Structure of Matter – MidTerm3

May 07, 2020

Upload your paper to your dropbox, a.s.a.p. after finishing the exam.

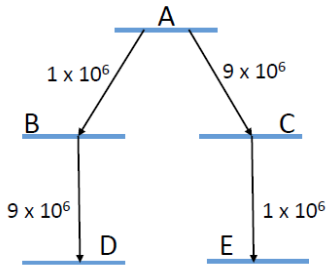
Motivate your answers!

PROBLEM 1. [13 pnts]

a) Calculate the proton density [per fm^3] of a $^{261}_{104}$Rf nucleus. [2 pnts]

b) The Rutherfordium isotope $^{261}_{104}$Rf can decay to nobelium (No) via α decay or to lawrencium (Lr) via β^+ decay. Give the complete formula for each of the decay reactions. (mind charge conservation) [3 pnts]

c) As is shown in the figure a nucleus A can decay via two channels creating two granddaughter nuclei D and E. Possible decay pathways are ABD and ACE. The transition rates per second are indicated in the figure. If initially 100,000 nuclei A were produced in an experiment how many granddaughters D and E are finally produced? [2 pnts].



d) Are both pathways equally fast? [2 pnts].

e) Use the liquid drop model approximation to verify whether $^{64}_{30}$Zn can or cannot decay to $^{64}_{29}$Cu. [4 pnts]

$$B(N,Z) = aA - bA^{\frac{2}{3}} - \frac{dZ^2}{A^{\frac{1}{3}}} - s\frac{(N-Z)^2}{A} - \frac{\delta}{A^{\frac{1}{2}}}$$

a=	15.8	δ=	11.2	odd-odd
b=	18.3		0	even-odd
d=	0.71		-11.2	even-even
s=	23.2	all parameters are in MeV		

PROBLEM 2. [12 pnts]

Use the generic sequence of nuclear shell filling: 1s, 1p, 1d, 2s, 1f, 2p, 1g, …….

a) Which of the tabulated nuclei have nuclear spin J=7/2? [3 pnts]

b) Which of the tabulated nuclei have even parity? [2 pnts]

c) Hyperfine structure: consider a Sc isotope with I=4. Sc has a $^2D_{3/2}$ level as its ground electronic level. What are the possible hyperfine levels F? [2 pnts]

d) Show that the space (number of states) spanned by I and J is the same as in the hyperfine description F. [2 pnts].

e) Back to the nucleus: Take A<45, what is the lightest and heaviest isotope of Sc, that in principle could have a nuclear spin of 4? [3 pnts]

element
$^{45}_{21}Sc$
$^{48}_{22}Ti$
$^{51}_{23}V$
$^{52}_{24}Cr$
$^{55}_{25}Mn$
$^{56}_{26}Fe$
$^{59}_{27}Co$
$^{59}_{28}Ni$
$^{63}_{29}Cu$