

### Quantum World (Part 2) & Quantum Numbers Worksheet

1. Calculate the de Broglie wavelength of a proton (mass =  $1.67 \times 10^{-27}$  kg) that is moving with a velocity 15.0% of the speed of light.

$$8.82 \times 10^{-15} \text{ m}$$

2. A particle ( $6.644 \times 10^{-27}$  kg) and a chemistry textbook (2.18 kg) are travelling at identical speeds. Considering the de Broglie equation, which object do you expect to have the shorter wavelength?

Chemistry textbook

3. If a proton and an electron have the same de Broglie wavelength, do they have the same speed? If not, how do they differ?

No, electron will have a higher speed

4. If a neutron and an electron have the same speed, which has the shorter de Broglie wavelength?

Neutron

5. Which of the following experiments most directly supports de Broglie's hypothesis of the wave nature of matter?
- Black body radiation
  - Photoelectric effect
  - Alpha particle scattering by metal foil
  - Electron diffraction by crystal
  - Emission spectrum of the hydrogen atom

6. What is the uncertainty in the position of a marble of mass 1.5g if it's speed is known to within  $\pm 0.55$  m/s?

$3.2 \times 10^{-32}$  m

7. Your bowling ball of mass 4.02kg rolls down a lane with a speed of  $2.35 \pm 0.1$  m/s. What is the minimum indeterminacy of its position? Can you blame the Heisenberg Uncertainty Principle when your ball misses the pins?

$6.6 \times 10^{-35}$  m

No, cannot blame the Uncertainty Principle

8. A professor is walking towards the class. An electron in his body has a speed of  $1.5 \pm 0.4$  m/s.
- a. What is the uncertainty in the position of the electron?

$7.2 \times 10^{-5}$  m

- b. If we want to calculate the uncertainty in position of the professor, would it be larger or smaller?

Smaller

9. **True** or False: It is impossible to determine both the speed and position of an electron with absolute uncertainty.

REVIEW PROBLEMS (Week 2 & 3 cumulative material):

10. Which of the following statements regarding electromagnetic radiation is true?
- a. Electromagnetic radiation with a wavelength of 400nm travels faster than that with a wavelength of 600nm.
  - b. Electromagnetic radiation with a wavelength of 600nm travels faster than that with a wavelength of 400nm.
  - c. The frequency of electromagnetic radiation determines how fast it travels.
  - d. Electromagnetic radiation with a wavelength of 400nm has a frequency that is smaller than that with a wavelength of 600nm.
  - e. Electromagnetic radiation with a wavelength of 600nm has a frequency that is smaller than that with a wavelength of 400nm.
11. True or false:
- a. For most metals, ultraviolet light is needed for the photoelectric effect to occur. **T**
  - b. Because a faint light contains very little energy, it takes as few minutes before electrons are emitted from the metal it is shining upon. **F**
  - c. A bright light always causes more electrons to be emitted than a faint light. **F**
  - d. Higher frequency light always emits electrons with higher kinetic energies. **F**

12. Order the following types of radiation in increasing wavelength:

Gamma rays, X-rays, UV, green color, red color, infrared, microwaves

Quantum Numbers:

1. What is the maximum number of electrons that can occupy the orbitals with principal quantum number = 4?
- 32**
2. What does the principal quantum number tell us?
- a. **Energy**
  - b. Rate of circulation
  - c. Orientation of motion
  - d. None of the above

3. If  $m_l = 3$ , what are the possibilities for  $m_s$ ?

$+1/2, -1/2$

4. Which of the following sets of quantum numbers is valid for an electron in a 4d orbital?

- a.  $n=4, l=3, m_l = 2, m_s = 1/2$
- b.  $n=4, l=1, m_l = 1, m_s = -1/2$
- c.  $n=4, l=2, m_l = 3, m_s = -1/2$
- d.  $n=4, l=2, m_l = 1, m_s = -1/2$

5. Which of the following set of quantum numbers are possible?

- a.  $n=4, l=3, m_l = 3, m_s = -1/2$
- b.  $n=3, l=3, m_l = 2, m_s = -1/2$
- c.  $n=2, l=0, m_l = 1, m_s = 1/2$
- d.  $n=3, l=3, m_l = 2, m_s = 1/2$
- e.  $n=2, l=1, m_l = 2, m_s = -1/2$

6. Which of the following changes as an electron moves from a 5s to 4d orbital?

- a.  $n$
- b.  $l$
- c. a and b
- d. None of the above