MARK SCHEME for the October/November 2010 question paper

for the guidance of teachers

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.

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Section A

1 (a) (i) rate of change of angle / angular displacement   M1
         swept out by radius   A1   [2]

     (ii) $\omega \times T = 2\pi$ B1   [1]

   (b) centripetal force is provided by the gravitational force   B1
      either $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$ M1
      $r^3 \times 4\pi^2 = GM \times T^2$ A1
      $GM/4\pi^2$ is a constant (*c*)   A1
      $T^2 = cr^3$ A0   [4]

   (c) (i) *either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$ C1
        $T = 165$ years   A1   [2]

     (ii) speed $= (2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$ C1
           $= 35$ km s^{-1} A1   [2]

2 (a) atoms / molecules / particles behave as elastic (identical) spheres   (1)
      volume of atoms / molecules negligible compared to volume of containing vessel   (1)
      time of collision negligible to time between collisions   (1)
      no forces of attraction or repulsion between atoms / molecules   (1)
      atoms / molecules / particles are in (continuous) random motion   (1)
      (*any four, 1 each*)   B4   [4]

   (b) $pV = \frac{1}{3}Nm<c^2>$ and $pV = nRT$ *or* $pV = NkT$ B1
      $\frac{1}{3}Nm<c^2> = nRT$ or $= NkT$ and $<E_K> = \frac{1}{2}m<c^2>$ B1
      $n = N/N_A$ *or* $k = R/N_A$ B1
      $<E_K> = \dfrac{3}{2} \times R/N_A \times T$ A0   [3]

   (c) (i) reaction represents   *either*   build-up of nucleus from light nuclei
                     or   build-up of heavy nucleus from nuclei   M1
        so fusion reaction   A1   [2]

     (ii) proton and deuterium nucleus will have equal kinetic energies   B1
        $1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$ C1
        $T = 5.8 \times 10^8$ K   A1   [3]
        (*use of $E = 2.4 \times 10^{-14}$ giving 1.16×10^9 K scores 1 mark*)

     (iii) *either*   inter-molecular / atomic / nuclear forces exist
         or   proton and deuterium nucleus are positively charged / repel   B1   [1]

3 **(a)** **(i)** 8.0 cm   A1   [1]

   (ii) $2\pi f = 220$ C1
   $f = 35$ (*condone unit*)   A1   [2]

   (iii) line drawn mid-way between AB and CD   (*allow ±2 mm*)   B1   [1]

   (iv) $v = \omega a$ C1
      $= 220 \times 4.0$
      $= 880$ cm s^{-1} A1   [2]

(b) **(i)** **1.** line drawn 3 cm above AB   (*allow ±2 mm*)   B1   [1]
       2. arrow pointing upwards   B1   [1]

   (ii) **1.** line drawn 3 cm above AB   (*allow ±2 mm*)   B1   [1]
        2. arrow pointing downwards   B1   [1]

   (iii) $v = \omega\sqrt{(a^2 - x^2)}$
       $= 220 \times \sqrt{(4.0^2 - 2.0^2)}$ C1
       $= 760$ cm s^{-1} A1   [2]
   (*incorrect value for x, 0/2 marks*)

4 **(a)** **(i)** work done moving unit positive charge   M1
         from infinity <u>to the point</u>   A1   [2]

   (ii) charge / potential (difference)   (*ratio must be clear*)   B1   [1]

(b) **(i)** capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^3)$ C1
        (*allow any appropriate values*)
        capacitance = 1.8×10^{-11} (*allow 1.8 ±0.05*)   A1   [2]

   (ii) *either* energy = $\frac{1}{2}CV^2$ *or*   energy = $\frac{1}{2}QV$ <u>and</u> $Q = CV$ C1
        energy = $\frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^3)^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^3$
             = 0.20 J   A1   [2]

(c) *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left
     or   full formula treatment   C1
     energy lost = 0.15 J   A1   [2]

5 (a) magnetic flux $= BA$

$\quad\quad\quad\quad = 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$ C1

$\quad\quad\quad\quad = 1.07 \times 10^{-4}$ Wb   A1   [2]

(b) (i) e.m.f. $= \Delta\phi / \Delta t$ C1

$\quad$ (for $\Delta\phi = 1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s   C1

