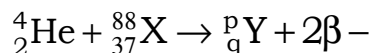


### Atoms, Nuclei and Molecules

- At a certain instant, a piece of radioactive material contains  $10^{12}$  atoms. The half-life of the material is 30 days. (i) Find the number of disintegrations in the first second. (ii) What time will elapse before  $10^4$  atoms remain? (iii) What is the count rate (activity) at this time?
- The table shows samples P, Q, R of different nuclides found in nuclear wastes
- | No. of atoms         | half-life |
|----------------------|-----------|
| P $1 \times 10^{20}$ | 1 min.    |
| Q $3 \times 10^{20}$ | 24 days   |
| R $8 \times 10^{20}$ | 1 year    |

Which of the three statements are correct?

- P has the greatest decay constant
  - Q has the greatest activity
  - R eventually would be most dangerous
- An alpha particle incident on a nuclide X produces a nuclide Y and two  $\beta$ -particles.



Find  $p$  and  $q$ .

- The radioactive isotope of  ${}^{131}\text{I}$  has a half life of 8 days and is used as tracer in medicine. Calculate:
  - the number of atoms of  ${}^{131}\text{I}$  which must be present in the patient when she is tested to give a disintegration rate of  $6.0 \times 10^5 \text{ s}^{-1}$ .
  - the number of atoms of  ${}^{131}\text{I}$  which must be present in a dose prepared 24 hours before.
- A sample initially contains No radioactive atoms of a single isotope of radioactive decay constant  $\lambda$ .
  - Explain the underlined term.
  - Give an equation for N, the number of these radioactive atoms present after time  $t$ . Sketch a graph for N versus  $t$ .
  - Derive an equation relating  $\lambda$  and  $T_{1/2}$ .
- Explain the meaning of the term mass difference and state the relationship between the mass difference and the binding energy of the nucleus.
- Sketch a graph of nuclear binding energy for nucleus versus mass number for the naturally occurring isotopes and show how it may be used to account for the possibility of energy by nuclear fission and nuclear fusion.
- Calculate the binding energy per nucleon for  ${}^4_2\text{He}$  and  ${}^3_2\text{He}$ . Comment on the difference in these binding energies and explain its significance in relation to the radioactivity of light nuclei.  
(Mass of  ${}^1_1\text{H} = 1.00783\mu$ , mass of  ${}^1_0\text{n} = 1.00867\mu$ , mass of  ${}^3_2\text{He} = 3.01664\mu$ , mass of  ${}^4_2\text{He} = 4.00387\mu$ ,  $1\mu \equiv 931 \text{ MeV}$ )

9. Define the following terms:  
Gamma, alpha, and beta rays, becquerel, mean life.
10. The half-life of radium is 1620 years. How many radium atoms decay in 1s in a 1g sample of radium? The atomic weight of radium is 226 kg/kmol.
11.  $^{60}\text{Co}$  is used as a radiation source. Its half life is 5.25 years. How long, after a new sample is delivered, will the activity have decreased to (a) about 1/8 of its original value (b) to about 1/3 of its original value?
12. The half-life of  $^{215}\text{At}$  is 100  $\mu\text{s}$ . If a sample initially contains 6 mg of the element, what is its activity (a) initially (b) after 200 $\mu\text{s}$ ?
13. Make an estimate of how large is (i) the largest nucleus (ii) smallest nucleus.

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