RADIOACTIVITY: spontaneous disintegration of the nucleus of certain atoms accompanied by the emission (release) of particles and/or energy

~ TRANSMUTATION: the change of one element into another due to changes in the nucleus
* can be caused by radioactive decay (called ____________________ transmutation)

- Particles that are emitted during radioactive decay
  ~ alpha particle (α) – written as ${}^{4}_{2}He$; low energy particle; blocked by paper, skin, clothing

$${}^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$$

  ~ beta emission (β) - written as ${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$; blocked by plastic, wood, light metals

$${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$$

  ~ positron emission (${}^{0}_{+1}\beta$); also written as ${}^{0}_{+1}e$

$${}^{38}_{19}K \rightarrow {}^{38}_{18}Ar + {}^{0}_{+1}\beta$$

  ~ gamma radiation (γ) – no mass or charge, just energy; blocked by lead or thick (1+ m) concrete

* can be caused by bombardment by subatomic particles (called ____________________ transmutation)
- particle accelerator:

  ~ proton (a hydrogen nucleus)

$${}^{9}_{4}Be + {}^{1}_{1}H \rightarrow {}^{6}_{3}Li + \_\_\_\_\_\_$$

  ~ alpha particle (a helium nucleus)

$${}^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P + \_\_\_\_\_\_$$

  ~ only charged particles can be accelerated – neutrons cannot be accelerated in ordinary particle accelerator

BALANCING NUCLEAR EQUATIONS NOTES

~ Nuclear equations are different than regular equations because the atomic number and mass number are given along with the symbol for the element.
~ To balance a nuclear equation, the sum of the mass numbers of the substances on one side of the equation must equal the sum of the mass numbers of the substances on the other side of the equation. The same is true for the atomic numbers.

~ EXAMPLE: ${}^{242}_{96}Cm + \_\_\_\_\_\_ \rightarrow {}^{245}_{98}Cf + {}^{1}_{0}n$

~ Top # = mass number… Left side = 242, Right side = 246
So, in blank space, top number must be 4
~ Bottom # = atomic number… Left side = 96, Right side = 98
So, in blank space, bottom number must be 2
~ So far the equation is ${}^{242}_{96}Cm + {}^{4}_{2}\_\_\_ \rightarrow {}^{245}_{98}Cf + {}^{1}_{0}n$
~ Determine the element using the atomic number. He has an atomic number of 2.
~ So, the final equation is ${}^{242}_{96}Cm + {}^{4}_{2}He \rightarrow {}^{245}_{98}Cf + {}^{1}_{0}n$

~ Here's another practice problem…

${}^{252}_{98}Cf$ + _____ → ${}^{258}_{103}Lr$ + 4 ${}^{1}_{0}n$

BALANCING NUCLEAR REACTIONS WORKSHEET

Predict the missing product or reactant in the following nuclear reactions.

1.) ${}^{42}_{19}K \rightarrow {}^{0}_{-1}e$ + ____

2.) ${}^{239}_{94}Pu \rightarrow {}^{4}_{2}He$ + ____

3.) ${}^{235}_{92}U \rightarrow$ ____ + ${}^{231}_{90}Th$

4.) ${}^{1}_{1}H + {}^{3}_{1}H \rightarrow$ ____

5.) ${}^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{4}_{2}He$ + ____

6.) ${}^{27}_{13}Al + {}^{4}_{2}He \rightarrow {}^{30}_{15}P$ + ____

7.) ${}^{9}_{4}Be + {}^{1}_{1}H \rightarrow$ ____ + ${}^{4}_{2}He$

8.) ${}^{37}_{19}K \rightarrow {}^{0}_{+1}e$ + ____

9.) ____ + ${}^{1}_{0}n \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3\,{}^{1}_{0}n$

10.) ${}^{238}_{92}U + {}^{4}_{2}He \rightarrow$ ____ + ${}^{1}_{0}n$

11.) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N$ + ____

12.) ${}^{187}_{75}Re$ + ____ → ${}^{188}_{75}Re + {}^{1}_{1}H$

13.) ${}^{22}_{11}Na$ + ____ → ${}^{22}_{10}Ne$

14.) ${}^{218}_{84}Po \rightarrow$ ____ + ${}^{4}_{2}He$

15.) ${}^{253}_{99}Es + {}^{4}_{2}He \rightarrow {}^{1}_{0}n$ + ____

~ NUCLEAR ENERGY: according to Einstein,

* FISSION REACTIONS:

