

UNIT 16 – NUCLEAR CHEMISTRY

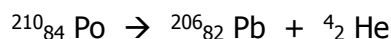
Radioactivity: spontaneous disintegration of the nucleus of certain atoms accompanied by the emission (release) of particles and/or energy

~ TRANSMUTATION: the change of one element into another due to changes in the nucleus

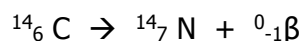
* can be caused by radioactive decay (called _____ transmutation)

- Particles that are emitted during radioactive decay

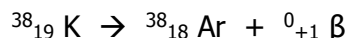
~ alpha particle (α) – written as ${}^4_2\text{He}$; low energy particle; blocked by paper, skin, clothing



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



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



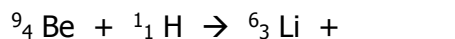
~ gamma radiation (γ) – no mass or charge, just energy; blocked by lead or thick (1+ m) concrete

* can be caused by bombardment by subatomic particles

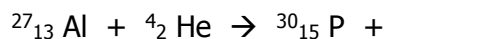
(called _____ transmutation)

- particle accelerator:

~ proton (a hydrogen nucleus)



~ alpha particle (a helium nucleus)



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

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BALANCING NUCLEAR EQUATIONS:

~ 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: $^{242}_{96}\text{Cm} + \underline{\hspace{2cm}} \rightarrow ^{245}_{98}\text{Cf} + ^1_0\text{n}$

~ 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

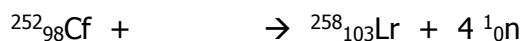
So, in blank space, bottom number must be 2

~ So far the equation is $^{242}_{96}\text{Cm} + ^4_2\underline{\hspace{1cm}} \rightarrow ^{245}_{98}\text{Cf} + ^1_0\text{n}$

~ Now, figure out which element this corresponds to by using the atomic number. He has an atomic number of 2.

~ So, the final equation is $^{242}_{96}\text{Cm} + ^4_2\text{He} \rightarrow ^{245}_{98}\text{Cf} + ^1_0\text{n}$

~ Here's another practice problem...



~ NUCLEAR ENERGY: according to Einstein,

* FISSION REACTIONS:

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



- 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:

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- mass defect:

- 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

~ Half-life:

- ^{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?
- ^{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?

PRACTICE HALF-LIFE PROBLEMS:

1. 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)?
2. Germanium-66 decays by positron emission, with a half-life of 2.5 hours. Write an equation for the decay. How much ^{66}Ge remains from a 25.0 gram sample after 10.0 hours?

* RADIOACTIVE WASTES

- Why are radioactive wastes so dangerous?
- What is done with solid, liquid, and gas waste that is radioactive?

~ SOLID/LIQUID:

~ GAS:

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BALANCING NUCLEAR REACTIONS WORKSHEET

Predict the missing product or reactant in the following nuclear reactions. Determine the type of nuclear reaction (α emission, β emission, γ emission, positron emission, artificial transmutation, fission, or fusion) described.

	<u>Type of Nuclear Reaction</u>
1.) ${}^{42}_{19}\text{K} \rightarrow {}^{0}_{-1}\text{e} + \underline{\hspace{2cm}}$	1.)
2.) ${}^{239}_{94}\text{Pu} \rightarrow {}^4_2\text{He} + \underline{\hspace{2cm}}$	2.)
3.) ${}^{235}_{92}\text{U} \rightarrow \underline{\hspace{2cm}} + {}^{231}_{90}\text{Th}$	3.)
4.) ${}^1_1\text{H} + {}^3_1\text{H} \rightarrow \underline{\hspace{2cm}}$	4.)
5.) ${}^6_3\text{Li} + {}^1_0\text{n} \rightarrow {}^4_2\text{He} + \underline{\hspace{2cm}}$	5.) ---
6.) ${}^{27}_{13}\text{Al} + {}^4_2\text{He} \rightarrow {}^{30}_{15}\text{P} + \underline{\hspace{2cm}}$	6.)
7.) ${}^9_4\text{Be} + {}^1_1\text{H} \rightarrow \underline{\hspace{2cm}} + {}^4_2\text{He}$	7.)
8.) ${}^{37}_{19}\text{K} \rightarrow {}^{0}_{+1}\text{e} + \underline{\hspace{2cm}}$	8.)
9.) $\underline{\hspace{2cm}} + {}^1_0\text{n} \rightarrow {}^{142}_{56}\text{Ba} + {}^{91}_{36}\text{Kr} + 3 {}^1_0\text{n}$	9.)
10.) ${}^{238}_{92}\text{U} + {}^4_2\text{He} \rightarrow \underline{\hspace{2cm}} + {}^1_0\text{n}$	10.)
11.) ${}^{14}_6\text{C} \rightarrow {}^{14}_7\text{N} + \underline{\hspace{2cm}}$	11.)
12.) ${}^{187}_{75}\text{Re} + \underline{\hspace{2cm}} \rightarrow {}^{188}_{75}\text{Re} + {}^1_1\text{H}$	12.)
13.) ${}^{22}_{11}\text{Na} + \underline{\hspace{2cm}} \rightarrow {}^{22}_{10}\text{Ne}$	13.) ---
14.) ${}^{218}_{84}\text{Po} \rightarrow \underline{\hspace{2cm}} + {}^4_2\text{He}$	14.)
15.) ${}^{253}_{99}\text{Es} + {}^4_2\text{He} \rightarrow {}^1_0\text{n} + \underline{\hspace{2cm}}$	15.)

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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?