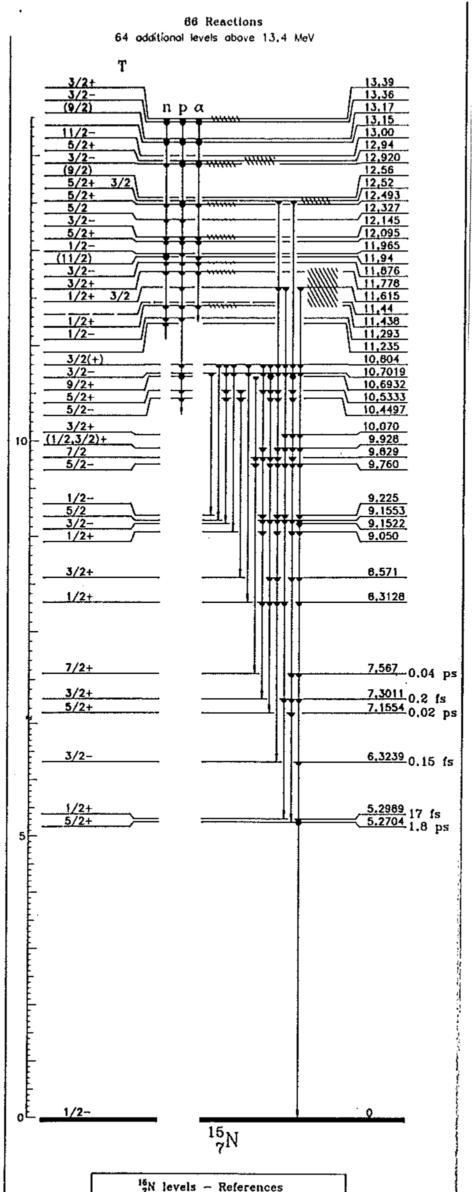
Ph 406 Problem Set 5

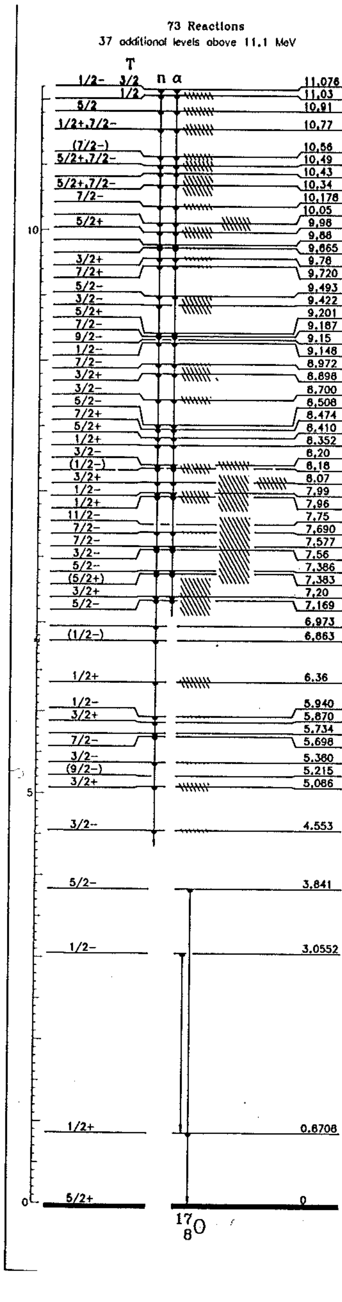
Due March 12, 1993

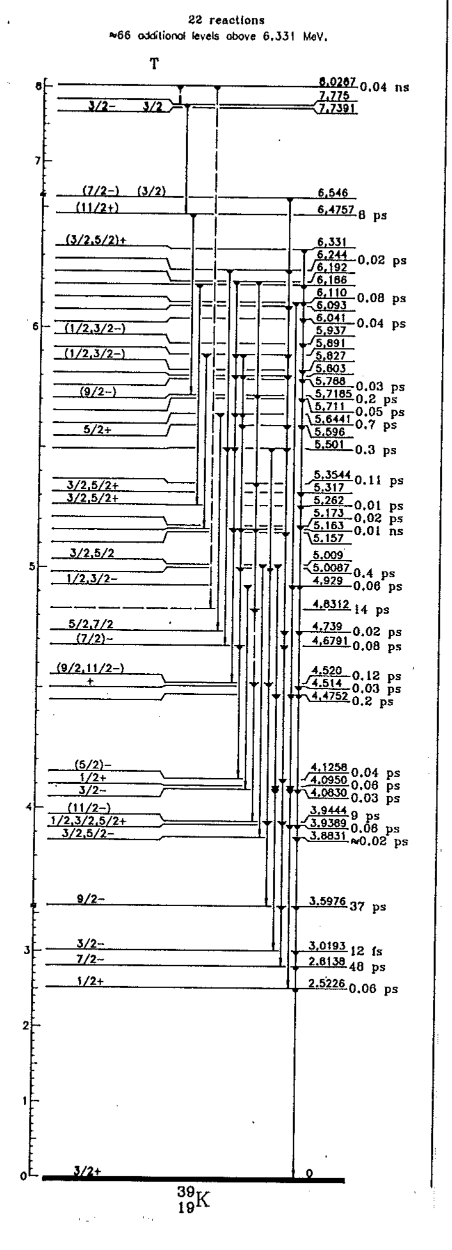
(1) The binding energies of the mirror nuclei ${}^{11}_{5}B$ and ${}^{11}_{6}C$ are 76.205 MeV and 73.443 MeV respectively. Assuming that the difference is due entirely to Coulomb effects, and that the proton charge is uniformly distributed through a sphere of radius R_C in both nuclei, find R_C. This was an early way of estimating the size of a nucleus. Compare R_C with the value $R = 1.1A^{\frac{1}{3}}$ fm, and comment on the difference.

(2) **15.11.** Compare the first few excited states of the nuclides ${}^{15}N$, ${}^{17}O$, and ${}^{39}K$ with the prediction of the single-particle shell model. Discuss spin, parity, and level ordering.



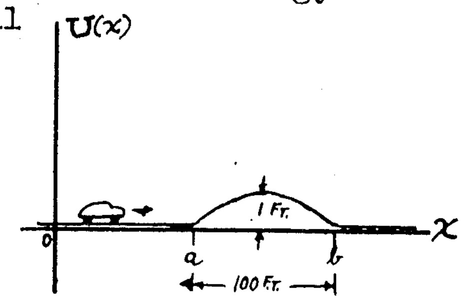
${}^{15}_{7}N$ levels – References
Decay: PC76 Alburgr, NP A268 1(76)
66 Reactions: NP A268 1(76)





(3) Problem: A very slowly moving car of 1 ton (kinetic energy considered almost zero) encounters a sinusoidal bump in the road which is 1 ft. high and 100 ft. long. Classically, the car can't get past. show that there actually is a finite probability (w) that the car can overcome the bump.

WHAT IS w?



$M = 10^6$ gm.

$b - a = 3050$ cm.

