CH18

I. Atomic symbols: ${}^{A}_{Z}X$

a. X: letter symbol (use z to search X on the periodic table)
Z: atomic # = # of proton
A: mass # = # of proton + # of neutron = # of nucleon
atomic symbol for proton (${}^{1}_{1}p$), neutron(${}^{1}_{0}n$), and electron (${}^{0}_{-1}e$)

b. Isotope: atoms with the same # of p (same z) but different # of neutron
atomic weight = weighted average of atomic mass

II. Radioactive decay: ${}^{A}_{Z}X = {}^{B}_{U}S + {}^{C}_{V}T$, A=B+C, Z=U+V

a. Type of particles: Alpha (α) = ${}^{4}_{2}\text{He}$ Beta (β) = ${}^{0}_{-1}e$ Gamma (γ) = ${}^{0}_{0}r$ positron = ${}^{0}_{+1}e$

b. atoms with even # of proton and neutron are more stable
magic # of *p*: 2, 8, 28, 82, 20, 50,126 → super stable

c. atom is not stable if the difference of mass # and atomic mass is >2
if the z > 83

d. type of decay will be determined by the N/Z ratio

Z	Threshold	> threshold, β **decay** → ${}^{0}_{-1}e$ at the product side
1:20	1	< threshold,
20:40	1.25	positron emission → ${}^{0}_{1}e$ at the product side
40:83	1.5	electron capture → ${}^{0}_{-1}e$ at the reactant side
>83	1.6	< threshold, α **decay** → ${}^{4}_{2}\text{He}$ at the product side

e. Decay kinetics: $\ln(\frac{A_t}{A_0}) = -kt$ $k*t_{1/2} = 0.693$

the rock contains A and B, B is the decay product of A, $\frac{A_t}{A_0}=\frac{A}{A+B}$ (note A is # of atoms, NOT the mass of atoms)

III. Thermodynamic stability

a. mass defect: difference in mass between actual and hypothetical formation of a nucleus

b. binding energy: $\Delta E = \Delta mc^2$
1 amu = $1.66*10^{-27}$ Kg = 931.5 MeV/c^2

IV. Particle accelerator : uses an electric field to accelerate charged particle (typically ${}^{4}_{2}\text{He}$) to bombard the atom.
The notation ${}^{A}_{Z}X({}^{4}_{2}\text{He}, {}^{1}_{0}n)$ means X + ${}^{4}_{2}\text{He}$ → Y + ${}^{1}_{0}n$)
Nuclear power station:

a. fission: splits a larger atom into smaller ones (most electric power is generated using fission)
fusion: joins 2 or more lighter atoms into a larger one

b. Breeder reactors convert the non-fissionable nuclide, 238U to a fissionable product.

c. The control rods in the nuclear fission reactors are composed of a substance that absorbs neutrons.

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18.I-II

1. ^{17}N is expected to be stable.[**F**]
   ^{74}As is expected to be stable[**T**]
   ^{24}Al is expected to be stable[**F**]
   ^{209}Bi is expected to be stable[**T**]

2. Y-95 is radioactive. Which mode of decay would be expected for this nucleus? [**Beta decay**]
   How would ^{141}Eu be expected to decay? [**positron or electron capture**]
   Which mode of decay would be expected for a nucleus of At-212 [**Alpha decay**]
   V-47 can undergo electron capture. What is the product nucleus? Enter your answer using the same format, i.e, symbol-mass number [**Ti-47**]

3. ^{244}Cf is produced (as well as 2 neutrons) when a nucleus reacts with an alpha particle. What is the reactant nucleus? (**^{242}Cm**)

4. Cesium-137 undergoes beta decay and has a half-life of 30 years. How many beta particles are emitted by a 14.0g sample of Cesium-137 in three minutes? (**8.1e15**)

5. A rock contains 0.275 mg of lead-206 for each milligram of uranium-238. The half-life for the decay of uranium-238 to lead-206 is 4.5 x 10^9 yr. The rock was formed __________ yr ago. (**1.79 x 10^9**)

18.III

6. An atom of ^{122}In has a mass of 121.910280 amu. Calculate the binding energy in MeV per atom, MeV per nucleon, MeV per mole, kJ per atom, kJ per nucleon, kJ per mole. Use the masses: mass of ^{1}H atom = 1.007825 amu; mass of a neutron = 1.008665 amu; c = 2.99792 x 10^8 m/s; c = 2.99792 x 10^8 m/s; 1 amu = 1.66*10^{-27} Kg = 931.5 MeV/c^2. Give your answer to 4 significant figures and DO NOT use E notation. [**1029.9 MeV/atom**]

7. Which of the following statement(s) is/are correct?
   i) **Breeder reactors convert the non-fissionable nuclide, 238U to a fissionable product**.
   ii) The control rods in nuclear fission reactors are composed of a substance that emits neutrons.
   iii) Electric power is widely generated using nuclear fusion reactors.

8. Which one of the following requires a particle accelerator to occur

$^{59}_{26}Fe \rightarrow ^{59}_{27}Co + ^{0}_{-1}e$

$^{59}_{27}Co + ^{1}_{0}n \rightarrow ^{60}_{27}Co$

$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{93}Np + ^{0}_{-1}e$

$^{239}_{94}Pu + ^{4}_{2}He \rightarrow ^{242}_{96}Cm + ^{1}_{0}n$

none of these