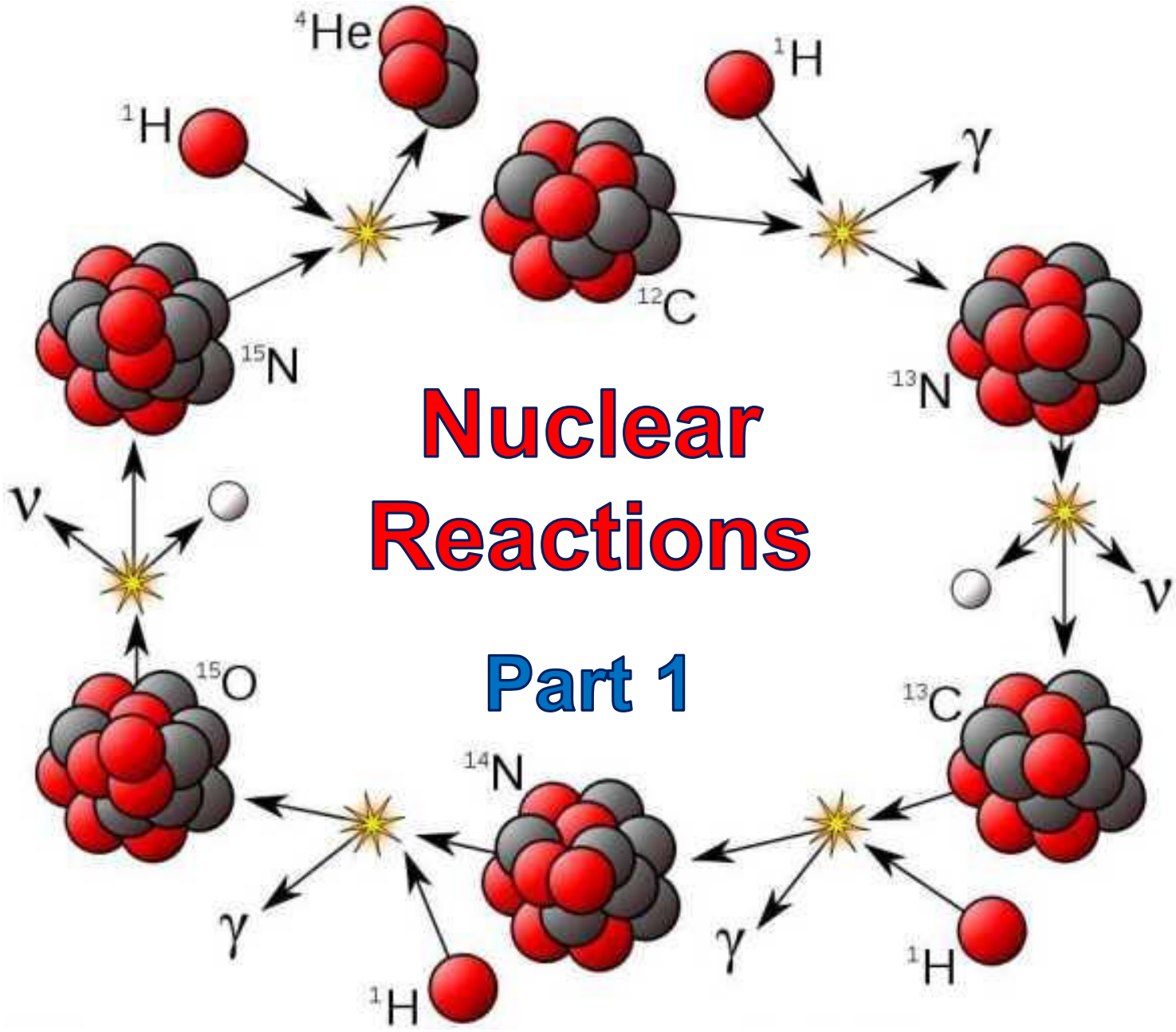


Nuclear Reactions

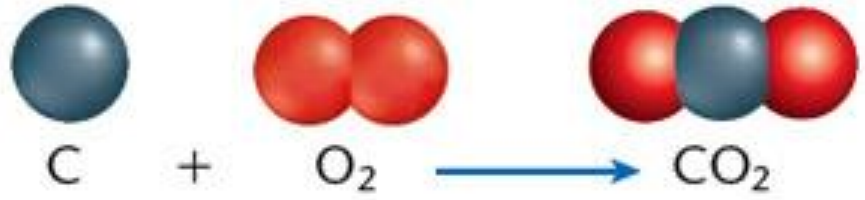
Part 1

Chemical Reactions

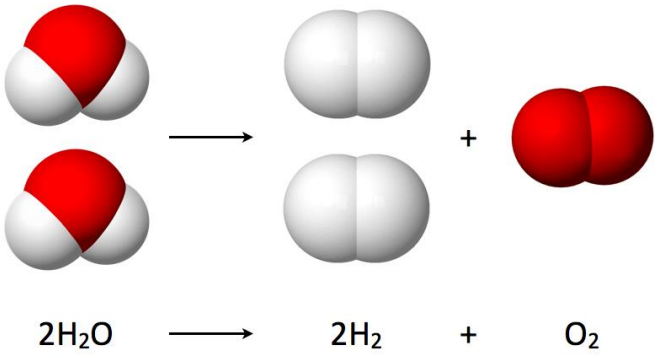
REVIEW

Change of matter that involves *bonding*, *separating* or *rearranging* of two or more atoms.

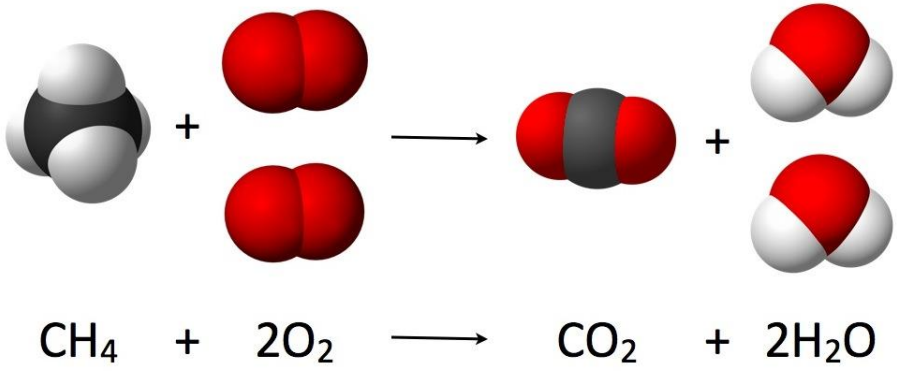
Formation of Carbon Dioxide



Electrolysis of Water



