PHYSICS **9702/04**

Paper 4 A Level Structured Questions **For Examination from 2016**

SPECIMEN MARK SCHEME

2 hours

MAXIMUM MARK: 100

1 (a) (i) $F_G = GMm / R^2$ C1
           $= (6.67 \times 10^{-11} \times 5.98 \times 10^{24}) / (6380 \times 10^3)^2$
           $= 9.80\,N$ A1   [2]

(ii) $F_C = mR\omega^2$ C1
      $\omega = 2\pi / T$ C1
      $F_C = (4\pi^2 \times 6380 \times 10^3) / (8.62 \times 10^4)^2$
           $= 0.0339\,N$ A1   [3]

(iii) $F_G - F_C = 9.77\,N$ A1   [1]

(b) $9.77\,m\,s^{-2}$ because acceleration is resultant force per unit mass   B1   [1]

[Total: 7]

2 (a) $pV / T = $ constant
      $T = (6.5 \times 10^6 \times 30 \times 300) / (1.1 \times 10^5 \times 540)$ C1
        $= 985\ K$ A1   [2]

(b) (i) $\Delta U = q + w$
      symbols explained ($q = $ heating, $w = $ work)   M1
      consistent set of directions of energy change   A1   [2]

(ii) q is zero   B1
      $\Delta U = w$ and so U increases   B1
      U increases so E_K of atoms increases and T increases   A1   [3]

[Total: 7]

3 (a) (i) $\omega = 2\pi f$ B1   [1]

(ii) *either* $(-)$ve because a and x are in opposite directions
      or a is always directed towards mean position   B1   [1]

(b) (i) forces in springs are $k(e + x)$ and $k(e - x)$ C1
      resultant $= k(e + x) - k(e - x)$ M1
           $= 2kx$ A0   [2]

(ii) $F = ma$ B1
      $a = -2kx / m$ A0
      $(-)$ sign explained   B1   [2]

(iii) $\omega^2 = 2k / m$ C1
      $(2\pi f)^2 = (2 \times 120) / 0.90$ C1
      $f = 2.6\,Hz$ A1   [3]

[Total: 9]

4	(a)	amplitude of carrier wave varies		M1	
		in synchrony with displacement of information signal		A1	[2]
	(b)	graph: three vertical lines		M1	
		symmetrical with smaller sidebands		A1	
		at frequencies 70, 75 and 80 kHz		A1	[3]
	(c)	bandwidth = 10 kHz		B1	[1]

[Total: 6]

5	(a)	unwanted energy / power that is random	B1	[1]
	(b)	number of dB = $10 \lg(P_{OUT} / P_{IN})$	C1	
		$63 = 10 \lg(P_{OUT} / (2.5 \times 10^{-6}))$	C1	
		$P_{OUT} = 5.0\,W$	A1	[3]
	(c)	attenuation = $10 \lg(5.0 / (3.5 \times 10^{-8})) = 81.5$ dB	C1	
		length = 81.5 / 12 = 6.8 km	A1	[2]

[Total: 6]

6	(a)	field strength equals the potential gradient	M1	
		field strength and potential gradient are in opposite directions	A1	[2]
	(b)	at $x = 10\,cm$, force is maximum	M1	
		because the gradient is largest	A1	
		repulsion / force to right because sphere and proton have like charges	B1	
		as x increases, force decreases	B1	
		becomes zero at $x = 35\,cm$	B1	
		as x increases from $x = 35\,cm$ to $x = 41\,cm$, force increases in opposite direction	B1	[6]

[Total: 8]

7	(a)	$+ -$		B1	[1]
	(b)	(i)	**1.** 4.5 V	A1	
			2. use of potential divider formula $(9 \times 800) / (800 + 2200)$	C1	
			2.4 V	A1	
			3. $- 9.0\,V$	B1	[4]
		(ii)	LED G (allow e.c.f. from (i))	B1	[1]
	(c)	as temperature rises, potential at B increases		M1	
		at 60 °C, green goes out and red comes on (allow ecf from (b)(ii))		A1	[2]

[Total: 8]

8 **(a)** **(i)** 50 mT (*allow 50 ± 1 mT for full credit*)   A1   [1]

    (ii) flux linkage = *BAN*   C1

         $= 50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$ M1

         $= 3.0 \times 10^{-4}$ Wb   A0   [2]

(b) e.m.f. (induced) is proportional to the rate   M1
of change of (magnetic) flux (linkage)   A1   [2]
(*allow 'rate of cutting'*)

