Mark scheme for Support Worksheet – Option J, Worksheet 2

1 If the mass of the particle produced is *m* then at the very minimum the energy required is $2mc^2$; since the mass of the electron is much less than *m*, to balance total energy a lot of kinetic energy must be provided. [2]

2 The photomultiplier is a sensitive detector of photons (photons cause the ejection of electrons i.e. create an electric current and the photomultiplier increases the current by having electrons cause ejection of even more electrons). [1]

3 The main function of the wire chamber is to establish the position of a particle by timing the arrival of ions caused by the particle at a wire mesh kept at high voltage; and so reconstruct the path of the particle. [2]

4 As the particles are accelerated the radius of their orbit must remain constant; from $R = \frac{mv}{qB}$ this implies that the magnetic field strength *B* must increase; and this can only happen with electromagnets. [2]

5 Charged particles injected in a region of magnetic field follow circular paths; the bottom pole of the magnet is divided into two pieces (the Dees) and an alternating potential difference is applied to the dees; if the frequency of the AC voltage applied is the same as the frequency of rotation of the particle in the field; the particle is accelerated every time it approaches the gap between the dees. [3]

6 The Higgs particle is responsible (through its interactions) to giving mass to the massive particles of the standard model. [1]

7 Experiments in which hadrons receive large amounts of energy and momentum; through interactions mainly with leptons. [2]

8 Asymptotic freedom means that quarks behave as free particles when the energy they exchange with other particles is very large. [1]

9 Any process in which a Z particle is being exchanged. [1]

10 From $E = \frac{3}{2}kT$, $\frac{3}{2} \times 1.38 \times 10^{-23} T = 0.50 \times 10^{6} \times 1.6 \times 10^{-19}$; giving $T = 3.9 \times 10^{9}$ K [2]

11 In string theories the fundamental building block is a string as opposed to a point particle; string theories cannot be formulated in the familiar 3 + 1 dimensions of space and time. [2]