Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

PHYSICS **9792/03**

Paper 3 Written Paper 3 **May/June 2017**

MARK SCHEME

Maximum Mark: 140

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

CAMBRIDGE International Examinations

Section A

Question	Answer	Marks
1(a)	force = mg and also GMm / r^2	**1**
	cancelling m to get $g = GM / r^2$ or equivalent	**1**
1(b)(i)	1.6300 ± 100 km	**1**
	2 g = 6.1 ± 0.1 (N kg^{-1}) OR force = 6.1 × 20 000	**1**
	= 122 000 ± 2000 (N)	**1**
1(b)(ii)	answer to (b)(i)2 = m v^2 / r OR their $g = v^2 / r$	**1**
	$v^2 = 6.1 \times 8.2 \times 10^6$	**1**
	$v = (7.1 \pm 0.1) \times 10^3$ (m s^{-1})	**1**
1(c)(i)	the (gravitational potential) energy (of a body) per unit mass / kg (at a point in a gravitational field)	**1**
1(c)(ii)	V = (–)GM / r	**1**
	= (–)gr OR (–) $4.0 \times 1 \times 10^n$	**1**
	= (–) $4.0 \pm 0.1 \times 10^7$	**1**
	= -4.0×10^7 (J kg^{-1})	**1**
	OR recognises that this is the area under the graph from point to infinity	**1**
	counting squares gives around 200 + some for large distance	**1**
	converting from squares to value (1 square is 2×10^5)	**1**
	total gravitational potential energy = $(-4.0 \pm 2.0) \times 10^7$ J kg^{-1}	**1**

Question	Answer	Marks
2(a)(i)	(pV = nRT gives) $1.0 \times 10^5 \times 750 \times 10^{-6} = n \times 8.31 \times 300$ OR n = 75 / 2493	**1**
	0.030	**1**
2(a)(ii)	pV/T = constant = $1 \times 10^5 \times 750 / 300 = 44 \times 10^5 \times 50 \times 10^6 / T$ OR $T = 300 \times 44 \times 50 \times 10^6 / 1 \times 750$	**1**
	880 (K)	**1**
	alternative: $T = Vp / nR = 44 \times 10^5 \times 50 \times 10^6 / 0.030 \times 8.31 = 220 / 0.25$	**1**
	880 (K)	**1**
2(a)(iii)	p / T = constant = $44 \times 10^5 / 880 = p / 1960$ OR $p = 44 \times 10^5 \times 1960 / 880$	**1**
	= 9.8×10^6 (Pa)	**1**
2(a)(iv)1	zero	**1**
2(a)(iv)2	work	**1**
	net work output for one cycle	**1**

Question	Answer	Marks
2(b)	(see table below)	
	first and third line correct	1
	second line correct	1
	– 220 correct in right hand column	1
	other two figures correct in bottom row	1
2(c)	work done = 810 – 360 = 450 J	1
	(efficiency = 450 / 670) = 0.67 or 67%	1

	work done on gas /J	heat supplied to gas /J	increase in internal energy of gas /J
A to B	+ 360	0	**+ 360**
B to C	**0**	+ 670	**+670**
C to D	**– 810**	0	– 810
D to A	**0**	**– 220**	**– 220**

Question	Answer	Marks
3(a)(i)	a region in which a charge will experience a force	**1**
	electric field strength as force per unit positive charge	**1**
3(a)(ii)	$E = Q / 4\pi\varepsilon_0 r^2$ OR $5.2 \times 10^{-7} / 4\pi \times 8.85 \times 10^{-12} \times 0.25^2$	**1**
	$= 7.48 \times 10^4$	**1**
	newton per coulomb OR volts per metre OR equivalent	**1**
3(b)	lines going into negative charge and leaving positive charges for all three charges number of lines greater for Z than X neutral point indicated consistent with field lines basic pattern correct and fills rectangle no crossings / joining	**max 4**

Question	Answer	Marks
4(a)	lower resistance (of primary or secondary coil) lower resistance of variable resistor a larger number of turns on the secondary coil decrease number of turns on primary increasing the e.m.f. of the supply increase the cross-sectional area of the primary coil / iron core **accept** higher frequency	**max 4**
4(b)	one positive and one negative blip	**1**
	horizontal section at zero in the middle	**1**
	on leaving larger amplitude **and** shorter duration	**1**

