Binding Energy

$$B = 15.56A - 17.23A^{2/3} - 0.72Z^2A^{-1/3} - 23.285\,(A-2Z)^2\,A^{-1} + 11A^{-1/2}$$

$$B = 931\,(1.00783Z + 1.00867N - M)$$

Nuclear Radius

$$R(\text{cm}) = 1.4 \times 10^{-13} A^{1/3}$$

Magic Numbers

2, 8, 20, 28, 50, 82, 126 (also 118 for p^+)

AMU

1 u=931 MeV

Coulomb Barrier

$$E_C = 1.11\frac{(A+A')}{A}\frac{ZZ'}{\left(A^{1/3}+A'^{1/3}\right)}$$

Specific Activity

A is mass number, T is half-life in days

$$\frac{\text{mCi}}{\text{mg}} \quad \frac{1.3\times10^8}{AT}$$

$$\frac{\text{MBq}}{\text{mg}} \quad \frac{4.8\times10^6}{AT}$$

Equilibrium

Secular

$$\lambda_d N_d = \lambda_p N_p \left(1 - \mathrm{e}^{-\lambda dt}\right)$$

Beta Recoil

$$E_{Max} = E_m \frac{m_e}{m_e + M_D}$$

Alpha Range

$$R_{air} = 0.31E_\alpha^{1.5}$$

$$R_? = R_{air} * \rho_{Air}/\rho_?$$

$$E_\alpha = E_{decay}\frac{m_{Daughter}}{m_\alpha + m_{Daughter}}$$

α produces 30 000 ion pairs per cm in air

Beta Ranges

$$E_{avg} \approx E_{max}/3$$

$$E_{max}^{daughter} = E_\beta \frac{m_\beta}{m_\beta + M_{daughter}}$$

$$R(mg/cm^2) = \begin{cases} 543E_m - 133 & E_m \geq 0.8\,\text{MeV} \\ 407E_m^{1.38} & E_m < 0.8\,\text{MeV} \end{cases}$$

Scattering increases with Z and surface density up to about 1/5 of the range

Compton

$$E_s = \frac{E_{tot}}{1 + \frac{E_{tot}}{m_e}(1 - \cos\theta_\gamma)}$$

counting

$$t_s/t_b = \sqrt{\frac{S/t_s}{B/t_b}}$$

Quality Factors

Particle	Energy	Q
γ, X-ray		1
$\beta^\pm$		1
neutron	0.025 eV	5
	0.01 MeV	5
	0.05 MeV	10
	10 MeV	10
	1 MeV	20
	>20 MeV	5
α		20
proton		5

Bio effects

Most to least sensitive: gonads, bone marrow, colon, lung, stomach, bladder, breast, liver, esophagus, thyroid, other (adrenals, brain, intestines, kidney muscle, pancreas, spleen, thymus, uterus, etc), bone surface, skin.
Natural sources (mSv yr^{-1}) cosmic rays (0.4), external (K,U,Th) (0.5), internal (^{40}K) (0.3), inhaled Rn (3), total (4.2)
Artificial (mSv per dose) local: external medical diagnosis (1-5), external therapy (50000), internal diagnosis (1-1000), internal therapy (10000)
whole body: external diagnosis (0.02-0.5), external therapy (up to 50), internal diagnosis (0.1-10), internal therapy (50)

PUREX

MOX + garbage + HNO_3 + TBP $\rightarrow$
(waste) + FeSulfamate ($FeH_4N_2O_6S_2$) $\rightarrow$ Pu^{3+} + U + garbage $\underset{\text{separate}}{\rightarrow}$

Detectors

Detector	PC	GM	SC(s)	SC(l)	SS
Energy discrimination	y	n	y	y	y
Detection Medium	gas	gas	sol	liq	sol
Amplification	10^3	10^8	10^6	10^6	10^0
ext amp needed	hi	lo	med	med	hi
resolving time (μs)	5	150	1	1	0.1
background	med	med	hi	hi	lo/med
external α efficiency	lo	lo	lo		hi
internal α efficiency	hi			hi	
external low-E β	lo	lo	lo		hi
internal low-E β	hi			hi	
external hi-E β	hi	med	med		hi
internal hi-E β	hi			hi	
external low-E γ	med	med	med		hi
internal low-E γ	med			med	
external hi-E γ	lo	lo	hi		hi
internal hi-E γ	lo			lo	
commonly-used sample form	sol	sol	liq	liq	sol