ENVH 557, Winter 2008 _________ANSWER KEY______________

NAME

MIDTERM EXAM Take home exam: Due in class on Thursday 2/21/08

Please show your work.

1. (20 pts) In your own words describe the following terms and indicate how they apply to exposure controls: a. Risk assessment matrix, b. Hierarchy of controls, c. Control chart and control banding, d. Capture velocity

ANS: (a) The RAM is a tool used to rank or prioritize health hazards for control or other actions (such as assessments). It includes an assessment of the consequences or severity of outcomes, and an assessment of the likelihood of the hazard occurring. (b) The hierarchy of controls refers to the order of preference for applying 5 basic control strategies (in order of preference): elimination, substitution, engineering controls, administrative controls and PPE. (c) Control banding is a tool similar to the RAM used to prioritize exposure hazards into those that require the most immediate actions. (d) Capture velocity refers to the concept that if a ventilation hood provides sufficient inlet velocity to overcome room air currents, it will adequately capture or control a contaminant. While a useful concept, it does not address all the variables needed to maintain source control, such as emission rate, volume flow rate, hood or source size, and inlet turbulence.

2. (15 pts) Identify and describe the two principal mechanisms that contribute to hood entry losses. How are these losses characterized in terms of measurements and tabulated values?

ANS: The two main losses at an entry are friction losses and dynamic losses. Friction losses are due to the viscosity of the air and the drag force from air moving over surfaces; dynamic losses are caused by changes in flow direction, which involve transfer of kinetic energy into random turbulence which is dissipated in the fluid. Both these losses in a hood are related to the hood static pressure which can be computed from the entry loss factor or from the hood coefficient of entry.

3. (15 pts) Describe in words and symbols why a hood with less than 100% efficiency will result in a volumetric flow rate less than the ideal flow rate. ANS: The coefficient of entry or Ce is defined by the volume flow rate (Q) into a hood: Ce=Qactual/Qideal = 4005*sqrt(Pv)*A/4005*sqrt(Psh)*A), so Ce = sqrt(Pv/Psh). When Ce=1, the hood static pressure equals the velocity pressure (Pv), and so this represents the ideal situation where all the static pressure is used to move the air and create airflow; in this case all the potential energy of the static pressure is converted without losses into the kinetic energy represented by the velocity pressure (Pv).

4. (15 pts) A person working in a small room of volume V=640 Cft 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. (Part A) If the solvent evaporates slowly and evenly during the day, estimate the air concentration for each solvent component in both ppm and mg/m3. (Part B) What would be the maximum concentration if he spilled half of the day's usage and it evaporated all at once?

ANSWER: Assume an 8 hr day and steady state conditions for the air in the room in part A, so C=G/Q where g is in mass/time and Q is in Volume flow/time. Mixing factor is assumed to be 1 here but you could justify a higher number.

For part B, assume the spill evaporates so fast that the dilution air flow is not significant, therefore we can get the concentration by calculating the mass released and divide by the room volume.

Question 4: Solvent Mixture		Liters/pint	SpGr_benz	SpGr_Hex	Mw_benz	Mw_Hex
Assume an 8 hr day		0.473	0.88	0.66	78.11	86.18
Part A: assume steady state concentration, M=1 (or another #)					8	=hours/day
# pints/day	Liters/day	Fract Benz	L Benz/day	L Hex/day	mg Benz/hr	mg Hex/hr
2	0.946	0.05	0.0473	0.8987	5203.00	74142.75
Room V CuFt	Air Ch/hr	Q = cuft/hr	Q m3/hr			
640	3	1920	54.38			
	Benz mg/m3	Hex mg/m3	ppm Benz	ppm Hex		
	95.7	1363.5	30.0	386.8		
Part B: assume instant release of 1/2 of days usage, and dilution only into the room volume						
Benz mg	Hexane mg	Benz mg/m3	Hex mg/m3	ppm Benz	ppm Hex	
20812.0	296571.0	1143.4	16292.9	357.9	4622.4	

