Chapter 43: ENERGY FROM THE NUCLEUS

1. If the nucleus of a lead atom were broken into two identical nuclei, the total mass of the resultant nuclei would be:

   A. the same as before
   B. greater than before
   C. less than before
   D. converted into radiation
   E. converted into kinetic energy

   ans: C

2. Consider the following energies:

   1. minimum energy needed to excite a hydrogen atom
   2. energy needed to ionize a hydrogen atom
   3. energy released in ^{235}U fission
   4. energy needed to remove a neutron from a ^{12}C nucleus

   Rank them in order of increasing value.

   A. 1, 2, 3, 4
   B. 1, 3, 2, 4
   C. 1, 2, 4, 3
   D. 2, 1, 4, 3
   E. 2, 4, 1, 3

   ans: C

3. The binding energy per nucleon:

   A. increases for all fission events
   B. increases for some, but not all, fission events
   C. decreases for all fission events
   D. decreases for some, but not all, fission events
   E. remains the same for all fission events

   ans: A

4. When uranium undergoes fission as a result of neutron bombardment, the energy released is due to:

   A. oxidation of the uranium
   B. kinetic energy of the bombarding neutrons
   C. radioactivity of the uranium nucleus
   D. radioactivity of the fission products
   E. a reduction in binding energy

   ans: E

5. The energy supplied by a thermal neutron in a fission event is essentially its:
   A. excitation energy
   B. binding energy
   C. kinetic energy
   D. rest energy
   E. electric potential energy

   ans: B

6. The barrier to fission comes about because the fragments:
   A. attract each other via the strong nuclear force
   B. repel each other electrically
   C. produce magnetic fields
   D. have large masses
   E. attract electrons electrically

   ans: A

7. ^{235}U is readily made fissionable by a thermal neutron but ^{238}U is not because:
   A. the neutron has a smaller binding energy in ^{236}U
   B. the neutron has a smaller excitation energy in ^{236}U
   C. the potential barrier for the fragments is less in ^{239}U
   D. the neutron binding energy is greater than the barrier height for ^{236}U and less than the barrier height for ^{239}U
   E. the neutron binding energy is less than the barrier height for ^{236}U and greater than the barrier height for ^{239}U

   ans: D

8. An explosion does not result from a small piece of ^{235}U because:
   A. it does not fission
   B. the neutrons released move too fast
   C. ^{238}U is required
   D. too many neutrons escape, preventing a chain reaction from starting
   E. a few neutrons must be injected to start the chain reaction

   ans: D

9. When ^{236}U fissions the fragments are:
   A. always ^{140}Xe and ^{94}Sr
   B. always identical
   C. never ^{140}Xe and ^{94}Sr
   D. never identical
   E. none of the above

   ans: E

10. Fission fragments usually decay by emitting:
   A. alpha particles
   B. electrons and neutrinos
   C. positrons and neutrinos
   D. only neutrons
   E. only electrons

   ans: B

11. When ^{236}U fissions, the products might be:
   A. ^{146}Ba, ^{89}Kr, and a proton
   B. ^{146}Ba, ^{89}Kr, and a neutron
   C. ^{148}Cs and ^{85}Br
   D. ^{133}I, ^{92}Sr, and an alpha particle
   E. two uranium nuclei

   ans: B

12. Consider all possible fission events. Which of the following statements is true?
   A. Light initial fragments have more protons than neutrons and heavy initial fragments have fewer protons than neutrons
   B. Heavy initial fragments have more protons than neutrons and light initial fragments have fewer protons than neutrons
   C. All initial fragments have more protons than neutrons
   D. All initial fragments have about the same number of protons and neutrons
   E. All initial fragments have more neutrons than protons

   ans: E

13. Which one of the following represents a fission reaction that can be activated by slow neutrons?
   A. $^{238}\mathrm{U}_{92} + {}^{1}\mathrm{n}_0 \to {}^{90}\mathrm{Kr}_{36} + {}^{146}\mathrm{Cs}_{55} + {}^{2}\mathrm{H}_1 + {}^{1}\mathrm{n}_0$
   B. $^{239}\mathrm{Pu}_{94} + {}^{1}\mathrm{n}_0 \to {}^{96}\mathrm{Sr}_{38} + {}^{141}\mathrm{Ba}_{56} + 3\,{}^{1}\mathrm{n}_0$
   C. $^{238}\mathrm{U}_{92} \to {}^{234}\mathrm{Th}_{90} + {}^{4}\mathrm{He}_2$
   D. $^{3}\mathrm{H}_1 + {}^{2}\mathrm{H}_1 \to {}^{4}\mathrm{He}_2 + {}^{1}\mathrm{n}_0$
   E. $^{107}\mathrm{Ag}_{47} + {}^{1}\mathrm{n}_0 \to {}^{108}\mathrm{Ag}_{47} \to {}^{108}\mathrm{Cd}_{48} + {}^{0}e_{-1}$

