M17/4/PHYSI/HP2/ENG/TZ2/XX/M

Markscheme

May 2017

Physics

Higher level

Paper 2

23 pages

Question			Answers	Notes	Total
1.	**a**		correct use of kinematic equation/equations ✓ 148.5 ***or*** 149 ***or*** 150 «m» ✓	*Substitution(s) must be correct.*	**2**
	b		$a=\frac{27}{11}$ ***or*** 2.45 «m s^{-2}» ✓ $F-160=492\times 2.45$ ✓ 1370 «N» ✓	*Could be seen in part (a).* *Award **[0]** for solution that uses a =9.81 m s^{-2}*	**3**

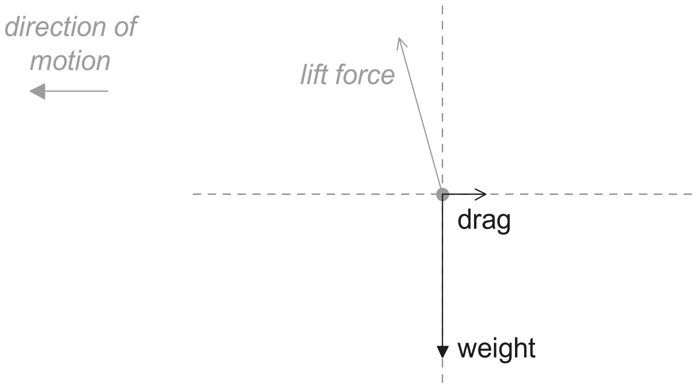
(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
	c		***ALTERNATIVE 1*** «work done to launch glider» $= 1370 \times 149$ «$= 204$ kJ» ✓ «work done by motor» $= \dfrac{204 \times 100}{23}$ ✓ «power input to motor» $= \dfrac{204 \times 100}{23} \times \dfrac{1}{11} = 80$ ***or*** 80.4 ***or*** 81 k«W» ✓ ***ALTERNATIVE 2*** use of average speed 13.5 m s^{-1} ✓ «useful power output» = force × average speed «$= 1370 \times 13.5$» ✓ power input $=$ «$1370 \times 13.5 \times \dfrac{100}{23} =$» 80 ***or*** 80.4 ***or*** 81 k«W» ✓ ***ALTERNATIVE 3*** work required from motor = KE + work done against friction «$= 0.5 \times 492 \times 27^2 + (160 \times 148.5)$» $= 204$ «kJ» ✓ «energy input» $= \dfrac{\text{work required from motor} \times 100}{23}$ ✓ power input $= \dfrac{883000}{11} = 80.3$ k«W» ✓	Award ***[2 max]*** for an answer of 160 k«*W*».	**3**

(continued…)

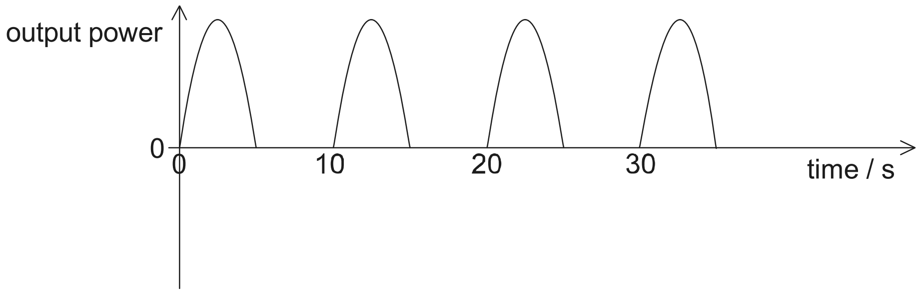
(Question 1 continued)

Question			Answers	Notes	Total
	d		 drag correctly labelled and in correct direction ✓ weight correctly labelled and in correct direction ***AND*** no other incorrect force shown ✓	*Award* ***[1 max]*** *if forces do not touch the dot, but are otherwise OK.*	**2**

Question			Answers	Notes	Total
2.	**a**		force/acceleration proportional to displacement «from equilibrium position» ✓ and directed towards equilibrium position/point ***OR*** and directed in opposite direction to the displacement from equilibrium position/point ✓	*Do not award marks for stating the defining equation for SHM.* *Award* ***[1 max]*** *for* $a = -\omega^2 x$ *with a and* x *defined.*	**2**
	b	**i**	frequency of buoy movement $= \frac{3.4}{35}$ ***or*** 0.097 «Hz» ***OR*** time period of buoy $= \frac{35}{3.4}$ ***or*** 10.3 «s» ***or*** 10 «s» ✓ $v =$ « $\frac{2\pi x_0}{T}$ ***or*** $2\pi f x_0$ » $= \frac{2\times\pi\times 4.3}{10.3}$ ***or*** $2\times\pi\times 0.097\times 4.3$ ✓ 2.6 «m s^{-1}» ✓		**3**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
	b	**ii**	peaks separated by gaps equal to width of each pulse «shape of peak roughly as shown» ✓ one cycle taking 10 s shown on graph ✓ 	*Judge by eye.* *Do not accept cos$_2$ or sin$_2$ graph* *At least two peaks needed.* *Do not allow square waves or asymmetrical shapes.* *Allow ECF from (b)(i) value of period if calculated.*	**2**
	c	**i**	PE of water is converted to KE of moving water/turbine to electrical energy «in generator/turbine/dynamo» ✓ idea of pumped storage, *ie*: pump water back during night/when energy cheap to buy/when energy not in demand/when there is a surplus of energy ✓		**2**

