
PHYSICS

9702/41

Paper 4 A Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.



Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- 1 (a) gravitational force provides/is the centripetal force B1
- $$GMm/r^2 = mv^2/r \quad \text{or} \quad GMm/r^2 = mr\omega^2$$
- $$\text{and } v = 2\pi r/T \quad \text{or} \quad \omega = 2\pi/T$$
- M1
- with algebra to $T^2 = 4\pi^2 r^3 / GM$ A1 [3]
- or
- acceleration due to gravity is the centripetal acceleration (B1)
- $$GM/r^2 = v^2/r \quad \text{or} \quad GM/r^2 = r\omega^2$$
- $$\text{and } v = 2\pi r/T \quad \text{or} \quad \omega = 2\pi/T$$
- (M1)
- with algebra to $T^2 = 4\pi^2 r^3 / GM$ (A1)
- (b) (i) equatorial orbit/orbits (directly) above the equator B1
- from west to east B1 [2]
- (ii) $(24 \times 3600)^2 = 4\pi^2 r^3 / (6.67 \times 10^{-11} \times 6.0 \times 10^{24})$ C1
- $$r^3 = 7.57 \times 10^{22}$$
- $$r = 4.2 \times 10^7 \text{ m}$$
- A1 [2]
- (c) $(T/24)^2 = \{(2.64 \times 10^7) / (4.23 \times 10^7)\}^3$ B1
- $$= 0.243$$
- $T = 12 \text{ hours}$ A1 [2]
- or
- $$k (= T^2/r^3) = 24^2 / (4.23 \times 10^7)^3$$
- $$= 7.61 \times 10^{-21}$$
- (B1)
- $$T^2 (= kr^3) = 7.61 \times 10^{-21} \times (2.64 \times 10^7)^3$$
- $$= 140$$
- $T = 12 \text{ hours}$ (A1)
- 2 (a) (i) $p \propto T$ or $pV/T = \text{constant}$ or $pV = nRT$ C1
- $T (= 5 \times 300 =) 1500 \text{ K}$ A1 [2]
- (ii) $pV = nRT$
- $$1.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 300$$
- or
- $$5.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 1500$$
- C1
- $n = 0.016 \text{ mol}$ A1 [2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- (b) (i) 1. heating/thermal energy supplied B1
2. work done on/to system B1 [2]
- (ii) 1. 240 J A1
2. same value as given in 1. (= 240 J) **and** zero given for 3. A1
3. zero A1 [3]
- 3 (a) $2k/m = \omega^2$ M1
- $\omega = 2\pi f$ M1
- $(2 \times 64 / 0.810) = (2\pi \times f)^2$ leading to $f = 2.0$ Hz A1 [3]
- (b) $v_0 = \omega x_0$ or $v_0 = 2\pi f x_0$
or
 $v = \omega(x_0^2 - x^2)^{1/2}$ and $x = 0$ C1
- $v_0 = 2\pi \times 2.0 \times 1.6 \times 10^{-2}$
 $= 0.20 \text{ ms}^{-1}$ A1 [2]
- (c) frequency: reduced/decreased B1
maximum speed: reduced/decreased B1 [2]
- 4 (a) (i) noise/distortion is removed (from the signal) B1
the (original) signal is reformed/reproduced/recovered/restored B1 [2]
- or
- signal detected above/below a threshold creates new signal (B1)
of 1s and 0s (B1)
- (ii) noise is superposed on the (displacement of the) signal/cannot be distinguished
or
analogue/signal is continuous (so cannot be regenerated)
or
analogue/signal is not discrete (so cannot be regenerated) B1
- noise is amplified with the signal B1 [2]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

(b) (i) $\text{gain/dB} = 10 \lg(P_2/P_1)$

$$32 = 10 \lg[P_{\text{MIN}}/(0.38 \times 10^{-6})]$$

or

$$-32 = 10 \lg(0.38 \times 10^{-6}/P_{\text{MIN}})$$

C1

$$P_{\text{MIN}} = 6.0 \times 10^{-4} \text{ W}$$

A1 [2]

(ii) $\text{attenuation} = 10 \lg[(9.5 \times 10^{-3})/(6.02 \times 10^{-4})]$

C1

$$= 12 \text{ dB}$$

$$\text{attenuation per unit length} (= 12/58) = 0.21 \text{ dB km}^{-1}$$

A1 [2]

