

**PHYSICS**

**9702/42**

Paper 4 A Level Structured Questions

**October/November 2017**

MARK SCHEME

Maximum Mark: 100

**Published**

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Question	Answer	Marks
1(a)	<u>force</u> proportional to <u>product</u> of masses and inversely proportional to square of separation	<b>B1</b>
	idea of <u>force</u> between <u>point</u> masses	<b>B1</b>
1(b)	mass of Jupiter ( $M$ ) = $(4/3)\pi R^3 \rho$	<b>B1</b>
	$\omega = 2\pi/T$ <b>or</b> $v = 2\pi nR/T$	<b>B1</b>
	$(m)\omega^2 x = GM(m)/x^2$ <b>or</b> $(m)v^2/x = GM(m)/x^2$	<b>M1</b>
	substitution and correct algebra leading to $\rho T^2 = 3\pi n^3/G$	<b>A1</b>
1(c)(i)	$n = (4.32 \times 10^5)/(7.15 \times 10^4)$ <b>or</b> $n = 6.04$	<b>C1</b>
	$\rho \times (42.5 \times 3600)^2 = (3\pi \times 6.04^3)/(6.67 \times 10^{-11})$	<b>C1</b>
	$\rho = 1.33 \times 10^3 \text{ kg m}^{-3}$	<b>A1</b>
1(c)(ii)	Jupiter likely to be a gas/liquid (at high pressure) [allow other sensible suggestions]	<b>B1</b>

Question	Answer	Marks
2(a)	(thermal) energy <u>per</u> (unit) mass (to cause change of state)	<b>B1</b>
	(energy required to cause/released in) change of state at constant temperature	<b>B1</b>
2(b)(i)	1. (work done on/against) the <u>atmosphere</u>	<b>B1</b>
	2. <u>water</u> as it turns from liquid to vapour	<b>M1</b>
	as potential energy of <u>molecules</u> increases	<b>A1</b>
	<b>or</b>	
	<u>surroundings</u> as its temperature rises	<b>(M1)</b>
	as energy is lost/transferred to surroundings	<b>(A1)</b>
2(b)(ii)	$VI - h = M/t \times L$ (where $h$ = power loss) <b>or</b> $L = (VI t - Q)/M$ (where $Q$ = energy loss)	<b>C1</b>
	$(14.2 \times 6.4) - (11.5 \times 5.2) = (9.1 - 5.0) \times L/300$ <b>or</b> $L = [(14.2 \times 6.4) - (11.5 \times 5.2)] \times 300 / (9.1 - 5.0)$	<b>C1</b>
	$L = 2300 \text{ J g}^{-1}$	<b>A1</b>

Question	Answer	Marks
3(a)(i)	angle (subtended) where arc (length) is equal to radius	<b>M1</b>
	(angle subtended) at the centre of a circle	<b>A1</b>
3(a)(ii)	angular frequency = $2\pi \times$ frequency <b>or</b> $2\pi /$ period	<b>B1</b>
3(b)(i)	$c/ML^3$ is a constant so acceleration is proportional to displacement	<b>B1</b>
	minus sign shows that acceleration and displacement are in opposite <u>directions</u>	<b>B1</b>
3(b)(ii)	$c/ML^3 = (2\pi f)^2$	<b>C1</b>
	$c = 4\pi^2 \times 3.2^2 \times 0.24 \times 0.65^3$	<b>C1</b>
	$= 27 \text{ kg m}^3 \text{ s}^{-2}$	<b>A1</b>

Question	Answer	Marks
4(a)	quartz/piezo-electric <b>and</b> crystal/transducer	<b>B1</b>
	p.d. across crystal causes it to distort	<b>B1</b>
	applying <u>alternating</u> p.d. causes oscillations/vibrations	<b>B1</b>
	when applied frequency is natural frequency, crystal resonates	<b>B1</b>
	natural frequency of crystal is in ultrasound range	<b>B1</b>
4(b)	small(er) structures can be resolved/observed/identified	<b>B1</b>

