Environmental Engineering Test 4

Number of Questions: 30 **Time: 75 min.**

Directions for questions 1 to 30: Select the correct alternative from the given choices.

1. SO_x in atmosphere is measured by
(A) Non-dispersive infrared analyzer
(B) West and Gack method
(C) Sodium arsenate method
(D) Gas Chromatography

2. Algae dies out, though fish life may survive, in a river zone, known as
(A) Zone of degradation
(B) Zone of active decomposition
(C) Zone of recovery
(D) None of these

3. Man hole covers are circular in shape to
(A) strengthen the cover
(B) make entry convenient
(C) for architectural reasons
(D) prevent falling of cover into manhole

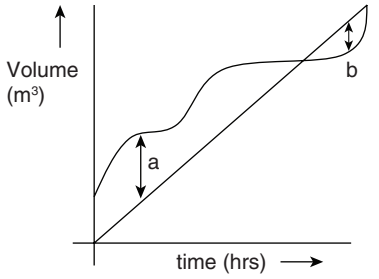
4. The factors which affect the sludge digestion are
1. Temperature
2. pH
3. Mixing and stirring of raw sludge
4. Seeding of sludge
(A) 1 and 2 (B) 2 and 3
(C) 2, 3, 4 only (D) All the above

5. Primary Clarifier used in waste water treatment follows _____ type of settling.
(A) Type I settling
(B) Type II settling
(C) Type III settling
(D) Type IV settling

6. If the Cl demand of water is 0.5 mg/l to have a residual Cl of 0.1 mg/l. What dose of bleaching powder is added to the water if bleaching powder contains 32% of available chlorine.
(A) 1.875 mg/l
(B) 1.25 mg/l
(C) 1.562 mg/l
(D) 2.188 mg/l

7. If the methyl orange alkalinity of water equals or exceeds total hardness, all of the hardness is
(A) Non-Carbonate hardness
(B) Carbonate hardness
(C) Pseudo hardness
(D) Negative non-carbonate hardness

8. The given figure shows roughly the daily mass curves of supply and demand from an elevated reservoir. The minimum required capacity of the reservoir is given by



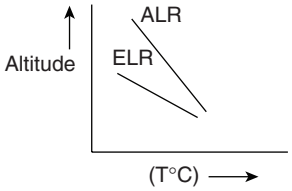
(A) $a - b$
(B) $a + b$
(C) $a \times b$
(D) larger of a or b

9. Which of the following are removed by rapid sand filter from water?
1. Dissolved solids
2. Suspended solids
3. Bacteria
4. Helminths
(A) 1 and 2
(B) 2 and 3
(C) 1 and 3
(D) 2, 3 and 4

10. The yield of a well depends upon
(A) permeability
(B) area of aquifer opening into the wells
(C) actual flow velocity
(D) All of the above

11. Match List - A (lapse rate) with List - B (different types of plumes) at stack level.

List – A (Lape rate)

P.


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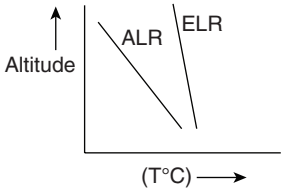
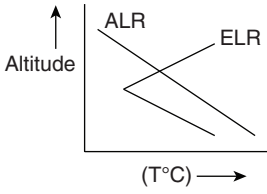
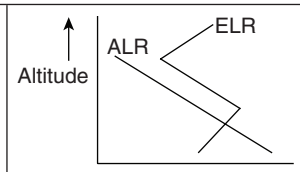
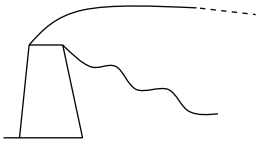
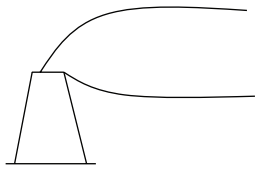
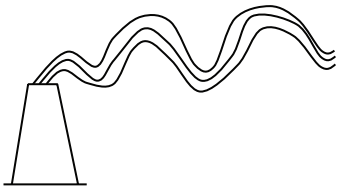
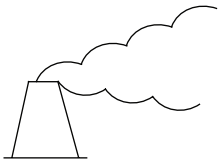


R.


