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MARK SCHEME for the May/June 2015 series

9702 PHYSICS

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 (a) (gravitational) force proportional to product of masses and inversely proportional to square of separation — M1
reference to *either* point masses *or* particles *or* 'size' much less than separation — A1 [2]

(b) gravitational force provides/is the centripetal force — B1
$GM_N m / r^2 = mr\omega^2$ (or mv^2 / r) — M1
$2\pi / T$ (*or* $v = 2\pi r / T$) leading to $GM_N = 4\pi^2 r^3 / T^2$ — A1 [3]

(c) $M_N / M_U = (3.55 / 5.83)^3 \times (13.5 / 5.9)^2$
x^3 factor correct — C1
T^2 factor correct — C1
ratio = 1.18 (*allow 1.2*) — A1

alternative method: mass of Neptune = 1.019×10^{26} kg — (C1)
mass of Uranus = 8.621×10^{25} kg — (C1)
ratio = 1.18 — (A1) [3]

2 (a) (sum of) potential energy and kinetic energy of molecules/atoms/particles — M1
mention of random motion/distribution — A1 [2]

(b) (i) $pV = nRT$
either at A, $1.2 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 290$
or at B, $3.6 \times 10^5 \times 4.0 \times 10^{-3} = n \times 8.31 \times 870$ — C1
$n = 0.20$ mol — A1 [2]

(ii) $1.2 \times 10^5 \times 7.75 \times 10^{-3} = 0.20 \times 8.31 \times T$ *or* $T = (7.75 / 4.0) \times 290$ — C1
$T = 560$ K — A1 [2]
(*Allow tolerance from graph*: $7.7–7.8 \times 10^{-3}$ m^3)

(c) temperature changes/decreases so internal energy changes/decreases — B1
volume changes (at constant pressure) so work is done — B1 [2]

3 (a) (numerically equal to) quantity of (thermal) energy/heat 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) at 70 W, mass $s^{-1} = 0.26$ g s^{-1} — A1
at 110 W, mass $s^{-1} = 0.38$ g s^{-1} — A1 [2]

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(ii) **1.** $P + h = mL$ or substitution of one set of values — C1
$(110 - 70) = (0.38 - 0.26)L$ — C1
$L = 330\,\text{J g}^{-1}$ — A1 [3]

2. *either* $70 + h = 0.26 \times 330$
or $110 + h = 0.38 \times 330$ — C1
$h = 17 / 16 / 15\,\text{W}$ — A1 [2]

4 **(a)** **(i)** frequency at which object is made to vibrate/oscillate — B1 [1]

(ii) frequency at which object vibrates when free to do so — B1 [1]

(iii) maximum amplitude of vibration of oscillating body — B1
when forced frequency equals natural frequency (of vibration) — B1 [2]

(b) e.g. vibration of quartz/piezoelectric crystal (*what is vibrating*) — M1
either for accurate timing
or maximise amplitude of ultrasound waves (*why it is useful*) — A1 [2]

(c) e.g. vibrating metal panels (*what is vibrating*) — M1
either place strengthening struts across the panel
or change shape/area of panel (*how it is reduced*) — A1 [2]

5 **(a)** (magnitude of electric field strength is the potential gradient — B1
use of gradient at $x = 4.0\,\text{cm}$ — M1
gradient $= 4.5 \times 10^4\,\text{N C}^{-1}$ (*allow* $\pm 0.3 \times 10^4$) — A1

or

$V = \dfrac{Q}{4\pi\varepsilon_0 x}$ and $E = \dfrac{Q}{4\pi\varepsilon_0 x^2}$ leading to $E = \dfrac{V}{x}$ — (B1)

$E = 1.8 \times 10^3 / 0.04$ — (M1)
$= 4.5 \times 10^4\,\text{N C}^{-1}$ — (A1) [3]

(b) **(i)** $3.6 \times 10^3\,\text{V}$ — A1 [1]

(ii) capacitance $= Q / V$ — C1
$= (8.0 \times 10^{-9}) / (3.6 \times 10^3)$
$= 2.2 \times 10^{-12}\,\text{F}$ — A1 [2]

6 **(a)** **(i)** gravitational — B1 [1]

(ii) gravitational and electric — B1 [1]

(iii) magnetic and one other field given — B1
magnetic, graviational and electric — B1 [2]

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(b) (i) out of (plane of) paper/page (*not "upwards"*) B1 [1]

