

Name Answer Key
Honors Physics
Period _____



Date _____
Modern WS #4H
Mrs. Nadworny

The Standard Model

Directions: Read online textbook pages 896 – 901 & 917 – 925. Then go to <http://www.particleadventure.org>, under “The Standard Model” click “GO!” to begin. Use the arrows in the top right corner to work your way through the information. Answer the following questions to the best of your ability, using the information from the website. This website uses pop-ups. It is best viewed with Internet Explorer.

1. Define fundamental:

Objects that are simple and structure-less. They are not made up of anything smaller.

2. In ancient times, people believed that the world was made of 4 elements. List them

Air, Fire, Water and Earth

3. Why is the term “atom” a misnomer?

The Greek root for the word atom “atomon” means “that which cannot be divided” but atoms are made of other, smaller particles.

4. Are atoms fundamental?

No, they are made of simpler building blocks

5. The nucleus is made of **protons** and **neutrons**.

6. The fundamental particles that make up protons and neutrons are called **quarks**.

7. Describe the modern atom model:

Electrons are in constant motion around the nucleus. Protons and neutrons jiggle within the nucleus. Quarks jiggle within the protons and neutrons.

8. A rough estimate of the size of a quark is 10^{-18} m.

9. The Standard Model explains

What the world is and what holds it together.

10. List the three main parts of the Standard Model

6 quarks, 6 leptons, force carrier particles.

11. The hundreds of particles known to human kind are made up of how many fundamental particles?

6 quarks, 6 anti-quarks, 6 leptons, 6 anti-leptons and force carriers

12. For each type of **matter particle** there exists a corresponding **anti-matter particle or anti-particle**

13. What happens when a matter particle and an antimatter particle collide?

They annihilate into pure energy.

14. The electron is a matter particle. The **positron** is the antimatter particle of the electron.

15. Why is there more matter than antimatter in the universe?

We don't know!

16. The quark exists in 3 pairs. List the three pairs AND their charge.

Up $+2/3 e$ + Down $-1/3 e$

Charm $+2/3 e$ + Strange $-1/3 e$

Top $+2/3 e$ + Bottom $-1/3 e$

17. The top quark was discovered in **1995**-

18. The word QUARK comes from what author? What book?

James Joyce – Finnegan's Wake

19. What is unusual about the charge of quarks?

They have fractional charge and color charge

20. Composite particles made of quarks are called **hadrons** which always have a(n) **integer** charge.

21. Baryons contain **3 quarks**

22. A proton is a baryon made up of what combination of 3 quarks? **2 up + 1 down**

23. A neutron is a baryon made up of what combination of 3 quarks? **1 up + 2 down**

24. Mesons contain **one quark and one anti-quark**
25. Mesons are unstable because
they contain a particle and an anti-particle, which have the possibility of annihilating each other.
26. The best known lepton is **the electron**
27. The other two charged leptons are called **muon** and **tau**
28. The three neutral leptons are called **neutrinos**
29. Quarks and leptons are both fundamental particles. A difference between them is
Quarks are sociable and only exist in composite particles with other quarks, whereas leptons are solitary particles
30. We don't see heavy leptons, tau and muon, in ordinary matter because
when they are produced they very quickly decay, or transform, into lighter leptons.
31. Since neutrinos have no **electrical** or **strong charge**, they rarely interact with other particles.
32. What are protons made of? **2 up quarks and 1 down quark (uud)**
33. What are electrons made of? **nothing**
34. List the four fundamental interactions that occur between particles
Attractive, repulsive, decay, annihilation
35. The particles which carry interactions are called **force carrier particles**
36. At a fundamental level, a force is a thing which **is passed between two particles.**
37. In the animated diagram of the two people on the ice pond, the repulsive force is provided by passing a basketball back and forth. The basketball acts like a **“force carrier particle”**

This is an example of Newton's **Third** Law, which states that “For every **action there is an equal and opposite reaction.**”
38. The electromagnetic force causes **like charges** to repel and **opposite charges** to attract.

39. The carrier particle for the electromagnetic force is the **photon**.

40. Photons have **zero** mass and travel at the speed of **light**.

41. The **residual electromagnetic force** allows atoms to bond and form molecules.

42. What force keeps the positive protons in the nucleus from exploding apart?

Strong nuclear force (color charge)

43. The force carrier particles of the strong force are called **gluons** because they hold quarks tightly together.

SKIP PAGES ABOUT COLOR CHARGE (Pick up again at the Residual Strong Force page)

44. In the nucleus, the **strong** force between quarks is big enough to overcome the repulsive electromagnetic force.

45. Weak interactions are responsible for

the decay of massive quarks and leptons into lighter quarks and leptons

46. The carrier particles for the weak interaction are **w⁺, w⁻** and **z**

47. In the Standard Model the weak and electromagnetic interactions have been combined into a unified **electroweak** theory.

48. The predicted force carrier particle for gravity is called the **graviton**.

Comparative strength of the 4 forces: Strong >> Electromagnetic, Weak >> Gravity

49. Which of the four forces is responsible for

- a. Friction? **Residual electromagnetic interactions**
- b. Nuclear bonding (holding a nucleus together)? **Residual strong interactions between various parts of the nucleus**
- c. Planetary orbits? **Gravity attracts them to the sun.**