Math for Occupational Hygienists

Chemicals and standards 1.

INTRODUCTION

- One of the most basic competencies required by any Occupational Hygiene Practitioner (OHyP)is the ability to provide data on the levels of airborne contaminants in work place air – exposure data.
- Measurement techniques result in generation of the key data required to enable the OHyP to calculate and correct levels measured into units comparable to the OEL standard units.
- The ability to perform these basic calculations is an absolute requirement for any Occupational Hygiene Practitioner from OH Technologist level.

1st steps:

- Check units!
- Variability in methods of sampling and analysis cause results and data to be recorded in variable units and one of the key steps for any person performing calculations is to first check the base units of measurement:
  - Flow rates – usually recorded in litres per minute (l/min) or millilitres per minute (ml/min)
  - Volumes – may be recorded in millilitres (ml)≈ (Cubic Centimetres, CC), Litres (l) or cubic metres (m^3)
  - Analysis results – usually recorded and reported in milligrams (mg) or micrograms (µg)

- As most OEL's are reported in units of mg/m^3 it is necessary for conversion of sampling data for air volume sampled to be converted to m^3

Basic conversions for volume:

- $1m^3$ ≈ 1000 litres ≈ 1000 000 millilitres
- So to convert litres to m^3 divide by 1000
- Basic conversions for weight
- 1 gram ≈ 1000 mg ≈ 1000 000 µg - as mg and µg are most common units used for OH results from the analysis labs, units reported in µg must be divided by 1000 to convert to mgs.

Try the following calculations:

1. Convert 728 litres to m^3
2. Convert 1.002 m^3 to litres
3. Convert 275 µg to mg
4. Convert 2.01 mg to µg
5. Convert 0.012g to µg
6. Convert 48000 ml to litres

Answers (1):

Question	equation	result	units
1			
2			
3			
4			
5			
6			

Basic calculations:

- Calculating air volumes from sample flow rates and sampling times:
- **Example 1: for high flow sampling** (1 to 3 **litres**/min)

Air volume (litres) = flow rate (l/min) x time (mins)

However we need the flow rate in m^3 to allow us to correct our result for direct comparison with the standard (in mg/ m^3) so divide result by 1000

$$\textbf{Air volume } (m^3) = \frac{\textbf{flow rate (l/min) x time (mins)}}{\textbf{1000}}$$

You take a sample over a 7 hour and 23 minute sampling period at a flow rate of 1.94 l/min – what is the air volume in m^3?

1. Convert time into mins = (7 x 60) 420 + 23 = 443mins

2. **Air volume (m^3) = $\frac{\text{flow rate (l/min) x time (mins)}}{1000}$**

3. **Air volume (m^3) = $\frac{\text{1.94 (l/min) x 443 (mins)}}{1000}$**

4. Result = 0.86 m^3

Important notes: time correction to minutes and correct units!

Try the following calculations:

1. A sample is taken for 6 hours and 53 minutes at 1.77 l/min. What is the air volume in m^3
2. A sample is taken for 2 hours and 33 minutes at 1.06 l/min. What is the air volume in m^3
3. A sample is taken for 11 hours and 13 minutes at 2.10 l/min. What is the air volume in m^3
4. A sample is taken from 08.06 am until 15.22 pm at 1.93 l/min. What is the air volume in m^3

