These problems are intended to ***supplement*** the problems in the textbook, not ***replace*** them.

## Questions

**Write balanced nuclear equations for the following.**

1. Antimony-124 decays by beta emission.
2. Iodine-117 decays by electron capture.
3. Samarium-146 decays by alpha emission.
4. Titanium-43 decays by positron emission.
5. Krypton-93 decays by beta emission.
6. Palladium-98 decays by positron emission.
7. Actinium-225 decays by alpha emission.
8. Polonium-209 decays by electron capture.
9. Bromine-87 decays by neutron emission.
10. Californium-254 undergoes spontaneous fission to molybdenum-106 and another nucleus plus four neutrons.
11. Iron-59 is produced by neutron capture.
12. Technetium-97 is produced by the combination of molybdenum-96 with deuterium (hydrogen-2) and the emission of another particle.
13. Curium-242 is produced by the combination of plutonium-239 with another nucleus, with the emission of one neutron.
14. Fermium-256 undergoes spontaneous fission to palladium-115 and xenon-138 plus three additional (identical) particles.
15. Five neutrons are emitted when uranium-238 combines with another nucleus to produce einsteinium-253.
16. Neptunium-239 is produced by neutron capture, with the emission of a beta particle.
17. The fusion of helium-3 with helium-4 creates a new nucleus plus gamma rays.
18. Nitrogen-14 absorbs a neutron, then splits into hydrogen-3 plus another nucleus.

**Answer the following questions.**

19. The half-life of krypton-85 is 10.76 years.
    a. What percentage of the original sample will remain after 25.0 years?
    b. How long will it take for 95.0% of a sample to decay?

20. The half-life of chromium-51 is 27.8 days. How long will it take for a 2.500 g sample to decay to 1.000 g?

21. The half-life for the beta decay of silicon-31 is 157 minutes. After 7.86 hours, how many micrograms will remain from a 2.68 μg sample?

22. The half-life of fluorine-18 is 109.8 minutes. How many hours will t take for 85.0% of the sample to decay?

23. A sample that contains manganese-56 has an activity of 1.00 mCi at one time and an activity of 0.77 mCi 0.97 hour later. What is the half-life of manganese-56?

24. Calculate the half-life for the decay of chlorine-39 if a 5.00 g sample decays to 0.625 g in 165 minutes.

25. Measurements of the linen wrappings from the Book of Isaiah in the Dead Sea Scrolls suggest that the scrolls contain 79.5% of the carbon-14 expected in living tissue. How old are the scrolls? The half-life of carbon-14 is 5730 years.

26. Indium-112 has a half-life of 14 minutes. What percentage of the original sample will remain after 2.0 hours?

27. The half-life of tritium (hydrogen-3) is 12.3 years. If 50.0 mg of tritium is released from a nuclear power plant during an accident, what mass of tritium will remain after…

    a. 20.0 years  b. 100.0 years

**For the remaining questions, use these values for constants and atomic masses:**

| Constants |
|---|
| $N_{AV} = 6.02214\times10^{23}$ |
| $c = 2.99792\times10^{8}$ m/s |
| proton = 1.00728 amu |
| neutron = 1.00867 amu |
| electron = 0.00055 amu |
| alpha particle = 4.00151 amu |

| Masses of Some Nuclei (amu) | | | |
|---|---|---|---|
| $^{1}_{1}H$ | 1.00728 | $^{40}_{18}Ar$ | 39.95251 |
| $^{2}_{1}H$ | 2.01355 | $^{56}_{26}Fe$ | 55.92068 |
| $^{3}_{1}H$ | 3.01550 | $^{94}_{40}Zr$ | 93.88438 |
| $^{4}_{2}He$ | 4.00151 | $^{140}_{58}Ce$ | 139.87362 |
| $^{24}_{12}Mg$ | 23.97846 | $^{206}_{82}Pb$ | 205.92946 |
| $^{25}_{12}Mg$ | 24.97926 | $^{235}_{92}U$ | 234.99345 |

**For the following nuclear reactions, calculate (a) the mass change, in grams per mole of reaction, and (b) the energy change, in kJ per mole of reaction**

28. $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

29. $^{24}_{12}Mg + {}^{2}_{1}H \rightarrow {}^{25}_{12}Mg + {}^{1}_{1}H$

30. $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{94}_{40}Zr + {}^{140}_{58}Ce + 6\ {}^{0}_{-1}\beta + 2\ {}^{1}_{0}n$

**For the following isotopes, calculate (a) the mass defect, in amu per atom, and (b) the nuclear binding energy, in J per nucleon**

31. $^{206}_{82}Pb$  32. $^{40}_{18}Ar$  33. $^{56}_{26}Fe$

**Answers**

If you cannot figure out how to get the correct answer, go to your instructor, Science Tutoring Center, etc.

