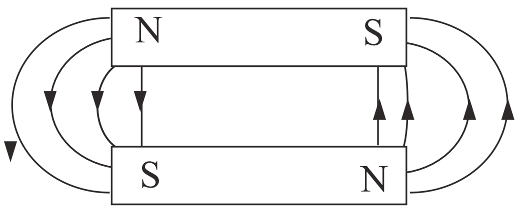
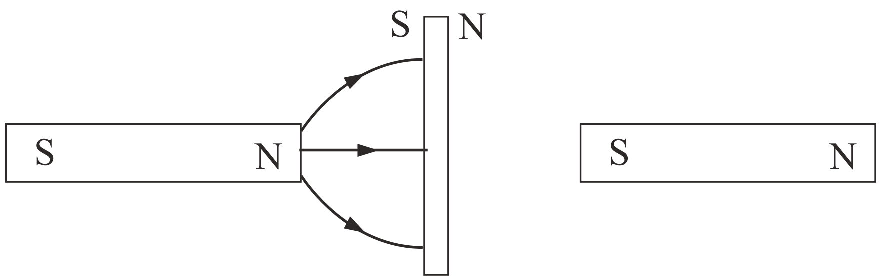
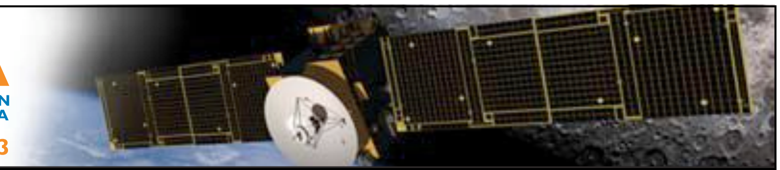
Motion and Forces in Electric and Magnetic Fields: Set 14

Set	Problem	Solution
14	1a	A magnetic field is a region of space in which a small (test) magnet experiences a force
	1b	Diagram: fig 4.9, page 52 of Physics in context Year 12 (STAWA publication)
	1c	Stroked wire acts as a bar magnet. Its field enters and leaves the ends of wire which are its poles. The field is always present. Diagram: fig 5.11, page 92 of Physics in context Year 12 (STAWA publication) Current-carrying wire has a field that exists only when the current flows. The field is arranged as concentric or nested cylinders. There are no poles. Diagram: fig 5.20, page 95 of Physics in context Year 12 (STAWA publication)
	1d	Bend the wire into a loop. Diagram: fig 5.21, page 95 of Physics in context Year 12 (STAWA publication)
	2a	Diagram: fig 4.7, page 51 of Physics in context Year 12 (STAWA publication)
	2b	Diagram: fig 4.13, page 53 of Physics in context Year 12 (STAWA publication)
	2c	Diagram: fig 4.12, page 532 of Physics in context Year 12 (STAWA publication)
	2d	
	2e	
	3a	Diagram: fig 5.20, page 95 of Physics in context Year 12 (STAWA publication)
	3b	Diagram: fig 5.21, page 95 of Physics in context Year 12 (STAWA publication)
	4a	The electron's motion is unchanged
	4b	The electron's path becomes an arc of a circle
	5	A has a positive charge B is neutral C has a negative charge
	6a	F = qvB
	6b	F is always at right angles to v. This is a requirement for circular motion.
	6c	$F_B = qvB$ $F_c = \frac{mv^2}{r}$ $\therefore qvb = \frac{mv^2}{r}$ $r = \frac{mv}{qB}$ where $v = \frac{2\pi r}{T}$



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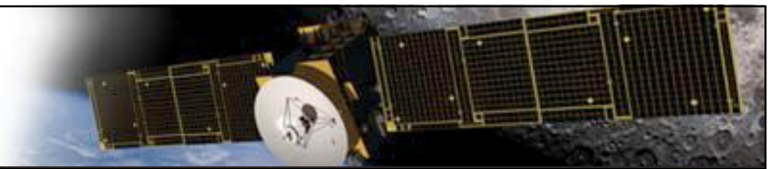
14	6c	$\therefore r = \frac{m\left(\frac{2\pi r}{T}\right)}{qB}$ $r = \frac{2\pi rm}{qBT}$ $T = \frac{2\pi rm}{qBr}$ $= \frac{2\pi m}{qB}$ where $f = \frac{1}{T}$ $\therefore \ f = \frac{qB}{2\pi m}$
	6d	The frequency gives no information about speed; but it allows the field strength to be determined if other variables (q, m) are known or can be measured.
	7	$F_B = qvB$ $F_c = \frac{mv^2}{r}$ $\therefore qvB = \frac{mv^2}{r}$ $m = \frac{rqB}{v}$ to get past the closest edge, r must be $\left(\frac{0.99}{2}\right)$ m $m = \frac{\left(\frac{0.99}{2}\right)(1.6\times10^{-19})(10)}{5\times10^{6}}$ kg $= 1.58\times10^{-26}$ kg to get inside the farthest edge, r must be $\left(\frac{1.01}{2}\right)$ m $m = \frac{\left(\frac{1.01}{2}\right)(1.6\times10^{-19})(10)}{5\times10^{6}}$ kg $= 1.62\times10^{-26}$ kg
	8a	$F_B = qvB$ $F_c = \frac{mv^2}{r}$ $\therefore qvB = \frac{mv^2}{r}$ $r - \frac{mv}{qB}$ $= \frac{(1.67\times10^{-27})(1.00\times10^{4})}{(1.6\times10^{-19})(2.50\times10^{-6})}$ $= 41.8$ m



