Gravitational Fields

Mark Scheme 4

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Gravitational Fields
Sub Topic	
Paper Type	Theory
Booklet	Mark Scheme 4

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1	**(a**	(region of space) where a <u>mass</u> experiences a force	B1	[1]
	(b) **(i)**	potential energy = $(-)GMm / x$	C1	
		$\Delta E_P = GMm/2R - GMm/3R$	M1	
		$= GMm/6R$	A0	[2]
	(ii)	$E_K = ½m\,(7600^2 - 7320^2)$	M	
		$= (2.09 \times 10^6)m$	A0	[1]
	(c) **(i)**	$2.09 \times 10^6 = (6.67 \times 10^{-11}\,M)/(6 \times 3.4 \times 10^6)$	C1	
		$M = 6.39 \times 10^{23}$ kg	A1	[2]
	(ii)	e.g. no energy dissipated due to friction with <u>atmosphere/air</u> rocket is outside atmosphere not influenced by another planet etc.	B1	[1]

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2	**(a)**	**(i)** $GMm\{(R+h_1)^{-1}-(R+h_2)^{-1}\}$	B1	
		$\frac{1}{2}m\{v_1^2-v_2^2\}$	B1	[2]
	(b)	$2M \times 6.67 \times 10^{-11}\{(26.28 \times 10^6)^{-1}-(29.08 \times 10^6)^{-1}\} = 5370^2 - 5090^2$	B1	
		$M \times 4.888 \times 10^{-19} = 2.929 \times 10^6$	C1	
		$M = 6.00 \times 10^{24}$ kg	A1	[3]
		(If equation in **(a)** *is dimensionally unsound, then 0/3 marks in* **(b)***, if dimensionally sound but incorrect, treat as e.c.f.)*		

3	**(a**	centripetal force is provided by gravitational force	B1	
		$mv^2 / r = GMm / r^2$	B1	
		hence $v = \sqrt{(GM / r)}$	A	**[2]**
	(b)	**(i)** E_K (= $\frac{1}{2}mv^2$) = $GMm / 2r$	B1	**[1]**
		(ii) $E_P = - GMm / r$	B1	**[1]**
		(iii) $E_T = - GMm / r + GMm / 2r$	C1	
		$= - GMm / 2r$.	A	**[2]**
	(c)	**(i)** if E_T decreases then $- GMm / 2r$ becomes more negative		
		or $GMm / 2r$ becomes larger	M1	
		so r decreases	A1	**[2]**
		(ii) $E_K = GMm / 2r$ and r decreases		
		so (E_K and) v increases	A1	**[2]**

4	**(a**	$GM / R^2 = R\omega^2$ ……	C1	
		$\omega = 2\pi / (24 \times 3600)$ ……	C1	
		$6.67 \times 10^{-11} \times 6.0 \times 10^{24} = R^3 \times \omega^2$		
		$R^3 = 7.57 \times 10^{22}$ ……	M1	
		$R = 4.23 \times 10^7$ m ……	A0	**[3]**
	(b)(i)	$\Delta\Phi = GM/R_e - GM/R_o$ ……		
		$= (6.67 \times 10^{-11} \times 6.0 \times 10^{24})(1 / 6.4 \times 10^6 - 1 / 4.2 \times 10^7)$		
		$= 5.31 \times 10^7$ J kg^{-1} ……	C1	
		$\Delta E_P = 5.31 \times 10^7 \times 650$ ……	C1	
		$= 3.45 \times 10^{10}$ J ……	A1	**[4]**
	(c)	e.g. satellite will already have some speed in the correct direction …	B1	**[1]**

5	**(a)**	(i)	(force)= $GM_1M_2/(R_1 + R_2)^2$	81	
		(ii)	(force)= $M_1R_1 m^2$ or $M_2R_2 m^2$	81	[2]
	(b)		m = 27T/(1.26 x 10^8) or 2rc/T	C1	
			= 4.99 x 10^{-a} rad s1	A1	[2]
			allow 2 s.f.: 1.591r x 10^{-8} scores 112		
	(c)	(i)	reference to either taking moments (about C) or same (centripetal) force	81	
			$M_1R_1 = M_2R_2$ or $M_1R_1 m^2 = M_2R_2 m^2$	81	
			hence $M_1/M_2 = R_2/R_1$	AO	[2]
		(ii)	R_2 = 3/4 X 3.2 X 10^{11} m = 2.4 X 10^{11} m	A1	
			R_1 = (3.2 x 10^{11}) - R_2 = 8.0 x 10^{10} m (allow *vice versa)*	A1	[2]
			if values are both wrong but have ratio of four to three, then allow 112		
	(d)	(i)	M_2 = {(R_1 + R_2)^2 x R_1 x m^2) / G (any subject for equation)	C1	
			= (3.2 X 10^1;/ X 8.0 X 10^{10} X (4.99 X 10·8)2/(6.67 X 10^{-11})	C1	
			= 3.06 x 10 kg	A1	
		(ii)	less massive (only award this mark if reasonable attempt at (i)) (9.17 x 10^{29} kg for more massive star)	81	[4]
			Total		**[12)**

6	**(a)**	**(i)**	radial lines.....	B1	
			pointing inwards	B1	
		(ii)	no difference OR lines closer near surface of smaller sphere	B1	[3]
	(b)	**(i)**	$F_G = GMm/R^2$.....	C1	
			= (6.67 X 10^{-11} x 5.98 x 10^{24})/(6380 x 10^3)^2		
			= 9.80 N	A1	
		(ii)	$F_C = mR\omega^2$	C1	
			$\omega = 2\pi/T$	C1	
			F_C = (4π^2 x 6380 x 10^3)/8.64 x 10^4)^2		
			= 0.0337 N	A1	
		(iii)	$F_G - F_C$ = 9.77 N.....	A1	[6]
	(c)		because acceleration (of free fall) is (resultant) force per unit mass	B1	
			acceleration = 9.77 m s^{-2}	B1	[2]