1\. a) $3\,CH_3COOH + Al(OH)_3$

$= (CH_3COO)_3Al + 3H_2O$

b) c) CH_3COOH : 60.05 g/mol

$Al(OH)_3$: 78.00 g/mol

$CH_3COOH: \dfrac{125\,g}{60.05\,g/mol} = 2.08$ mol

$Al(OH)_3 : \dfrac{275\,g}{78\,g/mol} = 3.53$ mol

CH_3COOH is the limiting reagent.

Mass of $(CH_3COO)_3Al$:

$2.08 \times \frac{1}{3} \times 204.11\,g/mol = 141.6\,g$

d) $275 - 2.08 \times \frac{1}{3} \times 78 = 220.9g$

2. Total energy of photons:

$$1mW \times 1s = 10^{-3} J$$

Energy per photon:

$$E = \frac{hc}{\lambda} = 5.89 \times 10^{-19} J$$

thus number of photon:

$$\frac{10^{-3} J}{5.89 \times 10^{-19} J} \doteq 1.7 \times 10^{15}$$

3. a) $h\nu_1 - W = K.E._1$

$h\nu_2 - W = K.E._2$

$$\Rightarrow h(\nu_1 - \nu_2) = K.E._1 - K.E._2$$

$$h = \frac{K.E_1 - K.E._2}{\nu_1 - \nu_2}$$

$$= \frac{0.5\ eV}{0.5 \times 10^{15} Hz} = 10^{-15}\ eV \cdot s^{-1}$$

$$= 3.6749 \times 10^{-17}\ J \cdot s^{-1}$$

b) $W = 0$

c) Yes. since $W=0$, so any photon will be able to produce photoelectrons)

(Poor experimental data!)

4. H: $Z_{eff} = Z = 1$

$$I.E. = R_\infty = 13.6\ eV$$

He: $Z_{eff} = 2 - \frac{1}{2} = 1.5$

$$I.E. = R_\infty \cdot 1.5^2 = 30.6\ eV$$

Li: $Z_{eff} = 3 - 2 = 1$

$$I.E. = R_\infty \cdot \frac{1}{2^2} = 3.4\ eV$$

5. (a) $|2\psi_{1s}(r)|^2 \Delta V$ $\quad\left(r = \sqrt{\left(\frac{1}{\sqrt{2}}a_0\right)^2 + \left(\frac{1}{\sqrt{2}}a_0\right)^2} = a_0\right)$

$$= \cancel{4} \cdot \frac{1}{\cancel{4}\pi a_0^3} e^{-2\cdot\frac{\cancel{a_0}}{\cancel{a_0}}} \cdot (0.0001 a_0)^3$$

$$= \frac{e^{-2}}{\pi} \cdot (0.0001)^3 = 4.3 \times 10^{-14}$$

(b) $(r = 5a_0)$

$$|2\psi_{1s}(r)|^2 \Delta V = \frac{e^{-10}}{\pi}(0.0001)^3 = 1.4 \times 10^{-17}$$

(c) $(r = 0.01\, a_0)$

$$|2\psi_{1s}(r)|^2 \delta V = \frac{e^{-0.02}}{\pi}(0.0001)^3 = 3.1 \times 10^{-13}$$

(d) Radial distribution function of 1s:

$$R(r) = 2\frac{1}{a_0^{\frac{3}{2}}} e^{-\frac{r}{a_0}}$$

thus probability is:

$$(10^{-12} m \doteq 0.0189 a_0)$$

$$4\pi r^2 |R(r)|^2 dr$$

$$= 4\pi \cdot \cancel{a_0^2} \cdot 4 \cdot \frac{1}{\cancel{a_0^3}} e^{-2\frac{a_0}{a_0}} \cdot 0.0189 \cancel{a_0}$$

$$= 16\pi e^{-2} \cdot 0.0189 = 0.129$$

(e) $4\pi r^2 |R(r)|^2 dr$

$$= 4\pi \cdot 25 \cancel{a_0^2} \cdot 4 \cdot \frac{1}{\cancel{a_0^3}} e^{-2 \cdot \frac{5a_0}{a_0}} \cdot 0.0189 \cancel{a_0}$$

$$= 16\pi \cdot 25 \cdot e^{-10} \cdot 0.0189 = 0.001$$

(f) $4\pi \cdot (0.01)^2 \cdot 4 \cdot e^{-0.02} \cdot 0.0189 \doteq 0.00009$

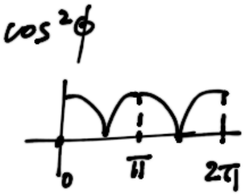
6. (a) First find maximum in r

(I need to use calculus here, but you won't need to use calculus in midterm)

$$\frac{d}{dr}\left(r^2 e^{-\frac{r}{a_0}}\right) = 2r e^{-\frac{r}{a_0}} + r^2\left(-\frac{1}{a_0}\right) e^{-\frac{r}{a_0}}$$

$$\Rightarrow \left(2 - \frac{r}{a_0}\right) = 0 \Rightarrow r = 2a_0$$

Then find maximum in θ, ϕ :



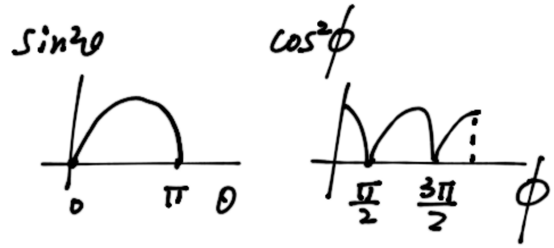
maximum achieved at : $\theta = \frac{\pi}{2}$ $\phi = 0, \pi, (2\pi = 0)$

(again, you don't need to know about spherical coordinates)

these corresponds to plus and minus x-axis

Thus probability is maximum at $x = \pm 2a_0,\ y = 0,\ z = 0$

b) Let $\sin^2\theta \cos^2\phi = 0$:



$\Rightarrow \theta = 0, \pi$ or $\phi = \frac{\pi}{2}, \frac{3\pi}{2}$

$\theta = 0, \pi$ gives z-axis

$\phi = \frac{\pi}{2}, \frac{3\pi}{2}$ gives the full y-z plane

Thus probability is minimum (0) at yz-plane

The yz-plane is actually the angular node of 2px orbital.