Name of the Student:_____
Max. Marks : 25 Marks **Time : 25 Minutes**

Mark Schemes

Q1.

Question Number	Answer		Mark
(a)(i)	Straight through, zero deflection, direction fired in. (Do not accept 'through' or 'directly behind' on its own)	**(1)**	**1**
(a)(ii)	(Atom consists) mainly/mostly of empty space **Or** Volume of atom very much greater than volume of nucleus. (do not credit if part of a list)	**(1)**	**1**
(b)	Most of the mass is in the nucleus/centre [it is not enough to say that the nucleus is dense/concentrated. Looking for idea that nearly all of the atom's mass is in the nucleus] Nucleus/centre is charged [ignore references to the charge being positive. Just saying the nucleus is positive does not get the mark.]	**(1)** **(1)**	**2**
(c)(i) E	Electrostatic/electromagnetic/electric/coulomb	**(1)**	**1**
(c)(ii)	Arrow starting on the path at closest point to the nucleus Arrow pointing radially away from nucleus (correct direction starting on the nucleus scores 2nd mark only)	**(1)** **(1)**	**2**
(c)(iii)	Deflection starts earlier Final deflection is greater (paths should diverge)	**(1)** **(1)**	**2**
	Total for question		**9**

Q2.

Question Number	Acceptable Answers		Additional guidance	Mark
a	• fundamental – quarks and leptons	(1)	MP2 and 3 could be given for a named particle and its quark composition	5
	• Baryons made of 3 q	(1)		
	• Mesons made of quark and antiquark	(1)	Can be inferred if either set named	
	• 6 quark **Or** 6 leptons	(1)		
	• Each particle has an antiparticle	(1)		

Question Number	Acceptable Answers		Additional guidance	Mark
b	• Use of $\Delta E = \Delta mc^2$	(1)	Example of calculation: $E = 2.2\times10^{-25}\text{kg}\times(3.0\times10^{8})^2(\text{ms}^{-1})^2$ $E = 1.98\times10^{-8}\text{J}$ $E = 1.98\times10^{-8}\text{J}\div1.6\times10^{-19}\text{JeV}^{-1}$ $E = 124\times10^{9}\text{eV}$	3
	• Conversion of J to eV	(1)		
	• mass = 120 GeV/c^2	(1)		

Question Number	Acceptable Answers		Additional guidance	Mark
c(i)	• Energy (of protons) converted to mass (of Higgs) **Or** Energy is required to overcome electrostatic repulsion between protons	(1)	Alternative based on numerical values: Observation that Higgs mass is 120 GeV/c^2 This requires an energy of at least 120 GeV Each beam of protons would need an energy of at least 60 GeV	3
	• Reference to $E = mc^2$ (can be written in any form)	(1)		
	• Because c^2 is very large (E must be large) **Or** Higgs particle is massive so needs a lot of energy to create it	(1)		
c(ii)	• Use of circumference = $2\pi r$	(1)	Example of calculation: $r = 27000\div2\pi$ $r = 4300\text{ m}$ $p = 8.3\text{T}\times1.6\times10^{-19}\text{C}\times4300\text{m}$ $p = 5.7\times10^{-15}\text{Ns}$	3
	• Use of $p = Bqr$	(1)		
	• $p = 5.7\times10^{-15}\text{Ns}$	(1)		
ciii	0	(1)	zero	1

Question Number	Acceptable Answers	Additional guidance	Mark
d	• High speeds (1) **Or** relativistic • Mass (of proton) increases (1) • **Or** this equation is only valid at non-relativistic speeds	Alt: speeds close to speed of light	**2**