AS Level Physics

Chapter 11 – Quantum Physics

11.1.2 Photons

Worked Examples

Photons

Exam Style Question 1

(a) In atomic physics electron energies are often stated in electronvolts (eV)

Define the electronvolt. State its value in joule.

(b) An electron is accelerated from rest through a potential difference of 300 V.

(i) Calculate the final kinetic energy of the electron

1) in eV

2) in J.

(ii) Show that the final speed of the electron is about $1 \times 10^7\ m\ s^{-1}$.

Photons

Exam Style Question 1

(a) Define the electronvolt. State its value in joule.

An eV is the energy acquired by an electron accelerated through a p.d. of $1\ V$.

$$1\ eV = 1.6 \times 10^{-19}\ J$$

(b) An electron is accelerated from rest through a potential difference of 300 V.

(i) Calculate the final kinetic energy of the electron

1) in eV

300 eV

2) in J.

$$300\ eV \times 1.6 \times 10^{-19}\ J = 4.8 \times 10^{-17}\ J$$

(ii) Show that the final speed of the electron is about $1 \times 10^7\ m\ s^{-1}$.

Use $KE = \frac{1}{2}mv^2$

$$4.8 \times 10^{-17}\ J = \frac{1}{2}(9.1 \times 10^{-31}\ kg)v^2$$

$$4.8 \times 10^{-17}\ J \times 2 = (9.1 \times 10^{-31}\ kg)v^2$$

$$9.6 \times 10^{-17} = (9.1 \times 10^{-31})v^2$$

$$v = \sqrt{\frac{9.6 \times 10^{-17}}{9.1 \times 10^{-31}}} = 1.03 \times 10^7\ m\ s^{-1}$$

tutorpacks.co.uk

Photons

Exam Style Question 2

Lasers are often used to form precision-welded joints in titanium. To form one such joint it is first necessary to increase the temperature of the titanium to its melting point. Fig. 5.1 shows the joint and the volume of titanium to be heated.

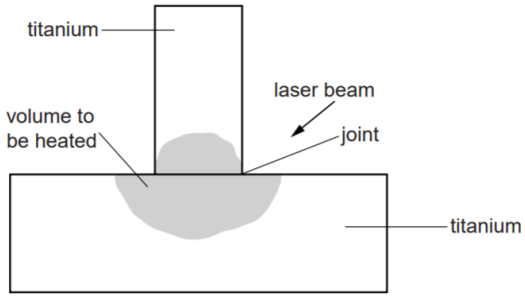

Fig. 5.1

The photon beam from the laser is focused onto the shaded volume of the joint and is converted into thermal energy in the titanium.

(a) The wavelength of the photons is $1.1 \times 10^{-6}\ m$.

Show that the energy of a photon in the beam is $1.8 \times 10^{-19}\ J$.

Photons

Exam Style Question 2

(a) Show that the energy of a photon in the beam is $1.8 \times 10^{-19}\ J$.

Use $E = \frac{hc}{\lambda}$

$$E = \frac{(6.63 \times 10^{-34}\ Js)(3.0 \times 10^{8}\ m\ s^{-1})}{(1.1 \times 10^{-6}\ m)}$$

$$E = 1.8 \times 10^{-19}\ J$$

tutorpacks.co.uk

Photons

Exam Style Question 3

When a photon of sunlight is incident on a photovoltaic cell, an electron in the cell gains sufficient energy to move through a potential difference of $0.48\ V$.

(a) What is a photon?

(b) Show that the energy required to move an electron through a potential difference of $0.48\ V$ is about $8 \times 10^{-20}\ J$.

(c) Photons of sunlight typically have energy $4.0 \times 10^{-19}\ J$. Calculate the efficiency of conversion of the energy of the photon.

Photons

Exam Style Question 3

(a) What is a photon?

A photon is a discrete packet of energy.

(b) Show that the energy required to move an electron through a potential difference of $0.48\ V$ is about $8 \times 10^{-20}\ J$.

Use $W = QV$

$$W = 1.6 \times 10^{-19}\ C \times 0.48\ V$$

$$W = 7.7 \times 10^{-20}\ J$$

(c) Photons of sunlight typically have energy $4.0 \times 10^{-19}\ J$. Calculate the efficiency of conversion of the energy of the photon.

Use

$$Efficiency = \frac{useful\ energy\ output}{total\ energy\ input} \times 100$$

$$Efficiency = \frac{7.7 \times 10^{-20}\ J}{4.0 \times 10^{-19}\ J} \times 100$$

$$Efficiency = 19\%$$

tutorpacks.co.uk

Please see ‘11.1.1 Photons notes’ pack for revision notes.

For more revision notes, tutorials and worked examples please visit www.tutorpacks.co.uk.

tutorpacks.co.uk