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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2016**

MARK SCHEME

Maximum Mark: 100

Published

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1	**(a)** force per unit mass	B1	[1]
	(b) (i) radius/diameter/size (of Proxima Centauri) ≪ /is <u>much</u> less than 4.0×10^{13} km/separation (of Sun and star) *or* (because) it is a <u>uniform</u> 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 × 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)	
	$= 2.0 \times 10^{16}$ N	A1	[2]
	(c) force (of 2×10^{16} N) would have little effect on (large) <u>mass</u> 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	
	$n = 0.38$ (mol)	C1	
	number of molecules or $N = 0.38 \times 6.02 \times 10^{23} = 2.3 \times 10^{23}$	A1	[3]

			or		
			$pV = NkT$	(C1)	
			$4.9 \times 10^5 \times 2.4 \times 10^3 \times 10^{-6} = N \times 1.38 \times 10^{-23} \times 373$	(M1)	
			number of molecules or $N = 2.3 \times 10^{23}$	(A1)	
	(c)		volume occupied by one molecule $= (2.4 \times 10^3) / (2.3 \times 10^{23})$	C1	
			$= 1.04 \times 10^{-20}\,\text{cm}^3$		
			mean spacing $= (1.04 \times 10^{-20})^{1/3}$	C1	
			$= 2.2 \times 10^{-7}$ cm (*allow 1 s.f.*)	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 (*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 <u>and</u> 0.525 s	A1	[1]
		(ii)	period or $T = 0.30$ s <u>and</u> $\omega = 2\pi / T$	C1	
			$\omega = 2\pi / 0.30$		
			$\omega = 21\,\text{rad s}^{-1}$	A1	[2]
		(iii)	speed $= \omega x_0$ or $\omega(x_0{}^2 - x^2)^{1/2}$ <u>and</u> $x = 0$	C1	
			$= 20.9 \times 2.0 \times 10^{-2} = 0.42\,\text{m s}^{-1}$	A1	[2]

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) $\mathrm{m\,s^{-1}}$ (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)<u>sound</u> and density (of medium) M1

reference to speed of sound <u>in medium</u> 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 $x = 11$ 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* $E = Q / 4\pi\varepsilon_0 r^2$ and r same (B1)

$Q_A / Q_B = 48 / 32$ (C1)

Q_A / Q_B or ratio = 1.5 (A1)

	(b)	**(i)**	for max. speed, $\Delta V = (0.76 - 0.18)$ V or $\Delta V = 0.58$ V	C1	
			$q\Delta V = ½mv^2$		
			$2 \times (1.60 \times 10^{-19}) \times 0.58 = ½ \times 4 \times 1.66 \times 10^{-27} \times v^2$	C1	
			$v^2 = 5.59 \times 10^7$		
			$v = 7.5 \times 10^3\,\text{m s}^{-1}$	A1	[3]
		(ii)	$\Delta V = 0.22$ V	C1	
			$2 \times (1.60 \times 10^{-19}) \times 0.22 = ½ \times 4 \times 1.66 \times 10^{-27} \times v^2$		
			$v^2 = 2.12 \times 10^7$		
			$v = 4.6 \times 10^3\,\text{m s}^{-1}$	A1	[2]
7	**(a)**	**(i)**	charge / potential (difference) or charge per (unit) potential (difference)	B1	[1]
		(ii)	($V = Q/4\pi\varepsilon_0 r$ and $C = Q/V$)		
			for sphere, C (= Q/V) = $4\pi\varepsilon_0 r$	C1	
			$C = 4\pi \times 8.85 \times 10^{-12} \times 12.5 \times 10^{-2} = 1.4 \times 10^{-11}$ F	A1	[2]
	(b)	**(i)**	$1/C_T = 1/3.0 + 1/6.0$		
			$C_T = 2.0\,\mu$F	A1	[1]
		(ii)	total charge = charge on 3.0 μF capacitor = 2.0 (μ) × 9.0 = 18 (μC)	C1	
			potential difference = Q/C = 18 (μ)C / 3.0 (μ)F = 6.0 V	A1	[2]
			or		
			argument based on equal charges:		
			$3.0 \times V = 6.0 \times (9.0 - V)$	(C1)	
			$V = 6.0$ V	(A1)	
		(iii)	potential difference (= 9.0 – 6.0) = 3.0 V	C1	
			charge (= 3.0 × 2.0 (μ)) = 6.0 μC	A1	[2]

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 V	A1	[2]
	(ii)	V_{IN} (= 5.0 / 5.0) = 1.0 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 <u>shown on diagram</u>	M1 A1 A1	[3]
	(b)	force $\propto$ current *or* $F = BIL$ *or* B (= 0.080 / 6.0L) = 1 / 75L	C1	
		maximum current = $2.5 \times \sqrt{2}$ = 3.54 A	C1	
		maximum force in one direction = $(3.54 / 6.0) \times 0.080$ = 0.047 N	C1	
		difference (= 2×0.047) = 0.094 N *or* force varies from 0.047 N upwards to 0.047 N downwards	A1	[4]
10		<u>nuclei</u> 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 <u>rate</u> of change of (magnetic) flux (linkage)	M1 A1	[2]
	(b)	(for same current) iron core gives large(r) (rates of change of) flux (linkage) e.m.f induced in solenoid is greater (for same current) induced e.m.f. opposes applied e.m.f. so current smaller/acts to reduce current	B1 M1 A1	[3]

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]

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

$= 30.98697 – 30.98413$

$= 2.84 \times 10^{-3}$ u C1 [2]

(ii) $E = c^2\Delta m$ or mc^2 C1

$= (3.0 \times 10^8)^2 \times 2.84 \times 10^{-3} \times 1.66 \times 10^{-27}$

$= 4.2 \times 10^{-13}$ J A1 [2]

(c) mass of products is greater than mass of A*l* 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]