

ATAR Physics

Year 12 2019

**Task 8:**

**Standard Model Research and Evaluation Validation**

Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Time allowed for this task: 60 minutes

Mark: \_\_\_\_\_\_\_\_\_\_ out of 60

I acknowledge that all the information contained in this task is my own work and not taken from other sources. If other sources have been used they have been acknowledged in my references.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Student Signature)

Teacher Comments:

Use your Research notes to complete the following questions. The notes must be submitted at the end of the assessment with this paper. All answers are to be written on the answer sheet provided.

**Multiple Choice**

1. Current thought is that all matter is composed of:
2. six quarks and six leptons.
3. six quarks.
4. six quarks and four leptons.
5. four quarks and six leptons.
6. What is the name of the group of particles which make up all matter?
7. Fermions
8. Bosons
9. Baryons
10. Quarks
11. What is the name given to the six types of matter particles including electrons which can exist on their own?
12. Baryons
13. Fermions
14. Leptons
15. Quarks
16. What is the name given to the group of particles that mediate forces?
17. Leptons
18. Baryons
19. Fermions
20. Bosons
21. What are the four fundamental forces of nature in order of increasing strength?
22. Weak, Gravity, Strong and Electromagnetic
23. Gravity, Weak, Electromagnetic and Strong
24. Electromagnetic, Weak, Strong and Electromagnetic
25. Electromagnetic, Gravity, Weak, and Strong
26. What is the strong force responsible for?
27. Particle decay
28. Holding the particles inside baryons and mesons together
29. Attraction and repulsion between charges
30. Pulling masses together
31. An antibaryon composed of two antiup quarks and one antidown quark would have a charge of
32. +1
33. 0
34. −1
35. −3
36. Which of the following is not conserved in a nuclear reaction?
37. nucleon number.
38. baryon number.
39. charge.
40. All of the above are conserved.

1. Particles that interact by the strong force are called
2. leptons.
3. hadrons.
4. muons.
5. electrons.

1. At the present time, the elementary matter particles are considered to be the
2. photons and baryons.
3. leptons and quarks.
4. baryons and quarks.
5. baryons and leptons.

1. The electron and muon are both
2. hadrons.
3. leptons.
4. baryons.
5. mesons.

1. Particles that make up the family of hadrons are
2. baryons and mesons.
3. leptons and baryons.
4. protons and electrons.
5. muons and leptons.
6. Which of the following is a particle-antiparticle pair?
7. proton -- positron
8. proton -- neutron
9. neutron -- neutrino
10. electron – positron
11. When an electron annihilates with a positron, the amount of energy released is equal to the
12. total rest mass of the electron and the positron.
13. rest mass of the electron.
14. rest mass of the positron.
15. binding energy of the hydrogen atom.
16. The neutrino interacts with the world primarily through the \_\_\_\_\_\_\_ force.
17. strong
18. electromagnetic
19. weak
20. gravitational
21. What is the exchange particle for the electromagnetic interaction?
22. Graviton
23. Gluon
24. W & Z
25. photon
26. Which of the following do NOT participate in the strong interaction?
27. hadrons
28. leptons
29. baryons
30. mesons
31. Which one of the following is NOT a member of the lepton family?
32. electron
33. muon
34. proton
35. neutrino
36. What type particle is most likely made up of two down antiquarks and one up antiquark?
37. neutrino
38. proton
39. antiproton
40. antineutron
41. Which of the following is NOT considered to be elementary?
42. neutrino
43. muon
44. neutron
45. quark
46. It is known that protons and neutrons are made up of smaller particles called quarks, and that one mole of Carbon 12 with a mass of 12.0 g, contains 6.02x1023 atoms of carbon.  
      
    What is the approximate number of quarks in 1.00 g of carbon-12?
47. 6x1023
48. 9x1023
49. 1.8x1024
50. 2.16x1025
51. An antiproton is an atomic particle that has
52. the mass of a proton and the charge of an electron.
53. the mass of an electron and the charge of a proton.
54. the mass of a neutron and the charge of a proton.
55. the mass of an electron and the charge of a positron.
56. The gluon is the force carrier for:
57. Strong force
58. Weak force
59. Gravity
60. Electromagnetic force
61. Which of the four fundamental forces has the shortest range?
62. Strong
63. Weak
64. Electromagnetism
65. Gravity

1. Given the properties of the up and down quarks and of the proton, what combination of quarks makes up a proton?

1. uuu
2. uud
3. udd
4. ddd

**END OF MULTIPLE CHOICE SECTION**

**PROCEED TO WRITTEN QUESTIONS ON ANSWER SHEET**

Use your Research notes to complete the following questions. The notes must be submitted at the end of the assessment with this paper.

