NE300 Fundamentals of Nuclear Engineering Reference Data Card

Number Density

$$\mathcal{A}_x = \sum \gamma_i \mathcal{A}_i \quad (1) \qquad w_x = \frac{n\mathcal{A}_x}{n\mathcal{A}_x + m\mathcal{A}_y} \quad (2) \qquad \mathcal{A}_x = \left[\sum \frac{w_i}{\mathcal{A}_i}\right]^{-1} \quad (3)$$

$$N_i = \frac{\gamma_i \rho_x N_a}{\mathcal{A}_x} \quad (4) \qquad \rho_i = w_i \rho_x \quad (5) \qquad N_i = \frac{w_i \rho_x N_a}{\mathcal{A}_i} \quad (6)$$

Modern Physics

$$T = mc^2 - m_0c^2 \quad (7) \qquad E_0 = m_0c^2 \quad (8) \qquad m = \frac{m_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} \quad (9)$$

$$\lambda = \frac{h}{p} \quad (10) \qquad E = h\nu \quad (11) \qquad p = \frac{E}{c} \quad (12)$$

Nuclear Energetics

$$E_B = a_v A - a_s A^{2/3} - a_c \frac{Z^2}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} - \frac{\pm a_p}{\sqrt{A}} \quad (13)$$

where $a_v = 15.835\,\text{MeV}$, $a_s = 18.33\,\text{MeV}$, $a_c = 0.714\,\text{MeV}$, $a_a = 23.20\,\text{MeV}$, and $a_p = \begin{cases} +11.2\,\text{MeV, if o/o} \\ 0\,\text{MeV, if e/o or o/e} \\ -11.2\,\text{MeV, if e/e} \end{cases}$

$$BE(^A_Z\text{X}) = \left[ZM(^1_1\text{H}) + (A-Z)m_n - M(^A_Z\text{X})\right]c^2 \quad (14)$$

$$S_n(^A_Z\text{X}) = \left[M(^{A-1}_{Z}\text{X}) + m_n - M(^A_Z\text{X})\right]c^2 \quad (15) \qquad S_p(^A_Z\text{Y}) = \left[M(^{A-1}_{Z-1}\text{X}) + M(^1_1\text{H}) - M(^A_Z\text{Y})\right]c^2 \quad (16)$$

$$Q = \left[\sum m_{0,i} - \sum m_{0,f}\right]c^2 \quad (17) \qquad Q = T_f - T_i \quad (18)$$

$$Q = T_1\left(\frac{m_1}{m_4} - 1\right) - \frac{2}{m_4}\sqrt{m_1 m_3 T_1 T_3}\cos\theta + T_3\left(\frac{m_3}{m_4} + 1\right) \quad (19)$$

Radioactivity

$$N = \frac{mN_a}{\mathcal{A}} \quad (20) \qquad A = \lambda N \quad (21)$$

$$T_{1/2} = \frac{\ln 2}{\lambda} \quad (22) \qquad \overline{T} = \frac{1}{\lambda} \quad (23)$$

$$N(t) = N_0 e^{(-\lambda t)} \quad (24) \qquad A(t) = A_0 e^{(-\lambda t)} \quad (25)$$

Binary Reactions

$$E_1^K \approx -\left(1 + \frac{m_1}{m_2}\right)Q \quad (26) \qquad E_1^C \approx 1.2\,\frac{Z_1 Z_2}{A_1^{1/3} + A_2^{1/3}} \quad (27)$$

$$E^* = S_n + T_n \quad (28) \qquad \left(E_1^{th}\right) = \max\left(E_1^K, E_1^C\right) \quad (29)$$

Radiation Interactions

$$I(x) = I_0 e^{-\mu_t x} \quad (30) \qquad \phi(x) = \phi_0 e^{-\Sigma_t x} \quad (31)$$

$$\overline{x} = \frac{1}{\mu_t} \quad (32) \qquad \overline{x} = \frac{1}{\Sigma_t} \quad (33)$$

$$\mu_t = \left(\frac{\mu_t}{\rho}\right)\rho \quad (34) \qquad \Sigma_t = \Sigma_s + \Sigma_a \quad (35)$$

$$\left(\frac{\mu_t}{\rho}\right) = \sum_i \left(\frac{\mu_i}{\rho}\right) \quad (36) \qquad \Sigma_i = N\sigma_i(E)g_i(T) \quad (37)$$

$$\left(\frac{\mu_i}{\rho}\right) = \sum_j w^j \left(\frac{\mu_i}{\rho}\right)^j \quad (38) \qquad \phi(r) = \frac{S_p}{4\pi r^2} e^{-\Sigma_t x} \quad (39)$$

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Reactor Physics

$$E' = \frac{1}{(A+1)^2}\left\{\sqrt{E}\cos\theta_s + \sqrt{E(A^2-1+\cos^2\theta_s)}\right\}^2 \quad (40)$$

$$E'_{av} = \frac{1}{2}(E+\alpha E) \quad (41) \qquad E'_{min} = \alpha E \quad (42) \qquad \alpha = \left(\frac{A-1}{A+1}\right)^2 \quad (43)$$

$$\xi = 1 + \frac{\alpha}{1-\alpha}\ln\alpha \quad (44) \qquad n = \frac{1}{\xi}\ln\frac{E_1}{E_2} \quad (45)$$

$$R_i = \Sigma_i \phi(E) \quad (46)$$

$$k_{eff} = \epsilon\, P_{NL}^f\, p\, P_{NL}^{th}\, f\, \eta \quad (47) \qquad k_\infty = \epsilon\, p\, f\, \eta \quad (48)$$

$$P_{NL}^f = e^{-B_C^2\tau_T} \quad (49) \qquad P_{NL}^{th} = \frac{1}{1+L_T^2 B_C^2} \quad (50) \qquad f = \frac{\overline{\Sigma}_a^F}{\overline{\Sigma}_a^F + \overline{\Sigma}_a^{NF}} \quad (51) \qquad \eta = \nu\frac{\overline{\Sigma}_f^F}{\overline{\Sigma}_a^F} \quad (52)$$

Thermal Reactor Neutron Lifecycle