1. $^{124}_{51}\text{Sb} \rightarrow {}^{0}_{-1}\beta + {}^{124}_{52}\text{Te}$

2. $^{117}_{53}\text{I} + {}^{0}_{-1}\text{e} \rightarrow {}^{117}_{52}\text{Te}$

3. $^{146}_{62}\text{Sm} \rightarrow {}^{4}_{2}\alpha + {}^{142}_{60}\text{Nd}$

4. $^{43}_{22}\text{Ti} \rightarrow {}^{0}_{1}\text{e} + {}^{43}_{21}\text{Sc}$

5. $^{93}_{36}\text{Kr} \rightarrow {}^{0}_{-1}\beta + {}^{93}_{37}\text{Rb}$

6. $^{98}_{46}\text{Pd} \rightarrow {}^{0}_{1}\text{e} + {}^{98}_{45}\text{Rh}$

7. $^{225}_{89}\text{Ac} \rightarrow {}^{4}_{2}\alpha + {}^{221}_{87}\text{Fr}$

8. $^{209}_{84}\text{Po} + {}^{0}_{-1}\text{e} \rightarrow {}^{209}_{83}\text{Bi}$

9. $^{87}_{35}\text{Br} \rightarrow {}^{1}_{0}\text{n} + {}^{86}_{35}\text{Br}$

10. $^{254}_{98}\text{Cf} \rightarrow {}^{106}_{42}\text{Mo} + 4\,{}^{1}_{0}\text{n} + {}^{144}_{56}\text{Ba}$

11. $^{1}_{0}\text{n} + {}^{58}_{26}\text{Fe} \rightarrow {}^{59}_{26}\text{Fe}$

12. $^{96}_{42}\text{Mo} + {}^{2}_{1}\text{H} \rightarrow {}^{97}_{43}\text{Tc} + {}^{1}_{0}\text{n}$

13. $^{239}_{94}\text{Pu} + {}^{4}_{2}\text{He} \rightarrow {}^{242}_{96}\text{Cm} + {}^{1}_{0}\text{n}$

14. $^{256}_{100}\text{Fm} \rightarrow {}^{115}_{46}\text{Pd} + {}^{138}_{54}\text{Xe} + 3\,{}^{1}_{0}\text{n}$

15. $^{238}_{92}\text{U} + {}^{20}_{7}\text{N} \rightarrow {}^{253}_{99}\text{Es} + 5\,{}^{1}_{0}\text{n}$

16. $^{1}_{0}\text{n} + {}^{238}_{92}\text{U} \rightarrow {}^{239}_{93}\text{Np} + {}^{0}_{-1}\beta$

17. $^{3}_{2}\text{He} + {}^{4}_{2}\text{He} \rightarrow {}^{7}_{4}\text{Be} + {}^{0}_{0}\gamma$

18. $^{14}_{7}\text{N} + {}^{1}_{0}\text{n} \rightarrow {}^{3}_{1}\text{H} + {}^{12}_{6}\text{C}$

19. a. 20% b. 46.6 yr

20. 36.8 days

21. 0.32 μg

22. 300.5 min (5.008 h)

23. 2.6 h

24. 55.0 min

25. $1.89\times10^{3}$ yr

26. 0.2%

27. a. 16 mg b. 0.18 mg

28. a. –0.01887 g/mol b. $-1.696\times10^{9}$ kJ/mol

29. a. –0.00547 g/mol b. $-4.92\times10^{8}$ kJ/mol

30. a. –0.22348 g/mol b. $-2.0085\times10^{10}$ kJ/mol

31. a. 1.74258 amu/atom b. $1.26245\times10^{-12}$ J/nucleon

32. a. 0.36927 amu/atom b. $1.3778\times10^{-12}$ J/nucleon

33. a. 0.52870 amu/atom b. $1.4090\times10^{-12}$ J/nucleon