G484 The Newtonian World

Question			Expected Answers	Marks	Additional guidance
1	a	i	Force is proportional to the <u>rate of change</u> of <u>**momentum**</u> *<u>(QWC This mark can only be scored if momentum is spelled correctly)</u>*	B1	Allow "equal" instead of proportional, allow "change in momentum over time" (WTTE) Do not allow F = ma or in words
		ii	When one body exerts a force on another the other body exerts an <u>equal</u> (in magnitude) <u>and opposite</u> (in direction) force on the first body (WTTE)	B1	Must refer to two bodies. Do not allow a bare "Action and reaction are equal and opposite".
	b	i	*area*: number of squares correctly counted: 20 - 24 (500 – 600) = **2.2** Ns {allow 2.0 to 2.4}	C1 A1	First mark for correct number of squares Second mark for correct conversion to Ns If 2 Δs assumed, area = 1.68 Ns and scores 1 mark 1680 scores 0 (2 errors) but 2200 scores 1 mark
		ii	<u>**Impulse**</u> QWC must be spelled correctly	B1	No not allow change of momentum.
		iii	recall of Impulse = change in momentum OR I = mv OR mv –mu (mv = 2.2 hence v = 2.2/0.046) v = **47.8** ms^{-1} (hence about 50) (2.0 gives 43.5, 2.1 45.7, 2.3 50, 2.4 52.2)	C1 A1	Allow 'Area = mv' Allow ecf from cand's value for (b)(i): e.g. mv = 1.68 v = 36.5 ms^{-1} and scores 2 marks mv = 2200 v = 47800 ms^{-1} also scores 2marks! (<u>ecf</u>)
		iv	initial horizontal velocity = 50cos42 = (37.2 ms^{-1}) initial vertical velocity = 50sin42 = (33.5 ms^{-1}) time taken to reach maximum height = 33.5/9.8 (= 3.41 s) total time to reach ground = 2x 3.41 = 6.82 s hence distance = 50cos42xtotal time = 37.2x6.82 = **253** m any valid assumption: eg no air resistance / horizontal velocity is constant/ acceleration due to gravity is 9.8 (or 10) ms^{-2} / ball follows a parabolic or symmetrical path (WTTE).	C1 C1 C1 A1 B1	Allow 1 mark for correct identification of cosine and sine components of v, without substitution. Allow ecf for cand's value of v throughout e.g if 47.8 is used for v, distance = **232** m and this scores <u>four</u> marks. if 47800 is used distance = 2.32 x 10^8 m! Also allow "only the gravitational force is acting" "no friction" "only gravity"
			Total	**12**	

Question			Expected Answers	Marks	Additional guidance
2	a	i	($v = 2\pi r/t$) $t = 2\pi 60/0.26$ = **1450** s	B1	Correct answer is 1449.96 hence allow 1.4 X 10^3 Do not allow a bare 1.5 x10^3
		ii	(ii) correct substitution into $F = mv^2/r$: eg F = $(9.7 \times 10^3 \times 0.26^2)/60$ F = **10.9** N	C1 A1	Allow 11 N
	b	i	THREE correct arrows at A, B and C **all** pointing towards the centre (judged by eye)	B1	Ignore starting point of arrow
		ii	1. Greatest reaction force is at **C** because it supports weight of sock AND provides the required upward resultant (centripetal) force (WTTE) 2. Least at **A** because sock's weight provides part of the required downward resultant (centripetal) force (WTTE)	**M1** A1 B1	This is a mandatory M mark. The second mark cannot be gained unless this is scored. Any indication that candidates think that the centripetal force is a **third** force loses this second and possibly the next mark. They must make correct reference to the resultant force that provides the required centripetal force/acceleration. Allow answers using the equation $F = mv^2/r$ such as N_c - mg (at C) = centripetal force OR mv^2/r OR mg +N_A (at A) = centripetal force OR mv^2/r
			Total	**7**	

Question			Expected Answers	Marks	Additional guidance
3	a		arrows (at least one) indicating direction is **towards** the planet. All lines looking as though they would meet at the centre judged by eye	B1 B1	 At least 4 drawn and care taken Some of the lines must be outside the planet.
	b	i	($mg = GMm/r^2$ and hence) $\mathbf{M = gr^2/G}$ correct substitution $M = 24.9 \times (7.14 \times 10^7)^2/6.67 \times 10^{-11}$ = **$\mathbf{1.9 \times 10^{27}}$** Kg (i.e about **$\mathbf{2 \times 10^{27}}$**)	C1 **M1** A1	Equation needs to be rearranged as shown for C1 mark
		ii	correct substitution into $V = (4/3)\pi r^3 = (4/3)\pi(7.14 \times 10^7)^3$ {= 1.52×10^{24} m^3} density = mass/volume = $1.9 \times 10^{27}/1.52 \times 10^{24}$ = **1250** kg m^{-3}	C1 A1	If m= 2 x 10^{27} kg is used d = 1312 scores 2 marks
			Total	**7**	

Question			Expected Answers	Marks	Additional guidance
4	a		The resultant force is zero (WTTE) Forces are weight and force from the spring (allow tension)	B1 B1	For the first mark allow - sum of forces is zero, - upward force = downward force, - forces cancel each other BUT do not allow forces are balanced Allow force of gravity for weight
	b	i	acceleration is (directly) proportional to displacement and is directed in the opposite direction to the displacement. (WTTE)	M1 A1	allow $a=-(2\pi f)^2$ x, provided a and x are identified and –ve sign must be explained. Do not allow "acceleration is prop to negative displacement for second mark. Allow always towards the equilibrium position
		ii	x= acos2πft $\Rightarrow$ 2πf = 7.85 (expressed in any form) f = (7.85/2π) = 1.25 (1.249Hz)	**M1** A1	Do not allow use of Fig 4.2 to show T= 0.8s and hence f=1.25 Hz. This scores 0.
		iii	correct subst^n in $V_{max} = (2\pi f)A \Rightarrow V_{max} = 2\pi x1.25x0.012$ V_{max} = **0.094** ms^{-1}	C1 A1	Many will forget to change 12 mm into 0.012m and have v = 94 ms^{-1} this scores 1 mark.
	c		roughly **sinusoidal** graph of <u>correct period</u> ie **0.8s** <u>90^o out of phase</u> with displacement graph (i.e. starts at origin with -ve initial gradient) <u>maximum velocity</u> correctly shown as 0.094 {allow ecf from (iii)}	B1 B1 B1	
			Total	**11**	

Question			Expected Answers	Marks	Additional guidance
5	a	i	correct substitution in $E = mc\Delta\theta$: eg $E = 0.08x4180x40$ ratio = $0.08x4180x40/5 \times 10^{-5} x2460x40$ = **$2.7(2) \times 10^3$**	C1 A1	Allow 80x4180/0.05x2460 (13376/4.92) for this C1 mark. 1: 2700 does not score the second mark.
		ii	*Any valid advantage: eg* car cooling systems <u>because</u> it absorbs large amounts of heat for a small rise in temp OR ideal fluid for central heating systems <u>because</u> it releases large amounts of heat for a small drop in temp. OR helps to maintain constant body temperature <u>since</u> body is mainly water which absorbs lots of heat for small temp rise	 B1 B1	 First mark for valid situation Second mark for correct explanation of <u>why</u> the high value of the shc is helpful.
	b		***labelled diagram (2 marks)*:** liquid in vessel with <u>electrical</u> heater (submerged) and thermometer ammeter connected in series between supply and heater AND voltmeter connected across heater. ***list of measurements (3 marks):*** mass of liquid, initial and final temperature/change of temp (of the liquid) I, V and t values OR energy meter readings OR power and time ***explanation (1 mark):*** $E = mc\Delta\theta$ rearranged to $c = E/m\Delta\theta$ ***uncertainties (2 marks) each stated with explanation of remedy**: e.g.* - heat losses (makes E or $\Delta\theta$ uncertain) *(solved by)* insulating beaker/use lid - false temp reading *(solved by)* stir the liquid - temp continues to rise after heater switched off measure highest value - thermal capacity of vessel (*solved by*) take this into account in calculation	 B1 B1 B1 B1 B1 B1 B1 B1 max 2	 Allow use of joule meter if convincingly connected to heater and power supply i.e. 2 wires from power supply two wires to heater Allow such things as “find mass”, “known mass”, “10K temp rise”, “time for 2 minutes” “known power”, etc. Allow $ItV/m\Delta\theta$. Do not allow “repeat the experiment”. Give credit for valid suggestions if mentioned anywhere in the description of the experiment.
			Total	**12**	

