TUTORIAL QUESTIONS QUANTUM PHYSICS

Question 1

Calculate the photon energy in Joules (J) and electronvolts (eV) for each of the following:

i.) red light of wavelength 640 nm.

ii.) X-rays of frequency 2.0×10^{19} Hz

iii.) UV radiation of wavelength 2.6×10^{-7} m

Question 2

A metal surface having a work function of 3.0 eV is illuminated with radiation of wavelength 350 nm.

Calculate:

a.) the minimum frequency and maximum wavelength of incident radiation which would cause electron emission.

b.) the maximum kinetic energy of the emitted photoelectrons.

Question 3

1.) Calculate the De Broglie wavelength of a bullet of mass of 30 g if it is moving at a velocity of 250 ms^{-1}.

2.) Calculate the associated (de Broglie) wavelength of the electrons in an electron beam which has been accelerated through a p.d. of 4000 V.

3.) An alpha particle emitted from a radon – 220 nucleus is found to have a de Broglie wavelength of 5.7×10^{-15} m. Use the following data to calculate the alpha particle energy in MeV.

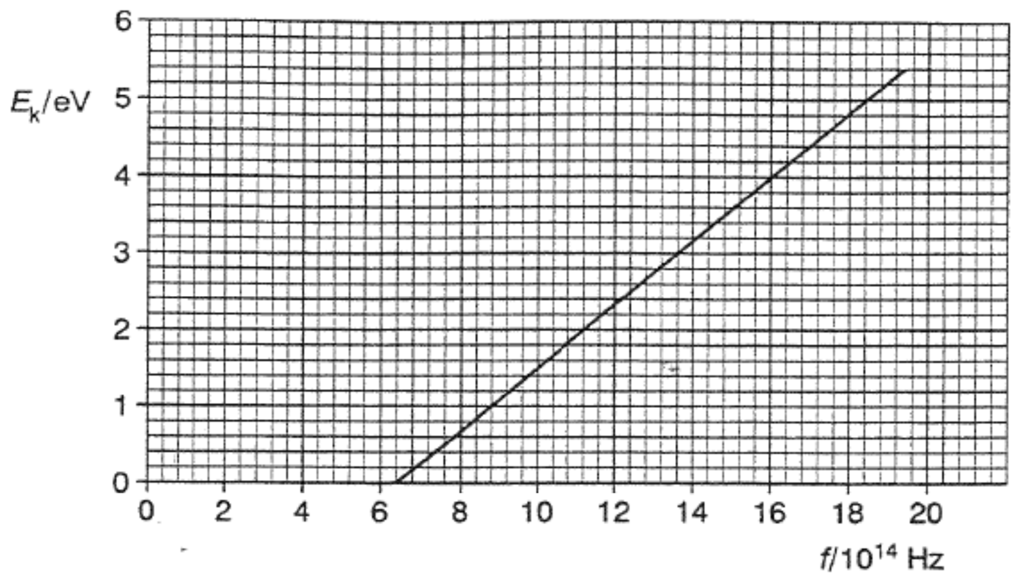
Question 4

1.)

a.) Describe the photoelectric effect.

b.) Explain how the photoelectric effect provides evidence for a particulate nature of electromagnetic radiation.

2.) Graph below shows how the maximum k.e. of a photoelectron from a particular material varies with the frequency of the em radiation that causes the emission of photoelectrons.



a.) Use the graph to determine

i.) threshold frequency for this material

ii.) the maximum k.e. of photoelectrons from this material when it is illuminated with em radiation of frequency 18.0 x 10^{14} Hz. Give your answer in joules.

b.) Use your photoelectric equation and your answers from (a) to determine the Planck constant.