Question	Answer	Marks
5(a)	charge stored per unit potential difference OR capacitance = charge / voltage	**1**
5(b)(i)	(Q = CV) = $56 \times 10^{-6} \times 12.0$	**1**
	= 672×10^{-6} (C)	**1**
5(b)(ii)	($E = ½CV^2 = ½QV = ½Q^2 / C$) e.g. $0.5 \times 56 \times 10^{-6} \times 12^2$ correct substitution into formula	**1**
	= 4.03×10^{-3} (J)	**1**
5(b)(iii)	unit of C is coulomb per volt = ampere second per volt unit of R is volt per ampere	**1**
	multiplication seen to get A and V cancelling to get second any valid method	**1**

Question	Answer	Marks
5(b)(iv)1	$t / CR = 1$ at time CR OR ratio $= 1 – e^{–1}$	**1**
	$= 0.63$	**1**
5(b)(iv)2	$Q / Q_0 = 0.99$	**1**
	$0.99 = 1 – e^{–t / CR}$ OR $e^{–t / CR} = 0.01$	**1**
	$–t / CR = \ln 0.01 = – 4.6$	**1**
	$t\ (= 4.6 \times 56 \times 10^{–6} \times 66 \times 10^{3}) = 17\ s$	**1**

Question	Answer	Marks
6(a)	Top particle deflected up the least / not at all	**1**
	middle particle deflected by greater angle , bottom particle almost reflected	**1**
6(b)(i)	mass of alpha particle $= 4 \times 1.66 \times 10^{–27}$ kg	**1**
	(kinetic energy $= 0.5 \times 4 \times 1.66 \times 10^{–27} \times (1.30 \text{ x } 10^{7})^{2}$) $= 5.61 \times 10^{–13}$ (J)	**1**

Question	Answer	Marks
6(b)(ii)	Charge on alpha particle = 2e, on gold nucleus = 79e	**1**
	All the kinetic energy becomes electrical potential energy	**1**
	$r = (Q_\alpha Q_{Au} / \{4\pi\varepsilon_0 \times \text{answer to (b)(i)}\}) = 158e^2 / 4\pi\varepsilon_0 \times 5.61 \times 10^{-13}$	**1**
	$r = 6.48 \times 10^{-14}$ (m)	**1**
6(b)(iii)	volume = $4\pi r^3 / 3$	**1**
	giving volume as between 10^{-29} to 10^{-33} (m^3)	**1**
6(b)(iv)	volume of nucleus between 10^{-39} and 10^{-45} OR ratio of radii cubed	**1**
	correct calculation from their estimates	**1**

<table>
<tr><th>Question</th><th colspan="2">Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">7(a)(i)</td><td colspan="2">wavelength at peak × temperature = 2.90×10^{-3}</td><td>1</td></tr>
<tr><td colspan="2">temperature (= $2.90 \times 10^{-3} / 582 \times 10^{-9}$) = 5000 (K)</td><td>1</td></tr>
<tr><td rowspan="4">7(a)(ii)</td><td colspan="2">(surface area of sphere of radius 3.80×10^{17}) = $4\pi \times (3.80 \times 10^{17})^2$ OR 1.81×10^{36}</td><td>1</td></tr>
<tr><td colspan="2">L = 2.38×10^{-8} × their surface area ($4\pi r^2$) OR 4.32×10^{28} (W)</td><td>1</td></tr>
<tr><td colspan="2">$r^2 = L/4\pi\sigma T^4$ OR r^2 = their $L / 4\pi \times 5.67 \times 10^{-8} \times 4983^4$</td><td>1</td></tr>
<tr><td colspan="2">$r = 9.9 \times 10^9$ [m]</td><td>1</td></tr>
<tr><td rowspan="4">7(b)</td><td>use of a diffraction grating</td><td>use of a double slit</td><td>1</td></tr>
<tr><td>measurement of angle of deflection θ</td><td>measurement of angle of deflection θ or fringe separation</td><td>1</td></tr>
<tr><td>$n\lambda = d \sin \theta$</td><td>$n\lambda = d \sin \theta$ or $\lambda = ax / D$</td><td>1</td></tr>
<tr><td>plus any two from:
• suitable source e.g. sodium lamp OR bright source of monochromatic light
• diagram / description for arrangement of set up (must include source, grating, and screen)
• method for measuring angle e.g. use of a spectrometer or protractor
• method for improving accuracy of result</td><td>plus any two from:
• suitable source e.g. sodium lamp OR bright source of monochromatic light
• diagram / description for arrangement of set up (must include source, grating, and screen)
• method for measuring angle e.g. use of a spectrometer or protractor
• method for improving accuracy of result</td><td>2</td></tr>
</table>