S.	

	List – B
1.	 Fumigation plume
2.	 Trapping plume
3.	 Looping plume
4.	 Coning plume

	P	Q	R	S		P	Q	R	S
(A)	3	4	1	2	(B)	3	1	2	4
(C)	1	4	2	3	(D)	4	2	1	3

12. Find the equivalent noise level for fluctuating noise level of 95 minutes. The one with 80 dB lasted for 10 minutes, followed by 60 dB for 80 minutes followed by 100 dB for 5 minutes.

(A) 68 dB (B) 74 dB
(C) 87 dB (D) 96 dB

13. In Delhi it has been decided to provide 200 Litre per head per day in 2020. Estimate the domestic water requirements of this city in 2020 by projecting the population of the town by incremental increase method.

Year	Population
1970	2, 37, 98, 624
1980	4, 50, 78, 325
1990	5, 53, 86, 432
2000	6, 91, 87, 241

(A) 18641 MLD (B) 19094 MLD
(C) 20986 MLD (D) 22782 MLD

14. A standard multiple tube fermentation test was conducted on a sample of water from a stream. The results of the analysis of the confirmed test are given below.

Sample size (ml)	No. of positive results out of 5 tubes	No. of negative results out of 5 tubes
10	2	3
1	0	5
0.1	2	3

MPN Index and 95% confidence limits for combination of positive results when 5 tubes used per dilution (1ml, 0.1ml, 0.01ml)

Combination of positives	MPN Index per 100 ml	95% Confidence limit	
		Lower	Upper
1 – 3 – 5	280	120	360
2 – 0 – 2	330	160	380
3 – 5 – 3	140	100	210

Using the above *MPN* Index table, the Most Probable number (*MPN*) of the sample is

(A) 25 (B) 14
(C) 28 (D) 33

15. 12 mg of copperas is consumed with lime at a coagulation basin per litre water. Determine the quantity of copperas and the quick lime required to treat 20 MLD. [F_e = 56, S = 32, O = 16, Ca = 40, H = 1]

(A) 240 and 16 kg/day
(B) 240 and 48.4 kg/day
(C) 180 and 16 kg/day
(D) 180 and 48.4 kg/day

Common Data for Questions 16 and 17:
In a slow sand filter, water is supplied at the rate of 24 million litres per day and rate of filtration is 5 $m^3/hr/m^2$. If Backwashing is done for 15 minutes at the rate of 5 times of rate of filtration for every 24 hours (Let L : B = 2:1)

16. Find the volume of water filtered between backwashing in m^3.

(A) 23750 m^3 (B) 24000 m^3
(C) 24,860 m^3 (D) 25,390 m^3

17. Volume of water used in backwashing in m^3.

(A) 250 m^3 (B) 500 m^3
(C) 750 m^3 (D) 1250 m^3

18. Calculate the requirement of soda ash or softening 2 MLD of water formed to have the following chemical composition.

CO_2 = 39.6 mg/l
Ca^{2+} = 44 mg/l
Mg^{2+} = 18 mg/l
HCO_3 = 122 mg/l

(A) 168.4 kg/day (B) 180.2 kg/day
(C) 230.1 kg/day (D) 242.8 kg/day

19. Which among the following are dechlorinating agents.
1. Sulphur dioxide gas
2. Ammonia
3. Sodium sulphate
4. Sodium sulphite

(A) 1 and 2 (B) 2, 3 and 4
(C) 1, 2 and 4 (D) All the above

20. A town with a population of one lakh is to be supplied with water, daily at 120 l/head. The variation in demand is as follows.

