I. ENVH 557 Exposure Controls
M. Yost, Winter 2006 Problem set I (due Thurs. Jan 19, 2006)

1. Fill in the following table, expressing each of these values in both ppm and mg/m^3, assuming standard conditions. If it is not appropriate to do so, say why.

Contaminant	(ppm)	(mg/m^3)
Lead fume		0.24
Styrene	45	
Chlorine	2.4	
cadmium dust		0.07

At the time the styrene concentration given above was measured, the actual ambient temperature was 105^0 F, and the pressure 13.6 psia. These pressure and temperature values were estimated from a crude instrument with a relative uncertainty (repeatability) of +/- 30% and overall stated accuracy of 10%. Compare the concentration of styrene in mg/m^3 to the standard Threshold Limit Values (TLV) or other stated exposure limit you select? What factors should be taken into account when making this comparison, and why are they important?

2. You are using an instrument that measures particle size based on the electrical mobility of the particles (electrical mobility analyzer). The instrument has an "absolute" calibration that depends only on the physical dimensions of the measuring cell. The mobility of collected particles is given by the formula:

$$\text{Mobility} = \frac{VD^2}{LP}$$

Where:

V = air velocity L = collector length
D = collector spacing P = collector voltage

Given the following data, estimate the uncertainty in the mobility measurement, assuming all the errors are independent.

Quantity	Operating value	Error tolerance
velocity (V)	252 fpm	30 fpm
spacing (D)	5.0 mm	0.2 mm
length (L)	6.0 in	1/8 in
voltage (P)	50 volts	5%

Does the uncertainty you estimated refer to the accuracy or the precision of the measurement? What is the worst-case uncertainty in the measurement? To improve the measurements, you can buy an accessory which controls the voltage to within 0.1%.

How much would this improve the uncertainty? What changes would you suggest to improve this instrument?

3. Workers in a fiberglass boat plant experienced exposures to styrene over an 8-hour shift. The following table gives the estimated amounts of styrene released over different time periods during the operation into a room volume of 150 $m.^3$ The room is well mixed and ventilated: your measurements show the airflow into the room is 175 ft^3 /min.

Styrene (grams)	Time (hrs)
0	0.5
120.0	2.5
0.0	2.0
50.0	1.0
0	2.0

Using the dilution ventilation (well mixed room) approach, compute the estimated concentration over time for styrene in each time period and estimate the TWA exposure over 8 hours. State what assumptions you need to make to estimate the exposure and comment on the exposure relative to the TLV = 20 ppm and STEL=40 ppm. Is your analysis likely to give conservative exposure estimates? What factors make your estimate more or less conservative? How would your analysis approach and results change if the airflow were reduced to only 70 ft^3 /min?

4. A person working in a small room of volume V=640 Cuft uses a solvent containing 1 part benzene in 19 parts hexane at a rate of 2 pints/day. The room is ventilated at a rate of 3 air changes per hour. If the solvent evaporates slowly and constantly during the day, estimate the air concentration for each solvent component in both ppm and mg/m^3. What would be the maximum concentration if he spilled half of the day's usage and it evaporated all at once?

5. Compute a Xi (individual value) control chart for the following flow rate data. You are told the first 20 data points represent the normal condition for this measurement. What conclusions can you make from the data? Should the initial data be screened for outliers? Do you think the first 20 points really represents the “in control” condition?

Sample #	Flow L/m
1	0.3
2	15.9
3	9.2
4	23.8
5	4.2
6	6.7
7	14.3
8	7.2
9	3.7
10	11.7
11	7.6
12	15.0
13	16.6
14	25.8
15	2.1
16	17.8
17	10.8
18	14.5
19	14.2
20	22.0
21	49.6
22	47.6
23	49.9
24	51.3
25	47.8
26	51.2
27	52.6
28	52.4
29	53.6
30	52.1