APPENDIX I TABLE OF CONSTANTS

Velocity of light	c	$= 2.99776\text{x}10^{10}$ cm sec^{-1}
Faraday constant	F	= 96500 abs coul per g equiv.
Electronic charge	e	$= 4.8025\text{x}10^{-10}$ abs esu
		$= 1.60203\text{x}10^{-19}$ abs coulombs
Planck constant	h	$= 6.624\text{x}10^{-27}$ erg sec
Avogadro's number	N	$= 6.0228\text{x}10^{23}$ mole^{-1}
Mass of electron	m	$= 9.1066\text{x}10^{-28}$gm
Atomic weight of electron	m	$= 5.4862\text{x}10^{-4}$ (physical scale)
Mass of unit atomic weight	M_o	$= 1.66035\text{x}10^{-24}$ gm
Nuclear radius	R	$= 1.4\text{x}10^{-13}A^{1/3}$ (A=mass number)

ATOMIC WEIGHTS:

Hydrogen	M_H	= 1.00814
Helium	M_{He}	= 4.00387
Neutron	M_n	= 1.00899

ENERGY EQUIVALENCE

1 atomic mass unit = 931 MeV
$= 1.49\text{x}10^{-3}$ erg
$= 3.56\text{x}10^{-11}$ cal

1 electron mass = 0.510 MeV

1 MeV $= 1.07\text{x}10^{-3}$ amu
$= 1.60\text{x}10^{-6}$ erg
$= 3.82\text{x}10^{-14}$ cal

1 eV/molecule = 23.06 kcal/mole

TIME:

Number seconds in a day	$8.64\text{x}10^{4}$
Number seconds in a year	$3.1536\text{x}10^{7}$
Number minutes in a day	1440
Number minutes in a year	$5.2596\text{x}10^{5}$
Number hours in a year	$8.766\text{x}10^{3}$

APPENDIX II ANSWERS

Part I

1. (a) $^{64}_{30}Zn$ (d) $^{61}_{28}Ni$

   (b) $^{1}_{1}H$ (e) $^{3}_{1}H$

   (c) $2\ ^{1}_{0}n$ (f) γ ray

2. (a) $\Delta m = +\ 0.01140$ amu

   $Q = -\ 10.61$ MeV

   (b) $\Delta m = +\ 0.025$ amu

   $Q = -\ 23.28$ MeV

   (c) $\Delta m = -0.0083$ amu

   $Q = +\ 7.73$ MeV

   (d) $\Delta m = -\ 0.0002$

   $Q = +\ 186$ keV

3. (a) $12\ ^{1}_{1}H + 12\ ^{1}_{0}n = ^{24}_{12}Mg$

   $\Delta m = -0.21300$ amu

   $BE = +\ 198.30$ MeV

   $BE/A = 8.26$ MeV

   (b) $27\ ^{1}_{1}H + 33\ ^{1}_{0}n = ^{60}_{27}Mg$

   $\Delta m = -0.56390$ amu

   $BE = +\ 524.99$ MeV

   $BE/A = 8.75$ MeV

(c) $79\ {}^{1}_{1}H + 118\ {}^{1}_{0}n = {}^{197}_{79}Au$

$m = -1.67630$ amu

$BE = 1560.64$ MeV

$BE/A = 7.92$ MeV

4.

${}^{4}_{2}He$	2.22 fm	${}^{165}_{67}Ho$	7.68 fm
${}^{16}_{8}O$	3.52 fm	${}^{206}_{82}Pb$	8.27 fm
${}^{56}_{26}Fe$	5.36 fm	${}^{238}_{92}U$	8.68 fm
${}^{75}_{33}As$	5.90 fm	${}^{256}_{100}Fm$	8.89 fm
${}^{112}_{48}Cd$	6.75 fm		

5. The radius doubles as the mass triples; i.e., there is very little change in size.

6. (a) $Z_u = 92$

$Z_H = 1$ $E_B = 13.12$ MeV

$R_u = 8.68 \times 10^{-13}$ cm

$R_H = 1.40 \times 10^{-13}$ cm

(b) $Z_{Fe} = 26$

$Z_H = 1$ $E_B = 5.53$ MeV

$R_{Fe} = 5.36 \times 10^{-13}$ cm

$R_H = 1.40 \times 10^{-13}$ cm

7. Radius of ${}^{27}Al = 4.20 \times 10^{-13}$ cm

Volume of ${}^{27}Al$ nucleus $= 4/3\ \pi r^3 = 3.10 \times 10^{-37}$ Al atoms cm^3