(ii) $B = mv/qr$ C1
$= (3.32 \times 10^{-26} \times 7.6 \times 10^{4}) / (1.6 \times 10^{-19} \times 6.1 \times 10^{-2})$ C1
$= 0.26\,\text{T}$ A1 [3]

(c) sketch: semicircle with diameter < 12.2 cm B1 [1]

7 (a) can change (output) voltage efficiently *or* to suit different consumers/appliances B1
by using transformers B1 [2]

(b) for same power, current is smaller B1

less heating in cables/wires
or thinner cables possible
or less voltage loss in cables B1 [2]

8 (a) (i) $p = h/\lambda$
$= (6.63 \times 10^{-34}) / (6.50 \times 10^{-12})$ C1
$= 1.02 \times 10^{-22}\,\text{N s}$ A1 [2]

(ii) $E = hc/\lambda$ *or* $E = pc$
$= (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (6.50 \times 10^{-12})$ C1
$= 3.06 \times 10^{-14}\,\text{J}$ A1 [2]

(b) (i) $0.34 \times 10^{-12} = (6.63 \times 10^{-34}) / (9.11 \times 10^{-31} \times 3.0 \times 10^{8}) \times (1 - \cos\theta)$ C1
$\theta = 30.7°$ A1 [2]

(ii) deflected electron has energy M1
this energy is derived from the incident photon A1
deflected photon has less energy, longer wavelength (so $\Delta\lambda$ always positive) B1 [3]

9 (a) nucleus/nuclei emits M1
spontaneously/randomly A1
α-particles, β-particles, γ-ray photons A1 [3]

(b) (i) $N - \Delta N$ A1 [1]

(ii) $\Delta N / \Delta t$ A1 [1]

(iii) $\Delta N / N$ A1 [1]

(iv) $\Delta N / N \Delta t$ A1 [1]

(c) graph: smooth curve in correct direction starting at (0,0) M1
n at $2t_{½}$ is 1.5 times that at $t_{½}$ (± 2 mm) A1 [2]

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Section B

10 (a) (i) (potential =) $1.2/(1.2 + 4.2) \times 4.5 = +1.0\,V$ A1 [1]

(ii) (for $V_{IN} > 1.0\,V$) $V^+ > V^-$ B1
output (of op-amp) is +5 V or positive M1
diode conducts giving +5 V across R or V_{out} is +5 V A1

(for $V_{IN} < 1.0\,V$) output of op-amp –5 V / negative so diode does not conduct, giving V_{out} = 0 or 0 V across R A1 [4]

(b) (i) square wave with maximum value +5 V and minimum value 0 M1
vertical sides in correct positions and correct phase A1 [2]

(ii) re-shaping (digital) signals/regenerator (amplifier) B1 [1]

11 (a) change/increase/decrease anode/tube voltage B1
electrons striking anode have changed (kinetic) energy/speed B1
X-ray/photons/beam have different wavelength/frequency B1 [3]

(b) (i) $I = I_0 e^{-\mu x}$ B1 [1]

(ii) contrast is difference in degree of blackening (of regions of the image) B1
μ (very) similar so similar absorption of radiation (for same thickness) so little contrast A1 [2]

12 (a) (i) loudspeaker/doorbell/telephone etc. B1 [1]

(ii) television set/audio amplifier etc. B1 [1]

(iii) satellite/satellite dish/mobile phone etc. B1 [1]

(b) e.g. lower attenuation/fewer repeaters
more secure
less prone to noise/interference
physically smaller/less weight
lower cost
greater bandwidth
(*any two sensible suggestions, 1 each*) B2 [2]

(c) (i) ratio = $25 + (62 \times 0.21)$ C1
= 38 dB A1 [2]

(ii) ratio / dB = $10 \lg (P_2 / P_1)$ C1
$38 = 10 \lg (P / \{9.2 \times 10^{-6}\})$

$P = 58$ mW or 5.8×10^{-2} W A1 [2]
(*allow 1/2 for missing 10 in equation*)

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13 (a) (i) to align nuclei/protons B1
to cause Larmor/precessional frequency to be in r.f. region B1 [2]

(ii) Larmor/precessional frequency depends on (applied magnetic) field strength B1
knowing field strength enables (region of precessing) nuclei to be located M1
by knowing the frequency A1 [3]

(b) $E = 2.82 \times 10^{-26} \times B$
$6.63 \times 10^{-34} \times 42 \times 10^{6} = 2.82 \times 10^{-26} \times B$ C1

$B = 0.99\,\text{T}$ A1 [2]

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