Quiz #10

Possibly useful constants: charge on electron = $1.6 \times 10^{-19}$ C; $h = 6.63 \times 10^{-34}$ J s.

1) A plate of Zinc is illuminated with UV light with a wavelength of 210 nm. The work function of Zinc is 4.3 eV. What is the maximum kinetic energy of the photoelectrons emitted from the surface? Please give your answer in eV. (3 pts)

\[
\hbar c = \frac{6.6 \times 10^{-34}}{1.6 \times 10^{-19}} \cdot \frac{1 \text{ eV}}{1 \text{ J}} \cdot \frac{3 \times 10^8}{5} \cdot \frac{1 \text{ nm}}{10^3 \text{ m}}
\]

\[
\approx 1240 \text{ eV nm}
\]

\[
KE_{\text{max}} = h\frac{c}{\lambda} - W_0
\]

\[
= \frac{1240 \text{ eV nm}}{210 \text{ nm}} - 4.3 \text{ eV}
\]

\[
= 5.9 \text{ eV} - 4.3 \text{ eV} \approx 1.6 \text{ eV}
\]

2) Neutrons (m = 1.67 x 10^{-27} kg) in a beam move in the x direction with a velocity of 2.3 x 10^3 m/s toward a screen in the y-z plane. The screen has in it a slit of width 0.12 mm in the y direction.

a) What is the wavelength of the neutron? (2 pt)

Neutrons are moving at non-relativistic speed: p = mv

\[
\lambda = \frac{\hbar}{p} = \frac{\hbar}{mv}
\]

\[
= \frac{6.6 \times 10^{-34}}{1.67 \times 10^{-27} \text{ kg} \cdot 2.3 \times 10^3 \text{ m/s}} = 1.7 \times 10^{-10} \text{ m}
\]

b) What is the uncertainty in the y-component of the neutron’s velocity after it traverses the slit? (1 pt)

\[
\Delta p_y = \Delta (mv_y) = m \Delta v_y
\]

\[
\Delta p_y \Delta y \geq \frac{\hbar}{2\pi} \Rightarrow m \Delta v_y \Delta y \geq \frac{\hbar}{2\pi} \Rightarrow \Delta v_y \geq \frac{\hbar}{2\pi m \Delta y}
\]

\[
\Delta v_y \geq \frac{\hbar}{2\pi m \Delta y} = \frac{6.6 \times 10^{-34}}{2\pi \cdot 1.67 \times 10^{-27} \text{ kg} \cdot 1.2 \times 10^{-4} \text{ m}} = 5.2 \times 10^{-4} \text{ m/s}
\]

(continued on other side)

Rewrite and sign the honor pledge: "I pledge my honor that I have not violated the Honor Code during this examination."
3) In the Bohr model of the hydrogen atom the energy levels are given by \( E_n = -\frac{(13.6 \text{ eV})}{n^2} \), where \( n \) is the principal quantum number. What is the wavelength of the emitted photon resulting from an n=3 to n=2 transition? (4 pts)

\[
hf = E_i - E_f = \frac{-13.6 \text{ eV}}{3^2} - \frac{-13.6 \text{ eV}}{2^2} \\
= -1.51 \text{ eV} + 3.40 \text{ eV} \\
= 1.89 \text{ eV}
\]

\[
\lambda = \frac{c}{f} = \frac{hc}{hf} = \frac{1240 \text{ nm.eV}}{1.89 \text{ eV}} \approx 656 \text{ nm}
\]