Density = $1.44 \times 10^{+14}$ g/cm^3

Part II

1. (a) $E(\beta^-) = -5.03$ MeV $E(\beta^+) = 1.77$ MeV

   (b) $E(\beta^-) = 1.68$ MeV $E(\beta^+) = -1.11$ MeV

   (c) $E(\beta^-) = 559$ KeV $E(\beta^+) = -3.44$ MeV

   (d) $E(\beta^-) = 6.61$ MeV $E(\beta^+) = 3.54$ MeV $E(\alpha) = 10.43$ MeV

   (e) $E(\beta^-) = 1.10$ MeV $E(\beta^+) = 553$ Kev $E(\alpha) = 8.00$ MeV

2. M $({}^{90}_{39}Y) = 89.9017$ amu

3. ${}^{115}_{49}In \xrightarrow{\beta^-} {}^{115}_{50}Sn$ $E(\beta^-)$ 599 keV spontaneous

   ${}^{115}_{50}Sn \xrightarrow{\beta^+} {}^{115}_{49}In$ $E(\beta^+) = -599$ keV

4. M $({}^{235}_{92}U) = 235.0439$ amu

5.

Isotope	(min^{-1})	N(atoms)	mass (g)
(a) ${}^{36}_{17}Cl$	4.39×10^{-12}	5.05×10^{20}	3.02×10^{-2}
(b) ${}^{76}_{33}As$	4.18×10^{-4}	5.30×10^{12}	6.70×10^{-10}
(c) ${}^{51}_{24}Cr$	1.73×10^{-5}	1.28×10^{14}	1.09×10^{-8}

6. $A_t = 1.96\times10^4$ cpm

7. $t_{1/2}$ parent = 23.5 m; $t_{1/2}$ daughter = 3.4×10^3 m
   (none of the daughter decays before all of the parent has

decayed)

6.9×10^3 dpm

8. From Graph: component (B) $t_{1/2} = 12$ hr

   component (A) $t_{1/2} = 3$ hr

9. Weight of $^{234}_{90}Th = 1.44 \times 10^{-8}$ g

10. Weight of ^{144}Pr/g $^{144}Ce = 4.21 \times 10^{-4}$ g

Part III

1. 2.3×10^5 ion pairs

2. 68 keV

3. Al: 8.2 mg/cm^2

   air: 4.9 cm (Compare with Curve II, figure 11, Section III (A))

4. Since the same dependence on velocity exists, i.e., $(\frac{dE}{dX}) \alpha \frac{1}{v^2}$, the specific ionization per unit path length will be much less for electrons than for heavy particles.

5. The ratio of energy lost by radiation and ionization is ~ 1. This implies that a 10 MeV electron will loose energy at approximately equal rates by both processes.

6. From Fig. 9, Pb: mostly pair production with some Compton effect

   Fig. 10, Al: Compton effect only

7. 50 mr (α) = 1 rem

   100 mr (β) = 0.1 rem

   150 mr (γ) = 0.1 rem

8. 25 years - 35 rems

   45 years - 135 rems

   60 years - 210 rems

Part IV

1. 1.6×10^5 ion pairs

2. Because of the smaller mass a β^- particle may loose a large fraction of its energy in one collision. When this happens the primary electron will be deflected through a larger angle and have considerably lower energy. They in turn will cause secondary ion pair formation.

3.

N	Eff (%)
1	63
2	86
3	95
4	98
5	99

The rate of energy loss ($^{-dE}/dX$) for such particles is in the order $\alpha > \beta > \gamma$. Therefore, the number of primary ion pairs formed is least for γ's. G.M. counting should be 100% efficient for α's, and β's

As $N \geq 6$, Eff(%) → 100%   since N>>6 but <100% efficient for γ's since N can be very small.

4. $\Delta V = 0.94V$

5. 2.73×10^{-14} coulombs

6. $R = 5.8\ mg/cm^2$

7. (a) 2.22×10^3 dpm. Count β^- using G.M. or proportional counter.

   (b) 2.22×10^5 dpm. Count rate too high for G.M. Also weak β^- probably wouldn't penetrate G.M. window (see Fig. 10)
   Use windowless proportional counter.

   (c) 22.2 dpm. Very low count rate. Can use ionization chamber on windowless proportional counter. Possible thin window proportional counter could be used.

