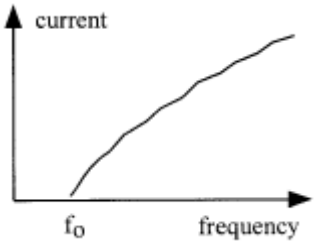
9. The apparatus shown is used to investigate photoelectric emission from a metal plate when electromagnetic radiation is shone on the plate.
The irradiance and frequency of the incident radiation can be varied as required.



(a) Explain what is meant by 'photoelectric emission' from a metal.
(b) What is the name given to the minimum frequency of the radiation that produces a current in the circuit?
(c) A particular source of radiation produces a current in the circuit. Explain why the current in the circuit increases as the irradiance of the incident radiation increases.

Work Function

10. In a study of photoelectric currents, the graph shown was obtained.



(a) What name is given to the frequency f_o ?
(b) Explain why no current is detected if the frequency of the incident radiation is below f_o.

11. The work function of a particular metal is 2.65×10^{-18} J. What is the lowest frequency of light which could cause photoelectric emission?

12. The threshold frequency for a metal is 1.25×10^{16} Hz. What is the work function?
How much kinetic energy would each photoelectron have if light of frequency 1.25×10^{16} Hz is incident on this metal ?

13. The minimum energy required to remove an electron from zinc is 6.1×10^{-19} J.
(a) What name is given to this minimum energy ?
(b) Calculate the value of *f*o for zinc.
(c) Photons with a frequency of 1.2×10^{15} Hz strike a zinc plate ejecting an electron from the surface.
(i) How much extra energy will the electron have after it is released ?
(ii) What will be the form of this extra energy ?

14. For a certain metal, the energy required to eject an electron from the atom is 3.3×10^{-19} J.
    (a) Calculate the minimum frequency of radiation required to emit a photoelectron from the metal.
    (b) Explain whether or not photoemission would take place using radiation of:
        (i) frequency 4×10^{14} Hz
        (ii) wavelength 5×10^{-7} m.

15. Radiation of frequency 5.0×10^{14} Hz can eject electrons from a metal surface.
    (a) Calculate the energy of each photon of radiation.
    (b) If the electrons are ejected from the surface with kinetic energy of 7.0×10^{-20} J, calculate the work function of the metal.

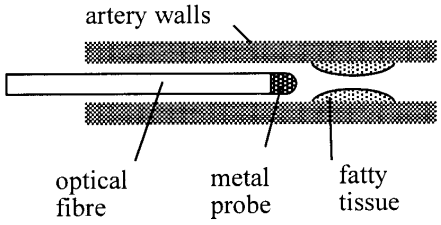
16. Calculate the kinetic energy of the photoelectrons emitted from sodium (work function = 2.9×10^{-19} J) when illuminated by radiation of frequency 5.0×10^{14} Hz.

17. Photoelectrons are ejected from zinc with a kinetic energy of 2.0×10^{-20} J. Calculate the frequency and wavelength of the incident radiation if the threshold frequency is 8.7×10^{14} Hz.

18. Zinc has a work function of 6.95×10^{-19} J.
    (a) Calculate the maximum wavelength of light which will produce photoelectrons from a negatively charged plate.
    (b) If a mercury lamp of wavelength 255 nm is shone on the negatively charged zinc plate, calculate the maximum kinetic energy of the resulting photons.

19. A metal has a work function of 3.04×10^{-19} J.
    (a) If a radiation of wavelength 5.00×10^{-7} m falls on the metal surface what would be the energy of the electrons ejected ?
    (b) If the mass of an electron is 9.10×10^{-31} kg, with what velocity will it be ejected from the surface ?

20. An argon laser is used in medicine to remove fatty deposits in arteries by passing the laser light along a length of optical fibre. The energy of this light is used to heat up a tiny metal probe to a sufficiently high temperature to vaporise the fatty deposit.



The laser has a power of 8·0 W. It emits radiation with a wavelength of 490 nm.

(a) How much energy is delivered from the laser in 5 s?
(b) Calculate the number of photons of this radiation required to provide the 5 s pulse of energy from the 8·0 W laser.