

PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination: Semester II

Academic Year: 2009

Date: December 20, 2009

Time: 13:30-16:30

Subject: 230-544 Air Pollution Control Technology
for Gaseous and Particulate Emissions

Room: S201

อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้
ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริต
และพักการศึกษา 1 ภาคการศึกษา

Name _____ Student No. _____

Please do all 6 questions. Show all your work to receive full or partial credit.
Final score is 90. (Total page = 12, including first page)

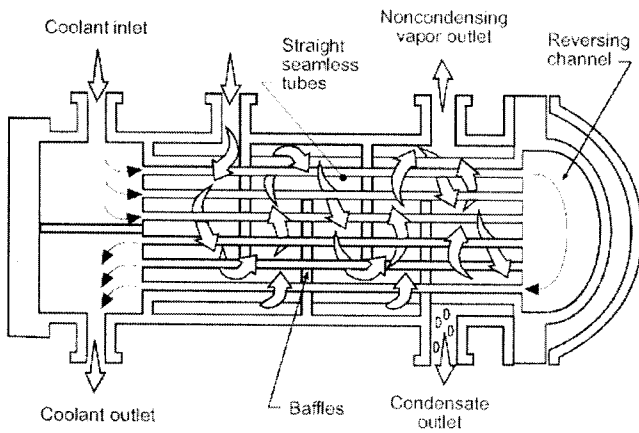
Question #	Total Score	Score
1	15	
2	10	
3	10	
4	20	
5	10	
6	25	
Total	90	

Asst. Prof. Chayanoot Sangwichien

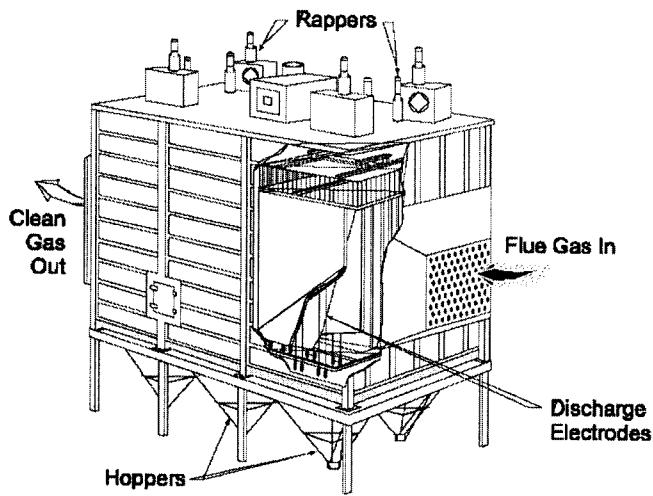
1. (15 points) Express the definition of the following ACRONYM

ACRONYM	DEFINITION
ACFM -	
BACT -	
CAAA -	
NTU -	
NESHAP -	
LEL -	
HAP -	
MACT -	
W.C. -	
SLA -	
SIP -	
MSDS -	
PM ₁₀ -	
EPA -	
NAAQS -	

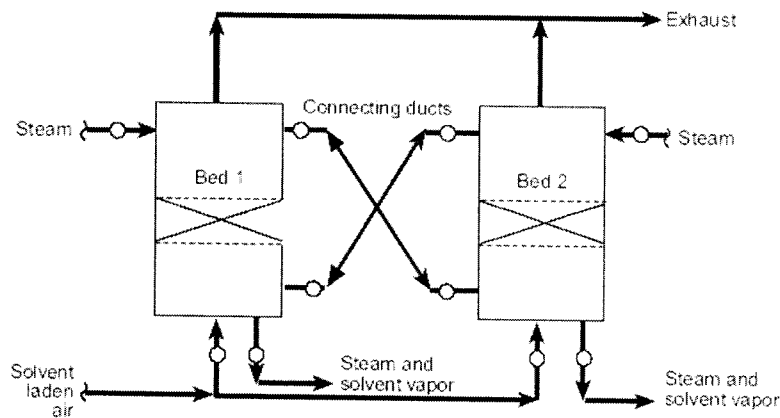
2. (10 points) Name the control technology with the device that is displayed and answer the questions in the spaces provided.



