This print-out should have 8 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Q01 03
001 10.0 points

Which of the following types of electromagnetic radiation has the shortest wavelength?

1. 3.57×10^{-19} J **correct**

2. 2.74×10^{-19} J

3. 3.12×10^{-19} J

4. 3.05×10^{-19} J

5. 2.83×10^{-19} J

Explanation:

LDE Q01 02
002 10.0 points

Which of the following types of electromagnetic radiation has the shortest wavelength?

1. Infrared

2. Ultraviolet

3. Microwave

4. Gamma **correct**

5. Radio

Explanation:

LDE Q01 06
003 10.0 points

Show that the wave nature of particles is negligible for macroscopic objects by calculating the de Broglie wavelength of a 2 g paper airplane thrown at Dr. Laude traveling at $5 \text{ m} \cdot \text{s}^{-1}$.

1. 1.656×10^{-33} m

2. 6.626×10^{-32} m **correct**

3. 6.037×10^{32} m

4. 1.509×10^{34} m

5. 2.650×10^{-34} m

Explanation:

$$\begin{aligned} 2 \text{ g} &= 2 \times 10^{-3} \text{ kg} \\ \lambda &= \frac{h}{mv} \\ &= \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{(2 \times 10^{-3} \text{ kg})\,(5 \text{ m} \cdot \text{s}^{-1})} \\ &= 6.626 \times 10^{-32} \text{ m} \end{aligned}$$

LDE uncertainty calculation 001
004 10.0 points

A proton in the form of a hydrogen ion has a fairly well defined position with an uncertainty of only 10^{-11} m. What would the minimum uncertainty in the proton's velocity be? (A proton has a mass of 1.672×10^{-27} kg)

1. $4,950 \text{ m} \cdot \text{s}^{-1}$

2. $9,900 \text{ m} \cdot \text{s}^{-1}$

3. $19,800 \text{ m} \cdot \text{s}^{-1}$

4. $3,150 \text{ m} \cdot \text{s}^{-1}$ **correct**

5. $31,100 \text{ m} \cdot \text{s}^{-1}$

Explanation:

$$\begin{aligned} \Delta x(m\Delta v) &\geq \frac{h}{4\pi} \\ \Delta v &\geq \frac{h}{4\pi m \Delta x} \\ &\geq \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{4\pi\,(1.672 \times 10^{-27} \text{ kg})\,(10^{-11} \text{ m})} \\ &\geq 3,153 \text{ m} \cdot \text{s}^{-1} \end{aligned}$$

LDE quantum rules
005 10.0 points

Which of the following sets of quantum numbers are **valid**, i.e. don't violate any boundary conditions?

I) $n = 3, \ell = 2, m_\ell = -2, m_s = +\frac{1}{2}$
II) $n = 9, \ell = 5, m_\ell = 6, m_s = +\frac{1}{2}$
III) $n = 2, \ell = 1, m_\ell = 0, m_s = +1$
IV) $n = 2, \ell = 0, m_\ell = 0, m_s = +\frac{1}{2}$

1. II, III

2. I, II, IV

3. IV only

4. I, III, IV

5. II only

6. III only

7. I, IV **correct**

8. I only

Explanation:
Set II and III are invalid. For II, $m_{ell} = 6$ is disallowed because $\ell = 5$. For III, $m_s = +1$ is disallowed because m_s may only be $+\frac{1}{2}$ or $-\frac{1}{2}$.

LDE Aufbau, Hund, Pauli 002
006 10.0 points

$3p$ ↑↑ ↑ ↑
$3s$ ↑↓
$2p$ ↑↓ ↑↓ ↑↓
$2s$ ↑↓
$1s$ ↑↓

Consider the electron filling diagram for a ground state atom above. Assume any unwritten orbitals are empty. Which of the following does it violate?
I) The Aufbau principle
II) Hund's rule
III) The Pauli exclusion principle

1. III only **correct**

2. II only

3. II, III

4. I, II, III

5. I, II

6. I only

7. I, III

Explanation:
The Pauli exclusion principle dictates that a given electron and a given set of quantum numbers have a 1 to 1 relation. The two electrons in first $3p$ orbital have the same spin and thus the same set of quantum numbers, in violation of the the Pauli exclusion principle.

Msci 05 1412
007 10.0 points
How many electrons can be in the $n = 2$ shell?

1. 2

2. 32

3. 18

4. 8 **correct**

Explanation:

LDE classical failure 001
008 10.0 points
Which of the following statement(s) is/are true about the photoelectric effect?
I) Classical physics failed to explain some of the observed phenomena.
II) Given light of high enough intensity, electrons can be ejected off any surface.
III) Einstein employed the concept that photons have quantized amounts of energy to explain the effect.

1. I, III **correct**

2. II, III

3. I only

4. I, II, III

5. I, II

Explanation:

Classical mechanics predicted that light of any wavelength would be able to eject electrons from a metal surface if it was sufficiently intense, which was inconsistent with the observed threshold effect. This threshold effect, the ejection energy, required that light energy was quantized.