Quantum Physics – Photoelectricity Questions.

A Physics

$h_{planck} = 6.6 \times 10^{-34}$ Js
$c_{light} = 3 \times 10^{8}$ m/s.

1. Sodium metal will emit photoelectrons when shone with blue light, but not with red.

$m_{electron} = 9.1 \times 10^{-31}$ kg

a) Explain why. (3)

What happens and why if....

b) the blue light is made brighter. (3)

c) the red light is made brighter. (3)

d) Explain the meaning of "work function." (2)

2. The maximum wavelength of radiation to eject photoelectrons from zinc metal is 3.4×10^{-7} m.

Calculate...

a) the threshold frequency (2)

b) the work function (2)

c) what will be the maximum velocity of electrons with radiation of $\lambda = 3.0 \times 10^{-7}$ m? (3)

d) Draw diagrams to show what happens with each radiation. (4)

3. When UV light, $\lambda = 79.6$ nm, is shone on copper the photoelectrons have a maximum velocity of 2×10^{6} m/s.

Calculate...

a) the max. electron k.E (2)

b) the work function for Cu. (2)

4. a) A metal emits photoelectrons only if $f > 5 \times 10^{14}$ Hz

What is the work function? (2)

b) What is the maximum electron k.E if $\lambda = 330$ nm? (2)

5. The work function of tungsten (light bulbs) is 7.2×10^{-19} J.

a) Calculate threshold frequency and wavelength. (4)

b) What happens if a photon of exactly twice the threshold frequency hits the metal surface? (2)

Quantum Physics — Photoelectricity

Answers

A Physics

1 a) photoelectrons emitted when photon energy exceeds threshold (1) ... "red" photons don't have enough energy (1) ... "blue" photons have higher f, higher energy (1) .... exceed threshold energy. (3

b) more photons of the same frequency/energy (1) .... more electrons (1) ... same max. velocity (1)

c) same frequency / photon energy (1) .... still < threshold energy (1) ... so no photoelectrons emitted. (1)

d) work function .... the minimum energy (1) needed just (1) to extract an electron from the metal it's in.

2. a) $c = f_0 \lambda_0$ (1) (threshold) $\rightarrow f_0 = c/\lambda_0 = \frac{3\times10^8}{3.4\times10^{-7}} = \underline{8.8\times10^{14}\ Hz}$ (1)

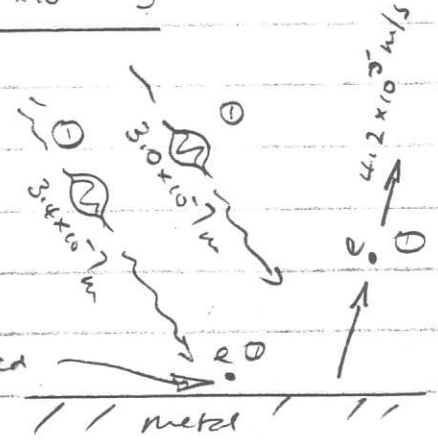
b) $hf_0 = \Phi \rightarrow \Phi = 6.6\times10^{-34} \times 8.8\times10^{14} = \underline{5.8\times10^{-19}\ J}$

c) for $\lambda = 3\times10^{-7}$ m .... $E_{photon} = hf = \frac{hc}{\lambda} = \underline{6.6\times10^{-19}\ J}$ (1)

$E_{photon} = \Phi(\text{extract}) + \frac{1}{2} m_e v^2 (\text{zoom})$

So ke max $= E - \Phi = 6.6\times10^{-19} - 5.8\times10^{-19} = \underline{8\times10^{-20}\ J}$ (1)

So $v_{max} = \left(\frac{2\times8\times10^{-20}}{9.1\times10^{-31}}\right)^{\frac{1}{2}} = \underline{4.2\times10^5\ m/s}$ (1)



(2) just extracted

3. a) $v_{max} = 2\times10^6$ m/s

$\rightarrow$ k.E. max $= \frac{1}{2} m_e v^2 = \underline{1.82\times10^{-18}\ J}$ (1) (1)

b) $hf = \frac{hc}{\lambda} = \Phi + k.E._{electron}$ (1) $\rightarrow \Phi_{copper} = \frac{hc}{\lambda} - k.E.$

So $\Phi = \frac{6.6\times10^{-34}\times3\times10^8}{79.6\times10^{-9}} - 1.82\times10^{-18}$

$= 2.49\times10^{-18} - 1.82\times10^{-18} = \underline{6.67\times10^{-19}\ J}$ (1)

4. a) $hf_0 = \Phi = 6.6\times10^{-34}\times5\times10^{14} = \underline{3.3\times10^{-19}\ J}$

b) if $\lambda = 330$ nm ... $E_{photon} = hf = \frac{hc}{\lambda} = \Phi + k.E\ max$ (1)

So k.E. max $= hc/\lambda - \Phi = \frac{6.6\times10^{-34}\times3\times10^8}{330\times10^{-9}} - 3.3\times10^{-19}\ J$

$= 6\times10^{-19} - 3.3\times10^{-19}$

$= \underline{2.7\times10^{-19}\ J}$ (1)

5. a) $\Phi = 7.2\times10^{-19}\ J = hf_0$ (1) $= hc/\lambda_0$ (1) $\rightarrow \underline{f_0 = 1.09\times10^{15}\ Hz}$ (1)

$\rightarrow \lambda_0 = 275\times10^{-9}\ m = 275\ nm$

$= \underline{2.75\times10^{-7}\ m.}$ (1)

b) $E_{photon} = hf = h(2f_0) = 2\Phi = \Phi + k.E.$

So $k.E. = \Phi = 7.2\times10^{-19}\ J$ (1)

So $\frac{1}{2} m_e v_{max}^2 = 7.2\times10^{-19} \rightarrow v_{max} = \underline{1.26\times10^6\ m/s}$ (1)

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