

Air Pollution

Q.1 Unsaturated hydrocarbons react with nitrogen dioxide in sunlight to form

- (a) Aerosols (b) Smog
(c) Smoke (d) Fumes

Q.2 Size of dust particles may range from

- (a) 1 to 1000 μm (b) 1 to $10^4 \mu\text{m}$
(c) 10 to $10^4 \mu\text{m}$ (d) 100 to $10^4 \mu\text{m}$

Q.3 Match List-I (Matter) with List-II (Size) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Smoke	1. 1 to 1000 μm
B. Fumes	2. 10 to 1000 μm
C. Spray	3. 0.03 to 0.3 μm
D. Fly ash	4. 0.5 to 1 μm

Codes:

A	B	C	D
(a) 3	4	2	1
(b) 3	4	1	2
(c) 4	3	1	2
(d) 4	3	2	1

Q.4 SO_2 is an irritant gas, and when inhaled, affects which part of our body?

- (a) Mucous membrane
(b) Liver
(c) Brain
(d) Eyes

Q.5 Consider the following statements:

- Ozone may be formed during photochemical oxidation of sulphur-dioxide to sulphuric acid.
- Photochemical decomposition of formaldehyde produces free-radicals and ozone.

Which of these statement/s is/are correct?

- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.6 The highest pH value of rain above which it can be called clean is

- (a) 7.0 (b) 6.5
(c) 5.6 (d) 4.8

Q.7 Match List-I (Gas) with List-II (Released in anaerobic digestion) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Carbon dioxide	1. 6%
B. Methane	2. 12%
C. Nitrous oxide	3. 25%
D. Chlorofluoro carbon	4. 57%

Codes:

A	B	C	D
(a) 2	4	3	1
(b) 4	2	1	3
(c) 4	2	3	1
(d) 2	4	1	3

Q.8 Ozone gas is chiefly present in layers between

- (a) 20 and 35 km above the ground level
(b) 25 and 40 km above the ground level
(c) 30 and 50 km above ground level
(d) 35 and 55 km above the ground level

Q.9 Vienna convention was concerned with

- (a) Ozone layer depletion
(b) Increasing global warming
(c) Melting ice caps
(d) Effect on aquatic life due to pollution

Q.10 Maximum permissible carbon monoxide emission while idling, for 2 and 3 wheelers, is

- (a) 2% (b) 3.5%
(c) 4% (d) 4.5%

Q.11 When Environmental Lapse Rate (ELR) is more than Adiabatic Lapse Rate (ALR), then the environment is said to be

- (a) stable (b) unstable
(c) neutral (d) none of above

Q.12 Ringelmann's scale is used to

- (a) measure CO
(b) measure SO_2
(c) grade density of smoke
(d) grade automobile exhaust gas

Q.13 Match List-I (causes) with List-II (effect) and select the correct answer using codes given below the lists:

List-I	List-II
A. Carbon monoxide	1. Acid rain
B. Carbon dioxide	2. Explosion
C. Methane	3. Asphyxiation
D. Sulphur dioxide	4. Greenhouse effect

List-II

1. Acid rain
2. Explosion
3. Asphyxiation
4. Greenhouse effect

Codes:

A	B	C	D
(a) 2	3	1	4
(b) 3	4	2	1
(c) 1	3	4	2
(d) 4	2	1	3

Q.14 Match List-I (Industry and unit of production) with List-II (water need in kl/unit/day) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Automobile (per vehicle)	1. 1 to 2
B. Leather (per 100 kg)	2. 4
C. Paper (per tonne)	3. 40
D. Crude petroleum refinery (per tonne)	4. 50-100

List-II

1. 1 to 2
2. 4
3. 40
4. 50-100
5. 200-400

Codes:

A	B	C	D
(a) 3	2	5	1
(b) 1	3	5	4
(c) 3	2	4	5
(d) 5	4	2	1

Q.15 Match List-I (Air pollutant) with List-II (Affect) and select correct answer using codes given below the lists:

List-I

- A. Carbon monoxide
B. Particulate matter
C. Nitrogen oxides
D. Sulphur dioxide

List-II

1. Respiratory distress for living beings
2. Chemical reaction with haemoglobin in blood
3. Reduction in visibility and aeroallergens carrier
4. Photochemical smog in atmosphere

Codes:

A	B	C	D
(a) 2	3	1	4
(b) 3	2	4	1
(c) 2	3	4	1
(d) 3	2	1	4

Q.16 Natural properties which continuously clean the environment automatically are

- dispersion
- gravitational settling
- absorption including washout and scavenging
- rainout
- adsorption

Which of these statements are correct?

