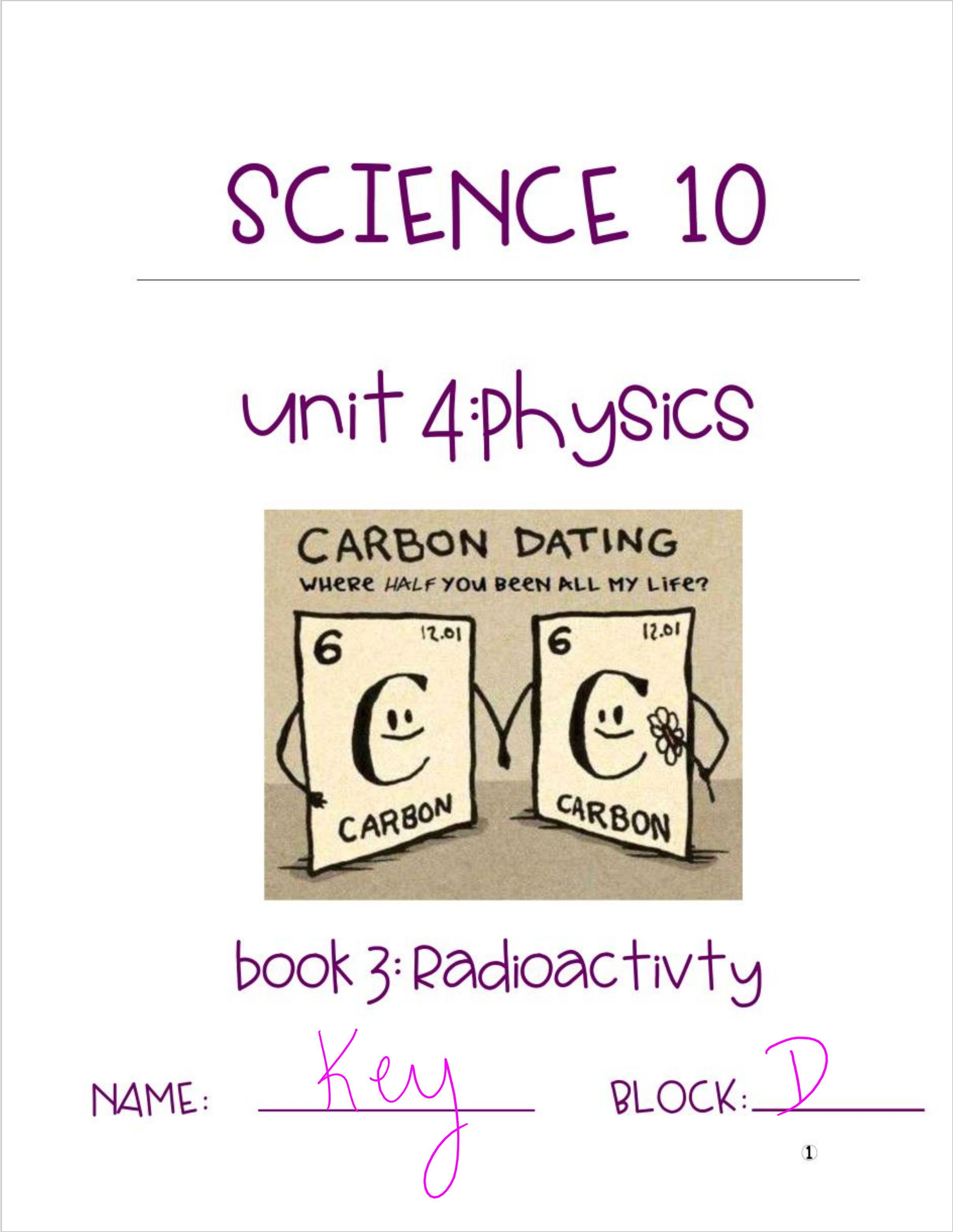
5.1 Radioactivity & Nuclear Equations

December 17, 2018 9:51 AM



SCIENCE 10

unit 4: physics

book 3: Radioactivty

NAME: Key BLOCK: D

①

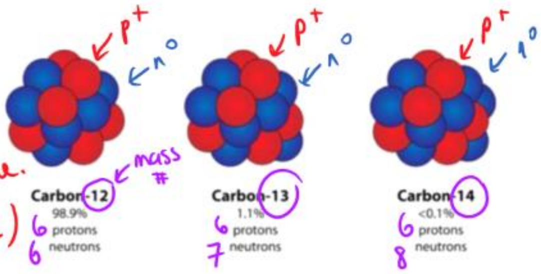
5.1 : RADIOACTIVITY & NUCLEAR EQUATIONS


our Sun is a huge nuclear furnace

Isotopes

- ☐ Isotopes are versions of an element with the same atomic # (# of p^+) but different # of n^0 (mass #) diff
- ☐ Because the number of protons is the same for all atoms of an element, it is the number of neutrons that determines the mass of the isotope
- ☐ Isotopes are commonly named by their element and mass # (# p^+ + # n^0)

☐ ***Example:*** carbon-14 is an isotope of carbon with a mass of 14. So, it has 6 ← from periodic table. protons and 14 − 6 = 8 neutrons.



ATOMIC # = # of p^+ (from P.T.)

MASS # = # p^+ + # n^0

Standard Atomic Notation

☐ Standard atomic notation (SAN) is how we represent different isotopes in nuclear reactions:

mass # (# of p^+ + n^0) ↘

$$^{238}_{92}\mathrm{U}$$

← element symbol (from periodic table)

atomic # (# of p^+) ↗

always the same (unless ions)

