Name: ____

Edexcel_Gravity_New

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: ______

Mark Scheme

Q1.

Question Number	Answer	Mark
	B	**1**

Q2.

Question Number	**Answer**	**Mark**
	D Both fields act on all particles.	**1**
	Incorrect Answers: A – this is a similarity B – this is a similarity C – this is a similarity	

Q3.

Question Number	Answer	Mark
	B	**1**

Q4.

Question Number	Answer	Mark
	C	**1**

Q5.

Question Number	Answer	Mark
	A	1

Q6.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• use of $F = Gm_1m_2/r^2$	(1)	<u>Example of calculation</u> $F = 6.67 \times 10^{-11}$ N m² kg⁻² × 29 × 1.99 × 10³⁰ kg × 36 × 1.99 × 10³⁰ kg / (6.5 × 10¹⁰ m)² force = 6.5 × 10³¹ N	
	• force = 6.5×10^{31} N	(1)		2

Question Number	Acceptable answers		Additional guidance	Mark
(b)	**Either**		<u>Example of calculation</u> $F = mv^2/r = m(2\pi r/T)^2/r$ $T^2 = 4\pi^2 mr/F$ $= 4\pi^2 \times 29 \times 1.99 \times 10^{30}$ kg $\times 3.6 \times 10^{10}$ m / 6.5×10^{31} N $= 1.21 \times 10^{12}$ s² $T = 1.12 \times 10^6$ s = 18700 min = 312 hours = 13 days	
	• use of $F = mv^2/r$ ecf from (a)	(1)		
	• use of $v = 2\pi r/T$	(1)		
	• $T = 1.1 \times 10^6$ s	(1)		
	Or			
	• use of $F = m\omega^2 r$ ecf from (a)	(1)		
	• use of $\omega = 2\pi/T$	(1)		
	• $T = 1.1 \times 10^6$ s	(1)		3

Q7.

Question Number	Answer		Mark
(a)(i)	Use of $\omega = \frac{2\pi}{T}$	(1)	
	See $F = \frac{GMm}{r^2}$ **and** $F = m\omega^2 r$	(1)	
	$GM = 4.07 \times 10^{14}$ ($m^3\ s^{-2}$)	(1)	
	Or		
	Use of $v = \frac{2\pi r}{T}$	(1)	
	See $F = \frac{GMm}{r^2}$ **and** $F = \frac{mv^2}{r}$	(1)	
	$GM = 4.07 \times 10^{14}$ ($m^3\ s^{-2}$)	(1)	3
	[If reverse "show that" attempted, max 2]		
	Example of calculation: $\omega = \frac{2\pi}{T} = \frac{2\pi\,\text{rad}}{2.36 \times 10^6\ \text{s}} = 2.66 \times 10^{-6}\ \text{rad s}^{-1}$ $\frac{GMm}{r^2} = m\omega^2 r$ $GM = \omega^2 r^3 = (2.66 \times 10^{-6}\ \text{s}^{-1})^2 \times (3.86 \times 10^8\ \text{m})^3 = 4.07 \times 10^{14}\ \text{m}^3\ \text{s}^{-2}$		
(a)(ii)	Use of $g = \frac{GM}{R^2}$ with $g = 9.81\ \text{N kg}^{-1}$	(1)	
	$R = 6.4 \times 10^6$ m [6.5×10^6 m if show that value used]	(1)	2
	Example of calculation: $R = \sqrt{\frac{GM}{g}} = \sqrt{\frac{4.07 \times 10^{14}\ \text{m}^3\ \text{s}^{-2}}{9.81\ \text{N kg}^{-1}}} = 6.44 \times 10^6\ \text{m}$		

(b)	Force varies with distance (from the Earth) according to inverse square law $F \propto \frac{1}{r^2}$	(1)	
	so force (on these asteroids) is (very) small	(1)	
	Or Gravitational field strength varies with distance (from the Earth) according to inverse square law $g \propto \frac{1}{r^2}$	(1)	
	so gravitational field strength is (very) weak at this distance	(1)	2
	[Accept idea that since the asteroids are much further from the Earth (than the moon) they are only weakly bound (to the Earth) for max 1 mark]		
	Total for Question		7

Q8.

Question Number	Answer	Mark
(a)(i)	See $F = GMm/r^2$ (1) Equated to mg to give required expression **Or** use of g = F/m (1)	**2**
(a)(ii)	Use of $g = \omega^2 r$ OR $g = v^2/r$ (1) Use of $\omega = 2\pi/T$ OR $v = 2\pi r/T$ (1) Correct algebra leading to expression given (1) <u>Example of calculation:</u> $\omega^2 r = \frac{GM}{r^2}$ $\left(\frac{2\pi}{T}\right)^2 = \frac{GM}{r^3}$ $r^3 = \frac{GMT^2}{4\pi^2}$	**3**
(a)(iii)	See T = 24 hours (1) T converted into s (1) $r = 4.2 \times 10^7$ m (1) <u>Example of calculation:</u> $T = 24 \times 60 \times 60 \text{ s} = 86\,400 \text{ s}$ $r^3 = \frac{GMT^2}{4\pi^2} = \frac{6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 6.0 \times 10^{24} \text{ kg} \times (86400 \text{ s})^2}{4\pi^2} = 7.57 \times 10^{22} \text{ m}^3$ $r = \sqrt[3]{7.57 \times 10^{22} \text{ m}^3} = 4.23 \times 10^7 \text{ m}$	**3**
(b)	The satellite must rotate with the Earth **Or** the satellite must be in a geosynchronous orbit **Or** any non-equatorial orbit would cause the satellite to move N-S	**1**
	Total for question	**9**

Q9.

Question Number	Answer		Mark
(a)	The gravitational field strength [accept "g"] decreases **Or** the (gravitational) force on the satellite/object/mass decreases It is a centripetal force (and not a centrifugal force) The satellite is accelerating and so is not in balance	 (1) (1) (1)	 3
(b)(i)	See $\frac{mv^2}{r} = \frac{GmM_E}{r^2}$ **Or** $m\omega^2 r = \frac{GMm}{r^2}$ $\therefore v^2 = \frac{GM_E}{r}$ **Or** $v = \sqrt{\frac{GM_E}{r}}$ GM_E is constant (and so v decreases as r increases) **Or** $v^2 \propto \frac{1}{r}$ **Or** $v \propto \frac{1}{\sqrt{r}}$	(1) (1) (1)	 3
(b)(ii)	State $T = \frac{2\pi}{\omega}$ and $\omega = \frac{v}{r}$ **Or** $T = \frac{s}{v}$ and $s = 2\pi r$ Hence $T = \frac{2\pi r}{v}$ (so smaller v leads to a larger value of T) [Accept $T = \frac{2\pi GM_E}{v^3}$ for final mark]	(1) (1)	 2
(c)	Use of $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ T = 5530 s [92 minutes] <u>Example of calculation</u> $T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2(6360000\,\text{m} + 400000\,\text{m})^3}{6.67\times10^{-11}\,\text{N m}^2\,\text{kg}^{-2} \times 5.98\times10^{24}\,\text{kg}}} = 5530\,\text{s}$	(1) (1)	 2
(d)	**Max 2** As radius decreases: There is a transfer of gravitational potential energy to kinetic energy [Accept kinetic energy increases and gravitational potential energy decreases] Sum of kinetic and gravitational potential energy decreases **Or** satellite does work against frictional forces **Or** transfer of kinetic energy of satellite to thermal energy **Or** heating occurs	 (1) (1)	 2