Markscheme

May 2018

Physics

Higher level

Paper 2

18 pages

Question			Answers	Notes	Total
1.	**a**		use of conservation of energy ***OR*** $v^2 = u^2 + 2as$ ✓ $v = \text{«}\sqrt{2 \times 60.0 \times 9.81}\text{»} = 34.3 \text{«ms}^{-1}\text{»}$ ✓		**2**
1.	**b**	**i**	use of impulse $F_{ave} \times \Delta t = \Delta p$ ***OR*** use of $F = ma$ with average acceleration ***OR*** $F = \frac{80.0 \times 34.3}{0.759}$ ✓ 3620 «N» ✓	*Allow ECF from (a).*	**2**
1.	**b**	**ii**	upwards ✓ clearly longer than weight ✓	*For second marking point allow ECF from (b)(i) providing line is upwards.*	**2**
1.	**b**	**iii**	$3620 + 80.0 \times 9.81$ ✓ 4400 «N» ✓	*Allow ECF from (b)(i).*	**2**

(continued…)

(Question 1 continued)

1.	**c**	**i**	(loss in) gravitational potential energy (of block) into kinetic energy (of block) ✓	*Must see names of energy (gravitational potential energy and kinetic energy) – Allow for reasonable variations of terminology (eg energy of motion for KE).*	**1**
1.	**c**	**ii**	(loss in) gravitational potential and kinetic energy of block into elastic potential energy of rope ✓	*See note for 1(c)(i) for naming convention.* *Must see either the block or the rope (or both) mentioned in connection with the appropriate energies.*	**1**
1.	**d**		k can be determined using $\text{EPE} = \frac{1}{2}kx^2$ ✓ correct statement or equation showing GPE at A = EPE at C ***OR*** (GPE + KE) at B = EPE at C ✓	*Candidate must clearly indicate the energy associated with either position A or B for MP2.*	**2**

(continued…)

(Question 1 continued)

1.	**e**	**i**	$T = 2\pi\sqrt{\frac{80.0}{400}} = 2.81$ **«s»** ✓ $\text{time} = \frac{T}{4} = 0.702$ **«s»** ✓	*Award **[0]** for kinematic solutions that assume a constant acceleration.*	**2**
1.	**e**	**ii**	***ALTERNATIVE 1*** $\omega = \frac{2\pi}{2.81} = 2.24$ **«**rad s^{-1}**»** ✓ $v = 2.24 \times 3.50 = 7.84$ **«**ms^{-1}**»** ✓ ***ALTERNATIVE 2*** $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ ***OR*** $\frac{1}{2}400 \times 3.5^2 = \frac{1}{2}80v^2$ ✓ $v = 7.84$ **«**ms^{-1}**»** ✓	*Award **[0]** for kinematic solutions that assume a constant acceleration.* *Allow ECF for T from (e)(i).*	**2**

2.	**a**		$\text{«}\frac{3.0\times 8.31\times 290}{0.15}\text{»}$ 48 **«**kPa**»** ✓		**1**
2.	**b**	**i**	$\text{mass} = \text{«}\frac{860}{3100\times 23}\text{»} 0.012$ **«**kg**»** ✓		**1**
2.	**b**	**ii**	***ALTERNATIVE 1*** average kinetic energy $= \frac{3}{2}1.38\times 10^{-23}\times 313 = 6.5\times 10^{-21}$ **«**J**»** ✓ number of particles $= 3.0\times 6.02\times 10^{23} = 1.8\times 10^{24}$ ✓ total kinetic energy $= 1.8\times 10^{24}\times 6.5\times 10^{-21} = 12$ **«**kJ**»** ✓ ***ALTERNATIVE 2*** ideal gas so $U = KE$ ✓ $KE = \frac{3}{2}8.31\times 313\times 3$ ✓ total kinetic energy = 12 **«**kJ**»** ✓		**3**
2.	**c**		larger temperature implies larger (average) speed/larger (average) KE of molecules/particles/atoms ✓ increased force/momentum transferred to walls (per collision) / more frequent collisions with walls ✓ increased force leads to increased pressure because P=F/A (as area remains constant) ✓	*Ignore any mention of PV=nRT*	**3**