Section B

Question	Answer	Marks
8(a)(i)	in equilibrium (vertically)	**1**
	weight equal (and opposite) to vertical component of tension	**1**
8(a)(ii)	not in equilibrium (horizontally)	**1**
	unbalanced force is horizontal component of tension	**1**
8(b)	$a = r\omega^2$ OR v^2/r **and** $v = r\omega$	**1**
	r = 4.1 + 3 sin 49 OR r = 6.36	**1**
	$a = (6.36 \times 1.33^2) = 11.3\ (\text{m s}^{-2})$	**1**
8(c)	• narrow ring drawn of width δr and radius r	**1**
	• mass of ring = $\delta m = 2\pi r\, \delta r\, t\, \rho$	**1**
	(M of I of ring = $\delta m\, r^2$ so M of I of disc =) • $I = \int_0^R 2\pi r\, t\, r^2\, dr$	**1**
	• leading to $I = ½MR^2$ OR $\pi t \rho R^4 / 2$	**1**
8(d)	torque = moment of inertia × angular acceleration	**1**
	angular momentum = moment of inertia × angular velocity	**1**
	kinetic energy = ½ moment of inertia × (angular velocity)^2	**1**
8(e)(i)	$\alpha = 1.34/30$ OR $\alpha = 0.04467$	**1**
	$\theta = ½ \times 0.04467 \times 30^2$ OR $\theta = 20.1$(rad)	**1**
	$(= 20.1 / 2\pi) = 3.2$ rev	**1**

Question	Answer	Marks
8(e)(ii)	(k.e. = $0.5 \times 12\,000 \times 1.34^2$) = 10 800 (J)	**1**
8(f)	(as the rate of rotation increases) the passengers move further from the centre	**1**
	moment of inertia is dependent on (the square of) this distance	**1**

Question	Answer	Marks
9(a)(i)	*a* is the acceleration and *f* is the frequency	**1**
9(a)(ii)	*a* is (always) in the opposite direction to *x* OR in terms of force	**1**
9(b)(i)	$v = -A(2\pi f) \sin(2\pi ft)$	**1**
9(b)(ii)	maximum velocity = $2\pi fA$	**1**
	(use of $f = 1 / T$) = 1 / 0.02 OR 50 (Hz)	**1**
	(maximum velocity = $2\pi \times 50 \times 8.0 \times 10^{-6}$) = 2.5×10^{-3} (m s^{-1})	**1**
9(b)(iii)1	($a_{max} = \omega^2 A = (2\pi / T)^2 \times A = = (2\pi \times 50)^2 \times 8.0 \times 10^{-6}$) = 0.7896 (m s^{-2})	**1**
9(b)(iii)2	graph inverted cosine curve	**1**
	correct values using their own value for a_{max} and y-axis labelled	**1**
	with correct values crossing x axis	**1**
9(b)(iv)	π radians OR 180 °	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="3">9(c)(i)</td><td>$T^2 = 4\pi^2 m / A\sigma g$</td><td>1</td></tr>
<tr><td>$(g = 4\pi^2 m / T^2 A\sigma$ and) $m / A = \rho L$</td><td>1</td></tr>
<tr><td>$(g =)\ 4\pi^2 \rho L / T^2 \sigma$</td><td>1</td></tr>
<tr><td>9(c)(ii)</td><td>(friction / drag acts on the rod and) loss of energy (causes amplitude decrease)</td><td>1</td></tr>
<tr><td>9(c)(iii)1</td><td>5 results correct
only 1 error is 1 mark only
more than 1 error 0 marks

<table><tr><th>time / s</th><th>displacement / cm</th></tr><tr><td>0.0</td><td>2.8</td></tr><tr><td>0.5</td><td>1.9</td></tr><tr><td>1.0</td><td>1.2</td></tr><tr><td>1.5</td><td>0.8</td></tr><tr><td>2.0</td><td>0.5</td></tr></table></td><td>2</td></tr>
<tr><td>9(c)(iii)2</td><td>calculate the logs and show constant difference OR calculate the ratios of consecutive values and show constant value

<table><tr><th>time / s</th><th>displacement / cm</th><th>ln displacement</th></tr><tr><td>0.0</td><td>2.8</td><td>1.03</td></tr><tr><td>0.5</td><td>1.9</td><td>0.642</td></tr><tr><td>1.0</td><td>1.2</td><td>0.182</td></tr><tr><td>1.5</td><td>0.8</td><td>–0.223</td></tr><tr><td>2.0</td><td>0.5</td><td>–0.692</td></tr></table></td><td>1</td></tr>
</table>

