# Nuclear Physics and Radioactivity

***Nuclear Structure:***

⇒ a special notation is used to indicate the composition of a nucleus: ${}^{A}_{Z}X$

Atomic number Z: # of protons in nucleus
Atomic mass number A: # of protons + # of neutrons (N) A = Z + N
X: chemical symbol for element

⇒ the average radius of a nucleus of atomic mass number A is give by: $r \approx (1.2 \times 10^{-15}\ \text{m})\, A^{1/3}$

***Radioactivity:***

⇒ there are three types of particles given off during the various processes of radioactive decay:

| | | | |
|---|---|---|---|
| $\alpha$ particle | $\rightarrow$ | ${}^{4}_{2}\text{He}$ | (2 protons and 2 neutrons) |
| $\beta$ particle | $\rightarrow$ | $\beta^{-}$ ${}^{0}_{-1}e$ | (electron) |
| | | $\beta^{+}$ ${}^{0}_{+1}e$ | (positron) |
| $\gamma$-ray | $\rightarrow$ | $\gamma$ | (high-energy photon) |

$\alpha$ – decay: ${}^{A}_{Z}P \rightarrow {}^{A-4}_{Z-2}D + {}^{4}_{2}He$

$\beta^{-}$ – decay: ${}^{A}_{Z}P \rightarrow {}^{A}_{Z+1}D + {}^{0}_{-1}e + {}^{0}_{0}\overline{\upsilon}$

$\beta^{+}$ – decay: ${}^{A}_{Z}P \rightarrow {}^{A}_{Z-1}D + {}^{0}_{+1}e + {}^{0}_{0}\upsilon$

$\gamma$ – decay: ${}^{A}_{Z}P^{*} \rightarrow {}^{A}_{Z}P + \gamma$

*Radioactive decay:* $N(t) = N_0 e^{-\lambda t}$ $N \rightarrow$ # of unstable nuclei

$A(t) = A_0 e^{-\lambda t}$ $A \rightarrow$ activity

$$\lambda = \frac{0.693}{T_{1/2}}$$

***Nuclear Binding Energy:***

*Binding energy:* $E_B$ = (total energy of Z protons + N neutrons) – (total energy of nucleus)

$E_B = (\Delta m)c^2$

*Mass Defect:* $\Delta m$ = (mass of Z protons + N neutrons) – (mass of nucleus)

⇒ if masses are in atomic mass units (u), you can use the following conversion: $c^2 = 931.494$ MeV/u