

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

Section: 44–2; Difficulty: E

2. A particle with spin angular momentum $\hbar/2$ is called a:

- A. lepton
- B. hadron
- C. fermion
- D. boson
- E. electron

ans: C

Section: 44–2; Difficulty: E

3. A particle with spin angular momentum $\hbar$ is called a:

- A. lepton
- B. hadron
- C. fermion
- D. boson
- E. electron

ans: D

Section: 44–2; Difficulty: E

4. An example of a fermion is a:

- A. photon
- B. pion
- C. neutrino
- D. kaon
- E. none of these

ans: C

Section: 44–2; Difficulty: E

5. An example of a boson is a:

- A. photon
- B. electron
- C. neutrino
- D. proton
- E. neutron

ans: A

Section: 44–2; Difficulty: E

6. 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

Section: 44–2; Difficulty: E

7. 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

Section: 44–3; Difficulty: E

8. 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

Section: 44–4; Difficulty: E

9. 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

Section: 44–4; Difficulty: E

10. Which of the following particles has a lepton number of zero?

- A. e^+
- B. μ^+
- C. ν_e
- D. $\bar{\nu}_\mu$
- E. p

ans: E

Section: 44–4; Difficulty: E

11. Which of the following particles has a lepton number of +1?
- A. e^+
 - B. μ^+
 - C. μ^-
 - D. $\bar{\nu}_e$
 - E. p
- ans: C
Section: 44–4; Difficulty: E
12. 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
Section: 44–5; Difficulty: E
13. π^+ represents a pion (a meson), μ^- represents a muon (a lepton), ν_e represents an electron neutrino (a lepton), ν_μ and $\bar{\nu}_\mu$ 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. $\pi^+ \longrightarrow \mu^+ + \bar{\nu}_e$
 - D. $\pi^+ \longrightarrow p + \bar{\nu}_\mu$
 - E. $\pi^+ \longrightarrow \mu^+ + \nu_\mu$
- ans: E
Section: 44–4, 5; Difficulty: M
14. 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
Section: 44–3, 4, 5; Difficulty: M

15. 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
Section: 44–3, 4, 5; Difficulty: M
16. 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
Section: 44–4, 5; Difficulty: E
17. 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
Section: 44–6; Difficulty: E
18. 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
Section: 44–6; Difficulty: E
19. 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
Section: 44–4, 5, 6; Difficulty: M

20. 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
Section: 44–4, 5, 6; Difficulty: M
21. 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
Section: 44–2, 4, 5, 6; Difficulty: M
22. 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
Section: 44–3, 4, 5, 6; Difficulty: M
23. 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
Section: 44–5, 6; Difficulty: M

24. 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
Section: 44-5, 6; Difficulty: M
25. 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
Section: 44-8; Difficulty: E
26. The baryon number of a quark is:
- A. 0
 - B. $1/2$
 - C. $1/3$
 - D. $2/3$
 - E. 1
- ans: C
Section: 44-8; Difficulty: E
27. 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
Section: 44-8; Difficulty: E
28. 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
Section: 44-8; Difficulty: E

29. 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

Section: 44–8; Difficulty: E

30. The quark content of a proton is:
- A. uuu
 - B. uud
 - C. udd
 - D. ddd
 - E. uds

ans: B

Section: 44–8; Difficulty: E

31. The quark content of a π^+ meson is:
- A. uu
 - B. $u\bar{u}$
 - C. $u\bar{d}$
 - D. $u\bar{d}$
 - E. $\bar{d}d$

ans: D

Section: 44–8; Difficulty: E

32. In terms of quark content a beta decay can be written:
- A. $udd \rightarrow uud + e^- + \nu$
 - B. $udd \rightarrow udd + d\bar{d} + \nu$
 - C. $udd \rightarrow udd + d\bar{d} + e^-$
 - D. $udd \rightarrow uud + u\bar{d} + \nu$
 - E. $udd \rightarrow uud + u\bar{d} + e^- + \nu$

ans: A

Section: 44–8; Difficulty: M

33. 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

Section: 44–8; Difficulty: M

34. 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

Section: 44–8; Difficulty: M

35. 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

Section: 44–9; Difficulty: E

36. 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

Section: 44–9; Difficulty: E

37. 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

Section: 44–9; Difficulty: E

38. 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

Section: 44–9; Difficulty: E

39. 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

Section: 44–9; Difficulty: E

40. Messenger particles of the electromagnetic interaction are called:
- A. gluons
 - B. photons
 - C. W and Z
 - D. gravitons
 - E. pions

ans: B

Section: 44–9; Difficulty: E

41. Messenger particles of the strong interaction are called:
- A. gluons
 - B. photons
 - C. W and Z
 - D. gravitons
 - E. pions

ans: A

Section: 44–9; Difficulty: E

42. Messenger particles of the weak interaction are called:
- A. gluons
 - B. photons
 - C. W and Z
 - D. gravitons
 - E. pions

ans: C

Section: 44–9; Difficulty: E

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

Section: 44–9; Difficulty: E

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

Section: 44–9; Difficulty: E

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

Section: 44–9; Difficulty: E

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

Section: 44–11; Difficulty: E

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

Section: 44–11; Difficulty: E

48. 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
Section: 44–12; Difficulty: E
49. 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
Section: 44–12; Difficulty: E
50. 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
Section: 44–13; Difficulty: E
51. 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
Section: 44–13; Difficulty: E

52. 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

Section: 44–14; Difficulty: E