Chapter 44: QUARKS, LEPTONS, AND THE BIG BANG

1. Which of the following particles is stable?
   A. Neutron
   B. Proton
   C. Pion
   D. Muon
   E. Kaon
   ans: B

2. The stability of the proton is predicted by the laws of conservation of energy and conservation of:
   A. momentum
   B. angular momentum
   C. baryon number
   D. lepton number
   E. strangeness
   ans: C

3. When a kaon decays via the strong interaction the products must include a:
   A. baryon
   B. lepton
   C. strange particle
   D. electron
   E. neutrino
   ans: C

4. A particle with spin angular momentum $\hbar/2$ is called a:
   A. lepton
   B. hadron
   C. fermion
   D. boson
   E. electron
   ans: C

5. A particle with spin angular momentum $\hbar$ is called a:
   A. lepton
   B. hadron
   C. fermion
   D. boson
   E. electron
   ans: D

6. An example of a fermion is a:
   A. photon
   B. pion
   C. neutrino
   D. kaon
   E. none of these

   ans: C

7. An example of a boson is a:
   A. photon
   B. electron
   C. neutrino
   D. proton
   E. neutron

   ans: A

8. All particles with spin angular momentum $\hbar/2$:
   A. interact via the strong force
   B. travel at the speed of light
   C. obey the Pauli exclusion principle
   D. have non-zero rest mass
   E. are charged

   ans: C

9. All leptons interact with each other via the:
   A. strong force
   B. weak force
   C. electromagnetic force
   D. strange force
   E. none of these

   ans: B

10. An electron participates in:
   A. the strong force only
   B. the strong and weak forces only
   C. the electromagnetic and gravitational forces only
   D. the electromagnetic, gravitational, and weak forces only
   E. the electromagnetic, gravitational, and strong forces only

   ans: D

11. Which of the following particles has a lepton number of zero?
   A. e^+
   B. μ^+
   C. ν_e
   D. $\overline{\nu}_\mu$
   E. p

   ans: E

12. Which of the following particles has a lepton number of +1?

A. e^+
B. μ^+
C. μ^-
D. $\overline{\nu}_e$
E. p

ans: C

13. π^+ represents a pion (a meson), μ^- represents a muon (a lepton), ν_e represents an electron neutrino (a lepton), ν_μ and p represents a proton represents a muon neutrino (a lepton). Which of the following decays might occur?

A. $\pi^+ \longrightarrow \mu^- + \nu_\mu$
B. $\pi^+ \longrightarrow p + \nu_e$
C. $\pi^+ \longrightarrow \mu^+ + \overline{\nu}_e$
D. $\pi^+ \longrightarrow p + \overline{\nu}_\mu$
E. $\pi^+ \longrightarrow \mu^+ + \nu_\mu$

ans: E

14. A particle can decay to particles with greater total rest mass:

A. only if antiparticles are produced
B. only if photons are also produced
C. only if neutrinos are also produced
D. only if the original particle has kinetic energy
E. never

ans: E

15. The interaction $\pi^- + p \rightarrow \pi^- + \Sigma^+$ violates the principle of conservation of:

A. baryon number
B. lepton number
C. strangeness
D. angular momentum
E. none of these

ans: C

16. The interaction $\pi^- + p \rightarrow K^- + \Sigma^+$ violates the principle of conservation of:

A. baryon number
B. lepton number
C. strangeness
D. angular momentum
E. none of these

ans: E

17. A neutral muon cannot decay into two neutrinos. Of the following conservation laws, which would be violated if it did?
    A. Energy
    B. Baryon number
    C. Charge
    D. Angular momentum
    E. None of the above

    ans: D

18. A positron cannot decay into three neutrinos. Of the following conservation laws, which would be violated if it did?
    A. Energy
    B. Baryon number
    C. Lepton number
    D. Linear momentum
    E. Angular momentum

    ans: C

19. Two particles interact to produce only photons, with the original particles disappearing. The particles must have been:
    A. mesons
    B. strange particles
    C. strongly interacting
    D. leptons
    E. a particle, antiparticle pair

