PROBLEMS

1. Compute the TWA for the following respirable dust exposures:

Hours	mg/m^3
2	3.0
1	3.5
3	2.0
2	2.5

$$\frac{2(3)+1(3.5)+3(2)+2(2.5)}{8}$$

$$= \frac{20.5}{8} = 2.56\ mg/m^3$$

Has the TLV for respirable dusts been exceeded? $< 3\ mg/m^3$

2. Air contains xylene at 60 ppm (TLV=100 ppm), toluene at 40 ppm (TLV=50 ppm), and trimethylbenzene at 15 ppm (TLV=25 ppm). What is the combined exposure? Is the TLV of the mixture exceeded? solvents – CNS/narcotic effect

$$\frac{TWA_1}{TLV_1} + \frac{TWA_2}{TLV_2} + \frac{TWA_3}{TLV_3} = \frac{60}{100} + \frac{40}{50} + \frac{15}{25} = 2 > 1$$

beyond limit

3. If the vapor pressure of #2 diesel fuel is 1 torr at 70°F, what is the maximum concentration that will occur in an enclosed space? 1 torr = 760 mm Hg

$$SVC_{ppm} = P_p / P \times 10^6$$

$$= \frac{VP}{P} \times 10^6 = \frac{1\ mm\ Hg}{760\ mm\ Hg} \times 10^6 = 1315\ ppm$$

What about for naphthalene, TLV=10 ppm, VP=0.08 torr?

$0.08 \times 1315 = 105$ ppm

What about for p-dichlorobenzene, TLV=10 ppm, VP=0.4 torr?

$0.4 \times 1315 = 526$ ppm

4. A gas cylinder contains 0.10% carbon monoxide in nitrogen. What is the concentration of CO in ppm?

$1\% = 10,000$ ppm

$0.1\% = \frac{0.1}{100} = \frac{0.1(10000)}{1000000} = 1000$ ppm

5. An air stream containing 100 ppm of CCl_4 is metered at 50 ml/min and is mixed with clean air at 4950 ml/min. What is the concentration of CCl_4 in the final mixture?

calc dilution factor × conc = final conc

$\frac{50 \text{ ml/min}}{50 \text{ ml/min} + 4950 \text{ ml/min}} = \frac{50}{5000} = 1/100$

$100(0.01) = 1$ ppm

6. A dental office had small but visible amounts of liquid mercury in every examination room. If the vapor pressure of mercury is 0.0029 mm, and assuming no make-up air, what is the concentration of mercury in ppm and mg/m³? How does this compare to the TLV? (MW=201; TLV=0.025 mg/m³)

$SVC = P_P / P_T \times 10^6 = \frac{0.0029 \text{ mm Hg}}{760 \text{ mm Hg}} \times 10^6 = 3.8$ ppm

$3.8 \text{ ppm} = \text{mg/m}^3 \times \frac{24.45}{MW = 201}$

$\frac{3.8(201)}{24.45} = 31 \text{ mg/m}^3$

7. A 10 liter sample of air was found to contain 1 mg of carbon tetrachloride (MW=154). What is the concentration in ppm?

ppm = mg/m³ × 24.45/MW

$= \frac{1 \text{ mg}}{10 \ell} \times \frac{1}{1 \text{ m}^3 / 1000 \text{L}} = 100 \text{ mg/m}^3$

$= 100 \times 24.45 / 154 = 15.9$ ppm

8. A cylinder of chlorine gas was damaged and released one pound of Cl_2 gas into a closed room of 60'x 30'x 15'. What is the concentration in ppm? (MW=70.9; 454 g/lb; 28.32 L/ft³)

$\frac{1 \text{ lb}(454 \text{ g/lb})(1000 \text{ mg/g})}{(60 \times 30 \times 15 \text{ ft}^3)(28.32 \text{ L/ft}^3)(1 \text{ m}^3/1000 \ell)} = 594 \text{ mg/m}^3$

ppm = mg/m³ (2445/mw)