Question	Answer	Marks
9(c)(iii)3	In displacement against time fully labelled	**1**
	straight line graph of negative gradient	**1**

Question	Answer	Marks
10(a)(i)	out of the page	**1**
10(a)(ii)1	force $=Bev$	**1**
10(a)(ii)2	$Bev = mv^2/r$	**1**
	so $v = Ber/m$	**1**
10(a)(ii)3	*use* $Bev = mv^2/r$ to get	**1**
	$e/m = v/Br$	**1**
10(b)(i)	gain in k.e. $=½mv^2 = eV$ OR work done $= Eqd = ½mv^2$	**1**
10(b)(ii)	(use $v = Ber/m$ and $½mv^2 = eV$ to obtain) $r^2 = 2Vm/eB^2$ OR $r = \sqrt{(2Vm/eB^2)}$	**1**
	correct substitution for V, m, e, B^2	**1**
	$r = 1.6 \times 10^{-2}$ (m)	**1**
10(c)	(the constant) force (on the electron) is perpendicular to its direction of motion	**1**
	no work is done on the electron	**1**

Question	Answer	Marks
10(d)(i)	any two from: (a uniform field) produces a constant force on electron path of constant radius owtte calculation of magnetic field strength is possible field magnitude can be controlled (by changing current)	**max 2**
10(d)(ii)	substituting for $x = ½R$ to see $(5/4\ R^2)^{3/2}$ OR $(R^2 + ¼R^2)^{3/2}$	**1**
	multiplied by 2n	**1**
	rearrangement leading to $\gamma = 0.716$ *(x = ½R* $(B(x) = 2n\ (\mu_0 I R^2) / 2(R^2 + ¼R^2)^{3/2})$ $= 2n\ (\mu_0 I R^2) / 2 \times (5/4\ R^2)^{3/2}$ $= n\ \mu_0 I R^2 / 1.39\ R^3$ so for n turns $B = n\mu_0 I / 1.39\ R = n \times 0.716\ \mu_0 I)$	**1**
10(d)(iii)	$R = 280 / (2 \times \pi \times 500)$ OR $R = 8.9 \times 10^{-2}$ m	**1**
	correct substitution in $B = 0.7 \dfrac{\mu_0 nI}{R}$	**1**
	1.4×10^{-3} (T) (1)	**1**

Question	Answer	Marks
11(a)	Any valid statement. E.g. The <u>resultant</u> force acting on a body is equal to the rate of change of (linear) momentum of that body.	**1**
11(b)	Newton's law of gravitation gives force	**1**
	Newton's second law determines the motion	**1**
11(c)(i)	evidence of existence of a perturbing influence (e.g. from other planets etc…)	**1**
	relevant reference to precision in measured quantity	**1**
	max 1 for any **two** from current/initial position of the object current/initial velocity of the object gravitational force acting on the object value of G distances to other relevant bodies (e.g. Sun, planets etc...) masses of relevant bodies	**1**
11(c)(ii)	any two from we do not have precise values for masses or constants (e.g. G) uncertainties in measured quantities limited precision in measuring instruments unable to include all perturbing influences	**2**
11(d)(i)	deterministic: future (state) is <u>completely / uniquely</u> determined by present (state / initial conditions)	**1**
11(d)(ii)	Newton's laws are deterministic (despite our inability to make precise predictions) because future positions and motions can be calculated from present positions and motions	**2**
11(e)(i)	that its entropy will increase (to a maximum value/will not decrease) OR more disordered OR tends towards heat death	**1**

Question	Answer	Marks
11(e)(ii)	(when it is spread out) there are many more ways in which the particles can be arranged states that can be arranged in a larger number of ways are more probable increasing numbers of ways correspond to increased entropy uniform spread corresponds to maximum number of ways	**max 2**
11(e)(iii)	Laplacian prediction – predicts the positions / motions of every particle – details of microstate Laplacian prediction is linked to a definite unique outcome Second law prediction – refers to macrostate (large scale) Second law predictions based on probabilities Macrostate realisable by many indistinguishable microstates Second law prediction is less detailed / contains less information / does not describe a unique future	**max 2**
11(f)(i)	E.g. collapse of the wavefunction falls to zero everywhere when electron/photon is detected at a particular position **OR** idea that making a measurement on one part of a quantum system affects values at distant points	**2**
11(f)(ii)	even if we know everything about a quantum state (e.g. radioactive nucleus) we can only predict the probability of an event (e.g. decay) **OR** the more precisely we measure one variable (e.g. position) the greater the uncertainty in another variable (e.g. momentum)	**2**
12(a)	reference to ‘absolute’ space – e.g. as a fixed background or coordinate system idea that velocity of light would be relative to aether and hence to absolute space idea that velocity of light would depend on velocity of observer (relative to aether / absolute space) experiments, e.g Michelson-Morley, showed no change to the speed of light due to the motion of the observer extra detail – – e.g. example leading to $c \pm v$ – practical detail of relevant experiment, e.g. Michelson-Morley – Reference to aether wind affecting measured speed of light 4 max with maximum 2 for extra detail	**max 4**