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Set	Problem	Solution
14	8b	$r = \frac{mv}{qB}$ where $v = \frac{2\pi r}{T}$ $\therefore r = \frac{m \frac{2\pi r}{T}}{qB}$ $r = \frac{2\pi rm}{qBT}$ $T = \frac{2\pi rm}{qBr}$ $= \frac{2\pi m}{qB}$ $= \frac{2\pi((1.67\times10^{-27})}{(1.6\times10^{-19})(1.00\times10^{-4})}$ $= 6.28\times10^{-3}$ s
	8c	$T = \frac{2\pi m}{qB}$ Thus, T is inversely proportional to B i.e. as B increases, T decreases.
	8d	T is independent of v i.e. changing v has no effect on T.
	9a	B_1 must be oriented out of the page B_2 must be oriented into the page
	9b	$F_B = qvB$ $= (1.6\times10^{-19})(1.5\times10^{6})(0.1)$ N $= 2.4 \times 10^{-14}$ N
	9c	The outer electrons are in the field for a longer time than the inner electrons; hence the magnetic force changes the momentum of the outer electrons more than the inner ones.
	9d	The field would have to vary in direction and strength; into the page and strongest at the top edge, decreasing to zero at the centre, and then increasing to out of the page and strongest at the bottom.
	10a	$F_B = qvB$ $F_c = \frac{mv^2}{r}$ $\therefore qvB \times \frac{mv^2}{r}$ $\frac{q}{m} = \frac{v}{rB}$

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Set	Problem	Solution
14	10b	$\frac{q}{m} = \frac{v}{rB}$ where $r_1 = 2.9\times10^{-2}$ m and $r_2 = 3.8\times10^{-2}$ m $\left(\frac{q}{m}\right)_1 = \frac{2.2\times10^5}{(2.9\times10^{-2})(0.12)}$ $= 6.3\times10^7$ C kg^{-1} $\left(\frac{q}{m}\right)_2 = \frac{2.2\times10^5}{(3.8\times10^{-2})(0.12)}$ $= 4.8\times10^7$ C kg^{-1}
	10c	These ions have the same charge so any difference in their $\frac{q}{m}$ value is due their atomic masses. Their atomic masses have the ratio 4:3 = 1.3 Their $\frac{q}{m}$ values have the ratio $\frac{6.3}{4.8} = 1.3$ So yes, they could be the isotopes that produce these lines.
	10d	$\frac{q}{m} = \frac{v}{rB}$ $m = \frac{qrB}{v}$ where $r_1 = 6.2\times10^{-2}$ m, $r_2 = 6.64\times10^{-2}$ m and $r_3 = 7.01\times10^{-2}$ m $m_1 = \frac{qrB}{v}$ $= \frac{(1.6\times10^{-19})(6.2\times10^{-2})(0.12)}{4.5\times10^4}$ kg $= 2.64\times10^{-26}$ kg $= \frac{2.64\times10^{-26}}{1.67\times10^{-27}}$ u $= 16$ u $m_2 = \frac{(1.6\times10^{-19})(6.64\times10^{-2})(0.12)}{4.5\times10^4}$ kg $= 2.83\times10^{-26}$ kg $= \frac{2.84\times10^{-26}}{1.67\times10^{-27}}$ u $= 17$ u $m_3 = \frac{(1.6\times10^{-19})(7.01\times10^{-2})(0.12)}{4.5\times10^4}$ kg $= 2.99\times10^{-26}$ kg $= \frac{2.99\times10^{-26}}{1.67\times10^{-27}}$ u $= 18$ u The oxygen isotopes therefore have mass numbers 16, 17 and 18. Their formulae are ${}^{16}_{8}O$, ${}^{17}_{8}O$ and ${}^{18}_{8}O$