92 p^+

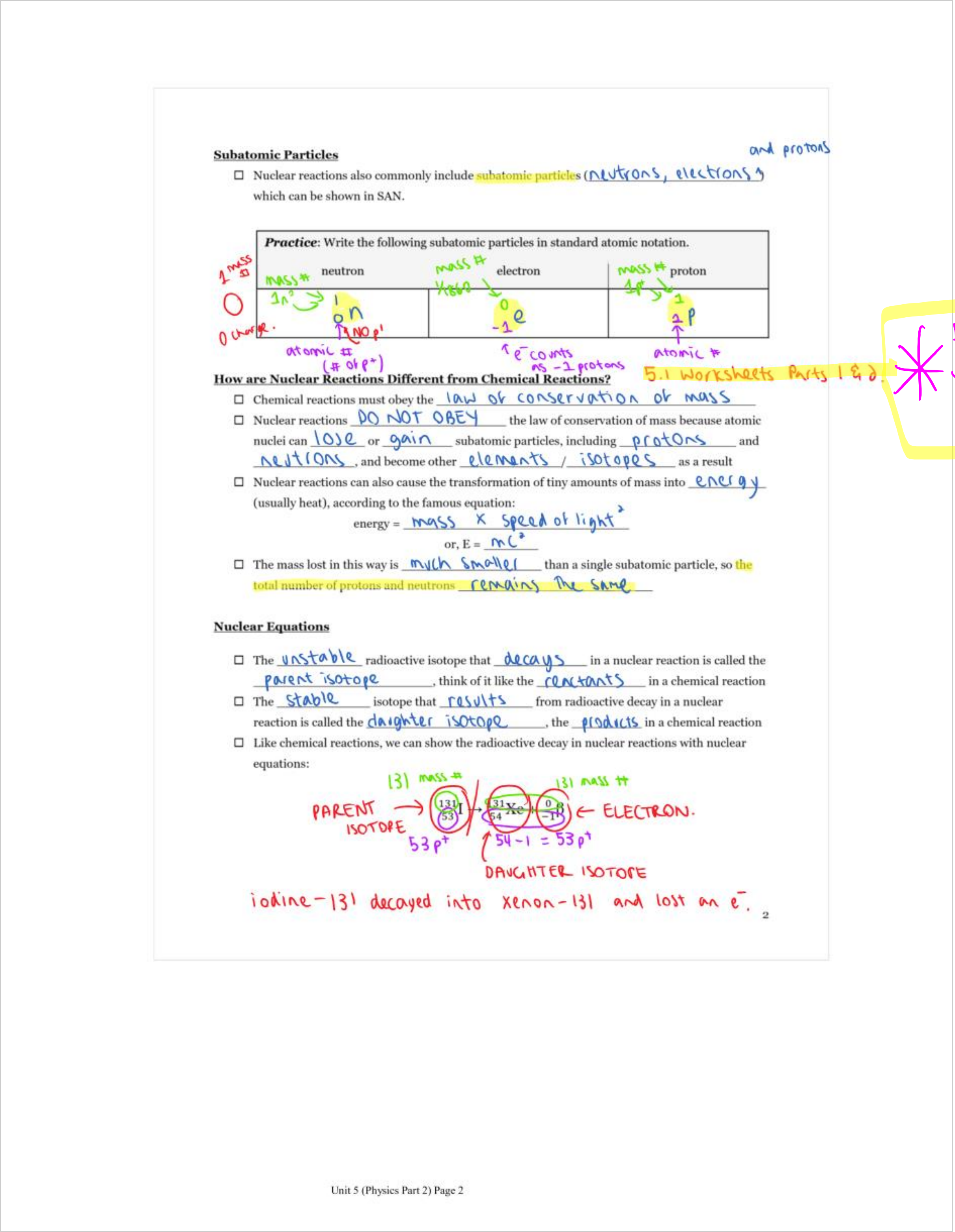
146 n^0

92 e^-

Practice: Write the following isotopes in standard atomic notation.	
potassium-39	potassium-41
biggest # → $^{39}_{19}\mathrm{K}$ smallest # →	$^{41}_{19}\mathrm{K}$

atomic #

②



Subatomic Particles

☐ Nuclear reactions also commonly include subatomic particles (neutrons, electrons and protons) which can be shown in SAN.

Practice: Write the following subatomic particles in standard atomic notation.

neutron	electron	proton
mass # $1n^0$ ${}^{1}_{0}n$ NO p+ atomic # (# of p^+) 1 mass # 0 charge.	mass # 1/1840 ${}^{0}_{-1}e$ e^- counts as −1 protons	mass # $1p^+$ ${}^{1}_{1}p$ atomic #

5.1 worksheets Parts 1 & 2.

How are Nuclear Reactions Different from Chemical Reactions?

☐ Chemical reactions must obey the law of conservation of mass

☐ Nuclear reactions DO NOT OBEY the law of conservation of mass because atomic nuclei can lose or gain subatomic particles, including protons and neutrons, and become other elements / isotopes as a result

☐ Nuclear reactions can also cause the transformation of tiny amounts of mass into energy (usually heat), according to the famous equation:

energy = mass × speed of light²

or, $E = mc^2$

☐ The mass lost in this way is much smaller than a single subatomic particle, so the total number of protons and neutrons remains the same

Nuclear Equations

☐ The unstable radioactive isotope that decays in a nuclear reaction is called the parent isotope, think of it like the reactants in a chemical reaction

☐ The stable isotope that results from radioactive decay in a nuclear reaction is called the daughter isotope, the products in a chemical reaction

☐ Like chemical reactions, we can show the radioactive decay in nuclear reactions with nuclear equations:

131 mass #

131 mass #

PARENT ISOTOPE →

$${}^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\beta$$

← ELECTRON.