(continued…)

(Question 2 continued)

Question			Answers	Notes	Total
	c	ii	specific energy available $= «gh=» 9.81\times 270 «=2650\,\text{J kg}^{-1}»$ ***OR*** $mgh=\frac{1}{2}mv^2$ ***OR*** $v^2=2gh$ ✓ $v=73 «\text{m s}^{-1}»$ ✓	 *Do not allow 72 as round from 72.8*	**2**
	c	iii	total energy $=«mgh=1.5\times10^{10}\times9.81\times270=» 4.0\times10^{13} «\text{J}»$ ***OR*** total energy $=«\frac{1}{2}mv^2=\frac{1}{2}\times1.5\times10^{10}\times(\text{answer (c)(ii)})^2=» 4.0\times10^{13} «\text{J}»$ time $=«\frac{4.0\times10^{13}}{4\times2.5\times10^{8}}=» 11.1\,\text{h}$ ***or*** $4.0\times10^{4}\,\text{s}$ ✓	*Use of 3.97×10^{13} «J» gives 11 h.* *For MP2 the unit **must** be present.*	**2**
	c	iv	friction/resistive losses in pipe/fluid resistance/turbulence/turbine or generator «bearings» ***OR*** sound energy losses from turbine/water in pipe ✓ thermal energy/heat losses in wires/components ✓ water requires kinetic energy to leave system so not all can be transferred ✓	*Must see "seat of friction" to award the mark.* *Do not allow "friction" bald.*	**2 max**

Question			Answers	Notes	Total
3.	**a**		«$\frac{1}{2}CV^2 = \frac{1}{2} \times 0.022 \times 24^2$» $= 6.3$ «J» ✓		**1**
	b		$\frac{1}{100} = e^{-\frac{t}{8.0 \times 0.022}}$ ✓ $\ln 0.01 = -\frac{t}{8.0 \times 0.022}$ ✓ 0.81 «s» ✓		**3**
	c	**i**	$c = \frac{Q}{m \times \Delta T}$ ***OR*** $\frac{6.3}{0.00061 \times 28}$ ✓ $370\ \text{J kg}^{-1}\ \text{K}^{-1}$ ✓	*Allow ECF from 3(a) for energy transferred.* *Correct answer only to include correct unit that matches answer power of ten.* *Allow use of g and kJ in unit but must match numerical answer, eg: 0.37 J kg^{-1} K^{-1} receives* ***[1]***	**2**

(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
	c	ii	***ALTERNATIVE 1*** some thermal energy will be transferred to surroundings/along connecting wires/to thermometer ✓ estimate «of specific heat capacity by student» will be larger «than accepted value» ✓ ***ALTERNATIVE 2*** not all energy transferred as capacitor did not fully discharge ✓ so estimate «of specific heat capacity by student» will be larger «than accepted value» ✓		**2 max**

Question			Answers	Notes	Total
4.	a		«light» superposes/interferes ✓ pattern consists of «intensity» maxima and minima ***OR*** consisting of constructive and destructive «interference» ✓ voltage peaks correspond to interference maxima ✓		**3**
	b	i	$«s=\frac{\lambda D}{d}=\frac{6.3\times10^{-7}\times5.0}{1.5\times10^{-3}}=»\ 2.1\times10^{-3}\ «\text{m}»$ ✓	*If no unit assume m.* *Correct answer only.*	**1**
	b	ii	correct read-off from graph of 25 m s ✓ $v=«\frac{x}{t}=\frac{2.1\times10^{-3}}{25\times10^{-3}}=»\ 8.4\times10^{-2}\ «\text{m s}^{-1}»$ ✓	*Allow ECF from (b)(i)*	**2**
	c	i	angular width of diffraction minimum $=\frac{0.13}{5.0}\ «=0.026\text{ rad}»$ ✓ slit width $=«\frac{\lambda}{d}=\frac{6.3\times10^{-7}}{0.026}=»\ 2.4\times10^{-5}\ «\text{m}»$ ✓	*Award **[1 max]** for solution using 1.22 factor.*	**2**
	c	ii	«beyond the first diffraction minimum» average voltage is smaller ✓ «voltage minimum» spacing is «approximately» same ***OR*** rate of variation of voltage is unchanged ✓	*OWTTE*	**2**

