Mark scheme for Extension Worksheet – Topic 5, Worksheet 5

1 **a** The gravitational field strength at the position of the Earth is the Earth's centripetal acceleration; hence $g = \frac{v^2}{r} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{4\pi^2 r}{T^2}$;

$g = \frac{4\pi^2 \times 1.5 \times 10^{11}}{(365 \times 23 \times 3600)^2} = 5.95 \times 10^{-3}\ \text{N kg}^{-1}$ [3]

b $g = \frac{GM}{r^2} = 5.95 \times 10^{-3}\ \text{N kg}^{-1} \Rightarrow M = \frac{5.95 \times 10^{-3} \times (1.5 \times 10^{11})^2}{6.67 \times 10^{-11}}$

$M = 2.0 \times 10^{30}\ \text{kg}$ [2]

2 A plastic rod rubbed with a cloth will become charged by friction and will repel a similar plastic rod that has also been rubbed by a cloth ; a glass rod rubbed in cloth will also repel a glass rod rubbed in cloth ; but a glass rod and a plastic rod that have been rubbed attract suggesting the existence of 2 types of electric charge. [3]

3 The original force is proportional to $F \propto 4 \times 8 = 32$; the new charges on the spheres will be $\frac{8 + (-2)}{2} = 3$ nC; and so the force will be proportional to $F \propto 3 \times 3 = 9$; so it will be $\frac{9}{32}$ times the original force; and repulsive as opposed to attractive. [4]

4 The kinetic energy of the accelerated particles is qV and so $\frac{E_p}{E_\alpha} = \frac{qV}{2qV} = \frac{1}{2}$; hence

$\frac{m_p v_p^2}{m_\alpha v_\alpha^2} = \frac{1}{2} \Rightarrow \frac{m_p v_p^2}{4 m_p v_\alpha^2} = \frac{1}{2}$; so $\frac{v_p}{v_\alpha} = \sqrt{2}$ [3]

5 **a** The force is $F = qE = 1.6 \times 10^{-19} \times 2.4 \times 10^3$; so $F = 3.8 \times 10^{-16}$ N [2]

b $qvB = qE \Rightarrow B = \frac{E}{v}$; hence $B = \frac{2.4 \times 10^3}{4.1 \times 10^6} = 5.9 \times 10^{-4}$ T ; the magnetic force must be directed to the left and so the magnetic field must be directed into the page. [3]

c The electric force on the alpha particle will double but so will the magnetic force; hence the net force will be zero and so the path will be undeflected. [2]

6 Conductors have lots of free electrons; whereas insulators do not. [2]

7 Electric current means the transfer of electric charge in a given direction; electrons move but in random directions so there is no net transfer of charge in any given direction. [2]

8 By definition, static electricity deals with situations where the electric current is zero; if there was an electric field inside the conductor, there would be a force on the free electrons and hence a motion of electrons (opposite to the direction of the electric field) and hence an electric current. [2]

9 By the right hand force rule for magnetic force (or any other method you know of) the forces have directions Right; Left; Out of the page; and zero (since in the last case the velocity is antiparallel to the field). [4]