Question	Answer	Marks													
5(a)	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">(0.2 ms)</td> <td style="width: 25%;">8.0 (mV)</td> <td style="width: 25%;">1000</td> <td style="width: 25%;"></td> </tr> </table>	(0.2 ms)	8.0 (mV)	1000		<b>B1</b>									
(0.2 ms)	8.0 (mV)	1000													
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">(0.8 ms)</td> <td style="width: 25%;">5.8 (mV)</td> <td style="width: 25%;">0101</td> <td style="width: 25%;"></td> </tr> </table>	(0.8 ms)	5.8 (mV)	0101		<b>B1</b>									
(0.8 ms)	5.8 (mV)	0101													
5(b)	series of steps	<b>B1</b>													
	all (step) changes are at 0.2 ms intervals	<b>B1</b>													
	steps with correct levels at correct times <i>(1 mark if five levels correct; 2 marks if all levels correct)</i> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <tr> <td style="width: 12.5%;">level</td> <td style="width: 12.5%;">0</td> <td style="width: 12.5%;">8</td> <td style="width: 12.5%;">10</td> <td style="width: 12.5%;">15</td> <td style="width: 12.5%;">5</td> <td style="width: 12.5%;">8</td> </tr> <tr> <td>time / ms</td> <td>0–0.2</td> <td>0.2–0.4</td> <td>0.4–0.6</td> <td>0.6–0.8</td> <td>0.8–1.0</td> <td>1.0–1.2</td> </tr> </table>	level	0	8	10	15	5	8	time / ms	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1.0	1.0–1.2
level	0	8	10	15	5	8									
time / ms	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1.0	1.0–1.2									
5(c)	smaller step heights (possible)	<b>B1</b>													
	smaller changes (in input signal) can be seen/reproduced/represented <b>or</b> (allows) more accurate <u>reproduction</u> (of the input signal)	<b>B1</b>													

Question	Answer	Marks
6(a)	electric field lines are radial/normal to surface (of sphere)	<b>B1</b>
	electric field lines <u>appear</u> to originate from centre (of sphere)	<b>B1</b>
6(b)(i)	tangent drawn at $x = 6.0$ cm and gradient calculation attempted	<b>C1</b>
	$E = 9.0 \times 10^4 \text{ NC}^{-1}$ (1 mark if in range $\pm 1.2$ ; 2 marks if in range $\pm 0.6$ )	<b>A2</b>
	<b>or</b>	
	correct pair of values of $V$ and $x$ read from curved part of graph and substituted into $V = q/4\pi\epsilon_0x$	<b>(C1)</b>
	to give $q = 3.6 \times 10^{-8} \text{ C}$	<b>(C1)</b>
	(then $E = q/4\pi\epsilon_0x^2$ and $x = 6$ cm gives) $E = 9.0 \times 10^4 \text{ NC}^{-1}$	<b>(A1)</b>
	<b>or</b>	
	( $E = q/4\pi\epsilon_0x^2$ and $V = q/4\pi\epsilon_0x$ and so) $E = V/x$	<b>(C1)</b>
	giving $E = 5.4 \times 10^3/0.060$ $= 9.0 \times 10^4 \text{ NC}^{-1}$	<b>(C1)</b> <b>(A1)</b>
6(b)(ii)	( $R =$ ) 2.5 cm	<b>B1</b>
	potential inside a conductor is constant <b>or</b> field strength inside a conductor zero (so gradient is zero)	<b>B1</b>

Question	Answer	Marks
7(a)(i)	(part of) the output is combined with the input	<b>M1</b>
	reference to potential/voltage/signal	<b>A1</b>
7(a)(ii)	<ul style="list-style-type: none"> <li>• increased (operating) stability</li> <li>• increased bandwidth/range of frequencies over which gain is constant</li> <li>• less distortion (of output)</li> </ul> <i>Any 2 points.</i>	<b>B2</b>
7(b)(i)	1. gain = $3.6 / (48 \times 10^{-3})$	<b>C1</b>
	= 75	<b>A1</b>
	2. gain = $1 + R_F / R$ $75 = 1 + (92.5 \times 10^3) / R$	<b>C1</b>
	$R = 1300 \Omega$	<b>A1</b>
7(b)(ii)	for 68 mV, gain $\times V_{IN} = 5.1$ (V) <b>or</b> output voltage would be greater than the supply voltage	<b>M1</b>
	amplifier would saturate (at 5.0 V) <b>or</b> output voltage = 5.0 (V)	<b>A1</b>