Question	Answer	Marks
12(b)(i)	0.80 c or 2.4×10^{8} ms^{-1}	1
12(b)(ii)	1.5 c or 4.5×10^{8} ms^{-1}	1
12(b)(iii)	idea that velocity measurements involve ratio of distance measurement/time measurement idea that distance and / or time measurements will differ between reference frames idea that measuring instruments disagree between reference frames idea that distances / time intervals between events are relative reference to relativistic velocity addition formula or failure of simple velocity addition formula for velocities comparable to c	max 2
12(b)(iv)1	$((0.70c+0.80c) / (1 + 0.80c \times 0.70c / c^2))$ $= 0.96c$ OR 2.88×10^{8} (m s^{-1})	1
12(b)(iv)2	substitutes $u = 0.70c$ and $v = c$ into equation $(0.70c + c) / (1 + c \times 0.70c / c^2)$	1
	rearranges equation to show that $w = c$ results	1

Question	Answer	Marks
12(b)(iv)3	Shows that uv / c^2 can be neglected	**1**
	Algebra showing that this leads to $w = v + u$	**1**
12(c)(i)	(=100/0.99) = 101 years	**1**
12(c)(ii)	$l' = l\sqrt{(1 - v^2 / c^2)} = 100\sqrt{(1 - 0.99^2)}$	**1**
	= 14.1 light years	**1**
12(c)(iii)	t' = 14.1 / 0.99 = 14.24 years OR by using the time dilation formula $t' = 101\sqrt{(1 - 0.99^2)}$	**1**
12(d)	They will not be synchronised OR the relativity of simultaneity	**max 3**
	any two from: • B will appear to have started first (be ahead of A) • Explanation: clock B approaches flash (in rocket's frame) • Speed of light is same for observers in both frames.	

Question	Answer	Marks
13(a)(i)	angular momentum = $mva_0 = h/2\pi$	**1**
	$2\pi a_0 = h / mv$ OR $2\pi a_0 = h / p$	**1**
	$2\pi a_0 = \lambda$	**1**
13(a)(ii)	• Circumference is equal to one wavelength • One complete wavelength reinforces itself around the orbit OR joins up with itself • Fits the boundary conditions max 2	**max 2**
13(a)(iii)	• Angular momentum is quantised • Discrete energy levels • Energy level number is the number of wavelengths • Destructive interference between energy levels • Circumference of orbit fits multiple ($n > 1$) wavelengths • Orbital radius / circumference increases • De Broglie wavelengths are shorter • Electrons have more momentum / KE max 3	**max 3**
13(b)(i)	$\Psi_1 = 30$ and $\Psi_2 = 10$	**1**
	$p_2 / p_1 = 1/9$ or 0.11	**1**
13(b)(ii)1	Realises that small δr justifies treating shell like flat sheet	**1**
	Volume = surface area × thickness = $4\pi r^2 \times \delta r$	**1**
	OR Uses difference in volumes of two spheres	**1**
	Neglects higher order terms (in δr^2) to get $4\pi r^2 \times \delta r$	**1**

Question	Answer	Marks
13(b)(ii)2	Starts from zero r **and** showing a parabolic increase (judged by eye – increasing gradient)	**1**
13(b)(iii)	Realises that probability $\propto 4\pi r^2 \mathrm{p}\delta r$	**1**
	Uses $p_2 / p_1 = 1/\ 9$	**1**
	Uses $r_2^{\,2} / r_1^{\,2} = 4 / 1$ (probability at two Bohr radii / probability at one Bohr radius	**1**
	$((2a_0)^2 p_2) / (a_0^{\,2} p_1) = 4 / 9$ OR $= 0.44$	**1**
13(b)(iv)1	$4\pi r^2$ approaches zero as r approaches zero OR δV approaches zero	**1**
13(b)(iv)2	$[\Psi]^2$ approaches zero faster than δV approaches infinity	**1**
	$[\Psi]^2$ or Ψ approaches zero as r approaches infinity	**1**