UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE International Examinations

Section A

1	(a)		work done moving <u>unit</u> mass from infinity to the point	M1 A1	[2]
	(b)	(i)	at R, ϕ = 6.3×10^{7} J kg^{-1} (allow $\pm$ 0.1×10^{7}) $\phi = GM / R$ $6.3 \times 10^{7} = (6.67 \times 10^{-11} \times M) / (6.4 \times 10^{6})$ $M = 6.0 \times 10^{24}$ kg (allow 5.95 $\rightarrow$ 6.14) Maximum of 2/3 for any value chosen for ϕ not at R	B1 C1 A1	 [3]
		(ii)	change in potential = 2.1×10^{7} J kg^{-1} (allow $\pm$ 0.1×10^{7}) loss in potential energy = gain in kinetic energy $\frac{1}{2} mv^2 = \phi$m or $\frac{1}{2} mv^2 = GM / 3R$ $\frac{1}{2} v^2 = 2.1 \times 10^{7}$ $v = 6.5 \times 10^{3}$ m s^{-1} ……….……(allow 6.3 $\rightarrow$ 6.6) (answer 7.9×10^{3} m s^{-1}, based on $x = 2R$, allow max 3 marks)	C1 B1 C1 A1	 [4]
		(iii)	e.g. speed / velocity / acceleration would be greater deviates / bends from straight path (any sensible ideas, 1 each, max 2)	B1 B1	 [2]
2	(a)	(i)	reduction in energy (of the oscillations) reduction in amplitude / energy of oscillations due to force (always) opposing motion / resistive forces any two of the above, max 2	(B1) (B1) (B1)	 [2]
		(ii)	amplitude is decreasing (very) gradually / oscillations would continue (for a long time) /many oscillations light damping	M1 A1	 [2]
	(b)	(i)	frequency = 1 / 0.3 = 3.3 Hz allow points taken from time axis giving f = 3.45 Hz	 A1	 [1]
		(ii)	energy = $\frac{1}{2} mv^2$ <u>and</u> $v = \omega a$ = $\frac{1}{2} \times 0.065 \times (2\pi/0.3)^2 \times (1.5 \times 10^{-2})^2$ = 3.2 mJ	C1 M1 A0	 [2]
	(c)		amplitude reduces exponentially / does not decrease linearly so will be not be 0.7 cm	M1 A1	 [2]

3	(a) (i)	1 deg C corresponds to (3840 – 190) / 100 Ω	C1	
		for resistance 2300 Ω, temperature is 100 × (2300 – 3840) / (190 – 3840)		
		temperature is 42 °C	A1	[2]
	(ii)	*either* 286 K ≡ 13 °C *or* 42 °C ≡ 315 K	B1	
		thermodynamic scale does not depend on the property of a substance	M1	
		so change in resistance (of thermistor) with temperature is non-linear	A1	[3]
	(b)	heat gained by ice in melting = 0.012 × 3.3 × 10^5 J	C1	
		= 3960 J		
		heat lost by water = 0.095 × 4.2 × 10^3 × (28 – θ)	C1	
		3960 + (0.012 × 4.2 × 10^3 × θ) = 0.095 × 4.2 × 10^3 × (28 – θ)	C1	
		θ = 16°C	A1	[4]
		(answer 18°C – melted ice omitted – allow max 2 marks)		
		(use of (θ – T) then allow max 1 mark)		
4	(a)	force = $q_1q_2 / 4\pi\varepsilon_0 x^2$	C1	
		= $(6.4 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times \{12 \times 10^{-6}\}^2)$	C1	
		= 2.56×10^{-17} N	A1	[3]
	(b)	potential at P is same as potential at Q	B1	
		work done = $q\Delta V$	M1	
		ΔV = 0 so zero work done	A0	[2]
	(c)	at midpoint, potential is $2 \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 6 \times 10^{-6})$	C1	
		at P, potential is $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 3 \times 10^{-6}) + (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$	C1	
		change in potential = $(6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$		
		energy = $1.6 \times 10^{-19} \times (6.4 \times 10^{-19}) / (4\pi\varepsilon_0 \times 9 \times 10^{-6})$	C1	
		= 1.0×10^{-22} J	A1	[4]
5	(a)	e.g. 'storage of charge' / storage of energy		
		blocking of direct current		
		producing of electrical oscillations		
		smoothing		
		(any two, 1 mark each)	B2	[2]
	(b) (i)	capacitance of parallel combination = 60 μF	C1	
		total capacitance = 20 μF	A1	[2]
	(ii)	p.d. across parallel combination = ½ × p.d. across single capacitor	C1	
		maximum is 9V	A1	[2]
	(c)	*either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ <u>and</u> $Q = CV$	C1	
		energy = $\frac{1}{2} \times 4700 \times 10^{-6} \times (18^2 - 12^2)$	C1	
		= 0.42 J	A1	[3]