Question			Expected Answers	Marks	Additional guidance
6	**a**		(n) number of **<u>moles</u>** (T) **absolute** temperature OR thermodynamic temp OR temp measured in **Kelvin**	B1 B1	 Accept **K** for Kelvin
	b	**i**	(When gas is heated) molecules gain KE/move faster this would cause more collisions<u>/sec</u> (with the walls) collisions exert more force/greater change in momentum per collision For constant pressure fewer collisions/sec are required Constant pressure is achieved by the increase in volume OR with a bigger volume there are fewer collisions/sec	B1 B1 B1 B1 B1 *max 4*	If no reference to <u>rate</u> of collisions, max of 3 marks This must be explained fully but can be done with reference to $P = (1/3)\rho \langle c^2 \rangle$
		ii	correct substitution in pV/T = constant: OR V/T = constant e.g. $1.2\text{x}10^{-4}$ /**293** = V/**363** V= (363/293)x$1.2\text{x}10^{-4}$ = **$1.49\ \text{x}10^{-4}$** m^3.	 C1 A1	 Both temps must be in Kelvin. Allow 1.5 x 10^{-4} m^3
	c		Use of $1/2m\langle c^2 \rangle = 3/2\ kT$ Correct substitution: $\sqrt{\langle c^2 \rangle} = \sqrt{(3kT/m)} = \sqrt{(3\text{x}1.38 \text{ x } 10^{-23}\text{x}363/4.7\text{x}10^{-26})}$ $\sqrt{\langle c^2 \rangle}$ = **565** ms^{-1}	C1 C1 A1	If 90^0 C is used $\sqrt{\langle c^2 \rangle}$ = 282 ms^{-1} and scores 2 marks Allow 570 ms^{-1} If they do not square root, they get 319225 ms^{-1} and score 2 marks
			Total	**11**	

RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE **G484**

The Newtonian World

Mark Scheme for June 2010

Question	Expected Answers	Marks	Additional guidance
1(a)	The magnitude of the impulse on each object is the same Total energy is conserved	B1 B1	For 3 or 4 ticks mark and deduct 1 mark for each error.
(b) (i)	Correct use of ½ mv^2 Loss of KE = 0.03(144-81) = **1.9** (or 1.89) **J**	C1 A1	0.27 J scores 1st mark Do not allow 1.8
(b) (ii)	Change in momentum = (0.06x12)+(0.06x9) = 1.26 (Ns) Average force=rate of change of momentum = 1.26/0.15 = **8.4** (or 8) **N**	C1 A1	Award 1 mark for 1.2 N ignore minus signs
(b) (iii)	**8.4 N** (or - 8.4)	B1	Allow ecf from (ii)
(c) (i)	ANY 3 of the following particles move with rapid, random motion (WTTE) elastic collisions negligible (or zero) volume of atoms (compared with volume of container) no intermolecular forces (except during collisions)/all internal energy is KE collision time negligible (compared to time between collision).	 B1 B1 B1	Allow " gravitational force on molecules is negligible" Do not allow a bare "large number of particles".
(c) (ii)	molecules make collisions with walls/surface (WTTE) (hence) exerts a force on the wall (or each collision has a change of momentum) Pressure = force/area	B1 B1 B1	Do not allow a bare "molecules collide with each other"
	Total	13	

Question	Expected Answers	Marks	Additional guidance
2 (a) (i)	Horizontal <u>component</u> of **L** provides the centripetal force (WTTE) Vertical <u>component</u> of **L** balances the weight (WTTE)	B1 B1	
(a) (ii)	$F = mv^2/r$ correct rearranged into $v = \sqrt{(Fr/m)}$ $v = \sqrt{(1.8 \times 10^6 \times 2000/1.2 \times 10^5)}$ = **173** m s^{-1} (or 170)	C1 A1	Allow correct substitution of values into $F = mv^2/r$ for C1 mark
(b)	$mv^2/r = GMm/r^2$ $T = 2\pi r/v$ Correct manipulation of equations to give $T^2 = \dfrac{4\pi^2 r^3}{GM}$	B1 M1 A1	Do not allow a bare $v^2 = GM/r$ for the first mark – we need to see where this has come from.
(c) (i)	**Equatorial** orbit (WTTE) (<u>QWC mark</u>) Period is 24h/1day/same as Earth **OR** moves from West to East (WTTE)	B1 B1	QWC <u>equatorial</u> or <u>equator</u> must be spelled correctly
(c) (ii)	Correct rearrangement of $T^2 = (4\pi^2 r^3/GM)$ to give $r^3 = T^2GM/4\pi^2$ correct sub. $r^3 = \{6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times (8.64 \times 10^4)^2\}/4\pi^2 = 7.57 \times 10^{22}$ r = **4.23×10^7 m** (or 4.2 or 4.3×10^7)	C1 C1 A1	(1 day = 8.64×10^4s is given on the data sheet). For those who use $g = GM/r^2$ with g = 9.81 award 1 mark for r= 6.4×10^6 m.
	Total	12	

Question	Expected Answers	Marks	Additional guidance
3(a)	Acceleration is (directly) proportional to the displacement/distance (from the equilibrium position/central pt) Acceleration is always directed towards the equilibrium position/central point.	B1 B1	Allow "fixed point" or "point" Allow acc. is in opposite direction to displacement (WTTE) If formula is used: allow $a \propto -x$ for 1st mark and 2nd mark if x is stated as displacement.
(b) (i)	Curve symmetrical about energy axis with maximum at 18 zero at +0.04 and – 0.04	B1 B1	Ignore points where graphs cross Give bod if not labelled **K** but correct
(b) (ii)	Horizontal straight line passing 18	B1	Give bod if not labelled **T** but correct
(c) (i)	0.04 m	B1	
(c) (ii)	$½m(v_{max})^2 = 0.018$ $v_{max} = \sqrt{(2x0.018/0.12)}$ = **0.55** ms^{-1} (0.548)	C1 A1	Many will use 18 instead of 0.018. This results in 17.3 and scores 1 mark. Allow ecf for cand's value of max KE. Do not allow 0.54 for second mark.
(c) (iii)	correct use of $v_{max} = 2\pi fA$ $f = (0.55/0.04x2\pi)$ = **2.2** (or 2.19 or 2.18)Hz	C1 A1	Allow ecf for cand's values from (c)(i) and/or (c) (ii). E.g for 17.3 f = 68.8 Hz. This scores 2 marks e.c.f. Do not allow 2.1
(d)	Award first mark for stating the **'driver'** of the oscillations and the second mark for stating what is **'driven'** i.e. oscillating useful applications: e.g. Cooking: **micro waves** cause **water molecules** to resonate Woodwind: **reed** causes **air column** to resonate Brass: **lips** cause **air column** to resonate MRI: **radio waves** (in a magnetic field) cause **nuclei/proton** to resonate Radios: **radio waves** cause **electrons/current** to resonate Person on swing: **intermittent pushes** cause **swing** to resonate problem: Bridges: **wind/walkers** causes **bridge** to resonate Vehicles: **engine vibrations** cause **panels/mirrors** to resonate Earthquakes: **ground vibrating** causes **buildings** to resonate	B1 B1 B1 B1	No marks to be awarded for a bare statement of the example e.g MRI. Please allow any other valid examples.
	Total	14	

Question	Expected Answers	Marks	Additional guidance
4 (a) (i)	**Brownian** (motion) (QWC mark)	B1	QWC Brownian spelled correctly
(a) (ii)	ANY two from the following three: air molecules are moving in different directions/randomly with different speeds mass/size of air molecules is smaller than smoke particles	 B1 B1	Answers that refer to smoke particles only cannot score the marks.
(b) (i)	vol = (4/3) πr^3 = 5.58 x 10^{-3} correct sub into pV = nRT i.e. with T as 290K n = (2.6x10^5x 5.58x10^{-3})/8.31x290 = 0.602 moles mass = n x 0.028 = **0.0169** kg (0.016856)	C1 C1 A1 A1	Allow ecf for wrong volume Allow use of pV = NkT and n = N/N_A Allow ecf for cand's value for n If 17^o C used allow maximum of 2 marks for n = 10.3 moles and m = 0.29 kg
(b) (ii) 1	no net heat flow between objects (WTTE)	B1	Allow "they are at the same temp."
(b) (ii) 2	correct use of P/T = constant: e.g. P = (273/290) x 2.6 x 10^5 P = **2.45 x 10^5** (or 2.4 x 10^5 or 2.5 x 10^5)Pa	C1 A1	Allow correct use of pV=nRT
	Total	10	