(continued…)

(Question 4 continued)

Question			Answers	Notes	Total
	d		«reflection at barrier» leads to two waves travelling in opposite directions ✓ mention of formation of standing wave ✓ maximum corresponds to antinode/maximum displacement «of air molecules» ***OR*** complete cancellation at node position ✓		**2 max**

5.	**a**		${}^{4}_{2}\alpha$ ***OR*** ${}^{4}_{2}\mathrm{He}$ ✓ ${}^{222}_{86}\mathrm{Rn}$ ✓	*These **must** be seen on the right-hand side of the equation.*	**2**

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
	b	i	***ALTERNATIVE 1*** 6 days is 5.18×10^{5} s ✓ activity after 6 days is $A_0 e^{-1.4\times10^{-11}\times5.18\times10^{5}} \approx A_0$ ***OR*** $\text{A} = 0.9999927\,A_0$ ***or*** $0.9999927\,\lambda N_0$ ***OR*** states that index of *e* is so small that $\frac{A}{A_0}$ is ≈ 1 ***OR*** $A - A_0 \approx 10^{-15}$ «s^{-1}» ✓ ***ALTERNATIVE 2*** shows half-life of the order of 10^{11} s ***or*** 5.0×10^{10} s ✓ converts this to year «1600 y» or days and states half-life much longer than experiment compared to experiment ✓	*Award **[1 max]** if calculations/substitutions have numerical slips but would lead to correct deduction.* *eg: failure to convert 6 days to seconds but correct substitution into equation will give MP2.* *Allow working in days, but for MP1 must see conversion of λ or half-life to day^{-1}.*	**2**

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
	b	ii	***ALTERNATIVE 1*** use of $A = \lambda N_0$ ✓ conversion to number of molecules $= nN_A = 3.7 \times 10^{20}$ ***OR*** initial activity $= 5.2 \times 10^9$ «s^{-1}» ✓ number emitted $= (6 \times 24 \times 3600) \times 1.4 \times 10^{-11} \times 3.7 \times 10^{20}$ ***or*** 2.7×10^{15} alpha particles ✓ ***ALTERNATIVE 2*** use of $N = N_0 e^{-\lambda t}$ ✓ $N_0 = n \times N_A = 3.7 \times 10^{20}$ ✓ alpha particles emitted «$=$ number of atoms disintegrated $= N - N_0 =$» $N_0(1 - e^{-\lambda \times 6 \times 24 \times 3600})$ ***or*** 2.7×10^{15} alpha particles ✓	*Must see correct substitution or answer to 2+ sf for MP3*	**3**

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
	c	**i**	alpha particles highly ionizing ***OR*** alpha particles have a low penetration power ***OR*** thin glass increases probability of alpha crossing glass ***OR*** decreases probability of alpha striking atom/nucleus/molecule ✓	*Do not allow reference to tunnelling.*	**1**
	c	**ii**	conversion of temperature to 291 K ✓ $p = 4.5\times10^{-9}\times8.31\times$ «$\frac{291}{1.3\times10^{-5}}$» ***OR*** $p = 2.7\times10^{15}\times1.38\times10^{-23}\times$ «$\frac{291}{1.3\times10^{-5}}$» ✓ 0.83 ***or*** 0.84 «Pa» ✓	*Allow ECF for 2.7×10^{15} from (b)(ii).*	**3**

(continued…)

(Question 5 continued)

Question			Answers	Notes	Total
	d		electron/atom drops from high energy state/level to low state ✓ energy levels are discrete ✓ wavelength/frequency of photon is related to energy change ***or*** quotes $E = hf$ ***or*** $E = \frac{hc}{\lambda}$ and is therefore also discrete ✓		**3**
	e		peer review guarantees the validity of the work ***OR*** means that readers have confidence in the validity of work ✓		**1**

Question			Answers	Notes	Total
6.	a		when an electric field is applied to any material «using a cell etc» it acts to accelerate any free electrons ✓ electrons are the charge carriers «in copper» ✓ metals/copper have many free electrons whereas insulators have few/no free electrons/charge carriers ✓		3
	b	i	$\text{area} = \frac{1.7\times10^{-8}\times35\times10^{3}}{64}$ «$= 9.3\times10^{-6}\,\text{m}^2$» ✓ $\text{radius} =$ «$\sqrt{\frac{9.3\times10^{-6}}{\pi}} =$» $0.00172\,\text{m}$ ✓		2
	b	ii	I_{peak} «$= \frac{P_{\text{peak}}}{V_{\text{peak}}}$» $= 730$ «A» ✓		1

