Higher Physics

# Unit 2 : PARTICLES & WAVES

## The Standard Model Answers

### Orders of Magnitude

1. A – Electron B – Proton C – Nucleus D – Neutron

2.

| Order of magnitude (m) | Object |
|---|---|
| $10^{-15}$ | Diameter of proton |
| $10^{-14}$ | Diameter of nucleus |
| $10^{-10}$ | Diameter of hydrogen atom |
| $10^{-4}$ | Size of dust particle |
| $10^{0}$ | Your height |
| $10^{3}$ | Height of Ben Nevis |
| $10^{7}$ | Diameter of Earth |
| $10^{9}$ | Diameter of the Sun |
| $10^{13}$ | Diameter of Solar System |
| $10^{21}$ | Distance to nearest galaxy |

3. D

4. C

5. C

6. A

7. E

8. 1000 km/100 m = 1000000/100 = 100000 = $10^4$

   The distance from Paris to Berlin is 4 orders of magnitude greater than the length of the running track.

9. 1000 kg/10 g = 1000000/10 = 100000 = $10^5$

   The mass of the bison is 5 orders of magnitude greater than the mass of the mouse.

# Unit 2 : PARTICLES & WAVES

## The Standard Model Answers

10. 7000 kg/85 kg = 82.4 ≅ 100 = $10^2$

The mass of the African Bush elephant is 2 orders of magnitude greater than the mass of Mr McFarlane.

11. 8848 m/76 m = 116.4 ≅ 100 = $10^2$

The height of Mount Everest is 2 orders of magnitude greater than the height of a Redwood tree.

12. $4.83 \times 10^{30}$ kg/$5.69 \times 10^{27}$ kg = 848.9 ≅ 1000 = $10^3$

The mass of the star is 3 orders of magnitude greater than the mass of the exoplanet.

13. $2.2 \times 10^{-25}$ kg/$9.1 \times 10^{-31}$ kg = $2.4 \times 10^5$

The mass of the Higgs Boson is 5 orders of magnitude greater than the mass of an electron.

### The Standard Model

1. (a) Proton (b) Antiproton (c) Electron

   (d) Antielectron (e) Neutrino (f) Antineutrino

2. This observation provides evidence of antimatter.

# Unit 2 : PARTICLES & WAVES

## The Standard Model Answers

3. (a) Fundamental particles are particles that cannot be broken down any further.

   (b) Fermions is the name given to the group of matter particles that contains both quarks and leptons.

4.

| Quarks | Leptons |
|---|---|
| bottom | electron |
| charm | electron neutrino |
| down | muon |
| strange | muon neutrino |
| top | tau |
| up | tau neutrino |

5. (a) Leptons are particles that are acted upon by the weak nuclear force, but not the strong nuclear force, whereas hadrons are particles that are acted upon by both the weak and strong nuclear force.

   (b) Examples of leptons – electrons, electron neutrino, muon, muon neutrino, tau, tau neutrino
   Examples of hadrons – baryons like the proton or neutron or mesons like pion

6. Baryons are hadrons which are made up of three quarks. However there are other hadrons called mesons. Mesons are made up of two quarks (one quark and one antiquark). So not all hadrons are baryons. Some hadrons are mesons.

7. (a) +1e (+1.6 x 10-19 C) (b) 0e (0 C)

   (c) -1e (-1.6 x 10-19 C) (d) 0e (0 C)

# Unit 2 : PARTICLES & WAVES

## The Standard Model Answers

8. (a) There are three quarks in each neutron and each proton.

   (b) A neutron contains one up quark and two down quarks to give a net charge of 0 and a proton is made up two up quarks and one down quark to give an overall charge of +1.

9. (a) The strong nuclear force holds quarks together to form hadrons and has arrange of less than $10^{-15}$ m and the weak nuclear force is involved in decay and acts over a distance of $10^{-18}$ m.

   (b) Beta decay is an example of particle decay associated with the weak nuclear force.

   (c) The strong nuclear force acts over a greater distance.

10. In a radioactive nucleus, a neutron at rest decays and emits a proton and a fast moving electron (a beta particle). The fact that the law of conservation of momentum is not observed when considering the resulting products infers the presence of another particle – an antineutrino (the neutrino).

11. (a) Leptons and quarks are known as fundamental particles as they cannot be broken down any further.

    (b) (i) The photon is the boson associated with the electromagnetic force.
    (ii) The gluon is the mediating particle for he strong nuclear force.

    (c) The gluon cannot be the force mediating particle for the gravitational force because the gluon is associated with the strong nuclear force which has only a range of $10^{-15}$ m whereas the gravitational force acts over very large distances.

    (d) A strange quark has a charge of -1/3 e.