British Physics Olympiad

Paper 1, September/October 2004

Answer all the Questions

Allow 1 hour Total 50 marks

(g = 9.81 m s^{-2} or N kg^{-1})

Graph Paper is available

1. Figure 1.1 shows a network of resistors, each of resistance R.

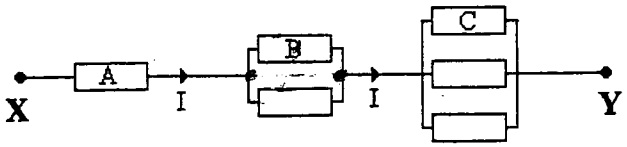

Figure 1.1

(a) The overall resistance, measured between X and Y, is 22 kΩ. What is the value of R?

(b) The power developed in resistor A, due to the current I, is 1.8 mW. Calculate the power developed in the resistor

(i) B,

(ii) C.

(10 marks)

2. (a) State Boyle's law.

(b) Figure 2.1 shows a length of capillary tubing in which a column of air is trapped by a mercury column of length 100 mm. The length of the air column is 400 mm. The bottom of the tubing is sealed and the top is open to the atmosphere.

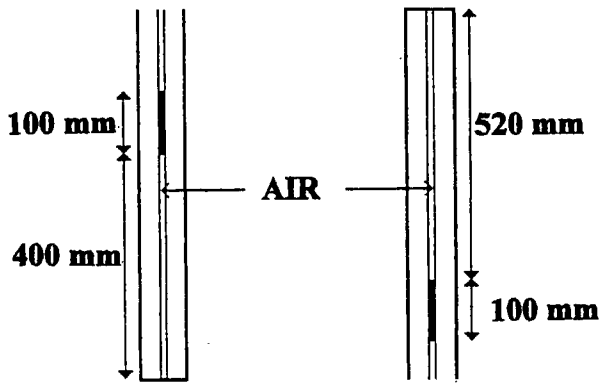

Figure 2.1 Figure 2.2

The tubing is now inverted, Figure 2.2, and the air column is seen to increase in length to 520 mm. Use this observation to calculate a value for atmospheric pressure, expressed in mm of mercury.

(c) A typical value for atmospheric pressure, expressed in SI units, is 101 kPa. The surface area A of the Earth is related to its mean radius R by the expression

$$A = 4\pi R^2,$$

where R has the value 6400 km.

Calculate

(i) the sum of the magnitudes of the forces exerted by the atmosphere on the surface of the Earth,

(ii). the mass of the Earth's atmosphere, assuming g does not vary with height above the Earth's surface.

(11 marks)

3. (a) A simple pendulum, Figure 3.1, has a period T of 1.00 s.

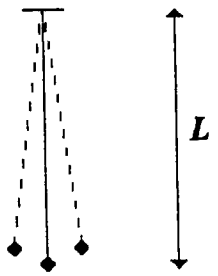

Figure 3.1

Use the expression $T = 2\pi(L/g)^{1/2}$ to calculate the length L of the pendulum.

(b) A small horizontal rod is now placed at a distance $L/2$ beneath the point of suspension of the pendulum (see Figure.3.2).

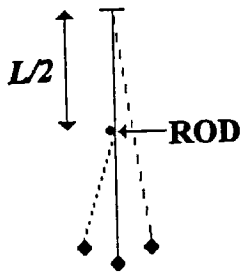

Figure 3.2

The string collides with the rod once in each oscillation. Calculate the new period T' of the pendulum.

(7 marks)

4. (a) An electric kettle is filled with 1.50 kg of water at 20°C.The power of the kettle's element is 2.1 kW. After switching on, the water reaches boiling point in 240 s. Calculate a value for the specific heat capacity of water. Assume that all the energy produced by the element is transferred to the water.

(b) The thermostat of the kettle jams and the water continues to boil. After 800 s only one-half of the water remains, the rest having turned to vapour. Calculate a value for the specific latent heat of vaporisation of water at 100°C.

(c) The vapour in (b) has a density 1/1600 of that of boiling water. Estimate the ratio of the mean separation of water molecules at 100°C in the vapour to that in the liquid.

(10 marks)

5. On a straight road, a stationary police motor-cyclist is passed by a stolen car travelling at a speed of 15 m s^{-1}. At time t = 0, when the car is level with him, the motor-cyclist accelerates at 4.0 m s^{-2} for 5.0 s and then travels at a constant speed.

(a) Draw speed – time graph during the period t= 0 to t = 15 s

(i) the stolen car, (ii) the police motor-cyclist.

(b) Use the graphs you have drawn to determine

(i) the greatest speed of the motor-cyclist,

(ii) the distance travelled by the motor-cyclist whilst accelerating,

(iii) the distance the car has travelled during the period from t = 0 to the moment when the motor-cyclist is level with it.

(12 marks)