1. DISTANCIA TIERRA – LUNA / UN AÑO LUZ

A. $\underline{Distancia\ Tierra - Luna = 384.000 km}$

$$1\ Br = 1{,}83m$$
$$1{,}83m\ (\frac{1\ km}{1000\ m})$$
$$1\ Br = 1.83X10^{-3}\ km = 0.00183\ km$$
$$384.000km\ (\frac{1\ Br}{0.00183\ km})$$
$$\cong 209836065.6\ Br = 2{,}09X10^{9}\ Br$$

B. $Distancia\ en\ Km\ de\ un\ Año\ luz\ (ly) = 9\ 460\ 730\ 472\ 581\ km$

$$1\ Br = 1{,}83m$$
$$1{,}83m\ (\frac{1\ km}{1000\ m})$$
$$1\ Br = 1.83X10^{-3}\ km == 0.00183\ km$$
$$9\ 460\ 730\ 472\ 581\ km\ \ (\frac{1\ Br}{0.00183\ km})$$
$$\cong 5.169798072X10^{15}\ Br$$

2. ERRORES EN MEDIDAS

A. TORNILLO MICROMETRICO

$$Diametro = 9.51\ mm$$
$$(La\ altura\ del\ cilindro\ es\ mayor\ a\ la\ medida\ maxima\ del\ instrumento)$$
$$Minima\ medida = 0.01mm$$
$$\frac{0.01mm}{2} = 5X10^{-3}mm$$
$$Diametro = 9.51mm \pm 5X10^{-3}mm$$

B. CALIBRADOR / PIE DE REY

$$Diametro = 8{,}1\ mm$$
$$Altura = 5{,}75\ mm$$
$$Minima\ medida = 0{,}05mm$$
$$\frac{0{,}05}{2} = 0.025\ mm = 2{,}5X10^{-2}mm$$
$$Diametro = 8{,}1\ mm \pm 2{,}5X10^{-2}mm$$
$$Altura = 5{,}75\ mm \pm 2{,}5X10^{-2}mm$$

C. FLEXOMETRO

$$Diametro = 9{,}0\ mm$$
$$Altura = 4{,}9\ mm$$
$$Minima\ medida = 1\ mm$$
$$\frac{1\ mm}{2} = 0.5\ mm = 5X10^{-1}mm$$
$$Diametro = 9{,}0\ mm \pm 5X10^{-2}mm$$
$$Altura = 4{,}9\ mm \pm 5X10^{-2}mm$$

3. VOLUMEN CILINDRO

5. Flexómetro (cilindro)

Diametro = 9,0 mm
Altura = 49 mm
Masa = 9,7 g

$9\,mm \times \frac{1\,cm}{10\,mm} = 0{,}9\,cm$

$49\,mm \times \frac{1\,cm}{10\,mm} = 4{,}9\,cm$

$5\times10^{-1}\,mm \times \frac{1\,cm}{10\,mm} = 0{,}05\,cm = 5\times10^{-2}\,cm$

- Error

Diametro = $9{,}0\,mm \pm 1\,mm$ $\quad \frac{1}{2} = 0{,}5\,mm$

Altura = $49\,mm \pm 1\,mm$

$9\,mm \pm 5\times10^{-1}\,mm$

$49\,mm \pm 5\times10^{-1}\,mm$

cm

$9\times10^{-1} \pm 5\times10^{-2}\,cm$

$49\times10^{-1} \pm 5\times10^{-2}\,cm$

Masa = $9{,}7\,g \pm 1\times10^{-1}\,g = 9{,}7\,g \pm 5\times10^{-2}\,g$

$\rho = \frac{m}{V}$

- Volumen

$V = \pi \cdot r^2 \cdot h$

Diametro = $9\times10^{-1} \pm 5\times10^{-2}\,cm$ $\longrightarrow$ $\frac{9\times10^{-1}}{2} = \frac{0{,}9}{2} = 0{,}45$

