Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Physics

Higher level

Paper 2

18 pages

Question			Answers	Notes	Total
1.	a		change in momentum each second $= 6.6\times10^{-6}\times5.2\times10^{4}$ «$= 3.4\times10^{-1}$ kg m s^{-1}» ✓ acceleration $=$ «$\frac{3.4\times10^{-1}}{740}$ =» 4.6×10^{-4} «m s^{-2}» ✓		2
1.	b	i	***ALTERNATIVE 1***: (considering the acceleration of the spacecraft) time for acceleration $= \frac{30}{6.6\times10^{-6}} =$ «4.6×10^{6}» «s» ✓ max speed = «answer to (a) $\times 4.6\times10^{6} =$» 2.1×10^{3} «m s^{-1}» ✓ ***ALTERNATIVE 2***: (considering the conservation of momentum) (momentum of 30 kg of fuel ions = change of momentum of spacecraft) $30\times5.2\times10^{4} = 710\times$ max speed ✓ max speed $= 2.2\times10^{3}$ «m s^{-1}» ✓		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 ✓		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*:** $r = \sqrt{\frac{\rho l}{\pi R}}$ ***OR*** $\sqrt{\frac{7.2\times10^{-7}\times12.5}{\pi\times0.1}}$ ✓ $r = 5.352\times10^{-3}$ ✓ 5.4×10^{-3} **«**m**»** ✓ ***ALTERNATIVE 2*:** $A = \frac{7.2\times10^{-7}\times12.5}{0.1}$ ✓ $r = 5.352\times10^{-3}$ ✓ 5.4×10^{-3} **«**m**»** ✓	*For MP2 accept any SF* *For MP3 accept only 2 SF* *For MP3 accept **ANY** answer given to 2 SF* *For MP2 accept any SF* *For MP3 accept only 2 SF* *For MP3 accept **ANY** answer given to 2 SF*	**3**
2.	b		current in lamp $= \frac{5}{24}$ **«**$= 0.21$**»** **«**A**»** ***OR*** $n = 24\times\frac{8}{5}$ ✓ so **«**38.4 and therefore**»** 38 lamps ✓	*Do not award ECF from MP1*	**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 ✓	*Accept converse arguments for adding lamps in series:* *when adding more lamps in series the brightness decreases* *when adding more lamps in series the pd decreases* *when adding more lamps in series the current decreases* *lamps can't be controlled independently* *the pd across each bulb is smaller in series* *the current in each bulb is smaller in series* *in series the pd across the lamps will less than the operating value/24 V* *Do not accept statements that only compare the overall resistance of the combination of bulbs.*	**1 max**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
2.	**d**	**i**	**«**as flux linkage change occurs in core, induced emfs appear so**»** current is induced ✓ 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 × time ***OR*** change in momentum ✓		**1**
3.	b	i	$E_k = mgh = 0.058 \times 9.81 \times 1.1 = 0.63$ J ✓	*Allow use of g = 10 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:*** **«**$E_k = \frac{1}{2}mv^2 = 0.63$ J**»** v = 4.7 m s^{-1} ✓ acceleration $=$ **«** $\frac{\Delta v}{\Delta t} =$ **»** $\frac{4.7}{55x10^{-3}} =$ **«**85 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 $= 2 \times 1.4$ « $= 2.8\ \text{m}$» ✓ $c =$ « $f\lambda =$» 120×2.8 « $= 340\ \text{m s}^{-1}$» ✓ $K =$ « $\rho c^2 = 1.3 \times 340^2 =$» 1.5×10^5 ✓ $\text{kg m}^{-1}\ \text{s}^{-2}$ ✓		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 nλ ***OR*** minimum when two waves occur 180° out of phase/path difference is (n + ½) λ ✓		2

Question			Answers	Notes	Total
5.	a	i	identifies $\lambda = 435\,\text{nm}$ ✓ $E = \text{«}\frac{hc}{\lambda} = \text{»}\frac{6.63\times10^{-34}\times3\times10^{8}}{4.35\times10^{-7}}$ ✓ 4.6×10^{-19} «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**	$\frac{\lambda}{2\Delta\lambda} = \frac{656.20}{0.181 \times 2} = 1813$ **«**lines**»** ✓ so spacing is $\frac{3.5 \times 10^{-3}}{1813}$ **«**$= 1.9 \times 10^{-6}$ m**»** ✓	*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 ✓ $\theta_v = 24 - 26$ **«**°**»** ***OR*** $\theta_r = 19 - 20$ **«**°**»** ✓ $\Delta\theta = 5 - 6$ **«**°**»** ✓	*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 ✓ coloured fringes are formed ✓ blue/violet edge of order is closer to centre of pattern ***OR*** red edge of order is furthest from centre of pattern ✓ the greater the order the wider the pattern ✓ there are gaps between **«**first and second order**»** spectra ✓		**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 $= \frac{15e^2}{4\pi\varepsilon_0 \times 5.3 \times 10^{-15}}$ ✓ $= 6.5 / 6.6 \times 10^{-13}$ ***OR*** $= 6.3 \times 10^{-13}$ «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 $= 6.05 \times 10^5$ «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 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	« $\frac{mv^2}{r} = \frac{GMm}{r^2}$ 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 $k = \frac{4\pi^2}{GM}$ ✓ $k = 9.2\times10^{-13}$ / 9.3×10^{-13} ✓	*Unit not required*	3

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
8.	b	ii	$R^3 = \frac{T^2}{k} = \frac{(8.9\times10^4)^2}{9.25\times10^{-13}}$ $R = 2.04\times10^7$ «m» ✓ $v = \text{«}\omega r = \frac{2\pi\times2.04\times10^7}{89000} =$» 1.4×10^3 «ms^{-1}» ***OR*** $v = \text{«}\sqrt{\frac{GM}{R}} = \sqrt{\frac{6.67\times10^{-11}\times6.4\times10^{23}}{2.04\times10^7}} =$» 1.4×10^3 «ms^{-1}» ✓		**2**
8.	c	i	use of $I \propto \frac{1}{r^2}$ «$1.36\times10^3\times\frac{1}{1.5^2}$» ✓ 604 «W m^{-2}» ✓		**2**
8.	c	ii	use of $\frac{600}{4}$ for mean intensity ✓ temperature/K = «$\sqrt[4]{\frac{600}{4\times5.67\times10^{-8}}} =$» 230 ✓		**2**
8.	c	iii	reference to greenhouse gas/effect ✓ recognize the link between molecular density/concentration and pressure ✓ low pressure means too few molecules (to produce a significant heating effect) ✓ ***OR*** low pressure means too little radiation re-radiated back to Mars ✓	*The greenhouse effect can be described, it doesn't have to be named*	**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 ✓	*Molecules/particles/atoms must be included once, if not, award **[1 max]***	**2 max**
9.	b	i	***ALTERNATIVE 1*:** flow rate of oxygen $= 8$ «g s^{-1}» ✓ «$2.1\times10^{5}\times8\times10^{-3}$» $= 1.7$ «kW» ✓ ***ALTERNATIVE 2*:** $Q =$ «$0.25\times32\times10^{-3}\times2.1\times10^{5} =$» 1680 «J» ✓ power = «1680 W =» 1.7 «kW» ✓		**2**
9.	b	ii	$T = 260$ «K» ✓ $V =$ «$\frac{nRT}{p} =$» 4.9×10^{-3} «m^3» ✓		**2**

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(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**