Question	Expected Answers	Marks	Additional guidance
5(a) (i)	Initial KE of car = 0.5x970x27^2 = **3.5 x 10^5 J** (353565J)	B1	
(a) (ii)	Work done = Av Force x distance moved Av Force = 3.5 x 10^5 J/40 = **8.8 x 10^3 N** (or 8750 N) (or 353565/40 = 8836.7 N) Assumption: **no air resistance**	C1 A1 B1	If $v^2 = u^2 + 2as$ is used. accept a = 0-27^2/(2x40) = 9.113 ms^{-2} C1 F = ma = 970x9.11 = 8.84 x 10^3 N A1 Allow air friction or drag
(b) (i)	correct use of E = mc$\Delta\theta$: 3.5 x 10^5/4 = 1.2x520x$\Delta\theta$ $\Delta\theta$ = **140^{O}C** (if 353565 is used $\Delta\theta$ = 142^{O}C)	C1 A1	If cand. forgets to divide by 4 allow any value between 560 and 570 for 1 mark.
(b) (ii)	Air resistance will be acting (slowing down the car) (hence) reducing the KE of the car (WTTE) The discs are hotter than the surroundings (hence) energy/heat will be lost from discs/brakes (WTTE)	M1 A1 B1 B1	Do not allow sound since only a tiny proportion of energy is lost in this way. Allow other valid comments as alternative ways of scoring one or both of the 'B' marks: e.g. 'hot spots' on discs; discs are different. Try to credit a well argued case based upon correct physics- e.g. wheels locking.
(b) (iii)	Any valid suggestion: e.g. use a material with a higher s.h.c use a disc with a higher heat capacity Use discs of greater mass put holes in the discs (to increase air flow)	 B1	Confusion between shc and heat capacity should not be penalised.
	Total	11	

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2011

G484 *The Newtonian World* JAN 2011 STANDARDISATION (SCORIS) mark-scheme

Question	Expected Answers	Marks	Additional guidance
1 (a)(i)	Total momentum is constant/conserved For a closed system/provided no external forces (WTTE)	B1 B1	"total momentum before = total momentum after" Allow $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ or equivalent Do not accept "momentum is constant" Do not accept "momentum is conserved"
(a)(ii)	Some loss of kinetic energy (OR KE OR E_K)(during the collision)	B1	Allow answers in terms of Coeff't of Res. Coeff't of Restitution < 1 e.g. speed of separation/speed of approach <1
(a)(iii) 1	(2.4x3.0) –(1.2x2.0) = 3.6*v* *v* = **1.3 m s^{-1}**	C1 A1	must see –ve sign hence 2.67 scores ZERO Allow 4/3 ms^{-1} and 1.34 but not 1.4
(a)(iii) 2	Any KE correctly calculated: 10.8J, 2.4J, (or 13.2 or 8.4), 3.18J **13.2** and **3.18** (or any value between 3.2 and 3.0) seen	C1 A1	ECF from a(iii)1 If 1.3 ms^{-1} is used KE after is 3.04 ECF from a(iii)1 provided final KE is less than initial KE Allow answers in terms of Coeff't of Res. e.g. speed of separation/speed of approach = 0/5 =0
(b)(i)	valid sub^n in $V = \pi r^2h$: e.g. π x 5.0^2x12 x 5.0 (= 1500π /4710 m^3) m = Vρ = π x 5.0^2 x 12 x 5.0 x 1.3 = **6126** kg	C1 A1	 Do not accept a bald answer of 6000
(b)(ii) 1	momentum = 6130 x 12 = **7.4 (or 7.36) x 10^4 (**kg m s^{-1})	B1	Allow 7.2x10^4 if 6000 kg used & ecf from (b)(i).
(b)(ii) 2	F = 73600/5 F = **14700 N**	C1 A1	 Accept 14400 if 7.2x10^4 is calculated in 1
(b)(ii) 3	mass of helicopter = 14700/9.81 = **1500** kg	B1	Allow ecf from (b)(ii)2. Allow g=10 N/kg
	Total	**13**	

Question	Expected Answers	Marks	Additional guidance
2 (a)(i)	resultant OR net OR overall force acts (on object) perpendicular to the velocity OR towards the centre of the circle	B1	Ignore any reference to "centripetal force"
(a)(ii)	velocity OR direction is always changing acceleration is in direction of force OR is towards the centre/perp. to velocity	B1 B1	Allow a (resultant) force is acting (hence there is an acceleration))
(b)	centripetal force OR $mv^2/r = GMm/r^2$ OR $v^2/r = GM/r^2$ $v^2 = GM/r \Rightarrow r = GM/v^2$ $r = 6.67 \times 10^{-11} \times 6 \times 10^{24} / 3700^2$ $r =$ **2.92×10^7** m	C1 C1 C1 A1	
(c)(i)	Any mass ejected in the same direction as the satellite (WTTE)	B1	Idea of rocket motor pushing against direction of motion of satellite.
(c)(ii)	v^2r = constant OR $v^2 = GM/r$ OR $v = \sqrt{\{(6.67 \times 10^{-11} \times 6 \times 10^{24})/2 \times 10^7\}}$ new $v = \sqrt{(3700^2 \times 2.94/2)}$ = **4500** m s^{-1} (4473)	C1 A1	
	Total	**10**	

Question	Expected Answers	Marks	Additional guidance
3(a)(i)	(1 kWh is) the **energy** used/provided by a 1 kW device in 1 hour	B1	Allow 1 kWh = 60x60x1000 = 3.6×10^6 J
(a)(ii)	Energy used in kWh = (70/1000) x (7 x 24) = 11.8 kWh Cost = 11.8 x 0.12 = **£1.41 (or £1.4)**	C1 A1	Any arithmetic error loses one mark
(b)(i)	use of E = mc $\Delta\theta$ e.g. E = 2 x 3800 x (18-3) = **1.14×10^5 J**	C1 A1	
(b)(ii)	Rate of energy loss = 1.14×10^5 /100x60 = **19** W	B1	Allow ecf for cand's (b)(i) value
(c)	1. 18 ^{o}C to 0 ^{o}C negative gradient line 2. horizontal line on time axis 3. 0^{o}C to -18 ^{o}C line of **steeper –ve gradient** (judged by eye) than in 1	B1 B1 B1	
	Total	**9**	

Question	Expected Answers	Marks	Additional guidance
4(a)(i)	displacement is the distance (of the body) from an equilibrium position. amplitude is the <u>maximum</u> displacement.	B1 B1	Allow mean/rest/central/mid point Not original, fixed point This mark can only be gained if the word <u>maximum/greatest/largest is spelled correctly</u>. Allow distance
(a)(ii)	frequency is the number of oscillations/cycles per unit time/second angular frequency is product of 2π x frequency OR 2π/period.	B1 B1	Do not allow "swings" Allow $2\pi f$
(b)(i) 1	amplitude = (18 – 13)/2 = **2.5** m	B1	
(b)(i) 2	frequency = 1/(12.5 x 3600) = (1/45000) = **2.2(2) x 10^{-5}** Hz	C1 A1	Accept any valid sub^{n} of time for 1st mark Accept 0.08 h^{-1} OR 1.3×10^{-3} min^{-1} if unit is seen to replace Hz.
(b)(ii)	correct use of $v_{max} = 2\pi fA$ e.g. $2\pi \times 2.22 \times 10^{-5} \times 2.5$ = **3.5 x 10^{-4}** m s^{-1} (3.46 or 3.49)	C1 A1	Allow ecf from (b)(i)1 and 2 for full marks: if A=5 is used $v_{max} = 6.98 \times 10^{-4}$ (6.9 to 7) if A=18 is used $v_{max} = 2.5 \times 10^{-3}$
(b)(iii)	correct use of A(cos $2\pi ft$): e.g. 2.5 cos [$2\pi \times 2.22 \times 10^{-5}$ t] (= 2.5 cos (1.39×10^{-4} xt) d = 15.5 + 2.5 cos [$2\pi \times 2.22 \times 10^{-5}$ t] OR 15.5 + 2.5 cos (1.39×10^{-4} x t)	C1 A1	Allow 2.5 cos[$2\pi t$/45000] Accept A(sin $2\pi ft$) throughout Allow ecf from (b)(i) and (b)(ii)
	Total	**11**	

Question	Expected answers	Mark	Additional guidance
5(a)(i)	smoke particles move in random/haphazard/zig-zag/jiggling/jerky manner	B1	random/haphazard/zig-zag/ jiggling/jerky must be spelled correctly
(a)(ii)	ANY 3 of the following: B1 + B1 +B1 movement of smoke particles caused by (being hit by) **randomly moving air molecules** smoke particles are continuously moving because the **air molecules** are **continuously moving** smoke particles are visible but air molecules are not hence **air molecules must be (very) small**. small movement of smoke particles is due to the large numbers of **air molecules hitting from all sides**	(B1) (B1) (B1) (B1) B3	An observation must be **linked** to an appropriate conclusion Condone reference to “water molecules” in place of air molecules. Condone air atoms/particles. Max 3
(b)	(absolute) temp $\propto$ mean <u>KINETIC ENERGY</u> $\frac{1}{2} m_o (v_o)^2 = \frac{1}{2} m_h (v_h)^2$ OR mv^2 is constant OR $v^2 \propto 1/m$ OR mean KE of oxygen = mean KE of hydrogen $v_o = \sqrt{(m_h / m_o)} \times 1800 = \sqrt{(.002/.032) \times 1800} =$ **450** m s^{-1}.	C1 C1 A1	Allow $(\frac{1}{2})m\langle c^2\rangle = (3/2)kT$
	Total	**7**	

