CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

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

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.

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CAMBRIDGE
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Section A

1	**(a)**	work done bringing unit mass from infinity (to the point)	M1 A1	[2]
	(b)	$E_P = -m\phi$	B1	[1]
	(c)	$\phi \propto 1/x$	C1	
		either at 6*R* from centre, potential is $(6.3 \times 10^7)/6$ $(= 1.05 \times 10^7 \text{ J kg}^{-1})$ <u>and</u> at 5*R* from centre, potential is $(6.3 \times 10^7)/5$ $(= 1.26 \times 10^7 \text{ J kg}^{-1})$ change in energy = $(1.26 - 1.05) \times 10^7 \times 1.3$ $= 2.7 \times 10^6$ J	 C1 C1 A1	
		or change in potential = $(1/5 - 1/6) \times (6.3 \times 10^7)$ change in energy = $(1/5 - 1/6) \times (6.3 \times 10^7) \times 1.3$ $= 2.7 \times 10^6$ J	(C1) (C1) (A1)	[4]
2	**(a)**	the number of atoms in 12 g of carbon-12	M1 A1	[2]
	(b)	**(i)** amount = 3.2/40 = 0.080 mol	 A1	[1]
		(ii) $pV = nRT$ $p \times 210 \times 10^{-6} = 0.080 \times 8.31 \times 310$ $p = 9.8 \times 10^5$ Pa *(do not credit if T in °C not K)*	 C1 A1	[2]
		(iii) *either* $pV = 1/3 \times Nm \langle c^2 \rangle$ $N = 0.080 \times 6.02 \times 10^{23}$ $(= 4.82 \times 10^{22})$ <u>and</u> $m = 40 \times 1.66 \times 10^{-27}$ $(= 6.64 \times 10^{-26})$ $9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 4.82 \times 10^{22} \times 6.64 \times 10^{-26} \times \langle c^2 \rangle$ $\langle c^2 \rangle = 1.93 \times 10^5$ $c_{RMS} = 440 \text{ m s}^{-1}$	 C1 C1 A1	[3]
		or $Nm = 3.2 \times 10^{-3}$ $9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 3.2 \times 10^{-3} \times \langle c^2 \rangle$ $\langle c^2 \rangle = 1.93 \times 10^5$ $c_{RMS} = 440 \text{ m s}^{-1}$	(C1) (C1) (A1)	
		or $1/2\, m\langle c^2 \rangle = 3/2\, kT$ $1/2 \times 40 \times 1.66 \times 10^{-27} \langle c^2 \rangle = 3/2 \times 1.38 \times 10^{-23} \times 310$ $\langle c^2 \rangle = 1.93 \times 10^5$ $c_{RMS} = 440 \text{ m s}^{-1}$	(C1) (C1) (A1)	
		(*if T in °C not K award max 1/3, unless already penalised in* ***(b)(ii)***)		

3 **(a)**	*either* change in volume = $(1.69 - 1.00 \times 10^{-3})$ *or* liquid volume << volume of vapour	M1	
	work done = $1.01 \times 10^{5} \times 1.69 = 1.71 \times 10^{5}$ (J)	A1	[2]
(b) **(i)**	**1.** heating of system/thermal energy supplied to the system	B1	[1]
	2. work done on the system	B1	[1]
(ii)	$\Delta U = (2.26 \times 10^{6}) - (1.71 \times 10^{5})$	C1	
	$= 2.09 \times 10^{6}$ J (*3 s.f. needed*)	A1	[2]
4 **(a)**	kinetic (energy)/KE/E_K	B1	[1]
(b)	*either* change in energy = 0.60 mJ *or* max E proportional to (amplitude)^2/equivalent numerical working	B1	
	new amplitude is 1.3 cm	B1	
	change in amplitude = 0.2 cm	B1	[3]
5 **(a)**	graph: straight line at constant potential = V_0 from $x = 0$ to $x = r$	B1	
	curve with decreasing gradient	M1	
	passing through $(2r, 0.50V_0)$ and $(4r, 0.25V_0)$	A1	[3]
(b)	graph: straight line at $E = 0$ from $x = 0$ to $x = r$	B1	
	curve with decreasing gradient from (r, E_0)	M1	
	passing through $(2r, \frac{1}{4}E_0)$ (*for 3rd mark line must be drawn to x = 4r and must not touch x-axis*)	A1	[3]
6 **(a)** **(i)**	energy $= EQ$	C1	
	$= 9.0 \times 22 \times 10^{-3}$ $= 0.20$ J	A1	[2]
(ii)	**1.** $C = Q / V$ $V = (22 \times 10^{-3})/(4700 \times 10^{-6})$	C1	
	$= 4.7$ V	A1	[2]
	2. *either* $E = \frac{1}{2}CV^2$	C1	
	$= \frac{1}{2} \times 4700 \times 10^{-6} \times 4.7^2$ $= 5.1 \times 10^{-2}$ J	A1	[2]
	or $E = \frac{1}{2}QV$	(C1)	
	$= \frac{1}{2} \times 22 \times 10^{-3} \times 4.7$ $= 5.1 \times 10^{-2}$ J	(A1)	
	or $E = \frac{1}{2}Q^2/C$	(C1)	
	$= \frac{1}{2} \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$ $= 5.1 \times 10^{-2}$ J	(A1)	

