Question Number	Answer	Mark
19(a)(i)	• Use of $r = p/Bq$ and $p = mv$ **Or** Use of $F = Bqv$ and $F = mv^2/r$ **(1)** • Use of $v = 2\pi r/t$ **(1)** • Algebra leading to $t = 2\ m\ \pi\ /Bq$ **(1)** Example of derivation $r = p/Bq$ $p = mv$ so $r = mv/Bq$ $v = 2\pi r/t$ so $r = m2\pi r\ /Bqt$ Therefore $t = 2\ m\ \pi\ /Bq$	**(3)**
19(a)(ii)	• Time independent of speed **Or** Time independent of radius **(1)** • So particles take constant time to complete circular path **Or** so particles spend the same time in each dee **(1)** • So a fixed frequency can be used for the p.d. **(1)** • because the p.d./field across the gap will be in the correct direction to increase the speed of the particles as they cross each time **(1)**	**(4)**
19(b)	• Use of $t = 2\pi m/Bq$ **(1)** • Use of $E_K = ½\ mv^2$ **(1)** • Use of $W = QV$ **(1)** • Total energy / accelerating p.d. for number of passes **(1)** • 1.9×10^{-6} s **(1)** Example of calculation $t = 2\pi \times 1.67 \times 10^{-27}$ kg / 1.6 T × 1.6×10^{-19} C $= 4.1 \times 10^{-8}$ s $E_K = ½ \times 1.67 \times 10^{-27}$ kg × $(1.5 \times 10^6)^2$ $= 1.88 \times 10^{-13}$ J $= 1.88 \times 10^{-13}$ J ÷ 1.6×10^{-19} C = 1.17×10^6 eV No of passes = 1.17×10^6 eV ÷ 13 000 eV = 90.3 2 passes per cycle, so 45.2 cycles 45.2 × 4.1×10^{-8} s = 1.85×10^{-6} s (or use 45.5 or 46)	**(5)**
19(c)	• High energy so particles have high momentum **(1)** • High momentum so that (de Broglie) wavelength is small **(1)** • Studying nucleons requires wavelengths of the order of nucleon size **(1)**	**(3)**
	Total for question 19	**15**