5 (a) in an electric field, charges (in a conductor) would move

B1

no movement of charge so zero field strength

or

charge moves until $F = 0$ / $E = 0$

B1 [2]

or

charges in metal do not move

(B1)

no (resultant) force on charges so no (electric) field

(B1)

(b) at P, $E_A = (3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] (= 10.79 \text{ NC}^{-1})$

M1

at P, $E_B = (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2] (= 10.79 \text{ NC}^{-1})$

M1

or

$$(3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] - (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2] = 0$$

or

$$(3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] = (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2]$$

(M2)

fields due to charged spheres are (equal and) opposite in direction, so $E = 0$

A1 [3]

(c) $\text{potential} = 8.99 \times 10^9 \{(3.0 \times 10^{-12})/(5.0 \times 10^{-2}) + (12 \times 10^{-12})/(10 \times 10^{-2})\}$

C1

$$= 1.62 \text{ V}$$

A1 [2]

(d) $\frac{1}{2}mv^2 = qV$

$$E_K = \frac{1}{2} \times 107 \times 1.66 \times 10^{-27} \times v^2$$

C1

$$qV = 47 \times 1.60 \times 10^{-19} \times 1.62$$

C1

$$v^2 = 1.37 \times 10^8$$

$$v = 1.2 \times 10^4 \text{ ms}^{-1}$$

A1 [3]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- 6 (a) reference to input (voltage) and output (voltage) B1
there is no time delay between change in input and change in output B1 [2]
- or
- reference to rate at which output voltage changes (B1)
infinite rate of change (of output voltage) (B1)
- (b) (i) $2.00/3.00 = 1.50/R$ C1
- or
- $V_+ = (3.00 \times 4.5)/(2.00 + 3.00) = 2.7$
 $2.7 = 4.5 \times R/(R + 1.50)$ (C1)
- resistance = $2.25 \text{ k}\Omega$ A1 [2]
- (ii) 1. correct symbol for LED M1
two LEDs connected with opposite polarities between V_{OUT} and earth A1 [2]
2. below 24°C , $R_T > 1.5 \text{ k}\Omega$ or resistance of thermistor increases/high B1
- $V_- < V_+$ or V_- decreases/low (must not contradict initial statement) M1
- V_{OUT} is positive/+5 (V) and LED labelled as 'pointing' from V_{OUT} to earth A1 [3]
- 7 (a) region (of space) where a force is experienced by a particle B1 [1]
- (b) (i) gravitational B1
- (ii) gravitational and electric B1
- (iii) gravitational, electric and magnetic B1 [3]
- (c) (i) force (always) normal to direction of motion M1
- (magnitude of) force constant
or
speed is constant/kinetic energy is constant M1
- magnetic force provides/is the centripetal force A1 [3]
- (ii) $mv^2/r = Bqv$ B1
- momentum or p or $mv = Bqr$ B1 [2]

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- 8 strong uniform magnetic field B1
- nuclei precess/rotate about field (direction) (1)
- radio-frequency pulse (applied) B1
- R.F. or pulse is at Larmor frequency/frequency of precession (1)
- causes resonance/excitation (of nuclei)/nuclei absorb energy B1
- on relaxation/de-excitation, nuclei emit r.f./pulse B1
- (emitted) r.f./pulse detected and processed (1)
- non-uniform magnetic field B1
- allows position of nuclei to be located B1
- allows for location of detection to be changed/different slices to be studied (1)
- any two of the points marked (1)* B2 [8]
- 9 (a) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) M1
A1 [2]
- (b) flux linkage = BAN
- $$= \pi \times 10^{-3} \times 2.8 \times \pi \times (1.6 \times 10^{-2})^2 \times 85 = 6.0 \times 10^{-4} \text{ Wb}$$
- B1 [1]
- (c) e.m.f. = $\Delta N\Phi / \Delta t$
- $$= (6.0 \times 10^{-4} \times 2) / 0.30$$
- C1
- $$= 4.0 \text{ mV}$$
- A1 [2]
- (d) sketch: $E = 0$ for $t = 0 \rightarrow 0.3 \text{ s}$, $0.6 \text{ s} \rightarrow 1.0 \text{ s}$, $1.6 \text{ s} \rightarrow 2.0 \text{ s}$ B1
- $E = 4 \text{ mV}$ for $t = 0.3 \text{ s} \rightarrow 0.6 \text{ s}$ (either polarity) B1
- $E = 2 \text{ mV}$ for $t = 1.0 \text{ s} \rightarrow 1.6 \text{ s}$ B1
- with opposite polarity B1 [4]