   ans: B

14. In the uranium disintegration series:
   A. the emission of a β^- particle increases the mass number A by one and decreases the atomic number Z by one
   B. the disintegrating element merely ejects atomic electrons
   C. the emission of an α particle decreases the mass number A by four and decreases the atomic number Z by two
   D. the nucleus always remains unaffected
   E. the series of disintegrations continues until an element having eight outermost orbital electrons is obtained

   ans: C

15. Separation of the isotopes of uranium requires a physical, rather than chemical, method because:
    A. mixing other chemicals with uranium is too dangerous
    B. the isotopes are chemically the same
    C. the isotopes have exactly the same number of neutrons per nucleus
    D. natural uranium contains only 0.7% ^{235}U
    E. uranium is the heaviest element in nature

    ans: B

16. Which one of the following is NOT needed in a nuclear fission reactor?
    A. Moderator
    B. Fuel
    C. Coolant
    D. Control device
    E. Accelerator

    ans: E

17. The function of the control rods in a nuclear reactor is to:
    A. increase fission by slowing down the neutrons
    B. decrease the energy of the neutrons without absorbing them
    C. increase the ability of the neutrons to cause fission
    D. decrease fission by absorbing neutrons
    E. provide the critical mass for the fission reaction

    ans: D

18. A nuclear reactor is operating at a certain power level, with its multiplication factor adjusted to unity. The control rods are now used to reduce the power output to one-half its former value. After the reduction in power the multiplication factor is maintained at:
    A. 1/2
    B. 1/4
    C. 2
    D. 4
    E. 1

    ans: E

19. The purpose of a moderator in a nuclear reactor is to:
    A. provide neutrons for the fission process
    B. slow down fast neutrons to increase the probability of capture by uranium
    C. absorb dangerous gamma radiation
    D. shield the reactor operator from dangerous radiation
    E. none of the above

    ans: B

20. In a neutron-induced fission process, delayed neutrons come from:
    A. the fission products
    B. the original nucleus just before it absorbs the neutron
    C. the original nucleus just after it absorbs the neutron
    D. the moderator material
    E. the control rods

    ans: A

21. In a nuclear reactor the fissionable fuel is formed into pellets rather than finely ground and the pellets are mixed with the moderator. This reduces the probability of:
    A. non-fissioning absorption of neutrons
    B. loss of neutrons through the reactor container
    C. absorption of two neutrons by single fissionable nucleus
    D. loss of neutrons in the control rods
    E. none of the above

    ans: A

22. In a subcritical nuclear reactor:
    A. the number of fission events per unit time decreases with time
    B. the number of fission events per unit time increases with time
    C. each fission event produces fewer neutrons than when the reactor is critical
    D. each fission event produces more neutrons than when the reactor is critical
    E. none of the above

    ans: A

23. In the normal operation of a nuclear reactor:
    A. control rods are adjusted so the reactor is subcritical
    B. control rods are adjusted so the reactor is critical
    C. the moderating fluid is drained
    D. the moderating fluid is continually recycled
    E. none of the above

    ans: B

24. In a nuclear power plant, the power discharged to the environment:
    A. can be made zero by proper design
    B. must be less than the electrical power generated
    C. must be greater than the electrical power generated
    D. can be entirely recycled to produce an equal amount of electrical power
    E. is not any of the above

    ans: E

25. The binding energy per nucleon:

A. increases for all fusion events
B. increases for some, but not all, fusion events
C. remains the same for some fusion events
D. decreases for all fusion events
E. decreases for some, but not all, fusion events

ans: A

26. To produce energy by fusion of two nuclei, the nuclei must:

A. have at least several thousand electron volts of kinetic energy
B. both be above iron in mass number
C. have more neutrons than protons
D. be unstable
E. be magic number nuclei

ans: A

27. Which one of the following represents a fusion reaction that yields large amounts of energy?

A. $^{238}U_{92} + {}^{1}n_0 \to {}^{90}Kr_{36} + {}^{146}Cs_{55} + {}^{2}H_1 + {}^{1}n_0$
B. $^{239}Pu_{92} + {}^{1}n_0 \to {}^{96}Sr_{38} + {}^{141}Ba_{56} + 3{}^{1}n_0$
C. $^{238}U_{92} \to {}^{234}Th_{90} + {}^{4}He_2$
D. $^{3}H_1 + {}^{2}H_1 \to {}^{4}He_2 + {}^{1}n_0$
E. $^{107}Ag_{47} + {}^{1}n_0 \to {}^{108}Ag_{47} \to {}^{108}Cd_{48} + {}^{0}e_{-1}$

