CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/43 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 — M1
from infinity (to the point) — 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 $(6.3 \times 10^7)/5$ $(= 1.26 \times 10^7 \text{ J kg}^{-1})$ — C1
change in energy = $(1.26 - 1.05) \times 10^7 \times 1.3$ — C1
$= 2.7 \times 10^6$ J — A1

or change in potential = $(1/5 - 1/6) \times (6.3 \times 10^7)$ — (C1)
change in energy = $(1/5 - 1/6) \times (6.3 \times 10^7) \times 1.3$ — (C1)
$= 2.7 \times 10^6$ J — (A1) [4]

2 **(a)** the number of atoms — M1
in 12 g of carbon-12 — A1 [2]

(b) **(i)** amount = 3.2/40
= 0.080 mol — A1 [1]

(ii) $pV = nRT$
$p \times 210 \times 10^{-6} = 0.080 \times 8.31 \times 310$ — C1
$p = 9.8 \times 10^5$ Pa — A1 [2]
(do not credit if T in °C not K)

(iii) *either* $pV = 1/3 \times Nm <c^2>$
$N = 0.080 \times 6.02 \times 10^{23}$ $(= 4.82 \times 10^{22})$
<u>and</u> $m = 40 \times 1.66 \times 10^{-27}$ $(= 6.64 \times 10^{-26})$ — C1
$9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 4.82 \times 10^{22} \times 6.64 \times 10^{-26} \times <c^2>$ — C1
$<c^2> = 1.93 \times 10^5$
$c_{RMS} = 440 \text{ m s}^{-1}$ — A1 [3]

or $Nm = 3.2 \times 10^{-3}$ — (C1)
$9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 3.2 \times 10^{-3} \times <c^2>$ — (C1)
$<c^2> = 1.93 \times 10^5$
$c_{RMS} = 440 \text{ m s}^{-1}$ — (A1)

or $1/2\, m<c^2> = 3/2\, kT$ — (C1)
$1/2 \times 40 \times 1.66 \times 10^{-27} <c^2> = 3/2 \times 1.38 \times 10^{-23} \times 310$ — (C1)
$<c^2> = 1.93 \times 10^5$
$c_{RMS} = 440 \text{ m s}^{-1}$ — (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 <u>max</u> 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 $(2r, \frac{1}{4}E_0)$		A1	[3]
		(*for 3rd mark line must be drawn to x = 4r and must not touch x-axis*)			
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	B1	
		V_H then non-zero constant	B1	
		V_H returns to zero when current switched off	B1	[3]
	(b) (i)	(induced) e.m.f. proportional to rate	M1	
		of change of (magnetic) flux (linkage)	A1	[2]
	(ii)	pulse as current is being switched on	B1	
		zero e.m.f. when current in coil	B1	
		pulse in opposite direction when switching off	B1	[3]
8	**(a)**	discrete and equal amounts (of charge)	B1	[1]
		allow: discrete amounts of 1.6×10^{-19} C/elementary charge/e		
		integral multiples of 1.6×10^{-19} C/elementary charge/e		
	(b)	weight = qV/d		
		$4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$	C1	
		$q = 4.9 \times 10^{-19}$ C	A1	[2]
	(c)	elementary charge = 1.6×10^{-19} C (*allow* 1.6×10^{-19} C to 1.7×10^{-19} C)	M0	
		either the values are (approximately) multiples of this		
		or it is a common factor	C1	
		it is the highest common factor	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	B1	
		energy required to bring electron to surface	B1	[2]

		(ii)	1. threshold frequency = 5.8×10^{14} Hz	A1	[1]
			2. $\Phi = hf_0$	C1	
			$= 6.63 \times 10^{-34} \times 5.8 \times 10^{14}$		
			$= 3.84 \times 10^{-19}$ (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)	$\Delta m = (2 \times 1.00867) + 1.00728 - 3.01551$	C1	
			$= 9.11 \times 10^{-3}$ 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 = $(1.76672 \times 930)/210$	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) taken from different angles to give image of the section/slice repeated for many slices to build up three-dimensional image (of whole object)	M1 M1 A1 M1 A1	[5]
	(b)	deduction of background from readings division by three *P* = 5 *Q* = 9 *R* = 7 *S* =13 (four correct 2/2, three correct 1/2)	C1 C1 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 transmits the bits one after another	B1 B1	[2]
	(c)	sampling frequency must be higher than/(at least) twice frequency to be sampled *either* higher (range of) frequencies reproduced on the disc *or* lower (range of) frequencies on phone *either* higher quality (of sound) on disc *or* high quality (of sound) not required for phone	M1 A1 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) 72 = 10 lg(P_{IN}/P_{OUT}) *or* –72 = 10 lg(P_{OUT}/P_{IN}) ratio = 1.6×10^7	C1 C1 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]