**Written Section**

1. An exotic hadron, initially seen over 40 years ago, has recently been confirmed at the European Organization for Nuclear Research (CERN). The Z(4430) particle consists of four quarks: a charm, an anti-charm, a down, and an anti-up. In the space below, determine the charge of the Z (4430) particle.

**(2)**

1. The table below contains information about some subatomic particles. Complete the last column of the table by writing baryon, meson or lepton to indicate the group of particles to which the individual particle belongs.

|  |  |  |  |
| --- | --- | --- | --- |
| **Particle** | **Quark structure** | **Decay products** | **Baryon, meson or lepton** |
| Lambda | charm, up, down | proton, pion, kaon |  |
| Tau | none | tau neutrino, electron, electron anti-neutrino |  |
| Kaon+ | strange, charm | muon and muon neutrino |  |
| Xi | up, strange, strange | lambda and pion |  |

**(4)**

1. The most common isotope of Lithium is Lithium 7 (atomic number 3). How many of each of the following items are found in **one** of these atoms?

|  |  |
| --- | --- |
| **Particle** | **Number found in atom of Lithium 7** |
| Electrons |  |
| Baryons |  |
| Hadrons |  |
| Neutrons |  |
| Leptons |  |
| Quarks |  |

**(6)**

1. All hadrons are composed of different combinations of fundamental particles called quarks.

All quarks have a baryon number of ; whilst all antiquarks have a baryon number of .

1. A Pion “π” is a type of hadron which can be further classified as a meson. Use Baryon numbers to determine the baryon number of a “Pion”.

**(2)**

Baryon number **must** be conserved in all reactions.

1. Determine, by applying conservation of baryon number, whether the following reaction can take place. Justify your answer with appropriate workings.

Proton + neutron → proton + pion

**(2)**

**30. a)** The Standard Model explains three of the four fundamental forces in terms of an exchange of force-carrying particles called gauge bosons. Complete the first four columns of the table below for the four forces. Gravity is completed as an example. **(3)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Force | Nature of force | Range over which force acts (m) | Force carrier  (gauge bosons) | Rank |
|  | causes radioactive decay | 10−18 | W+, W− and Z |  |
|  | responsible for both electric and magnetic fields exerting forces of attraction or repulsion | infinite |  |  |
|  |  | ~10−15 |  |  |
| gravity | a force of attraction between any two objects with mass | infinite | graviton  (theoretical and unobserved) |  |

In the final column of the table, rank these four fundamental forces in order of their strength from strongest (1) to weakest (4). **(1)**

**31.** Baryon number **must** be conserved in all reactions.

The tables below give symbols of common leptons (left) and hadrons (right) as well as their antiparticles.

|  |  |  |
| --- | --- | --- |
| **Lepton** | **Lepton symbol** | **Antilepton symbol** |
| Electron |  |  |
| Electron neutrino |  |  |
| Muon |  |  |
| Muon neutrino |  |  |
| Tau |  |  |
| Tau neutrino |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Symbol** | **Antiparticle symbol** |
| Mesons | pion | π+ | π− |
| π° | π° |
| Baryons | proton | p |  |
| neutron | n |  |
| lambda | Λ° |  |
| sigma | Σ° |  |

1. Complete the particle interactions indicated below. Explain your choice of particle.

**i**  **(3)**

|  |
| --- |
|  |
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**ii**  **(4)**

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| --- |
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|  |

**32 a)** A meson of rest mass 2.4 × 10−28 kg travels at 0.85c.

Calculate the meson’s kinetic energy at this speed.

**(3)**

**b)** If while travelling at this speed the meson decays completely to electromagnetic radiation, what energy is released with the radiation?

**(2)**

**c)** Physicists observing the meson whilst moving through the CERN Large Hadron Collider at 0.85c, normally record a half-life of 2.6×10−7 s as it decays into energy. How long would physicists observe this process to take if they were looking at a stationary meson?

**(3)**