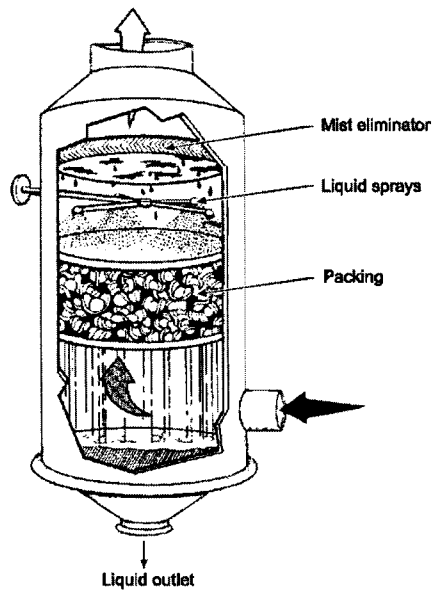
Answer



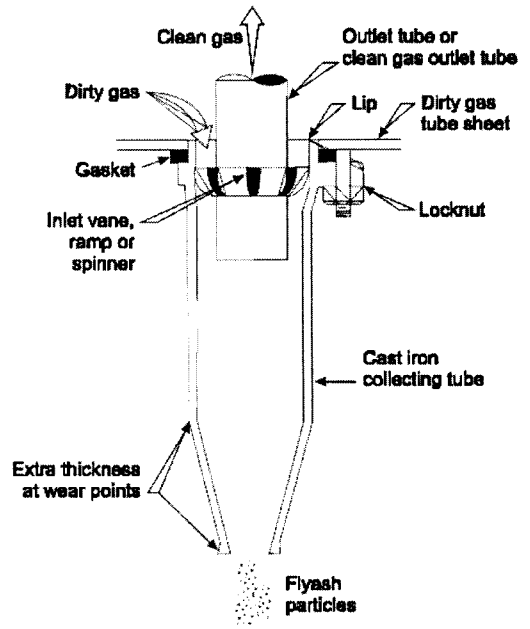
Answer



Answer



Answer



Answer

3. (10 points) Please choose the best answer

3.1 What fraction of the sulfur present in a fossil fuel (i.e. coal, oil) is converted to sulfur dioxide in a utility or industrial boiler?

- a. 25% to 30 %
- b. 50% to 75%
- c. 75% to 90 %
- d. 94% to 95 %
- e. 100 %

3.2 What factors influence the formation of NO_x in a boiler?

- a. Temperatures
- b. Oxygen concentrations
- c. Fuel nitrogen content
- d. All of the above
- e. a and b

3.3 What categories of air pollutants are responsible for the formation of photochemical smog? Select all that apply.

- a. Volatile organic compounds
- b. Nitrogen oxides
- c. Sulfur dioxide
- d. Ammonia
- e. TRS compounds
- f. Carbon monoxide

3.4 Ozone is aair pollutant.

- a. primary
- b. secondary

3.5 What category of sources is most responsible for VOC emissions?

- a. Transportation (automobiles, trucks, planes)
- b. Fuel handling and distribution
- c. Solvent utilization
- d. Fuel combustion
- e. None of the above

3.6 What category of sources is most responsible for sulfur dioxide emissions?

- a. Utility and industrial boilers
- b. Industrial processes
- c. Transportation
- d. None of the above

3.7 What category of sources has the highest NO_x emissions?

- a. Transportation (automobiles, trucks, planes)
- b. Fuel handling and distribution
- c. Solvent utilization
- d. Fuel combustion (electric utilities)
- e. None of the above

