Physics 2020, Adam Johnston
As always, show all your work and circle your final answer. All numeric values are good to 3 significant figures.

\[ h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}, \quad m_e = 9.11 \times 10^{-31} \text{ kg}, \quad 1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}, \quad c = 3.00 \times 10^8 \text{ m/s}, \quad \hbar = 1240 \text{ eV nm} \]

\[ K = \frac{1}{2} mv^2, \quad p = mv, \quad E = hf, \quad c = \lambda f, \quad K_{\text{max}} = hf - \phi_0, \quad p = \frac{h}{\lambda}, \quad \lambda = \frac{\hbar}{p} \]

\[ \Delta p \Delta x \geq \frac{h}{2\pi}, \quad \Delta E \Delta t \geq \frac{h}{2\pi}, \quad E_n = -(13.6 \text{ eV}) \frac{Z^2}{n^2} \]

1. [3 pts.] An electron is

| A. a particle. | B. a wave. | C. both a particle and a wave. | D. just a figment of our imagination. | E. 42 |

2. [3 pts.] Electrons are emitted from a metal surface when the metal is illuminated by light of frequency \( f \). How will the kinetic energy of each electron change if the frequency of the light is increased?

| A. No change in each electron’s kinetic energy. | B. Each electron will have a greater kinetic energy. | C. Each electron will have a lower kinetic energy. | D. No sure prediction can be made. | E. 42 |

3. [3 pts.] What observation led Rutherford to propose that atoms have a small nucleus containing most of the atom’s mass?

| A. Alpha particles are readily absorbed by thin gold foil. | B. Alpha particles are all reflected and scattered equally in all directions when they contact gold foil. | C. Alpha particles all go through gold foil, being scattered equally in all directions. | D. Most alpha particles go through gold foil, but some are scattered backwards when they contact the foil. | E. The alpha particles whispered into Rutherford’s ear what they discovered about atoms after they encountered gold foil. |

4. [5 pts.] Find the wavelength of the radiation emitted when a hydrogen atom makes a transition from the \( n=4 \) state to the \( n=2 \) state.

\[ \Delta E = E_{\text{photon}} \]

\[ E_n - E_2 = \frac{\hbar c}{\lambda} \]

\[ -13.6 \text{ eV} \]

\[ \frac{4^2 - 2^2}{2^2} = \frac{1240 \text{ eV nm}}{\lambda} \]

\[ \lambda = \frac{1240 \text{ eV nm}}{2.55 \text{ eV}} \]

\[ \lambda = 486 \text{ nm} \]

5. [6 pts.] Light of wavelength 280 nm is incident upon a metal that has a work function of 1.30 eV. What is the maximum speed of the emitted electrons?

\[ K = \frac{hc}{\lambda} - \phi = \frac{1240 \text{ eV nm}}{280 \text{ nm}} - 1.30 \text{ eV} = 3.13 \text{ eV} \]

\[ \frac{1}{2} m_e v^2 = 3.13 \text{ eV} \left(1.60 \times 10^{-19} \text{ J} \right) \frac{1}{eV} = 5.01 \times 10^{-19} \text{ J} \]

\[ v = \sqrt{\frac{2(5.01 \times 10^{-19} \text{ J})}{9.11 \times 10^{-31} \text{ kg}}} = 1.05 \times 10^6 \text{ m/s} \]