Question	Expected answer	Mark	Additional guidance
6(a)(i)	pressure is inversely proportional to volume (WTTE) for a <u>fixed mass</u> of gas at <u>constant temperature</u> (WTTE)	B1 B1	Accept $P \propto 1/V$ or PV = constant
(a)(ii) 1	hyperbolic (i.e.Boyles law) curve shape looks asymptotic to both axes i.e does not touch axes	B1 B1	
(a)(ii) 2	straight line through origin OR would extrapolate back to the origin	B1	
(b)(i)	correct sub^n in $pV = nRT \Rightarrow 5 \times 10^5 \times 0.040 = n \times 8.31 \times \underline{288}$ OR sub^n into $pV = NkT \Rightarrow 5 \times 10^5 \times 0.040 = N \times 1.38 \times 10^{-23} \times \underline{288}$ (hence) $n = 5 \times 10^5 \times 0.040 / (8.31 \times 288)$ = **8.4 (8.36)** mol (hence) $N = 5.03 \times 10^{24}$ molecules $\Rightarrow$ **8.36 moles**	C1 A1	Any incorrect Kelvin temp (eg 188) correctly used treat as an AE. Allow 8.35 **Use of 15^{0}C scores ZERO**
(b)(ii)	from $pV = nRT$ new n = 7.52 mol moles lost is 8.36 – 7.52 = 0.84 mol = **2.3 (2.34) x 10^{-2}** kg (0.023)	C1 C1 A1	Allow ecf from b(i) OR Pressure has dropped by 1/10 number of moles lost = 0.836 mol; Mass lost = $0.836 \times 0.028 = 2.3 \times 10^{-2}$ kg
	Total	**10**	

OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2011

Q1	Expected Answers	Marks	Additional guidance
(a)(i)	A body will remain at rest or continue to move with constant velocity unless acted upon by a force (WTTE)	B1	Do not allow speed unless "speed in a straight line" is stated. Allow "uniform motion"
(a)(ii)	The force which gives a mass of 1 kg an acceleration of 1 m s^{-2}	B1	**Allow** 1N = 1 kg m s^{-2}
(b)(i)	Use of $v = u + at$ OR $a = (v – u) / t$ $\Rightarrow a = (55 – 0) / 2.2$ $a = 25$ (m s^{-2})	C1 A1	
(b)(ii)	Use of $s = ut + ½ at^2$ e.g. $s = 0 + ½ \times 25 \times 2.2^2$ $s = 60.5$ (m)	C1 A1	**Allow** other valid solutions e.g. using $v^2 = u^2 + 2as$
(b)(iii)	$F = ma = 3.2 \times 10^4 \times 25 = 8.0 \times 10^5$ (N)	A1	**Allow** ecf from (b)(i)
(c)(i)	<u>towards the centre of the circle</u>.	B1	Do not allow a bare "perpendicular to the velocity" Do not allow "in the same direction as the acceleration."
(c)(ii)	use $F = mv^2/r$ e.g. $F = (3.2 \times 10^4 \times 120^2)/870$ $F = 5.3 \times 10^5$ (529655) (N)	C1 A1	If 55 is used instead of 120 for the velocity F = 1.1×10^5 ms^{-1} and scores 1 mark
(d)(i)	At top of the circle when the weight provides/equals the required centripetal force	M1 A1	**Allow** "when the resultant force = weight"
(d)(ii)	realisation that acc = g (OR 9.81) AND (hence) $v^2/r = g$ $\{v = \sqrt{(gr)} = \sqrt{(9.81 \times 1500)}\} \Rightarrow v = 120$ (m s^{-1}) (121.3)	M1 A1	**Accept** 121.24 as this corresponds to 9.8, do **not** allow 122.5 since this assumes g = 10 ms^{-2}
	Total	**14**	

Q2	Expected Answers	Marks	Additional guidance
(a)(i)	Force/acceleration is proportional to displacement **(**from equilibrium position**)** (Resultant force) force/acceleration is (always) towards equilibrium position (WTTE, e.g. allow fixed point).	B1 B1	**Allow** force/acceleration is in opposite direction to the displacement. **Allow** acc $\propto$ *x*, provided *x* is identified as the displacement for 1st mark. 2nd mark only scored if –ve sign used and explained.
(a)(ii)	True; False False; False	B2	-1 for each error stop at zero Assume ✓ means true and X means false Do not credit blank spaces
(b)	***Measurements***: angle measured <u>with protractor</u> stated or shown on the diagram <u>stop-watch/ms timer/data-logger</u> to measure time stated or shown on the diagram ***Conclusion:*** compare periods for different angles stated/implied OR plot period against angle ***major difficulty:*** angle of swing decreases during the timing of the swing ***solution:*** e.g. measure time for ¼, ½ or 1 swing accurately (using electronic timer/datalogger) OR use data logger with motion sensor to record many swings and analyse how the period changes over time OR video the motion with onscreen timer and analyse	B1 B1 B1 M1 A1	**Allow** ruler used to measure initial and subsequent displacement/amplitude if explained. **Allow** table of results with correct column headings i.e. at least angle and period Do not allow 'time is short so measure nT and divide by n to reduce (%) error'.(WTTE)
	Total	**9**	

Q3	Expected Answers	Marks	Additional guidance
(a)	Force per unit mass (at a point in a gravitational field).	B1	Accept $g = F/m$ if F and m are identified
(b)(i)	Recognition that inverse square law needs to be verified: e.g. $g \propto 1/r^2$ hence gr^2 = constant $\Rightarrow$ 9.8 x 6400^2 = 4.0 x 10^8 (or 4 x 10^{14}) AND 2.7 x 10^{-3} x (3.8 x $10^5)^2$ = 3.9 x 10^8 (or 3.9 x 10^{14}) (n.b values in brackets correspond to radius in metres) Any appropriate comment consistent with the calculations e.g. values are close enough (to verify the relationship).	B1 B1 B1	Do not accept a bare $g = GM/r^2$ unless G and M are stated as constants or following calculations shows this. They must use values in table and do both calculations for this mark **Allow** other valid approaches e.g. g ratio compared to $1/r^2$ ratio (3630 and 3530) OR (2.75 x 10^{-4} , 2.84 x 10^{-4} ,)
(b)(ii)	($mg = GmM / r^2 \Rightarrow M = gr^2$ / G) M = 9.81 x (6.4 x $10^6)^2$ / 6.67 x 10^{-11} M = 6.024 x 10^{24} kg	 C1 A1	(this formula is given on data sheet) Correct substitution into formula **Allow** 6.018 x 10^{24} this is for g = 9.8 and allow any value between 6.0 x 10^{24} and 6.03 x 10^{24} but not 6x 10^{24} Also **allow** data for the moon to be used i.e M_E = 2.7x10^{-3} x 3.8 x 10^8 / 6.67 x 10^{-11} = 5.846 x 10^{24} kg ≈ 6 x 10^{24} kg
(b)(iii)	volume = $(4/3)\pi r^3 = (4/3)\pi$ (6.4 x $10^6)^3$ (= 1.10x10^{21} m^3) $\rho = M/V$ = 6.0 x 10^{24} / 1.10 x 10^{21} = 5500 (5464)(kg m^{-3})	C1 A1	mark for correct substitution e.g. 6.4 x 10^6 (in m) used and not 6.4 x 10^3 (km) **allow** ecf from b(ii) for cand's value of M but no ecf for wrong volume <u>formula</u> If r = 6.4 x10^3 is used V = 1.1 x10^{12} $\Rightarrow$ ρ = 5.5x 10^{12} and scores 1 mark
	Total	**8**	

Q4	Expected Answers	Mark	Additional guidance
(a)(i)	Latent heat of <u>fusion</u>.	B1	QWC fusion spelled correctly ignore any reference to specific.
(a)(ii)	Latent heat of <u>vaporisation</u>.	B1	QWC Vaporisation spelled correctly. **Accept** vaporization but not vapourisation.
(b)(i)	E = $mc\Delta\theta$ used correctly e.g. 0.8 x 4200 x 82 = 2.8 x 10^5 (J) (275520)	C1 A1	0.8 x 4200 x (82+273) scores zero
(b)(ii)	Any two from: Some heat/energy used to heat kettle Some heat/energy lost to surroundings/air/environment. Some heat/energy used to boil water before kettle switches off	B1 B1	Do **not allow** "some heat lost" i.e. they must state where/how Do **not allow** "kettle if not 100% efficient". Do not allow "energy lost as sound/light"
(b)(iii)	1 kWh = 1000 x 3600 = 3.6 x 10^6 J Wastage per year = (2.8 x 10^5 x 365) / 3.6 x 10^6 = 28 kWh (27.9)	C1 A1	**Allow** 1 mark for energy lost per year = 1.02 x 10^8 <u>Joules</u> Allow ecf from (b)(i)
	Total	**8**	

