
PHYSICS

9702/42

Paper 4 A Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 100

Published

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

- 1 (a) force per unit mass B1 [1]
- (b) (i) radius/diameter/size (of Proxima Centauri) \ll /is much less than 4.0×10^{13} km/separation (of Sun and star)
or
(because) it is a uniform sphere B1 [1]
- (ii) 1. field strength = GM/x^2
 $= (6.67 \times 10^{-11} \times 2.5 \times 10^{29}) / (4.0 \times 10^{13} \times 10^3)^2$ C1
 $= 1.0 \times 10^{-14} \text{ N kg}^{-1}$ A1 [2]
2. force = field strength \times mass
 $= 1.0 \times 10^{-14} \times 2.0 \times 10^{30}$ C1
- or
force = GMm/x^2
 $= (6.67 \times 10^{-11} \times 2.5 \times 10^{29} \times 2.0 \times 10^{30}) / (4.0 \times 10^{13} \times 10^3)^2$ (C1)
 $= 2.0 \times 10^{16} \text{ N}$ A1 [2]
- (c) force (of $2 \times 10^{16} \text{ N}$) would have little effect on (large) mass of Sun B1
would cause an acceleration of Sun of $1.0 \times 10^{-14} \text{ ms}^{-2}$ /very small/negligible acceleration B1 [2]
or
many stars all around the Sun (B1)
net effect of forces/fields is zero (B1)
- 2 (a) (i) number of moles/amount of substance B1 [1]
- (ii) kelvin temperature/absolute temperature/thermodynamic temperature B1 [1]
- (b) $pV = nRT$
 $4.9 \times 10^5 \times 2.4 \times 10^3 \times 10^{-6} = n \times 8.31 \times 373$ B1
 $n = 0.38 \text{ (mol)}$ C1
number of molecules or $N = 0.38 \times 6.02 \times 10^{23} = 2.3 \times 10^{23}$ A1 [3]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

or

$$pV = NkT \quad \text{(C1)}$$

$$4.9 \times 10^5 \times 2.4 \times 10^3 \times 10^{-6} = N \times 1.38 \times 10^{-23} \times 373 \quad \text{(M1)}$$

$$\text{number of molecules or } N = 2.3 \times 10^{23} \quad \text{(A1)}$$

(c) volume occupied by one molecule = $(2.4 \times 10^3) / (2.3 \times 10^{23})$ C1

$$= 1.04 \times 10^{-20} \text{ cm}^3$$

$$\text{mean spacing} = (1.04 \times 10^{-20})^{1/3} \quad \text{C1}$$

$$= 2.2 \times 10^{-7} \text{ cm (allow 1 s.f.)} \quad \text{A1 [3]}$$

(allow other dimensionally correct methods e.g. $V = (4/3)\pi r^3$)

- 3 (a) (sum of/total) potential energy and kinetic energy of (all) molecules/particles M1
reference to random (distribution) A1 [2]

- (b) (i) no heat enters (gas)/leaves (gas)/no heating (of gas) B1

work done by gas (against atmosphere as it expands) M1

internal energy decreases A1 [3]

- (ii) volume decreases so work done on ice/water B1
(allow work done negligible because ΔV small)

heating of ice (to break rigid forces/bonds) M1

internal energy increases A1 [3]

- 4 (a) (i) 0.225 s and 0.525 s A1 [1]

