Treatment of Uncertainties in Calculations

Error Propagation -> The estimation of an overall uncertainty based on component parts.

Absolute Uncertainty -> The comparison between the measurement you need to take and the accuracy of the instrument you are using. If for example you were to measure 20.1 cc of water in a 50 cc burette, your absolute uncertainty would be ±0.1 cc

The Percent Uncertainty or Fractional Uncertainty can be calculated by:

( Absolute Uncertainty / Measured Value ) × 100

If you are **adding two volumes or two masses**, them the absolute uncertainties are merely **added ONLY, even when you are doing subtraction**.

The **maximum absolute uncertainty** is the sum of the individual uncertainties.

If you are **multiplying, dividing, or using exponents** :

- You have to calculate the percent uncertainties using (Absolute / Value) x 100.

-Add the **percent** uncertainties.

-Convert the overall percent uncertainty back to a numerical quantity by setting up a proportion.

Examples for adding uncertain values ->

Initial Temp = 34.50 (±0.05)

Final Temp = 45.21 (±0.05)

ΔT = 45.21 – 34.50 = 10.71 (±0.05 + ±0.05 = ±0.1)

ΔT = 10.7 (±0.1) *The final answer is recorded with one decimal place because the uncertainties are also considered part of the calculations. According to the rules of sig figs, because the uncertainties have one significant figure after the decimal place, the final answer must also.*

Examples for multiplication of uncertain values->

Mass = 9.24 g (±0.05g)

Volume = 14.1cm3 (±0.5cm3)

Calculate density = 9.24/14.1 = 0.655 g/cm3

Convert absolute uncertainties to percentages by dividing the absolute uncertainties by their respective values.

0.05/9.24 = 0.54% error

0.5/14.1 = 3.55% error

Add the percent uncertainties: 3.55% + 0.54%

Therefore 0.655 (±4.09%)

4.09% rounds to 4%. *You need to round this because uncertainties can only have 1 sig figs if they are greater than 2%, and 2 sig figs if they are lower than 2%.*

Now in order to get the numerical uncertainty multiply the final density by the percent uncertainty:

0.655 x 4/100 = 0.0262 *Round the numerical uncertainty to two 1 sig fig therefore:*

0.03, finally ensure that the numerical value has the same number of decimal places as the uncertainty and the final answer is

0.66 ± 0.03 g/cm3

Multiplying or dividing an exact number (a number with no decimal places):

Molar masses, Avogadro’s Number, Metric Conversions, 22.4 L/mol (relative volume of gases per mole), 273.15 K to Celsius (Temp Conversions), and any other constants are **EXACT NUMBERS AND DO NOT HAVE UNCERTAINTIES.**

Example : (4.95 ± 0.05) x 10 = (49.5 ± 0.5)

*Note that both the* **actual value***,* **and the uncertainty** *get multiplied by the exact number.*

Powers

When you raise and uncertain value to the nth power, **multiply the percent uncertainty by n.**

**Example:** (4.3 ± 0.5 cm)3 = 4.33 ± ((0.5/4.3) x 3) -> 79.5 (±0.349%) -> (*round so decimal places are equivalent)* 79.5 (±0.3) cm3

Formulas

- Follow order of operations.

- This can require the multiplication and addition of multiple uncertainties.

Repeated Measurements

-If you wanted to find the average of multiple uncertain values, you **DO NOT** do anything with the uncertainty, you only perform operations with the numbers.