Combustion (burning) of Methane



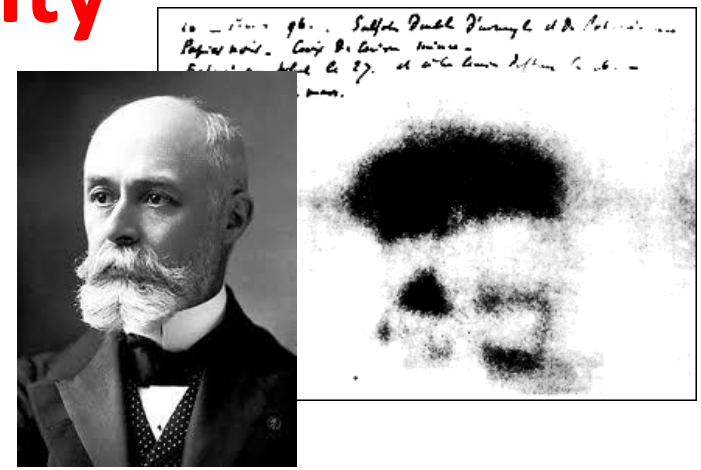
Nuclear Reactions
involve change of the atomic nucleus

1. **Radioactive decay** – an unstable nucleus spontaneously emits a small particle of **ionizing radiation** to become a **different isotope** of the same element or a **different element** (the latter process is called ***transmutation***).