   (d) 22.2×10^3dpm. Proportional counter for β^- or count γ's by NaI(Tl) scintillation counter.

Part V

1. By precipitation via

$$Ag^+ + I^- \rightarrow AgI \text{ (insoluble in } H_2O)$$

$$Ag^+ + PO_4^{-3} \rightarrow AgPO_4^{-2} \text{ (soluble in acidic solution)}$$

2. (a) No, one would need 40M sulfate ion

   (b) 8.2×10^{-10}

3. solvent 1 - 4.9×10^{-4} g/ml

   solvent 2 - 2.4×10^{-5} g/ml

4. solvent 1 - 43 cpm

   solvent 2 - 1707 cpm

5. The vapor pressures of the two substances are considerably different and that of one is large enough to be useful.

6. Ion exchange chromatography using Dowex-50 and concentrated HCl.

7. $Zn \rightarrow Zn^{+2} + 2e^-$

   $Fe \rightarrow Fe^{+2} + 2e^-$ (cathode)

   $Sn \rightarrow Sn^{+2} + 2e^-$

   $H_2O \rightarrow 1/2\ O_2 + 2H^+ + 2e^-$ (anode)

   The voltage which must be applied to cause deposition

	E_{app}(V)
Zn	+ 2.19
Fe	+ 1.87
Sn	+ 1.57

Part VI

1. σ = 387; 149,613 → 150,387 counts

2. R_s = 560 ± 6 cpm

   Ignoring the contribution of the background error

$R_s = 560 \pm 6$

Probable error = $\pm$ 4

3. t_s = 13.6 m t_b = 16.4 m

   $\sigma_s = \pm$ 2 cpm or 3%

4. 3,2,4

5. $t_{GM} < t_{prop}$, therefore G.M. will require less time for the same error

6. 3080, and 3580 should be rejected

7. shielded - 4.8 m;unshielded - 7.9 m

8. No; yes

9. $4.5x10^5$, $1.8x10^4$, $4.5x10^3$, 180, 45, 1.8

   Use. eqn. 11 and assume $R_b << R_s$, therefore $(1+2\frac{R_b}{R_s}) \rightarrow 1$ and $R_s \rightarrow R_t$

10. (a) yes (b) not operating normally

Part VII

1. $E_e = \frac{4E_\gamma^2}{4E_\gamma+1}$

   (a) 0.79 MeV for E_γ = 0.986

   1.10 MeV for E_γ = 1.314

   (b) 0.342 MeV

   (c) 0.022 MeV

2. (a) E_γ = 1.314, Compton

E_γ = 0.986; Compton, some photoelectric

(b) Compton with considerable photoelectric

(c) Primarily photoelectric, some Compton

3. Pair Production $E_\gamma > 1.5$ MeV

   (a) Full energy peak: due to multiple processes

   (b) Single escape peak: E = 1.78 - .51 = 1.27 MeV

   (c) Double escape peak: E = 1.78 - 2(.51) = 0.76 MeV

   (d) Annihilation peak: E = .51 MeV

4. For constant E_γ as the size of the crystal increases the percent total absorption increases. For a constant crystal size, typically 3x3, the percent total absorption decreases with increasing E_γ.

5. From a graph, % resolution = 7.1%

   energy of x-ray escape peak = $\gamma_1 - E_{x\text{-ray}}$

   140 keV - 100 keV = 40 keV = $E_{x\text{-ray}}$

6. (a) $E_{\gamma 1}$ = 1.33 MeV

   (b) $E_{\gamma 2}$ = 1.17 MeV

   (c) 1.12 MeV Compton edge for 1.33 MeV γ-ray

   (d) 0.96 MeV Compton edge for 1.17 MeV γ-ray

Part VIII

1. ^{247}Cf = 43.2 MeV

2. 66.8 MeV

3. Ca. 236 MeV

4. (a) 3.44 MeV

   (b) 17.87 MeV

5. 4.8 y

6. 815 b

7. $3x10^3$s

Part IX

1. (a) $t >> t_{1/2}$, $e^{-\lambda t} \rightarrow o$, thus the saturation factor, $(1-e^{-\lambda t}) \rightarrow 1$; the activity of the product nuclide reaches a maximum.

   (b) $t << t_{1/2}$, $e^{-\lambda t}$ can be approximated by $(1 - \lambda t)$, therefore, the saturation factor becomes $1-(1-\lambda t) = \lambda t$. The activity of the product nuclide increases proportionally with the irradiation time.