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- 10 (a)** electromagnetic radiation/photons incident on a surface B1
causes emission of electrons (from the surface) B1 [2]
- (b)** $E = hc / \lambda$
 $= (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (436 \times 10^{-9})$ C1
 $= 4.56 \times 10^{-19} \text{ J } (4.6 \times 10^{-19} \text{ J})$ A1 [2]
- (c) (i)** $\Phi = hc / \lambda_0$
 $\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (1.4 \times 1.60 \times 10^{-19})$ C1
 $= 890 \text{ nm}$ A1 [2]
- (ii)** $\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (4.5 \times 1.60 \times 10^{-19})$
 $= 280 \text{ nm}$ A1 [1]
- (d)** caesium:
wavelength of photon less than threshold wavelength (or v.v.)
or
 $\lambda_0 = 890 \text{ nm} > 436 \text{ nm}$
so yes A1
- tungsten:
wavelength of photon greater than threshold wavelength (or v.v.)
or
 $\lambda_0 = 280 \text{ nm} < 436 \text{ nm}$
so no A1 [2]
- 11** in metal, conduction band overlaps valence band/no forbidden band/no band gap B1
as temperature rises, no increase in number of free electrons/charge carriers B1
as temperature rises, lattice vibrations increase M1
(lattice) vibrations restrict movement of electrons/charge carriers M1
(current decreases) so resistance increases A1 [5]

Page 8	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	41

- 12 (a) (i) time for number of atoms/nuclei or activity to be reduced to one half M1
- reference to (number of...) original nuclide/single isotope
or
reference to half of original value/initial activity A1 [2]
- (ii) $A = A_0 \exp(-\lambda t)$ and either $t = t_{1/2}$, $A = \frac{1}{2}A_0$ or $\frac{1}{2}A_0 = A_0 \exp(-\lambda t_{1/2})$ M1
- so $\ln 2 = \lambda t_{1/2}$ (and $\ln 2 = 0.693$), hence $0.693 = \lambda t_{1/2}$ A1 [2]
- (b) $A = \lambda N$
- $N = 200 / (2.1 \times 10^{-6})$ C1
- $= 9.52 \times 10^7$ C1
- mass = $(9.52 \times 10^7 \times 222 \times 10^{-3}) / (6.02 \times 10^{23})$
- or*
- mass = $9.52 \times 10^7 \times 222 \times 1.66 \times 10^{-27}$ C1
- $= 3.5 \times 10^{-17} \text{ kg}$ A1 [4]

PHYSICS

9702/42

Paper 4 A Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

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 $1.0 \times 10^{-14} \text{ m s}^{-2}$ /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

$$pV = NkT \quad (C1)$$

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

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

$$\begin{aligned} \text{(c) volume occupied by one molecule} &= (2.4 \times 10^3) / (2.3 \times 10^{23}) && C1 \\ &= 1.04 \times 10^{-20} \text{ cm}^3 \end{aligned}$$

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

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

(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
reference to random (distribution) M1
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
(allow work done negligible because ΔV small) B1

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 $T = 0.30 \text{ s}$ and $\omega = 2\pi / T$ C1

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

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

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

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

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

$$Q_A / Q_B \text{ or ratio} = 1.5$$

A1 [3]

or

$$E \propto Q \text{ because } r \text{ same or } E = Q / 4\pi\epsilon_0 r^2 \text{ and } r \text{ same}$$

(B1)

$$Q_A / Q_B = 48 / 32$$

(C1)

$$Q_A / Q_B \text{ or ratio} = 1.5$$

(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

$$q\Delta V = \frac{1}{2}mv^2$$

$$2 \times (1.60 \times 10^{-19}) \times 0.58 = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 \quad \text{C1}$$

$$v^2 = 5.59 \times 10^7$$

$$v = 7.5 \times 10^3 \text{ ms}^{-1} \quad \text{A1} \quad [3]$$

(ii) $\Delta V = 0.22 \text{ V}$ C1

$$2 \times (1.60 \times 10^{-19}) \times 0.22 = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2$$

$$v^2 = 2.12 \times 10^7$$

$$v = 4.6 \times 10^3 \text{ ms}^{-1} \quad \text{A1} \quad [2]$$

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

$$C = 4\pi \times 8.85 \times 10^{-12} \times 12.5 \times 10^{-2} = 1.4 \times 10^{-11} \text{ F} \quad \text{A1} \quad [2]$$

