EASTERN UNIVERSITY, SRI LANKA

THIRD EXAMINATION IN SCIENCE - 2004/2005

First Semester (January/February 2006)

NUCLEAR PHYSICS - PH 303

Answer ALL questions.

Time: 1 hour

01. What do you understand by *chain integration* of a radioactive substance?

Consider the decay chain $A \xrightarrow{\lambda_A} B \xrightarrow{\lambda_B} C$ (stable). The decay constant of A and B are λ_A and $\lambda_B (>> \lambda_A)$ respectively. Under the initial condition, the number of atoms of B is zero.

(a) Derive an expression for the number of atoms of the second element to be formed of the form $N_B = \frac{\lambda_A N_{oA}}{(\lambda_B - \lambda_A)}[\exp(-\lambda_A t) - \exp(-\lambda_B t)]$, where N_{oA} is the number of atoms of parent nuclide present initially.

(b) If the daughter is short lived than parent, then show that for large times, the ratio of the activities of the parent and daughter becomes constant and has the value $\frac{N_B \lambda_B}{N_A \lambda_A} = [1 - \exp(-\lambda_B t)]$.

Consider the chain ${}^{235}_{92}U \longrightarrow {}^{231}_{90}Th \longrightarrow {}^{231}_{91}Pa$. The half-life time of ${}^{235}_{92}U$ and ${}^{231}_{90}Th$ are 7.13×10^8 years and 25.6 hours (1.063 days = 25.5 hours) respectively.

i. Determine the ratio ${}^{231}_{90}Th$ to the initial ${}^{235}_{92}U$ atoms after 50 hours.
ii. Determine the rate of particle emission to the initial value after 50 hours.
iii. What is the atomic ratio of the two nuclide when radioactive equilibrium is attained?

02. What do you mean by the term "Nuclear Binding Energy". Draw a graph of binding energy per nucleon and hence explain how both nuclear fission and fusion can be drawn from the shape of the graph.
Explain in what way does an atomic nucleus behave like a liquid drop model?
The binding energy E_B of a nucleus by the semi-empirical formula is given by

$$E_B = C_1 A + C_2 A^{\frac{2}{3}} + C_3 \frac{Z(Z-1)}{A^{\frac{1}{3}}} + C_4 \frac{\left(Z - \frac{A}{2}\right)}{A} + \delta$$

where $\delta = C_5 \begin{Bmatrix} +1 \\ 0 \\ -1 \end{Bmatrix} A^{-\frac{3}{4}}$

Discuss the physical interpretation of each term corresponding to parameters, $C_i, i = 1,2,..5$.

(a) Using the above formula, show that the mass of an atom is given by

$$M_a(Z,A) = \alpha A + \beta Z + \gamma Z^2 \mp \delta$$

where α, β, γ and δ are function of A.

(b) Show that the masses $M_a(Z,A)$ for a particular set of isobar with an odd A value take the following form

$M_a(Z,A) - M_a(Z_0,A) = \gamma(Z - Z_0)^2$, where Z_0 is the most stable isobar.

(c) Show that the energy released between neighboring isobars in β^+ decay is given by $Q_{\beta^+} = 2\gamma\left(Z - Z_0 - \frac{1}{2}\right) - 2M_e$, where M_e is the mass of electron.