2. **Nuclear Fusion** – the **joining** of two atomic nuclei to form a larger one.

3. **Nuclear Fission** – the **splitting** of an atomic nucleus into two smaller ones.

Discovery of Radioactivity



- **Henri Becquerel, 1896:**

  - radioactivity was first discovered in uranium salts during his work on phosphorescence.

- **Marie Sklodowska-Curie and Pierre Curie, 1898:**

  - conducted a systematic study to determine which other elements and compounds emitted "mysterious radiation" that they called "radioactivity";

  - isolated a new radioactive element, *polonium* (named in honor of Marie's home country);

  - four years later, discovered an even more intensely radioactive substance, which they called *radium*.

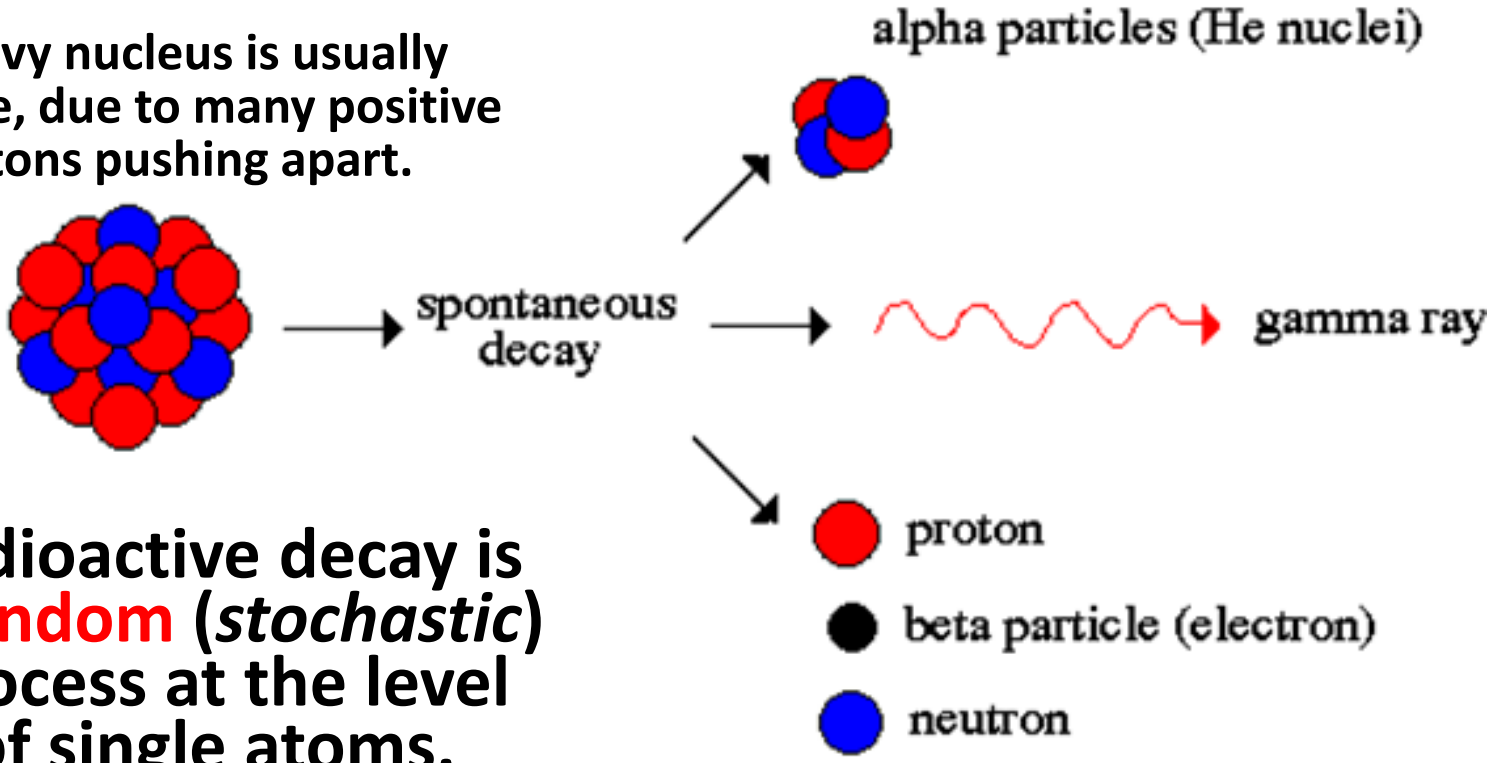
- **Ernest Rutherford and Frederick Soddy, 1899-1903:**

