PHYSICS 4, CHAPTER 5
ADDITIONAL PROBLEMS

1. Your starship passes Earth with a relative speed of 0.9990c. After traveling 10.0 y (your time), you stop at lookout post LP13, turn, and then travel back to Earth with the same relative speed. The trip back takes another 10.0 y (your time). How long does the round trip take according to measurements made on Earth? (Neglect any effects due to the accelerations involved with stopping, turning, and getting back up to speed.)

ANSWER: 448y

2. An unstable high-energy particle enters a detector and leaves a track of length 1.05 mm before it decays. Its speed relative to the detector was 0.992c.What is its proper lifetime? That is, how long would the particle have lasted before decay had it been at rest with respect to the detector?

ANSWER: 0.446 ps

3. A rod lies parallel to the x axis of reference frame S, moving along this axis at a speed of 0.630c. Its rest length is 1.70 m. What will be its measured length in frame S?

ANSWER: 1.32m

4. A spaceship of rest length 130 m races past a timing station at a speed of 0.740c.
(a) What is the length of the spaceship as measured by the timing station?
(b) What time interval will the station clock record between the passage of the front and back ends of the ship?

ANSWER: (a) 87.4 m; (b) 394 ns

5. A 2.71 g sample of KCl from the chemistry stockroom is found to be radioactive, and it is decaying at a constant rate of 4490 Bq. The decays are traced to the element potassium and in particular to the isotope ^{40}K, which constitutes 1.17 % of normal potassium. Calculate the half-life of this nuclide.

ANSWER: 1.25×10^9 y

6. Calculate the disintegration energy Q for the beta decay of ^{32}P. The needed atomic masses are 31.973 91 u for ^{32}P and 37.972 07 u for ^{32}S.

*ANSWER:*1.71 MeV

7. What is the nuclear mass density of
(a) the fairly low mass nuclide ^{55}Mn and
(b) the fairly high-mass nuclide ^{209}Bi?
(c) Compare the two answers, with an explanation.
What is the nuclear charge density of
(d) ^{55}Mn and
(e) ^{209}Bi?
(f) Compare the two answers, with an explanation.

ANSWER: (a) 2.3×10^{17} kg/m^3; (b) 2.3×10^{17} kg/m^3; (d) 1.0×10^{25} C/m^3; (e) 8.8×10^{24} C/m^3

8. Consider an initially pure 3.4 g sample of ^{67}Ga,, an isotope that has a half-life of 78 h.
(a) What is its initial decay rate?
(b) What is its decay rate 48 h later?

ANSWER: (a) 7 .5 $\times 10^{16}$ s^{-1}; (b) 4.9×10^{16} s^{-1}

9. A radioactive isotope of mercury, ^{197}Hg, decays to gold, ^{197}Au, with a disintegration constant of 0.0108 h^{-1}.
(a) Calculate the half-life of the ^{197}Hg.
What fraction of a sample will remain at the end of
(b) three half-lives and
(c) 10.0 days?

ANSWER: (a) 64.2 h; (b) 0.125; (c) 0.0749

10. A certain stable nuclide, after absorbing a neutron, emits an electron, and the new nuclide splits spontaneously into two alpha particles. Identify the nuclide.

ANSWER: .^7Li

11. The ratio of ^{235}U to ^{238}U in natural uranium deposits today is 0.0072. What was this ratio 2.0×10^9 y ago? The half-lives of the two isotopes are 7.04×10^8 y and 44.7×10^8 y, respectively.

ANSWER: 3.8%

12. The radionuclide ^{64}Cu has a half-life of 12.7 h. If a sample contains 5.50 g of initially pure ^{64}Cu at t = 0, how much of it will decay between t = 14.0 h and t = 16.0 h?

ANSWER: 265 mg

13. Calculate the disintegration energy Q for the fission of ^{52}Cr into two equal fragments. The masses you will need are 51.940 51 u for ^{52}Cr and 25.982 59 u for ^{26}Mg.

ANSWER: -23.0 MeV

14. Find the disintegration energy Q for the fission event of the equation: $^{235}U \rightarrow {}^{140}Ce + {}^{94}Zr + n$. Some needed atomic and particle masses are ^{235}U = 235.0439 u; ^{140}Ce = 139.9054 u; n = 1.008 66 u; ^{93}Zr = 93.9063 u.

ANSWER: 208 MeV