$= 594(24.45/71)$

$= 204$ ppm

9. An air sample (200 ml/min for 8 hours) was taken for benzene in Denver (air temperature 40°F and barometric pressure 638 mmHg). The lab reported 100 μg of benzene in the sample. What was the concentration of benzene at NTP and how does that compare with the TLV? 100 μg (1 mg/1000 μg) = 0.1 mg

volume = 200 ml/min x 8 hr x 60 min/hr x 1 m³/10⁶ = 0.096 m³

$\frac{0.1 \text{ mg}}{0.096 \text{ m}^3}$ = 1.04 mg/m³ at 638 mm Hg + 40°F

ppm = mg/m³ x 24.45/mw x (760/P)(°R/530)

= 1.04 x 24.45/78 x (760/638)(500/530) = 0.367 ppm < 1 ppm

10. Xylene spilled onto the floor of a lab. The vapor pressure of xylene is 7 mmHg, the flash point occurs at 90°F, and the flammable limits are 0.9-6.7% by volume. The PEL is 900 ppm. What is the maximum concentration of xylene vapor that will occur in an enclosed space? Is the atmosphere hazardous? Why?

SVC = P_p/P x 10⁶ = VP x 1315 = 7 x 1315 = 9205 ppm

LEL = 0.9% = 9000 ppm; > LEL (less than 10% LEL is best practice)

10 x PEL → hazardous

11. How can the OEL for 1,3-dichloropropene (1 ppm) be modified for a 10 hour work day, 4 day work week? adjust stds re odd work shifts

$TLV_{mod} = TLV \times \frac{8}{T_{hrs}} \times \frac{24 - T_{hrs}}{16} = 1 \text{ ppm} \left(\frac{8}{10}\right)\left(\frac{14}{16}\right) = 0.7 \text{ ppm}$

12. How should the TLV be modified for exposure 10 hours/day, 4 day work week to 1,3-dichloropropene with an estimated biological half-life of 17 hours?

$K = \frac{\ln 2}{T_{1/2}} = \frac{0.693}{17} = 0.041$

$t_1 = 10$; $t_2 = 24$ (days worked 4) = 96

$OEL \left(\frac{1-e^{-0.328}}{1-e^{-0.41}}\right)\left(\frac{1-e^{-4.92}}{1-e^{-3.94}}\right)$

$= 1\left(\frac{1-0.72}{1-0.663}\right)\left(\frac{1-0.0073}{1-0.19}\right)$

= 1 (0.279/0.336) (0.992/0.98)

13. Describe the preparation of a 100 ppm standard of acetone using a 10 liter gas bag. How many microliters of liquid acetone are required? MW=58.1, density=0.7972

$C_{ppm} = V_{ml} \cdot R (0.8) \times \frac{24.45}{mwt}$

$V_{ml} = \frac{100 \times 10 \times 58}{0.8 \times 24.45 \times 10^6} = 0.003 \text{ ml} = 3 \mu l$

14. How many microliters of liquid solvent are required to prepare the following standards in a 10 liter gas bag?

SOLVENT	Acetone	Benzene	Ethanol	Toluene
MW	58	78	46	92
DENSITY	0.7972	0.8794	0.7893	0.8660
VP (mmHg)	180	100	57	37
TLV (ppm)	750	0.3	1000	50

CONCENTRATION (ppm) $C_{ppm} = V_{ml}\, \rho \left(\frac{24.45}{MW}\right)(10^6) / V_t$

CONCENTRATION (ppm)	Acetone	Benzene	Ethanol	Toluene
1.0	0.0298	0.0363	0.0238	0.0435
5.0	0.1488	0.181	0.1192	0.2173
10	0.2976	0.363	0.2384	0.4345
50	1.4878	1.81	1.19	2.17
100	2.9756	3.63	2.38	4.35
500	14.8782	18.1	11.9	21.7
1000	29.7565	36.3	23.8	43.5

15. A direct reading organic vapor analyzer was used to monitor for methyl acrylate (PEL = 10 PPM). Ten randomly selected values obtained: 8.4, 10.1, 12.5, 7.6, 6.1, 9.3, 8.5, 10.5, 7.0, 4.3.