ans: D

28. The barrier to fusion comes about because protons:

A. attract each other via the strong nuclear force
B. repel each other electrically
C. produce magnetic fields
D. attract neutrons via the strong nuclear force
E. attract electrons electrically

ans: B

29. High temperatures are required in thermonuclear fusion so that:

A. some nuclei are moving fast enough to overcome the barrier to fusion
B. there is a high probability some nuclei will strike each other head on
C. the atoms are ionized
D. thermal expansion gives the nuclei more room
E. the uncertainty principle can be circumvented

ans: A

30. For a controlled nuclear fusion reaction, one needs:

A. high number density n and high temperature T
B. high number density n and low temperature T
C. low number density n and high temperature T
D. low number density n and low temperature T
E. high number density n and temperature $T = 0\,\mathrm{K}$

ans: A

31. Most of the energy produced by the Sun is due to:

A. nuclear fission
B. nuclear fusion
C. chemical reaction
D. gravitational collapse
E. induced emfs associated with the Sun's magnetic field

ans: B

32. Nuclear fusion in stars produces all the chemical elements with mass numbers less than:

A. 56
B. 66
C. 70
D. 82
E. 92

ans: A

33. Nuclear fusion in the Sun is increasing its supply of:

A. hydrogen
B. helium
C. nucleons
D. positrons
E. neutrons

ans: B

34. Which of the following chemical elements is not produced by thermonuclear fusion in stars?

A. Carbon ($Z = 6,\ A \approx 12$)
B. Silicon ($Z = 14,\ A \approx 28$)
C. Oxygen ($Z = 8,\ A \approx 16$)
D. Mercury ($Z = 80,\ A \approx 200$)
E. Chromium ($Z = 24,\ A \approx 52$)

ans: D

35. The first step of the proton-proton cycle is:

A. $^1\text{H} + {}^1\text{H} \rightarrow {}^2\text{H}$
B. $^1\text{H} + {}^1\text{H} \rightarrow {}^2\text{H} + e^+ + \nu$
C. $^1\text{H} + {}^1\text{H} \rightarrow {}^2\text{H} + e^- + \nu$
D. $^1\text{H} + {}^1\text{H} \rightarrow {}^2\text{H} + \gamma$
E. $^1\text{H} + {}^1\text{H} \rightarrow {}^3\text{H} + e^- + \nu$

ans: B

36. The overall proton-proton cycle is equivalent to:

A. $2\,{}^1\text{H} \rightarrow {}^2\text{H}$
B. $4\,{}^1\text{H} \rightarrow {}^4\text{H}$
C. $4\,{}^1\text{H} \rightarrow {}^4\text{H} + 4\text{n}$
D. $4\,{}^1\text{H} + 2e^- \rightarrow {}^4\text{He} + 2\nu + 6\gamma$
E. $4\,{}^1\text{H} + 2e^+ \rightarrow {}^4\text{He} + 2\nu + 3\gamma$

ans: D

37. The energy released in a complete proton-proton cycle is about:

A. 3 keV
B. 30 keV
C. 3 MeV
D. 30 MeV
E. 300 MeV

ans: D

38. For purposes of a practical (energy producing) reaction one wants a disintegration energy Q that is:

A. positive for fusion reactions and negative for fission reactions
B. negative for fusion reactions and positive for fission reactions
C. negative for both fusion and fission reactions
D. positive for both fusion and fission reactions
E. as close to zero as possible for both fusion and fission reactions

ans: D

39. Lawson's number is $10^{20}\,\mathrm{s\cdot m^{-3}}$. If the density of deuteron nuclei is $2\times10^{21}\,\mathrm{m^{-3}}$ what should the confinement time be to achieve sustained fusion?

A. 16 ms
B. 50 ms
C. 160 ms
D. 250 ms
E. 500 ms

ans: B

40. Tokamaks confine deuteron plasmas using:

A. thick steel walls
B. magnetic fields
C. laser beams
D. vacuum tubes
E. electric fields

ans: B

41. Most magnetic confinement projects attempt:

A. proton-proton fusion
B. proton-deuteron fusion
C. deuteron-deuteron fusion
D. deuteron-triton fusion
E. triton-triton fusion

ans: C

42. Compared to fusion in a tokamak, laser fusion makes use of:
   A. smaller particle number densities
   B. greater particle number densities
   C. longer confinement times
   D. higher temperatures
   E. lower temperatures

   ans: B

43. Most laser fusion projects attempt:
   A. proton-proton fusion
   B. proton-deuteron fusion
   C. deuteron-deuteron fusion
   D. deuteron-triton fusion
   E. triton-triton fusion

   ans: D

44. In laser fusion, the laser light is:
   A. emitted by the reacting nuclei
   B. used to cause transitions between nuclear energy levels
   C. used to cause transitions between atomic energy levels
   D. used to replace the emitted gamma rays
   E. used to heat the fuel pellet

   ans: E