- (ii) period or $T = 0.30$ s and $\omega = 2\pi / T$ C1

$$\omega = 2\pi / 0.30$$

$$\omega = 21 \text{ rad s}^{-1} \quad \text{A1 [2]}$$

- (iii) speed = ωx_0 or $\omega(x_0^2 - x^2)^{1/2}$ and $x = 0$ C1

$$= 20.9 \times 2.0 \times 10^{-2} = 0.42 \text{ ms}^{-1} \quad \text{A1 [2]}$$

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

- or
- use of tangent method:
 correct tangent shown on Fig. 4.2 (C1)
 working e.g. $\Delta y/\Delta x$ leading to maximum speed in range $(0.38-0.46) \text{ m s}^{-1}$ (A1)
- (b) sketch: reasonably shaped continuous oval/circle surrounding (0,0) B1
 curve passes through (0, 0.42) and (0, -0.42) B1
 curve passes through (2.0, 0) and (-2.0, 0) B1 [3]
- 5 (a) transducer/transmitter can be also be used as the receiver
 or
 transducer both transmits and receives
- receives reflected pulses between the emitted pulses
 (needs to be pulsed) in order to measure/determine depth(s)
 (needs to be pulsed) to determine nature of boundaries
- Any three of the above marking points, 1 mark each* B2 [2]
- (b) (i) product of speed of (ultra)sound and density (of medium) M1
 reference to speed of sound in medium A1 [2]
- (ii) if Z_1 and Z_2 are (nearly) equal, I_T/I_0 (nearly) equal to 1/unity/(very) little reflection/mostly transmission B1
 if $Z_1 \gg Z_2$ or $Z_1 \ll Z_2$ or the difference between Z_1 and Z_2 is (very) large, then I_T/I_0 is small/zero/mostly reflection/little transmission B1 [2]
- 6 (a) $E = 0$ or $E_A = (-)E_B$ (at $x = 11 \text{ cm}$) B1
 $Q_A/x^2 = Q_B/(20 - x)^2 = 11^2/9^2$ C1
 Q_A/Q_B or ratio = 1.5 A1 [3]
- or
- $E \propto Q$ because r same or $E = Q/4\pi\epsilon_0 r^2$ and r same (B1)
 $Q_A/Q_B = 48/32$ (C1)
 Q_A/Q_B or ratio = 1.5 (A1)

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

- (b) (i) for max. speed, $\Delta V = (0.76 - 0.18) \text{ V}$ or $\Delta V = 0.58 \text{ V}$ C1
- $$q\Delta V = \frac{1}{2}mv^2$$
- $$2 \times (1.60 \times 10^{-19}) \times 0.58 = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2$$
- $$v^2 = 5.59 \times 10^7$$
- $$v = 7.5 \times 10^3 \text{ ms}^{-1}$$
- (ii) $\Delta V = 0.22 \text{ V}$ C1
- $$2 \times (1.60 \times 10^{-19}) \times 0.22 = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2$$
- $$v^2 = 2.12 \times 10^7$$
- $$v = 4.6 \times 10^3 \text{ ms}^{-1}$$
- 7 (a) (i) charge / potential (difference) or charge per (unit) potential (difference) B1 [1]
- (ii) ($V = Q/4\pi\epsilon_0 r$ and $C = Q/V$)
- for sphere, $C (= Q/V) = 4\pi\epsilon_0 r$ C1
- $$C = 4\pi \times 8.85 \times 10^{-12} \times 12.5 \times 10^{-2} = 1.4 \times 10^{-11} \text{ F}$$
- (b) (i) $1/C_T = 1/3.0 + 1/6.0$
- $$C_T = 2.0 \mu\text{F}$$
- (ii) total charge = charge on $3.0 \mu\text{F}$ capacitor = $2.0 (\mu) \times 9.0 = 18 (\mu\text{C})$ C1
- potential difference = $Q/C = 18 (\mu\text{C})/3.0 (\mu\text{F}) = 6.0 \text{ V}$ A1 [2]
- or
- argument based on equal charges:
- $$3.0 \times V = 6.0 \times (9.0 - V)$$
- (C1)
- $$V = 6.0 \text{ V}$$
- (A1)
- (iii) potential difference (= $9.0 - 6.0$) = 3.0 V C1
- charge (= $3.0 \times 2.0 (\mu)$) = $6.0 \mu\text{C}$ A1 [2]

