Practice problem

1.
a) Write the balanced equation for the reaction of acetic acid with aluminum hydroxide to form water and aluminum acetate.
b) Using the equation from problem part a, determine the mass of aluminum acetate that can be made if I do this reaction with 125 grams of acetic acid and 275 grams of aluminum hydroxide.
c) What is the limiting reagent in part b?
d) How much of the excess reagent will be left over after the reaction is complete?

2. The power output of a laser is measured in units of watts (W), where one watt is equal to one joule per second. ($1J = 1W \times 1s^{-1}$) What is the number of photons emitted per second by a 1.00 mW nitrogen laser? The wavelength emitted by a nitrogen laser is 337 nm.

3. An experiment is conducted to investigate the photoelectric effect. When light of frequency 1.0×10^{15} hertz is incident on a photocathode, electrons are emitted with maximum kinetic energy 1.0 eV. Light of frequency 1.5×10^{15} hertz produces photoelectrons with maximum kinetic energy 1.5 eV.

a) Calculate an experimental value of Planck's constant based on these data.
b) Calculate the work function of the photocathode.
c) Will electrons be emitted from the photocathode when green light of wavelength 5.0×10^{-7} meter is incident on the photocathode?

4. Use the simple Z_{eff} model from lecture, i.e.,

$$Z_{eff} = Z - \#.e^{-}\, in\, lower\, shells - \frac{1}{2}\#.other\, e^{-}\, in\, the\, same\, shell$$

estimate the ionization energies of H, He, and Li.

5. Consider an electron in the 1s state of the hydrogen atom. Its normalized wavefunction is given by:

$$\psi_{1s}(r) = 2(\frac{1}{4\pi a_0^3})^{1/2} e^{-\frac{r}{a_0}} \qquad (r = \sqrt{x^2 + y^2 + z^2})$$

(a) What is the probability of finding the electron in the region:
$\frac{1}{\sqrt{2}}a_0 < x < (\frac{1}{\sqrt{2}} + 0.0001)a_0$,
$\frac{1}{\sqrt{2}}a_0 < y < (\frac{1}{\sqrt{2}} + 0.0001)a_0$,
$0 < z < 0.0001a_0$?
(b) Same, for the region:
$\frac{5}{\sqrt{2}}a_0 < x < (\frac{5}{\sqrt{2}} + 0.0001)a_0$,
$\frac{5}{\sqrt{2}}a_0 < y < (\frac{5}{\sqrt{2}} + 0.0001)a_0$,
$0 < z < 0.0001a_0$?
(c) And, finally, same, but for the region:
$\frac{0.01}{\sqrt{2}}a_0 < x < (\frac{0.01}{\sqrt{2}} + 0.0001)a_0$,
$\frac{0.01}{\sqrt{2}}a_0 < y < (\frac{0.01}{\sqrt{2}} + 0.0001)a_0$,

$0 < z < 0.0001a_0$?
(d) What is the probability of finding the electron having a distance between a_0 and $a_0 + 10^{-12}m$ from the nucleus?
(e) Same, but for the distance between $5a_0$ and $5a_0 + 10^{-12}m$ from the nucleus.
(f) Finally, same, but for the distance between $0.01a_0$ and $0.01a_0 + 10^{-12}m$ from the nucleus.

6. Now consider an electron in the 2px state of the hydrogen atom:

$$\psi_{2p}(r,\theta,\phi) = \frac{1}{4}(\frac{1}{2\pi a_0^3})^{1/2}\frac{r}{a_0}e^{-\frac{r}{2a_0}} sin\theta cos\phi$$

Suppose we go looking for the this electron in a small volume $(10^{-12}m)^3$ centered at various positions.
(a) At what position will the probability of finding the electron be a maximum?
(b) At what position will it be a minimum?