

Markscheme

November 2018

Physics

Higher level

Paper 2

18 pages

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Question			Answers	Notes	Total
1.	a		change in momentum each second = $6.6 \times 10^{-6} \times 5.2 \times 10^4 \llcorner = 3.4 \times 10^{-1} \text{ kg m s}^{-1} \llcorner \checkmark$ acceleration = $\llcorner \frac{3.4 \times 10^{-1}}{740} = \llcorner 4.6 \times 10^{-4} \llcorner \text{ m s}^{-2} \llcorner \checkmark$		2
1.	b	i	ALTERNATIVE 1: (considering the acceleration of the spacecraft) time for acceleration = $\frac{30}{6.6 \times 10^{-6}} = \llcorner 4.6 \times 10^6 \llcorner \llcorner \text{ s} \llcorner \checkmark$ max speed = $\llcorner \text{answer to (a)} \times 4.6 \times 10^6 = \llcorner 2.1 \times 10^3 \llcorner \llcorner \text{ m s}^{-1} \llcorner \checkmark$ ALTERNATIVE 2: (considering the conservation of momentum) (momentum of 30 kg of fuel ions = change of momentum of spacecraft) $30 \times 5.2 \times 10^4 = 710 \times \text{max speed} \checkmark$ max speed = $2.2 \times 10^3 \llcorner \text{ m s}^{-1} \llcorner \checkmark$		2
1.	b	ii	as fuel is consumed total mass changes/decreases so acceleration changes/increases OR external forces (such as gravitational) can act on the spacecraft so acceleration isn't constant $\checkmark$		1

(continued...)

(Question 1 continued)

Question			Answers	Notes	Total
1.	b	iii	problem may be too complicated for exact treatment ✓ to make equations/calculations simpler ✓ when precision of the calculations is not important ✓ some quantities in the problem may not be known exactly ✓		1 max
1.	c	i	ions have same (sign of) charge ✓ ions repel each other ✓		2
1.	c	ii	the forces between the ions do not affect the force on the spacecraft. ✓ there is no effect on the acceleration of the spacecraft. ✓		2

Question			Answers	Notes	Total
2.	a		ALTERNATIVE 1: $r = \sqrt{\frac{\rho l}{\pi R}} \quad \text{OR} \quad \sqrt{\frac{7.2 \times 10^{-7} \times 12.5}{\pi \times 0.1}} \quad \checkmark$ $r = 5.352 \times 10^{-3} \quad \checkmark$ $5.4 \times 10^{-3} \text{ «m» } \checkmark$ ALTERNATIVE 2: $A = \frac{7.2 \times 10^{-7} \times 12.5}{0.1} \quad \checkmark$ $r = 5.352 \times 10^{-3} \quad \checkmark$ $5.4 \times 10^{-3} \text{ «m» } \checkmark$	<i>For MP2 accept any SF</i> <i>For MP3 accept only 2 SF</i> <i>For MP3 accept ANY answer given to 2 SF</i>	3
2.	b		current in lamp = $\frac{5}{24}$ «= 0.21» «A» OR $n = 24 \times \frac{8}{5} \quad \checkmark$ so «38.4 and therefore» 38 lamps $\checkmark$	<i>Do not award ECF from MP1</i>	2

(continued...)

(Question 2 continued)

Question			Answers	Notes	Total
2.	c		when adding more lamps in parallel the brightness stays the same ✓ when adding more lamps in parallel the pd across each remains the same/at the operating value/24 V ✓ when adding more lamps in parallel the current through each remains the same ✓ lamps can be controlled independently ✓ the pd across each bulb is larger in parallel ✓ the current in each bulb is greater in parallel ✓ lamps will be brighter in parallel than in series ✓ In parallel the pd across the lamps will be the operating value/24 V ✓	<i>Accept converse arguments for adding lamps in series:</i> <i>when adding more lamps in series the brightness decreases</i> <i>when adding more lamps in series the pd decreases</i> <i>when adding more lamps in series the current decreases</i> <i>lamps can't be controlled independently</i> <i>the pd across each bulb is smaller in series</i> <i>the current in each bulb is smaller in series</i> <i>in series the pd across the lamps will less than the operating value/24 V</i> <i>Do not accept statements that only compare the overall resistance of the combination of bulbs.</i>	1 max

(continued...)

