Closed book. No work needs to be shown for multiple-choice questions.

1. An electron and a proton both moving at nonrelativistic speeds have the same de Broglie wavelength. Which of the following are also the same for the two particles?

a. The speed is the same for both particles.
b. The kinetic energy is the same for both particles.
c. The momentum is the same for both particles.
d. The frequency is the same for both particles.
e. All of the above statements are correct.

2. A rock of mass 0.100 kg is thrown with a speed of 50.0 m/s. What is its de Broglie wavelength?

a. 5.30×10^{-34}m.
b. 6.63×10^{-34}m.
c. 1.27×10^{-28}m.
d. 1.33×10^{-34}m.
e. 1.66×10^{-31}m.

3. Electromagnetic radiation with a wavelength of 5.70×10^{-12}m is incident on stationary electrons. Radiation that has a wavelength of 6.57×10^{-12}m is detected at a scattering angle of:

a. 0^{o}.
b. 120^{o}.
c. 40^{o}.
d. 50^{o}.
e. 60^{o}.

4. In the photoelectric effect experiment the stopping potential, ΔV_s, is:

a. the energy required to remove an electron from the sample.
b. the kinetic energy of the most energetic electron ejected.
c. the potential energy of the most energetic electron ejected.
d. the photon energy.
e. the electric potential that causes the electric current to vanish.

5. A sodium surface is illuminated with light of wavelength 300 nm. The work function for sodium metal is 2.46 eV. Find the maximum kinetic energy of the ejected photoelectrons.

a. 4.13 eV.
b. 2.46 eV.
c. 1.67 eV.
d. 6.59 eV.
e. 0.54 eV.

6. A sodium surface is illuminated with light of wavelength 300 nm. The work function for sodium metal is 2.46 eV. Find the cutoff wavelength for sodium.

a. 300 nm.
b. 188 nm.
c. 743 nm.
d. 504 nm.
e. 1,240 nm.

7. A proton has four times the momentum of an electron. If the electron has a de Broglie wavelength λ_e, what is the de Broglie wavelength of the proton?

a. λ_e.
b. $\lambda_e/4$.
c. $4\lambda_e$.
d. $\lambda_e/16$.
e. $16\lambda_e$.

8. Of the following, which is the best evidence for the ***wave*** nature of ***matter***?

a. The interference pattern obtained when photons pass through a single slit system.
b. The interference pattern obtained when electrons pass through a two-slit system.
c. The photoelectric effect.
d. Compton scattering.
e. Blackbody radiation.

9. According to Heisenberg's uncertainty principle, the more accurately we know about a subatomic particle's momentum, the less we know about its precise:

a. kinetic energy.
b. mass.
c. speed.
d. location.
e. energy.

10. An X-ray of energy 75.0 keV strikes an electron initially at rest. The X-ray is scattered through an angle of 75.0° compared to the incident direction. What is the new wavelength of the X-ray after scattering?

a. 1.83×10^{-11} m.
b. 1.48×10^{-11} m.
c. 1.66×10^{-11} m.
d. 1.80×10^{-12} m.
e. 1.96×10^{-11} m.