CMA 44 Answers (1997)

Q1 $\boxed{\text{B}}$ There is an ordinary Doppler shift owing to the galaxy's rotational motion. As the shift is small, the centre wavelength (which is unshifted by rotation) will be the arithmetic mean, namely $(726.6 + 718.4)/2 = 722.5$ nm.

Q2 $\boxed{\text{E}}$ How long does the disc, 60 000 light years in diameter, take to rotate? Its speed at the edge, relative to the centre, is v_{rot}, where

$$\frac{v_{\text{rot}}}{c} \cong \frac{726.6 - 722.5}{722.5} = 5.7 \times 10^{-3}$$

[We have used the fact that $\lambda = c/v$ so that, for Δv small, $\Delta v/v = -\Delta\lambda/\lambda$]

Then T, the period, is

$$T = \frac{2\pi R}{v_{\text{rot}}}$$

1 light year $= 9.46 \times 10^{15}$ m and 1 year $= 3.156 \times 10^{7}$ s.

$R = 3 \times 10^{4}$ light years so

$$T = \frac{2\pi \times 3 \times 10^{4} \times 9.46 \times 10^{15}}{5.7 \times 10^{-3} \times 3 \times 10^{8}}\,\text{s} = 1.04 \times 10^{15}\,\text{s}$$

$$T = \frac{1.04 \times 10^{15}}{3.156 \times 10^{7}}\,\text{years} \approx 3.3 \times 10^{7}\,\text{years}.$$

Q3 $\boxed{\text{D}}$

$$z = \frac{Hr}{c} \qquad \text{But } z = \frac{722.5 - 656.3}{656.3} = 0.101$$

so,

$$r = \frac{3 \times 10^{8} \times 0.101}{1.6 \times 10^{-18}}\,\text{m} = 1.9 \times 10^{25}\,\text{m}$$

$$r = \frac{1.9 \times 10^{25}}{9.46 \times 10^{15}}\,\text{light years} = 2 \times 10^{9}\,\text{light years}$$

[If you took 722.5 instead of 656.3 in the denominator of z above you get 1.8×10^{9} light years; this is not strictly correct, but is acceptable.]

Q4 $\boxed{\text{B}}$ The size of the Local Group is about 2×10^{7} light years, but this galaxy is about 2×10^{9} light years away. Also, note that a redshift of around 0.1 indicates that the galaxy lies well within the range where Hubble's law holds.