NUEN 301 Notes

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1 Material for Test One

I = beam intensity $\frac{neutrons}{cm^2s}$
u = neutron density $\frac{neutrons}{cm^3}$
v = neutron speed $\frac{cm}{s}$
A = target area cm^2
Δx = target thickness cm
σ_t = constant of proportionality [area per nucleus]
Reaction rate = $\sigma_t IAN\Delta x$
$[\frac{particles}{s}] = [\frac{cm_2}{nucleaus}][\frac{particles}{cm^2s}][cm^2][\frac{nuclei}{cm^3}][cm]$
$\sigma + t$ is effective cross sectional area that a nucleus presents to a neutron units of barns.
$1barn = 1[b] = 10^-24[cm^2]$

Microscopic cross sections depend on relative speeds of the neutrons and nucleus and on nuclide (type of nucleus).
$\sigma_t = \sigma_s + \sigma_a$
σ_t = total microscopic cross section
σ_s = scattering microscopic cross section
σ_a = absorption cross section

$\sigma_t = \sigma_s + \sigma_a = \sigma_e + \sigma_p + \sigma_i n + \sigma_\alpha + \sigma_f + \sigma_n, 2n + \sigma_n, 3n\sigma_n.\alpha + \sigma_n, p$
σ_e = elastic scattering microscopic cross section
σ_e, r = resonance elastic scattering microscopic cross section
σ_p = potential scattering microscopic cross section
$\sigma_i n$ = inelastic scattering microscopic cross section
σ_α = radiative capture microscopic cross section
σ_f = fission microscopic cross section

$\sigma_n, 2n =$ 2 neutrons emitted microscopic cross section
$\sigma_n, 3n =$ 3 neutrons emitted microscopic cross section
$\sigma_n, \alpha =$ alpha particle emitted microscopic cross section
$\sigma_n, p =$ proton emitted microscopic cross section

$\frac{\sigma_x}{\sigma_t} =$ probability in a given collision that X will occur.
Macroscopic cross section for reaction X $\Sigma = N\sigma_x[cm^-1]$

For multiple isotopes $N^i = \gamma^i \frac{\rho N_a}{M}$ where γ^i is the atom fraction
Density from weight percent $N^i = w^i \frac{\rho N_a}{M_i}$ where $w^i = \gamma^i \frac{M}{M^i}$
I(x) = intensity of neutrons that reach X distance into material without interacting with atoms
$I(x + dx) = AI(x) + PR + -LR = AI(x) + 0 + \Sigma I(x)Adx$ cancel the area
$I(x + dx) = I(x) - \Sigma dx$ simplify
$\frac{dI}{dx} = -\Sigma(x)$ integrate both sides $I_x = I_0 e^{(-\Sigma x)}$
Mean free path $= \frac{1}{\Sigma_t}$
Absorption mean free path $= \frac{1}{\Sigma_a}$
Scattering mean free path $= \frac{1}{\Sigma_s}$
$\Sigma_t = \Sigma_s + \Sigma_a$
$1 = \frac{\Sigma_s}{\Sigma_t} + \frac{\Sigma_a}{\Sigma_t}$

Molar mass $A_x = \Sigma_i(\frac{\gamma_i}{100})A_i$ [g/mol]
Atomic mass $M_x = A_x * U$ [amu]

Example:
H_2O molar mass
$2M_H + M_O = M_{H_2O}$
$2(\gamma_H M_{H_1} + (1 - \gamma_{H_1})M_{H_2} + M_O$
Molar density:
$N_{H_2O} = \frac{\rho_{H_2O} N_a}{M_{H_2O}}$
$N_H = 2N_{H_2O}$
$N_{H_1} = \gamma_{H_1} N_H$
$N_{H_2} = \gamma_{H_2} N_H$
$N_O = N_{H_2O}$
Macroscopic scattering cross section of H_2O
$\Sigma_s^{H_2O} = N_H \sigma_s^H + N_O \sigma_s^O$