3.	**a**	**i**	superposition of light from each slit / interference of light from both slits ✓ with path/phase difference of any half-odd multiple of wavelength/any odd multiple of π (in words or symbols) ✓ producing destructive interference ✓	*Ignore any reference to crests and troughs.*	**3**
3.	**a**	**ii**	light waves (from slits) must have constant phase difference / no phase difference / be in phase ✓	*OWTTE*	**1**
3.	**a**	**iii**	evidence of solving for D **«**$D = \frac{sd}{\lambda}$**»** ✓ **«**$\frac{4.50 \times 10^{-3} \times 0.300 \times 10^{-3}}{633.0 \times 10^{-9}} \times 2$**»** $= 4.27$**«**m**»** ✓	*Award **[1]** max for 2.13 m.*	**2**

(continued…)

(Question 3 continued)

3.	**b**	**i**	$\sin\theta = \frac{4 \times 633.0 \times 10^{-9}}{0.300 \times 10^{-3}}$ ✓ $\theta = 0.0084401\ldots$ ✓ final answer to three sig figs (*eg* 0.00844 or 8.44×10^{-3}) ✓	*Allow ECF from (a)(iii).* *Award **[1]** for 0.121 rad (can award MP3 in addition for proper sig fig)* *Accept calculation in degrees leading to 0.481 degrees.* *Award MP3 for <u>any</u> answer expressed to 3sf.*	**3**
3.	**b**	**ii**	use of diffraction formula **«**$b = \frac{\lambda}{\theta}$**»** ***OR*** $\frac{633.0 \times 10^{-9}}{0.00844}$ ✓ **«=»** 7.5**«**00**»** $\times 10^{-2}$ **«**mm**»** ✓	*Allow ECF from (b)(i).*	**2**

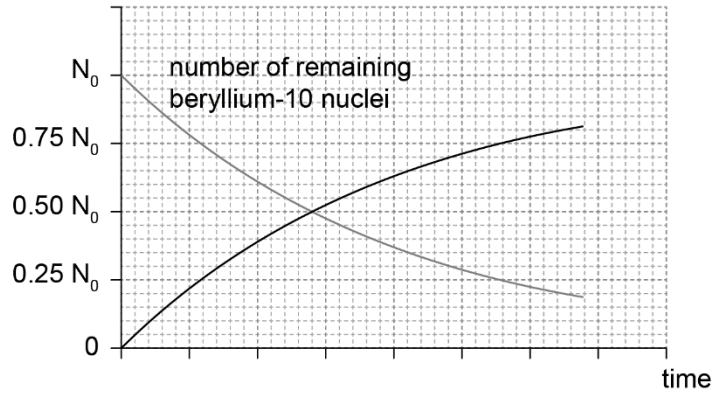
(continued…)

(Question 3 continued)

3.	**c**		wavelength increases (so frequency decreases) / light is redshifted ✓ galaxy is moving away from Earth ✓	*Allow ECF for MP2 (ie wavelength decreases so moving towards).*	**2**
3.	**d**	**i**	$\frac{633.0}{1.33} = 476$ **«**nm**»** ✓		**1**
3.	**d**	**ii**	distance between peaks decreases ✓ intensity decreases ✓		**2**

4.	**a**		$1.7\times10^{-8}\times\frac{0.10}{(0.02\times10^{-2})^2}$ ✓ 0.043 **«Ω»** ✓		**2**
4.	**b**		v **«**$=\frac{I}{neA}$**»** $=\frac{2.0}{8.5\times10^{22}\times1.60\times10^{-19}\times0.02^2}$ ✓ 0.37 **«**cm s^{-1}**»** ✓		**2**
4.	**c**	**i**	$V = RI \ = 0.086$ **«***V***»** ✓ **«**$\frac{V}{d}=\frac{0.086}{0.10}=$**»** 0.86 **«**V m^{-1}**»** ✓	*Allow ECF from 4(a).* *Allow ECF from MP1.*	**2**
4.	**c**	**ii**	***ALTERNATIVE 1*** clear use of Ohm's Law (*V*=*IR*) ✓ clear use of $R=\frac{\rho L}{A}$ ✓ combining with *I* = *nAve* and *V* = *EL* to reach result. ✓ ***ALTERNATIVE 2*** attempts to substitute values into equation. ✓ correctly calculates LHS as 4.3×10^9. ✓ correctly calculates RHS as 4.3×10^9. ✓	***For ALTERNATIVE 1 look for:*** *V = IR* $R=\frac{\rho L}{A}$ *V = EL* *I = nAve* $V=I\frac{\rho L}{A}$ $EL=I\frac{\rho L}{A}$ $E=I\frac{\rho}{A}$ $E=nAve\frac{\rho}{A}=nve\rho$ $\frac{v}{E}=\frac{1}{ne\rho}$	**3**