(c) **(i)** new flux linkage $= 8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$

                 $= 4.8 \times 10^{-4}$ Wb   C1

         change $= 2.52 \times 10^{-4}$ Wb   A1   [2]

    (ii) e.m.f. $= (2.52 \times 10^{-4}) / 0.30$ C1

         $= 8.4 \times 10^{-4}$ V   A1   [2]

(d) flux linkage decreases as distance increases   B1
so speed must increase to keep rate constant   B1   [2]

[Total: 11]

9 **(a)** into the plane of the paper / downwards   B1   [1]

(b) **(i)** centripetal force $= mv^2 / r$ B1
$mv^2 / r = Bqv$ hence $q / m = v / rB$ (*some algebra essential*)   B1   [2]

    (ii) $q / m = (8.2 \times 10^6) / (23 \times 10^{-2} \times 0.74)$ C1

         $= 4.82 \times 10^7$ C kg^{-1} A1   [2]

[Total: 5]

10 **(a)** single diode   M1
either in series with R *or* in series with a.c. supply   A1   [2]

(b) **(i)** **1.** 5.4 V (*allow ±0.1 V*)   A1   [1]

         2. $V = IR$

            $I = 5.4 / (1.5 \times 10^3)$

             $= 3.6 \times 10^{-3}$ A   A1   [1]

         3. time $= 0.027$ s   A1   [1]

    (ii) **1.** $Q = It$

            $= 3.6 \times 10^{-3} \times 0.027$ C1

            $= 9.72 \times 10^{-5}$ C   A1   [2]

         2. $C = \Delta Q / \Delta V$ (*allow Q/V*)   C1

            $= (9.72 \times 10^{-5}) / 1.2$

            $= 8.1 \times 10^{-5}$ F   A1   [2]

(c) line: reasonable shape with less ripple   B1   [1]

[Total: 10]

11 at 0 K, VB is filled, CB is empty   B1
as temperature rises, electrons gain energy to enter CB   M1
           positive holes are formed in VB   A1
           lattice vibrations increase   B1
effect due to increase in charge carriers outweighs effect due to increase in
lattice vibrations   M1
so current larger and resistance smaller   A1   [6]

[Total: 6]

12 (a) (i) clear distinction of boundaries between regions   B1   [1]

     (ii) significant difference in degree of blackening between regions   B1   [1]

   (b) (i) $\frac{1}{2} = e^{-\mu}$ C1
         $\mu = 0.693 \, \text{mm}^{-1}$ A1   [2]

     (ii) X-ray photons are more penetrating   M1
         μ is smaller   A1   [2]

[Total: 6]

13 (a) (i) probability of decay (of a nucleus)   M1
         per unit time   A1   [2]

     (ii) greater energy of α-particle   M0
         (parent) nucleus less stable   A1
         nucleus more likely to decay   A1
         hence radium-224 A1   [3]

   (b) (i) $\lambda = \ln 2 \, / \, 3.6$
         $= 0.193$ A1
         unit: day^{-1} A1   [2]
         (*allow full credit for 2.23 × 10⁻⁶ s⁻¹*)

     (ii) $N = \{(2.24 \times 10^{-3}) \, / \, 224\} \times 6.02 \times 10^{23}$ C1
         $= 6.02 \times 10^{18}$ C1
         activity $= \lambda N$
            $= 2.23 \times 10^{-6} \times 6.02 \times 10^{18}$ C1
            $= 1.3 \times 10^{13} \, \text{Bq}$ A1   [4]

[Total: 11]

Categorisation of marks

The marking scheme categorises marks on the *MACB* scheme.

B marks: These are awarded as <u>independent</u> marks, which do not depend on other marks. For a B-mark to be scored, the point to which it refers must be seen specifically in the candidate's answer.

M marks: These are <u>method</u> marks upon which A-marks (accuracy marks) later depend. For an M-mark to be scored, the point to which it refers must be seen in the candidate's answer. If a candidate fails to score a particular M-mark, then none of the dependent A-marks can be scored.

C marks: These are <u>compensatory</u> method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a C-mark and the candidate does not write down the actual equation but does correct working which shows he/she knew the equation, then the C-mark is awarded.

A marks: These are accuracy or <u>answer</u> marks which either depend on an M-mark, or allow a C-mark to be scored.

Conventions within the marking scheme

BRACKETS
Where brackets are shown in the marking scheme, the candidate is not required to give the bracketed information in order to earn the available marks.

UNDERLINING
In the marking scheme, underlining indicates information that is essential for marks to be awarded.