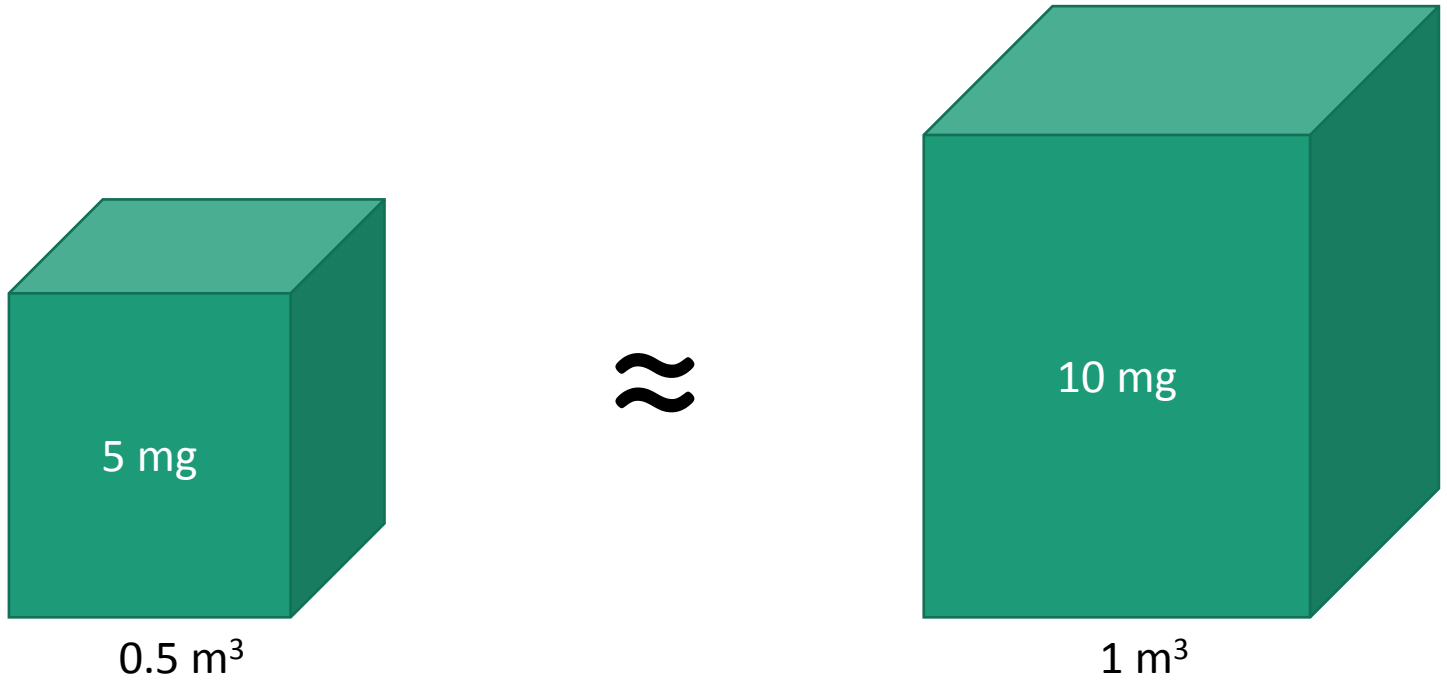
Answers (2):

Question	equation	result	units
1			
2			
3			
4			

Sample results:

- Most results for high flow sampling (dust or gravimetric sampling) are reported in milligrams (mg)
- Correction of your result into mg/m^3 is important for direct comparison to the OEL in mg/m^3
- In real terms you rarely sample exactly $1m^3$ of air so the dust weight is representative of the amount of dust in the air volume you have sampled – say 0.80 m^3
- Thus your result would be X mg/0.8 m^3 this also represents the correction you need to make – divide the dust weight (mg) by your air volume (m^3) to give the equivalent amount of dust in $1m^3$ of air so: mg/m^3

Equivalent mass per volume:



- 5 mg in air volume sampled $0.5\ m^3 \approx 5$ mg divided by $0.5\ m^3 = 10\ mg/m^3$

Calculating airborne particulate results

- The most common result used in particulate calculations is from basic gravimetric sampling where particulates are captured on filters mounted in cassette holders.
- Filters are weighed prior to use in strict laboratory conditions and are reweighed after sampling. By subtracting the weight of the filter (plus correction against laboratory reference filters) the difference is the weight of dust collected
- This is normally reported in mg

Mass on Filter

- Mass (mg)= (post weight of filter - pre weight of filter (mg))+ blank (mg)

- Note: the blank result is also the sum of the post weight of the reference filter minus the pre weight of the reference filter both weighed at the same time as the sample filters:
- Blank weight = post weight of reference filter – pre weight of reference filter = (may be positive or negative result)

Sample Concentration

$$\text{Dust concentration (mg/m}^3\text{)} = \frac{\text{Mass of contaminant (mg)*}}{\text{Sample volume (m}^3\text{)}}$$

* Corrected for blank

Example Calculation

If flow rate was 2.2 l/min and sampling time was 7 hours and 42 minutes

Then:

Volume (L) = 2.2 l/min x 462 (min) =1016.4 litres

$$\text{Volume } (m^3) = \frac{1016.4 \text{ litres}}{1000}$$

$$= 1.02 \ m^3 \text{ (rounded up)}$$

Example Calculation

If the filter pre weight = 5.76 mg

and post weight = 7.84 mg

and blank = - 0.01mg

Corrected mass on filter = 7.84 - 5.75 - (- 0.01)

= 2.08 + 0.01

= 2.09 mg

Example Calculation

Dust concentration (mg/m^3) = $\frac{2.09\ mg}{1.02\ m^3}$

$= 2.049\ mg/m^3$

$= 2.0*mg/m^3$

*rounded based on uncertainty of balance

Calculation of Personal Exposure

Time of sample: 09:12 to 15:45

Flow Rate of Pump = 2.0 l/min

Weight of Filter before exposure: 25.82 mg

Weight of Filter after exposure: 27.21 mg

Weight of blank = - 0.01mg

What is the Personal Exposure?

