

### Question #78803, Chemistry / General Chemistry

A 20 mL pipette was calibrated and found to deliver a volume of 19.996 mL with an uncertainty of 0.042 mL. The masses of this same liquid delivered by this pipette were 18.001 g, 18.005 g, and 18.008 g. Calculate the relative uncertainty (only) associated with the density of the liquid. Please report an answer in decimal form, accurate to four decimal places. Do not use Scientific notation, and do not include the units when entering your answer.

#### Solution

1. Find value of mass with absolute uncertainty.

The masses given are : 18.001 g, 18.005 g, 18.008 g.

The range of these measurements is: 18.008 g -18.001 g= 0.007 g

The absolute uncertainty is half of this: 0.007 g/2 = 0.0035 g = 0.004 g

The average of these measurements is :  $\frac{18.001+18.005+18.008}{3} = 18.005 \text{ g}$

Complete value with absolute uncertainty is: Mass =18.005±0.004 g

2. Find density of the liquid.

$$d = m/V$$

We should divide two values, each with its uncertainty.

$$V = 19.996 \pm 0.042 \text{ mL} = 19.996 \pm 0.042 \text{ cm}^3$$

$$m = 18.005 \pm 0.004 \text{ g}$$

$$d = \frac{m}{V} = \frac{18.005 \text{ g}}{19.996 \text{ cm}^3} = 0.900 \frac{\text{g}}{\text{cm}^3}$$

Find the uncertainty:

$$\text{Proportional uncertainty (V)} = \frac{0.042}{19.996} = 0.0021 = 0.002 \text{ (rounded to 3dp)}$$

$$\text{Proportional uncertainty (m)} = \frac{0.004}{18.005} = 0.0002 = 0.000 \text{ (rounded to 3dp)}$$

$$\text{Absolute uncertainty (d)} = 0.002 + 0.000 = 0.002$$

Complete value of density with absolute uncertainty: density=0.900±0.002

3. Find relative uncertainty (only) associated with the density of the liquid.

$$\text{Relative uncertainty is: } \frac{0.002}{0.900} = 0.0022$$

**Answer: 0.0022**