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| Year 12 – Evaluation and Analysis Research Assessment  *The Standard Model* |
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| **Multiple Choice Question Booklet** |

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.

**PLEASE DO NOT MARK THIS BOOKLET**

**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**

**GO ON AND COMPLETE WRITTEN QUESTIONS ON ANSWER SHEET**

**Written Section**

1. Charge: 2/3 - 2/3 – 1/3 -2/3 = -1

(2)

27.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Description** |  | **Marks** |
| baryon |  |  | 1 |
| lepton |  |  | 1 |
| meson |  |  | 1 |
| baryon |  |  | 1 |
|  |  | **Total** | **4** |

28

Electrons – 7 3

Baryons – 7

A **baryon** is a composite subatomic particle made up of three quarks

Hadrons – 7

a subatomic particle of a type including the baryons and mesons, which can take part in the strong interaction.

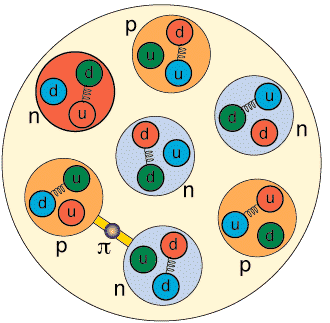
Neutrons – 4

Leptons – 3

Quarks - 21

## Quark Content of Lithium-7

If we look more closely, we will notice that the protons and neutrons (nucleons) are made up of quarks interacting via gluon exchange. This is shown schematically in the picture below.



29 a

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Description** |  | **Marks** |
| +1/3 – 1/3 = 0 |  |  | 1 |
|  |  | **Total** | **1** |

b

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Total baryon number on LHS = 1 +1 = 2 | 1 |
| Total baryon number of RHS = 1 + 0 = 1 | 1 |
| Reaction **cannot** occur as baryon number before and after reaction is not conserved. | 1 |
| **Total** | **3** |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Force | Nature of force | Range over which force acts (m) | Force carrier  (gauge bosons) | Rank |
| weak nuclear (½) | causes radioactive decay | 10−18 | W+, W− and Z | 3 |
| electromagnetic(½) | responsible for both electric and magnetic fields exerting forces of attraction or repulsion | infinite | photon(½) | 2 |
| strong nuclear(½) | **acts between quarks and holds the nucleus of atoms together** (½) | ~10−15 | gluon (½) | 1 |
| gravity | a force of attraction between any two objects with mass | infinite | graviton  (theoretical and unobserved) | 4 |

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

|  |  |
| --- | --- |
| Description | Marks |
| Muon neutrino | 1 |
| Baryon No 0 🡪 0 + 0 + 0 ✓  Lepton No (electrons) 0 🡪 1 + -1 + 0 ✓  Lepton No (muons) 1 🡪 0 + 0 + 1 ✓  Charge -1 🡪 -1 + 0 + 0 ✓ YES  or written explanation | 1-2 |

**ii**  **(4)**

|  |  |
| --- | --- |
| Description | Marks |
| Antipion π− | 1 |
| Baryon No 1 + 0 🡪 1 + 0 + 0 ✓  Lepton No (electrons) 0 + 0 🡪 0 + 1 + -1 ✓  Charge 1 + -1 🡪 1 + -1 + 0 ✓ YES  or written explanation | 1-3 |
| After the reaction, the lepton number = 0, so the missing reactant can’t be a lepton. Must be negatively charged to balance electron. Cannot be a Baryon as this would unbalance baryon number |  |

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

Calculate the meson’s kinetic energy at this speed.

|  |  |
| --- | --- |
| Description | Marks |
| Mass of meson at 085*c*: | 1 |
| *E*k = γ*m*o*c*2 − *m*o*c*2 can be done using RELATIVISTIC mc2 – REST. | 1 |
| *i.e. E*k = 4.10X10-11 – mc2 |  |
| *E*k = (γ*m*o − *m*o)*c*2 = (4.56 × 10−28 − 2.4 × 10−28)*c*2  **= 1.94 × 10−11 J** | 1 |

**(3)**

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

|  |  |
| --- | --- |
| Description | Marks |
| *E*t = γ*m*o*c*2 | 1 |
| *E*t = γ*m*o*c*2 = 4.56 × 10−28 × (3 × 108)2 = 4.1 × 10−11 J | 1 |

**(2)**

1. 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?

|  |  |
| --- | --- |
| Description | Marks |
|  |  |
|  | 1 |
|  | 1 |
|  | 1 |

**(3)**