(b) (i) $1/C_T = 1/3.0 + 1/6.0$

$$C_T = 2.0 \mu\text{F} \quad \text{A1} \quad [1]$$

(ii) total charge = charge on $3.0 \mu\text{F}$ capacitor = $2.0 (\mu) \times 9.0 = 18 (\mu\text{C})$ C1

$$\text{potential difference} = Q/C = 18 (\mu)\text{C} / 3.0 (\mu)\text{F} = 6.0 \text{ V} \quad \text{A1} \quad [2]$$

or

argument based on equal charges:

$$3.0 \times V = 6.0 \times (9.0 - V) \quad (\text{C1})$$

$$V = 6.0 \text{ V} \quad (\text{A1})$$

(iii) potential difference (= $9.0 - 6.0$) = 3.0 V C1

$$\text{charge} (= 3.0 \times 2.0 (\mu)) = 6.0 \mu\text{C} \quad \text{A1} \quad [2]$$

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) $\text{gain} = (50 \times 10^3) / 100 = 500$ C1
 $V_{\text{IN}} (= 5.0 / 500) = 0.010 \text{ V}$ A1 [2]
- (ii) $V_{\text{IN}} (= 5.0 / 5.0) = 1.0 \text{ V}$ 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
 $= 3.54 \text{ A}$
maximum force in one direction $= (3.54 / 6.0) \times 0.080$ C1
 $= 0.047 \text{ N}$
difference $(= 2 \times 0.047) = 0.094 \text{ N}$
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

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

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

(ii) $\lambda = h/mv$

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

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

PHYSICS

9702/43

Paper 4 A Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- 1 (a) gravitational force provides/is the centripetal force B1
- $$GMm/r^2 = mv^2/r \quad \text{or} \quad GMm/r^2 = mr\omega^2$$
- $$\text{and } v = 2\pi r/T \quad \text{or} \quad \omega = 2\pi/T$$
- M1
- with algebra to $T^2 = 4\pi^2 r^3 / GM$ A1 [3]
- or
- acceleration due to gravity is the centripetal acceleration (B1)
- $$GM/r^2 = v^2/r \quad \text{or} \quad GM/r^2 = r\omega^2$$
- $$\text{and } v = 2\pi r/T \quad \text{or} \quad \omega = 2\pi/T$$
- (M1)
- with algebra to $T^2 = 4\pi^2 r^3 / GM$ (A1)
- (b) (i) equatorial orbit/orbits (directly) above the equator B1
- from west to east B1 [2]
- (ii) $(24 \times 3600)^2 = 4\pi^2 r^3 / (6.67 \times 10^{-11} \times 6.0 \times 10^{24})$ C1
- $$r^3 = 7.57 \times 10^{22}$$
- $$r = 4.2 \times 10^7 \text{ m}$$
- A1 [2]
- (c) $(T/24)^2 = \{(2.64 \times 10^7) / (4.23 \times 10^7)\}^3$ B1
- $$= 0.243$$
- $T = 12 \text{ hours}$ A1 [2]
- or
- $$k (= T^2/r^3) = 24^2 / (4.23 \times 10^7)^3$$
- $$= 7.61 \times 10^{-21}$$
- (B1)
- $$T^2 (= kr^3) = 7.61 \times 10^{-21} \times (2.64 \times 10^7)^3$$
- $$= 140$$
- $T = 12 \text{ hours}$ (A1)
- 2 (a) (i) $p \propto T$ or $pV/T = \text{constant}$ or $pV = nRT$ C1
- $T (= 5 \times 300 =) 1500 \text{ K}$ A1 [2]
- (ii) $pV = nRT$
- $$1.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 300$$
- or
- $$5.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 1500$$
- C1
- $n = 0.016 \text{ mol}$ A1 [2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- (b) (i) 1. heating/thermal energy supplied B1
2. work done on/to system B1 [2]
- (ii) 1. 240 J A1
2. same value as given in 1. (= 240 J) **and** zero given for 3. A1
3. zero A1 [3]
- 3 (a) $2k/m = \omega^2$ M1
- $\omega = 2\pi f$ M1
- $(2 \times 64 / 0.810) = (2\pi \times f)^2$ leading to $f = 2.0$ Hz A1 [3]
- (b) $v_0 = \omega x_0$ or $v_0 = 2\pi f x_0$
- or
- $v = \omega(x_0^2 - x^2)^{1/2}$ and $x = 0$ C1
- $v_0 = 2\pi \times 2.0 \times 1.6 \times 10^{-2}$
- $= 0.20 \text{ ms}^{-1}$ A1 [2]
- (c) frequency: reduced/decreased B1
- maximum speed: reduced/decreased B1 [2]
- 4 (a) (i) noise/distortion is removed (from the signal) B1
- the (original) signal is reformed/reproduced/recovered/restored B1 [2]
- or
- signal detected above/below a threshold creates new signal (B1)
- of 1s and 0s (B1)
- (ii) noise is superposed on the (displacement of the) signal/cannot be distinguished
- or
- analogue/signal is continuous (so cannot be regenerated)
- or
- analogue/signal is not discrete (so cannot be regenerated) B1
- noise is amplified with the signal B1 [2]