    ans: E

20. Two baryons interact to produce pions only, the original baryons disappearing. One of the baryons must have been:
    A. a proton
    B. an omega minus
    C. a sigma
    D. an antiparticle
    E. none of these

    ans: D

21. A baryon with strangeness -1 decays via the strong interaction into two particles, one of which is a baryon with strangeness 0. The other might be:
    A. a baryon with strangeness 0
    B. a baryon with strangeness $+1$
    C. a meson with strangeness -1
    D. a meson with strangeness $+1$
    E. a meson with strangeness 0

    ans: C

22. A baryon with strangeness 0 decays via the strong interaction into two particles, one of which is a baryon with strangeness +1. The other might be:

A. a baryon with strangeness 0
B. a baryon with strangeness +1
C. a baryon with strangeness −1
D. a meson with strangeness +1
E. a meson with strangeness −1

ans: E

23. In order of increasing strength the four basic interactions are:

A. gravitational, weak, electromagnetic, and strong
B. gravitational, electromagnetic, weak, and strong
C. weak, gravitational, electromagnetic, and strong
D. weak, electromagnetic, gravitational, and strong
E. weak, electromagnetic, strong, and gravitational

ans: A

24. The two basic interactions that have finite ranges are:

A. electromagnetic and gravitational
B. electromagnetic and strong
C. electromagnetic and weak
D. gravitational and weak
E. weak and strong

ans: E

25. A certain process produces baryons that decay with a lifetime of 4×10^{-24} s. The decay is a result of:

A. the gravitational interaction
B. the weak interaction
C. the electromagnetic interaction
D. the strong interaction
E. some combination of the above

ans: D

26. A certain process produces mesons that decay with a lifetime of 6×10^{-10} s. The decay is a result of:

A. the gravitational interaction
B. the weak interaction
C. the electromagnetic interaction
D. the strong interaction
E. some combination of the above

ans: B

27. Compared to the lifetimes of particles that decay via the weak interaction, the lifetimes of particles that decay via the strong interaction are:

A. 10^{-12} times as long
B. 10^{-23} times as long
C. 10^{24} times as long
D. 10^{12} times as long
E. about the same

ans: A

28. Strangeness is conserved in:

A. all particle decays
B. no particle decays
C. all weak particle decays
D. all strong particle decays
E. some strong particle decays

ans: D

29. Different types of neutrinos can be distinguished from each other by:

A. the directions of their spins
B. the leptons with which they interact
C. the baryons with which they interact
D. the number of photons that accompany them
E. their baryon numbers

ans: B

30. All known quarks have:

A. charges that are multiples of e and integer baryon numbers
B. charges that are multiples of e and baryon numbers that are either $+1/3$ or $-1/3$
C. charges that are multiples of $e/3$ and integer baryon numbers
D. charges that are multiples of $e/3$ and baryon numbers that are either $+1/3$ or $-1/3$
E. charges that are multiples of $2e/3$ and baryon numbers that are either $+1/3$ or $-1/3$

ans: D

31. The baryon number of a quark is:

A. 0
B. 1/2
C. 1/3
D. 2/3
E. 1

ans: C

32. Quarks are the constituents of:

A. all particles
B. all leptons
C. all strongly interacting particles
D. only strange particles
E. only mesons

ans: C

33. Any meson is a combination of:

A. three quarks
B. two quarks and an antiquark
C. one quark and two antiquarks
D. one quark and one antiquark
E. two quarks

ans: D

34. Any baryon is a combination of:

A. three quarks
B. two quarks and an antiquark
C. one quark and two antiquarks
D. one quark and one antiquark
E. two quarks

ans: A

35. The quark content of a proton is:

A. uuu
B. uud
C. udd
D. ddd
E. uds

ans: B

36. The quark content of a π^+ meson is:

A. uu
B. $\mathrm{u\overline{u}}$
C. ud
D. $\mathrm{u\overline{d}}$
E. $\mathrm{\overline{d}d}$

ans: D

37. In terms of quark content a beta decay can be written:

A. $\mathrm{udd} \rightarrow \mathrm{uud} + e^- + \nu$
B. $\mathrm{udd} \rightarrow \mathrm{udd} + \mathrm{d\overline{d}} + \nu$
C. $\mathrm{udd} \rightarrow \mathrm{udd} + \mathrm{d\overline{d}} + e^-$
D. $\mathrm{udd} \rightarrow \mathrm{uud} + \mathrm{u\overline{d}} + \nu$
E. $\mathrm{udd} \rightarrow \mathrm{uud} + \mathrm{u\overline{d}} + e^- + \nu$