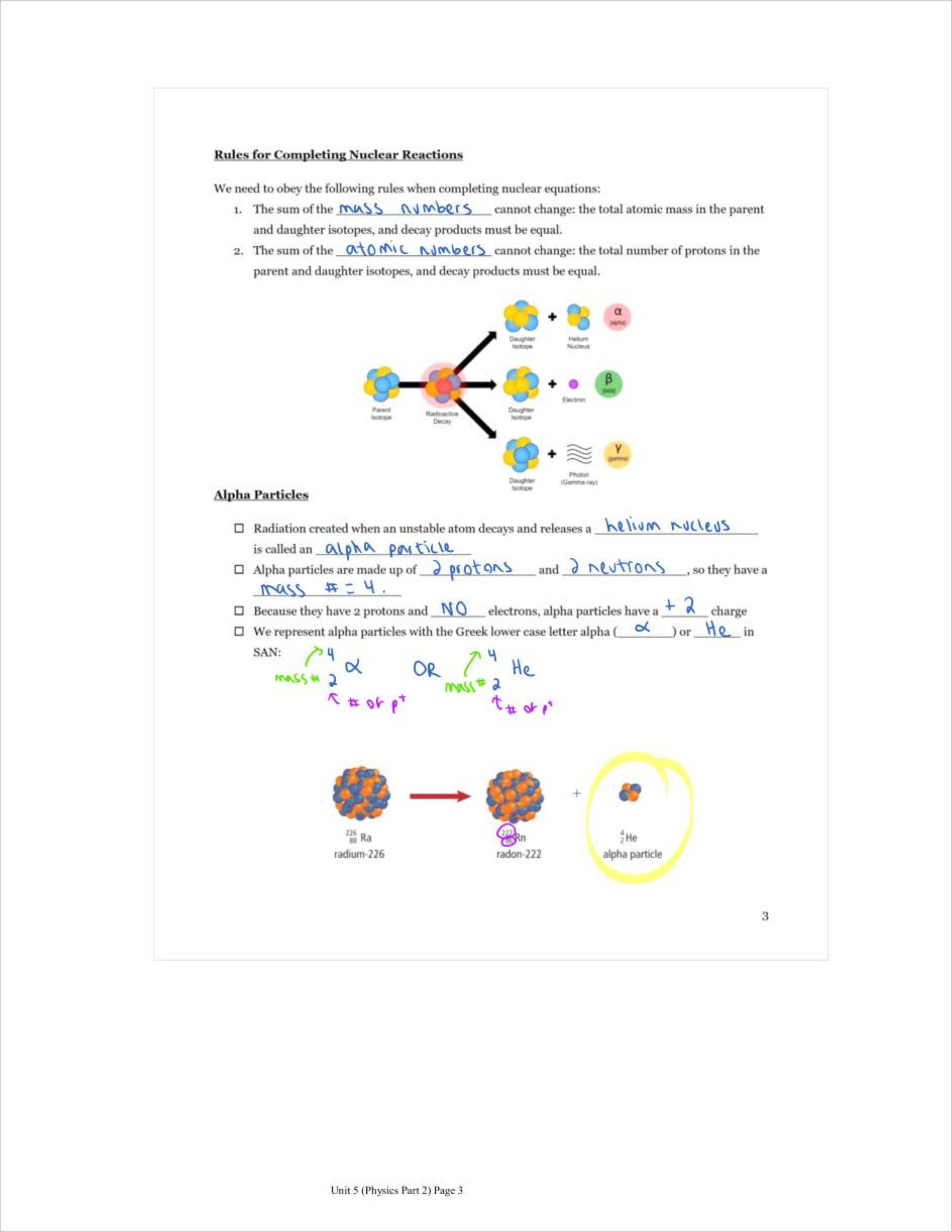
$53p^+$

$54 - 1 = 53p^+$

DAUGHTER ISOTOPE

iodine-131 decayed into xenon-131 and lost an e^-.

* Homework if you get up to here



Rules for Completing Nuclear Reactions

We need to obey the following rules when completing nuclear equations:

1. The sum of the mass numbers cannot change: the total atomic mass in the parent and daughter isotopes, and decay products must be equal.
2. The sum of the atomic numbers cannot change: the total number of protons in the parent and daughter isotopes, and decay products must be equal.

Alpha Particles

- ☐ Radiation created when an unstable atom decays and releases a helium nucleus is called an alpha particle
- ☐ Alpha particles are made up of 2 protons and 2 neutrons, so they have a mass # = 4.
- ☐ Because they have 2 protons and NO electrons, alpha particles have a +2 charge
- ☐ We represent alpha particles with the Greek lower case letter alpha (α) or He in SAN:

mass # $^{4}_{2}\alpha$ OR mass # $^{4}_{2}\text{He}$

\# of p^+ \# of p^+

3

Unit 5 (Physics Part 2) Page 3

Example: Write an equation for the alpha decay of uranium-238.

mass #

decrease by 4

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + \boxed{^{4}_{2}\alpha}$$

OR $\boxed{^{4}_{2}He}$

atomic # parent isotope decrease by 2

ex 2: alpha decay of cerium-145

$$^{145}_{58}Ce \rightarrow ^{141}_{56}Ba + ^{4}_{2}\alpha$$ ✓

⇒ 5.1 worksheet part 4.