(Question 2 continued)

Question			Answers	Notes	Total
2.	d	i	«as flux linkage change occurs in core, induced emfs appear so» <u>current</u> is <u>induced</u> ✓ induced currents give rise to resistive forces ✓ eddy currents cause thermal energy losses «in conducting core» ✓ power dissipated by eddy currents is drawn from the primary coil/reduces power delivered to the secondary ✓		2 max
2.	d	ii	power = 190 OR 192 «W» ✓ required power = $190 \times \frac{100}{95}$ «= 200 or 202 W » ✓ so $\frac{200}{240} = 0.83$ OR 0.84 «A rms» ✓ peak current = «$0.83 \times \sqrt{2}$ OR $0.84 \times \sqrt{2}$» = 1.2/1.3 «A» ✓		4

Question			Answers	Notes	Total
3.	a		force $\times$ time OR change in momentum ✓		1
3.	b	i	$E_k = mgh = 0.058 \times 9.81 \times 1.1 = 0.63 \text{ J}$ ✓	Allow use of $g = 10 \text{ m s}^{-2}$ (which gives 0.64 «J») Substitution and at least 2 SF must be shown	1
3.	b	ii	ALTERNATIVE 1: initial momentum = $mv = \sqrt{2 \times 0.058 \times 0.63}$ « = 0.27 kg m s ⁻¹ » OR $mv = 0.058 \times \sqrt{2 \times 9.81 \times 1.1}$ « = 0.27 kg m s ⁻¹ » ✓ force = « $\frac{\text{change in momentum}}{\text{time}} = \frac{0.27}{0.055}$ » ✓ 4.9 «N» ✓ $F - mg = 4.9$ so $F = 5.5$ «N» ✓ ALTERNATIVE 2: $\langle E_k = \frac{1}{2}mv^2 = 0.63 \text{ J} \rangle$ $v = 4.7 \text{ m s}^{-1}$ ✓ acceleration = « $\frac{\Delta v}{\Delta t} = \frac{4.7}{55 \times 10^{-3}} = 85 \text{ m s}^{-2}$ » ✓ 4.9 «N» ✓ $F - mg = 4.9$ so $F = 5.5$ «N» ✓	Accept negative acceleration and force.	4

(continued...)

(Question 3 continued)

Question			Answers	Notes	Total
3.	b	iii	ALTERNATIVE 1: concrete reduces the stopping time/distance ✓ impulse/change in momentum same so force greater OR work done same so force greater ✓ ALTERNATIVE 2: concrete reduces the stopping time ✓ deceleration is greater so force is greater ✓	Allow reverse argument for grass.	2

Question			Answers	Notes	Total
4.	a	i	horizontal line shown in centre of pipe ✓		1
4.	a	ii	«air molecule» moves to the right and then back to the left ✓ returns to X/original position ✓		2
4.	b		wavelength = 2×1.4 « = 2.8 m » ✓ $c = \ll f \lambda = \gg 120 \times 2.8$ « = 340 m s^{-1} » ✓ $K = \ll \rho c^2 = 1.3 \times 340^2 = \gg 1.5 \times 10^5$ ✓ $\text{kg m}^{-1} \text{s}^{-2}$ ✓		4
4.	c	i	construction showing formation of image ✓	Another straight line/ray from image through the wall with line/ray from intersection at wall back to transmitter. Reflected ray must intersect boat.	1
4.	c	ii	interference pattern is observed OR interference/superposition mentioned ✓ maximum when two waves occur in phase/path difference is $n\lambda$ OR minimum when two waves occur 180° out of phase/path difference is $(n + \frac{1}{2})\lambda$ ✓		2

Question			Answers	Notes	Total
5.	a	i	identifies $\lambda = 435 \text{ nm}$ ✓ $E = \left\langle \frac{hc}{\lambda} = \right\rangle \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.35 \times 10^{-7}} \text{ ✓}$ $4.6 \times 10^{-19} \text{ «J»}$ ✓		3
5.	a	ii	-0.605 OR -0.870 OR -1.36 to -5.44 AND arrow pointing downwards ✓	Arrow MUST match calculation in (a)(i) Allow ECF from (a)(i)	1
5.	a	iii	Difference in energy levels is equal to the energy of the photon ✓ Downward arrow as energy is lost by hydrogen/energy is given out in the photon/the electron falls from a higher energy level to a lower one ✓		2

(continued...)