6	**(a)**	**(i)** straight line with positive gradient	M1	
		through origin	A1	[2]
		(ii) maximum force shown at $\theta = 90°$	M1	
		zero force shown at $\theta = 0°$	M1	
		reasonable curve with F about ½ max at 30°	A1	[3]
	(b)	**(i)** force on electron due to magnetic field	B1	
		force on electron normal to magnetic field and direction of electron	B1	[2]
		(ii) quote / mention of (Fleming's) left hand rule	M1	
		electron moves towards QR	A1	[2]
7	**(a)**	*either* the value of steady / constant voltage	M1	
		that produces same power (in a resistor) as the alternating voltage	A1	[2]
		or if alternating voltage is squared and averaged	(M1)	
		the r.m.s. value is the square root of this averaged value	(A1)	
	(b)	**(i)** 220 V	A1	[1]
		(ii) 156 V	A1	[1]
		(iii) 60 Hz	A1	[1]
	(c)	power = V_{rms}^2 / R	C1	
		$R = 156^2 / 1500$		
		$= 16\ \Omega$	A1	[2]
8	**(a)**	**(i)** number = $(5.1 \times 10^{-6} \times 6.02 \times 10^{23}) / 241$	C1	
		$= 1.27 \times 10^{16}$	A1	[2]
		(ii) $A = \lambda N$	C1	
		$5.9 \times 10^5 = \lambda \times 1.27 \times 10^{16}$		
		$\lambda = 4.65 \times 10^{-11}\ s^{-1}$	A1	[2]
		(iii) $4.65 \times 10^{-11} \times t_{½} = \ln 2$	C1	
		$t_{½} = 1.49 \times 10^{10}$ s		
		= 470 years	A1	[2]
	(b)	sample / activity would decay appreciably whilst measurements are being made	B1	[1]

Section B

9	(a)	(i)	fraction of the output (signal) is added to the input (signal)	M1	
			out of phase by 180° / π rad / to inverting input	A1	[2]
		(ii)	e.g. reduces gain increases bandwidth greater stability reduces distortion (any two, 1 mark each)	B2	[2]
	(b)	(i)	gain = 4.4 / 0.062 = 71	A1	[1]
		(ii)	71 = 1 + 120/R	C1	
			R = $1.7 \times 10^3\ \Omega$	A1	[2]
	(c)		for the amplifier not to saturate	B1	
			maximum output is ($71 \times 95 \times 10^{-3}$ =) approximately 6.7 V	M1	
			supply should be +/– 9 V	A1	[3]
10	(a)	(i)	strain gauge	B1	[1]
		(ii)	piezo-electric / quartz crystal / transducer	B1	[1]
	(b)		circuit: coil of relay connected between sensing circuit output and earth	B1	
			switch across terminals of external circuit	B1	
			diode in series with coil with correct polarity for diode	B1	
			second diode with correct polarity	B1	[4]
11			*either* quartz *or* piezo-electric crystal	B1	
			opposite faces /two sides coated (with silver) to act as electrodes	B1	
			either molecular structure indicated *or* centres of (+) and (–) charge not coincident	B1	
			potential difference across crystal causes crystal to change shape	B1	
			alternating voltage (in US frequency range) applied across crystal	B1	
			causes crystal to oscillate / vibrate	B1	
			(crystal cut) so that it vibrates at resonant frequency	B1	[6]
			(max 6)		

12 **(a)** signal becomes distorted / noisy B1
signal loses power / energy / intensity / is attenuated B1 [2]

(b) **(i)** *either* numbers involved are smaller / more manageable / cover wider range
or calculations involve addition & subtraction rather than multiplication and division
B1 [1]

(ii) $25 = 10 \lg(P_{min} / (6.1 \times 10^{-19}))$ C1
minimum signal power $= 1.93 \times 10^{-16}$ W C1
signal loss $= 10 \lg(6.5 \times 10^{-3})/(1.93 \times 10^{-16})$
$= 135$ dB C1
maximum cable length $= 135 / 1.6$ C1
$= 85$ km so no repeaters necessary A1 [5]