NUCLEAR RADIATION

$^4_2\alpha$ (= $^4_2He^{2+}$) ← HELIUM NUCLEUS

$^{0}_{-1}\beta$ (= $^{0}_{-1}e^-$) β-particle is an ELECTRON ejected from nucleus

AmBe, PuBe to get ^1_0n ← MEMORY S.F. Pball GOLD RUSH

FISSION RXN (→ smaller nuclei) but >> α, β

RXN to produce (plus USE of ^1_0n)

$^{222}_{86}Rn \rightarrow ^{218}_{84}Po + ^4_2\alpha$ (OOPS)

ALPHA decay

$^{238}_{92}U + ^1_0n \rightarrow [^{239}_{92}U] \rightarrow ^{0}_{-1}\beta + ^{239}_{93}Np + ^0_0\gamma$

NEUTRON ACTIVATN — BETA decay

another β → $^{239}_{94}Pu$ ⊗

* Am → $^4_2\alpha$ + ^9_4Be → $^{12}_6C + ^1_0n$
Pb → 2α

Step 1 — Step 2 — DETAILS NOT NECESSARY

$^{235}_{92}U + ^1_0n \rightarrow ^{236}_{92}U \rightarrow ^{90}_{38}Sr + ^{143}_{54}Xe + 3\,^1_0n$ — 2 of 3 given?

[variety of fission-product combos, as in pg 290 pic, w- 2 ^1_0n, or 3 ^1_0n]

⊗ $^{239}_{94}Pu + ^1_0n \rightarrow ^{240}_{94}Pu \rightarrow ^{135}_{53}I + ^{102}_{43}Nb + 3\,^1_0n$

→ Pu-239 produced in nuclear rctrs

FIRST 3 BOMBS, 1945 (→ electricty, Pu)
July 16 (Pu, NewMex), Aug 6 (^{235}U), Aug 9 (Pu)

* the smaller fission product ranges from 33-46% of original mass; pg 290
pg 289: chain reaction + critical mass

IONIZING RADN (all: α, β, γ, FAST n)

① $H_2O \xrightarrow{\alpha,\beta}_{\gamma,n} H_2O^+ + e^-$ (not β!) — CHEM RXN
② $H_2O^+ + H_2O \rightarrow OH\cdot + H_3O^+$
③ ok DNA $\xrightarrow{H_2O^+}_{OH\cdot}$ bad DNA
⊗ Ar $\xrightarrow{\alpha\,\beta}_{\gamma}$ Ar$^+$ + e$^-$ — FLOW of ELECTRONS "click" — • is FREE RADICAL
RADICAL = unpaired e

β RXNS (OR FISSION?) if neutron-rich,
• after ^1_0n-activation (^{238}U, ^{107}Ag, ^{109}Ag, ^{59}Co, etc)
• FISSION PRODUCTS

^{131}I (β) vs ^{127}I (STABLE) — [53 I 126.9] — A# is 127
AVG for Ag, w- 107, 109, 108 — [47 Ag 107.9]

check on β (290): $^{93}_{38}Sr$ vs 88, $^{142}_{54}Xe$ vs 131 (Sr-89 vs 79, etc)

lab manual (3-3, 3-4)
neutrons (slow, fast, thermal) danger, PENETRN to TISSUES RXNS

γ (≈ x-rays but higher energy) have most penetrn (γ > α, β)
stopped by Pb (lead)

* β-decay with γ or without γ, both possible, we will tell you

PENETRATION (what SHIELDING needed to stop?)

α easily stopped by AIR (4-7"), PAPER, SKIN (top layer)
so α outside body = SAFE
but α inside body = BAD, EXAMPLE may → lung cancer (as in $^{222}Rn \rightarrow \alpha$)

β is in-between, stopped by Al or by a little bit of SOFT TISSUE
EX: β out of neck after ^{131}I medcl TREATMENT (as in QUIZ 3, 3h) 2 week GROWTH CYCLE of cells
β inside body, ^{131}I in thyroid gland, after Chernobyl, ... (thyroid cancer) + 1945 - HIROSH-NAG

γ is EM-radn, and (due to source) is nuclear-radn because its produced by nuclear rxns
γ has mass = 0, $^{0}_{-1}e$ has mass ≈ 0

HEALTH EFFECTS depends on factors:
2 factors → Ci rate
• AMOUNT of materl
• $t_{1/2}$ (short → MORE RADACTIVE)
• outside or inside BODY
• PENETRATN/SHIELDING which depends on
• TYPE of radn (α β γ, n) — penetrn damage
(EX: DAMAGE Q = 20 for α)

(Sec 7.6 pg 304) [curie (Ci) # from SAMPLE / s
rem, damage to TISSUE
(≡ of background radn)

• BIO-accumulation
EX: I (127 or 131) in THYROID GLAND
Sr (mimics Ca) in BONES
Cs (mimics Na)
• CHEMICAL toxicity (ignored in 108?)