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

(b) (i) $\text{gain/dB} = 10 \lg(P_2/P_1)$

$$32 = 10 \lg[P_{\text{MIN}}/(0.38 \times 10^{-6})]$$

or

$$-32 = 10 \lg(0.38 \times 10^{-6}/P_{\text{MIN}})$$

C1

$$P_{\text{MIN}} = 6.0 \times 10^{-4} \text{ W}$$

A1 [2]

(ii) $\text{attenuation} = 10 \lg[(9.5 \times 10^{-3})/(6.02 \times 10^{-4})]$

C1

$$= 12 \text{ dB}$$

$$\text{attenuation per unit length} (= 12/58) = 0.21 \text{ dB km}^{-1}$$

A1 [2]

5 (a) in an electric field, charges (in a conductor) would move

B1

no movement of charge so zero field strength

or

charge moves until $F = 0$ / $E = 0$

B1 [2]

or

charges in metal do not move

(B1)

no (resultant) force on charges so no (electric) field

(B1)

(b) at P, $E_A = (3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] (= 10.79 \text{ NC}^{-1})$

M1

at P, $E_B = (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2] (= 10.79 \text{ NC}^{-1})$

M1

or

$$(3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] - (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2] = 0$$

or

$$(3.0 \times 10^{-12})/[4\pi\epsilon_0(5.0 \times 10^{-2})^2] = (12 \times 10^{-12})/[4\pi\epsilon_0(10 \times 10^{-2})^2]$$

(M2)

fields due to charged spheres are (equal and) opposite in direction, so $E = 0$

A1 [3]

(c) $\text{potential} = 8.99 \times 10^9 \{(3.0 \times 10^{-12})/(5.0 \times 10^{-2}) + (12 \times 10^{-12})/(10 \times 10^{-2})\}$

C1

$$= 1.62 \text{ V}$$

A1 [2]

(d) $\frac{1}{2}mv^2 = qV$

$$E_K = \frac{1}{2} \times 107 \times 1.66 \times 10^{-27} \times v^2$$

C1

$$qV = 47 \times 1.60 \times 10^{-19} \times 1.62$$

C1

$$v^2 = 1.37 \times 10^8$$

$$v = 1.2 \times 10^4 \text{ ms}^{-1}$$

A1 [3]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- 6 (a) reference to input (voltage) and output (voltage) B1
there is no time delay between change in input and change in output B1 [2]
- or
- reference to rate at which output voltage changes (B1)
infinite rate of change (of output voltage) (B1)
- (b) (i) $2.00/3.00 = 1.50/R$ C1
- or
- $V_+ = (3.00 \times 4.5)/(2.00 + 3.00) = 2.7$
 $2.7 = 4.5 \times R/(R + 1.50)$ (C1)
- resistance = $2.25 \text{ k}\Omega$ A1 [2]
- (ii) 1. correct symbol for LED M1
two LEDs connected with opposite polarities between V_{OUT} and earth A1 [2]
2. below 24°C , $R_T > 1.5 \text{ k}\Omega$ or resistance of thermistor increases/high B1
- $V_- < V_+$ or V_- decreases/low (must not contradict initial statement) M1
- V_{OUT} is positive/+5 (V) and LED labelled as 'pointing' from V_{OUT} to earth A1 [3]
- 7 (a) region (of space) where a force is experienced by a particle B1 [1]
- (b) (i) gravitational B1
- (ii) gravitational and electric B1
- (iii) gravitational, electric and magnetic B1 [3]
- (c) (i) force (always) normal to direction of motion M1
- (magnitude of) force constant
or
speed is constant/kinetic energy is constant M1
- magnetic force provides/is the centripetal force A1 [3]
- (ii) $mv^2/r = Bqv$ B1
- momentum or p or $mv = Bqr$ B1 [2]