(Question 5 continued)

Question			Answers	Notes	Total
5.	b	i	$\frac{\lambda}{2\Delta\lambda} = \frac{656.20}{0.181 \times 2} = 1813 \text{ «lines» } \checkmark$ so spacing is $\frac{3.5 \times 10^{-3}}{1813} \text{ «} = 1.9 \times 10^{-6} \text{ m} \text{» } \checkmark$	Allow use of either wavelength or the mean value Must see at least 2 SF for a bald correct answer	2
5.	b	ii	$2 \times 4.1 \times 10^{-7} = 1.9 \times 10^{-6} \sin \theta_v$ seen OR $6.6 \times 10^{-7} = 1.9 \times 10^{-6} \sin \theta_r$ seen $\checkmark$ $\theta_v = 24 - 26 \text{ «}^\circ \text{»}$ OR $\theta_r = 19 - 20 \text{ «}^\circ \text{» } \checkmark$ $\Delta\theta = 5 - 6 \text{ «}^\circ \text{» } \checkmark$	For MP3 answer must follow from answers in MP2 For MP3 do not allow ECF from incorrect angles	3
5.	b	iii	centre of pattern is white $\checkmark$ coloured fringes are formed $\checkmark$ blue/violet edge of order is closer to centre of pattern OR red edge of order is furthest from centre of pattern $\checkmark$ the greater the order the wider the pattern $\checkmark$ there are gaps between «first and second order» spectra $\checkmark$		3 max

Question			Answers	Notes	Total
6.	a	i	it is constant ✓		1
	a	ii	$R = 1.20 \times 10^{-15} \times 31^{\frac{1}{3}} = 3.8 \times 10^{-15}$ «m» ✓	Must see working and answer to at least 2SF	1
6.	b	i	separation for interaction = 5.3 or 5.5 «fm» ✓		1
6.	b	ii	energy required = $\frac{15e^2}{4\pi\epsilon_0 \times 5.3 \times 10^{-15}}$ ✓ = $6.5 / 6.6 \times 10^{-13}$ OR 6.3×10^{-13} «J» ✓	Allow ecf from (b)(i)	2
6.	c		«electron» <u>antineutrino</u> also emitted ✓ energy split between electron and «anti»neutrino ✓		2
6.	d	i	probability of decay of a nucleus ✓ OR the fraction of the number of nuclei that decay in one/the next second OR per unit time ✓		2
6.	d	ii	1 week = 6.05×10^5 «s» ✓ $17 = 24e^{-\lambda \times 6.1 \times 10^5}$ ✓ 5.7×10^{-7} «s ⁻¹ » ✓	Award [2 max] if answer is not in seconds If answer not in seconds and no unit quoted award [1 max] for correct substitution into equation (MP2)	3

Question			Answers	Notes	Total
7.	a		charge stored on capacitor = $12 \times 10^{-3} \times 7.5 = 0.09$ «C» ✓		1
7.	b		energy stored in capacitor « $\frac{1}{2}CV^2$ or $\frac{1}{2}QV = \frac{1}{2} \times 12 \times 10^{-3} \times 7.5^2$ «= 0.338 J» ✓ height = « $\frac{1}{3} \times \frac{0.338}{9.81 \times 4.5 \times 10^{-2}} = 0.25/0.26$ «m» ✓	Allow use of $g = 10 \text{ m s}^{-2}$ which gives 0.25 «m»	2
7.	c		C <u>halved</u> ✓ so energy stored is halved/reduced so rises «less than» half height ✓ discharge time/raise time less as RC halved/reduced ✓	Allow 6 mF	3