$\quad$ e.m.f. $= (1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$

$\quad\quad\quad\quad = 8.0 \times 10^{-3}$ V   A1   [3]

(ii) current $= 8.0 \times 10^{-3} / 0.12$ M1

$\quad\quad\quad\quad \approx 70$ mA   A0   [1]

(c) force on wire $= BIL$

$\quad = 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$ C1

$\quad \approx 3 \times 10^{-4}$ (N)   M1

$\quad$ suitable comment e.g. this force is too / very small (to be felt)   A1   [3]

6 (a) power / heating depends on I^2 M1

$\quad$ so independent of current direction   A1   [2]

(b) *either* maximum power $= I_0^2 R$ *or* average power $= I_{RMS}^2 R$ M1

$I_0 = \sqrt{2} \times I_{RMS}$ M1

maximum power $= 2 \times$ average power

ratio $= 0.5$ A1   [3]

7 (a) force due to E-field is <u>equal and opposite</u> to force due to B-field   B1

$\quad Eq = Bqv$ B1

$\quad v = E/B$ B1   [3]

(b) *either* charge and mass are not involved in the equation in **(a)**

$\quad$ *or* F_E and F_B are both doubled

$\quad$ *or* E, B and v do not change   M1

$\quad$ so no deviation   A1   [2]

8 (a) minimum frequency for electron to be emitted (from surface)   M1

$\quad$ of electromagnetic radiation / light / photons   A1   [2]

(b) $E = hc / \lambda$ *or* $E = hf$ <u>and</u> $c = f\lambda$ C1

$\quad$ *either* threshold wavelength $= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (5.8 \times 10^{-19})$

$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad = 340$ nm

$\quad$ *or* energy of 340 nm photon $= 4.4 \times 10^{-19}$ J

$\quad$ *or* threshold frequency $= 8.7 \times 10^{14}$ Hz

$\quad$ *or* 450 nm $\rightarrow 6.7 \times 10^{14}$ Hz   A1

$\quad$ appropriate comment comparing wavelengths / energies / frequencies   B1

$\quad$ so no effect on photo-electric current   B1   [4]

Section B

9 (a) (i) edges can be (clearly) distinguished   B1   [1]

(ii) e.g. size of X-ray source / anode / target / aperture
scattering of X-ray beam
pixel size
(*any two, 1 each*)   B2
further detail e.g. use of lead grid   B1   [3]

(b) X-ray image involves a <u>single</u> exposure   B1
CT scan: exposure of a <u>slice</u> from many different angles   M1
repeated for different slices   A1
CT scan involves a (much) <u>greater exposure</u>   B1   [4]

10 (a) e.g. infinite input impedance / resistance
zero output impedance / resistance
infinite gain
infinite bandwidth
infinite slew rate
(*any three, 1 each*)   B3   [3]

(b) (i) with switch open, V^- is less (positive) than V^+ M1
output is positive   A1
with switch closed, V^- is more (positive) than V^+ so output is negative   A1   [3]
(*allow similar scheme if V^- more positive than V^+ treated first*)

(ii) 1. diodes connected correctly between output and earth   M1
2. green identified correctly   A1   [2]
(*do not allow this mark if not argued in (i)*)

11 (a) (i) I / I_0 = exp(–1.5 × 2.9)   C1
= 0.013   A1   [2]

(ii) I / I_0 = exp(–4.6 × 0.95)
= 0.013   A1   [1]

(b) attenuation (coefficients) in muscle and in fat are similar   B1
attenuation (coefficients) in bone and muscle / fat are different   B1
contrast depends on difference in attenuation   B1   [3]

12 (a) (i) 1. signal has same variation (with time) as the data   B1

             2. consists of (a series of) 'highs' and 'lows'   B1

                either   analogue is continuously variable (between limits)

                or   digital has no intermediate values   B1   [3]

     (ii) e.g.   can be regenerated / noise can be eliminated

               extra data can be added to check / correct transmitted signal

       (*any two reasonable suggestions, 1 each*)   B2   [2]

   (b) (i) analogue signal is sampled at (regular time) intervals   B1

         sampled signal is converted into a binary number   B1   [2]

     (ii) one channel is required for each bit (of the digital number)   B1   [1]