UNIT 8 Review

Knowledge/Understanding

Multiple Choice

In your notebook, choose the most correct answer for each of the following questions. Outline your reasons for your choice.

1. The strong nuclear force has a limited range. A consequence of this is the
   - **(a)** magnitude of nuclear binding energies
   - **(b)** instability of large nuclei
   - **(c)** ratio of atomic size to nuclear size
   - **(d)** existence of isotopes
   - **(e)** existence of neutrinos
2. The number of elementary charge units in a nucleus determines the atomic
   - **(a)** size
   - **(b)** weight
   - **(c)** mass
   - **(d)** number
   - **(e)** density
3. The half-life of ^{28}Ni is six days. What fraction of a sample of this nuclide will remain after 30 days?
   - **(a)** $\frac{1}{4}$
   - **(b)** $\frac{1}{8}$
   - **(c)** $\frac{1}{16}$
   - **(d)** $\frac{1}{32}$
   - **(e)** $\frac{1}{64}$
4. After 4 h, $\frac{1}{16}$ of the initial amount of a certain radioactive isotope remains undecayed. The half-life of the isotope is
   - **(a)** 15 min
   - **(b)** 30 min
   - **(c)** 45 min
   - **(d)** 1 h
   - **(e)** 2 h
5. The ratio of neutrons to protons in a nucleus is
   - **(a)** less than one
   - **(b)** equal to one
   - **(c)** starts near one but increases with the atomic number
   - **(d)** decreases with atomic number
   - **(e)** always greater than one
6. A good moderator
   - **(a)** absorbs neutrons
   - **(b)** is much larger than a neutron
   - **(c)** is radioactive
   - **(d)** is similar in size to a neutron
   - **(e)** speeds up neutrons

Short Answer

7. Differentiate between a transmutation and a radioactive decay.
8. Distinguish between the terms isotope and nuclide.
9. Explain how beta (negative) decay results in a more stable nucleus.
10. What is the source of the energy released by nuclear fission?
11. What is the function of control rods in a nuclear fission reactor?
12. Explain why fission products are highly radioactive.
13. What is necessary to cause nuclear fusion?

Inquiry

14. Assume that a pure sample of a radioisotope contains exactly 1.6×10^4 nuclei with a half-life of 10.0 s.
    - **(a)** Determine the expected number of nuclei remaining after time intervals of 10 s, 20 s, 30 s, 40 s, 50 s, and 60 s.
    - **(b)** Draw an accurate graph of the data with the time interval (t) on the x-axis and the number of nuclei remaining (N) on the y-axis.
    - **(c)** The activity at any given time is given by $A = \Delta N/\Delta t$. What property of the graph does this ratio represent?
    - **(d)** Determine the activity of the sample at 10 s, 20 s, 30 s, 40 s, and 50 s.
    - **(e)** Draw an accurate graph of the data with the time interval (t) on the x-axis and the activity (A) on the y-axis.
    - **(f)** Compare the two graphs.
15. Do research to learn about Wilson cloud chambers and how they work. What discoveries have been made with cloud chambers? Design and assemble a cloud chamber.

Communication

16. Explain what limits the size of a stable nucleus.
17. Use the binding energy curve to explain why both fission (the splitting of a nucleus) and fusion (the joining of two nuclei) release energy.
18. Explain why gamma decay usually accompanies beta decay.

19. If half of the nuclei in a sample decay in one half-life, explain why all of the nuclei do not decay in two half-lives.

20. Explain the function of moderators in nuclear fission reactors and why they are needed.

21. Describe how a nuclear chain reaction is generated and how it is maintained at exactly a critical level in a reactor.

22. What is the purpose of the very strong magnetic fields in the design of nuclear fusion reactors that are currently being tested? Why are these magnetic fields needed?

Making Connections

23. Use print or Internet resources to find out how carbon-14, a radioactive isotope of carbon, was used to determine the sequence of reactions in photosynthesis.

24. Read about radioactive dating and write a short paper on one study that used radioactive dating.

25. The problem of nuclear waste disposal has not yet been solved on any permanent basis. Use print or Internet resources to learn about proposals for nuclear waste disposal and what currently is the position of the government on the direction that will be taken in dealing with the problem.

Problems for Understanding

26. A prediction of the lifetime of the Sun can be calculated by analyzing its observed rate of energy emission, 3.90×10^{26} J/s. (Hint: In making the following calculations, pay close attention to unit analysis.)

(a) Calculate the amount of energy released in the conversion of four protons to one helium nucleus: $4{}^{1}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + 2{}^{0}_{1}\text{e}$.

(b) If the above is considered as one reaction, how many reactions must occur each second to produce the observed rate of energy emission?

(c) How much helium is produced during each reaction?

(d) How much helium is produced per second?

(e) Let the lifetime of the Sun be defined as the time it takes 10.0% of the Sun's total mass to be converted into helium. (You can make this assumption, since it is accepted that only the reactions in the Sun's core need be considered.) Calculate the lifetime of the Sun in years.

27. The lifetime of the Sun can also be determined by calculating the total energy available and dividing by the energy radiated per second.

(a) Calculate the mass defect for converting four protons into one helium nucleus.

(b) What fraction of the mass of the initial four protons does this mass defect represent? This is the fraction of the mass of each proton that is converted into energy.

(c) Suppose the Sun's entire mass (1.99×10^{30} kg) was composed of protons. What is the total energy available?

(d) Assume that only 10.0% of the Sun's mass of protons are available to undergo fusion and calculate the lifetime of the Sun in years. (The Sun radiates 3.90×10^{26} J/s.)

28. Consider a sample of rock that solidified with Earth 4.55×10^{9} years ago. If it contains N atoms of uranium-235 (half-life: 7.04×10^{8} a), how many atoms were in the rock when it solidified?

29. The half-life of iodine-131 is 8.0 days. Your laboratory received 25 μg today but you are not ready to do the experiment yet. Your experiment requires at least 15 μg. How many days do you have to prepare for your experiment?

30. How much energy is released in the decay of radium-223 to radon-219?

${}^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

$m({}^{4}_{2}\text{He}) = 4.002603250$ u

$m({}^{219}_{86}\text{Rn}) = 219.009474832$ u

$m({}^{223}_{88}\text{Ra}) = 223.018497140$ u