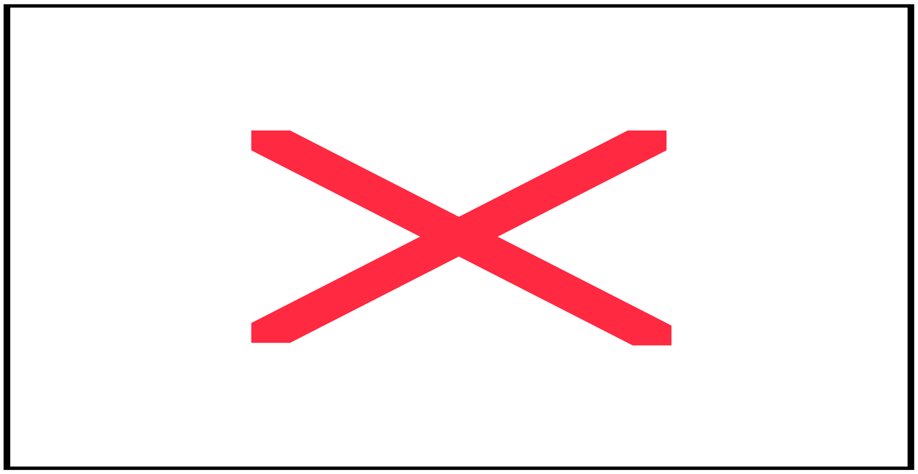
5. (15 pts) You have been asked by a large Northwest manufacturer to evaluate the ventilation in a fabrication facility and make recommendations for improvements. The facility uses a combination of dilution ventilation and local exhaust ventilation. You decide to make some tracer gas measurements to evaluate the overall ventilation effectiveness in one room. You release a known mass of tracer gas into the room, use a fan to mix the tracer with the room air, and then make measurements of the concentration over the next several hours.

a. Draw a sketch of what the concentration measurements look like over time. What equation is convenient and appropriate for these test conditions?

b. If C_{tracer} (at t = 0) = 896 ppm, and C_{tracer} (at t = 95 min) = 321 ppm, how many room air changes per hour are occuring? If the room volume is 12,000 ft^3, what is the effective ventilation rate?

c. If the contaminant of concern has a TLV of 100 ppm, is of moderate toxicity, and is generated at rate of 0.1 cfm, is the ventilation rate measured above sufficient to maintain the steady-state concentration at or below the TLV? Indicate what action must be taken, if any.

ANS: (a) Sketch an exponential decay curve starting at 896 ppm and decaying toward zero
It follows the equation: C(t)= Co exp (-t/tau)



Where t is time starting at t=0 with concentration Co = initial concentration
and tau = V/Q = room time constant. note V = room volume and Q = volume flow rate

(b) For part B we need to find Tau and thus Q

PART B -- FIND TAU AND Q

Co	896	Ppm
Room Vol	12000	CuFt
delta t	95	
C(t=0)	896	Ppm
C(95 min)	321	Ppm
Tau	92.54756	min
Q	129.6631	CuFt/min

(c) For part C, find the steady state concentration = Css = G/Q
This is the concentration that will be reached in the room after a long period of time (i.e. t/tau>>1) with a constant emission rate.

Part C -- find steady state concentration

G = 0.1 CuFt/min

Css= G/Q

Note G is given in cuft/min so Css is already in vol/vol units
and we get ppm if we simply multiply by 1e6

Css 771.2

Note that Css is >> 100 ppm so dilution ventilation is not really a viable option
Without a large increase in airflow

6. (20 pts) Complete the following table.
ANS: Use TP = SP+VP and the sign convention says TP and SP are negative upstream of the fan. Note that if the diameter is constant the VP is constant. Also use TP1=TP2 + losses with the friction loss which is given to find other points. To find the diameter, use Q=VA where V is the velocity and V=4005*sqrt(VP); V=4387ft/min; thus A=0.1965sqft and diameter = 0.5 ft (6”) for a round duct.

Pressure, inches H_2O

Location	**TP**	**SP**	**VP**

1	-2.0	-3.2	1.2
2	-3.3	-4.5	1.2
3	11.1	9.9	1.2
4	10.4	9.2	1.2

Duct is constant diameter, and Fe = 2.17(Pv) per 100 ft
If Q=862 CFM for this system, what diameter is the duct?