Altura = $49\times10^{-1} \pm 5\times10^{-2}\,cm$

$\frac{0{,}05}{2} = 0{,}025.$

$45\times10^{-2} \pm 25\times10^{-3}$

$r^2 = (45\times10^{-2}).(45\times10^{-2}) \pm \left(45\times10^{-2} \cdot (25\times10^{-3}) + (45\times10^{-2} \cdot (25\times10^{-3})\right)$

$(45\times10^{-2} \cdot (2{,}5\times10^{-2}) + (45\times10^{-2} \cdot (2{,}5\times10^{-2}))$

$r^2 = 0{,}2025$

$= 20{,}25\times10^{-2}$

$= 2025\times10^{-4} \pm (18\times10^{-4} + 18\times10^{-4})$

$= 2025\times10^{-4} \pm 36\times10^{-4}\,cm^2$

$r^2.h = (2025\times10^{-4}).(49\times10^{-1}) \pm \left(2025\times10^{-4} \cdot (5\times10^{-2}) + 49\times10^{-1} \cdot (36\times10^{-4})\right)$

$r^2.h = (2{,}025\times10^{-1}).(49\times10^{-1}) \pm \left(20{,}25\times10^{-2} \cdot (5\times10^{-2}) + 49\times10^{-1} \cdot (0{,}036\times10^{-1})\right)$

$r^2.h = 99{,}225\times10^{-2} \pm (101{,}25\times10^{-4} + 1{,}764\times10^{-1})$

$r^2.h = 99{,}225\times10^{-2} \pm (0{,}10125\times10^{-1} + 1{,}764\times10^{-1})$

$r^2.h = 99{,}225\times10^{-2} \pm 18{,}6525\times10^{-2}\,cm^3$

$\pi.r^2.h = \pi \cdot (99{,}225\times10^{-2}) \pm \pi \cdot (18{,}6525\times10^{-2})\,cm^3$

$= 3{,}12 \pm 0{,}59\,cm^3$

$V_{cilindro} = 3{,}12 \pm 59\times10^{-2}\,cm^3 = 3{,}1 \pm 59\times10^{-2}\,cm^3$

4. MASA CILINDRO

$$m_{cilindro} = 9{,}7\ g$$
$$Minima\ medida = 0{,}1\ g$$
$$\frac{0{,}1g}{2} = 0{,}05\ g = 5X10^{-2}g$$
$$m_{cilindro} = 9{,}7\ g\ \pm\ 5X10^{-2}g$$

5. DENSIDAD CILINDRO

FLEXOMERO

$$\rho = \frac{m}{V} \qquad \pm \frac{(b\Delta c + c\Delta b)}{c^2}$$

b: masa = $9{,}7g \pm 5\times10^{-2}g$

c: volumen = $3{,}12 \pm 59\times10^{-2}cm^3$

$$\rho = \frac{9{,}7}{3{,}1} \pm \frac{(9{,}7\times(59\times10^{-2})) + (3{,}1\ \times(5\times10^{-2}))}{(3{,}1)^2}$$

$5{,}723 \approx 57\times10^{-1}$

$$\rho = 3{,}1 \pm \frac{(572{,}3\times10^{-2}) + (15{,}5\times10^{-2})}{9{,}61}$$

$1{,}5$

$0{,}155$

$0{,}2$

$$\rho = 3{,}1 \pm \frac{5{,}7 + 0{,}2}{9{,}6}$$

$$\rho = 3{,}1 \pm \frac{57\times10^{-1} + 2\times10^{-1}}{96\times10^{-1}} = 3{,}1 \pm \frac{59\times10^{-1}}{96\times10^{-1}} = 3{,}1 \pm 0{,}614$$

