Unit 12 Nuclear Chemistry

Nuclear Chemistry- study of the structure of atomic nuclei and nuclear change.

Nuclear Reactions- isotopes of one element are changed into isotopes of another element.

Chemical Symbols

mass number = 14

atomic number = 6

$$^{14}_{6}C$$

Radioactive decay- when unstable nuclei lose energy by emitting radiation to attain more stable atomic configurations. Three types:

Alpha (α) decay- radioactive decay of an atomic nucleus that is accompanied by the emission of an alpha particle ($^{4}_{2}He$).

Beta (β) decay- radioactive decay in which an electron ($^{0}_{-1}e$) is emitted.

Gamma (γ) decay- high energy photons that are emitted by radioactive nuclei.

Alpha particle has 2 protons and 2 neutrons, just like the $^{4}_{2}He$ nucleus. An **α-** particle will decrease the atomic number by 2, decrease mass by 4, and carries a +2 charge.

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

Beta particle is a fast moving electron, denoted by the symbol e^- or $^{0}_{-1}e$. A ß-particle has insignificant mass, carries a -1 charge, and increases the atomic number by 1.

$$^{14}_{6}C \Rightarrow {}^{14}_{7}N + {}_{-01}e$$

Gamma rays have no mass, do not carry a charge, and usually accompany α- and β-particles.

Penetration of radiation — Least → Most

Alpha ➔ Beta ➔ Gamma

paper ➔ wood➔ concrete

Nuclear Fission- splitting of a nucleus. A very heavy nucleus is split into 2 approximately equal fragments. Chain reaction releases several neutrons which split more nuclei.

$$^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 2 \times 10^{2}\ kJ/mol$$

Nuclear Fusion - combining of nuclei. Two lighter nuclei combine to form a single heavier nucleus. Does not occur under standard conditions (+ repels +).

Advantages - inexpensive, no radioactive waste.

Disadvantages- requires huge amount of energy to start, difficult to control.

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + n^{0} + 17.59\ MeV$$

http://cnx.org/content/m42659/latest/?collection=col11406/latest

Half Life- time required for half of a radioisotope's nuclei to decay into its products.

For example, suppose you have 10.0 grams of strontium-90, which has a half life of 29 years. How much will be remaining after x number of years?

$$\mathbf{mass_{final} = mass_{initial} \times (0.5)^{n}} \qquad \mathbf{n = number\ of\ half\text{-}lives}$$

Example problems

If gallium-68 has a half-life of 68.3 minutes, how much of a 160.0 mg sample is left:

after 1 half life?

Answer = 80.0 mg; $m_f = 160.0\ mg \times (0.5)^1 = 80.0\ mg$

After 2 half lives?

Answer = 40.0 mg; $m_f = 160.0\ mg \times (0.5)^2 = 40.0\ mg$

After 3 half lives?

Answer = 20.0 mg; $m_f = 160.0\ mg \times (0.5)^3 = 20.0\ mg$

Assignment

Problem 1

Iodine-131 is a radioactive isotope with a half-life of 8 days. How many grams of a 64 g sample of iodine-131 will remain at the end of 8 days?

Problem 2

How many grams of a 64 g sample of iodine-131 will remain at the end of 32 days?

Problem 3

Complete the equation below by filling in the missing part:

$$^{226}_{88}\mathbf{Ra} \rightarrow {}^{222}_{86}\mathbf{Rn} + \mathbf{X}$$

what is X?

two neutrons? two protons? beta particle, $^{0}_{-1}e$? alpha particle, $^{4}_{2}He$?

Problem 4

Complete the equation below by filling in the missing part:

$$^{239}_{93}\mathbf{Np} \rightarrow {}^{239}_{94}\mathbf{Pu} + \mathbf{X}$$

What is the particle X?

a positron? a neutron? alpha particle, $^{4}_{2}He$? beta particle, $^{0}_{-1}e$?

Alternate Assignment

Problem 1

Iodine-131 is a radioactive isotope with a half-life of 8 days. How many grams of a 64 g sample of iodine-131 will remain at the end of 8 days?

Problem 2

How many grams of a 64 g sample of iodine-131 will remain at the end of 24 days?

Problem 3

In the equation

$$^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + X$$

what is X?

two neutrons? two protons?

beta particle, $^{0}_{-1}e$? alpha particle, $^{4}_{2}He$?

Problem 4

In the nuclear change

$$_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + X$$

What is X?

a proton? a neutron?

alpha particle, $^{4}_{2}He$? beta particle, $^{0}_{-1}e$?