Calculation of Personal Exposure (3)

Time of sample: 09:12 to 15:45 = mins

Sample Volume =

Sample Volume = litres

Sample Volume = m^3

Mass of material on filter = mg

Personal Exposure =

Personal Exposure = mg/m^3

Calculation desk top practical

Time of sample: 08:45 to 15:30

Flow Rate of Pump = 2.1 l/min

Weight of Filter before exposure: 24.66 mg

Weight of Filter after exposure: 31.84 mg

What is the Personal Exposure in mg/m^3?

Calculation example (4)

Time of sample: 08:30 to 15:40 = mins

Sample Volume =

Sample Volume = litres

Sample Volume = m^3

Mass of material on filter =

Mass of material on filter = mg

Calculation example

Personal Exposure =

Personal Exposure = mg/m^3

Basic calculations:

- Calculating air volumes from sample flow rates and sampling times:
- **Example 2: for low flow sampling** (10 to 200 **millilitres**/min)

Air volume (millilitres) = flow rate (ml/min) x time (mins)

However we need the flow rate in litres or m^3 to allow us to correct result for direct comparison with the standards (in mg/ m^3) so divide result by 1000 for litres or 1 000 000 for m^3

$$\textbf{Air volume (litres)} = \frac{\textbf{flow rate (ml/min) x time (mins)}}{\textbf{1000}}$$

Notes for low flow sampling

- The majority of low flow sampling techniques require flow rates to be set at ml/ min (normally from 20 to 200 ml/min)
- Most external analytical laboratories will report results for VOC's and chemicals sampled at low flow rates in micrograms (µg) and not in milligrams (mg)
- µg/ litre is equivalent to mg/m^3
- Therefore if we divide the laboratory result in µg by an air volume in litres our result can be represented as mg/m^3 This is comparable to our normal standards (OEL's)
  - Result $mg/m^3 = \frac{\text{result I (µg)}}{\text{flowrate (ml) x time (min)/ 1000}}$
- The most important issue is ensuring that you are correcting units as required – look carefully at units!

Notes for low flow sampling

- If you feel more confident using the air volume in m^3 you must also convert the laboratory result by 1000 to convert the µg units to mg – in this case the equation would be:

  - Result mg/m^3 = $\frac{\text{result (µg)/ 1000}}{\text{flowrate (ml) x time (min)/ 1000 / 1000}}$

  - As you can see one of the lower 1000 cancels out the top line 1000 resulting in the previous calculation.

Try the following calculations:

1. A sample is taken for 7 hours and 47 minutes at 99.5 ml/min. What is the air volume in litres
2. A sample is taken for 6 hours and 14 minutes at 101 ml/min. What is the air volume in m^3
3. A sample is taken for 10 hours and 03 minutes at 47 ml/min. What is the air volume in litres
4. A sample is taken from 07.46 am until 16.02 pm at 92.0 ml/min. What is the air volume in litres

Answers (5):

Question	equation	result	units
1			
2			
3			
4			

Try the following calculations:

1. A sample is taken for 7 hours and 47 minutes at 99.5 ml/min. The analytical laboratory report 219 µg of Toluene on the sorbent tube. What is the result in mg/m^3
2. A sample is taken for 6 hours and 14 minutes at 101 ml/min. The analytical laboratory report 78 µg of Hexane on the sorbent tube. What is the result in mg/m^3
3. A sample is taken for 10 hours and 03 minutes at 47 ml/min. The analytical laboratory report 12.9 µg of Benzene on the sorbent tube. What is the result in mg/m^3
4. A sample is taken from 07.46 am until 16.02 pm at 92.0 ml/min. The analytical laboratory report 781 µg of Ethyl Acetate on the sorbent tube. What is the result in mg/m^3

Answers (6):

Question	equation	result	units
1			
2			
3			
4			