Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
Study Guide for “The Particle Adventure – The Standard Model” Part 2 Period\_\_\_\_\_\_\_\_\_\_\_\_\_
http://www.particleadventure.org/

After accessing The Particle Adventure website, enter “The Standard Model” tutorial. Click on the tab marked “What Holds It Together?” and begin with “The Four Interactions.” Use the blue arrows and home button at the upper right of the app to navigate. Answer all questions.

1. The interactions between fundamental particles include \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and annihilation.
2. All the observable phenomena in the universe are caused by these four \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between fundamental particles.
3. A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the effect on a particle due to the presence of other particles.
4. At a fundamental level, a force isn't just “something that happens” to particles. It is a thing which is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ two particles.
5. All interactions which affect matter particles are due to an exchange of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles, a different type of particle altogether. These particles are like basketballs tossed between matter particles (which are like the basketball players). What we normally think of as "\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ " are actually the effects of force carrier particles on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles.
6. A particular force carrier particle can only be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ by a matter particle which is affected by that particular force. As an example, electrons and protons have electric charge, so they can produce and absorb the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force carrier, the photon.
7. Photons have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mass and as far as we know, always travel at the speed of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
8. The charged electrons in one atom are attracted to the oppositely charged \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in other atoms, which helps them bond to one another. This effect is called “residual \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force.”
9. What binds the liked-charged particles in the nucleus together – why doesn’t it blow apart? The quarks exchange \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ , which are carriers of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force which binds quarks together. In addition to electric charge, quarks also carry \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ charge, which activates the strong force.
10. The color force field that binds the quarks together gets \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as the quarks get further apart. (Most force fields get weaker with increasing distance.)
11. The "color charge" has nothing to do with the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, it is just a convenient naming convention.
12. Color charged particles such as quarks are always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with other quarks (such as baryons and mesons). In these composite particles, the color charges always add to zero: this is called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_. Combinations of quarks that are not color neutral states are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ observed.
13. The strong force between the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in one proton and the quarks in another \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is strong enough to overwhelm the repulsive \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ force. This is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and it is what "glues" the nucleus together.
14. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are responsible for the decay of massive quarks and leptons into lighter quarks and leptons. The carrier particles of the weak interactions are the \_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_ , and \_\_\_\_\_\_\_\_\_ particles.
15. When fundamental particles \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, we observe the particle \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and being replaced by two or more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles. Some of the original particle's mass is converted into \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and the resulting particles always have less mass than the original \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that decayed.
16. The Standard Model has united electromagnetic interactions and weak interactions into one unified interaction called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
17. A force-carrying particle for gravity has been predicted, but has not been found. It is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. The effects of gravity are extremely \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in most particle physics situations compared to the other three interactions so it is generally negligible.
18. (The Pauli Exclusion Principle) This principle states that that no two particles in the same quantum state could exist in the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ at the same time. Particles that obey the PEP are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and have \_\_\_\_\_\_\_\_\_\_\_\_\_ inter spin. Particles that violate the PEP (and can have multiple particles together, all in the same quantum state) are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and have \_\_\_\_\_\_\_\_\_\_\_\_\_\_ integer spin.
19. The most well-known example of a fermion is the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. All of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ particles are bosons.