Indian Institute of Technology Delhi
ESL 330 ENERGY, ECOLOGY AND ENVIRONMENT

Major **Total Marks: 30**

1. Suppose a bonfire emits CO at the rate of 20 g/s on a clear night when the wind is blowing at 2 m/s. If the effective stack height at the fire is 6 m, (a) what would you expect the ground-level CO concentration to be at 400 m downwind? (b) Estimate the maximum ground-level concentration. Consider normalized concentration as $3.8\times10^{-3}/m^2$ [3+2=5]

2. For stability class C, the ratio of σ_y/σ_z is essentially a constant, independent of distance x. Assuming it is a constant,
   (a) show that the distance downwind from a stack at which the maximum concentration occurs corresponds to the point where $\sigma_z = H/\sqrt{2} = 0.707\,H$.
   (b) show that the maximum concentration is

$$C_{max} = \frac{Q}{\pi\sigma_y\sigma_z u e} = \frac{0.117Q}{\sigma_y\sigma_z u}$$

   (c) show that C_{max} is inversely proportional to H^2. [4+3+3=10]

3. Consider a box model for an air shed over a city 1×10^5 m on a side, with a mixing depth of 1,200 m. Winds with no SO_2 blow at 4 m/s against one side of the box. SO_2 is emitted in the box at the rate of 20 kg/s. If SO_2 is considered to be conservative, estimate the steady-state concentration in the air shed. [5]

4. A wastewater treatment plant discharges 1.0 m^3/s of effluent having an ultimate BOD of 40.0 mg/L into a stream flowing at 10.0 m^3/s. Just upstream from the discharge point, the stream has an ultimate BOD of 3.0 mg/L. The deoxygenation constant k_d is estimated at 0.22/day.
   (a) Assuming complete and instantaneous mixing, find the ultimate BOD of the mixture of waste and river just downstream from the outfall.
   (b) Assuming a constant cross-sectional area for the stream equal to 55 m^2, what ultimate BOD would you expect to find at a point 10,000 m downstream? [2+3=5]

5. A lake with constant volume 10×10^6 m^3 is fed by a pollution-free stream with flow rate 50 m^3/s. A factory dumps 5 m^3/s of a nonconservative waste with concentration 100 mg/L into the lake. The pollutant has a reaction rate coefficient K of 0.25/day. Assuming the pollutant is well mixed in the lake, find the steady-state concentration of pollutant in the lake. [5]

Table1:

Wind Profile Exponent *p*, for Rough Terrain[a]

Stability Class	Description	Exponent *p*
A	Very unstable	0.15
B	Moderately unstable	0.15
C	Slightly unstable	0.20
D	Neutral	0.25
E	Slightly stable	0.40
F	Stable	0.60

Table:2

Atmospheric Stability Classifications

	Day Solar Insolation			Night Cloudiness[e]	
Surface Windspeed[a](m/s)	Strong[b]	Moderate[c]	Slight[d]	Cloudy (≥4/8)	Clear (≤3/8)
<2	A	A–B[f]	B	E	F
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
>6	C	D	D	D	D

Table:3

Values of the Constants *a*, *c*, *d*, and *f* for Use in (47) and (48)

		$x \leq 1$ km			$x \geq 1$ km		
Stability	*a*	*c*	*d*	*f*	*c*	*d*	*f*
A	213	440.8	1.941	9.27	459.7	2.094	−9.6
B	156	106.6	1.149	3.3	108.2	1.098	2.0
C	104	61.0	0.911	0	61.0	0.911	0
D	68	33.2	0.725	−1.7	44.5	0.516	−13.0
E	50.5	22.8	0.678	−1.3	55.4	0.305	−34.0
F	34	14.35	0.740	−0.35	62.6	0.180	−48.6

Table:4

Dispersion Coefficients (m) for Selected Distances Downwind (km), Computed with (47) and (48)

Distance *x*	Stability Class and σ_y						Stability Class and σ_z					
(km)	A	B	C	D	E	F	A	B	C	D	E	F
0.2	51	37	25	16	12	8	29	20	14	9	6	4
0.4	94	69	46	30	22	15	84	40	26	15	11	7
0.6	135	99	66	43	32	22	173	63	38	21	15	9
0.8	174	128	85	56	41	28	295	86	50	27	18	12
1	213	156	104	68	50	34	450	110	61	31	22	14
2	396	290	193	126	94	63	1953	234	115	51	34	22
4	736	539	359	235	174	117		498	216	78	51	32
8	1367	1001	667	436	324	218		1063	406	117	70	42
16	2540	1860	1240	811	602	405		2274	763	173	95	55
20	3101	2271	1514	990	735	495		2904	934	196	104	59

Table:5

Some Measured Pollutant Emission Rates for Various Sources

	Pollutant Emission Rate, (mg/hr)			
Source	CO	NO_x[a]	SO_2	HCHO
Gas range				
Oven	1900	52	0.9	23
One top burner	1840	83	1.5	16
Kerosene heater[b]				
Convective	71	122	—	1.1
Radiant	590	15	—	4.0
One cigarette				
(sidestream smoke)[c](mg)	86	0.05	—	1.44