$$\rho = 3{,}1 \pm 61\times10^{-2}\ \frac{g}{cm^3}$$

Aluminio $2{,}7\ g/cm^3$

Porcentaje de error

$$\%\ Error = \left|\frac{V_{teor} - V_{exp}}{V_{exp}}\right| \times 100$$

$$\begin{array}{r} 3{,}1 \\ 2{,}7 \\ \hline -0{,}4 \end{array}$$

$$\%\ Error = \left|\frac{2{,}7 - 3{,}1}{3{,}1}\right| \times 100 = \left|\frac{-0{,}4}{3{,}1}\right| \times 100$$

$$= |-0{,}129| \times 100 = |-0{,}1| \times 100 = 0{,}1 \times 100 = 10\%$$

CALIBRADOR

5. Calculo de la densidad

Calibrador

Diametro = 8,1 mm
Altura = 5,75 mm
Masa = 9,7 g

$$\rho = m V_c^{-1}$$

$$\rightarrow V_c = V_c \pm \Delta V_c$$

$$V_c = \pi r^2 h \pm \Delta V_c$$

$$r = \frac{d}{2} = \frac{8,1\,mm}{2} = 4,05\,mm = 4,05 \times 10^{-1}\,cm$$

$$V_c = \pi (4,05\,mm)^2 (5,75\,mm) \pm \Delta V_c$$

$$V_c \approx 9,431\pi \times 10^{-1}\,mm \pm \Delta V_c \approx 2,962 \times 10^{-2}\,mm \pm \Delta V_c$$

$$9,962 \times 10^{-2}\,mm^3 \left(\frac{1\,cm^3}{10\,mm^3}\right) = 9,962 \times 10^{-3}\,cm^3$$

$$\Delta V_c = \left|\left(\frac{\partial V_c}{\partial r}\right)\right|\Delta r + \left|\left(\frac{\partial V_c}{\partial h}\right)\right|\Delta h \rightarrow \left| h \cancelto{0}{\frac{d(\pi r^2)}{dh}} + \pi r^2 \frac{d(h)}{dh} \right| \Delta$$

$$\cdots + \left| h \frac{d(\pi r^2)}{dr} + \pi r^2 \cancelto{0}{\frac{d(h)}{d(r)}} \right| \Delta h \rightarrow \pi r^2 \Delta r + h 2\pi r \Delta h$$

$$\Delta r = 5 \times 10^{-4}\,m \left(\frac{100\,cm}{1\,m}\right) = 5 \times 10^{-2}\,cm$$

$$\Delta h = 5 \times 10^{-2}\,cm$$

$$\Delta V_c = \pi (4,05 \times 10^{-1}\,cm)^2 (5 \times 10^{-2}\,cm) + 2\pi (4,05 \times 10^{-1}\,cm) \cdot$$
$$(5,75 \times 10^{-1}\,cm)(5 \times 10^{-2}\,cm) = 9,9 \times 10^{-2}\,cm$$

$$V_c = 9,962 \times 10^{-3}\,cm^3 \pm 9,9 \times 10^{-2}\,cm^3$$

$$\rho = m \cdot V^{-1}$$

$$\Delta \rho = \left|\left(\frac{\partial \rho}{\partial m}\right)\right| \Delta m + \left|\frac{\partial \rho}{\partial V}\right| \Delta V$$

$$\Delta \rho = \left| \left(\frac{1}{V}\right) \frac{d(m)}{dm} + m \frac{\cancel{d\left(\frac{1}{V}\right)}^{\,0}}{\cancel{dm}} \right| \Delta m + \left| \left(\frac{1}{V}\right) \frac{\cancel{dm}^{\,0}}{dV} + \frac{m\left(\frac{1}{V}\right)}{dV} \right| \Delta V$$

$$\Delta \rho = \frac{1}{V} \Delta m + m \left|\left(-\frac{1}{V^2}\right)\right| \Delta V = \frac{\Delta m}{V} + \frac{m \Delta V}{V^2}$$

$$\Delta m = 1{,}2345 \times 10^{-1}\, g \quad ; \quad \Delta V = 9{,}9 \times 10^{-2}\, cm^3$$