ans: A

38. The up quark u has charge $+2e/3$ and strangeness 0; the down quark d has charge $-e/3$ and strangeness 0; the strange quark s has charge $-e/3$ and strangeness -1. This means there can be no baryon with:

A. charge 0 and strangeness 0
B. charge $-e$ and strangeness -1
C. charge $+e$ and strangeness -1
D. charge $+e$ and strangeness -2
E. charge 0 and strangeness $+2$

ans: C

39. The up quark u has charge $+2e/3$ and strangeness 0; the down quark d has charge $-e/3$ and strangeness 0; the strange quark s has charge $-e/3$ and strangeness -1. This means there can be no meson with:

A. charge 0 and strangeness -1
B. charge $-e$ and strangeness -1
C. charge $+e$ and strangeness -1
D. charge $+e$ and strangeness $+1$
E. charge 0 and strangeness $+1$

ans: C

40. Messenger particles of the electromagnetic interaction are called:

A. gluons
B. photons
C. W and Z
D. gravitons
E. pions

ans: B

41. Messenger particles of the strong interaction are called:

A. gluons
B. photons
C. W and Z
D. gravitons
E. pions

ans: A

42. Messenger particles of the weak interaction are called:

A. gluons
B. photons
C. W and Z
D. gravitons
E. pions

ans: C

43. A down quark can be changed into an up quark (plus other particles perhaps) by

A. the gravitational interaction
B. the electromagnetic interaction
C. the weak interaction
D. the strong interaction
E. none of these

ans: C

44. The color theory explains why quarks:

A. form particles in pairs and triplets
B. have charge that is a multiple of $e/3$
C. have spin
D. have mass
E. none of the above

ans: A

45. Color is carried by:

A. only quarks
B. only leptons
C. only quarks and leptons
D. only quarks and gluons
E. only photons and gluons

ans: D

46. Hubble's law is evidence that:

A. the speed of light is increasing
B. the universe is expanding
C. the Earth is slowing down in its orbit
D. galaxies have rotational motion
E. none of the above

ans: B

47. Objects in the universe are receding from us with a speed that is proportional to:

A. the reciprocal of their distance from us
B. the reciprocal of the square of their distance from us
C. their distance from us
D. the square of their distance from us
E. their distance from the center of the universe

ans: C

48. The velocities of distant objects in the universe indicate that the time elapsed since the big bang is about:

A. 10^5 y
B. 10^{10} y
C. 10^{15} y
D. 10^{20} y
E. 10^{25} y

ans: B

49. The intensity of the microwave background radiation, a remnant of the big bang:

A. is greatest in directions toward the center of the galaxy
B. is least in directions toward the center of the galaxy
C. is proportional to the reciprocal of the distance from us
D. is proportional to the square of the distance from us
E. is nearly the same in all directions

ans: E

50. As a result of the big bang there is, in addition to the microwave background radiation, a uniform distribution of background:

A. electrons
B. quarks
C. gluons
D. neutrinos
E. atoms

ans: D

51. Dark matter is suspected to exist in the universe because:

A. the night sky is dark between stars
B. the orbital period of stars in the outer parts of a galaxy is greater than the orbital period of stars near the galactic center
C. the orbital period of stars in the outer parts of a galaxy is less than the orbital period of stars near the galactic center
D. the orbital period of stars in the outer parts of a galaxy is about the same as the orbital period of stars near the galactic center
E. all galaxies have about the same mass

ans: D

52. If dark matter did not exist it is likely that:

A. the universe would expand forever
B. the universe would begin contracting soon
C. the night sky would be brighter
D. the night sky would be darker
E. we would be able to see the center of the universe

ans: A