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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
$= 24.6\,\text{N}$ (*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
$= 2.50 \times 6.37 \times 10^6 \times (2\pi/24 \times 3600)^2$
$= 0.0842\,\text{N}$ (*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 = $1.44 \times 10^3\,\text{m s}^{-1}$ A1 [1]

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

(c) root-mean-square speed = $1.45 \times 10^3\,\text{m s}^{-1}$ 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 $\times$ L C1

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

$110 \times 60 = L \times (372 - 325) \times 10^{-3}/7.0$
$L = 9.80 \times 10^5\,\text{J kg}^{-1}$ (*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]

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(b) (i) $\frac{1}{3}\pi$ 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 $x_0 = 1.7\,\text{cm}$ 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** $\Delta V/\Delta x$ 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]

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(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]

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Section B

9 (a) $V_B = 1000\,\text{mV}$ C1
when strained, $V_A = 2000 \times 121.5/(121.5 + 120.0)$
$= 1006.2\,\text{mV}$ M1
change = 6.2 mV (*allow 6 mV)* A1 [3]

(b) (i) 1. resistor between V_{IN} and V^- **and** V^+ connected to earth B1
resistor between V^- and V_{OUT} B1 [2]

2. P / + sign shown on earth side of voltmeter B1 [1]

(ii) ratio of $R_F / R_{IN} = 40$ M1
R_{IN} between 100 Ω and 10 kΩ A1 [2]
(any values must link to the correct resistors on the diagram)

10 (a) product of density (of medium) and speed (of ultrasound) M1
in the medium A1 [2]

(b) (i) $7.0 \times 10^6 = 1.7 \times 10^3 \times$ speed C1
speed = $4.12 \times 10^3\,\text{m s}^{-1}$
wavelength $= (4.12 \times 10^3)/(9.0 \times 10^5)\,\text{m}$ C1
$= 4.6\,\text{mm}$ *(2 s.f. minimum)* A1 [3]

(ii) for air/tissue boundary, $I_R / I \approx 1$ M1
for air/tissue boundary, (almost) complete reflection/no transmission A1
for gel/tissue boundary, $I_R / I = 0.1^2 / 3.1^2$
$= 1.04 \times 10^{-3}$ *(accept 1 s.f.)* M1
gel enables (almost) complete transmission (into the tissue) 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 B1
either large (range of) numbers are easier to handle (on a log scale)
or compounding attenuations/amplifications is easier B1 [2]

(c) attenuation = $190 \times 11 \times 10^{-3} = 2.09\,\text{dB}$ C1
$-2.09 = 10\,\lg(P_{OUT} / P_{IN})$ C1
ratio = 0.62 A1 [3]

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12 handset transmits (identification) signal to number of base stations B1
base stations transfers (signal) to cellular exchange B1
(idea of station<u>s</u> 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)

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