**7.1 Atomic Theory, Isotopes, and Radioactive Decay**

**Isotopes**

Isotopes (or radioisotopes):

They are represented by a nuclear symbol:

X

mass # element symbol

atomic #

*mass number =*

*atomic number* =

Isotopes of Carbon

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Isotope name** | **Nuclear**  **symbol** | **Mass Number** | **Atomic number** | **Neutrons** | **% of a sample** |
| *C-12*  *(stable)* |  |  |  |  | 98.9% |
| *C-13*  *(stable)* |  |  |  |  | 1.1% |
| *C-14*  *(unstable)* |  |  |  |  | 1 in 1 trillion |

*Examples – Write the nuclear symbols for each isotope:*

*a) magnesium-26 b) nitrogen-15*

*b) silicon-28 c) chlorine-37*

**Radioactive Decay**

During radioactive decay, the unstable nuclei of radioisotopes emit radiation in the form of:

a)

b)

The three most common types of radiation emitted during radioactive decay are:

1) Alpha Decay:

*Example:*

radium-226 → radon-222 + alpha particle

2) Beta Decay:

*Example:*

iodine-131 → xenon-131 + beta particle

3) Gamma Decay:

*Example:*

nickel\*-60 → nickel-60 + gamma ray

Properties of Alpha, Beta, and Gamma Radiation

|  |  |  |  |
| --- | --- | --- | --- |
| **Property** | **Alpha** | **Beta** | **Gamma** |
| Symbol |  |  |  |
| Composition |  |  |  |
| Description of radiation |  |  |  |
| Charge |  |  |  |
| Relative penetrating power |  |  |  |

*Examples – complete the radioactive decay equations:*

*1) 212 208*

*Po → Pb +*

*84 82 \_\_\_\_\_\_\_*

*2) 90 90*

*Sr → Y +*

*38 39 \_\_\_\_\_\_\_*

*3) 239 0*

*Np → + β*

*93 \_\_\_\_\_\_\_ -1*

*4) 144 4*

*Nd → + α*

*60 \_\_\_\_\_\_\_ 2*

*5) 42 0*

*K\* → + γ*

*19 \_\_\_\_\_\_\_ 0*

*6) 146 142*

*Sm → Nd +*

*62 60 \_\_\_\_\_\_\_*

**7.2 Half-Life**

***Half-life***

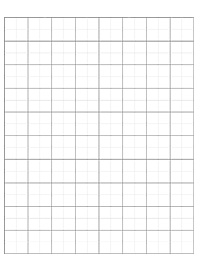
Half life:

It is equal to the time required for half the nuclei in a sample to decay

*Example:*

* *Carbon-14 (half life = 5,730 years).*
* *Used to carbon date plant and animal remains up to 50,000 years old (e.g. a wooly mammoth tusk)*
* A decay curve is a graph showing the rate at which a radioisotope decays:

Decay Curve for C-14



Carbon-14

Parent isotope

(%)

Time (y)

**Isotope Pairs**

-isotope pairs consist of a parent isotope and a daughter isotope

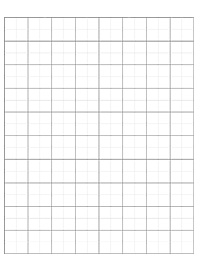
-the parent isotope undergoes decay, producing a stable daughter isotope

*Example:*

*-potassium-40 and argon-40 (half-life = 1.3 billion years)*

*-used to date rocks from 10,000 to 3 billion years old*

**Decay Curve for K-40 and Ar-40**



Isotope remaining

or produced

(%)

Time (y)

*1) How much of each isotope will remain after 3.9 billion years?*

a) K-40

b) Ar-40

2) *How much parent isotope will remain after 5 half-lives?*

**7.3 Nuclear Reactions**

**Nuclear Reactions**

* During a nuclear reaction, an atom’s nucleus changes by releasing particles or energy
* Nuclear equations use isotope symbols to indicate changes in the nuclei of atoms

There are two types of nuclear reactions:

1) *Nuclear Fission*:

*Example: occurs in atomic bombs and nuclear reactors. Uranium-235 nuclei are bombarded with neutrons:*

*1 235 92 1*

*n + U → Kr + + 3 n + energy*

*0 92 36 \_\_\_\_\_ 0*

*\*the release of 3 neutrons triggers a chain reaction* of *fission reactions*

2) *Nuclear Fusion:*

*Example: occurs in hydrogen-fusion bombs and the sun’s core:*

*2 3 1*

*H + H → + n + energy*

*1 1 \_\_\_\_\_ 0*

*Examples – Identify each nuclear equation (fission or fusion) and complete the equation:*

*#1) Type: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

*1 235 115 1*

*n + U → In + + 3 n + energy*

*0 92 49 \_\_\_\_\_ 0*

*#2) Type: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

*2 2 3*

*H + H → He + + energy*

*1 1 2 \_\_\_\_\_*

Comparison of Fission and Fusion Reactions

|  |  |  |
| --- | --- | --- |
|  | Fission | Fusion |
| Description |  |  |
| What is produced? |  |  |
| Are the products radioactive? |  |  |
| Where is it used? |  |  |
| Example |  |  |