  - discovered three different types of radiation "rays" with very different powers of penetration, introduced the term "half-life", and proposed that atoms were not conserved in radioactive emissions.

Radioactive Decay

Radioactive decay, also known as radioactivity or nuclear decay, is the process by which a nucleus of an unstable atom loses energy by emitting ionizing radiation: ^4He (alpha particles), β particles (electrons), γ rays (energetic photons), neutrons.

A heavy nucleus is usually unstable, due to many positive protons pushing apart.



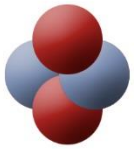
Radioactive decay is a random (*stochastic*) process at the level of single atoms.

Ionizing Radiation can pose a serious health threat to humans: it is capable of changing the basic makeup of atoms and molecules in cells, and more specifically the DNA molecules inside of cells.

Alpha Particle

LARGE PARTICLE, TRAVELS A FEW INCHES

STOPPED BY A SHEET OF PAPER



- interacts strongly with matter
- unable to penetrate the outer layer of dead skin cells
- capable of causing serious cell damage if an alpha emitting substance is ingested in food or air

Beta Particle

VERY SMALL PARTICLE, TRAVELS A FEW FEET

STOPPED BY WOOD, PLASTIC OR ALUMINUM

- can penetrate skin a few centimeters
- main threat is still primarily from internal emission from ingested material

Neutron

SMALL PARTICLE, TRAVELS A FEW FEET

ENERGY ABSORBED BY WATER AND CONCRETE

- the only type of radiation that is able to turn other materials radioactive

Gamma Ray

HIGH ENERGY, TRAVELS LONG DISTANCES

ENERGY ABSORBED BY HEAVY METALS AND CONCRETE

- very high energy electromagnetic radiation
- cause diffuse damage throughout the body (“radiation sickness”)