$$\Delta \rho = \frac{1{,}2345 \times 10^{-1}\, g}{9{,}962 \times 10^{-2}} + \frac{9{,}7\, g\, (9{,}9 \times 10^{-2}\, cm^3)}{(9{,}962 \times 10^{-2}\, cm^3)^2}$$

$$\Delta \rho \approx (1{,}05 \times 10^{-2})\, g/cm^3$$

$$\rho = \rho \pm \Delta \rho = \frac{9{,}7\, g}{(9{,}962 \times 10^{-2})\, cm^3} \pm (1{,}05 \times 10^{-2})\, g/m^3$$

$$= (100{,}831 \times 10^{-2} \pm 1{,}05 \times 10^{-2})\, g/cm^3$$

$$\rho = \rho \pm \Delta \rho = \frac{9{,}7\, g}{(9{,}962 \times 10^{-2})\, cm^3} \pm (1{,}05 \times 10^{-2})\, g/m^3$$

$$= (100{,}831 \times 10^{-2} \pm 1{,}05 \times 10^{-2})\, g/cm^3$$

Porcentaje de error

$$E\% = \left| \frac{V.Teo - V.Exp}{V.exp} \right| \times 100 = \left| \frac{(2{,}7 - 100{,}831)}{100{,}831} \right| \times 100$$

$$= 97{,}32\%$$

6. CAIDA LIBRE 2M

TIEMPO

$t_1 = 0,6\ s$
$t_2 = 0,65\ s$
$t_3 = 0,44\ s$
$t_4 = 0,67\ s$
$t_5 = 0,21 s$
$t_6 = 0,49\ s$
$t_7 = 0,43\ s$
$t_8 = 0,52\ s$
$t_9 = 0,62\ s$
$t_{10} = 0,34\ s$
$t_{11} = 0,46\ s$
$t_{12} = 0,45\ s$
$t_{13} = 0,63\ s$
$t_{14} = 0,41\ s$
$t_{15} = 0,34\ s$

VALOR CENTRAL

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$\bar{x} = \frac{\begin{pmatrix} 6 + 6,5 + 4,4 + 6,7 + 2,1 + 4,9 + 4,3 + 5,2 \\ +6,2 + 3,4 + 4,6 + 4,5 + 6,3 + 4,1 + 3,4 \end{pmatrix} \times 10^{-1} s}{15}$$

$$\bar{x} = \frac{7,26 s}{15}$$

$$\bar{x} = 0,484 s$$

$$\bar{x} = 4,84 \times 10^{-1} s$$

ERROR DEL VALOR CENTRAL

Error (Desviación estandar) =

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} \rightarrow \text{sea } S = \sum_{i=1}^{n} (x_i - \bar{x})^2$$

-> Entonces $S_i = (x_i - \bar{x})^2$:

$S_1 = 1,345 \times 10^{-2}\ s^2$

$S_2 = 2,755 \times 10^{-2}\ s^2$

$S_3 = 1,936 \times 10^{-3}\ s^2$

$S_4 = 3,459 \times 10^{-2}\ s^2$

$S_5 = 7,507 \times 10^{-3}\ s^2$

$S_6 = 3,6 \times 10^{-5}\ s^2$

$S_7 = 2,916 \times 10^{-3}\ s^2$

$S_8 = 1,296 \times 10^{-3}\ s^2$

$S_9 = 1,849 \times 10^{-2}\ s^2$

$S_{10} = 2,073 \times 10^{-2}\ s^2$

$S_{11} = 5,76 \times 10^{-4}\ s^2$

$S_{12} = 1,156 \times 10^{-3}\ s^2$

$S_{13} = 2,131 \times 10^{-2}\ s^2$

$S_{14} = 5,476 \times 10^{-3}\ s^2$

$S_{15} = 2,073 \times 10^{-2}\ s^2$

$$S = 2,66 \times 10^{-1}\ s$$

$$\frac{S}{n-1} = \frac{2,66 \times 10^{-1}}{14}\ s = 1,9 \times 10^{-2}\ s$$

$$\sigma = \sqrt{\frac{S}{n-1}} = \sqrt{1,9 \times 10^{-2}\ s^2} = 1,378 \times 10^{-1}\ s$$

En conclusión el dato de tiempo de caída de forma aproximada es de =

$$t = 4,84 \times 10^{-1}\ s \pm 1,378 \times 10^{-1}\ s$$

7. GRAVEDAD

7.