Q5	Expected answers	Mark	Additional guidance
(a)(i)	A collision with no change / loss of kinetic energy.	B1	**Allow** coeff't of restitution = 1
(a)(ii)	Any 3 from Volume of particles negligible compared to volume of vessel OR molecules much smaller than distance between them No intermolecular forces acting (other than during collisions) OR molecules only have kinetic energy (and no PE) Particles travel in straight lines/at uniform velocity between collisions OR force of gravity on molecules is negligible time of collisions much smaller than time between collisions gas consists of a large number of molecules moving randomly (both needed for the mark)	B1 B1 B1	do not allow a bare "negligible volume of molecules " Do not allow "collisions between molecules are elastic" because this is given in the question. do not allow a bare "negligible time of collisions" Do not allow a bare "rapid random motion"
(b)(i)	$\Delta p = mv - mu$ $= 4.8 \times 10^{-26}$ [500 - (-500)] $= 4.8 \times 10^{-23}$ kg m s^{-1}	C1 A1	 2.4×10^{-23} scores zero
(b)(ii)	(time between collisions = 0.4 /500 s) . Number of collisions/sec. = 500/0.4 = 1250	A1	Correct answer only
(b)(iii)	(Mean) force = $\Delta p/t$ OR Force = rate of change of momentum OR Impulse = change in momentum Force = $1250 \times 4.8 \times 10^{-23} /1 = 6.0 \times 10^{-20}$ N	C1 A1	**Allow** ecf from (b)(i) and (b)(ii) e.g. if 2500 is used from (b)(ii) $F = 2500 \times 4.8 \times 10^{-23} = 1.2 \times 10^{-19}$ N and this scores 2 marks
(b)(iv)	Same value as candidate's (b)(iii) due to Newton's third law OR this force acts in opposite direction	B1	 OR –ve sign shown
(c)(i)	$3 \times 6 \times 10^{23} = 1.8 \times 10^{24}$	B1	1.806×10^{24} if 6.02 is used
(c)(ii)	(very) large number of particles that are moving randomly means that at any instant the number of collisions on each face will be the same (WTTE)	B1	Allow no gravitational forces and hence uniform density
(c)(iii)	(mean) KE/speed of molecules increases Increased rate of collisions with wall OR 'harder' collisions with wall	B1 B1	Also **allow** greater change of momentum per collision (WTTE) Not just "more collisions".
	Total	**14**	

Q6	Expected answers	Mark	Additional guidance
(a)(i)	Straight line (judged by eye)with positive slope AND passing through the origin	B1	correct answer only
(a)(ii)	8.31 (J mol^{-1} K^{-1})	B1	Allow *R* and molar gas constant, but do not allow *pV*/*T* OR *nR*
(b)(i)	-40 ^oC = 233 K, AND 250 ^oC = 523 K Use of $V_1/T_1 = V_2/T_2$ 2.4 x 10^{-2} / 233 = V_2 / 523 V_2 = 0.053(8) (m^3)	M1 C1 A1	No marks scored if 40^o C and/or 250^oC are used Accept other correct versions.
(b)(ii)	Use of $p = nRT/V$ = 1.5 x 8.31 x 233 / 2.4 x 10^{-2} = 1.21 x 10^5 (Pa)	C1 A1	Allow T= 523 and V= 0.053 hence p = 1.2 x10^5 Allow ecf from (b)(i)
	Total	**7**	

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2012

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
✓	Correct response
AE	Arithmetic error
?	Wrong physics or equation

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

The use of ticks to indicate where marks are awarded is strongly advised in all questions but the following questions **must always** be annotated with ticks.
Q3(a)(i), Q4(a), Q5(a)(ii), Q5(a)(iii)

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B-**mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A-**marks (accuracy marks) later depend. For an **M-**mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M-**mark, then none of the dependent **A-**marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C-**mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C-**mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M-**mark, or allow a **C-**mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more significant figures.

(Significant figures are rigorously assessed in the practical skills.)

Question			Answer	Marks	Guidance
1	(a)	(i)	(linear momentum =) mass x velocity	B1	**Allow**: momentum = $m\,v$ where m is mass and v is velocity **Not**: mass x speed
		(ii)	Any **two** from: momentum / vector has magnitude and direction velocity is a vector A product of a scalar and vector is a vector	B1 x 2	
	(b)	(i)1	$a = \Delta v/\Delta t = 7.5 / 0.28$ $a = 27$ (m s^{-2})	A1	Ignore sign
		2	$F = ma$ $F = 850 \times 27$ $= 2.3 \times 10^4$ (N)	C1 A1	Possible ecf from b(i) for acceleration
		(ii)	$E = \frac{1}{2}mv^2$ $0.45 \times 10^6 = \frac{1}{2} \times 850 \times v^2$ $v = \sqrt{(2 \times 0.45 \times 10^6 / 850)}$ $v = 33$ (m s^{-1})	C1 A1	Mark is for correct substitution **Note**: Possible POT error
	(c)		$m_1u = (m_1 + m_2)v$ $850 \times 7.5 = (850 + 1200)\,v$ $v = 850 \times 7.5 / 2050$ $v = 3.1$ (m s^{-1})	C1 A1	Mark is for correct substitution
			Total	**10**	

Question			Answer	Marks	Guidance
2	(a)	(i)	amplitude = 0.4(0) (m) **and** period = 5.(0) (s)	B1	**Note**: Both values are required. **Allow** 1 sf values
		(ii)	$\omega = (2\pi f) = 2\pi / \tau$ $\omega = 2\pi / 5.0 = (2\pi \times 0.2)$ $\omega = 1.3$ (rad s^{-1})	 C1 A1	Possible ecf from a(i) for period Mark is for correct substitution
	(b)	(i)	V clearly marked at any point where graph crosses time axis	B1	
		(ii)	A clearly marked at any point where graph crosses time axis	B1	
		(iii)	P clearly marked at any point where graph crosses time axis	B1	
	(c)	(i)	Selecting from data sheet $a = -(2\pi f)^2 x$ $a_{max} = (-)(2\pi \times 2.4 \times 10^3)^2 \times 1.8 \times 10^{-3}$ $a_{max} = 4.1 \times 10^5$ (m s^{-2})	C1 C1 A1	**Allow**: $a = (-)\ \omega^2 x$ **Note**: Ignore sign of a **Allow**: 2 marks for 4.1×10^n , $n \neq 5$ [POT error]
		(ii)	Work done = mean force x distance moved For ¼ oscillation distance moved = 1.8 mm, Work done = $0.25 \times 1.8 \times 10^{-3}$ (= 4.5×10^{-4} J) Time taken $\Delta t = ¼\ T = ¼\ (1/2.4 \times 10^3) = 1.04 \times 10^{-4}$ Power = work done / Δt = $0.25 \times 1.8 \times 10^{-3} / 1.04 \times 10^{-4}$ = **4.3 W** Power = 4.3 (W)	 C1 C1 A1	**Allow:** other correct values of distance moved and compatible time taken. Eg 7.2 (mm) and 4.17×10^{-4} (s) for 1 complete oscillation
			Total	**12**	

Question			Answer	Marks	Guidance
3	(a)	(i)	**geostationary** or **synchronous** ✐**The term geostationary** or **synchronous to be included and spelled correctly to gain the B1 mark**	B1	**Must use tick or cross on Scoris to show if the mark is awarded**
		(ii)	So that they stay: above the same point (at all times) at same point in the sky	B1	**Allow**: travel at same (angular) speed / period and same direction as the Earth
		(iii)	<u>Dish</u> can be fixed to point in one (specific) direction/ <u>Dish</u> does not have to track the satellite (across the sky)	B1	**Allow**: Receiver / aerial for dish
		(iv)	Select from data sheet $T^2 = (4\pi^2/GM)r^3$ $r^3 = T^2\ (GM/4\pi^2)$ $r^3 = (8.64 \times 10^4)^2\ (6.67 \times 10^{-11} \times 6.0 \times 10^{24} / 4\pi^2)$ any subject $(= 7.56 \times 10^{22})$ $r = 4.2 \times 10^7$ (m) $r \approx 4 \times 10^7$ (m)	 C1 C1 A1 A0	**Allow**: Full credit if candidate assumes r = 4 x 10^7 and shows T is approx 1 day. 1 day = 8.64 x 10^4 s G = 6.67 x 10^{-11} N m^2 kg^{-2} Mark for radius can only be awarded if suitable working is shown
	(b)	(i)	The cube of the planets distance (from the Sun) divided by the square of the (orbital) period is the same (for all planets) (WTTE)	B1	**Allow**: radius for distance., **Allow:** $T^2 \propto r^3$ or r^3 / T^2 = constant provided T and r are <u>identified</u>
		(ii)	$\text{ratio}^3 = \left(\frac{27.3}{1}\right)^2$ ratio = $(27.3)^{2/3}$ ratio = 9.1	C1 A1	**Allow:** 1 mark for correct value of distance of Moon from Earth's centre 3.8 x 10^8(m) **Note**: Full credit for 4 x 10^7 (m) used from (a)(iv)
			Total	**9**	