3.8 When were National Ambient Air Quality Standards initiated for sulfur dioxide?

- a. 1961
- b. 1970
- c. 1977
- d. 1990

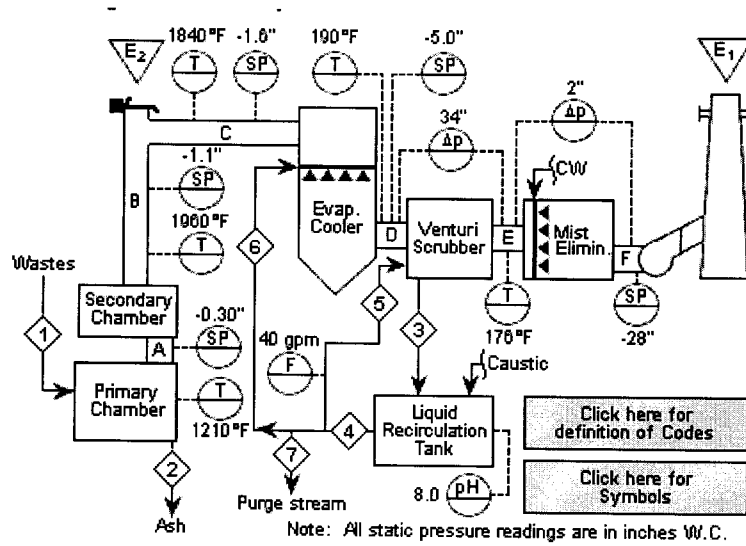
3.9 What type of regulations limits the emission of toxic pollutants?

- a. NSPS
- b. NAAQS
- c. MACTS
- d. BACT

3.10 Why are VOC emission controlled?

- a. To achieve the ozone NAAQS
- b. To achieve the hydrocarbon NAAQS
- c. To achieve the NO_x NAAQS
- d. To achieve the MACTs

4. (20 points) Use the flowchart to answer the following questions.



- i. Draw a temperature profile for the readings provided in the process.
- ii. Do any readings appear inconsistent with the process? Explain.
- iii. Draw a static pressure profile for the readings provided in the process.
- iv. Do any readings appear inconsistent with the process?

-This page is for Problem No. 4 -

5. (10 points) A gas stream contains Carbon Disulfide at 2,000 ppm, Methylene Chloride at 800 ppm, and Styrene at 1,000 ppm. Estimate the UEL for the gas mixture using Le Chatelier approach.

6. (25 points) To design a vapor phase activated carbon treatment unit. Use the following data to answer the following questions.

Given:

Flow rate of air entering a unit: 2,000 ft³/min
 Run time between carbon changes: 3 months/vessel
 Number of carbon vessels: 2 (in series)
 Atmospheric pressure: 12.7 psia
 Temperature of air entering a unit 60 °F
 Contaminants MW and their concentrations in the air phase:

- Perchloroethylene (PCE) 15 ppm (MW = 166)
- Trichloroethylene (TCE) 14 ppm (MW = 131.39)
- Benzene 9 ppm (MW = 78.11)
- Toluene 5 ppm (MW = 92.14)

Activated carbon density = 30 lb_m/ft³

The saturation capacity of contaminant adsorbed per weight of carbon can be estimated from the Freundlich isotherm relationship:

$$\frac{x}{m} = KC^n$$

Where x/m = saturation capacity (per weight of carbon)

C = conc. or partial pressure (psia)

K, 1/n = constant (shown in Table 1)

Table 1 (Freundlich Isotherm Data)

Contaminant	K	1/n	C (psia)	x/m
PCE	1.4	0.156		
TCE	1.4	0.23		
Benzene	1.1	0.131		
Toluene	0.7	0.111		

- i. Calculate C and x/m and fill in Table 1

ii. Determine the weight of each contaminant to be adsorbed per unit time (lb/min) (Given the universal constant, $R = 10.73 \frac{ft^3 psia}{lbmole \cdot R}$)

iii. Determine the amount of carbon needed.

iv. Assume a maximum air velocity through the carbon vessels is 50 ft/min. Calculate the diameter of the vessel.

v. Determine the depth of the carbon in the vessels.