2. (a) $8.58x10^6$ dpm

   (b) $2.68x10^2$ dpm

   (c) $1.58x10^6$ dpm

   (d) $1.67x10^6$ dpm

   Use: $A_2 = \frac{X(g)\sigma f\Phi}{M}$

   Where M is molecular weight of desired element

3. $3.3x10^9$ dpm

4. Irradiation time 2 $t_{1/2} \rightarrow$ 75% saturation = $(1 - e^{-\lambda t})$

   Actual disintegration rate = $5.6x10^8$ dpm = A_y

   $A_y = N_x\sigma\Phi$ (.75)

   $N_x = 1.3x10^{20}$ atoms

   $^{127}I = 2.8x10^{-2}$ g originally present

5. $\Phi = 9.39x10^{11}$ neutrons/cm^2/sec

6. Weight of unknown sample = 5.29×10^{-6} g

   Correct for efficiencies of the counters used

7.

Isotope	Decay Mode	Mode of Production
$^{137}_{55}Cs$	β^-	reactor
$^{14}_{6}C$	β^-	reactor
$^{147}_{61}Pm$	β^-	reactor or fission
$^{58}_{27}Co$	β^+	accelerator
$^{35}_{16}S$	β^-	reactor
$^{197}_{80}Hg$	EC	accelerator
$^{36}_{17}Cl$	β^-	reactor
$^{60}_{21}Co$	β^-	reactor

8. ^{160}Tb: 2.06×10^{11} dpm

   ^{161}Tb: 7.86×10^{10} dpm

9. 17%

10. 8.5 yr.

Part X

1. M_2Cl_6 143 cpm

2. 295 ml

3. 132 mg

4. 2.2×10^{-4} mg

5. 5 mg

6. Pb = 0.058 mg/l   Bi = 0.01 mg/l

7. 5.73×10^{-4}M

Part XI

1. (a) 76%

   (b) 3660 dpm

2. 454 ± 7 cpm

3. ^{14}C: 7590 cpm

   ^{3}H: 14910 cpm

4. 750 mg.

