Topic 12.2 – Nuclear physics – AHL   NAME: _____

Show formulas, substitutions, answers (in spaces provided) and units!

The following questions are about using head-on collisions between alpha particles and nuclei to determine an estimate of the nuclear radius.

1. Derive the formula $R_0 = 2Zke^2 / E_{K\alpha}$. _____

    _____
    _____
    _____

2. Suppose an alpha particle having a kinetic energy of 5.15 MeV is made to approach an iron nucleus ($Z = 26$). Find a ballpark figure for the radius of the iron nucleus. Use the formula $R_0 = 2Zke^2 / E_{K\alpha}$.

    2. _____

3. Find the radius of an iron nucleus ($A = 55.8$) . Use the formula $R = R_0 A^{1/3}$ where $R_0 = 1.2 \times 10^{-15}$ m.

    3. _____

4. Show that the density of an iron nucleus is about $\rho = 2.3 \times 10^{17}$ kg m^{-3}. _____

    _____

The following questions are about using diffracted beams of electrons and neutrons to determine the nuclear diameter.

5. A beam of 75.0 MeV neutrons are diffracted upon passing through a thin metal foil. The first minimum in the diffraction pattern is measured at 2.5°. Estimate the diameter of the metal's nucleus.

    5. _____

6. A beam of 500 MeV electrons are diffracted upon passing through the same metal foil. Using the diameter of the nucleus from the previous problems determine the expected location of the first minimum in the diffraction pattern.

    6. _____

7. In the experiment of the previous problem, in addition to the normal diffraction pattern, small and unexpected anomalies are also present in the pattern. Explain how these irregularities might constitute evidence for an internal structure of the nucleus (protons and neutrons). _____

    _____
    _____

The following questions are about decay particles.

8. List the three types of radioactive decay.   8. _____, _____, _____

9. Which of these three types has a pretty constant energy of about 4 to 5 MeV?   9. _____

10. Which of these resulted in the prediction of the neutrino, and why did the neutrino need to be present?   10. _____

    _____

11. Which of these decay types is evidence for the existence of nuclear energy levels?

11. _____

The following questions are about nuclear stability.

12. Explain why nuclei having many protons might be unstable. _____

_____

13. Why do neutrons add nuclear stability to the higher atomic-numbered nuclei? _____

_____

The following questions are about the radioactive decay law and half-life and the decay constant.

14. State the radioactive decay law as an exponential function.   14. _____

15. Define the decay constant of a radioactive nuclide. _____

_____

16. The half-life of a radioactive nuclide 3.25×10^8 y.   Find its decay constant.   16. _____

17. How does the Schrödinger equation and quantum tunneling relate to nuclear decay?

_____

_____

The following questions are about activity rates.

18. Activity rates are measured with a _____ and are measured in _____.

19. Why is the activity rate A proportional to the population of nuclides N? _____

_____

_____

The activity per gram of an isotope is 6.8 disintegrations per hour at t = 0.00 h and 4.8 disintegrations per hour at t = 4.10 h. A sample of 25.0 g of this isotope is placed in a sealed 45.0 g container.

20. Find the decay constant of this isotope.   20. _____

21. Find the half-life of this isotope.   21. _____

22. Find the activity per gram of the isotope of at $t = 10.$ h.   22. _____

23. Find the activity of the sample at $t = 10.$ h.   23. _____

24. What is the mass of the sealed container after exactly three half-lives?   24. _____