M501: MEASUREMENT OF HAZARDOUS SUBSTANCES INCLUDING RISK ASSESSMENT

STUDENT SUPPORT INFORMATION – KEY CALCULATIONS

The following are calculations that are required to be performed on a frequent basis. It is not an absolute list of calculations and reference should be made to the Student Manual for further information.

1. Time Weighted Average – Exposure Standard *(Refer page 39 of Student Manual)*

   The 8-hour reference period may be represented mathematically by:

   $$\frac{C_1T_1 + C_2T_2 + ... + C_nT_n}{8}$$

   Where C_1 is the Concentration for Time period 1, C_2 is the Concentration for Time period T2 and so on.

2. Mixtures – Exposure Standards *(Refer page 42 of Student Manual)*

   $$C_1/TLV_1 + C_2/TLV_2 + \ldots\ldots + C_n/TLV_n \leq 1$$

   C = Airborne concentration for each component

   TLV = Threshold Limit Value (Exposure Standard) for each component

3. Conversion of ppm to mg/m^3 *(Refer to pages 43 & 44 of Student Manual)*

   $$\text{Concentration in mg/m}^3 = \frac{\text{Concentration in ppm x Molecular Weight}}{24.45}$$

   where 24.45 = molar volume of air in litres at NTP conditions (25°C and 1 atm)

4. Basic Statistical Values *(Refer to pages 79& 80 of Student Manual)*

$$AM = \frac{\Sigma X_i}{n}$$

$$SD(s) = \sqrt{\frac{\Sigma (X_i - \bar{X})^2}{n - 1}}$$

Where Σ = sum of data items of X and n is the number of observations

$$GM = e^{\frac{\Sigma (\ell nX)}{n}}$$

$$GSD = e^{\sqrt{\frac{\Sigma (y_i - \bar{y})^2}{n - 1}}}$$

Where $y = \ell nX$ and n = number of observations

Note: If you cannot remember the formulae, a simple way to calculate the geometric mean of a data set is as follows:

a) Multiply all exposure values together

b) Take the ℓn ($\log_e$)

c) Divide by the number of samples

d) Take the antilog (e^x) of this number which is the GM

5. Calculations for Dust Sampling *(Refer to pages 167 & 168 of Student Manual)*

- ***Calculation of Total Volume of Air Sampled***

If we know the flowrate of a sampling pump (as detailed in section 8.5) and the time that sampling was undertaken, we can calculate the total volume of air sampled. For example, if the flowrate was 2.2 L/min and sampling was performed for 7 hours 42 minutes, we can make the following calculation.

Volume (Litres) = 2.2 x 462
= 1,016.4

$$\text{Volume } (m^3) = \frac{1{,}016.4}{1{,}000}$$

= 1.0164 (Note: 1 m^3 = 1000 L)

- ***Calculation of Mass on Filter***

If, for example, we are sampling for respirable or inhalable dust and analysing by gravimetric means, we need to establish the total amount of dust on the filter (usually in mg). This is done by subtracting the pre weight of the filter from the post weight of the filter and correcting for moisture pick-up or loss via a blank correction. Thus the weight of the dust on the filter is:

Mass (mg) = post – pre weight of filter (mg) – blank correction (mg)

Thus, if the pre weight of the filter was 5.76 mg and the post weight of the filter was 7.84 mg and the blank was -0.01 mg, then:

Corrected Mass on Filter (mg) = 7.84 – 5.76 – (-0.01)
= 2.08 – (-0.01)
= 2.08 + 0.01
= 2.09

and the concentration of dust in the atmosphere would therefore be:

$$\text{Concentration (mg/m}^3\text{)} = \frac{2.09}{1.0164}$$

= 2.056

= 2.1*

* (Rounded depending on the uncertainty of the balance used - which was a 5 place microbalance in this case)

Calculations for Organic Vapour Sampling *(Refer to pages 192 – 195 of Student Manual)*

a) Pump and Tube (Active Sampling)

- **Calculation of Total Volume of Air Sampled**

If we know the flowrate of a sampling pump (as detailed in section 8.5) and the time that sampling was undertaken, we can calculate the total volume of air sampled. For example, if the flowrate was 100 mL/min and sampling was performed for 5 hours, we can make the following calculation.

Volume (Litres) = 5 x 60 x 100 / 1,000
= 30

Volume (m^3) = 0.030
($1m^3$ = 1,000 L)

- **Calculation of Mass on Sample Media**

  If the laboratory analysis resulted in 6.3 μg of toluene being measured on the charcoal tube with an assumed desorption efficiency of 100% and zero breakthrough and zero blank, then

  $$\text{Mass (mg) of toluene} = \frac{6.3}{1000} = 0.0063$$

- **Calculation of Concentration**

  Using the formula

  $$\text{Conc (mg/m}^3\text{)} = \frac{M_F + M_R - M_B}{D \times V}$$

  Where
  M_F = mass of analyte in front section (mg)
  M_R = mass of analyte in backup section (mg)
  M_B = mass of blank
  D = desorption efficiency (as a fraction)
  V = volume in m^3

  $$\text{Concentration of toluene mg/m}^3 = \frac{0.0063}{1 \times 0.03} = 0.21$$

b) Diffusion Monitors (Passive Sampling)

The time weighted average concentration of contaminant in mg/m^3 can be calculated from the following expression:

$$C\ (\text{mg/m}^3) = \frac{W\ (\text{micrograms}) \times A}{r \times t\ (\text{minutes})}$$

The time weighted average concentration of contaminant in ppm can be calculated from the following expression:

$$C\text{ (ppm)} = \frac{W\text{ (micrograms)} \times B}{r \times t\text{ (minutes)}}$$

Where

$$A = \frac{1{,}000}{\text{Sampling Rate*}}$$

$$B = \frac{1{,}000 \times 24.45}{\text{Sampling Rate* } \times \text{ Molecular Weight}}$$

r = Recovery coefficient*

W = Mass of compound (µg) collected

t = Sampling time (minutes)

* Information provided by manufacturer

Example Calculations

Contaminant:		Benzene
Length of sampling time (t)		420 minute
Temperature (T)		75 °F
Calculation Constant	A	28.2
	B	8.82
Contaminant weight (W)		27.2µg
Recovery coefficient (r)		0.97

$$C\text{ (mg/m}^3\text{)} = \frac{27.2 \times 28.2}{0.97 \times 420}$$

$$= 1.88\text{ mg/m}^3$$

$$C\text{ (ppm)} = \frac{27.2 \times 8.82}{0.97 \times 420}$$

$$= 0.59\text{ ppm}$$