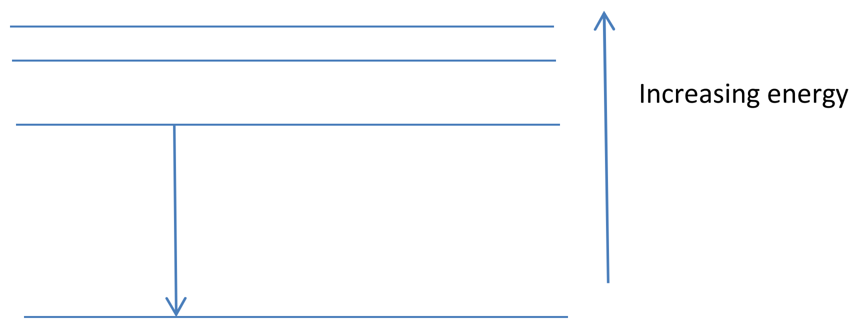
3.)

a.) Em waves have a wave nature as well as particulate nature. This is known as wave-particle duality. Describe a situation in which particles can be shown to have wave nature.

b.) Calculate the wavelength of a particle of mass 1.82 x 10^{-28} kg when travelling with a speed equal to 10% of the speed of light.

Question 5

Figure below shows 4 energy levels for electrons in a hydrogen atom. It shows onetransition, which results in the emission of light of wavelength 486 nm.



a.) On the figure, draw arrows to show

i.) another transition which results in the emission of light of shorter wavelength (label this transition L)

ii.) a transition which results in the emission of infra-red radiation (label this transition R)

iii.) a transition which results from absorption. (label this transition A)

b.) Calculate the energy change which an electron has to undergo in order to produce light of wavelength 486 nm.

Question 6

Electromagnetic radiation is incident normally on the surface of a metal. Electrons are emitted from the surface and these are attracted to a positively charged electrode, as shown in Fig. 6.1.

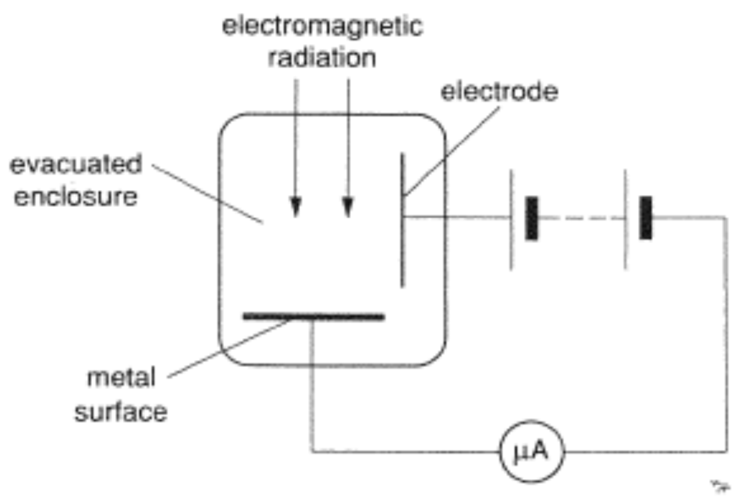


Fig. 6.1

(a) Name the effect which gives rise to the emission of the electrons.

(b) State a word equation, based on the principle of conservation of energy, which describes this effect.

(c) The current recorded on the microammeter is 2.1 μA. Calculate the number of electrons emitted per second from the surface.

(d) The incident radiation has wavelength 240 nm. Calculate the energy of a photon incident on the surface.

(e) The intensity of the incident radiation is $8.2 \times 10^3\,\mathrm{W\,m^{-2}}$. The area of the surface is $2.0\,\mathrm{cm^2}$. Calculate

(i) the power of the radiation incident on the surface,

(ii) the number of photons incident per second on the surface.

(iii) Hence determine the ratio

$$\frac{\text{number of electrons emitted per second}}{\text{number of photons incident per second}}.$$

(f) Comment on your answer to **(e)(iii)**.

Question 7

A parallel beam of violet light of wavelength 4.5×10^{-7} m and intensity $700\ \mathrm{W\,m^{-2}}$ is incident normally on a surface.

(a) Calculate

(i) the energy of a photon of violet light,

(ii) the number of photons incident per second on $1.0 \times 10^{-4}\ \mathrm{m^2}$ of the surface.

(b) **(i)** State the de Broglie relation for the momentum p of a particle in terms of its associated wavelength λ.

(ii) Use the equation in **(i)** to calculate the momentum of a photon of the violet light.

(c) **(i)** Use your answers to **(a)** and **(b)** to calculate the change in momentum of photons incident on $1.0 \times 10^{-4}\ \mathrm{m^2}$ of the surface in one second. Assume that the photons are absorbed by the surface.

(ii) Suggest why the quantity you have calculated in **(i)** is referred to as a 'radiation pressure'.