Name Answer Key Date ____________

Honors Physics Modern WS #7H

Period ____________ Mrs. Nadworny

Standard Model

Directions: Read textbook pages 840 – 847. Solve the following problems using the GUESS method and proper significant figures. Be sure to show ALL work.

1. According to the Standard Model of Particle Physics, a neutrino is a type of

   (A) lepton (B) meson (C) photon (D) baryon

2. Which combination of quarks produces a neutral baryon?

   (A) cts (B) uds (C) dsb (D) uct

3. The quarks that compose a baryon may have charges of

   (A) $+\frac{2}{3}e, +\frac{2}{3}e, \text{and} -\frac{1}{3}e$ (C) $-1e, -1e, \text{and } 0$

   (B) $+\frac{1}{3}e, -\frac{1}{3}e, \text{and } +\frac{2}{3}e$ (D) $+\frac{2}{3}e, +\frac{2}{3}e, \text{and } 0$

4. What is the quark composition of a proton?

   (A) uud (B) udd (C) csb (D) uds

5. An antibaryon composed of two antiup quarks and one antidown quark would have a charge of

   (A) +1e (B) 0e (C) -1e (D) -3e

6. The composition of a meson with a charge of −1 elementary charge could be

   (A) $s\bar{c}$ (B) dss (C) $u\bar{b}$ (D) $\bar{u}\bar{c}b$

7. Compared to the mass and charge of a proton, an antiproton has

   (A) the same mass and the same charge (C) the same mass and the opposite charge

   (B) greater mass and the same charge (D) greater mass and the opposite charge

Tritium is a radioactive form of the element hydrogen. A tritium nucleus is composed of one proton and two neutrons. When a tritium nucleus decays, it emits a beta particle (an electron) and an antineutrino to create a stable form of helium. During beta decay, a neutron is spontaneously transformed into a proton, an electron, and an antineutrino.

8. What fundamental interaction is responsible for binding together the protons and neutrons in a helium nucleus?

   Strong nuclear force

9. What is the total number of quarks in a tritium nucleus?

   p + n + n = uud + udd + udd = 9

10. What is the total charge, in elementary charges, of a proton, an electron, and an antineutrino?

    +1e, -1e, 0

Continued on next page

Two experiments running simultaneously at the Fermi National Accelerator Laboratory in Batavia, Ill., have observed a new particle called the cascade baryon. It is one of the most massive examples yet of a baryon—a class of particles made of three quarks held together by the strong nuclear force—and the first to contain one quark from each of the three known families, or generations, of these elementary particles. Protons and neutrons are made of up and down quarks, the two first-generation quarks. Strange and charm quarks constitute the second generation, while the top and bottom varieties make up the third. Physicists had long conjectured that a down quark could combine with a strange and a bottom quark to form the three-generation cascade baryon. On June 13, the scientists running Dzero, one of two detectors at Fermilab's Tevatron accelerator, announced that they had detected characteristic showers of particles from the decay of cascade baryons. The baryons formed in proton-antiproton collisions and lived no more than a trillionth of a second. A week later, physicists at CDF, the Tevatron's other detector, reported their own sighting of the baryon...
Source: D.C., "Pas de deux for a three-scoop particle," Science News, Vol. 172, July 7, 2007

11. Which combination of three quarks will produce a neutron?

udd

12. What is the magnitude and sign of the charge, in elementary charges, of a cascade baryon?

-1e

13. The Tevatron derives its name from teraelectronvolt, the maximum energy it can impart to a particle. Determine the energy, in joules, equivalent to 1.00 teraelectronvolt.

$$1.00\text{ TeV} = \left(\frac{10^{12}\text{ eV}}{1\text{ TeV}}\right)\left(\frac{1.60 \times 10^{-19}\text{ J}}{1\text{ eV}}\right) = 1.60 \times 10^{-7}\text{ J}$$

14. Calculate the maximum total mass, in kilograms, of particles that could be created in the head-on collision of a proton and an antiproton, each having an energy of 1.60×10^{-7} joule.

$$E = mc^2$$
$$m = \frac{E}{c^2}$$
$$m = \frac{2\,(1.60 \times 10^{-7}\text{ J})}{(3.00 \times 10^8\text{ m/s})^2}$$

or

$$E = mc^2$$
$$m = \frac{E}{c^2}$$
$$m_{total} = m + m_p + m_{\bar{p}}$$
$$m_{total} = \frac{E}{c^2} + m_p + m_{\bar{p}}$$
$$m_{total} = \frac{2\,(1.60 \times 10^{-7}\text{ J})}{(3.00 \times 10^8\text{ m/s})^2} + 1.67 \times 10^{-27}\text{ kg} + 1.67 \times 10^{-27}\text{ kg}$$

(m_p) mass of proton

$(m_{\bar{p}})$ mass of antiproton

$m = 3.56 \times 10^{-24}$ kg

Answers in size order: -1, -1, 3.56×10^{-24}, 1.60×10^{-7}, 0, +1, 9