3. The maximum energy, or minimum wavelength, photon is produced when the electron loses all of its kinetic energy in a single collision. Therefore, $E_{max} = hc/\lambda_{min} = KE_i = e\,\Delta V$, or

$$\lambda_{min} = \frac{hc}{e\,\Delta V} = \frac{(6.63\times10^{-34}\ \text{J}\cdot\text{s})(3.00\times10^{8}\ \text{m/s})}{(1.60\times10^{-19}\ \text{C})(3.00\ \text{J/C})} = 4.14\times10^{-7}\ \text{m} = 414\ \text{nm}$$

and we see that (c) is the correct choice.

9. Diffraction, polarization, interference, and refraction are all processes associated with waves. However, to understand the photoelectric effect, we must think of the energy transmitted as light coming in discrete packets, or quanta, called photons. Thus, the photoelectric effect most clearly demonstrates the particle nature of light, and the correct choice is (b).

10. Electron diffraction by crystals, first detected by the Davisson-Germer experiment in 1927, confirmed de Broglie's hypothesis and, of the listed choices, most clearly demonstrates the wave nature of electrons. The correct answer is (b).

2. A microscope can see details no smaller than the wavelength of the waves it uses to produce images. Electrons with kinetic energies of several electron volts have wavelengths of less than a nanometer, which is much smaller than the wavelength of visible light (having wavelengths ranging from about 400 to 700 nm). Therefore, an electron microscope can resolve details of much smaller sizes as compared to an optical microscope.

6. Light has both wave and particle characteristics. In Young's double-slit experiment, light behaves as a wave. In the photoelectric effect, it behaves like a particle. Light can be characterized as an electromagnetic wave with a particular wavelength or frequency, yet at the same time, light can be characterized as a stream of photons, each carrying a discrete energy, hf.

27.10 (a) The kinetic energy of the most energetic electrons is $KE_{max} = \frac{1}{2}m_e v_{max}^2$, so the photoelectric effect equation ($KE_{max} = hc/\lambda - \phi$) gives the work function as

$$\phi = \frac{hc}{\lambda} - \frac{1}{2}m_e v_{max}^2 = \frac{(6.63\times10^{-34}\ \text{J}\cdot\text{s})(3.00\times10^{8}\ \text{m/s})}{625\times10^{-9}\ \text{m}} - \frac{1}{2}(9.11\times10^{-31}\ \text{kg})(4.6\times10^{5}\ \text{m/s})^2$$

$$= 2.2\times10^{-19}\ \text{J}\left(\frac{1\ \text{ev}}{1.6\times10^{-19}\ \text{J}}\right) = \boxed{1.4\ \text{ev}}$$

(b) At the cutoff wavelength, $KE_{max} = 0$ and $\phi = hc/\lambda_c$, or $\lambda_c = hc/\phi$. The cutoff frequency is then

$$f_c = \frac{c}{\lambda_c} = \frac{c}{hc/\phi} = \frac{\phi}{h} = \frac{2.2\times10^{-19}\ \text{J}}{6.63\times10^{-34}\ \text{J}\cdot\text{s}} = \boxed{3.3\times10^{14}\ \text{Hz}}$$

27.27 (a) From $\lambda = h/p = h/mv$, the speed is

$$v = \frac{h}{m_e \lambda} = \frac{6.63\times10^{-34}\ \text{J}\cdot\text{s}}{\left(9.11\times10^{-31}\ \text{kg}\right)\left(5.00\times10^{-7}\ \text{m}\right)} = 1.46\times10^{3}\ \text{m/s} = \boxed{1.46\ \text{km/s}}$$

(b) $$\lambda = \frac{h}{m_e v} = \frac{6.63\times10^{-34}\ \text{J}\cdot\text{s}}{\left(9.11\times10^{-31}\text{kg}\right)\left(1.00\times10^{7}\ \text{m/s}\right)} = \boxed{7.28\times10^{-11}\ \text{m}}$$

27.37 The maximum time one can use in measuring the energy of the particle is equal to the lifetime of the particle, or $\Delta t_{\text{max}} \approx 2\ \mu\text{s}$. One form of the uncertainty principle is $\Delta E\,\Delta t \geq h/4\pi$. Thus, the minimum uncertainty one can have in the measurement of a muon's energy is

$$\Delta E_{\text{min}} = \frac{h}{4\pi\,\Delta t_{\text{max}}} = \frac{6.63\times10^{-34}\ \text{J}\cdot\text{s}}{4\pi\left(2\times10^{-6}\ \text{s}\right)} = \boxed{3\times10^{-29}\ \text{J}}$$