- (a) 1, 2 and 4 (b) 2, 3 and 5
(c) 1, 2, 4 and 5 (d) 1, 2, 3, 4 and 5

- Q.17 The height of chimney required for effective disposal of 27 kg/hr of SO_2 emission is
(a) 42 m (b) 30 m
(c) 222 m (d) 81 m
- Q.18 Effective stack height of a load burning power plant with physical stack height of 200 m and stack diameter of 8 m, stack gas exit velocity of 18.3 m/s, temperature of gas 140°C , when the ambient air temperature is 8°C , atmospheric pressure is 1000 millibars and average wind speed 4.5 m/s, will be
(a) 272 m (b) 372 m
(c) 472 m (d) 572 m
- Q.19 Emission rate of sulphur dioxide of a plant assuming burning of 24,000 tonnes of coal per day with a sulphur content of 4.2% will be
(a) 21 t/hr (b) 42 t/hr
(c) 63 t/hr (d) 84 t/hr
- Q.20 If a sample of air is analyzed at standard temperature and pressure and air is found to contain 0.3 ppm of SO_2 , the equivalent SO_2 concentration in $\mu\text{g}/\text{m}^3$ will be
(a) 8000 (b) 800
(c) 80 (d) 0.8
- Q.21 The minimum size of the particulate matter of sp. gravity 2 that will get removed by a 100% efficient settling chamber of 10 m length and 1.5 m height, if the viscosity of hot emission is 2×10^{-5} kg/m sec and $V_g = 0.3$ m/s, will be (Correction factor is 2)
(a) 4.06 μm (b) 40.6 μm
(c) 406 μm (d) None of these
- Q.22 During temperature inversion in atmosphere, air pollutants tend to
(a) accumulate above inversion layer
(b) accumulate below inversion layer
(c) disperse laterally
(d) disperse vertically
- Q.23 Which one of the following unit is employed for the removal of particulate matter above 50μ in size?

- (a) Gravity settling chamber
(b) Cyclone collector
(c) Fabric filter
(d) Electrostatic precipitator

- Q.24 Pollution by depletion of ozone layer, in the environment, is caused due to the reaction of ozone with
(a) carbon monoxide
(b) chlorine
(c) sulphur dioxide
(d) nitrous oxide
- Q.25 Which one of the following plume behaviour occurs when atmospheric inversion begins from the ground level and continues?
(a) Looping (b) Fumigation
(c) Coning (d) Fanning
- Q.26 Which one of the following toxic gas has physiological action as asphyxiant?
(a) SO_2 (b) NO_2
(c) Cl_2 (d) CO
- Q.27 Acid rain may occur
(a) equally in all regions
(b) predominantly in arid regions
(c) predominantly in tropical regions
(d) predominantly in temperate regions
- Q.28 Two electrostatic precipitators are in series. The fractional efficiencies of the upstream and downstream precipitators for size dP are 70% and 60% respectively. What is the overall efficiency of the system for the same dP ?
(a) 70% (b) 60%
(c) 65% (d) 88%
- Q.29 The role of the bed material in a "packed tower" used for removing particulate matter from gaseous emission is to
(a) act as a filter bed to capture the particulates within the pores
(b) provide a large surface area on which the particulate matter can be collected
(c) reduce the flow of gas
(d) uniformly distribute the spray of water

- Q.30 Pneumoconiosis is caused due to inhalation of which one of the following?

- (a) Silica (b) NO_x
(c) Lead (d) Cadmium

- Q.31 A power plant has a stack with diameter of 2 m and emits gases with a stack exit velocity of 15 m/sec and heat emission rate of 4800 kW/s. The wind speed is 5 m/s. Stability is neutral. If stack has geometric height of 40 m, the effective stack height is
(a) 78.7 m (b) 48.7 m
(c) 38.7 m (d) 68.7 m

- Q.32 A clean filter is found to weigh 10.00 g. After 24 h in a ϕ -volume sampler, the filter plus dust weighs 10.00 g. The air flow at start and end of

the test was 60 and $40 \text{ m}^3/\text{min}$ respectively. The concentration of particulate matter?