(4) The zero-temperature radiative capture cross-section illustrated in Fig. 8.5 is the intrinsic cross-section to which the Breit–Wigner formula is immediately applicable. The excited state has spin $\frac{1}{2}$, and there are two significant decay channels; the dominant one is γ-emission and the other is neutron emission. Estimate the relative probability of neutron radiative capture at resonance, and estimate the elastic neutron scattering cross-section at resonance. (Hint: use equation (D.11).)

(5) If the neutron density $\rho(\mathbf{r},t)$ in a material is slowly varying over distances long compared with the neutron mean free path l, $\rho(\mathbf{r},t)$ approximately satisfies the 'diffusion equation with multiplication',

$$\frac{\partial \rho}{\partial t} = \frac{(\nu - 1)}{t_{\mathrm{p}}}\rho + D\,\nabla^2 \rho.$$

The coefficient of diffusion is given in simple transport theory by $D = lv/3$, where v is the neutron velocity (assumed constant). At a free surface, the effective boundary condition, again obtained from transport theory, is

$$0.71l\frac{\partial \rho}{\partial n} + \rho = 0,$$

where $\partial/\partial n$ denotes differentiation along the outward normal to the surface.

Using the data given in § 9.4, estimate the critical radius of a bare sphere of ^{235}U. Look for spherically symmetric solutions of the equation of the form $\rho(r,t) = f(r)e^{\lambda t}$, and replace the boundary condition at the surface $r = R$ by the approximation $\rho(R + 0.71l, t) = 0$.