NUC SOURCE + CHEM RCTNS,
n → α sh, n → γ e, n → β sh, n → n

ISOTOPES
same p# (same elmnt), diff n# (and mass#)
compared to p (1/1836) or n (1/1838) — almost same
same chemical rxns (almost =)
may have diff nuclear rxns

DECAY SERIES
if n#(Z) ↑ p#, → β⁻ ... and ... β
if mass#(A) ↑ p#, → α ... and β
α: A (-4), Z p (-2), n (-2)
β: A n (-1), Z p (+1), A (0)

238-U decay series, because 238U (WAS) abundant and remains (long $t_{1/2}$), yet does decay some to → steady state w- all isotopes that are part of decay series: all have A# EVEN# (no ODD#s) why?
CHAIN STOPS at Pb (82)
pg 298

if %, 100 → 50 → 25 → 12.5 → 6.25 → etc REMAINS } TWO ≠ QUESTNS
0 → 50 → 75 → 87.5 → 93.75 → etc DECAYED
HALF-LIVES } 0, 1, 2, 3, 4
if $t_{1/2}$ = 3.8 d, 0, 3.8 d, 7.6 d, 11.4 d, 15.2 d
if # or mass GIVEN) 4000 → 2000 → 1000 → 500 → 250 → ; 4.0 g, 2.0 g, 1.0 g, .50 g, .25 g

less than 1% remains (1/128) after 7 half-lifes, 7 (3.8 d) = 26.6 d
[is it "gone"? depends on initial amount (LARGE? small?)] ≡ + definition of GONE

compare to find SIMILARITIES, DIFFERENCES } pne, atoms, decays — Q1, Q2, Q3 (QUIZ 3)

A = mass# U (EX $^{238}_{92}U$) # of MASSIVE NUCLEONS
Z = atomic# — # of PROTONS, which ≡ is the atom as U

≡ of background radtn, G-1
Fig 7.18, pg 304, pg 303
Rn is 55% (by Rem, w Q = 20)
bg radn (not by Ci) ≈ 360 Rem average

Fine Print (handouts), etc
Learn@UW - Content (L Notes and More)
[SECTIONS-PAGE — Craig
google Chem 108

X in this area + lots more in COLORIZED

* after bombs (1945) or Chernobyl (1986), ^{131}I ($t_{1/2}$ = 8 d) very dangerous, but after 1 yr it isn't. But in 2012 still dangerous now are Sr-90 and Cs-137, both w- $t_{1/2}$ ≈ 30 yr, due to medium-long $t_{1/2}$ (large $t_{1/2}$ → large sample size) (small $t_{1/2}$ → high rate per atom)

Ci rate (radioactivity) = (# of atoms)(RATE per atom)
≈ 30 y has endurance (# still high) and fairly high RATE-per-atom.

But IF same # of isotope-atoms for each, ^{131}I ($t_{1/2}$ = 8 d) will have higher Ci-rate than the isotopes w- ≈ 30 yr

CHEMICAL(S) STUFF
all molecules SAME
= compare molecules ≠
PURE SUBSTANCE — MIXTURE (He, H_2, CO_2 together in a tank) — HOMOG, HETEROG
IF molecules differ
compare ATOMS in molecule
He or H_2, or ... = ELEMENT (if only one TYPE of atom)
≠ CO_2 or H_2O ... COMPOUND (if 2 or more TYPES of atoms)
you cannot say "one atom" because H_2, O_2, ... are elmnts

to get HIGH Ci-rate: medium-long $t_{1/2}$ (see 3d in post-Quiz 3 questions), 1-100 y, can be physiological danger, w- combo of endurance + activity

rapidly dividing cells: pg 303 (top), lecture W-22 (slide 7a)

2 week growth cycle of cells → delay of radn sickness (new cells needed after 14 d, but not available due to rad damg)
CANCER - if cells live, but in DNA-damaged form
RADIATION SICKNESS if cells die

UNIT	FOCUS	What is measured? } What determns "how much"?
curie, Ci	sample	disintegrations / second } depends on $t_{1/2}$ and sample size
rad	tissue	energy absorbed by tissue
rem	tissue	biological damage (≡ rads × Q) } Q = 20 for α, Q = 1 for β, γ

$t_{1/2}$: remaining, decayed; %, fraction, mass, #, radioactivity; time, # of half-lifes