CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9702 PHYSICS

9702/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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1 **(a)** **(i)** **1.** $F = Gm_1m_2 / x^2$
$= (6.67 \times 10^{-11} \times 2.50 \times 5.98 \times 10^{24}) / (6.37 \times 10^6)^2$ M1
$= 24.6$ N (*accept 2 s.f. or more*) A1 [2]

2. $F = mx\omega^2$ **or** $F = mv^2 / x$ **and** $v = \omega x$ *(accept x or r for distance)* C1
$= 2.50 \times 6.37 \times 10^6 \times (2\pi / 24 \times 3600)^2$
$= 0.0842$ N (*accept 2 s.f. or more*) A1 [2]

(ii) reading $= 24.575 - 0.0842$ B1
$= 24.5$ N (*accept only 3 s.f.*) A1 [2]

(b) gravitational force provides the centripetal force M1
gravitational force is 'equal' to the centripetal force
(*accept* $Gm_1m_2 / x^2 = mx\omega^2$ **or** $F_C = F_G$) M1
'weight'/sensation of weight/contact force/reaction force is difference between F_G and F_C which is zero A1 [3]

2 **(a)** mean speed $= 1.44 \times 10^3$ m s^{-1} A1 [1]

(b) evidence of summing of individual squared speeds C1
mean square speed $= 2.09 \times 10^6$ m^2 s^{-2} A1 [2]

(c) root-mean-square speed $= 1.45 \times 10^3$ m s^{-1} A1 [1]
(allow ECF from ***(b)*** *but only if arithmetic error)*

3 **(a)** (numerically equal to) quantity of heat/(thermal) energy to change state/phase of unit mass M1
at constant temperature A1 [2]
(*allow 1/2 for definition restricted to fusion or vaporisation*)

(b) **(i)** constant gradient/straight line *(allow linear/constant slope)* B1 [1]

(ii) $Pt = mL$ *or* power = gradient × L C1

use of gradient of graph
(*or two points separated by at least 3.5 minutes*) M1

$110 \times 60 = L \times (372 - 325) \times 10^{-3} / 7.0$
$L = 9.80 \times 10^5$ J kg^{-1} (*accept 2 s.f.*) (*allow 9.8 to 9.9 rounded to 2 s.f.*) A1 [3]

(iii) some energy/heat is lost to the surroundings *or* vapour condenses on sides M1
so value is an overestimate A1 [2]

4 **(a)** displacement (directly) proportional to acceleration/force M1
either displacement and acceleration in opposite directions
or acceleration (always) towards a (fixed) point A1 [2]

	(b)	**(i)**	⅓π rad or 1.05 rad (*allow 60° if unit clear*)	A1	[1]
		(ii)	$a_0 = -\omega^2 x_0$		
			$= (–)\ (2\pi / 1.2)^2 \times 0.030$	C1	
			$= (–)\ 0.82\,\text{m s}^{-2}$	A1	[2]
			(*special case: using oscillator P gives $x_0 = 1.7$ cm and $a_0 = 0.47\,\text{m s}^{-1}$ for 1/2*)		
		(iii)	max. energy $\propto x_0^2$		
			ratio $= 3.0^2 / 1.7^2$	C1	
			$= 3.1$ *(at least 2 s.f.)*	A1	[2]
			(*if has inverse ratio but has stated max. energy $\propto x_0^2$ then allow 1/2*)		
	(c)		graph: straight line through (0,0) with negative gradient	M1	
			correct end-points (–3.0, +0.82) and (+3.0, –0.82)	A1	[2]
5	**(a)**		work done bringing/moving per unit positive charge	M1	
			from infinity (to the point)	A1	[2]
	(b)	**(i)**	slope/gradient (of the line/graph/tangent)	B1	[1]
			*(allow dV / dx, but **not** ΔV / Δx or V / x)*		
			(allow potential gradient)		
			(negative sign not required)		
		(ii)	maximum at surface of sphere A or at $x = 0$ (cm)	B1	
			zero at $x = 6$ (cm)	B1	
			then increases but in opposite direction	B1	[3]
			(any mention of attraction max. 2/3)		
	(c)	**(i)**	M shown between $x = 5.5$ cm and $x = 6.5$ cm	B1	[1]
		(ii)	**1.** $\Delta V = (570 - 230) = 340\,\text{V}$ *(allow 330 V to 340 V)*	A1	[1]
			2. $q(\Delta)V = \frac{1}{2}mv^2$ **or** change/loss in PE = change/gain in KE **or** $\Delta E_K = \Delta E_P$	B1	
			$4.8 \times 10^7 \times 340 = \frac{1}{2}v^2$	C1	
			$v^2 = 3.26 \times 10^{10}$		
			$v = 1.8 \times 10^5\,\text{m s}^{-1}$ *(not 1 s.f.)*	A1	[3]
6	**(a)**		packet/quantum/discrete amount of energy	M1	
			of electromagnetic energy/radiation/waves	A1	[2]
	(b)	**(i)**	arrow below axis and pointing to right	B1	[1]