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
	b	iii	resistance of cable identified as «$\frac{64}{32}$ =» 2 Ω ✓ $\frac{\text{a power}}{35000}$ seen in solution✓ plausible answer calculated using $\frac{2I^2}{35000}$ «plausible if in range 10 W m⁻¹ to 150 W m⁻¹ when quoted answers in (b)(ii) used» 31 «W m⁻¹»✓	*Allow **[3]** for a solution where the resistance per unit metre is calculated using resistivity and answer to (a) (resistance per unit length of cable =5.7×10^{-5} m)* *Award **[2 max]** if 64 Ω used for resistance (answer×32).* *An approach from $\frac{V^2}{R}$ or VI using 150 kV is incorrect (award **[0]**), however allow this approach if the pd across the cable has been calculated (pd dropped across cable is 1.47 kV).*	**3**
	c		«$\frac{\text{response to (b)(ii)}}{2\sqrt{2}}$» = 260 «A» ✓		**1**

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
	d		wires/cable attract whenever current is in same direction ✓ charge flow/current direction in both wires is always same «but reverses every half cycle» ✓ force varies from 0 to maximum ✓ force is a maximum twice in each cycle ✓	*Award **[1 max]** if response suggests that there is repulsion between cables at any stage in cycle.*	**2 max**
	e	**i**	higher voltage gives lower current ✓ «energy losses depend on current» hence thermal/heating/power losses reduced ✓		**2**
	e	**ii**	laminated core ✓	*Do not allow "wires are laminated".*	**1**

Question			Answers	Notes	Total
7.	a	i	wavelength $= «\frac{hc}{E} = \frac{1.99\times10^{-25}}{3.5\times10^{-19}} =» 5.7\times10^{-7}$ «m» ✓	*If no unit assume m.*	**1**
	a	ii	«potential» energy is required to leave surface ✓ all/most energy given to potential «so none left for kinetic energy» ✓	*Do not allow reference to "binding energy".* *Ignore statements of conservation of energy.*	**2**
	b		energy surplus $= 1.7\times10^{-19}$ J ✓ $v_{max} = \sqrt{\frac{2\times1.7\times10^{-19}}{9.1\times10^{-31}}} = 6.1\times10^{5}$ «m s^{-1}» ✓	*Award* ***[1 max]*** *if surplus of* 5.2×10^{-19}*J used (answer:* 1.1×10^{6} *m* s^{-1}*)*	**2**
	c	i	«same intensity of radiation so same total energy delivered per square metre per second» light has higher photon energy so fewer photons incident per second ✓	*Reason is required*	**1**
	c	ii	1:1 correspondence between photon and electron ✓ so fewer electrons per second ✓ current smaller ✓	*Allow ECF from (c)(i)* *Allow ECF from MP2 to MP3.*	**3**

Question			Answers	Notes	Total
8.	a		potential is defined to be zero at infinity ✓ so a positive amount of work needs to be supplied for a mass to reach infinity ✓		**2**
	b	i	$V_S = -\frac{GM}{r}$ so $r \times V_S$ «$= -GM$» $=$ constant because G and M are constants ✓		**1**
	b	ii	$GM = 1.33 \times 10^{20}$ «J m kg^{-1}» ✓ GPE at Earth orbit «$= -\frac{1.33 \times 10^{20} \times 6.0 \times 10^{24}}{1.5 \times 10^{11}}$» $=$ «$-$» 5.3×10^{33} «J» ✓	*Award **[1 max]** unless answer is to 2 sf.* *Ignore addition of Sun radius to radius of Earth orbit.*	**2**

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
	b	iii	***ALTERNATIVE 1*** work leading to statement that kinetic energy $= \frac{GMm}{2r}$, ***AND*** kinetic energy evaluated to be «+» 2.7×10^{33} «J» ✓ energy «= PE + KE = answer to (b)(ii) + 2.7×10^{33} » = «−»2.7×10^{33} «J» ✓ ***ALTERNATIVE 2*** statement that kinetic energy is $= -\frac{1}{2}$ gravitational potential energy in orbit ✓ so energy «$= \frac{\text{answer to (b)(ii)}}{2}$» = «−»$2.7\times10^{33}$ «J» ✓	*Various approaches possible.*	**2**
	b	iv	«KE will initially decrease so» total energy decreases ***OR*** «KE will initially decrease so» total energy becomes more negative ✓ Earth moves closer to Sun ✓ new orbit with greater speed «but lower total energy» ✓ changes ellipticity of orbit ✓		**2 max**

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
	c		centripetal force is required ✓ and is provided by gravitational force between Earth and Sun ✓	*Award **[1 max]** for statement that there is a "centripetal force of gravity" without further qualification.*	**2**