

First Name: \_\_\_\_\_

Last Name: \_\_\_\_\_

104 - Worksheet - Quantum Mechanics

Textbook Questions

Pg 728 #1: What is the wavelength of a proton moving at  $1.0 \times 10^5$  m/s?

$$v = 1.0 \times 10^5 \text{ m/s}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$\lambda = \frac{h}{p} \quad \text{where } p = mv$$

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{(1.67 \times 10^{-27} \text{ kg})(1.0 \times 10^5 \text{ m/s})}$$

$$\lambda = 3.97 \times 10^{-12} \text{ m}$$

Pg 728 #2: What is the speed of an electron that has a wavelength of 420 nm?

$$\lambda = 420 \times 10^{-9} \text{ m}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$v = ?$$

$$\lambda = \frac{h}{p} \quad \text{where } p = mv$$

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

$$420 \times 10^{-9} \text{ m} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{(9.11 \times 10^{-31} \text{ kg})v}$$

$$v = 1732.79 \text{ m/s}$$

Pg 736 #1: What is the wavelength of an electron that is moving at 20,000 m/s?

$$\lambda = ?$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$v = 20,000 \text{ m/s}$$

$$\lambda = \frac{h}{p} \quad \text{where } p = mv$$

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{(9.11 \times 10^{-31} \text{ kg})(20,000 \text{ m/s})}$$

$$= 3.639 \times 10^{-8} \text{ m or } 36.39 \text{ nm}$$

Pg 736 #2: Calculate the momentum of a 500-nm photon.

$$\lambda = 500 \times 10^{-9} \text{ m}$$

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

$$500 \times 10^{-9} \text{ m} = \frac{6.63 \times 10^{-34} \text{ J}\cdot\text{s}}{p}$$

$$p = 1.326 \times 10^{-27} \text{ kg}\cdot\text{m/s}$$

■ KEY ■

**Pg 736 #5:** In your television set, an electron is accelerated through a potential difference of 21,000 V.

a. How much energy does the electron acquire?

$$V = \frac{E}{q} \quad V = 21,000 \text{ V} \quad \text{and} \quad q = 1.60 \times 10^{-19} \text{ C}$$

$$21,000 \text{ V} = \frac{\Delta E}{1.60 \times 10^{-19} \text{ C}} \quad \Delta E = 3.36 \times 10^{-15} \text{ J}$$

b. What is the wavelength of an electron of this energy?

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

$$3.36 \times 10^{-15} \text{ J} = \frac{1}{2}(9.11 \times 10^{-31} \text{ kg})v^2$$

$$v^2 = 7.377 \times 10^{15}$$

$$v = 8.589 \times 10^7 \text{ m/s}$$

$$\lambda = \frac{h}{p} \quad \text{where } p = mv$$

$$\lambda = \frac{(6.63 \times 10^{-34} \text{ J}\cdot\text{s})}{(9.11 \times 10^{-31} \text{ kg})(8.589 \times 10^7 \text{ m/s})}$$

$$\lambda = 8.4736 \times 10^{-12} \text{ m}$$

**Pg 736 #6:** If an electron and a proton each have the same velocity, how do their wavelengths compare? Express your answer numerically as a ratio.

$$\lambda_e = \frac{h}{m_e v}$$

$$\lambda_p = \frac{h}{m_p v}$$

Since  $m_p > m_e$ , then  $\lambda_p < \lambda_e$ .

Rearranging both formula...

$$\lambda_e m_e = \frac{h}{v} \quad \lambda_p m_p = \frac{h}{v}$$

$$\therefore \lambda_e m_e = \lambda_p m_p$$

$$\rightarrow \text{OPTION \#1: } \lambda_e = \left(\frac{m_p}{m_e}\right) \lambda_p$$

$$\lambda_e = (1.833 \times 10^3) \lambda_p$$

$$\rightarrow \text{OPTION \#2: } \lambda_p = \left(\frac{m_e}{m_p}\right) \lambda_e$$

