1. $^{3}_{1}H \rightarrow ^{3}_{2}He + ^{0}_{-1}e$ β- decay

2. $^{232}_{92}U \rightarrow ^{228}_{90}Th + ^{4}_{2}He$ α decay

3. $^{144}_{58}Ce \rightarrow ^{144}_{59}\mathrm{Pr} + ^{0}_{-1}e$ β- decay

4. $^{65}_{30}Zn \rightarrow ^{65}_{29}Cu + ^{0}_{+1}e$ β+ decay

5. $^{40}_{19}K \rightarrow ^{40}_{18}Ar + ^{0}_{+1}e$ β+ decay

6. $^{7}_{4}Be \rightarrow ^{7}_{4}Be + \gamma$ γ decay

7. $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{236}_{92}U \rightarrow ^{141}_{55}Cs + ^{92}_{37}Rb + 3^{1}_{0}n$ Fission

8. $^{222}_{86}Rn \rightarrow ^{218}_{84}Po + ^{4}_{2}He$ α decay

9. $^{129}_{53}I \rightarrow ^{129}_{54}Xe + ^{0}_{-1}e$ β- decay

10. $^{239}_{94}Pu \rightarrow ^{235}_{92}U + ^{4}_{2}He$ α decay

11. $^{15}_{8}O \rightarrow ^{15}_{7}N + ^{0}_{+1}e$ β+ decay

12.

a. $^{234}_{90}Th \rightarrow ^{230}_{88}Ra + ^{4}_{2}He$

b. $^{59}_{26}Fe \rightarrow ^{59}_{27}Co + ^{0}_{-1}e$

c. $^{99}_{43}Tc \rightarrow ^{99}_{43}Tc + \gamma$

d. $^{11}_{6}C + ^{0}_{-1}e \rightarrow ^{11}_{5}B$

13. $^{1}_{1}\mathrm{H} + ^{7}_{3}\mathrm{Li} \rightarrow 2^{4}_{2}\mathrm{He}$ or $^{8}_{4}\mathrm{Be}$

14. $^{7}_{4}\mathrm{Be} + ^{1}_{0}\mathrm{n} \rightarrow 2^{2}_{1}\mathrm{H} + ^{4}_{2}\mathrm{He}$ or $^{1}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} + ^{4}_{2}\mathrm{He}$

15. $^{246}_{96}Cm + ^{12}_{6}C \rightarrow ^{254}_{102}No + 4^{1}_{0}n$

16. $^{250}_{98}Cf + ^{10}_{5}B \rightarrow ^{258}_{103}Lr + 2^{1}_{0}n$

1. Define half-life.

The half-life of a radioactive isotope is the length of time during which half of the atoms in a sample will have decayed. This is also sometimes expressed in terms of the time taken for the activity measured to halve, or for the mass of the sample, as represented by atoms of the radioisotope in question, to decrease by half. [NB: there are some problems with these definitions since an isotope often decays into another radioactive isotope – so there may be activity measured which is due to the daughter isotope. Also, the mass of the sample may not actually appreciably decrease since atoms of the radioisotope of interest are being replaced by daughter atoms of a different element.

2. How is the half-life of a radioisotope similar to a sporting tournament in which the losing team is eliminated?

During each round of the competition, half of the teams will be eliminated – although it will not always be possible to pick which particular team will be eliminated.

3. The half-life of radium-226 is 1600 years. If a sample of radium-226 has an original activity of 200 Bq, what will its activity be after 4800 years?

   $t_{1/2}(^{226}Ra)$ = 1600 y; A_O = 200 Bq; t = 4800 y; A = ?

   $A = A(1/2)^{t/t1/2} = 200 \times (0.5)^3 = 25$ Bq

4. Sodium-24 has a half-life of 15 hours. If a sample of sodium-24 has an original activity of 500 Bq, what will its activity be after 60 hours?

   $t_{1/2}(^{24}Na)$ = 15 h; A_O = 500 Bq; t = 60 h y; A = ?

   $A = A(1/2)^{t/t1/2} = 500 \times (0.5)^4 = 31.25$ Bq

5. After 42 days the activity of a sample of phosphorus-32 has decreased from 400 Bq to 50 Bq. What is the half-life of phosphorus-32?

   t = 42 d; A_O = 400 Bq; A = 50 Bq; $t_{1/2}$ = ?

   $\ln(A/A_O) = t/t_{1/2} \times \ln(0.5)$

   $t_{1/2} = \ln(0.5)(42)/\ln(50/400)$

   = 14 days

6. The half-life of radon-222 is 3.8 days. What was the original activity if it has an activity of 10 Bq after 7.6 days?

$t_{1/2}(^{222}Ra)$ = 3.8 d; A = 10 Bq; t = 7.6 d y; A_O = ?

$A_O = A/0.5^{t/t1/2}$

= 40 Bq

7. The half-life of thorium-227 is 19 days. How many days are required for 75% of a sample to decay?

   After 1 half life has passed, 50% activity has decayed. After 2 half lives, 75% has decayed.

   ∴ 2 x 19 = 38 days

8. The half-life of protactinium-234 is 6.75 hours. What percentage of a sample will remain after 27 hours?

No of half lives which will have passed in 27 h = 27/6.75 = 4 half lives.

∴ 100% → 50% → 25% → 12.5 % → 6.25%

∴ after 27 hours, 6.25% of the original sample will remain

9. A rock once contained 1.0 mg of uranium-238, but now contains only 0.25 mg. Given that the half-life for uranium-238 is 4.5 x 10^9 (4.5 billion) years, how old is the rock?

1.0 mg → 0.5 mg → 0.25 mg

∴ 2 half lives have passed

∴ the rock is 2 x 4.5 x 10^9 = 9.0 x 10^9 years old i.e. 9 billion years old.

10. The half-life of tritium (hydrogen-3) is 12.3 years. If 48.0 mg of tritium is released from a nuclear power plant during the course of a mishap, what mass of the sample will remain after 49.2 years?

$t_{1/2}(^{3}H)$ = 12.3 y d; A_O = 48 mg; t = 49.2 y; A = ?

∴ A = 48.0 x $(0.5)^{49.2/12.3}$

= 3.00 mg