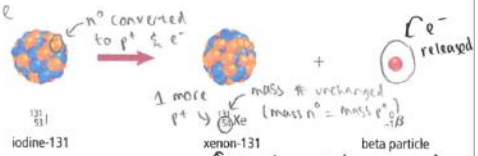
HW if you get this part*

STEPS:

1. ✓ Write the parent isotope in SAN
2. ✓ Put an arrow after the parent isotope
3. ✓ Complete the daughter isotope as follows: **decrease** the **atomic number** of the parent isotope by 2 and the **decrease** the **atomic mass** by 4. Then, find the new element that you have created on the periodic table (based on the atomic number), and add the symbol.
4. ✓ For the other product, add an alpha particle in SAN
5. ✓ Make sure that atomic masses and atomic numbers are balanced.

Beta Particles

- ☐ Radiation created when a neutron in an unstable atom decays and releases an electron is called a beta particle
  - ☐ The neutron is really converted into a proton and an electron
  - ☐ The proton remains inside the nucleus and the electron is ejected
- ☐ Because they are electrons, beta particles have NO mass and a -1 charge
- ☐ We represent beta particles with the Greek lower case letter beta (β) or e in SAN: $^{0}_{-1}\beta$ or $^{0}_{-1}e$



↑ NEW element (new p⁺ #)

Example: Write an equation for the beta decay of mercury-201.

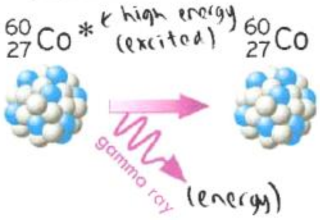
$$^{201}_{80}Hg \rightarrow ^{201}_{81}Tl + ^{0}_{-1}\beta$$

STEPS:

1. Write the parent isotope in SAN
2. Put an arrow after the parent isotope
3. Complete the daughter isotope as follows: **increase** the **atomic number** of the parent isotope by **1**. Then, find the new element that you have created on the periodic table (based on the atomic number), and add the symbol.
4. For the other product, add a beta particle in SAN
5. Make sure that atomic masses and atomic numbers are balanced.

Gamma Rays

- ☐ Radiation created when an unstable atom releases excess energy as high-energy light is called gamma radiation
- ☐ Atoms that release gamma rays do not give off protons or neutrons, so the elements DO NOT CHANGE
- ☐ Because they are a form of light, gamma radiation has an extremely small mass (far smaller than we can measure in atomic mass)
- ☐ We represent gamma radiation with the Greek lower case letter gamma (γ) in SAN: $^{0}_{0}\gamma$



Example: Write an equation for the gamma decay of potassium-42.

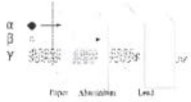
$$^{42}_{19}K^{*} \rightarrow ^{42}_{19}K + ^{0}_{0}\gamma$$

STEPS:

1. Write the parent isotope in SAN. Use an asterisk to denote that it is high energy.
2. Put an arrow after the parent isotope
3. Complete the daughter isotope as follows: keep it the same as the parent isotope.
4. For the other product, add a gamma particle in SAN
5. Make sure that atomic masses and atomic numbers are balanced.

Summary

	Alpha	Beta	Gamma
Symbol	$^{4}_{2}\alpha$ OR $^{4}_{2}He$	$^{0}_{-1}\beta$ or $^{0}_{-1}e$	$^{0}_{0}\gamma$
Description	helium nucleus	electron	gamma ray
Mass	4	0	0

Description	helium nucleus	electron	gamma ray
Mass	4	0	0
Charge	+2	-1	0
Penetration  	Paper	Aluminum	Lead

Look at your Data Page:

RADIOACTIVITY SYMBOLS

$^{4}_{2}\alpha$, $^{4}_{2}He$	$^{0}_{-1}\beta$, $^{0}_{-1}e$	$^{0}_{0}\gamma$
$^{1}_{0}n$		$^{1}_{1}p$, $^{1}_{1}H$

*⇒ 5.1 WS Parts 3, 5, 6, 7 * Homework