APPENDIX III

Common Radioisotopes Listed According to Half-life

Half-life[a]	Isotope	Maximum Specific Activity[b]	Radiation	Production Method: Reactor	Production Method: Cyclotron
12.3 h	^{130}I	~40 Ci/g I	β, γ	(n, γ)	
12.36 h	^{42}K	>450 mCi/g K	β, γ	(n, γ)	
12.80 h	^{64}Cu	~25 Ci/g Cu	EC, β⁻, β⁺, γ	(n, γ)	
13.47 h	^{109}Pd	~6 Ci/g Pd	β, γ	(n, γ)	
14.12 h	^{72}Ga	~2 Ci/g Ga	β, γ	(n, γ)	
14.96 h	^{24}Na	~10 Ci/g Na	β, γ	(n, γ)	
17.4 h	^{194}Ir	>30 Ci/g Ir	β, γ	(n, γ)	
19.2 h	^{142}Pr	>10 Ci/g Pr	β, γ	(n, γ)	
23.9 h	^{187}W	~10 Ci/g W	β, γ	(n, γ)	
24 h	^{197m}Hg	~500 mCi/g Hg	EC, γ	(n, γ)	
26.4 h	^{76}As	~4 Ci/g As	β, γ	(n, γ)	
35.34 h	^{82}Br	~1 Ci/g Br	β, γ	(n, γ)	
38.7 h	^{77}As	CF	β, γ	(n, γ), β→	
40.22 h	^{140}La	~9 Ci/g La	β, γ	(n, γ)	
46.8 h	^{153}Sm	~40 Ci/g Sm	β, γ	(n, γ)	
53.5 h	^{115}Cd	~50 mCi/g Cd	β, γ	(n, γ)	
64.0 h	^{90}Y	CF, >1 Ci/g	β	Fission, β→ (n, γ)	
64.728 h	^{198}Au	~60 Ci/g Au	β, γ	(n, γ)	
65 h	^{197}Hg	~1 Ci/g Hg	EC, γ	(n, γ)	
66.7 h	^{99}Mo	>140 mCi/g Mo	β, γ	(n, γ)	
67.2 h	^{122}Sb	~2 Ci/g Sb	β, γ	(n, γ)	
3.15 d	^{199}Au	CF	β, γ	(n, γ)	
3.70 d	^{186}Re	~15 Ci/g Re	EC, β, γ	(n, γ)	
4.535 d	^{47}Ca	>150 mCi/g Ca	β, γ	(n, γ)	
5.013 d	^{210}Bi	~50 mCi/g Bi	β, γ	(n, γ)	
5.270 d	^{133}Xe	CF	β, γ	Fission	
6.7 d	^{177}Lu	~20 Ci/g Lu	β, γ	(n, γ)	
7.5 d	^{111}Ag	CF	β, γ	(n, γ), β→	
8.05 d	^{131}I	CF	β, γ	(n, γ), β→	
9.3 d	^{169}Er	~1 Ci/g Er	β, γ	(n, γ)	
11.06 d	^{147}Nd	CF	β, γ	Fission	
12.0 d	^{131}Ba	~10 mCi/g Ba	EC, γ	(n, γ)	
12.80 d	^{140}Ba	CF	β, γ	Fission	
13.59 d	^{143}Pr	CF	EC, γ	Fission	
14.28 d	^{32}P	CF	β		^{32}S(n, p)^{32}P
15.0 d	^{191}Os	>400 mCi/g Os	β, γ	(n, γ)	
16.0 d	^{48}V	CF	β⁺, EC, γ		^{48}Ti(p, n)^{48}V
18.66 d	^{86}Rb	~1 Ci/g Rb	β, γ	(n, γ)	
27.8 d	^{51}Cr	~500 Ci/g Cr	EC, γ	(n, γ)	
32.5 d	^{141}Ce	~2 Ci/g Ce	β, γ	(n, γ)	
35.0 d	^{95}Nb	CF	β, γ	Fission	
35.1 d	^{37}Ar	CF	EC		^{40}Ca(n, α) ^{37}Ar
39.5 d	^{103}Ru	CF	β, γ	Fission	
42.5 d	^{181}Hf	~2 Ci/g Hf	β, γ	(n, γ)	
43 d	^{115m}Cd	~100 mCi/g Cd	β, γ	(n, γ)	
45.6 d	^{59}Fe	~20 Ci/g Fe	β, γ	(n, γ)	
46.9 d	^{203}Hg	~1 Ci/g Hg	β, γ	(n, γ)	
50.0 d	^{114m}In	~1 Ci/g In	γ	(n, γ)	
52.7 d	^{89}Sr	CF	β	Fission	
53 d	^{7}Be	CF	EC		^{7}Li(p, n) ^{7}Be
58.8 d	^{91}Y	CF	β, γ	Fission	
60.2 d	^{125}I	CF	EC, γ	(n, γ), EC→	
60.4 d	^{124}Sb	~2 Ci/g Sb	β, γ	(n, γ)	
64 d	^{85}Sr	CF	EC, γ		^{85}Rb(p, n) ^{85}Sr

