Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Study Guide for “The Particle Adventure – The Standard Model” Period\_\_\_\_\_\_\_\_\_\_\_\_\_   
http://www.particleadventure.org/  
  
After accessing The Particle Adventure website, enter “The Standard Model” tutorial. Start at the beginning. Use the blue arrows and home button at the upper right of the app to navigate. Answer all questions.

1. What does fundamental mean?
2. Is the atom fundamental? Explain.
3. Is the nucleus fundamental? Explain.
4. Are protons and neutrons fundamental? Explain.
5. What are the truly fundamental particles that make up an atom according to the modern atom model?
6. The nucleus is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ times smaller than the diameter of an atom. Quarks and electrons are definitely smaller than \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ meters and might literally be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, but we do not know for sure.
7. In our attempts to study the structure of atoms, we have discovered over \_\_\_\_\_\_\_\_\_\_\_\_\_\_ different subatomic particles, but most of them are not \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
8. According to the Standard Model, all subatomic particles and their interactions can be explained using the following fundamental particles: six \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, six \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles.
9. For each kind of matter particle (quarks and leptons) there is a corresponding \_\_\_\_\_\_\_\_\_\_\_\_\_\_ particle.
10. Antiparticles look and behave just like their corresponding matter particles, except they have opposite \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
11. When a matter particle and an antimatter particle meet, they \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ into pure \_\_\_\_\_\_\_\_\_\_\_\_\_\_.
12. Why is there so much more matter in the universe than antimatter? Do we know?
13. There are **six quarks**, but physicists usually talk about them in terms of three pairs: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
14. Quarks have the unusual characteristic of having a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ electric charge, unlike the proton and electron, which have integer charges of \_\_\_\_\_ and \_\_\_\_\_ respectively. However, they combine in such a way that resulting particles have net \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ charge.
15. Another word used to describe “kinds” of quarks is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
16. Composite particles made of quarks are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
17. Hadrons made up of three quarks are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Hadrons made up of two quarks (one quark and one \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
18. Protons are baryons made up of two \_\_\_\_\_\_\_\_\_\_\_\_\_\_ quarks and one \_\_\_\_\_\_\_\_\_\_\_\_\_\_ quark.
19. Neutrons are baryons made up of two \_\_\_\_\_\_\_\_\_\_\_\_\_ quarks and one \_\_\_\_\_\_\_\_\_\_\_\_\_\_ quark.
20. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ appear to be point-like particles without internal structure. The best known lepton is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
21. A special type of lepton with very little mass and zero electrical charge is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
22. Quarks are sociable and only exist in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles with other quarks, whereas leptons are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles and can exist independently of atoms or other leptons.
23. The “anti-electron” has a special name, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
24. The heavier leptons, the \_\_\_\_\_\_\_\_\_\_\_\_\_ and the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, are not found in ordinary matter at all. This is because when they are produced they very quickly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, or transform, into lighter leptons. Electrons and the three kinds of neutrinos are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and thus the types we commonly see around us.
25. When a heavy lepton decays, one of the particles it decays into is always its corresponding \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. The number of members in each lepton-neutrino family must remain \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in a decay.
26. Most neutrinos pass right through the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ without ever interacting with a single atom. Neutrinos were discovered through careful study of radioactive \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.