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- 8 strong uniform magnetic field B1
- nuclei precess/rotate about field (direction) (1)
- radio-frequency pulse (applied) B1
- R.F. or pulse is at Larmor frequency/frequency of precession (1)
- causes resonance/excitation (of nuclei)/nuclei absorb energy B1
- on relaxation/de-excitation, nuclei emit r.f./pulse B1
- (emitted) r.f./pulse detected and processed (1)
- non-uniform magnetic field B1
- allows position of nuclei to be located B1
- allows for location of detection to be changed/different slices to be studied (1)
- any two of the points marked (1)* B2 [8]
- 9 (a) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) M1
A1 [2]
- (b) flux linkage = BAN
- $$= \pi \times 10^{-3} \times 2.8 \times \pi \times (1.6 \times 10^{-2})^2 \times 85 = 6.0 \times 10^{-4} \text{ Wb}$$
- B1 [1]
- (c) e.m.f. = $\Delta N\Phi / \Delta t$
- $$= (6.0 \times 10^{-4} \times 2) / 0.30$$
- C1
- $$= 4.0 \text{ mV}$$
- A1 [2]
- (d) sketch: $E = 0$ for $t = 0 \rightarrow 0.3 \text{ s}$, $0.6 \text{ s} \rightarrow 1.0 \text{ s}$, $1.6 \text{ s} \rightarrow 2.0 \text{ s}$ B1
- $E = 4 \text{ mV}$ for $t = 0.3 \text{ s} \rightarrow 0.6 \text{ s}$ (either polarity) B1
- $E = 2 \text{ mV}$ for $t = 1.0 \text{ s} \rightarrow 1.6 \text{ s}$ B1
- with opposite polarity B1 [4]

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- 10 (a)** electromagnetic radiation/photons incident on a surface B1
causes emission of electrons (from the surface) B1 [2]
- (b)** $E = hc / \lambda$
 $= (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (436 \times 10^{-9})$ C1
 $= 4.56 \times 10^{-19} \text{ J } (4.6 \times 10^{-19} \text{ J})$ A1 [2]
- (c) (i)** $\Phi = hc / \lambda_0$
 $\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (1.4 \times 1.60 \times 10^{-19})$ C1
 $= 890 \text{ nm}$ A1 [2]
- (ii)** $\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (4.5 \times 1.60 \times 10^{-19})$
 $= 280 \text{ nm}$ A1 [1]
- (d)** caesium:
wavelength of photon less than threshold wavelength (or v.v.)
or
 $\lambda_0 = 890 \text{ nm} > 436 \text{ nm}$
so yes A1
- tungsten:
wavelength of photon greater than threshold wavelength (or v.v.)
or
 $\lambda_0 = 280 \text{ nm} < 436 \text{ nm}$
so no A1 [2]
- 11** in metal, conduction band overlaps valence band/no forbidden band/no band gap B1
as temperature rises, no increase in number of free electrons/charge carriers B1
as temperature rises, lattice vibrations increase M1
(lattice) vibrations restrict movement of electrons/charge carriers M1
(current decreases) so resistance increases A1 [5]

Page 8	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	43

- 12 (a) (i) time for number of atoms/nuclei or activity to be reduced to one half M1
reference to (number of...) original nuclide/single isotope
or
reference to half of original value/initial activity A1 [2]
- (ii) $A = A_0 \exp(-\lambda t)$ and either $t = t_{1/2}$, $A = \frac{1}{2}A_0$ or $\frac{1}{2}A_0 = A_0 \exp(-\lambda t_{1/2})$ M1
so $\ln 2 = \lambda t_{1/2}$ (and $\ln 2 = 0.693$), hence $0.693 = \lambda t_{1/2}$ A1 [2]
- (b) $A = \lambda N$
 $N = 200 / (2.1 \times 10^{-6})$ C1
 $= 9.52 \times 10^7$ C1
mass = $(9.52 \times 10^7 \times 222 \times 10^{-3}) / (6.02 \times 10^{23})$
or
mass = $9.52 \times 10^7 \times 222 \times 1.66 \times 10^{-27}$ C1
 $= 3.5 \times 10^{-17} \text{ kg}$ A1 [4]