- neutrons are captured by the nucleus, causing it to disintegrate; 2 or more neutrons are released

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{38}Sr +$ ______ $+ 3\, ^{1}_{0}n$

- only elements w/ high atomic #s (that are unstable) can be used in fission rxns
- chain reaction:

* NUCLEAR REACTOR
- most produce energy from the fission of uranium-235

* FUSION REACTIONS:
- fuels:
- only occur at extremely high temperature and pressure
- proceed very slowly
- problems with containing energy released in fusion reactions
- nuclear fusion is not a practical source of energy

~ USES OF RADIOISOTOPES
- In the laboratory
  ~ TRACER:

- In medicine

- In industry

- In geology and archaeology

* RADIOACTIVE WASTES
- Why are radioactive wastes so dangerous?

- What is done with solid, liquid, and gas waste that is radioactive?
  ~ SOLID/LIQUID:
  ~ GAS:

~ Half-life:

Several Types of Problems Involving Radioactive Decay & Half-Life

Given	Asked for	Steps to Solve...
*half-life (h) *elapsed time (T) *initial amount (A_i)	*amount remaining (A_R)	1. Calculate number of half-lives in elapsed time. (T/h) 2. Divide original amount by 2 for the number of half-lives calculated in step 1. SEE EXAMPLE 1 BELOW.

*half-life (h) *initial amount (A_i) *amount remaining (A_R)	*elapsed time (T)	1. Determine how many half-lives elapsed in order to get from original amount to amount remaining. (How many times you had to divide by 2.) 2. Multiply half-life by the number of half-lives from step 1. SEE EXAMPLE 2 BELOW.
*elapsed time (T) *initial amount (A_i) *amount remaining (A_R)	*half-life (h)	1. Determine how many half-lives elapsed in order to get from original amount to amount remaining. (How many times you had to divide by 2.) 2. Divide elapsed time by number of half-lives from step 1. SEE EXAMPLE 3 BELOW.

Example 1: ^{32}P has a half-life of 14.3 days. If 32 grams were present to start, how many grams remain after 71.5 days?

Example 2: ^{131}I has a half-life of 8.07 days. In how many days will a 12 gram sample of ^{131}I decay, leaving a total of 1.5 grams of the original isotope?

Example 3: In 6.20 hours, a 100. gram sample of ^{112}Ag decays to 25.0 grams. What is the half-life of ^{112}Ag (in hours)?

HALF-LIFE PROBLEMS WORKSHEET

1. What is the half-life of a 100.0 g sample of nitrogen-16 that decays to 12.5 grams in 21.6 seconds?

2. All isotopes of technetium are radioactive, but they have widely varying half-lives. If an 800.0 gram sample of technetium-99 decays to 100.0 g of technetium-99 in 639,000 years, what is its half-life?

3. A 208 g sample of sodium-24 decays to 13.0 g of sodium-24 within 60.0 hours. What is the half-life of this radioactive isotope?

4. If the half-life of iodine-131 is 8.10 days, how long will it take a 50.00 g sample to decay to 6.25 g?

5. The half-life of hafnium-156 is 0.025 seconds. How long will it take a 560 g sample to decay to one-fourth of its original mass?

6. Chromium-48 has a short half-life of 21.6 hours. How long will it take 360.00 g of chromium-48 to decay to 11.25 g?

7. Potassium-42 has a half-life of 12.4 hours. How much of an 848 g sample of potassium-42 will be left after 62.0 hours?

8. Carbon-14 has a half-life of 5730 years. How much of a 144 g sample of carbon-14 will remain after 1.719×10^4 years?

9. If the half-life of uranium-235 is 7.04×10^8 years and 12.5 g of uranium-235 remain after 2.82×10^9 years, how much of the radioactive isotope was in the original sample?

10. Germanium-66 decays by positron emission, with a half-life of 2.5 hours. Write a nuclear equation for the decay. How much ^{66}Ge remains from a 25.0 gram sample after 10.0 hours?

Answers:

1. 7.2 sec	2. 213,000 yrs	3. 15 hrs	4. 24.30 days	5. 0.050 sec
6. 108 hrs	7. 26.5 g	8. 18 g	9. 200 g	10. 1.5625 g