$Y = 0{,}5gt^2$ $\qquad g = \frac{Y}{0{,}5\cdot t^2}$

$Y = 2m \pm 0{,}01m = 0{,}005m$

$= 2m \pm 5\times10^{-3}m$

$t = 48{,}4\times10^{-2} \pm 14\times10^{-2}s$

$\frac{1}{0{,}5}\cdot\frac{Y}{t^2} = 0{,}5g\cdot\frac{1}{0{,}5}$

$\frac{Y}{0{,}5\cdot t^2} = g$

$t^2 = (48{,}4\times10^{-2})\cdot(48{,}4\times10^{-2}) \pm (48{,}4\times10^{-2}\cdot(14\times10^{-2}) + 48{,}4\times10^{-2}\cdot(14\times10^{-2}))$

$t^2 = 0{,}234256 \pm (0{,}06776 + 0{,}06776)$

$t^2 = 2{,}34\times10^{-1} \pm (6{,}8\times10^{-2} + 6{,}8\times10^{-2})$

$t^2 = 2{,}34\times10^{-1} \pm (13{,}6\times10^{-2})$

$0{,}5\cdot t^2 = (0{,}5)\cdot(2{,}34\times10^{-1}) \pm (0{,}5)\cdot(13{,}6\times10^{-2})$

$= 0{,}117 \pm 0{,}068$

$= 11{,}7\times10^{-2} \pm 6{,}8\times10^{-2}$

$g = \frac{2m}{11{,}7\times10^{-2}s^2} \pm \frac{\overset{0{,}136}{(2m\cdot(6{,}8\times10^{-2}s^2))} + \overset{(117\times10^{-3})}{(11{,}7\times10^{-2}s^2\cdot(5\times10^{-3}m))}}{(11{,}7\times10^{-2}s^2)^2}$

$g = 17{,}09401709\,m/s^2 \pm \frac{136\times10^{-3}m\cdot s^2 + 585\times10^{-3}s^2\cdot m}{0{,}013689\,s^4}$

$g = 1709\times10^{-2}m/s^2 \pm \frac{721\times10^{-3}s^2\cdot m}{13{,}7\times10^{-3}s^4}$

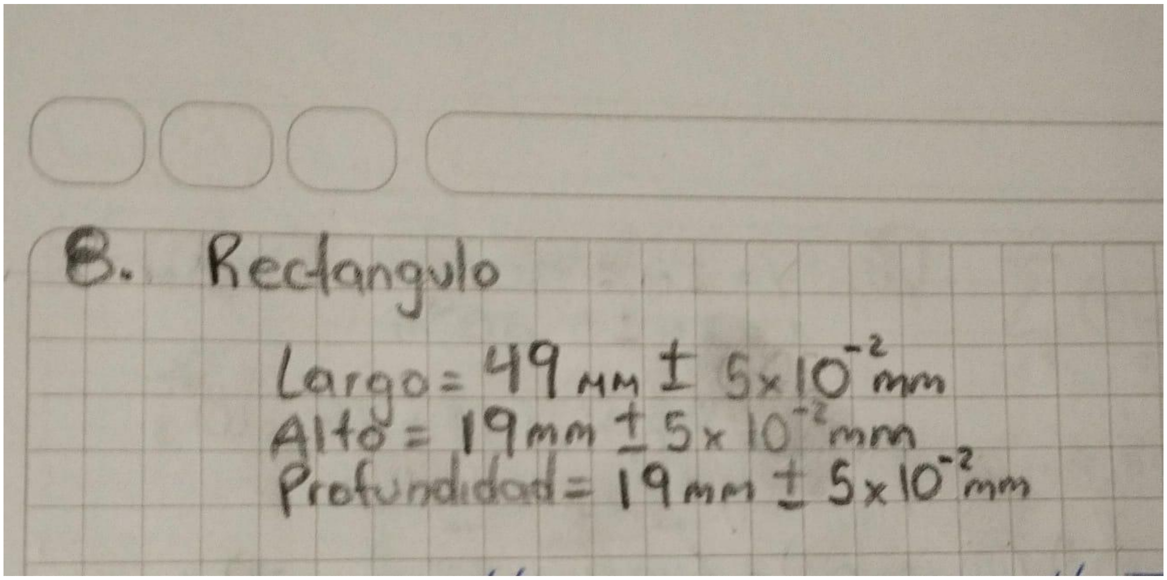
$g = 1709\times10^{-2}m/s^2 \pm 52{,}62773723\,m/s^2$