	(b)		energy lost (as thermal energy) in resistance/wires/battery/resistor *(award only if answer in **(a)(i)** > answer in **(a)(ii)2**)*	B1	[1]
7	**(a)**		graph: V_H increases from zero when current switched on V_H then non-zero constant V_H returns to zero when current switched off	B1 B1 B1	[3]
	(b)	**(i)**	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)	M1 A1	[2]
		(ii)	pulse as current is being switched on zero e.m.f. when current in coil pulse in opposite direction when switching off	B1 B1 B1	[3]
8	**(a)**		discrete and equal amounts (of charge) *allow: discrete amounts of 1.6 × 10^{-19}C/elementary charge/e* *integral multiples of 1.6 × 10^{-19}C/elementary charge/e*	B1	[1]
	(b)		weight = qV/d $4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$ $q = 4.9 \times 10^{-19}$ C	 C1 A1	[2]
	(c)		elementary charge = 1.6×10^{-19} C (*allow* 1.6×10^{-19} C to 1.7×10^{-19} C) *either* the values are (approximately) multiples of this *or* it is a common factor it is the highest common factor	M0 C1 A1	[2]
9	**(a)**		e.g. no time delay between illumination and emission max. (kinetic) energy of electron dependent on frequency max. (kinetic) energy of electron independent of intensity rate of emission of electrons dependent on/proportional to intensity (*any three separate statements, one mark each, maximum 3*)	B3	[3]
	(b)	**(i)**	(photon) interaction with electron may be below surface energy required to bring electron to surface	B1 B1	[2]

(ii) **1.** threshold frequency = 5.8×10^{14} Hz	A1	[1]
2. Φ = hf_0	C1	
= $6.63 \times 10^{-34} \times 5.8 \times 10^{14}$		
= 3.84×10^{-19} (J)	C1	
= $(3.84 \times 10^{-19})/(1.6 \times 10^{-19})$		
= 2.4 eV	A1	[3]
or		
$hf = \Phi + E_{MAX}$	(C1)	
chooses point on line and substitutes values E_{MAX}, f and h into equation with the units of the hf term converted from J to eV	(C1)	
Φ = 2.4 eV	(A1)	
10 **(a)** energy required to separate the nucleons (in a nucleus)	M1	
to infinity	A1	[2]
(*allow reverse statement*)		
(b) **(i)** Δm = (2 × 1.00867) + 1.00728 – 3.01551	C1	
= 9.11×10^{-3} u	C1	
binding energy = $9.11 \times 10^{-3} \times 930$		
= 8.47 MeV	A1	[3]
(*allow 930 to 934 MeV so answer could be in range 8.47 to 8.51 MeV)*		
(*allow 2 s.f.*)		
(ii) Δm = 211.70394 – 209.93722		
= 1.76672 u	C1	
binding energy per nucleon = (1.76672 × 930)/210	C1	
= 7.82 MeV	A1	[3]
(*allow 930 to 934 MeV so answer could be in range 7.82 to 7.86 MeV*)		
(*allow 2 s.f.*)		
(c) <u>total</u> binding energy of barium and krypton	M1	
is greater than binding energy of uranium	A1	[2]

Section B

11 **(a)** **(i)** inverting amplifier	B1	[1]
(ii) gain is <u>very</u> large/infinite	B1	
V^+ is earthed/zero	B1	
for amplifier not to saturate, P must be (almost) earth/zero	B1	[3]
(b) **(i)** R_A = 100 kΩ	A1	
R_B = 10 kΩ	A1	
V_{IN} = 1000 mV	A1	[3]
(ii) variable range meter	B1	[1]

12	**(a)**	series of X-ray images (for one section/slice)	M1	
		taken from different angles	M1	
		to give image of the section/slice	A1	
		repeated for many slices	M1	
		to build up three-dimensional image (of whole object)	A1	[5]
	(b)	deduction of background from readings	C1	
		division by three	C1	
		$P = 5$ $Q = 9$ $R = 7$ $S = 13$		
		(four correct 2/2, three correct 1/2)	A2	[4]
13	**(a)**	e.g. noise can be eliminated/waveform can be regenerated extra bits of data can be added to check for errors cheaper/more reliable greater <u>rate</u> of transfer of data (*1 each, max 2*)	B2	[2]
	(b)	receives bits all at one time	B1	
		transmits the bits one after another	B1	[2]
	(c)	sampling frequency must be higher than/(at least) twice frequency to be sampled	M1	
		either higher (range of) frequencies reproduced on the disc *or* lower (range of) frequencies on phone	A1	
		either higher quality (of sound) on disc *or* high quality (of sound) not required for phone	B1	[3]
14	**(a)**	reduction in power (*allow intensity/amplitude*)	B1	[1]
	(b)	**(i)** attenuation = 2.4×30 = 72 dB	A1	[1]
		(ii) gain/attenuation/dB = $10 \lg(P_2/P_1)$	C1	
		$72 = 10 \lg(P_{IN}/P_{OUT})$ *or* $-72 = 10 \lg(P_{OUT}/P_{IN})$	C1	
		ratio = 1.6×10^7	A1	[3]
	(c)	e.g. enables smaller/more manageable numbers to be used e.g. gains in dB for series amplifiers are added, not multiplied	B1	[1]