Periodic Table Showing Isotopes

1,2 H 1 Hydrogen																	3, 4 He 2 Helium
6, 7 Li 3 Lithium	9 Be 4 Beryllium											10, 11 B 5 Boron	12, 13 C 6 Carbon	14, 15 N 7 Nitrogen	16, 17, 18 O 8 Oxygen	19 F 9 Fluorine	20, 21, 22 Ne 10 Neon
23 Na 11 Sodium	24, 25, 26 Mg 12 Magnesium											27 Al 13 Aluminum	28, 29, 30 Si 14 Silicon	31 P 15 Phosphorus	32, 33, 34, 36 S 16 Sulfur	35,37 Cl 17 Chlorine	36,38,40 Ar 18 Argon
39, 41 K 19 Potassium	40,42,43, 44,46,48 Ca 20 Calcium	45 Sc 21 Scandium	46,47,48, 49,50 Ti 22 Titanium	51 V 23 Vanadium	50,52,53, 54 Cr 24 Chromium	55 Mn 25 Manganese	54,56,57, 58 Fe 26 Iron	59 Co 27 Cobalt	58,60,61, 62,64 Ni 28 Nickel	63,65 Cu 29 Copper	64,66,67, 68, 70 Zn 30 Zinc	69,71 Ga 31 Gallium	70,72,73, 74,76 Ge 32 Germanium	75 As 33 Arsenic	74,76,77, 78,80,82 Se 34 Selenium	79,81 Br 35 Bromine	78,80,82, 83,84,86 Kr 36 Krypton
85 Rb 37 Rubidium	84,86,87, 88 Sr 38 Strontium	89 Y 39 Yttrium	90,91,92, 94,96 Zr 40 Zirconium	93 Nb 41 Niobium	92, 94-100 Mo 42 Molybdenum	none Tc 43 Technetium	96,104, 98-103 Ru 44 Ruthenium	104 Rh 45 Rhodium	102,108,110 104-106 Pd 46 Palladium	107,109 Ag 47 Silver	106,108,114, 110-112,116 Cd 48 Cadmium	113 In 49 Indium	112,114-120, 122,124 Sn 50 Tin	121 Sb 51 Antimony	120,122,128, 124-126,130 Te 52 Tellurium	127 I 53 Iodine	124,126,134, 128-132,136 Xe 54 Xenon
133 Cs 55 Cesium	130,132, 134-138 Ba 56 Barium		174, 176-180 Hf 72 Hafnium	180,181 Ta 73 Tantalum	180,182,183, 184,186 W 74 Tungsten	185 Re 75 Rhenium	184,192, 186-190 Os 76 Osmium	191,193 Ir 77 Iridium	192,198, 194-196 Pt 78 Platinum	197 Au 79 Gold	196,204, 198-202 Hg 80 Mercury	203, 205 Tl 81 Thallium	204, 206-208 Pb 82 Lead	none Bi 83 Bismuth	none Po 84 Polonium	none At 85 Astatine	none Rn 86 Radon
none Fr 87 Francium	none Ra 88 Radium																

139 La 57 Lanthanum	136, 138, 140 Ce 58 Cerium	141 Pr 59 Praseodymium	142,143,145, 146,148,150 Nd 60 Neodymium	none Pm 61 Promethium	144,152,154, 148,149,150 Sm 62 Samarium	151, 153 Eu 63 Europium	152, 160, 154-158 Gd 64 Gadolinium	159 Tb 65 Terbium	156, 158, 160-164 Dy 66 Dysprosium	165 Ho 67 Holmium	162,164,166, 167,168,170 Er 68 Erbium	169 Tm 69 Thulium	168, 176, 170-174 Yb 70 Ytterbium	175 Lu 71 Lutecium
none Ac 89 Actinium	none Th 90 Thorium	none Pa 91 Protactinium	none U 92 Uranium	none Np 93 Neptunium	none Pu 94 Plutonium	none Am 95 Americium	none Cm 96 Curium	none Bk 97 Berkelium	none Cf 98 Californium	none Es 99 Einsteinium	none Fm 100 Fermium	none Md 101 Mendelevium	none No 102 Nobelium	none Lr 103 Lawrencium