APPENDIX III con't

Half-life[a]	Isotope	Maximum Specific Activity[b]	Radiation	Production Method: Reactor	Production Method: Cyclotron
65.5 d	^{95}Zr	CF	β, γ	Fission	
72 d	^{58}Co	CF	EC, γ		$^{58}Ni(p, n)\ ^{58}Co$
75 d	^{185}W	~500 mCi/g W	EC, β, γ	(n, γ)	
83.9 d	^{46}Sc	>5 Ci/g Sc	β, γ	(n, γ)	
87.9 d	^{35}S	CF	β		$^{35}Cl(n, p)$ S
106.7 d	^{88}Y	CF	EC, γ		$^{88}Sr(p, n)$ Y
109 d	^{127m}Te	~500 mCi/g Te	β, γ	(n, γ)	
115 d	^{113}Sn	~300 mCi/g Sn	EC, γ	(n, γ)	
115.1 d	^{182}Ta	>500 mCi/g Ta	β, γ	(n, γ)	
120.4 d	^{75}Se	~500 Ci/g Se	EC, γ	(n, γ)	
134 d	^{170}Tm	~600 Ci/g Tm	β, γ	(n, γ)	
140 d	^{139}Ce	CF	EC, γ		$^{139}La(p, n)\ ^{139}Ce$
144 d	^{159}Dy	~1 Ci/g Dy	EC, γ	(n, γ)	
165 d	^{45}Ca	~10 Ci/g Ca	β	(n, γ)	
183 d	^{195}Au	CF	EC, γ		$^{195}Pt(p, n)\ ^{195}Au$
242 d	^{153}Gd	~3 Ci/g Gd	EC, γ	(n, γ)	
245 d	^{65}Zn	~3 Ci/g Zn CF	EC, β+, γ	(n, γ)	$^{65}Cu(p, n)\ ^{65}Zn$
255 d	^{110m}Ag	~1 Ci/g Ag	β, γ	(n, γ)	
270 d	^{57}Co	CF	EC, γ		$^{56}Fe(p, γ)\ ^{57}Co$
280 d	^{68}Ge	CF	β+, EC, γ		$^{69}Ga(p, 2n)\ ^{69}Ge$
284 d	^{144}Ce	CF	β, γ	Fission	
303 d	^{54}Mn	CF	EC, γ		$^{54}Fe(n, p)\ ^{54}Mn$
330 d	^{49}V	CF	EC		$^{49}Ti(p, n)\ ^{49}V$
368 d	^{106}Ru	CF	β	Fission	
453 d	^{109}Cd	~1 Ci/g Cd, CF	EC, γ	(n, γ)	$^{109}Ag(p, n)\ ^{109}Cd$
700.8 d	^{171}Tm	CF	β	(n, γ), β→	
2.05 y	^{134}Cs	~25 Ci/g Cs	β, γ	(n, γ)	
2.6 y	^{55}Fe	~12 Ci/g Fe, CF	EC	(n, γ)	$^{55}Mn(p, n)\ ^{55}Fe$
2.62 y	^{147}Pm	CF	β, γ	Fission	
2.62 y	^{22}Na	>1 mCi/mg Na, CF	β+, EC, γ		$^{24}Mg(d, α)\ ^{22}Na$
2.71 y	^{125}Sb	CF	β	(n, γ), β→	
3.81 y	^{204}Tl	~1 Ci/g Tl	EC, β	(n, γ)	
5.263 y	^{60}Co	~50 Ci/g Co	β, γ	(n, γ)	
7.2 y	^{133}Ba	~1 Ci/g Ba	EC, γ	(n, γ)	
10.76 y	^{85}Kr	~21 Ci/g Kr	β, γ	Fission	
12.262 y	^{3}H	CF	β		$^{6}Li(n, α)\ ^{3}H$
12.7 y	^{152}Eu	>250 mCi/g Eu	EC, β, γ	(n, γ)	
16 y	^{154}Eu	>250 mCi/g Eu	β, γ	(n, γ)	
27.7 y	^{90}Sr	CF	β	Fission	
30.0 y	^{137}Cs	CF	β	Fission	
30.2 y	^{207}Bi	CF	EC, γ		$^{207}Pb(p, n)\ ^{207}Bi$
48 y	^{44}Ti	CF	EC, γ		$^{45}Sc(p, 2n)\ ^{44}Ti$
87 y	^{151}Sm	25 Ci/g Sm	β, γ	Fission	
92 y	^{63}Ni	~10 Ci/g Ni	β	(n, γ)	
1.2 × 10³ y	^{166m}Ho	~1 mCi/g Ho	β, γ	(n, γ)	
5730 y	^{14}C	>2 Ci/g C	β		$^{14}N(n, p)\ ^{14}C$
2 × 10⁴ y	^{94}Nb	0.2 mCi/g Nb	β, γ	(n, γ)	
8 × 10⁴ y	^{59}Ni	~10 mCi/g Ni	EC	(n, γ)	
2.12 × 10⁵ y	^{99}Te	20 mCi/g Te	β	Fission	
3.08 × 10⁵ y	^{36}Cl	~10 mCi/g Cl	β	(n, γ)	
7.4 × 10⁵ y	^{26}Al	~1 μCi/g Al	β+, γ		$^{27}Al(p, pn)\ ^{26}Al$
2.7 × 10⁶ y	^{10}Be	~15 μCi/g Be	β	(n, γ)	
1.7 × 10⁷ y	^{129}I	~260 μCi/g I	β, γ	Fission	

[a]h = hour, d = day, y = year
[b]Cf = carrier-free

APPENDIX IV

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Copies of the monographs listed below are available from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Viginia 22151. The minimum price is $3.00 for either one, two or three randomly selected publications. Additional individual copies will be sold in increments of three for $3.00.

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Thorium	NAS-NS-3004 (1960)
Fluorine, Chlorine Bromine, Iodine	NAS-NS-3005 (1960)
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b) Radiochemical Techniques

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