Question			Answer	Marks	Guidance
4	(a)		latent heat of **fusion** **The term fusion to be included and spelled correctly to gain the B1 mark**	B1	**Allow**: Specific latent heat of fusion **Allow**: (Specific) latent energy of fusion **Must use tick or cross on Scoris to show if the mark is awarded**
	(b)	(i)	Total / sum of randomly (distributed) kinetic energy and potential energy of molecules/atoms	B2	**Allow**: 1 mark only if molecules / atoms and/or randomly are omitted
		(ii)	Potential energy of the molecules increases Kinetic energy of molecules is the same for water and steam (since the temperature is the same) / work is done in moving molecules apart	B1 B1	**Allow** : work is done to break the bonds (between molecules)
	(c)	(i)	Mass of air = volume x density = 15 x 1.2 (= 18 kg) Heat energy transferred to air in one hour Q = 12 x 60 x 60 (= 43200 J) $\Delta\theta = Q / mc$ = 12 x 60 x 60 / 18 x 990 Temperature rise in one hour = 2.4 K	C1 C1 A1	**Allow**: any subject Treat a transcription error as one AE. **Allow**: 2 K as question asks for an estimate
		(ii)	Any **two** from • Heat lost to structure of greenhouse / contents • Heat lost through glass / from the greenhouse / surroundings • Average rate of loss of heat reduces (as temperature falls)	B1 x 2	
			Total	**10**	

Question			Answer	Marks	Guidance
5	(a)	(i)	Collision in which kinetic energy is conserved	B1	**Allow**: no ke lost (wtte)
		(ii)	Any **four** from • Many molecules collide with the walls • A change in momentum occurs when molecule(s) collide with (and rebound from) the walls of container • Force is rate of change of momentum • The force exerted by the molecule(s) on wall is equal to force exerted by the wall on the molecule(s) (by Newton's third law) • pressure (on wall) = (total) force (on wall) / area (of wall)	B1 x 4	Symbols must be defined in formulae
		(iii)	Any **two** from • Molecules move faster/have greater kinetic energy (at higher temperature) • There is an increased rate of collision / more collisions occur per second / collisions occur more often • Each collision involves a greater change in momentum	B1 x 2	**Not**: greater force **Not**: harder collisions
	(b)	(i)	$P_1V_1/ T_1 = P_2V_2/T_2$ with T stated in Kelvin or clearly shown in subsequent working P_2 = 105 x 5x10^3 x (273 – 30)/ (273 + 20) x 1.2 x 10^4 P_2 = 36 (kPa)	C1 C1 A1	Temperatures must be in kelvin to score this mark. **Allow** : consistent working in pascal
		(ii)	Risk that balloon will burst (with further increase in volume)	B1	**Allow**: pop / explode
			Total	**11**	

Question			Answer	Marks	Guidance
6	(a)		Mass of one hydrogen molecule $= 2.02 \times 10^{-3} / 6.02 \times 10^{23}$	C1	
			Mass $= 3.4 \times 10^{-27}$ **(**kg)	A1	
	(b)		Mean k.e = $3kT/2$		
			Mean ke $= 3/2 \times 1.38 \times 10^{-23} \times 1100$	B1	
			Mean ke $= 2.3 \times 10^{-20}$ (J)	B1	
			Mean ke $\approx 2 \times 10^{-20}$ (J)	A0	
	(c)		$E_k = ½ mv^2$ $2.3 \times 10^{-20} = ½ \times 6.6 \times 10^{-27} v^2$ $v^2 = (2 \times 2.3 \times 10^{-20} / 6.6 \times 10^{-27})$ $v = (2 \times 2.3 \times 10^{-20} / 6.6 \times 10^{-27})^{1/2}$	M1	**Note**: Full credit to be given for the use of 2×10^{-20} (J) from (b) giving $v = 2.5 \times 10^3$ (ms^{-1}) **Note:** If 3.36×10^{-27} is used from (a) (hydrogen molecules) then speed $= 3.68 \times 10^3$ m s^{-1} and scores max 1 mark
			$v = 2.6 \text{ X } 10^3$ (m s^{-1})	A1	
	(d)		Helium atoms have a range of speeds / kinetic energies	M1	Accept equivalent wording or suitable diagram
			Hence some atoms have a velocity greater than 11 km s^{-1} / escape velocity	A1	.
			Total	**8**	

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for June 2012

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
✓	Correct response
AE	Arithmetic error
?	Wrong physics or equation

The abbreviations, annotations and conventions used in the detailed mark scheme are:

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

Q2a, Q2bii, Q3bi, Q5a should be full annotated on all scripts. Ticks are preferred on **all** questions where credit is given.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance Column.

Question			Answer	Marks	Guidance
1	(a)	(i)	Force changes the momentum of / accelerates / decelerates the object	B1	**Allow:** Change of speed / velocity / direction <u>of motion</u>
	(b)	(i)	Force x time <u>for which the force acts</u> / <u>duration of collision</u>	B1	**Allow:** $F\,\Delta t$ with both symbols defined **Not:** change of momentum
		(ii)	Area under graph = impulse OR Area = change in momentum final velocity = Area under graph / mass	B1 B1	**Allow:** Area under graph = mv OR ... = $m(v-u)$ **Note:** v must be the subject to score this mark
	(c)	(i)	mean force on ball x time = increase in momentum of ball mean force = $\dfrac{0.058 \times 52}{4.2 \times 10^{-3}}$ = 720 (N)	 C1 A1	 Mark for correct substitution **Note:** Answer to 3 sf is 718 (N) Bald 720 (N) scores 2 marks
		(ii)	momentum change of racket = momentum (change) of ball M (38 – 32) = 0.058 x 52 $M = \dfrac{0.058 \times 52}{6}$ = 0.50 (kg)	 C1 A1	 **Allow:** use of mean force from c(i) and time 4.2ms . Possible ECF from c(i) **Note:** Answer to 3 sf is 0.503 (kg) **Allow:** 0.5 (kg)
		(iii)	The person / hand / arm holding the racket also changes momentum (AW)	B1	**Not:** references to angles or initial speed of ball
			Total	**9**	

Question			Answer	Marks	Guidance
2	(a)		acceleration proportional to <u>displacement</u> (from the equilibrium position) and is always acting towards the equilibrium position / the mid-point of the motion (AW)	B1 B1	✐ **displacement** must be spelled correctly to score the mark. **Allow:** acceleration proportional to distance <u>from equilibrium position</u> with equilibrium spelled correctly for first B1 **Allow:** 'acceleration is in the opposite direction to displacement' for the second B1 mark **Use tick or cross on Scoris**
	(b)	(i)	$v_{max} = 2\pi f A$ $f = 1/0.08 = 12.5$ $v_{max} = 2\pi\left(\frac{1}{0.080}\right)\times 1.2\times 10^{-3}\left(= 2\pi \times 12.5\times 1.2\times 10^{-3}\right)$ $v_{max} = 9.4\times 10^{-2}$ (m s^{-1})	C1 A1	If A = 0.6 mm used $v_{max} = 2\pi\left(\frac{1}{0.080}\right)\times 0.6\times 10^{-3}$ (✓) $v_{max} = 4.7\times 10^{-2}$ (m s^{-1}) (✓) **Note:** Answer to 3 sf is 9.42 x 10^{-2} (m s^{-1}) **Allow:** 1 mark for 94(.2) (m s^{-1}) not converting mm to m
		(ii)	This occurs at the highest point (top) of the oscillations When acceleration of plate equals/exceeds free fall acceleration /g/ 9.81 $g = (2\pi f)^2 A_0$ hence $A_0 = \frac{9.81}{\left(2\pi\times\frac{1}{0.080}\right)^2}$ $A_0 = 1.6 \times 10^{-3}$ (m)	B1 B1 C1 A1	**Allow:** equation with any subject for this mark **Note:** Answer to 3 sf is 1.59 x 10^{-3} (m)
	(c)	(i)	Resonance Driving / drum frequency matches natural frequency (of casing) (AW)	B1 B1	
		(ii)	Graph with peak amplitude **less than** original peak amplitude Similar shape curve with peak at the **same** or **lower** frequency than given curve Curve is lower than given curve at all frequencies	M0 A1 A1	Must see this before subsequent marks can be scored.
			Total	**12**	