$\boxed{g = 1709\times10^{-2}m/s^2 \pm 5263\times10^{-2}m/s^2}$

$\%\ Error = \left|\frac{V_{teo} - V_{exp}}{V_{exp}}\right|\times100 = \left|\frac{977\times10^{-2} - 1709\times10^{-2}}{1709\times10^{-2}}\right|\times100$

$\left|\frac{-732\times10^{-2}}{1709\times10^{-2}}\right|\times100 \quad |-0{,}428|\times100 = \boxed{42{,}8\ \%}$

8. MEDIDAS RECTANGULO



9. VOLUMEN RECTANGULO

CALIBRADOR / PIE DE REY

$Diametro = 4{,}9\ cm$

$Altura = 1{,}9\ cm$

$Produndidad = 1{,}9\ cm$

$Minima\ medida = 0.01\ mm$

$\frac{0.05mm}{2} = 0{,}025\ mm = 0.0025 = 2{,}5X10^{-3}$ cm

$Altura = 4{,}9\ cm \pm 2{,}5X10^{-3}\ cm$

$Ancho = 1{,}9\ cm \pm 2{,}5X10^{-3}\ cm$

$Profundidad = 1{,}9\ cm\ \pm 2{,}5X10^{-3}\ cm$

$FORMULA\ VOLUMEN: bxhxa$

$bxh = [(4{,}9cm\ )\ (1{,}9cm\ )] \pm [4{,}9cm(2{,}5X10^{-3}\ cm) + 1{,}8cm\ (2{,}5X10^{-3}\ cm)]$

$bxh = 9{,}31\ cm^2 \pm 16.75X10^{-3}\ \ cm^2$

$bxhxa = [(9{,}31\ cm^2\ )\ (1{,}9\ cm\ )]$
$\pm [9{,}31\ cm^2\ \ (2{,}5X10^{-3}\ cm) +\ \ 1{,}9\ cm(16.75\ cm^2X10^{-3}cm^2\ )]$

$bxhxa =\ 17.69\ cm^3 \pm\ \ 55.1\ cm^3\ X10^{-3}\ cm^3$

11. DENSIDAD RECTANGULO

$$p = \frac{m}{v}$$

$$p = \frac{m}{v} \pm \frac{(m\Delta v \ + v\Delta m)}{v^2}$$

$$p = \frac{33.55\ g}{17.69\ cm^3} \pm \frac{(33.55\ g(55.1\ x\ 10^{-3}\ cm^3)\ + 17.69\ cm^3(5\ x\ 10^{-2}g))}{(17.69\ cm^3)^2}$$

$$p = 1.90\ \frac{g}{cm^3} \pm \frac{(1848.6\ x\ 10^{-3}\ g\ cm^3 + 88.45\ x\ 10^{-2}\ g\ cm^3)}{(17.69\ cm^3)^2}$$

