6) Gasorowicz 1-3:

The photon energy is $E = h\nu = \frac{hc}{\lambda} = \frac{1240\,eV.nm}{350\,nm} = 3.54\,eV.$

In general the maximum KE is

$$KE = h\nu - W \Rightarrow W = h\nu - KE_{max}$$
$$= 3.54 - 1.6 \qquad \boxed{W = 1.943\,eV}$$

Gasorowicz 1-4:

We are getting 2.3 eV @ 200 nm and 0.90 eV @ 258 nm. From above

$$W = h\nu - KE_{max} \Rightarrow h\nu_1 - KE_1 = h\nu_2 - KE_2$$

$$h(\nu_1 - \nu_2) = KE_1 - KE_2 \qquad h = \frac{KE_1 - KE_2}{\nu_1 - \nu_2}$$

but

$$\lambda\nu = c \Rightarrow \nu_1 = c/\lambda_1 \ldots$$

$$h = \frac{1}{c}\frac{KE_1 - KE_2}{1/\lambda_1 - 1/\lambda_2} = \left(\frac{2.3eV - 0.9eV}{1/200nm - 1/258nm}\right)\frac{1}{3\times10^{17}\,nm/s}$$

$$\boxed{h = 4.15\times10^{-15}\,eV\cdot s = 6.65\times10^{-34}\,J\cdot s}$$

As in 1-3 we can get W once we know h

$$W = h\nu - KE = (4.15\times10^{-15}\,eV.s)\frac{3\times10^{17}\,nm/s}{200\,nm} - 2.3\,eV = \boxed{3.93\,eV}$$

7) From class $C_v = 3R\frac{(\epsilon/kT)^2 e^{\epsilon/kT}}{[e^{\epsilon/kT} - 1]^2}$ $\qquad 3R = 24.94\,J/K$

Lets try calculating C_v at a few points

$$\frac{\epsilon}{kT} = 1 \Rightarrow C_v = (0.921)\cdot 3R$$

$$\frac{\epsilon}{kT} = 2 \Rightarrow C_v = (0.724)\cdot 3R = 18.06\,J/mol\,K.$$

From a plot of the data it looks like $C_v \simeq 18\ J/K$ at around 345 K $\Rightarrow$

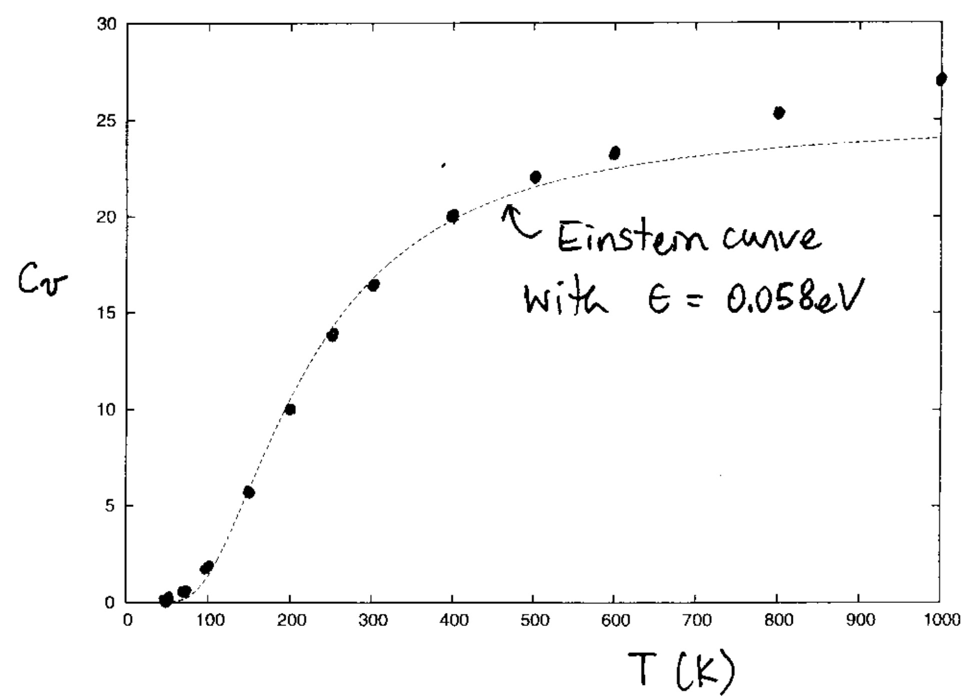
$$\epsilon = 2kT = 2(1.38\times10^{-23} J/K)(345K) = 9.5\times10^{-21} J$$
$$= 0.059\ eV$$

Lets try a graph for that value. To simplify write $\epsilon = 2kT \Rightarrow \epsilon/k = 2(345K) = 690\ K$ and so $\epsilon/kT = \frac{690K}{T}$

After looking at the graph I conclude that a slightly smaller value of ϵ would look better overall.