- (a) $33 \mu\text{g}/\text{m}^3$ (b) $38 \mu\text{g}/\text{m}^3$
(c) $41 \mu\text{g}/\text{m}^3$ (d) $49 \mu\text{g}/\text{m}^3$

- Q.33 Assume the following information

d_p = particle diameter = $45 \mu\text{m}$ (45 microns)
 P_p = particle density = $0.899 \text{ g}/\text{cm}^3$
 P_a = fluid (gas) density = $0.012 \text{ g}/\text{cm}^3$
 μ = fluid (gas) viscosity = $1.82 \times 10^{-4} \text{ g}/\text{cm-sec}$
 C_p = 1.0 (if applicable)
The settling velocity of the particle moving in a gas stream is:
(a) 4.42 cm/sec (b) 5.98 cm/sec
(c) 5.38 cm/sec (d) 4.98 cm/sec

Answers Air Pollution

1. (b), 2. (a), 3. (d), 4. (a), 5. (a), 6. (c), 7. (b), 8. (b), 9. (a), 10. (d)
11. (b), 12. (c), 13. (b), 14. (a), 15. (c), 16. (d), 17. (a), 18. (c), 19. (d), 20. (b)
21. (b), 22. (b), 23. (a), 24. (b), 25. (d), 26. (d), 27. (c), 28. (d), 29. (b), 30. (a)
31. (a), 32. (d), 33. (c)

Explanations Air Pollution

5. (a)
Photochemical decomposition of aldehydes produces free-radicals and O_3 .
6. (c)
Generally, 'clean' air is slightly acidic as it dissolves varying amounts of carbon dioxide. If pH of rain drops to 5.6 or below then it is called acid rain.
9. (a)
Vienna convention and Montreal Protocol were concerned with ozone layer depletion.
11. (b)
When
ELR < ALR - Environment is Stable
ELR = ALR - Environment is Neutral
ELR > ALR - Environment is Unstable

17. (a)
Height of chimney required for SO_2 is
$$h = 14(Q)^{1/3}$$

$$\therefore h = 14 \times (27)^{1/3}$$

$$= 14 \times 3 = 42 \text{ m}$$
18. (c)
Holland's equation to determine the plume rise Δh
$$\Delta h = \frac{V_g d}{u} \left[1.5 + 2.68 \times 10^{-3} p \frac{\Delta T_g}{T_a} \right]$$

$$= \frac{18.3 \times 8}{4.5} \left[1.5 + \frac{2.68 \times 10^{-3} \times 1000 \times (140 - 8) \times 8}{(140 + 273)} \right]$$

$$= 272 \text{ m}$$

$$\therefore \text{Effective stack height} = 200 + 272 = 472 \text{ m}$$

$$\Delta T = [\text{Stack gas temp. } (T_g) - \text{Air temp. } (T_a)] \text{ in kelvin}$$

$$d = \text{Inside stack diameter (m)}$$

u = wind speed m/s
 p = atmospheric pressure (millibars)

19. (d) Burning of sulphur per day

$$24000 \times \frac{4.2}{100} = 1008 \text{ t}$$

$$\text{emission rate of SO}_2 = \frac{1008 \times 64}{32} \\ = 2016 \text{ t/day} = 84 \text{ t/hr}$$

20. (b) SO₂ in µg/m³

$$= \frac{\text{SO}_2 \text{ in ppm} \times 64000}{24.04} = \frac{0.3 \times 64000}{24.04}$$

21. (b)

$$d = \left[\text{correction factor} \times \frac{18\mu \times V_n \times H}{gP} \right]^{1/2}$$

$$d = \left[\frac{2 \times 18 \times 2 \times 10^{-5} \times 0.3 \times 1.5}{9.81 \times 10 \times 2000} \right]^{1/2}$$

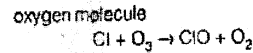
$$= 4.063 \times 10^{-4} \text{ m} = 40.6 \text{ µm}$$

22. (b) Negative lapse rate occurs under conditions, usually referred to as inversion, a state in which the warmer air lies below the colder air. Such temperature inversions represent a highly stable environment. During temperature inversion the pollutants accumulate below inversion layer.

23. (a)

Name of mechanical device	Minimum particle size that can be removed	Efficiency
(i) Gravity settling chamber	> 50 µm	< 50%
(ii) Centrifugal collectors including cyclone collectors	> 5-25 µm	50-90%
(iii) Electrostatic precipitator	> 1 µm	95-99%
(iv) Fabric filters	< 1 µm	> 99%

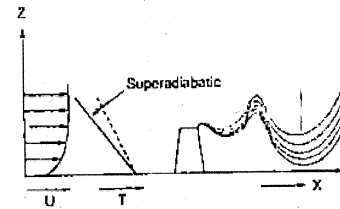
24. (b) Ozone reacts with chlorine atom and gets breakdown into chlorine monoxide (ClO) and



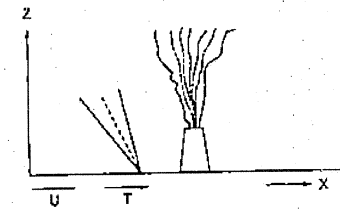
25. (d)