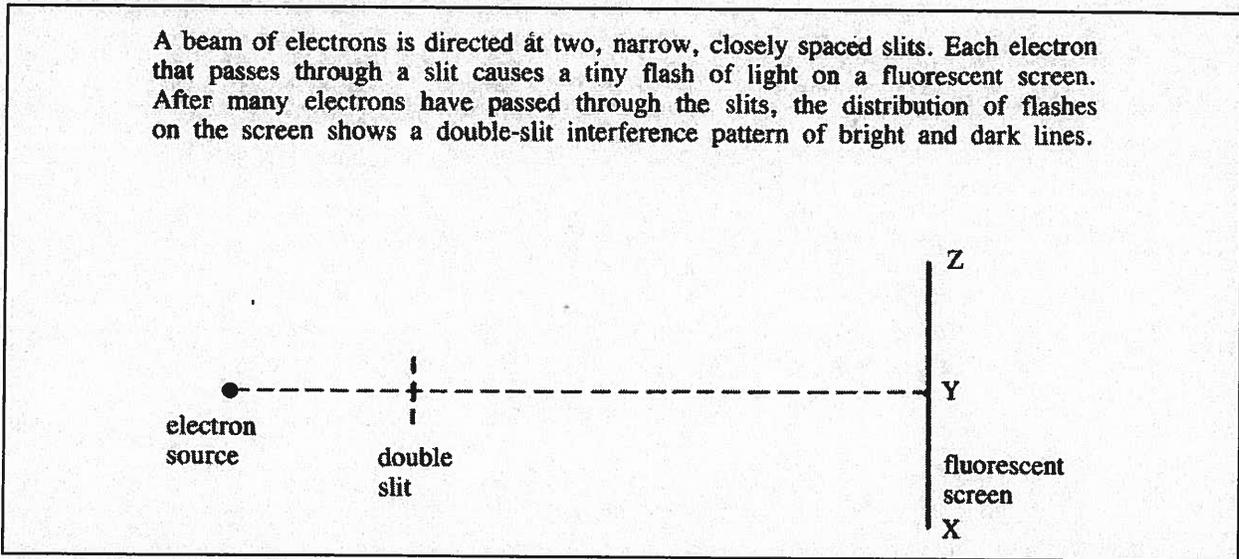
$$\lambda_p = (5.455 \times 10^{-4}) \lambda_e$$

**LC4 – Quantum Mechanics (Basic Concepts)**

**Q861:** Louis de Broglie is associated with the

- a. Uncertainty principle
- b. Momentum of photons
- c. Wave character of particles
- d. Explanation of the photoelectric effect

Use the following information to answer Q863:



**Q863:** A probable distribution of flashes on the screen after the first 20 electrons have passed through the slits could be represented by

- A.
- B.
- C.
- D.

**Q867:** The concept that particles exhibit wave-like properties was proposed by

- a. De Broglie
- b. Compton
- c. Einstein
- d. Plank

**Q869:** Evidence of the wave-like properties of matter can be found in the

- a. Refraction of light
- b. Diffraction of electrons
- c. Compton scattering of X-ray photons
- d. Conservation of momentum of photons

**L04 – Quantum Mechanics (Basic Concepts)**

**Q870:** The de Broglie wavelength for an electron moving with a velocity of  $2.0 \times 10^7$  m/s is

- a.  $2.7 \times 10^{10}$  m
- b.  $3.6 \times 10^{-11}$  m
- c.  $1.8 \times 10^{-23}$  m
- d.  $4.6 \times 10^{-38}$  m

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

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

$$(9.11 \times 10^{-31})(2.0 \times 10^7) = \frac{(6.63 \times 10^{-34})}{\lambda}$$

$$\lambda = 3.64 \times 10^{-11} \text{ m}$$

**Q874:** An alpha particle and an electron are travelling at the same speed. The de Broglie wavelength for the alpha particle is

- a. Longer because of the greater mass of the alpha particle
- b. Shorter because of the greater mass of the alpha particle
- c. Longer because of the greater charge of the alpha particle
- d. Shorter because of the greater charge of the alpha particle

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

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

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

Alpha particle has larger mass, so smaller wavelength.

**Q875:** The speed of an electron that has the same momentum as a photon with a wavelength of  $5.10 \times 10^{-7}$  m is

- a.  $7.10 \times 10^2$  m/s
- b.  $1.01 \times 10^3$  m/s
- c.  $1.43 \times 10^3$  m/s
- d.  $2.98 \times 10^8$  m/s

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

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

$$(9.11 \times 10^{-31})v = \frac{(6.63 \times 10^{-34})}{(5.10 \times 10^{-7})}$$

$$v = 1427 \text{ m/s}$$

$$\approx 1.43 \times 10^3 \text{ m/s}$$