

## Section 12: Modern Physics I

### 1. De Broglie Wavelength

Calculate the de Broglie wavelength of an electron with a kinetic energy of 150 eV.

### 2. Macroscopic Limits

Calculate the de Broglie wavelength of a 50-gram golf ball traveling at a speed of 60 m/s. Why are quantum effects not noticeable for macroscopic objects?

### 3. Photon vs Electron

What happens to the energy of a photon if its wavelength is doubled? What happens to the kinetic energy of an electron (non-relativistically) if its de Broglie wavelength is doubled?

### 4. Photoelectric Effect

The work function of potassium is 2.3 eV. What is the maximum kinetic energy of electrons ejected from potassium when it is illuminated with ultraviolet light of wavelength 350 nm?

### 5. Heisenberg Principle

Using the Heisenberg Uncertainty Principle ( $\Delta x \Delta p \geq \hbar/2$ ), what is the minimum uncertainty in the velocity of an electron that is confined within a region of space 0.1 nm wide (the size of an atom)?

### 6. Emission Spectra

Calculate the energy of the photon emitted by a hydrogen atom when an electron transitions from the  $n=3$  state to the  $n=1$  state. What is the wavelength of this photon?

### 7. Bohr Model

Calculate the radius of the second orbit ( $n=2$ ) in a hydrogen atom using the Bohr model.

### 8. Angular Momentum

What is the angular momentum of an electron in the  $n=4$  state of a hydrogen atom, according to the Bohr model?

### 9. Threshold Frequency

For light of what frequency will the photoelectric effect begin for a metal with a work function of 4.5 eV?

### 10. X-Ray Production

What is the minimum potential difference that must be applied across an X-ray tube to produce X-rays with a wavelength of 0.01 nm? (Hint:  $E = hf = hc/\lambda = qV$ ).