5.	**a**		out of the page plane / ⊙ ✓	*Do not accept just "up" or "outwards".*	**1**
5.	**b**		$1.60\times10^{-19}\times6.8\times10^{5}\times8.5=9.2\times10^{-13}$ **«**N**»** ✓		**1**
5.	**c**	**i**	the magnetic force does not do work on the electron hence does not change the electron's kinetic energy ***OR*** the magnetic force/acceleration is at right angles to velocity ✓		**1**
5.	**c**	**ii**	the velocity of the electron is at right angles to the magnetic field ✓ (therefore) there is a centripetal acceleration / force acting on the charge ✓	*OWTTE*	**2**

6.	**a**		$^{10}_{4}\text{Be} \rightarrow {}^{10}_{5}\text{B} + {}^{0}_{-1}\text{e} + {}^{0}_{0}\overline{\text{V}}_{\text{e}}$ antineutrino ***AND*** charge ***AND*** mass number of electron $^{0}_{-1}\text{e}$, $\overline{\text{V}}$ ✓ conservation of mass number ***AND*** charge $^{10}_{5}\text{B}$, $^{10}_{4}\text{Be}$ ✓	*Do not accept V .* *Accept* $\overline{V}$ *without subscript* e.	**2**
6.	**b**	**i**	correct shape *ie* increasing from 0 to about 0.80N_0 ✓ crosses given line at 0.50N_0 ✓ number of nuclei  		**2**

(continued…)

(Question 6b continued)

6.	**b**	**ii**	***ALTERNATIVE 1*** fraction of Be $= \frac{1}{8}$, 12.5%, or 0.125 ✓ therefore 3 half lives have elapsed ✓ $t_{\frac{1}{2}} = \frac{4.3\times10^6}{3} = 1.43\times10^6$ **«**$\approx 1.4\times10^6$**»** **«**y**»** ✓ ***ALTERNATIVE 2*** fraction of Be $= \frac{1}{8}$, 12.5%, or 0.125 ✓ $\frac{1}{8} = e^{-\lambda}\left(4.3\times10^6\right)$ leading to $\lambda = 4.836\times10^{-7}$ **«**y^{-1}**»** ✓ $\frac{ln2}{\lambda} = 1.43\times10^6$ **«**y**»** ✓	*Must see at least one extra sig fig in final answer.*	**3**
6.	**b**	**iii**	λ **«**$= \frac{\ln 2}{1.4\times10^6}$**»** $= 4.95\times10^{-7}$ **«**y^{-1}**»** ✓ rearranging of $A = \lambda N_0 e^{-\lambda t}$ to give $-\lambda t = \ln\frac{8.0\times10^{-3}\times365\times24\times60\times60}{4.95\times10^{-7}\times7.6\times10^{11}}$ **«**$= -0.400$**»** ✓ $t = \frac{-0.400}{-4.95\times10^{-7}} = 8.1\times10^5$ **«**y**»** ✓	*Allow ECF from MP1*	**3**

(continued…)

(Question 6 continued)

6.	**c**	**i**	emission of (infrared) electromagnetic/infrared energy/waves/radiation. ✓		**1**
6.	**c**	**ii**	the (peak) wavelength of emitted em waves depends on temperature of emitter/reference to Wein's Law ✓ so frequency/color depends on temperature ✓		**2**
6.	**c**	**iii**	$\lambda = \frac{2.90 \times 10^{-3}}{253}$ ✓ $= 1.1 \times 10^{-5}$ **«**m**»** ✓	*Allow ECF from MP1 (incorrect temperature).*	**2**
6.	**c**	**iv**	from the laboratory to the sample ✓ conduction – contact between ice and lab surface. ***OR*** convection – movement of air currents ✓	*Must clearly see direction of energy transfer for MP1.* *Must see more than just words "conduction" or "convection" for MP2.*	**2**
6.	**c**	**v**	correct units for Intensity (allow *W, Nms^{-1} OR Js^{-1} in numerator)* ✓ rearrangement into proper SI units = kgs^{-3} ✓	*Allow ECF for MP2 if final answer is in fundamental units.*	**2**

