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 — 49ers MEMORY S.F. Football 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 → $^4_2\alpha$ + $^9_4Be \rightarrow ^{12}_6C + ^1_0n$ (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 pie, w 2 ^1_0n, or 3 ^1_0n

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

IONIZING RADN (all: α, β, γ, fast n)

1. H_2O →(α, β, γ, n) H_2O^+ + e⁻ (not β) — CHEM RXN
2. $H_2O^+ + H_2O \rightarrow OH\cdot + H_3O^+$
3. ok DNA →(H_3O^+, $OH\cdot$) bad DNA

⊗ Ar →(α, β) Ar^+ + e⁻ — Ar⁺ is FREE RADICAL; FLOW of ELECTRONS "click"

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

β RXNS if neutron-rich (OR FISSION?)

- after n-activation (^{238}U, ^{107}Ag, ^{59}Co, ^{109}Ag, etc)
- FISSION PRODUCTS (RATIO of n#/p#): $^{131}_{53}I$ (β) vs $^{127}_{53}I$ STABLE; 53 I 126.9; A# is 127; AVG for Ag, w 107, 109 → 108; 47 Ag 107.9
- check on $^{90}_{38}Sr$ vs 88, $^{143}_{54}Xe$ vs 131 (Sr-89 vs 79, etc) — RADIOACTIVE ISOTOPES

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

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

Pu-239 produced in nuclear rctrs

FIRST 3 BOMBS, 1945 (→ electricity, Pu): July 16 (Pu, New Mex), Aug 6 (²³⁵U), Aug 9 (Pu)

* the smaller fission product ranges from 33–46% of original mass, pg 290

pg 289: chain reaction + critical mass

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 ²²²Rn → α)
- β is in-between, stopped by Al or by a little bit of SOFT TISSUE. EX: β out of neck after ¹³¹I medl TREATMENT (as in QUIZ 3, 3h) 2 week GROWTH CYCLE of cells. Β inside body, ¹³¹I in thyroid gland, after Chernobyl, ... (thyroid cancer) + 1945 – HIROSH-NAG
- γ: this is why γ (not β) used in GAMMA KNIFE. $^{59}_{27}Co + ^1_0n \rightarrow ^{60}_{27}Co$ (→ β γ γ). HEALTHY TISSUE hit by 1 beam, minimal damage; CANCER-TUMOR hit by many beams to kill cancer cells. etc; ⊕ vs SURGERY; not in 2011. Stopped by Pb (lead)

γ is EM-radn, and (due to source) is nuclear-radn because it's 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 (penetration damage)
- TYPE of radn (α, β, γ, n) (EX: DAMAGE Q = 20 for α)
- Curie (Ci) # from SAMPLE (see TABLE, Sec 7.6, p 304)
- 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; n → β; n → n

ISOTOPES: same p# (same elmnt), diff n# (and mass#); compare $^0_{-1}e$ ($\frac{1}{1836}$) p ($\frac{1}{1836}$) or n ($\frac{1}{1838}$) almost same

- same chemical rxns (almost =)
- may have diff nuclear rxns

Fine Print (handouts), etc

Learn@UW – Content (Notes and more)

SECTIONS-PAGE, google chem 108 — Craig

DECAY SERIES

if ↑p#, n#(Z) and β

if ↑p#, mass#(A) and β

α: An (−4), Δp (−2), Δn (−2)

β: Δn (−1), Δp (+1), (0) ΔA#

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 %: DRAW A DIAGRAM

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

REMAINS ≠ DECAYED: TWO QUESTNS

less than 1% remains ($\frac{1}{128}$) after 7 half-lifes, 7 (3.8 d) = 26.6 d (10 half-lives is a good memory)

[is it "gone"? depends on initial amount (LARGE? small?) + definition of GONE]

compare to find SIMILARITIES, DIFFERENCES: one, atoms, decays (Q1, Q2, Q3; Quiz 3)

A = mass #, Z = atomic # — $^{238}_{92}U$ (EX): # of MASSIVE NUCLEONS; # 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) (α) (not by Ci); bg radn ≈ 360 Rem average

CHEMICAL(S) STUFF: compare molecules (molecules same); ≠ MIXTURE (He, H_2, CO_2) together in a tank — HOMOG, HETEROG; molecules different; PURE SUBSTANCE; compare ATOMS in molecule; ELEMENT — if only one TYPE of atom (He or H_2...); COMPOUND (≠ CO_2 or H_2O...) — if 2 or more TYPES of atoms; "you cannot say 'the atom' because H_2, O_2, ... are elmts"

* immediately after bomb (1945) or Chernobyl (1986), ¹³¹I ($t_{1/2}$ = 8.0 days) was dangerous, but 1 year later (or 66y, 25y) it isn't. But Sr-90 (29y) and Cs-137 (30y) are still dangerous now, due to medium-long $t_{1/2}$ (still large SAMPLE SIZE, large $t_{1/2}$ ← small $t_{1/2}$) plus HIGH RADIOACTIVITY per ATOM (2 TIMING FACTORS)

many atoms ← due to HIGH $t_{1/2}$; high activity per atom (due to LOW $t_{1/2}$)

≈ 30 y is HIGH enough for endurance (MANY ATOMS) but LOW enough for a high radioactivity per atom and this COMBINATION leads to a high Curie-rate of disintegrations/second, for the medium-long $t_{1/2}$.

but IF sample size (# of isotope-atoms) is same, isotope w shorter $t_{1/2}$ will have higher Ci-rate

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

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 – cells live, but in DNA-damaged form

radiation sickness: cells die

UNIT	FOCUS	What is measured?	What determines "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