TOTAL 10 MARKS

SECTION A

Attempt ALL questions. You MUST write in this answer booklet.

1. A student is set the task of determining the density of the metal used to make ball bearings.

(a) To find the diameter of the bearings the student lined up 10 identical balls in a row and placed a ruler against them as shown in Figure 1.

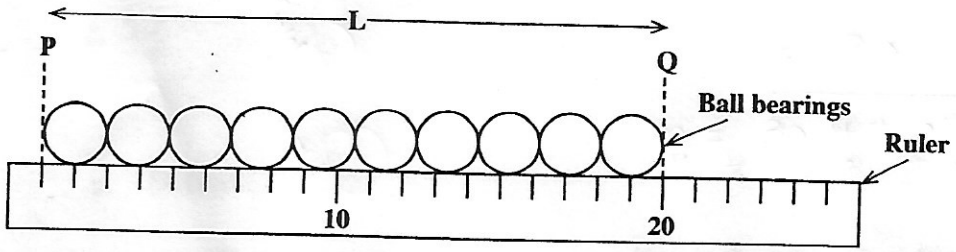

Figure 1

The positions on the scale were estimated to be: P 1.0 ± 0.2 cm, Q 20.2 ± 0.2 cm

$L = Q - P$
$= 20.2 - 1 = 19.2$

(i) Write down the value for the distance L using the same format

$\Delta L = \Delta Q + \Delta P$
$= 0.2 + 0.2$
$= 0.4$

$L =$ 19.2 ± 0.4 cm (1) **[1 mark]**

(ii) What value does this imply for the diameter D of one of the spheres?

$D =$ 1.92 ± 0.04 cm (1) **[1 mark]**

(b) The only balance available to the student was a 0 - 500 g instrument whose smallest division is 5 g. Using this balance the student obtained a mass of 30.4 ± 0.3 g for one of the ball bearings.

Suggest how the mass of one of the ball bearings could have been determined to the precision indicated above.

Find the mass of 10 balls (1)

Divide by 10 to get mass 1 ball (1)

Error is ±2.5g divided by 10 gives error ±0.25g ≃ 0.3g. (1)

[3 marks]

(c) Find the density of the metal used to make the ball bearings, giving your answer to a suitable number of significant figures together with the error (uncertainty) in the value.

$V = \frac{1}{6}\pi D^3$

$V = \frac{1}{6} \times \pi \times (1.92)^3$

$= 3.71\ cm^3$

$\frac{\Delta V}{V} = \frac{3\Delta D}{D}$ (1/2)

$\frac{\Delta V}{V} = \frac{3 \times 0.04}{1.92}$ (1/2)

$\frac{\Delta V}{V} = 0.625$ (1/2)

$\Delta V = 0.625 V$ (1/2)

$= 0.625 \times 3.71$

$= 0.232$

$V = 3.71 \pm 0.232\ cm^3$ (1/2)

$\rho = \frac{mass}{volume}$ (1/2)

$m = 30.4 \pm 0.3\ g$

$V = 3.71 \pm 0.232\ cm^3$

$\rho = \frac{m}{V} = \frac{30.4}{3.71} = 8.19$ (1/2)

$\frac{\Delta \rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta V}{V}$ (1/2)

$\frac{\Delta \rho}{\rho} = \frac{0.3}{30.4} + \frac{0.232}{3.71}$

$\frac{\Delta \rho}{\rho} = 0.072$ (1/2)

$\Delta \rho = 0.072 \rho$

$\Delta \rho = 0.072 \times 8.19$

$= 0.59$

(Volume of a sphere = $\frac{1}{6}\pi D^3$)

[5 marks]

Total 10 marks

Hence density

$\rho = (8.19 \pm 0.59)\ g/cm^3$ (1/2)