Chapter 5 Orbits. Revision Questions page 149-151 – Multiple Choice Answers

Q	Ans	Explanation
1	A	That statement is Kepler's first law. Options B & C are Newton's laws, and option D is not a part of Kepler's laws and is false anyway.
2	D	According to Kepler's 2nd law, planets travel fastest when they are closest to the Sun (star). This is because when they are close the swept area has to be the same as when they are distant, so the length of the section of the orbit must be longer when the planet is close to the central star. Travelling a bigger distance in the same time means a faster speed. If it is travelling at 15 km^{-1} on average then nearer the star it would be faster. The only faster option is D
3	A	According to Kepler's 2nd law as a body approaches the star it speeds up. Same reason as for Q 2 above.
4	C	$\frac{T_M{}^2}{r_M{}^3} = \frac{T_E{}^2}{r_E{}^3}$ (where M is Mars, E = Earth) $T_M{}^2 = \frac{T_E{}^2 r_M{}^3}{r_E{}^3}$ $= \frac{1^2 \times (1.584 r_E)^3}{r_E{}^3}$ (time in years, distance in relative units) $= 1.584^3$ $T_M = \sqrt[2]{3.539}$ $= 1.88\ y$
5		$\frac{T_J{}^2}{r_J{}^3} = \frac{T_E{}^2}{r_E{}^3}$ (where J is Jupiter, E = Earth) $r_J{}^3 = \frac{T_J{}^2 \times r_E{}^3}{T_E{}^2}$ $= \frac{(12T_E)^2 \times r_E{}^3}{T_E{}^2}$ $= 12^2 \times r_E{}^3$ $= 144 \times r_E{}^3$ $r_J = \sqrt[3]{144 r_E{}^3}$ $= 5.24 r_E$

6	C	$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ $M = \frac{4\pi^2 r^3}{GT^2}$ $= \frac{4\pi^2 \times (385000\times 10^3)^3}{6.67\times 10^{-11}\times(27.4\times 24\times 60\times 60)}$ $= 6.0\times 10^{24}\ kg$
7	C	$\frac{T_U{}^2}{r_U{}^3} = \frac{T_S{}^2}{r_S{}^3}$ (where U is Uranus, S = Saturn) $T_U{}^2 = \frac{T_S{}^2 r_U{}^3}{r_S{}^3}$ $= \frac{29.5^2 \times 2.87^3}{1.43^3}$ (time in years, distance in billion km) $= 7035$ $T_U = \sqrt[2]{7035}$ $= 84\ y$
8	D	The equation for Newton's version of Kepler's third law is: $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$ Only option D lists two useful quantities: r and T for the Earth about the Sun. Option A lists two values for r for different planets; Option B lists M and T for Earth but not M of the central body (Sun); Option C has T for around the Sun and the period of rotation doesn't apply.

9	D	$\frac{T^2}{r^3}=\frac{4\pi^2}{GM}$ $r^3=\frac{T^2GM}{4\pi^2}$ $r^3=\frac{\left(\frac{2\pi r}{v}\right)^2 GM}{4\pi^2}$ $r^3=\frac{r^2GM}{v^2}$ $v^2=\frac{GM}{r}$ $v=\sqrt{\frac{GM}{r}}$ $v=\sqrt{\frac{Gm_E}{r}}$ (for the specific case of a satellite orbiting around Earth)
10	C	The diameter of the Sun doesn't come in to any calculation about orbits, so is not applicable.