M.E. (Civil) 2nd Semester Final Examination, 2013
AIR POLLUTION CONTROL ENGINEERING
(CE 1019)

Time : 3 hours | Full Marks : 70

Answer any five questions

1. (a) What is stokes diameter for a suspended particle? How it differs from the aerodynamic particle diameter? How are they related mathematically?

(b) What is known as PM_{10}? How is it estimated in a high volume sampler?

(c) Two wet scrubbers are described below. Using the data provided, determine which situation should exhibit better inertial impaction efficiency. Assume a gas viscosity of 1.8×10^{-4} gm/cm·sec. For both Scrubbers #1 and #2, the water droplets are moving in the same direction as the gas stream.

Parameter	Scrubber #1	Scrubber #2
Stokes Particle Size (μm)	10	14
Particle Velocity (m/s)	1	1.5
Particle Density (gm/cm^3)	1.5	1.0
Water Droplet Size (mm)	0.1	0.1
Water Droplet Velocity (m/s)	0.01	0.01
Cunningham Slip Correction Factor	1.7	1.02

(4+4+6)

2. (a) Mention the relative efficiencies of the following control devices for removal of particulate matters – ESP, 1enture scrubber, bag filter, spray tower.

(b) Explain the working principle of an ESP.

(c) Name one adsorbent that is used in air pollution control. Mention the pollutant gas which may be removed by the adsorbent.

(d) How NO_x reduction can be achieved in coal-fired thermal power plants during the combustion process?

(e) Discuss about one process of pre-combustion control that is applied to reduce SO_2 emissions from fossil-fuel combustion.

(3+3+2+3+3)

3. (a) Ozone is an air pollutant – do you agree?

(b) As per the CPCB norms, the ambient air quality standard for SO_2 is 50 μg/m3 (annual average). How the 'annual average' concentration is estimated? Express the concentration in ppm

(c) What are the precursors (which helps formation) of photochemical smog? Name some common components of photochemical smog. What hydrocarbon reacting with OH^- Radical would produce acetaldehyde in photochemical reactions?

(d) Name a device which can be useful to control emissions of particulate matter as well as any of the gaseous pollutant. Briefly describe the principle of operation.

(e) Which is the air pollutant(s), the emission of which is regulated in cement industry?

(2+4+4+3+1)

4. (a) Suppose the following atmospheric altitude versus temperature data have been collected.

Altitude (m)	Temperature (°C)
0	20
100	18
200	16
300	15
400	16
500	17
600	18

What would be the mixing depth?

How high would you expect a plume to rise if it is emitted at 21°C from a 100 m stack if it rises at dry adiabatic lapse rate? Would you expect the plume to be looping, coning, fanning, or fumigating?

(b) The rate of emission of SO_2 from the stack of a power plant is 126.1 g/s. The effective height of the stack is 46 m. Calculate the SO_2 concentration in ppm at a parking lot located 900 m downwind from the stack on a sunny day when the wind velocity is 4m/s. Use class 'C' stability.

(c) How many meters downwind from the stack does the maximum ground-level concentration of SO_2 occur and what is the maximum concentration?

(6+4+4)

5. (a) A power plant of 500MW capacity burns 20 T coals/MW/Day. During thus burning process, the plant has the following information.

Sulphur in coal: 0.5% (weight/weight) Temperature in stack: 125°C

Pressure in stack: 1.1 atm Stack exit velocity: 15m/s Diameter of stack: 10m

Estimate SO_2 concentration in kg/day, ppm & mg/N (normal) m^3

If hydrogen content of coal was 10%(w/w), calculate concentration of SO_2 in mg/Nm^3 on dry basis.

(*Assume complete combustion of sulphur components*)

(b) What is the physical basis for needing the Cunnigham correction to Stoke's law? At roughly what particle size does this correction become important?

(c) Name five particle formation processes. Also indicate the particle sizes corresponding to these formation mechanisms.

(7+3+4)

6. (a) What are the principal factors that cause plume rise for a stack?

(b) A 750 MW coal-fired power plant has a 250 m stack with inside radius 4 m. The exit velocity of the stack gases is estimated at 15 m/s, at a temperature of 140°C. Ambient temperature is 25°C and winds at stack height are estimated to be 5 m/s. Estimate the effective height of the stack if the atmosphere is stable with temperature increasing at the rate of 2°C per km.

(c) Why higher stacks may help reduce the pollution problem?

(d) What is unstable atmosphere with respect to vertical dispersion of air pollutants? Characterise radiation inversion.

(2+6+3+3)

7. (a) Mention two categories of stationary sources of air pollution with examples. What are primary and secondary air pollutants?

(b) How SO_x and NO_x may generate acid by atmospheric reactions to cause acid rain? Mention two reaction pathways for atmospheric generation of each pollutant.

(c) The average ozone concentration is 300 Dobson units. What is 'Dobson unit'? As O_2 can also absorb UV radiation, why presence of O_3 in the stratosphere is considered so important? Show the catalytic reaction how CFC can destroy ozone molecules.

(d) Explain how the presence of certain gases helps warming of the Earth's lower atmosphere.

(3+4+5+2)

8. (a) Estimate the total hydrocarbon concentration at a point 300 m downwind from an expressway at 5:30 P.M. on an overcast day. The wind is perpendicular to the highway and has a speed of 4 m/s. The traffic density along the highway is 8000 vehicles per hour, and the average vehicle speed is 40 miles per hour. The average vehicle emission rate of hydrocarbons is 2×10^{-2} g/s.

(b) Calculate the stoichiometric A/F ratio for a fuel whose average formula is C_8H_{17}. Depict the effect of air-fuel ratio on emissions of a petrol-driven vehicle.

(c) According to the Bharat Stage IV norms for automobile exhaust, which pollutants are monitored in the petrol and diesel-driven automobiles?

(d) How the catalytic convertors are helpful in reducing the automotive pollution? How does the effectiveness of a catalytic convertor depend on air-fuel ratio?

(4+4+2+4)

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