$\epsilon/k = 670K$ seems better (see below)

$$\Rightarrow \quad \epsilon = (670K)\cdot 1.38\times10^{-23} J/K$$
$$\boxed{\epsilon = 9.25\times10^{-21} J = 0.058 eV}$$



8) Momentum is conserved. For the photon $E = pc$ so $p = E/c$. The ^{14}N nucleus will have that same momentum. But for the nucleus the KE will be $\ll$ than mc^2 so the motion is non-relativistic, and

$$\therefore \quad E = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{(pc)^2}{2mc^2} \qquad pc = E_\gamma = 6\,\text{MeV}$$

$$mc^2 = 14 \times 938\,\text{MeV}$$

$$E_{RECOIL} = \frac{(6\,\text{MeV})^2}{2(14)(938\,\text{MeV})}$$

$$\boxed{E_{recoil} = 1.37 \times 10^{-3}\,\text{MeV} = 1.37\,\text{keV}}$$

9) First find the reduced mass

$$\mu = \frac{m_1 m_2}{m_1 + m_2} \Rightarrow \mu c^2 = \frac{(m_1c^2)(m_2c^2)}{m_1c^2 + m_2c^2} = \frac{(3727\,\text{MeV})(105.66\,\text{MeV})}{(3727 + 105.66)\,\text{MeV}}$$

$$\underline{\mu c^2 = 102.75\,\text{MeV}} = 1.0275 \times 10^8\,\text{eV}$$

Here the nucleus has charge $q = 2e$ so in our hydrogen formulas $e^2 \to Ze^2$ where $Z = 2$

$$r_1 = \frac{4\pi\epsilon_0}{Ze^2}\frac{\hbar^2}{\mu} = \frac{1}{2}\,\frac{1}{1.44\,\text{eV}\cdot\text{nm}}\,\frac{(197.3\,\text{eV}\cdot\text{nm})^2}{1.0275 \times 10^8\,\text{eV}} = \boxed{1.32 \times 10^{-4}\,\text{nm} = 132\,\text{fm}}$$

$$E_1 = -\frac{1}{2}\left(\frac{Ze^2}{4\pi\epsilon_0}\right)^2 \frac{\mu c^2}{\hbar^2 c^2}$$

$$= -\frac{1}{2}(4)(1.44)^2 \frac{1.0275 \times 10^8\,\text{eV}}{(197.3)^2} = \boxed{10.94\,\text{keV}}$$

10) For the Harmonic Oscillator $\vec{F} = -kr\hat{r}$ (attractive) and $V = \frac{1}{2}kr^2$

$$\vec{F} = m\vec{a} \Rightarrow \frac{mv^2}{r} = kr \qquad \boxed{mv^2 = kr^2} \quad ①$$

Angular momentum:

$$L = mrv = n\hbar \Rightarrow \boxed{v = \frac{n\hbar}{mr}} \quad ②$$

Substitute into ①

$$m\left(\frac{n\hbar}{mr}\right)^2 = kr^2 \qquad r^4 = \frac{n^2\hbar^2}{km}$$

so $$\boxed{r = \left(\frac{n\hbar}{\sqrt{km}}\right)^{\frac{1}{2}}}$$

Then
$$E = \frac{1}{2}mv^2 + \frac{1}{2}kr^2 \overset{\text{from (1)}}{=} \frac{1}{2}kr^2 + \frac{1}{2}kr^2$$

$$E = k\left(\frac{n\hbar}{\sqrt{km}}\right) = n\hbar\sqrt{\frac{k}{m}} \qquad \boxed{E_n = n\hbar\sqrt{\frac{k}{m}}}$$

So the energy levels are equally spaced with spacing $\epsilon = \hbar\omega$.

11)(a) $E_n = -\frac{1}{2}\left(\frac{q^2}{4\pi\epsilon_0}\right)\frac{m}{\hbar^2}\frac{1}{n^2}$

Lets work in S.I. Units $\quad \frac{1}{4\pi\epsilon_0} = 9\times10^9\ N\cdot m^2/c^2$

$$E_1 = -\frac{1}{2}(10^{-4}c)^2\left(9\times10^9\ \frac{N\cdot m^2}{c^2}\right)(10^{-3}kg)/(1.054\times10^{-34}J\cdot s)$$
$$\boxed{E_1 = -4.0\times10^{66}J}$$

(b) $L = mrv = n\hbar$ so lets find v

$$\frac{mv^2}{r} = F = \frac{q^2}{4\pi\epsilon_0}\frac{1}{r^2} \qquad v^2 = \frac{1}{m}\frac{q^2}{4\pi\epsilon_0}\frac{1}{r} \qquad v = 950\ m/s$$

$$n = mvr/\hbar = (10^{-3})(950)(0.1)/(1.05\times10^{-34}) = 9\times10^{32}$$

(c) $f_{orbit} = \frac{v}{2\pi r} = \frac{950\ m/s}{2\pi(.1m)} = 1512\ /s.$

In the Bohr model

$$h\nu = E_i - E_f = -\frac{1}{2}\left(\frac{q^2}{4\pi\epsilon_0}\right)^2\frac{m}{\hbar^2}\left(\frac{1}{n^2} - \frac{1}{(n-1)^2}\right)$$

$$\nu = -\frac{1}{4\pi\hbar}\left(\frac{q^2}{4\pi\epsilon_0}\right)^2\frac{m}{\hbar^2}\left[\frac{1}{n^2} - \frac{1}{n^2}\left(1-\frac{1}{n}\right)^{-2}\right] = -\frac{1}{4\pi}\left(\frac{q^2}{4\pi\epsilon_0}\right)^2\frac{m}{\hbar^3}\frac{1}{n^2}\left(\frac{2}{n}\right)$$

$$= +\frac{1}{2\pi}\left(\frac{q^2}{4\pi\epsilon_0}\right)^2\frac{m}{\hbar^3}\frac{1}{n^3} = 1510/s \qquad \text{- close enough.}$$