Physics 10164 - Spring 2019 Exam 4C

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (25 pts) Two light sources illuminate a screen with two parallel slits. Light source A has a wavelength of 523 nm. Light source B has an unknown wavelength. On a viewing screen, light source A produces its third bright fringe at the same place where the light from source B produces its fourth dark fringe. The fringes are counted relative to the central (zeroth) bright fringe. What is the unknown wavelength?

1st dark: $\frac{\lambda}{2}$
2nd dark: $\frac{3\lambda}{2}$
3rd dark: $\frac{5\lambda}{2}$
4th dark: $\frac{7\lambda}{2}$

A: $d \sin\theta = 3\lambda_A$

B: $d \sin\theta = \frac{7}{2}\lambda_B$

$3\lambda_A = \frac{7}{2}\lambda_B$

$\frac{3(523\ nm)}{3.5} = \lambda_B$

$\boxed{\lambda_B = 448\ nm}$

2. (25 pts) A diffraction grating contains 2200 lines/cm. When used with light of a certain wavelength, a third-order maximum is formed at an angle of 25°.

a) What is the wavelength of this light?
b) How many complete orders of visible light (400 - 700 nm) are visible upon reflecting from this diffraction grating?

$$d = \frac{1}{n} = \frac{1\,cm}{2200\,lines} \cdot \frac{1\,m}{100\,cm} = 4.545 \times 10^{-6}\,m$$

a) 3rd-order max: $d \sin\theta = 3\lambda$

$$\lambda = \frac{d \sin\theta}{3} = \boxed{640\,nm}$$

b) For what m does $\theta = 90°$?

$d \sin 90° = m\lambda$ assume red light since it has biggest θ

$$m = \frac{d}{\lambda} = 6.49$$

so $\boxed{6 \text{ complete orders visible}}$

3. (25 pts) A hydrogen atom's electron is in energy level n = 5, and a photon is emitted by the electron. Determine (a) the energy and wavelength of the photon that has the shortest possible wavelength. Also, determine (b) the energy and wavelength of the photon that has the longest possible wavelength. Answer this question with 3 SF.

a) Shortest λ = biggest ΔE (5 → 1)

$$E = 13.6\left(\frac{1}{1} - \frac{1}{25}\right) = \boxed{13.1\ eV}$$

$$\frac{1}{\lambda} = 1.097 \times 10^7\left(\frac{1}{1} - \frac{1}{25}\right) \Rightarrow \boxed{\lambda = 95.0\ nm}$$

b) Longest λ = smallest ΔE (5 → 4)

$$E = 13.6\left(\frac{1}{16} - \frac{1}{25}\right) = \boxed{0.306\ eV}$$

$$\frac{1}{\lambda} = 1.097 \times 10^7\left(\frac{1}{16} - \frac{1}{25}\right) \Rightarrow \boxed{\lambda = 4050\ nm}$$

4. (25 pts) Palladium-106 has a mass number of 106 and an atomic number 46. The nuclear mass is 105.878242 u.

Bismuth-212 has a mass number of 212 and an atomic number 83. The nuclear mass is 211.945721 u.

a) Calculate the binding energy per nucleon for each nucleus and determine which has a higher value.
b) The half-life of Bismuth-212 is 60.5 seconds. Determine the activity (in Curies) of a 1.00 milligram sample of Bismuth-212.

Palladium: $\Delta m = |105.878242 - 46m_p - 60m_n|$

$= 0.976354\ u$

$= 909.47\ MeV$ ← higher value

$BE/_{nuc} = \frac{909.47}{106} = \boxed{8.58\ MeV}$

Bismuth: $\Delta m = |211.945721 - 83m_p - 129m_n|$

$= 1.77597\ u$

$= 1654.32\ MeV$

$BE/_{nuc} = 1654.32/_{212} = \boxed{7.80\ MeV}$

$N_{Bi} = \frac{m_{tot}}{m_{Bi}} = \frac{1.0 \times 10^{-6}\ kg}{212u\ (1.66 \times 10^{-27}\ kg/u)} = 2.84 \times 10^{18}$

$\lambda = 0.693/60.5 = .01145$

$a = \lambda N = 3.25 \times 10^{16}\ Bq$

$= \boxed{8.78 \times 10^{5}\ Ci}$