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PHYSICS **9702/41**

Paper 4 A Level Structured Questions **October/November 2019**

MARK SCHEME

Maximum Mark: 100

Published

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Question	Answer	Marks
2(a)	(total volume of molecules is) negligible	**M1**
	compared with volume occupied by the gas	**A1**
2(b)(i)	$pV = NkT$	**C1**
	$4.60 \times 10^5 \times 2.40 \times 10^{-2} = N \times 1.38 \times 10^{-23} \times (273 + 23)$	**C1**
	or	
	$pV = nRT$	**(C1)**
	$4.60 \times 10^5 \times 2.40 \times 10^{-2} = n \times 8.31 \times (273 + 23)$ $n = 4.49$ (mol) $N = nN_A$ $= 4.49 \times 6.02 \times 10^{23}$	**(C1)**
	$N = 2.7 \times 10^{24}$	**A1**

Question	Answer	Marks
2(b)(ii)	volume of one atom $= d^3$ (= 2.7×10^{-29} m^3)	**C1**
	volume of all atoms $= 2.7 \times 10^{-29} \times 2.7 \times 10^{24}$	**C1**
	$= 7 \times 10^{-5}$ m^3	**A1**
	or	
	volume of one atom $= (4/3)\pi r^3$ (= 1.41×10^{-29} m^3)	**(C1)**
	volume of all atoms $= 2.7 \times 10^{24} \times 1.41 \times 10^{-29}$	**(C1)**
	$= 4 \times 10^{-5}$ m^3	**(A1)**
2(c)	numerical comparison between answer to **(b)(ii)** and 2.4×10^{-2} (m^3) showing **(b)(ii)** is <u>much</u> less than 2.4×10^{-2} (m^3)	**B1**

Question	Answer	Marks
3(a)	(thermal) energy per (unit) mass (to change state)	B1
	(heat transfer during) change of state at constant temperature	B1
3(b)(i)	32 g	A1
3(b)(ii)	temperature difference (between liquid and surroundings) does not change	B1
3(b)(iii)	$VIt = mL$	C1
	$230 \times 1.2 \times 60 \times 10 = (56 \times L) + H$ **or** $190 \times 1.0 \times 60 \times 10 = (32 \times L) + H$	C1
	$86 \times 600 = (56 - 32) \times L$	C1
	or	
	$230 \times 1.2 = (56 \times L) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times L) / (60 \times 10) + P$	(C1)
	$276 - 190 = (24 \times L) / 600$	(C1)
	$L = 2200\ \text{J g}^{-1}$	A1

Question	Answer	Marks
3(b)(iv)	$230 \times 1.2 \times 600 = (56 \times 2150) + H$ **or** $190 \times 1.0 \times 600 = (32 \times 2150) + H$	**C1**
	$H = 45\,200$ rate $= 45\,200 / 600$ $= 75$ W	**A1**
	or	
	$230 \times 1.2 = (56 \times 2150) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times 2150) / (60 \times 10) + P$	**(C1)**
	rate (= P) = 75 W	**(A1)**

Question	Answer	Marks
4(a)(i)	distance from a (reference) point in a given direction	**B1**
4(a)(ii)	line is not straight **or** gradient is not constant	**B1**
4(b)(i)	0.85–0.90 cm	**A1**
4(b)(ii)	$a = -(2\pi f)^2 x$	**C1**
	e.g. $1.2 = 4\pi^2 \times f^2 \times (0.90 \times 10^{-2})$	**C1**
	$f = 1.8$ Hz	**A1**
4(c)	complete circle/ellipse enclosing the origin	**B1**
	closed shape passing through $(0, \pm v_0)$ and $(\pm x_0, 0)$	**B1**

Question	Answer	Marks
5(a)(i)	provides return for the signal	**B1**
	shields signal from noise	**B1**
5(a)(ii)	e.g. connection between aerial and TV set	**B1**
5(b)(i)	gain / dB = 10 lg (P_1 / P_2)	**C1**
	32 = 10 lg {P_{MIN} / (7.6 × 10^{-6})} P_{MIN} = 0.012 W	**A1**
5(b)(ii)	attenuation per unit length = (1 / L) × 10 lg (P_1 / P_2) 6.3 = (1 / L) × 10 lg (2.6 / 0.012)	**C1**
	L = 3.7 km	**A1**

Question	Answer	Marks
6(a)	$(E =)\ Q / 4\pi\varepsilon_0 r^2$	**M1**
	where ε_0 is permittivity (of free space)	**A1**
6(b)(i)	field does not change direction/field does not become zero	**M1**
	so (charges have) opposite (sign)	**A1**
6(b)(ii)	minimum is at the midpoint (between the charges)	**M1**
	so (magnitudes are the) same	**A1**
6(c)	force = field strength × charge **and** force = mass × acceleration **or** acceleration is proportional to field strength	**B1**
	(from $x = 3.0$ cm) to $x = 5.0$ cm: acceleration decreases	**B1**
	at $x = 5.0$ cm: acceleration is a minimum	**B1**
	from $x = 5.0$ cm (to $x = 7.0$ cm): acceleration increases	**B1**

