

Practice Problems: Quantum Theory

CHEM 1A

1. Hydrogen has a red emission line at 656.3 nm, what is the energy and frequency of a photon of this light? Note: Planck's constant = 6.626×10^{-34} J·s, speed of light = 2.998×10^8 m/s

$$E_{\text{photon}} = h\nu = \frac{hc}{\lambda}$$

$$E_{\text{photon}} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s}) (2.998 \times 10^8 \text{ m/s})}{656.3 \text{ nm} \left(\frac{10^{-9} \text{ m}}{1 \text{ nm}} \right)}$$

$$E_{\text{photon}} = 3.02677861 \times 10^{-19} \text{ J}$$

$$\nu = \frac{c}{\lambda}$$

$$\nu = \frac{(2.998 \times 10^8 \text{ m/s})}{656.3 \text{ nm} \left(\frac{10^{-9} \text{ m}}{1 \text{ nm}} \right)}$$

$$\nu = 4.568032912 \times 10^{14} \text{ s}^{-1}$$

Answer (E): $3.027 \times 10^{-19} \text{ J}$ Answer (ν): $4.568 \times 10^{14} \text{ s}^{-1}$ or Hz

2. What is the de Broglie wavelength for an electron moving at 2.42×10^6 m/s?
Note: $m_e = 9.109 \times 10^{-31}$ kg

$$\lambda = \left(\frac{h}{mv} \right)$$

$$\lambda = \left(\frac{6.626 \times 10^{-34} \text{ J}\cdot\text{s}}{(9.109 \times 10^{-31} \text{ kg}) (2.42 \times 10^6 \text{ m/s})} \right) = 3.00583657 \times 10^{-10} \text{ m}$$

Answer: $3.01 \times 10^{-10} \text{ m}$ $\leftarrow$ many orders of magnitude larger than the diameter of an electron

3. Using the Bohr equation, calculate is the change in energy when an electron transitions from $n = 3$ to $n = 2$ in a hydrogen atom.

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n_{\text{final}}^2} - \frac{Z^2}{n_{\text{initial}}^2} \right)$$

$$\Delta E = -2.18 \times 10^{-18} \text{ J} \left(\frac{1^2}{2^2} - \frac{1^2}{3^2} \right)$$

$$\Delta E = -3.02777778 \times 10^{-19} \text{ J}$$

Answer: $-3.03 \times 10^{-19} \text{ J}$

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