(ii) **1.** $E = hc/\lambda$			
$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/(6.80 \times 10^{-12})$	C1		
$= 2.93 \times 10^{-14}$ J (*accept 2 s.f.*)	A1	[2]	
2. energy of electron $= (3.06 - 2.93) \times 10^{-14}$			
$= 1.3 \times 10^{-15}$ J	C1		
speed $= \sqrt{(2E/m)}$	C1		
$= 5.4 \times 10^{7}$ m s^{-1}	A1	[3]	

(c) momentum is a vector quantity — B1
either must consider momentum in two directions
or direction changes so cannot just consider magnitude — B1 [2]

7 (a) moving magnet gives rise to/causes/induces e.m.f./current in solenoid/coil — B1
(induced current) creates field/flux in solenoid that opposes (motion of) magnet — B1
work is done/energy is needed to move magnet (into solenoid) — B1
(induced) current gives heating effect (in resistor) which comes from the work done — B1 [4]

(b) current in primary coil give rise to (magnetic) flux/field — B1
(magnetic) flux / field (in core) is in phase with current (in primary coil) — B1
(magnetic) flux threads/links/cuts secondary coil inducing e.m.f. in secondary coil — B1
*(there **must** be a mention of secondary coil)*
e.m.f. induced proportional to <u>rate</u> of change/cutting of flux/field so not in phase — B1 [4]

8 (a) (i) energy $= 5.75 \times 1.6 \times 10^{-13}$
$= 9.2 \times 10^{-13}$ J — A1 [1]

(ii) number $= 1900/(9.2 \times 10^{-13} \times 0.24)$ — C1
$= 8.6 \times 10^{15}$ s^{-1} — A1 [2]

(b) (i) decay constant $= 0.693/(2.8 \times 365 \times 24 \times 3600)$ — C1
$= 7.85 \times 10^{-9}$ s^{-1} *(allow 7.8 or 7.9 to 2 s.f.)* — A1 [2]

(ii) $A = \lambda N$
$8.6 \times 10^{15} = 7.85 \times 10^{-9} \times N$ — C1
$N = 1.096 \times 10^{24}$ — C1

mass $= (1.096 \times 10^{24} \times 236)/(6.02 \times 10^{23})$ — M1
$= 430$ g — A1 [4]

(c) $0.84 = 1.9 \exp(-7.85 \times 10^{-9} t)$ — C1
$t = 1.04 \times 10^{8}$ s
$= 3.3$ years — A1 [2]

Section B

9	**(a)**	V_B = 1000 mV when strained, V_A = 2000 × 121.5/(121.5 +120.0) = 1006.2 mV change = 6.2 mV (*allow 6 mV*)	C1 M1 A1	[3]
	(b)	**(i)** **1.** resistor between V_{IN} and V^- **and** V^+ connected to earth resistor between V^- and V_{OUT}	B1 B1	[2]
		2. P/+ sign shown on earth side of voltmeter	B1	[1]
		(ii) ratio of R_F/R_{IN} = 40 R_{IN} between 100 Ω and 10 kΩ *(any values must link to the correct resistors on the diagram)*	M1 A1	[2]
10	**(a)**	product of density (of medium) and speed (of ultrasound) in the medium	M1 A1	[2]
	(b)	**(i)** 7.0 × 10^6 = 1.7 × 10^3 × speed speed = 4.12 × 10^3 m s^{-1} wavelength = (4.12 × 10^3)/(9.0 × 10^5) m = 4.6 mm *(2 s.f. minimum)*	C1 C1 A1	[3]
		(ii) for air/tissue boundary, $I_R/I \approx 1$ for air/tissue boundary, (almost) complete reflection/no transmission for gel/tissue boundary, $I_R/I = 0.1^2/3.1^2$ $= 1.04 \times 10^{-3}$ *(accept 1 s.f.)* gel enables (almost) complete transmission (into the tissue)	M1 A1 M1 A1	[4]
11	**(a)**	**(i)** metal (*allow specific example of a metal*)	B1	[1]
		(ii) e.g. provides 'return' for the signal shields inner core from interference/reduces cross-talk/reduces noise increased security *(any two sensible suggestions, 1 each)*	 B2	[2]
	(b)	**(i)** (gradual) loss of power/intensity/amplitude	B1	[1]
		(ii) dB is a log scale *either* large (range of) numbers are easier to handle (on a log scale) *or* compounding attenuations/amplifications is easier	B1 B1	[2]
	(c)	attenuation = 190 × 11 × 10^{-3} = 2.09 dB –2.09 = 10 lg(P_{OUT}/P_{IN}) ratio = 0.62	C1 C1 A1	[3]

12	handset transmits (identification) signal to number of base stations	B1	
	base stations transfers (signal) to cellular exchange	B1	
	(idea of stations needed at least once in first two marking points)		
	computer at cellular exchange selects base station with strongest signal	B1	
	computer at cellular exchange selects a carrier frequency for mobile phone	B1	[4]
	(idea of computer needed at least once in these two marking points)		