Phys 100 2023

Lecture 39

Test 3: Covers Ch 9.1-9.6 Waves, Light

Ch 12, 13 Quantum Theory

* Lectures 29-39
* HW 8-11

Study 2021 Test 3 Q 1-8, 10

2022 Test 3 Q 1-8, 11-13

HW, Lectures

Bring: Calculator

Given: Formulas on exam cover

HW 11 Solution

Q5

4 — 7.8×10^{-19} J

3 — 7.0×10^{-19} J

2 — 4.0×10^{-19} J

1 — 3.6×10^{-19} J

System needs to change energy - require difference between energy levels.

a) 4-01 energy lost = $7.8\times10^{-19}\text{J} - 3.6\times10^{-19}\text{J} = 4.2\times10^{-19}\text{J}$

$$\text{freq} = \frac{\text{energy lost}}{6.63\times10^{-34}\text{Js}} = \frac{4.2\times10^{-19}\text{J}}{6.63\times10^{-34}\text{Js}} = 6.3\times10^{14}\text{Hz}$$

Check solutions on (D2L)

Ch 9 Waves

Know: * wave terminology - wavelength
- speed
- amplitude
- frequency
- period

* interference

* evidence for wave picture of light - double slit interference expts.

Quiz) 90%

1 Hydrogen radiation from stars

Hydrogen emits radio waves (type of electromagnetic waves) with a wavelength of 21 cm = 0.21 m.

a) Determine the frequency of these waves.

b) Suppose that such waves take 10 years to travel from a star to Earth. Determine the distance from the star to Earth.

c) Determine how many crests from these waves arrive at the Earth in one minute.

Answer: a) $\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$

$= \frac{3 \times 10^8 \text{ m/s}}{0.21 \text{ m}} = 1.4 \times 10^9 \text{ Hz}$

b) distance = speed x time → must be in seconds

$= 3 \times 10^8 \text{ m/s} \times \text{time in seconds}$

$1 \text{ yr} = 365 \text{ days} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ s}}{1 \text{ min}} = 3.15 \times 10^7 \text{ s}$

$\text{distance} = 3 \times 10^8 \text{ m/s} \times 3.15 \times 10^8 \text{ s} = 9.5 \times 10^{16} \text{ m}$ (10 yrs)

c) Freq = number of crests each second = 1.4×10^9 Hz

In one minute $1.4 \times 10^9 \text{ Hz} \times 60 \text{ s} = 8.4 \times 10^{10}$

Quiz 2 90%

Ch 12

Know : * particle properties of light
- evidence

* meaning of a photon, energy of a photon
* photons in interference, probabilities.
* wave properties of particles, de Broglie evidence
* particles in interference.

Quiz 3 90%

2 Green photons

A green light bulb produces light with wavelength 560 nm = 5.60×10^{-7} m. The bulb produces 60 J of energy every second.

a) Determine the energy of each photon.

b) Determine the number of photons produced every second.

Answer: a) energy photon $= 6.63 \times 10^{-34}$ J·s $\times$ frequency

We get frequency via:

speed of light = frequency $\times$ wavelength

$\Rightarrow$ frequency $= \dfrac{\text{speed of light}}{\text{wavelength}}$

$= \dfrac{3.0 \times 10^{8} \text{ m/s}}{5.6 \times 10^{-7} \text{ m}}$

$\Rightarrow$ frequency $= 5.36 \times 10^{14}$ Hz

energy photon $= 6.63 \times 10^{-34}$ J·s $\times 5.36 \times 10^{14}$ Hz

energy photon $= 3.6 \times 10^{-19}$ J

b) total energy in 1s = (number of photons in 1s) $\times$ (energy photon)

$\Rightarrow$ number of photons in 1s $= \dfrac{\text{total energy in 1s}}{\text{energy photon}}$

$= \dfrac{60 \text{ J}}{3.6 \times 10^{-19} \text{ J}}$

$\Rightarrow$ number of photons in 1s $= 1.7 \times 10^{20}$

Quiz 4 80%

This requires

$$\text{wavelength} = \frac{6.6 \times 10^{-34}\ \text{J}\cdot\text{s}}{\text{mass} \times \text{speed}}$$

and

larger mass ⇒ divide by larger ⇒ small result (wavelength)
smaller mass ⇒ " " smaller ⇒ larger wavelength

Ch 13.1, 13.6-13.7

Know: * atomic spectra
* energy level model of atoms to predict spectra

Quiz 5 (after next page)

3 Light emitted by an atom

An artificial atom has three energy levels as illustrated. The atom is initially in the highest level state and it jumps to the lowest level state.

16.0×10^{-19} J ——

14.0×10^{-19} J ——

10.0×10^{-19} J ——

a) Determine the energy of the emitted photon.

b) Determine the frequency of emitted photon.

Answer: a) energy photon = energy lost by atom

$= 16.0 \times 10^{-19}\text{J} - 10.0 \times 10^{-19}\text{J}$

$= 6.0 \times 10^{-19}\text{J}$

b) frequency = $\frac{\text{energy photon}}{6.63 \times 10^{-34}\text{ J s}}$

$= \frac{6.0 \times 10^{-19}\text{J}}{6.63 \times 10^{-34}\text{ J.s}}$

$= 9.1 \times 10^{14}\text{ Hz}$