Element Symbol — Li — Element Name

6, 7 — Mass Numbers of Stable Isotopes

3 — Atomic Number

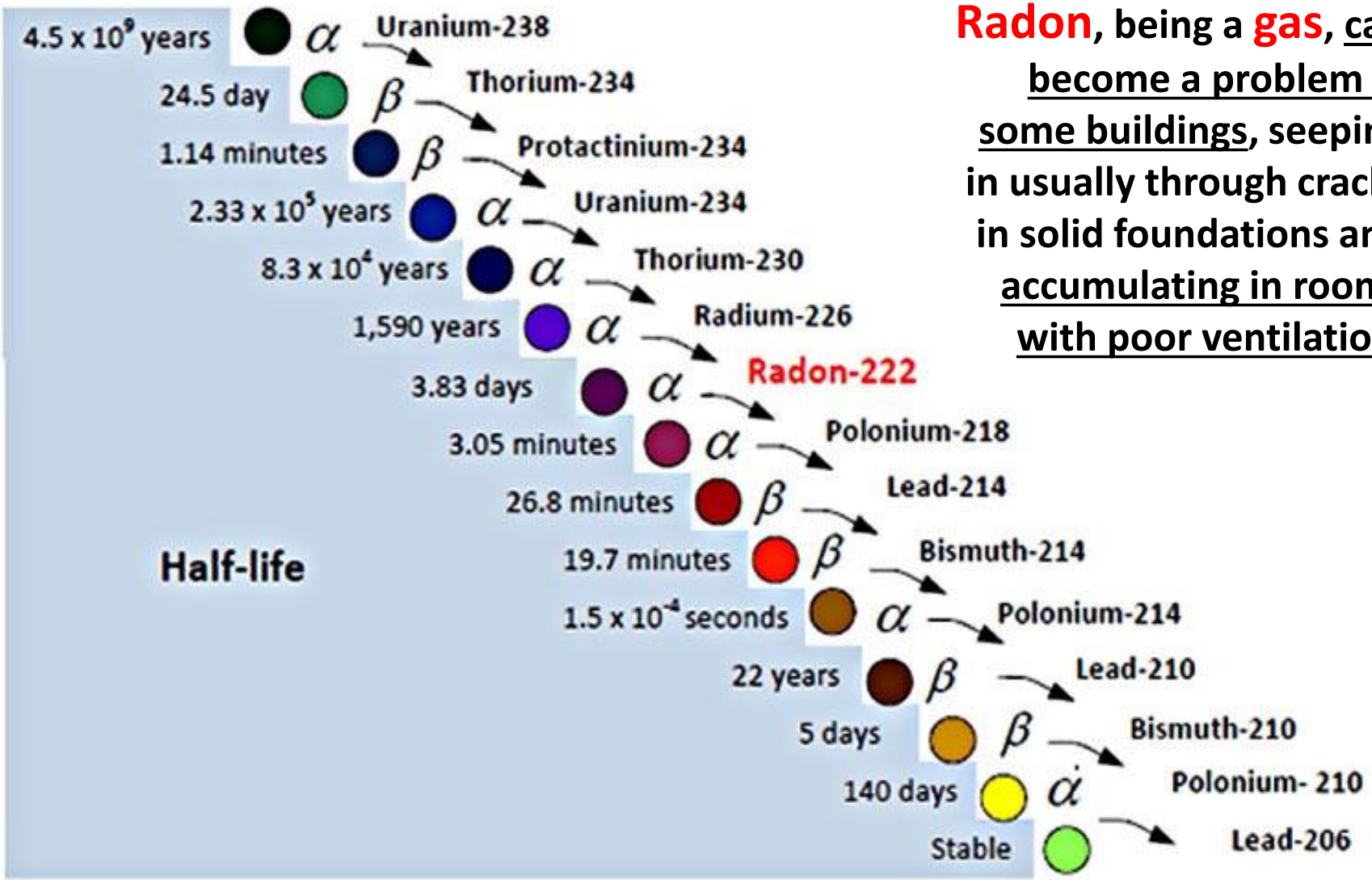
- The <u>heaviest element</u> that still has stable isotopes is **Lead**.
- Naturally occurring in the Earth's crust, **Potassium-40 and various isotopes of Uranium, Thorium, Radium, and Radon are the <u>most commonly found radioactive elements</u>.**

Half-Life of Radioactive Isotope

The decay rate of a radioactive isotope is characterized by its half-life: the *time it takes for one-half of the atoms* of a radioactive material *to disintegrate*.

Radioisotope	Half-life
Polonium-215	0.0018 seconds
Bismuth-212	60.5 seconds
Sodium-24	15 hours
Iodine-131	8.07 days
Cobalt-60	5.26 years
Radium-226	1600 years
Uranium-238	4.5 billion years

Uranium-238 Decay Chain



Radon, being a gas, can become a problem in some buildings, seeping in usually through cracks in solid foundations and accumulating in rooms with poor ventilation.