$$p = 1.90\ \frac{g}{cm^3} \pm \frac{(184.86\ x\ 10^{-2}\ g\ cm^3 + 88.45\ x\ 10^{-2}\ g\ cm^3)}{(17.69\ cm^3)^2}$$

$$p = 1.90\ \frac{g}{cm^3} \pm \frac{(273.31\ x\ 10^{-2}\ g\ cm^3)}{(17.69\ cm^3)^2}$$

$$p = 1.90\ \frac{g}{cm^3} \pm \frac{(273.31\ x\ 10^{-2}\ g\ cm^3)}{312.94\ \ cm^6}$$

$$p = 1.90\ \frac{g}{cm^3} \pm 0.87\ x\ 10^{-2}\ \frac{g}{cm^3}$$

Material con el cual se va a comparar= Calcio

$$p_{Calcio}\ = \ 1.58\ \frac{g}{cm^3}$$

$$\%Error\ = \ \left|\frac{Vteo - Vexp}{Vexp}\right| x\ 100$$

$$\%Error = \left|\frac{1.58\ \ - 1.90}{1.90\ \frac{g}{cm^3}}\right| x\ 100$$

$$\%Error = 16.84$$

14. VOLUMEN ESFERA Y COMPARACION

$$V = \frac{4}{3}\pi\, r^3$$

CALIBRADOR / PIE DE REY

$$Diametro = 20{,}6\, mm \pm\ 2{,}5X10^{-2}mm$$
$$Radio = 10{,}3\ mm \pm 2{,}5X10^{-2}mm$$
$$\frac{0{,}05}{2} = 0.025\ mm = 2{,}5X10^{-2}mm$$

$$rxr = [(10{,}3\ mm\ )\ (10{,}3\ mm\ )] \pm [10{,}3\ mm(2{,}5X10^{-2}mm) + 10{,}3\ mm(2{,}5X10^{-2}mm)]$$

$$rxr = 106{,}09\ mm^2 \pm 51.5X10^{-2}\ mm^2$$

$$rxrxr = [(106{,}09\ mm^2\ )\ (10{,}3\ mm\ )] \pm [106{,}09\ mm^2\ \ (25X10^{-2}\ cm) + 10{,}3\ mm(51.5\ mm^2X10^{-2})]$$

$$rxrxr = 1092.7\ mm^3 \pm 3182.7cm^3\ X10^{-2}\ mm^3$$

$$V = \frac{4}{3}(3.14)(1092.7\ mm^3 \pm\ 318{,}27mm^3\ X10^{-2}\ mm^3)$$
$$V = 13324{,}9\ mm^3 \pm 318{,}27mm^3X10^{-2}\ mm^3$$
$$V = 1332{,}49\ cm^3 \pm\ 318{,}27X10^{-3}\ cm^3$$
$$V = 1{,}3\ X10^3cm^3 \pm\ 318{,}27X10^{-3}\ cm^3$$

$$\rho_{ESFERA} = \frac{m}{v}$$
$$\rho_{ESFERA} = \frac{28{,}6\ g}{1{,}3\ X10^3cm^3 \pm 318{,}27X10^{-3}\ cm^3}$$
$$\rho_{ESFERA} = 22\frac{g}{cm^3} \pm 318{,}27X10^{-3}\ \frac{g}{cm}^3$$

$$\rho_{esfera\ teorica} = 19.34\ \frac{g}{cm}^3$$

$$\%ERROR = \frac{19.34\frac{g}{cm}^3 - 22\frac{g}{cm^3} \pm\ 318{,}27X10^{-3}\ \frac{g}{cm}^3}{22\frac{g}{cm^3} \pm\ 318{,}27X10^{-3}\ \frac{g}{cm}^3} XI100I$$

$$\%ERROR = 12.09\frac{g}{cm^3} \pm 318{,}27X10^{-3}\ \frac{g}{cm}^3$$

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