Question			Answers	Notes	Total
8.	a	i	force per unit mass ✓ acting on a small/test/point mass «placed at the point in the field» ✓		2
8.	a	ii	Mars is spherical/a sphere «and of uniform density so behaves as a point mass» ✓ satellite has a much smaller mass/diameter/size than Mars «so approximates to a point mass» ✓		2
8.	b	i	$\left\langle \frac{mv^2}{r} = \frac{GMm}{r^2} \right\rangle$ hence $v = \sqrt{\frac{GM}{R}}$. Also $v = \frac{2\pi R}{T}$ OR $m\omega^2 r = \frac{GMm}{r^2}$ hence $\omega^2 = \frac{GM}{R^3}$ ✓ uses either of the above to get $T^2 = \frac{4\pi^2}{GM} R^3$ OR uses $k = \frac{4\pi^2}{GM}$ ✓ $k = 9.2 \times 10^{-13} / 9.3 \times 10^{-13}$ ✓	Unit not required	3

(continued...)

(Question 8 continued)

Question			Answers	Notes	Total
8.	b	ii	$R^3 = \frac{T^2}{k} = \frac{(8.9 \times 10^4)^2}{9.25 \times 10^{-13}} \quad R = 2.04 \times 10^7 \text{ «m» } \checkmark$ $v = \omega r = \frac{2\pi \times 2.04 \times 10^7}{89000} = 1.4 \times 10^3 \text{ «ms}^{-1}\text{»}$ OR $v = \sqrt{\frac{GM}{R}} = \sqrt{\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{2.04 \times 10^7}} = 1.4 \times 10^3 \text{ «ms}^{-1}\text{» } \checkmark$		2
8.	c	i	use of $I \propto \frac{1}{r^2}$ $\text{«}1.36 \times 10^3 \times \frac{1}{1.5^2}\text{» } \checkmark$ 604 «W m⁻²» $\checkmark$		2
8.	c	ii	use of $\frac{600}{4}$ for mean intensity $\checkmark$ temperature/K = $\sqrt[4]{\frac{600}{4 \times 5.67 \times 10^{-8}}} = 230 \checkmark$		2
8.	c	iii	reference to greenhouse gas/effect $\checkmark$ recognize the link between molecular density/concentration and pressure $\checkmark$ low pressure means too few molecules (to produce a significant heating effect) $\checkmark$ OR low pressure means too little radiation re-radiated back to Mars $\checkmark$	<i>The greenhouse effect can be described, it doesn't have to be named</i>	3

Question			Answers	Notes	Total
9.	a		Internal energy is the sum of all the PEs and KEs of the molecules (of the oxygen) ✓ PE of molecules in gaseous state is zero ✓ (At boiling point) average KE of molecules in gas and liquid is the same ✓ gases have a higher internal energy ✓	<i>Molecules/particles/atoms must be included once, if not, award [1 max]</i>	2 max
9.	b	i	ALTERNATIVE 1: flow rate of oxygen = 8 g s^{-1} ✓ $\llcorner 2.1 \times 10^5 \times 8 \times 10^{-3} \llcorner = 1.7 \text{ kW} \llcorner$ ✓ ALTERNATIVE 2: $Q = \llcorner 0.25 \times 32 \times 10^{-3} \times 2.1 \times 10^5 = \llcorner 1680 \text{ J} \llcorner$ ✓ power = $\llcorner 1680 \text{ W} = \llcorner 1.7 \text{ kW} \llcorner$ ✓		2
9.	b	ii	$T = 260 \text{ K} \llcorner$ ✓ $V = \llcorner \frac{nRT}{p} = \llcorner 4.9 \times 10^{-3} \text{ m}^3 \llcorner$ ✓		2

(continued...)

(Question 9 continued)

Question			Answers	Notes	Total
9.	c		ideal gas has point objects ✓ no intermolecular forces ✓ non liquefaction ✓ ideal gas assumes monatomic particles ✓ the collisions between particles are elastic ✓	Allow the opposite statements if they are clearly made about oxygen eg oxygen/this can be liquified	1 max