- When the ambient lapse rate is super-adiabatic (greater than the adiabatic), the turbulence of the air itself causes the atmosphere to serve as an effective vehicle of dispersion. As indicated in Fig. (a), the resultant plume is designated as a looping plume.
- When the ambient lapse rate is equal to or very near the dry adiabatic lapse rate, the plume issuing from a single chimney or smokestack tends to rise directly into the atmosphere until it reaches air of density similar to that of the plume itself. This type of emission is called as neutral plume, and is seen in Fig. (b).
- When the ambient lapse rate is sub-adiabatic (less than the dry adiabatic), the atmosphere is slightly stable. Under such conditions, there is limited vertical mixing, and the probability of air pollution problems in the area is increased. The typical plume in such a situation is said to be coning.
- When the lapse rate is negative, as in the presence of an inversion, the dispersion of stack gas is minimal, because of lack of turbulence. In the extremely stable air, a plume spreads horizontally, with little vertical mixing, and is said to be fanning Fig. (d).
- When the lapse rate is super-adiabatic above the emission source and inversion conditions exist below the source, the plume is said to be lofting. As shown in Fig. (e), a lofting plume has minimal downward mixing, and the pollutants are dispersed downwind without any significant ground-level concentrations.
- When an inversion layer occurs at a short distance above the top of the stack and super adiabatic conditions prevail below the stack, then plume is said to be fumigating Fig. (f).
- When inversion layer exists above the emission source, as well as below the

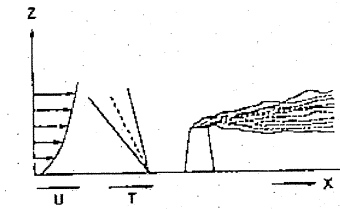
source, then naturally, the emitted plume will neither go up, nor will it go down and would remain confined between the two inversion layers Fig. (g). Such a plume is called a trapping plume.



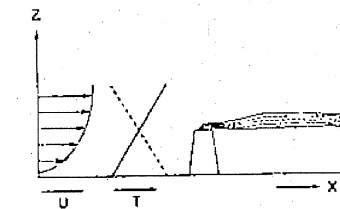
(a) Looping Plume



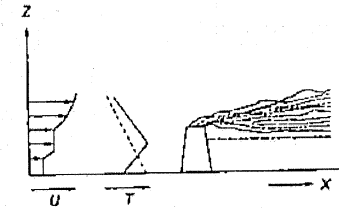
(b) Neutral Plume



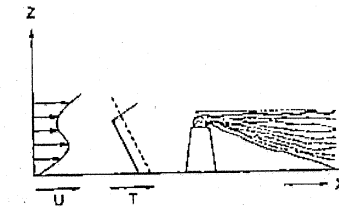
(c) Coning plume



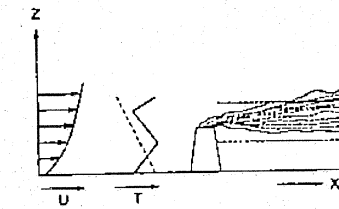
(d) Fanning plume



(e) Lofting plume



(f) Fumigating plume



(g) Trapping plume

SYMBOLS:

..... Adiabatic lapse rate
 ——— Environmental lapse rate

28. (d) Fractional efficiencies of the two ESPs are 70% and 60%, so overall efficiency,

$$\eta = 70 + (100 - 70) \times \frac{60}{100} = 88\%$$

31. (a)

$$h = 0.35 \times \frac{15 \times 2}{5} + \frac{2.64 \sqrt{4800}}{5} = 38.70 \text{ m}$$

$$\therefore H = hg + h \\ = 40 + 38.70 = 78.70 \text{ m}$$

32. (d)

Weight of particulates (dust)

$$= (10.10 - 10)g \times 10^6 \mu g/g$$

$$= 0.10 \times 10^6 \mu g$$

Average air flow

$$= \frac{(60 + 40)}{2} = 50^3/\text{min}$$

Total air through filter

$$= 50 \times 24 \times 60 = 2038 \text{ m}^3$$

Total suspended particulate matter

$$= (0.1 \times 10^6 \mu g)/2038 = 49 \mu g/\text{m}^3$$

33. (c)

$$C_d = d_p \left(\frac{g P_p P_a}{\mu^2} \right)^{0.33}$$

$$= 45 \times 10^{-4} \left\{ \frac{(980 \times 0.899 \times 0.012)}{(1.82 \times 10^{-4})^2} \right\}^{0.33}$$

\therefore Flow regime is laminar

Settling velocity,

$$v = \frac{g P_p d_p^2 C_i}{18\mu}$$

$$= \frac{980 \times 0.899 \times (45 \times 10^{-4})^2 \times 1}{(18 \times 1.82 \times 10^{-4})}$$

$$= 5.38 \text{ cm/sec}$$

■■■■