A. Calculate the mean. $\bar{x} = \frac{\Sigma x}{n} = \frac{84.3}{10} = 8.43$

B. Calculate the standard deviation. $\sigma = \sqrt{\Sigma (x_i - \bar{x})^2 / n-1} = 2.34$

C. Calculate the 95% confidence interval for the mean.

$\bar{x} \pm 1.645\, \sigma / \sqrt{n}$

$8.43 \pm 1.645 \frac{(2.34)}{\sqrt{10}}$

8.43 ± 1.22

7.21 to 9.65

D. Classify the exposure status.

compliance

16. A charcoal tube and personal pump were used to sample for toluene (PEL = 100 PPM, MW = 92). The flow rate was 200 mL/min for 8 hours. The laboratory reported 50 mg of toluene and gave a CV of 0.09 for sampling and a CV of 0.11 for analysis.

A. What is the concentration of toluene in PPM?

0.2 lpm x 480 min = 96 liter volume

$$\frac{50\text{ mg}}{96\text{ l}} \times \frac{1000\text{ l}}{1\text{ m}^3} = 520.8\text{ mg/m}^3 = 138\text{ ppm}$$

B. Compute the cumulative coefficient of variation.

$$\sqrt{(0.09)^2 + (0.11)^2} = 0.142$$

sampling analysis

C. Compute the 95% confidence interval for the sample.

$$\frac{TWA}{PEL} \pm \frac{1.645\ CV}{\sqrt{n}} = \frac{138}{100} \pm \frac{1.646\ (0.142)}{\sqrt{1}}$$

$$= 1.38 \pm 0.23$$

1.15 to 1.61

D. Classify the exposure status.

overexposure

17. A charcoal tube and personal pump were used to sample for benzene. A flowrate of 100 ml/min. was used for 8 hours. The result was 1.25 ppm with a coefficient of variation of 0.10. The standard is 1.0 ppm. What is the compliance status?

1.25 ± 0.1645

non-compliance

18. If in the above example the sample time was 6 hours, what is the compliance status?

1.33 = 8/6

possible overexposure

19. An oxygen sensor indicates 20.2% oxygen concentration in a tank that stored petroleum distillates (PEL = 400 ppm, LEL = 1100 ppm, IDLH = 10,000 ppm).

difference between 20.2% & 20.9% = 0.7%

A. Is the tank safe for entry? Why or why not?

Not safe.

20.9% O_2 = normal

B. What approximate concentration of displacing gases are in the tank that could produce an oxygen reading of 20.2%?

0.7% = 7000 ppm

20. For the following benzene exposure data in ppm, compute the mean, standard deviation and 95% confidence interval for the mean. Plot the cumulative percent frequency on probability paper. What percent of the time would you expect the exposure to exceed the standard (PEL=1.0 ppm)? Repeat the above with the log-transformed data.

0.68	0.73	0.31	0.46	0.61	1.52	0.48	0.30
0.34	0.36	0.47	0.63	1.35	0.34	0.39	1.04
0.60	0.60	1.29	0.52	0.95	0.98	0.69	0.50
0.91	0.80	2.45	0.55	0.29	0.44	0.26	0.35
0.54	0.34	0.42	0.88	0.41	0.90	0.74	1.56
1.07	1.09	1.03	0.43	1.16	1.00	1.36	0.71
1.21	1.37	0.85	0.49				

$$\bar{X} = \frac{\sum x_i}{n} = 0.764$$

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = 0.428$$

$$CI_{95\%} = \bar{X} \pm 1.645 \frac{\sigma}{\sqrt{n}}$$

$$= 0.76 \pm 1.645 \frac{(0.428)}{\sqrt{52}}$$

$$= 0.76 \pm 0.097$$

$$0.66 \le CI_{95\%} \le 0.86$$