7.	**a**		$d = \text{«}\frac{8.85\times10^{-12}\times0.025^2}{4.3\times10^{-12}} = \text{»} 1.3\times10^{-3}$ «m» ✓		**1**
7.	**b**		6.9 x 10^{-11} <<C>> ✓ negative charge/sign ✓		**2**
7.	**c**		charge increases ✓ because capacitance increases ***AND*** pd remains the same.✓		**2**

(continued…)

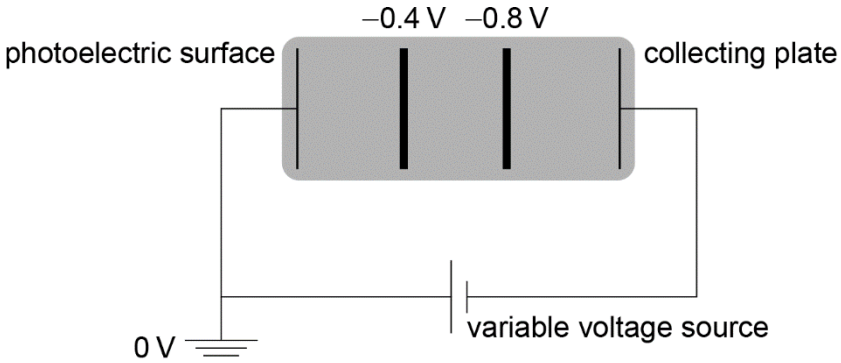
(Question 7 continued)

7.	**d**		***ALTERNATIVE 1*** $\varepsilon_s = \frac{1200}{100} \times 220$ ✓ $= 2640$ **«V»** ✓ $V_{rms} = \frac{2640}{\sqrt{2}} = 1870$ **«V»** ✓ ***ALTERNATIVE 2*** (Primary) $V_{rms} = \frac{220}{\sqrt{2}} = 156$ **«V»** ✓ (Secondary) $V_{rms} = \frac{156 \times 1200}{100}$ ✓ V_{rms} = 1870 **«V»** ✓	*Allow ECF from MP1 and MP2.* *Award **[2]** max for 12.96 V (reversing N_p and N_s).*	**3**
7.	**e**		step-up transformers increase voltage/step-down transformers decrease voltage ✓ (step-up transformers increase voltage) from plants to transmission lines / (step-down transformers decrease voltage) from transmission lines to final utilizers ✓ this decreases current (in transmission lines) ✓ to minimize energy/power losses in transmission ✓		**3 max**

8.	**a**		$E_1 = -13.6$ **«**eV**»** $E_2 = -\frac{13.6}{4} = -3.4$ **«**eV**»** ✓ energy of photon is difference $E_2 - E_1 = 10.2$ **«**≈ 10 eV**»** ✓	*Must see at least 10.2 eV.*	**2**
8.	**b**	**i**	$10 - 5.1 = 4.9$ **«**eV**»** ✓ $4.9 \times 1.6 \times 10^{-19} = 7.8 \times 10^{-19}$ **«**J**»** ✓	*Allow* 5.1 *if* 10.2 *is used to give* 8.2×10^{-19} **«**J**»**.	**2**
8.	**b**	**ii**	EPE produced by battery ✓ exceeds maximum KE of electrons / electrons don't have enough KE ✓	*For first mark, accept explanation in terms of electric potential energy difference of electrons between surface and plate.*	**2**
8.	**b**	**iii**	4.9 **«**V**»** ✓	*Allow 5.1 if 10.2 is used in (b)(i).* *Ignore sign on answer.*	**1**

(continued…)

(Question 8 continued)

8.	**c**	**i**	two equally spaced vertical lines (judge by eye) at approximately 1/3 and 2/3✓ labelled correctly ✓ 		**2**
8.	**c**	**ii**	kinetic energy at collecting plate $= 0.9$ «eV» ✓ speed $= \text{«}\sqrt{\frac{2\times 0.9\times 1.6\times 10^{-19}}{9.11\times 10^{-31}}}\text{»} = 5.6\times 10^{5}$ «ms^{-1}» ✓	*Allow ECF from MP1*	**2**