Physics 30 – Lesson 33
Wave-Particle Duality

/41

1)

$$\lambda = \frac{h}{mv}$$

/4

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{9.11\times10^{-31}\,kg(1.23\times10^{6}\ m/s)}$$

$$\boxed{\lambda = 5.92\times10^{-10}\,m}$$

2)

$$v = \sqrt{\frac{2E_k}{m}}$$

/5

$$v = \sqrt{\frac{2(1.14\times10^{-15}\,J)}{9.11\times10^{-31}\,kg}}$$

$$v = 5.0\times10^{7}\ m/s$$

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{9.11\times10^{-31}\,kg(5.0\times10^{7}\ m/s)}$$

$$\boxed{\lambda = 1.45\times10^{-11}\,m}$$

3)

$$r = ?$$

$$\lambda = 2.0\times10^{-10}\,m$$

/3

$$n = 1$$

$$2\pi r = n\lambda$$

$$r = \frac{n\lambda}{2\pi}$$

$$r = \frac{1(2.0\times10^{-10}\,m)}{2\pi}$$

$$\boxed{r = 3.2\times10^{-11}\,m}$$

4)

$$E_{ioniz} = E_k = 35.7eV \times \frac{1.60\times10^{-19}\,J}{eV}$$

$$E_k = 5.712\times10^{-18}\,J$$

/9

$$v = \sqrt{\frac{2E_k}{m}}$$

$$v = \sqrt{\frac{2(5.712\times10^{-18}\,J)}{9.11\times10^{-31}\,kg}}$$

$$v = 3.54\times10^{6}\ m/s$$

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{9.11\times10^{-31}\,kg(3.54\times10^{6}\ m/s)}$$

$$\lambda = 2.06\times10^{-10}\,m$$

$$r = \frac{n\lambda}{2\pi}$$

$$r = \frac{1(2.06\times10^{-10}\,m)}{2\pi}$$

$$\boxed{r = 3.27\times10^{-11}\,m}$$

5)

$$\lambda = \frac{h}{mv}$$

/3

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{0.20kg(1.0\,{}^{m}\!/\!_{s})}$$

$$\boxed{\lambda = 3.3\times10^{-33}\,m}$$

6)

/6

$$E = qV$$

$$E = 1.60\times10^{-19}\,C(100V)$$

$$E = 1.60\times10^{-17}\,J$$

$$v = \sqrt{\frac{2E}{m}}$$

$$v = \sqrt{\frac{2(1.60\times10^{-17}\,J)}{9.11\times10^{-31}\,kg}}$$

$$v = 5.93\times10^{6}\,{}^{m}\!/\!_{s}$$

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{(9.11\times10^{-31}\,kg)(5.93\times10^{6}\,{}^{m}\!/\!_{s})}$$

$$\boxed{\lambda = 1.23\times10^{-10}\,m}$$

7)

/4

a)

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63\times10^{-34}\,J\cdot s}{(9.11\times10^{-31}\,kg)(2.19\times10^{6}\,{}^{m}\!/\!_{s})}$$

$$\boxed{\lambda = 3.32\times10^{-10}\,m}$$

b)

$$C = 2\pi r$$

$$C = 2\pi(5.3\times10^{-11}\,m)$$

$$C = 3.3\times10^{-10}\,m$$

$\therefore$ they are equal

8)

/3

$$\lambda = \frac{d\sin\theta}{n}$$

$$\lambda = \frac{2.0\times10^{-6}\,m\sin(1.6\times10^{-4})}{1}$$

$$\boxed{\lambda = 5.6\times10^{-12}\,m}$$

$$\lambda = \frac{h}{p}$$

$$p = \frac{h}{\lambda}$$

$$p = \frac{6.63\times10^{-34}\,J\cdot s}{5.6\times10^{-12}\,m}$$

$$\boxed{p = 1.2\times10^{-22}\,\tfrac{kg\cdot m}{s}}$$

$$v = \frac{p}{m} = \frac{1.2\times10^{-24}\,\tfrac{kg\cdot m}{s}}{9.11\times10^{-31}\,kg} = 1.3037\times10^{8}\,\tfrac{m}{s}$$

$$E_k = \tfrac{1}{2}mv^2$$

$$E_k = \tfrac{1}{2}(9.11\times10^{-31}\,kg)(1.3037\times10^{8}\,\tfrac{m}{s})^2$$

$$\boxed{E_k = 7.7\times10^{-15}\,J}$$

9) (c) The double-slit experiment demonstrates that light has both wave and particle characteristics. As a wave, the interference pattern is understood as different light waves

2/ interfering either constructively or destructively depending on the phase difference between the light rays. As a particle, the photons are particle waves that land on the screen in a location that is governed by probability. After a sufficient number of photons have gone through the double slit apparatus, the pattern appears.

10)

a. False. The results of the double-slit experiment apply to light as well.

/2

b. True. The double-slit experiment applies to any wave phenomenon.