Half-Life

Aim

- to explain half-life and solve half-life problems

Notes

Half life

- Definition - the amount of time it takes for half of a radioactive sample to decay
- Explanation
  - During radioactive decay, high speed particles are emitted that bang into other atoms and cause them to decay
  - As a sample decays the amount of radioactive material decreases
  - As the size of the radioactive sample decreases, the number of particles emitted decreases
  - As the number of particles emitted decreases, the number of collisions decreases and radioactive decay slows down
  - Radioactive decay slows down over time in such a way that the amount of time it takes for half a sample to decay is constant regardless of the size of the sample
- Radioactive dating
  - Carbon dating
    - Carbon-14 is radioactive and has a half life of 5,700 years
    - Carbon dioxide in the air contains carbon-14
    - Plants take in carbon dioxide and make carbohydrates as long as they are alive
    - Animals eat plants as long as they are alive
    - As soon as an organism dies, it stops taking in carbon, so its amount of c-14 begins to decrease
  - Uranium dating
    - Uranium-238 is radioactive and has a half life of 10^9 years
    - Uranium-238 is found in igneous rock
    - Uranium-238 decays into lead
    - After the rock cools, the amount of uranium-238 in the rock begins to decrease and the amount of lead begins to increase
    - the fraction of uranium left can be determined by comparing its mass to the mass of the lead
  - number of half lives and time elapsed

    T_e = Time elapsed

    $t_{½}$ = ½ life

    n = number of ½ lives

    f = fraction left

    $f = (½)^n$ $T_e = n(t_{½})$
    - Half Life Problems
      - Half life problems of all types are best solved by setting up a table that shows the *number of half lives*, the *mass*, the *time elapsed*, and the *fraction left*. (any of these 4 variables can be the unknown)
      - Half lives of many elements are listed in *Table N*

Sample Problem

An ore that once contained 320 g of ^{60}Co now contains only twenty grams of the radio active material. How long has it been decaying?

Step 1: divide the mass in half repeatedly until it is reduced from 320 g to 20 g
Step 2: look up the half life and fill in the rest of the table

number of half lives	mass	time elapsed	fraction left
0	320 g	0	1 (100 %)
1	160 g	5.26 y	1/2
2	80 g	10.52 y	1/4
3	40 g	15.78 y	1/8
4	20 g	21.04 y	1/16

Answer the questions below by circling the number of the correct response

1. How much of an 8 gram sample of $^{226}_{38}\mathrm{Ra}$ will remain unchanged at the end of 3 half-life periods?
   (1) 1 g (3) 3 g
   (2) 2 g (4) 4 g

2. What is the total mass of a 10. gram sample of ^{42}K that will remain unchanged after 12.4 hours?
   (1) 2.5 g (3) 7.5 g
   (2) 5. 0 g (4) 10. g

3. As the temperature of a radioactive sample increases, the rate of nuclear decay
   1 decreases
   2 increases
   3 remains the same

4. A sample contains 100 milligrams of iodine-131. At the end of 32 days, the number of milligrams of iodine-131 that will remain will be
   (1) 25.00 (3) 6.250
   (2) 12.50 (4) 3.125

5. Approximately how many grams of a 40-gram sample of $^{131}_{53}\mathrm{I}$ will remain unchanged after 24 days?
   (1) 5 (3) 13
   (2) 10 (4) 20

6. How much of an 8 gram sample of $^{226}_{38}\mathrm{Ra}$ will remain unchanged at the end of 3 half-life periods?
   (1) 1 g (3) 3 g
   (2) 2 g (4) 4 g

7. What is the number of half-life periods required for a sample of a radioactive material to decay to $^{1}/_{16}$ of its original mass?
   (1) 8 (3) 3
   (2) 16 (4) 4

8. As a sample of the radioactive isotope ^{131}I decays, its half–life
   (1) decreases
   (2) increases
   (3) remains the same

9. Exactly how much time must elapse before 16 grams of potassium–42 decays, leaving 2 grams of the original isotope?
   (1) 8 × 12.4 hours (3) 3 × 12.4 hours
   (2) 2 × 12.4 hours (4) 4 × 12.4 hours