Question	Answer	Marks
8(a)(i)	DERQ and CFSP	<b>B1</b>
8(a)(ii)	charge carriers moving normal to (magnetic) field	<b>B1</b>
	<u>charge carriers</u> experience a <u>force</u> normal to $I$ (and $B$ )	<b>B1</b>
	charge build-up sets up electric field across the slice <b>or</b> build-up of charges results in a p.d. across the slice	<b>B1</b>
	charge stops building up/ $V_H$ becomes constant when $F_B = F_E$	<b>B1</b>
8(b)	$V_H$ inversely proportional to $n$ /number density of charge carriers	<b>B1</b>
	number density of charge carriers ( $n$ ) lower in semiconductors so $V_H$ larger for semiconductor slice	<b>B1</b>
	<b>or</b>	
	$V_H$ proportional to $v$ /drift velocity	<b>(B1)</b>
	(for same current) drift velocity ( $v$ ) higher in semiconductors so $V_H$ larger for semiconductor slice	<b>(B1)</b>

Question	Answer	Marks
9(a)	region (of space)	<b>B1</b>
	where an object/particle experiences a force	<b>B1</b>
9(b)	electric and magnetic fields normal to each other	<b>B1</b>
	velocity of particle normal to both fields	<b>B1</b>
	forces (on particle) due to fields are in opposite directions	<b>B1</b>
	<u>forces are equal</u> for particles with a particular speed/for a selected speed/for speed given by $v = E(q)/B(q)$	<b>B1</b>
9(c)(i)	path labelled Q shown undeviated	<b>B1</b>
9(c)(ii)	reasonable curve in field and no 'kink' on entering, labelled V	<b>B1</b>
	deviated 'upwards'	<b>B1</b>

Question	Answer	Marks
10(a)	$\lambda_0$ marked and graph line passing through $E_{\text{MAX}} = 0$ at $\lambda = \lambda_0$	<b>B1</b>
	graph line with $\lambda$ always $< \lambda_0$	<b>B1</b>
	negative gradient with correct concave curvature	<b>B1</b>
10(b)	curve with negative gradient and correct concave curvature	<b>M1</b>
	not touching either axis	<b>A1</b>

Question	Answer	Marks
11(a)(i)	circles drawn only around the top left and bottom right diodes	<b>B1</b>
11(a)(ii)	B shown as (+)ve and A shown as (-)ve	<b>B1</b>
11(b)(i)	$V_{r.m.s.} (= 5.6 / \sqrt{2}) = 4.0\text{ V}$	<b>A1</b>
11(b)(ii)	$380 = 2\pi f$ <b>or</b> $f = 60.5\text{ Hz}$	<b>C1</b>
	number ( $= 2f$ ) = 120	<b>A1</b>
11(c)(i)	peak values (all) unchanged	<b>B1</b>
	(all) minima shown at 4.0 V	<b>B1</b>
	three lines from near peak showing concave curves after leaving dotted line not 'kinked' and not cutting the peak reaching <u>candidate's</u> minimum at the point where the decay meets the next dotted line	<b>B1</b>
	three lines drawn along the dotted lines showing rise in voltage from minima back to peak values	<b>B1</b>
11(c)(ii)	<u>mean</u> p.d. is higher <b>or</b> <u>r.m.s.</u> p.d. is higher <b>or</b> capacitor supplies energy <u>to resistor</u>	<b>M1</b>
	so (mean) power increases	<b>A1</b>

Question	Answer	Marks
12(a)(i)	<u>nucleus</u> emits particles/EM radiation/ionising radiation	<b>B1</b>
	emission/release from unstable <u>nucleus</u> <b>or</b> emission from <u>nucleus</u> is random and/or spontaneous	<b>B1</b>
12(a)(ii)	probability of decay (of a nucleus) <b>or</b> fraction of (number of undecayed) nuclei that will decay	<b>M1</b>
	per unit time	<b>A1</b>
12(b)	energy is shared with another particle	<b>B1</b>
	mention of antineutrino	<b>B1</b>
12(c)(i)	number = $[(1.2 \times 10^{-9}) / 131] \times 6.02 \times 10^{23}$ <b>or</b> number = $(1.2 \times 10^{-3} \times 10^{-9}) / (131 \times 1.66 \times 10^{-27})$  (= $5.51 \times 10^{12}$ )	<b>C1</b>
	$A = \lambda N$	<b>C1</b>
	= $[0.086 / (24 \times 3600)] \times 5.51 \times 10^{12}$  = $5.5 \times 10^6$ Bq	<b>A1</b>
12(c)(ii)	$1/50 = \exp(-0.086t)$ <b>or</b> $1/50 = 0.5^n$	<b>C1</b>
	$t = 45$ days	<b>A1</b>