1) $^{233}_{92}U \rightarrow {}^{229}_{90}Th^{2-} + {}^{4}_{2}He^{2+} + 4.908\ MeV$

a) $E_{Th} = \left(\frac{4}{233}\right) 4.908\ MeV = 0.084\ MeV$ "recoil"

$\left[E_{He} = \left(\frac{229}{233}\right) 4.908\ MeV = 4.824\ MeV\right]$

b) $^{4}He + {}^{229}Th$ reaction in lab w/ alpha beam

$$V_{coul}^{CMS} = \frac{Z_1 Z_2 e^2}{R_1 + R_2} = \frac{2 \times 90 \times 1.439\ MeV\text{-}fm}{\underbrace{1.2\left(4^{1/3} + 229^{1/3}\right) fm}_{9.25\ fm}} = 28.0\ MeV$$

$$V_{coul}^{LAB} = \left(\frac{233}{229}\right) V_{coul}^{CMS}$$

$$= \left(\frac{233}{229}\right) 28.0\ MeV = 28.5\ MeV$$

[not a large difference with light beam and heavy target]

2) $^{235}U(n,\gamma)$ cross section for 1eV neutrons

$$\sigma_{REACTION} \simeq \pi\left(R_1 + \lambda_{dB}\right)^2$$

$$R_1 = 1.2A^{1/3} = 1.2(235)^{1/3}\ fm$$

$$R_1 = 7.41\ fm$$

$$\lambda_{dB} = \frac{h}{mv} = \frac{h}{\sqrt{2m\,KE}}$$

$$\sigma_{Reat} \simeq \pi\left(7.41 \times 10^{-15}\ m + 2.86 \times 10^{-11}\ m\right)^2$$

$$\lambda_{dB} = \frac{6.626 \times 10^{-34}\ J \cdot s}{\left(2 * 1.675 \times 10^{-27}\ kg \times 1eV \times 1.602 \times 10^{-19}\ \frac{J}{eV}\right)^{1/2}}$$

$$\lambda_{dB} = \frac{6.626 \times 10^{-34}\ J \cdot s}{2.316 \times 10^{-23}\ \frac{kg \cdot m}{s}} = 2.86 \times 10^{-11}\ m$$

$$\sigma_{React} \simeq 2.57 \times 10^{-21}\ m^2$$

or 2.57×10^{7} barns

Table 2: Full table of target nuclei and products for neutron irradiation of NH_4Cl. Notice that after a couple of hours for decay of ^{38}Cl the only significant activity is due to ^{32}P with a small amount of ^{3}H and the very long-lived ^{36}Cl.

Nuclide	Isotopic Abundance	Nuclear Reaction	Reaction Product	Half-life
^{1}H	99.989%	(n,γ)	^{2}H	stable
^{1}H	99.989%	(n,α)	NO reaction	
^{2}H	0.011%	(n,γ)	^{3}H	12.3 y
^{2}H	0.011%	(n,α)	NO reaction	
^{14}N	99.632%	(n,γ)	^{15}N	stable
^{14}N	99.632%	(n,α)	^{11}B	stable
^{15}N	0.368%	(n,γ)	^{16}N	7.1 s
^{15}N	0.368%	(n,α)	^{12}B	20.2 ms
^{35}Cl	75.78%	(n,γ)	^{36}Cl	301 ky
^{35}Cl	75.78%	(n,α)	^{32}P	14.3 d
^{37}Cl	24.22%	(n,γ)	^{38}Cl	37.2 m
^{37}Cl	24.22%	(n,α)	^{34}P	12.4 s