Physics 10164 - Exam #4/5B

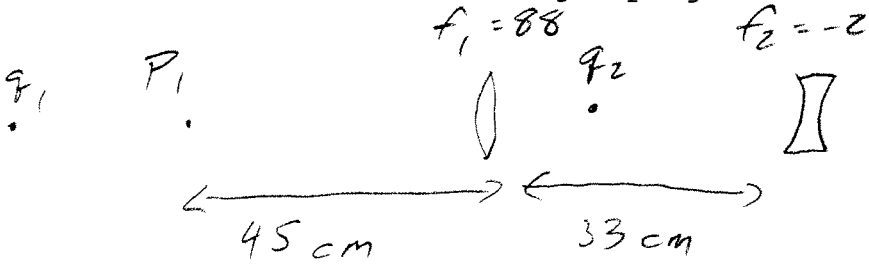
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box. If you give more than one answer without indicating which is correct, you will definitely lose points, even if one answer is correct. Each question is worth 25 points.

1. A 15-cm high object is placed 45 cm in front of a two-lens system. The first lens is a converging lens with a focal length of 88 cm. 33 cm behind the first lens is a diverging lens with a focal length of -25 cm.

a) Where is the final image located, with respect to the 2nd lens?

b) What is the size of the final image, in cm?

c) Is the final image upright or inverted?



$$\frac{1}{45} + \frac{1}{q_1} = \frac{1}{88} \Rightarrow q_1 = -92$$

$$p_2 = 33 + 92 = 125\text{ cm}$$

$$\frac{1}{125} + \frac{1}{q_2} = \frac{1}{-25} \Rightarrow q_2 = -21 \text{ or } \boxed{21\text{cm in front of lens 2}}$$

$$M_1 = -\frac{-72}{45} = 2.04$$

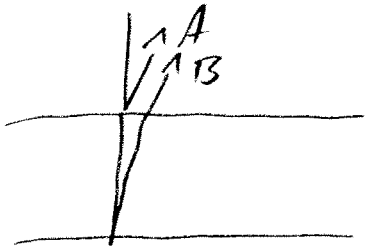
$$M_2 = -\frac{-21}{125} = 0.168$$

$$M_{TOT} = 0.34 \qquad y_i = (.34)(15) = \boxed{5.1\text{ cm}}$$

M_{TOT} + $\rightarrow$ **image upright**

2. An observer notices that red light of wavelength 656 nm reflects strongly off of an oil slick when observed from directly above. The oil (n = 1.43) is a thin film on top of water (n = 1.33).

What are the two smallest possible thicknesses of the oil film?



$$\phi_A = \frac{1}{2}$$

$$\phi_B = 0 + \frac{2(1.43)t}{\lambda_0}$$

$$\phi_B - \phi_A = 0, 1, 2, \ldots$$

$$\frac{2.86t}{\lambda_0} - \frac{1}{2} = 0 \Rightarrow t = \frac{\lambda_0}{2(2.86)} = \boxed{115\ nm}$$

$$\frac{2.86t}{\lambda_0} - \frac{1}{2} = 1 \Rightarrow t = \frac{3\lambda_0}{2(2.86)} = \boxed{344\ nm}$$

3. An electron is in energy level 6 of a Hydrogen atom. It jumps from levels 6 --> 3 (transition A), then
3 --> 2 (transition B), then
2 --> 1 (transition C).

a) Determine the wavelengths of the photons emitted by the atom when electrons make each of these transitions.

b) Transition B is also known as "Balmer-alpha". How many Hydrogen atoms would need to be emitting the photon from this particular transition in order for a cloud of Hydrogen to emit 15 Joules of energy?

a) $6 \to 3$ $\quad \frac{1}{\lambda} = (1.097 \times 10^7)\left(\frac{1}{9} - \frac{1}{36}\right)$

$= 9.14 \times 10^5$

$\boxed{\lambda = 1094\ nm}$

$3 \to 2$ $\quad \frac{1}{\lambda} = (1.097 \times 10^7)\left(\frac{1}{4} - \frac{1}{9}\right)$

$= 1.52 \times 10^6$

$\boxed{\lambda = 656\ nm}$

$2 \to 1$ $\quad \frac{1}{\lambda} = (1.097 \times 10^7)\left(\frac{1}{1} - \frac{1}{4}\right)$

$= 8.23 \times 10^6$

$\boxed{\lambda = 122\ nm}$

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b) $E = 13.6\left(\frac{1}{4} - \frac{1}{9}\right) = 1.89\ eV = 3.02 \times 10^{-19}$

$N = \frac{E_{tot}}{E_{atom}} = \frac{15}{3.02 \times 10^{-19}} = \boxed{4.96 \times 10^{19}\ atoms}$

4. Cobalt-56, a common by-product of a nuclear fission weapon, has a half-life of 77.3 days. A sample of Cobalt-56 is found to have an activity of 0.25 Curies (Ci).

a) What is the mass of the sample?

b) How long will it take for the activity to decrease to 3.0 μCi?

a) $T_{1/2} = 77.3\,d = 6.68 \times 10^{6}\,s$

$\lambda = 1.04 \times 10^{-7}$

$a = 0.25\,Ci \cdot \frac{1\,Bq}{2.7 \times 10^{-11}} = 9.26 \times 10^{9}\,Bq$

$9.26 \times 10^{9} = (1.04 \times 10^{-7})N$

$N = 8.9 \times 10^{16}\ atoms$

$M_{TOT} = N m_{atom} = (8.9 \times 10^{16})(56\,u)\left(\frac{1.66 \times 10^{-27}\,kg}{1\,u}\right)$

$= \boxed{8.3 \times 10^{-9}\,kg}$

b) $\frac{a}{a_0} = \frac{3 \times 10^{-6}}{0.25} = 1.2 \times 10^{-5} = e^{-(1.04 \times 10^{-7})t}$

$-11.33 = -(1.04 \times 10^{-7})t$

$\boxed{t = 1.09 \times 10^{8}\,s}$ or 1261 d or 3.5 yrs