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

- 8 (a) P shown between earth symbol and voltmeter B1 [1]
- (b) (i) gain = $(50 \times 10^3) / 100 = 500$ C1
 $V_{IN} (= 5.0 / 500) = 0.010 \text{ V}$ A1 [2]
- (ii) $V_{IN} (= 5.0 / 5.0) = 1.0 \text{ V}$ A1 [1]
- (c) e.g. multi-range (volt)meter
c.r.o. sensitivity control
amplifier channel selector B1 [1]
- 9 (a) (by Newton's third law) force on wire is up(wards)
by (Fleming's) left-hand rule/right-hand slap rule to give current
in direction left to right shown on diagram M1
A1
A1 [3]
- (b) force \propto current or $F = BIL$ or $B (= 0.080 / 6.0L) = 1 / 75L$ C1
- maximum current = $2.5 \times \sqrt{2}$ C1
= 3.54 A
- maximum force in one direction = $(3.54 / 6.0) \times 0.080$ C1
= 0.047 N
- difference (= 2×0.047) = 0.094 N
or
force varies from 0.047 N upwards to 0.047 N downwards A1 [4]
- 10 nuclei emitting r.f. (pulse) B1
- Larmor frequency/r.f. frequency emitted/detected depends on magnitude of magnetic field B1
- nuclei can be located (within a slice) B1
- changing field enables position of detection (slice) to be changed B1 [4]
- 11 (a) (induced) e.m.f. proportional/equal to rate
of change of (magnetic) flux (linkage) M1
A1 [2]
- (b) (for same current) iron core gives large(r) (rates of change of) flux (linkage) B1
e.m.f induced in solenoid is greater (for same current) M1
induced e.m.f. opposes applied e.m.f. so current smaller/acts to reduce current A1 [3]

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

or

same supply so same induced e.m.f. balancing it (B1)
 (rate of change of) flux linkage is same (M1)
 smaller current for same flux when core present (A1)

(c) e.g. (heating due to) eddy currents in core

(heating due to current in) resistance of coils

hysteresis losses/losses due to changing magnetic field in core

Any two of the above marking points, 1 mark each B2 [2]

12 (a) (i) electron diffraction/electron microscope (allow other sensible suggestions) B1 [1]

(ii) photoelectric effect/Compton scattering (allow other sensible suggestions) B1 [1]

(b) (i) arrow clear from -0.54 eV to -3.40 eV B1 [1]

(ii) $E = hc/\lambda$ or $E = hf$ and $c = f\lambda$ C1

$$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / [(3.40 - 0.54) \times 1.60 \times 10^{-19}] = 4.35 \times 10^{-7} \text{ m} \quad \text{A1 [2]}$$

(c) (i) wavelength associated with a particle M1
 that is moving/has momentum/has speed/has velocity A1 [2]

(ii) $\lambda = h/mv$

$$v = (6.63 \times 10^{-34}) / (9.11 \times 10^{-31} \times 4.35 \times 10^{-7}) \quad \text{C1}$$

$$= 1.67 \times 10^3 \text{ m s}^{-1} \quad \text{A1 [2]}$$

13 X-ray image of a (single) slice/cross-section (through the patient) M1
 taken from different angles/rotating X-ray (beam) A1

computer is used to form/process/build up/store image B1
2D image (of the slice) B1

repeated for many/different (neighbouring) slices M1
 to build up 3D image A1 [6]

Page 8	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	42

- 14 (a) (i) ${}^4_2\text{He}$ or ${}^4_2\alpha$ B1 [1]
- (ii) ${}^1_0\text{n}$ B1 [1]
- (b) (i) $\Delta m = (29.97830 + 1.00867) - (26.98153 + 4.00260)$ C1
 $= 30.98697 - 30.98413$
 $= 2.84 \times 10^{-3} \text{ u}$ C1 [2]
- (ii) $E = c^2\Delta m$ or mc^2 C1
 $= (3.0 \times 10^8)^2 \times 2.84 \times 10^{-3} \times 1.66 \times 10^{-27}$
 $= 4.2 \times 10^{-13} \text{ J}$ A1 [2]
- (c) mass of products is greater than mass of Al plus α
or
reaction causes (net) increase in (rest) mass (of the system) B1
 α -particle must have at least this amount of kinetic energy B1 [2]