Question	Answer	Marks
7(a)(i)	all frequencies are amplified equally	B1
7(a)(ii)	no drop in output voltage (when there is a current)	B1
7(b)(i)	gain = 1 + R_F / R_{IN} = 1 + (4000 / 800)	C1
	= 6.0	A1
7(b)(ii)	2.0 / V_{IN} = 6.0 V_{IN} = (+)0.33 V	A1
7(b)(iii)	5.0 V	A1
7(b)(iv)	V = 5.0 – 2.2 (= 2.8 V)	C1
	R = V / I = 2.8 / 0.020 = 140 Ω	A1

Question	Answer	Marks
8(a)	concentric circles (around the wire)	**M1**
	at least 3 circles shown, all with increasing separation	**A1**
	direction anticlockwise	**B1**
8(b)(i)	$B = (4\pi \times 10^{-7} \times 6.2) / (2\pi \times 3.1 \times 10^{-2})$	**C1**
	$= 4.0 \times 10^{-5}$ T	**A1**
8(b)(ii)	$F = BIL$ **or** $F / L = BI$	**C1**
	$F / L = 4.0 \times 10^{-5} \times 8.5$ $= 3.4 \times 10^{-4}$ N m^{-1}	**A1**
8(c)	correct application of Newton's 3rd law to the forces **or** F / L is proportional to the product of the two currents	**M1**
	so same magnitude	**A1**

Question	Answer	Marks
9(a)	nuclei precess	**B1**
	precession is about (direction of magnetic) field **or** frequency of precession is in radio-frequency range	**B1**
9(b)	• frequency (of precession) depends on field strength • to locate/find position of (spinning) nuclei • to change region where nuclei are detected *any two points, one mark each*	**B2**

Question	Answer	Marks
10(a)(i)	lower right **and** upper left diodes circled	**B1**
10(a)(ii)	maximum = $7.0\sqrt{2}$ = 9.9 V	**A1**
10(b)(i)	correct symbol for capacitor, shown connected in parallel with R	**B1**
10(b)(ii)	**1.** (ripple) decreases	**B1**
	2. (ripple) increases	**B1**

Question	Answer	Marks
11(a)	energy (of photon) required to remove electron	**M1**
	from a surface **or** reference to <u>minimum</u> energy **or** reference to zero <u>kinetic</u> energy	**A1**
11(b)(i)	**1.** photon energy $= hc / \lambda$	**C1**
	$= (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (280 \times 10^{-9})$ $= 7.1 \times 10^{-19}$ J	**A1**
	2. electron energy $= (7.1 - 5.5) \times 10^{-19}$ J	**C1**
	$½ \times 9.11 \times 10^{-31} \times v^2 = (7.1 - 5.5) \times 10^{-19}$	**C1**
	$v = 5.9 \times 10^{5}$ m s^{-1}	**A1**
11(b)(ii)	energy is required to bring electron to the surface	**B1**
11(c)	<table><tr><td>no change</td><td>decreases</td></tr><tr><td>increases</td><td>decreases</td></tr></table>	**B4**

Question	Answer	Marks
12(a)	$E = (3.0 \times 10^8)^2 \times 1.66 \times 10^{-27}$ (= 1.49×10^{-10} J)	**M1**
	= $(1.49 \times 10^{-10}) / (1.60 \times 10^{-19}) = 9.34 \times 10^8$ = 934 MeV	**A1**
	or	
	binding energy = 8.443×95 [or equivalent using La-139 nucleus]	**(M1)**
	binding energy / mass defect = $(8.443 \times 95) / 0.859$ = 934 MeV	**(A1)**
12(b)(i)	binding energy = 1.865×934 (= 1741.91 MeV)	**C1**
	binding energy per nucleon = 1741.91 / 235 = 7.41 (MeV)	**A1**
12(b)(ii)	less (than)	**B1**
12(c)	energy = $\{(1.219 + 0.859) - 1.865)\} \times 934$ **or** energy = $(95 \times 8.443) + (139 \times 8.189) - (235 \times 7.412)$	**C1**
	= 199 MeV	**A1**
12(d)	number of reactions = $1.2 \times 10^{-7} \times 6.02 \times 10^{23}$ = 7.22×10^{16}	**C1**
	energy release (for one reaction) = $199 \times 1.60 \times 10^{-13}$ (= 3.18×10^{-11} J)	**C1**
	power = $(7.22 \times 10^{16} \times 3.18 \times 10^{-11}) / (25 \times 10^{-3})$ = 9.2×10^7 W	**A1**