Question			Answer	Marks	Guidance
3	(a)	(i)	Arrow (labelled F) directed towards centre of circle	B1	**Allow:** arrow drawn parallel to the string
		(ii)	Resultant force (F) acts at 90^{o} to motion / velocity of bung so no work done is done by F (hence no change in speed)	B1 B1	**Allow:** No component of F acts in the direction of motion (B1) hence there is no acceleration <u>in the direction of motion</u> (AW) (B1)
	(b)	(i)	Student <u>tries to</u> rotate bung at <u>constant</u> radius / <u>tries to</u> keep reference mark at end of tube (AW) Force F is calculated using $F = Mg$. where M is mass of slotted masses Measure time t for n revolutions of the bung (hence calculate T for 1 revolution). Measure radius r when <u>stationary</u> Calculate v using $2\pi r\ n/t$ (or $2\pi r/T$).	B1 B1 B1 B1 B1	**Not:** bald 'constant radius' **Not** : F = weight **Not:** 'take time for 1 revolution'
		(ii)	**1** Straight line of positive gradient <u>passing through the origin</u> **2** $F = \frac{m}{r}v^2$ hence gradient $= \frac{m}{r}$ Mass = <u>gradient</u> (of graph) x radius (of orbit)	B1 B1 B1	 Cannot award this mark if graph is curved Can score this mark if graph is curved
			Total	**11**	

Question			Answer	Marks	Guidance
4	(a)	(i)	Energy required to raise the temperature of a unit mass of a substance by unit temperature rise.	B1	**Allow:** $c = \dfrac{Q}{m\Delta\theta}$ with all symbols defined.
		(ii)	LH of fusion is energy needed to change (a substance) from <u>solid to liquid</u> LH of vaporisation is energy needed to change (a substance) from <u>liquid to gas/vapour</u>	B1	Allow: a single reference to energy (either statement acceptable)
	(b)	(i)	**A to B**: KE of molecules <u>increases</u> <u>AND</u> PE of molecules (small) <u>increases</u> **B to C**: KE of molecules remain constant <u>AND</u> PE of molecules <u>increases</u>	B1 B1	
		(ii)	c_{solid} is **less than** c_{liquid} Correct reason **Eg** gradient for solid is greater than gradient for liquid AND gradient is inversely proportional to specific heat capacity (AW}	B1 B1	
	(c)	(i)	<u>In one second</u> volume flowing through = $(3.6 \times 10^{-3} /60)$ = 6.0×10^{-5} mass flowing through = $6.0 \times 10^{-5} \times 1000$ = (6.0×10^{-2}) Energy gained by water $E = mc\,\Delta\theta = 0.060 \times 4200 \times (36.7 - 17.4)$ (= 4864) Power of heater = E / t = 4864 /1 Power of heater = 4.9×10^{3} ≈ 5 kW	 C1 C1 C1 A1 A0	**Alternative** <u>In one minute</u> volume flowing through = 3.6×10^{-3} mass flowing through = 3.6 (C1) Energy gained $E = mc\,\Delta\theta$ = $3.6 \times 4200 \times (36.7 - 17.4)$ (C1) (= 2.92×10^{5} J) Power = E / t = 2.92×10^{5} /60 (C1) Power of heater = 4.9×10^{3} (A1) ≈ 5 kW (A0)
		(ii)	EITHER rate of flow of water changes **because** water pressure changes OR Inlet temperature changes **because** ambient temperature changes	 M1 A1	
			Total	**12**	

Question			Answer	Marks	Guidance
5	(a)		Gas molecules move in **random / erratic / haphazard** motion (AW) :	B1	**Use tick or cross on Scoris** ✎ **random / erratic / haphazard** must be spelled correctly to score the mark.
	(b)	(i)	constant temperature	B1	
		(ii)	$P_1V_1 = P_2V_2$ $350 \times 120 \times (A) = P_2 \times 55 \times (A)$ $P_2 = \dfrac{350 \times 120}{55}$ = 760 (kPa)	 C1 A1	 **Note:** Answer to 3 sf is 764 (kPa) **Note**: 7.6 x 10^5 (kPa) scores 1 mark
		(iii)	When a molecule collides with the (moving) piston it rebounds with higher speed / ke / momentum (Mean) kinetic energy of molecules is <u>proportional / ∝</u> to (Kelvin) temperature	B1 B1	Must refer to collisions with piston or rebounds from piston not collisions within gas molecules. Allow: $E_k = 3kT/2$ without definition of terms.
			Total	**6**	

Question			Answer	Marks	Guidance
6	(a)	(i)	Force between two (point) masses is proportional to the product of masses and inversely proportional to the square of the distance between them	B1 B1	**Not:** radius **Allow:** $F = GMm/r^2$ B1 **All** symbols defined B1
		(ii)	Force per (unit) mass	B1	**Allow:** $g = F/m$ with symbols defined
	(b)	(i)	$v = \frac{2\pi R}{T}$ $v = \frac{2\pi \times 1.2 \times 10^9}{16 \times 86400}$ $v = 5.5 \times 10^3$ (ms^{-1})	C1 A1	**Note:** Answer to 3 sf is 5.45 x 10^3 **Allow:** 1 mark for 4.7 x 10^8 not converting days to s **Allow:** 1 mark for 5.5 not converting km to m
		(ii)	$m_T \frac{v^2}{r} = \frac{GM_S m_T}{r^2}$ $M_S = \frac{v^2 r}{G}$ $M_S = \frac{(5.45 \times 10^3)^2 \times 1.2 \times 10^9}{6.67 \times 10^{-11}}$ $M = 5.3 \times 10^{26}$ (kg)	C1 C1 A1	**Allow:** alternative method using Kepler's third law Possible ECF from b(i) **Note :** An answer of 5.3 x 10^{26} (or 5.4 x 10^{26}) **without substitution shown** scores 2 marks since this is a '**show'** question. **Note:** Use of 5.5 x 10^3 gives 5.4 x 10^{26} (kg)
	(c)		Reference to $T^2 = (4\pi^2/GM)\, r^3$ OR $T^2 \propto r^3$ $\frac{T_R}{T_T} = \sqrt{\frac{r_R^3}{r_T^3}}$ OR $\frac{T_R}{T_T} = \left(\frac{r_R}{r_T}\right)^{\frac{3}{2}}$	B1 B1	**Not:** $\left(\frac{T_R}{T_T}\right)^2 = \left(\frac{r_R}{r_T}\right)^3$
			Total	**10**	

RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced GCE

Unit **G484:** The Newtonian World

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error
SF	Error in number of significant figures
✓	Correct response
AE	Arithmetic error
?	Wrong physics or equation

The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

Annotation	Meaning
/	Alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more sf.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance Column.

CATEGORISATION OF MARKS

The mark scheme categorise marks on the MACB scheme.

B marks:	These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.
M marks:	These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
C marks:	These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.
A marks:	These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Question			Answer	Marks	Guidance
1	(a)		Rate of change of momentum (of a body) is proportional / equal to the (net) force (acting on it) and takes place in the direction of that force.	M1 A1	**Allow:** Force = change in momentum / time (taken) ✐ **Note: momentum** must be spelled correctly to score the mark. **Allow** this mark if the M1 mark is lost for spelling error
	(b)	(i)	(3 x 5) – (7 x 2) = 10v *v* = (15 – 14)/10 = 0.10 (m s^{-1}) to the right (AW)	C1 M1 A1	Signs must be correct for the mark to be scored **Allow** 1 sf answer **Not** forwards/towards **B** but **allow** correct arrow → or east
		(ii)	Impulse = 3(0.1 – 5) (= - 14.7) = (-)15 (Ns) to the left (AW)	 M1 A1	**Allow:** ecf from (b)(i) **Ignore** sign **Not** backwards/towards **A** but **allow** correct arrow ← or west
		(iii)	(Newton's 3rd law says) Force on B (due to A) is equal and opposite to force on A (due to B) time (of contact) / *t* is same for both **AND** Impulse = *Ft* impulse on A is equal and opposite to impulse on B	 M1 A1 A0	**Allow**: use of minus sign to indicate 'opposite' **Not**: Action and reaction are equal and opposite.
			Total	**9**	

