Quantum Physics

Modern physics · 4 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$E = hf = hc / \lambda$ $hf = \varphi + \tfrac{1}{2}mv_{max}^2$ $\lambda = h / p$ $hf = E_1 - E_2$

Questions

Show your working in the space under each question.

1. Find the de Broglie wavelength of an electron moving at 1.0×10^6 m s^{-1}.

2. Ultraviolet light of wavelength 300 nm shines on zinc (φ = 4.3 eV) and on sodium (φ = 2.3 eV). What happens in each case?

3. How many photons per second does a 1.0 mW laser of wavelength 633 nm emit?

4. Find the de Broglie wavelength of an electron accelerated through 100 V.

Step-by-step answers

Quantum Physics

1. $\lambda = h/(mv) = 6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 1.0 \times 10^{6}) =$ **7.3×10^{-10} m**.

2. 1. Photon energy $= hc/\lambda = (6.63 \times 10^{-34})(3.0 \times 10^{8})/(300 \times 10^{-9}) = 6.63 \times 10^{-19}$ J $=$ **4.1 eV**.

2. Zinc: 4.1 eV < 4.3 eV, so **no electrons are emitted**, however bright the light.

3. Sodium: maximum kinetic energy $= 4.1 - 2.3 =$ **1.8 eV**.

Answer: Zinc: no emission. Sodium: electrons with up to 1.8 eV

3. $E = hc/\lambda = 3.14 \times 10^{-19}$ J; $N = 1.0 \times 10^{-3}/3.14 \times 10^{-19} =$ **3.2×10^{15} s^{-1}**.

4. $p = \sqrt{(2meV)} = 5.40 \times 10^{-24}$ kg m s^{-1}; $\lambda = h/p =$ **1.2×10^{-10} m**.