Question Number	Answer	Mark
18(a)(i)	**Either** 1st generation, u and d, are a pair and 2nd gen, s and c, are a pair **(1)** So 6th quark is a pair with b **(1)** By symmetry of the standard model **(1)** **Or** A quark to match each lepton **(1)** (Electron and muon had associated neutrino, so predict) neutrino for tau, so 6th quark would match that **(1)** By symmetry of the standard model **(1)**	**3**
18(a)(ii)	Mesons and baryons **(1)**	**1**
18(b)(i)	**Either** • If target is stationary there is resultant momentum, so products must have resultant momentum after collision **(1)** • So products must have high kinetic energy **(1)** • (Therefore) less/little energy available for formation of particles **(1)** • (so) less massive particles formed **(1)** **Or** • If beams collide there is zero resultant momentum, so products may have no/low momentum after collision **(1)** • So products do not have high kinetic energy **(1)** • (Therefore) all/most/more energy available for formation of particles **(1)** • (so) more massive particles formed **(1)**	**4**
18(b)(ii)	Use of total energy = rest mass energy + kinetic energy **(1)** Use of eV to J conversion **(1)** Kinetic energy = 1.16×10^{-7} J **(1)** Example of calculation Kinetic energy = 900 GeV – 173 GeV = 727 GeV Kinetic energy = 727×10^{9} eV $\times 1.6 \times 10^{-19}$ J eV^{-1} Kinetic energy = 1.16×10^{-7} J	**3**
18(b)(iii)	Use of $\Delta E = c^2 \Delta m$ to convert from GeV/c^2 to kg **(1)** Use of $E_K = ½ mv^2$ **(1)** $v = 8.8 \times 10^{8}$ m s^{-1}, which is greater than the speed of light **(1)** Example of calculation $\text{mass} = \frac{173 \text{ GeV}/c^2 \times 10^9 \times 1.6 \times 10^{-19} \text{JeV}^{-1}}{(3 \times 10^8)^2 \text{ (m s}^{-1})^2} = 3.08 \times 10^{-25}$ kg 1.16×10^{-7} J = ½ × 3.08×10^{-25} kg × v^2 $v = 8.8 \times 10^{8}$ m s^{-1}	**3**