Question			Answer	Marks	Guidance
2	(a)	(i)	$g = \frac{v^2}{r}$ or $v^2 = \frac{GM}{r}$ $v = \sqrt{gr}$ $v = \sqrt{7.7 \times 7.2 \times 10^6}$ $v = 7400$ (m s^{-1})	C1 C1 A1	Correct formula in any form **Allow:** use of *a* for *g* Mark is for substitution (**Note** Mass of Earth is 6.0 x 10^{24} kg) **Any use of r = 800 km is WP scores 0/3** **Note:** Answer to 3 sf is 7450 (m s^{-1})
		(ii)	$T = \frac{2\pi r}{v}$ $T = \frac{2\pi \times 7.2 \times 10^6}{7450}$ = 6100 (s) $T^2 = \frac{4\pi^2 r^3}{GM}$ $T^2 = \frac{4\pi^2 (7.2 \times 10^6)^3}{6.67 \times 10^{-11} \times 6 \times 10^{24}}$ T = 6100 (s)	C1 A1	**Allow:** possible ecf for *v* from (a)(i) **No ecf** for use of *r* = 6.4 x 10^6 again or use of r = 800 km Both score 0/2 **Note:** Answer to 3 sf using v = 7400 is 6110 (s) Answer to 3 sf using v = 7450 is 6070 (s)
	(b)	(i)	Number of orbits = $\frac{24 \times 3600}{6080}$ (= 14.2) ≈ 14	B1	**Allow** any correct method **Allow** ora **No ecf** from a(ii)
		(ii)	Circumference = $2\pi r$ $\frac{\text{equatorial circumference}}{\text{width of photograph}} = \frac{2\pi \times 6400}{3000} = 13.4$ (But each orbit crosses the equator twice hence) number of orbits = 6.7 This is fewer than 14 orbits so whole of Earth's surface can be photographed (AW)	C1 C1 A1 A0	**Allow**: Circumference = $2\pi r$ (C1) length of equator covered per orbit = 2π x 6.4 x 10^3/14 (C1) (= 2872) (But each orbit crosses the equator twice hence) min width to be photographed = ½ x 2872 = 1400 km (A1) < 3000 km so all of Earth's surface can be photographed in one day (A0)

Question			Answer	Marks	Guidance
	(c)		suitable example: eg weather / spy / surveying / mapping / GPS	B1	**Ignore** TV / radio / communications
			Total	**10**	

Question			Answer	Marks	Guidance
3	(a)		Force is proportional to the product of the masses and inversely proportional to the square of their separation (AW)	B1	**Allow:** $F = \frac{GmM}{r^2}$ with **all** symbols defined.
	(b)	(i)	$mg = \frac{GmM_J}{r^2}$ $M_J \left(= \frac{gr^2}{G} \right) = \frac{7.5 \times (1.3 \times 10^8)^2}{6.67 \times 10^{-11}}$ M_J = 1.9 x 10^{27} (kg)	C1 C1 A1	**Allow:** formula with m cancelled **Allow:** use of $T^2 = \frac{4\pi^2 r^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2 (1.3 \times 10^8)^3}{6.67 \times 10^{-11} \times (7.2 \times 60^2)^2}$ **Note:** mark is for substitution with any subject
		(ii)	$\frac{g_M}{g_A} = \frac{r_A{}^2}{r_M{}^2}$ $\frac{g_M}{7.5} = \frac{(1.3 \times 10^8)^2}{(2.4 \times 10^{10})^2}$ g_M = 2.2 x 10^{-4} (N kg^{-1})	C1 A1	**Allow:** use of $g = \frac{GM_J}{r^2}$ with possible ecf for M_J from (b)(i) $g_M = \frac{(6.67 \times 10^{-11}) \times (1.9 \times 10^{27})}{(2.4 \times 10^{10})^2}$ **Note:** mark is for substitution g_M = 2.2 x 10^{-4} (N kg^{-1})
		(iii)	$T^2 \propto r^3$ OR T^2/r^3 = constant (= $4\pi^2/GM_J$) $\frac{T_M{}^2}{7.2^2} = \frac{(2.4 \times 10^{10})^3}{(1.3 \times 10^8)^3}$ T_M = 1.8 x10^4 (hours)	C1 C1 A1	**Allow:** possible ecf for M_J from b(i) **Allow:** use of other **c**orrect formulae **Note:** mark is for substitution **Note** using times in seconds gives T_M = 6.49 x10^7 (s) scores 2 marks
			Total	**9**	

Question			Answer	Marks	Guidance
4	(a)		Obtain a set of readings for: mass *m*, time period AND calculate frequency using <u>*f* = 1/*T*</u>. Plot graphs of *f* against 1/*m* AND *f* against 1/√*m* The graph which is a straight line through the origin provides the correct relationship Reference to one method of improving reliability eg counting more than 5 oscillations to find *T* or *f* taking repeat measurements of *T* or *f* (and average values) time oscillations from equilibrium position	B1 B1 B1 B1	**Not** number of oscillations in a set time **Allow:** product method using two or more points (B1) Select the relation which gives a constant product (B1) **Allow:** plot ln *f* against ln *m* (B1) gradient= -1 then $f \propto 1/m$ **or** gradient= -0.5 then $f \propto 1/\sqrt{m}$ (B1)
	(b)	(i)	$v_{max} = 2\pi f A = 2\pi\left(\frac{1}{1.2}\right)\times 36\times10^{-3}$ $v_{max} = \frac{3\pi}{50} \quad (= 0.188)$ $KE_{max} = \frac{1}{2}\times 0.4\times\left(\frac{3\pi}{50}\right)^2$ $KE_{max} = 7.1\times10^{-3}$ (J)	C1 C1 A1	**Note:** mark is for substitution
		(ii)	$a_{max} = (2\pi f)^2 A = \left[2\pi\left(\frac{1}{1.2}\right)\right]^2 \times 36\times10^{-3}$ $a_{max} = 0.99$ (ms^{-2})	C1 A1	**Note:** mark is for correct substitution

Question			Answer	Marks	Guidance
	(c)		**Reference to** : kinetic energy (of masses and spring), gravitational potential energy (of mass and spring), elastic (potential) energy / strain energy of spring	B1	**Note:** mark to be awarded only if **all** 3 forms are quoted ✐ **Note: potential** must be spelled correctly throughout to score this mark
			KE: zero (at lowest point), increasing to max at equilibrium point, decreasing to zero (at highest point)	B1	
			GPE: increases (as masses rise from lowest to highest point) (clearly worded ora)(AW)	B1	
			strain / elastic energy: decreases (as masses rise from lowest to highest point) (clearly worded ora) (AW)	B1	
			Total	**13**	

Question			Answer	Marks	Guidance
5	(a)	(i)	n = number of moles (in sample) **AND** N = number of atoms / molecules (in sample)	B1	**Note: both** definitions are required **Not:** particles / Avogadro's constant
		(ii)	n or N **AND** T is constant (and R and k are constants) for a fixed mass (of gas), pV = constant / $p \propto 1/V$	M1 A1	nRT or NkT is constant is **not** sufficient
		(iii)	Shows that $Nm^{-2} \times m^3 = Nm$	B1	**Allow:** Use of base units for **both** pV **and** work done
	(b)	(i)	Calculates $p \times (1/V)^{-1}$ at **two** points on the graph values are the same pV = constant / $p \propto 1/V$ / nRT = constant	M1 A1	Expected values for pV are 7500 (Nm) or 0.075 ($\times 10^{-5}$)for most points **Allow:** Correct calculation of gradient (M1) Calculates intercept = 0 hence graph is through the origin and pV = constant / $p \propto 1/V$ (A1)
		(ii)	Number of moles in 0.050 kg = 0.05/0.016 (= 3.125) $T = \frac{pV}{nR} = \frac{7500}{3.125 \times 8.31}$ $= 289$ (K) $T = 16$ (°C)	C1 C1 A1	**Allow:** possible ecf from (b)(i) or error in n but apply POT error for use of pV = 0.075 leading to $T = 2.9 \times 10^{-3}$ K **Note:** Mark is for correct conversion of their T (K) value **Note**: Allow full range of marks for other sensible alternative approaches e.g. use of a molecular mass of 0.032 kg/mol giving a temperature of 305°C
			Total	**9**	

Question			Answer	Marks	Guidance
6	(a)	(i)	vibrate (about their 'fixed' positions)	B1	**Allow:** molecules vibrate
		(ii)	greater amplitude / greater frequency (of vibration)	B1	**Not:** faster / more / bigger /more vigorous (vibrations)
		(iii)	**Either** internal energy increases **Or** potential energy (of molecules) increases and the kinetic energy remains constant temperature remains constant	B1 B1	
	(b)	(i)	$P\,t = m\,c\,\Delta\theta$ 48 x 720 = 0.98 x *c* x (54 - 18) + 0.027 x 850 x (38-18) *c* = 970 (J kg^{-1} K^{-1})	C1 C1 C1 A1	**Note:** mark is for correct substitution for total energy input **and** heat gained by **metal** **Note:** mark is for adding a correct substitution for heat gained by insulation into this equation **Note:** answer to 3 sf = 967 Calculation of *c* = 980 ignoring energy used to heat insulation scores 2 marks
		(ii)	Without the insulation there will be **more** heat lost to the surroundings / air (AW) final temperature will be **lower** **OR** a **lower** temperature rise **OR** more energy will be required to give the **same** temperature rise / final temperature **AND** hence c is **higher** than that calculated in (i)	M1 A1	**Not:** lost to wires / data logger
			Total	**10**	