

Markscheme

November 2018

Physics

Higher level

Paper 2

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| Question | | | Answers | Notes | Total |
|----------|---|----|--|-------|-------|
| 1. | a | | change in momentum each second = $6.6 \times 10^{-6} \times 5.2 \times 10^4$ « $3.4 \times 10^{-1} \text{ kg m s}^{-1}$ » ✓ acceleration = « $\frac{3.4 \times 10^{-1}}{740} = \text{» } 4.6 \times 10^{-4} \text{ « m s}^{-2}$ » ✓ | | 2 |
| 1. | b | i | <p>ALTERNATIVE 1: (considering the acceleration of the spacecraft) time for acceleration = $\frac{30}{6.6 \times 10^{-6}} = \text{« } 4.6 \times 10^6 \text{ « s » } \checkmark$</p> <p>max speed = « answer to (a) $\times 4.6 \times 10^6 = \text{» } 2.1 \times 10^3 \text{ « m s}^{-1}$ » ✓</p> <p>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 = $2.2 \times 10^3 \text{ « m s}^{-1}$ » ✓</p> | | 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 | <p>ALTERNATIVE 1:</p> $r = \sqrt{\frac{\rho l}{\pi R}} \quad \text{OR} \quad \sqrt{\frac{7.2 \times 10^{-7} \times 12.5}{\pi \times 0.1}} \quad \checkmark$ $r = 5.352 \times 10^{-3} \quad \checkmark$ $5.4 \times 10^{-3} \text{ «m»} \quad \checkmark$ <p>ALTERNATIVE 2:</p> $A = \frac{7.2 \times 10^{-7} \times 12.5}{0.1} \quad \checkmark$ $r = 5.352 \times 10^{-3} \quad \checkmark$ $5.4 \times 10^{-3} \text{ «m»} \quad \checkmark$ | <p><i>For MP2 accept any SF</i></p> <p><i>For MP3 accept only 2 SF</i></p> <p><i>For MP3 accept ANY answer given to 2 SF</i></p> | 3 |
| 2. | b | <p>current in lamp = $\frac{5}{24}$ «= 0.21» «A»</p> <p>OR</p> $n = 24 \times \frac{8}{5} \quad \checkmark$ <p>so «38.4 and therefore» 38 lamps \checkmark</p> | <p><i>Do not award ECF from MP1</i></p> | 2 |

(continued...)

(Question 2 continued)

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

(continued...)

(Question 2 continued)

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

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

(continued...)

(Question 3 continued)

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

| 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 ✓ | <i>Another straight line/ray from image through the wall with line/ray from intersection at wall back to transmitter. Reflected ray must intersect boat.</i> | 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 | $\frac{\lambda}{2\Delta\lambda} = \frac{656.20}{0.181 \times 2} = 1813 \text{ «lines» } \checkmark$ <p>so spacing is $\frac{3.5 \times 10^{-3}}{1813} \text{ «} = 1.9 \times 10^{-6} \text{ m» } \checkmark$</p> | <p>Allow use of either wavelength or the mean value Must see at least 2 SF for a bald correct answer</p> | 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 $\theta_r = 19 - 20 \text{ «}^\circ \text{» } \checkmark$ $\Delta\theta = 5 - 6 \text{ «}^\circ \text{» } \checkmark$ | <p>For MP3 answer must follow from answers in MP2 For MP3 do not allow ECF from incorrect angles</p> | 3 |
| 5. | b | iii | <p>centre of pattern is white \checkmark coloured fringes are formed \checkmark blue/violet edge of order is closer to centre of pattern</p> <p>OR</p> <p>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</p> | | 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 $\times 10^{-13}$ «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 = 6.05×10^5 «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 $\frac{1}{2}QV$ » $\Rightarrow \frac{1}{2} \times 12 \times 10^{-3} \times 7.5^2$ «= 0.338 J» ✓ height = « $\frac{1}{3} \times \frac{0.338}{9.81 \times 4.5 \times 10^{-2}}$ » $\Rightarrow 0.25/0.26$ «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 | <p>«$\frac{mv^2}{r} = \frac{GMm}{r^2}$ hence» $v = \sqrt{\frac{GM}{R}}$. Also $v = \frac{2\pi R}{T}$</p> <p>OR</p> <p>$m\omega^2 r = \frac{GMm}{r^2}$ hence $\omega^2 = \frac{GM}{R^3}$ ✓</p> <p>uses either of the above to get $T^2 = \frac{4\pi^2}{GM} R^3$</p> <p>OR</p> <p>uses $k = \frac{4\pi^2}{GM}$ ✓</p> <p>$k = 9.2 \times 10^{-13} / 9.3 \times 10^{-13}$ ✓</p> | Unit not required | 3 |

(continued...)

(Question 8 continued)

| Question | | | Answers | Notes | Total |
|----------|---|-----|---|---|-------|
| 8. | b | ii | $R^3 = \frac{T^2}{k} = \frac{(8.9 \times 10^4)^2}{9.25 \times 10^{-13}} \quad R = 2.04 \times 10^7 \text{ «m» } \checkmark$ $v = \omega r = \frac{2\pi \times 2.04 \times 10^7}{89000} = 1.4 \times 10^3 \text{ «ms}^{-1}\text{»}$ <p>OR</p> $v = \sqrt{\frac{GM}{R}} = \sqrt{\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{2.04 \times 10^7}} = 1.4 \times 10^3 \text{ «ms}^{-1}\text{» } \checkmark$ | | 2 |
| 8. | c | i | <p>use of $I \propto \frac{1}{r^2}$ «$1.36 \times 10^3 \times \frac{1}{1.5^2}$» \checkmark</p> <p>604 «W m⁻²» \checkmark</p> | | 2 |
| 8. | c | ii | <p>use of $\frac{600}{4}$ for mean intensity \checkmark</p> <p>temperature/K = «$\sqrt[4]{\frac{600}{4 \times 5.67 \times 10^{-8}}}$» = 230 \checkmark</p> | | 2 |
| 8. | c | iii | <p>reference to greenhouse gas/effect \checkmark</p> <p>recognize the link between molecular density/concentration and pressure \checkmark</p> <p>low pressure means too few molecules (to produce a significant heating effect) \checkmark</p> <p>OR</p> <p>low pressure means too little radiation re-radiated back to Mars \checkmark</p> | <p><i>The greenhouse effect can be described, it doesn't have to be named</i></p> | 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 = $8 \text{ «g s}^{-1}\text{»}$ ✓ $\text{«}2.1 \times 10^5 \times 8 \times 10^{-3}\text{»} = 1.7 \text{ «kW»}$ ✓ ALTERNATIVE 2: $Q = \text{«}0.25 \times 32 \times 10^{-3} \times 2.1 \times 10^5\text{»} = 1680 \text{ «J»}$ ✓ power = $\text{«}1680 \text{ W} = \text{»} 1.7 \text{ «kW»}$ ✓ | | 2 |
| 9. | b | ii | $T = 260 \text{ «K»}$ ✓ $V = \text{«}\frac{nRT}{p}\text{»} = 4.9 \times 10^{-3} \text{ «m}^3\text{»}$ ✓ | | 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 |
