

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 383 – Modern Physics

Fall 2023

Problem Set #7

Problem Set Due: Thurs., Mar. 28, 2024

Read Krane: Chapter 7.1-7.8

1. **OpenStax University Physics Vol. 3: Section 1.7:** Problem 64
2. **OpenStax University Physics Vol. 3: Section 1.7:** Problem 65
3. **OpenStax University Physics Vol. 3: Section 2.1:** Problem 26 (see solution to #27)

4. **Krane: Problem 20** **page 233** (just show calculation)
5. **Krane: Problem 21** **page 233** (just show calculation)
6. **Krane: Problem 24** **page 234** (sketch energy level diagram)
7. **Krane: Problem 26** **page 234** (sketch energy level diagram)
8. **Krane: Problem 27** **page 234** (sketch energy level diagram)

Problem # 9 is on the next page

9. *Selection rules for an infinite square well potential:* Recall in Lecture that the electric dipole is defined as $\vec{p} = Q\vec{r}$ where $\vec{r}$ is the distance between a pair of positive and negative charges $+Q$ and $-Q$. Thus, the average electric dipole, or expectation value of the electric dipole, is $\langle \vec{p} \rangle = \langle Q\vec{r} \rangle$ which in one-dimensions becomes $\langle p_x \rangle = \langle ex \rangle$ for an electron cloud about a nucleus. We can use this to construct a general condition necessary for an atom in an excited state to radiate a photon (electromagnetic waves):

$$\int_{-\infty}^{\infty} x \psi_i \psi_f^* dx \neq 0 \quad (\text{allowed transitions})$$

$$\int_{-\infty}^{\infty} x \psi_i \psi_f^* dx = 0 \quad (\text{forbidden transitions})$$

where i = initial state, f = final state. The wave function for an infinite square well potential is

$$\psi = A \sin\left(\frac{n\pi x}{L}\right) \quad (n = 1, 2, 3, \dots) \quad \text{and} \quad (0 < x < L)$$

- Show whether $\Delta n = \pm 1$ transitions are allowed by examining the $n = 2 \rightarrow n = 1$ transition.
- Show whether $\Delta n = \pm 2$ transitions are allowed by examining the $n = 4 \rightarrow n = 2$ transition.
- Show whether $\Delta n = \pm 3$ transitions are allowed by examining the $n = 4 \rightarrow n = 1$ transition.
- Generalize the selection rules for any Δn , and show all the allowed transitions in the energy level diagram below:

