Mark Scheme for Chittagong Group C

Ques no	Answer and Marks
1	The displacement of the released mass will be twice of the mass attached to the pulley ((0.5 marks) . The displacement of the heavier mass is h – thus the released mass can travel upto 2h (0.5 marks)
2	The objects will meet at their center of mass (1 mark) The location of the mass measured from 3 kg will be deduced from $\bar{r} = \frac{mr_1+Mr_2}{m+M} = \boldsymbol{7m}$ (1 Mark)
3	If the extension of the spring is x then $\frac{mv^2}{r} = kx$ (1 Marks) But $x = (r - L)$ (0.5 marks) Which leads to $k = \mathbf{1000\ Nm^{-1}}$ (0.5 marks)
4	Let the other charge be q. So when the spheres touch their common charge becomes $(q+2)/2$ (0.75 Marks) Initial force was $K\frac{2q}{r^2}$ (0.5 marks) Final force $K\frac{\left(\frac{q+2}{2}\right)^2}{(4r)^2}$ (0.75 Marks) Thus $K\frac{\left(\frac{q+2}{2}\right)^2}{(4r)^2} = -\frac{1}{20}K\frac{2q}{r^2}$ (0.25 Marks) Solving this $q = \mathbf{-0.4C\ or -10C}$ **(Any one answer will do**) (0.75 Marks)
5	Since the temperature is kept at 0^0C We will apply Boyle's law $P_iV_i = P_fV_f$ (0.5 Marks) where $P_i = 1\ atm,\ V_i = \left(2\times10^{-3} - \frac{1}{920}\right)m^3$, (Volume of ice subtracted 0.5 Marks) $V_f = \left(2\times10^{-3} - \frac{1}{1000}\right)m^3$ (Volume of water subtracted , 0.3 marks) $P_f = 0.91\ atm$ (correct value , 0.4 Marks) $\frac{\Delta P}{P_i} = \frac{P_f - P_i}{P_i} = \frac{0.91-1}{1} = \mathbf{-8.7}\%$ (0.3 Marks)
6	Current through 20 Ohm = 10/20 = 0.5 A (0.5 Marks) Total current through R_2 = 2+0.5 = 2.5 A (0.5 Marks) Voltage drop through R_2 = 250/2.5= 100V (1 Mark)\ Thus the voltage between the end points = 100 + 10 = 110V (1 mark) If the correct answer is found directly and workout provided full 3 Marks will be awarded.

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7	The initial kinetic energy of the pen is constant (0.4 Marks) It is used for work against the frictional force and gravity (0.4 Marks) Energy conservation gives $\frac{1}{2}mv_0^2 = f_k s + mgh = \mu_k Rs + mgh = \mu_k mgs\cos\alpha + mgs\sin\alpha$ $s(\mu_k\cos\alpha + \sin\alpha) = constant$ (1.5 mark) Using any two values yields ***about*** $\mu_k = \mathbf{0.25}$ **(0.7 Marks)**
8	Due to Lorentz contraction the circular stadium will look like an ellipse (1 Mark) Area of ellipse $A = \pi ab$ (0.5 marks) The semimajor axis a will be the radius= 1km (0.3 Marks) The semiminor axis will be b = a $\sqrt{1-\frac{v^2}{c^2}}$ = 0.6 km (1 Marks) The area A= 1.88 km^2 (0.2 marks)
9	No horizontal external force on the plank-pendulum system. So, momentum is conserved in this direction: (0.8 Marks) $mv = MV \Rightarrow V = \frac{1}{2}v$ (0.5 Marks) Applying conservation of energy: $mgh = \frac{1}{2}mv^2 + \frac{1}{2}MV^2$ (1 mark) Plugging $h = L(1 - cos\phi)$ gives$v = \mathbf{1.14\ ms^{-1}}$.(0.7 Marks)
10	Relativistic energy conservation gives $pc = 2E$ where p is the photon momentum and E is the energy of either the electron and positron (seen from their center of mass frame). (0.5Marks) Momentum conservation along the direction of the photon momentum gives $p = 2p_e\cos\theta, p_e$ being the electron (positron) momentum. (0.5 marks) The ratio of these equations give $c = \frac{E}{p_e\cos\theta}$ => $E^2 = c^2\,(p_e\cos\theta)^2$ (0.5 marks) But this is incompatible with $E^2 = c^2\,{p_e}^2 + m^2c^4$ which requires $cos^2\theta$ to be greater than 1 which impossible. (0.5 marks)

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11	The potential energy for the particle is U = -∫ F dx = - $\frac{mk^2}{2x^2}$. (0.7 Marks) Energy conservation gives the relation between $E = \frac{1}{2}mv^2 - \frac{mk^2}{2}. = -\frac{mk^2}{2d^2}$ (1 Mark) Solving this one gets $t = \int \mathrm{dt} = \int \frac{\mathrm{dx}}{\mathrm{v}} = \frac{\mathrm{d}}{\mathrm{k}} \int \frac{\mathrm{x\ dx}}{\sqrt{d^2-x^2}}$ (1 mark) Result of the integration should be $t = \frac{d^2}{k}$ (0.8 Marks) Messing up with sign should be ignored.
12	When the switch is turned OFF, the capacitors are in series, (0.5 Marks) each having the same charge $Q = C_{eq}V = 28.8\ \mu C$ (0.5 Marks) After the switch is turned ON, the capacitors will have a voltage of $12V$ across each of them. (0.5 marks) And the respective charges would be $Q_{2\mu F} = 24\mu C$ (0.4 Marks)and $Q_{3\mu F} = 36\mu C$(0.4Marks). So, a total of $4.8 + 7.2 = \mathbf{12\mu C}$ flows down the conductor (0.2 marks) . Some students might write 7.2 – 4.8 = 2.4 μC which can also be accepted as an valid answer to the last part as the question leaves some room for confusion. - 2.4 μC is also acceptable .