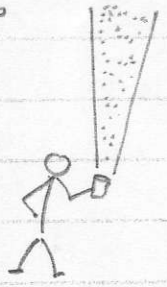
Quantum Physics – Light & Photons (energy levels) A Physics



Data:..

$c_{light} = 3 \times 10^8$ m/s

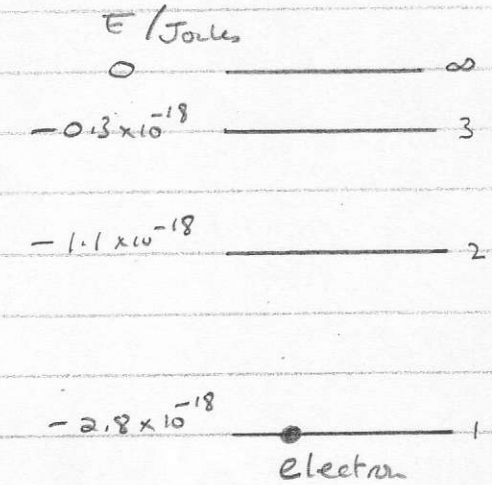
Max Planck's constant, $h = 6.6 \times 10^{-34}$ Js.

1. A torch gives a beam of light of average wavelength 5×10^{-7} m.

(a) Calculate the average light frequency and photon energy (4)

(b) If the bulb power is 60 mW, and it is 20% efficient as a light emitter, how many photons are emitted each second? (4)

2. The diagram shows the energy levels of the newly discovered atom, Eatonium.



(a) Use the diagram to explain....

- ground state (1)
- excited state (1)
- ionisation (1)
- photon (1)
- line spectrum (2)

(6)

b) Why do all levels have negative energy? (2) (2)

c) An electron falls from level 3 to level 1. Explain what happens and calculate the frequency and wavelength of radiation (4)

d) What minimum energy is needed to ionise the atom? If this is done by EM radiation, what minimum frequency is needed? (4)

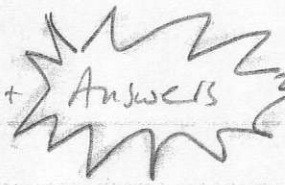
e) What is needed for the electron to go from level 1 to level 2? What f and λ of radiation will do this? (4)

(f) What is the energy difference in eV between levels 1 + 3? What is an electron volt? (4)

TW 02.05

Q... 1 out of 8 / 2 / 24 Total / 32

Quantum Physics – Light + photons



A Physics

1. a) $c = f\lambda \rightarrow f = c/\lambda = 6 \times 10^{14}$ Hz (1) (1)

photon $E = hf = hc/\lambda = 6.6\times10^{-34} \times 3\times10^{8}/5\times10^{-7} = 3.96 \times 10^{-19}$ J (1)

b) 60 mW = 60×10^{-3} J/s (1) ..... $\times 20\% = 12 \times 10^{-3}$ J/s (1)

$= 12\times10^{-3}/3.96\times10^{-19} = 3 \times 10^{16}$ photons/sec (1) (1) (4)

2. a) ground ... level 1 ... "normal" ... no extra energy.

excited ... level 2 ↑ .... extra energy given to atom

ionisation ... electron totally removed from atom

photon ... a "particle" of light energy

line spectrum .... excited atom(s) emit light (1) of only certain wavelengths. (1)

b) Electron outside the atom has zero energy. (1) Energy must be supplied to the electron to remove it from the atom (1)

c) level 3 → 1, Excess energy emitted as light (1)

E diff = $2.8\times10^{-18} - 0.3\times10^{-18} = 2.5\times10^{-18}$ J (1) = $hf \rightarrow f = 3.8 \times 10^{15}$ Hz (1)

$c = f\lambda$ (1) $\rightarrow \lambda = c/f = 3\times10^{8}/3.8\times10^{15} = 7.9 \times 10^{-8}$ m (1) (4)

d) To ionise .... need 2.8×10^{-18} J (1) = hf_{min} (1)

So $f_{minimum} = 2.8\times10^{-18}/h$ (1) $= 4.2 \times 10^{15}$ Hz (1) (4)

e) to go level 1 → 2 ... electron needs extra energy (1)

$= 2.8\times10^{-18} - 1.1\times10^{-18} = 1.7\times10^{-18}$ J (1)

E diff = $hf \rightarrow f = 2.6 \times 10^{15}$ Hz

and $c = f\lambda \rightarrow \lambda = c/f = \frac{3\times10^{8}}{2.6\times10^{15}} = 116$ nm (1)

$= 1.16 \times 10^{-7}$ m

f) Levels 1 – 3 ... energy diff. = 2.5×10^{-18} J (1)

$= \frac{2.5\times10^{-18}}{1.6\times10^{-19}} = 15.6$ eV (1)

TN 2.00 1 eV is the energy difference (1) involved in 1 electron moving across a potential difference of 1 volt (1)