6am – 10am – 50% of total demand
10am – 12pm – 10% of total demand
12pm – 6pm – 5% of total demand
6pm – 12am – 30% of total demand
12am – 6am – 5% of total demand

Determine the capacity of service reservoir assuming pumping to be at uniform rate and the period of pumping from 6am – 10am and6pm – 10pm (Neglect fire demand)

(A) 1.2 ML (B) 2.4 ML
(C) 3.6 ML (D) 4.8 ML

21. A 30 cm diameter sewer with an invert slope of 1 in 400 is running full. Calculate the rate of flow in the sewer. (use mannings equation and $N = 0.015$)

(A) 0.02 m^3/s (B) 0.03 m^3/s
(C) 0.04 m^3/s (D) 0.05 m^3/s

22. If the percapita contribution of suspended solids and B.O.D is 100 gm and 60 gm, find the population equivalent of 50,000 liters daily of industrial waste water containing 1800 mg/l of suspended solids.

(A) 800 (B) 900
(C) 1000 (D) 1100

23. The following data are given for a channel type grit chamber of length 8 m.
1. Flow through velocity = 0.4 m/s
2. Depth of waste water at peak flow in the channel = 1m
3. Specific Gravity of inorganic particles = 2.6
4. $g = 9.8\ m/s^2$, $\mu = 1.002 \times 10^{-3}$ N–s/m^2 at 20°C, $\rho_w = 1000\ kg/m^3$

Assuming that the stokes law is valid, the largest diameter particle that would be removed with 100%. efficiency is.

(A) 0.08 mm (B) 0.12 mm
(C) 0.18 mm (D) 0.24 mm

24. A sedimentation tank is treating 5 million litres of sewage per day containing 300 ppm of suspended solids. The tank removes 60% of suspended solids. Calculate the quantity of sludge produced per day is bulk and weight respectively if moisture content of sludge is 98% (assume specific gravity of wet sludge = 1.02)

(A) 78.43m^3 and 80 tonnes
(B) 66.67m^3 and 68 tonnes
(C) 50.98m^3 and 52 tonnes
(D) 44.12m^3 and 45 tonnes

25. Match List - I with List - II

	List – I (Treatment units)		**List – II (Types of Processes)**
a.	Trickling filter	1.	Symbiotic
b.	Activated sludge	2.	Extended aeration
c..	Oxidation ditch	3.	Suspended growth
d.	Oxidation pond	4.	Attached growth

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

Common Data for Questions 26 and 27:
The sewage is flowing at 6 MLD from a primary clarifier to a standard rate tricking filter. The 5 day BOD of the influent is 150 mg/l. The adopted organic loading is to be 160 gm/m^3/day and surface loading 2000 l/m^2/day.

26. Determine the volume of the trickling filter.

(A) 4532 m^3 (B) 5138 m^3
(C) 5625 m^3 (D) 6100 m^3

27. Calculate the efficiency of the filter

(A) 85% (B) 74%
(C) 61% (D) 91%

28. The composition of a certain MSW sample and specific weight of its various components are given below.

Component	**% by weight**	**Specific weight (kg/m^3)**
Food waste	60	250
Dirt and Ash	20	400
Plastics	10	70
Wood and Yard waste	10	130

Specific weight (kg/m^3) of the MSW sample is

(A) 120 (B) 143
(C) 196 (D) 219

29. In a stream flowing at 6 m^3/s has no concentration of chemical. Industrial water is released into stream at 25 MLD with chemical concentration as 30 mg/l. If rate of dissipation of impurities in stream is 0.13 mg/l/hr. Calculate the distance at which the chemical is removed completely from stream (velocity of stream is 0.3 m/s)

(A) 9.72 km
(B) 11.47 km
(C) 8.61 km
(D) 12.43 km

30. A sewage containing 300 mg/l of suspended solids is passed through primary settling tank where 60% of suspended solids are removed. 70% of suspended solids are volatile. The solids from the primary settling tank are digested to recover the gas where volatile matter is reduced by 70%. Methane and CO_2 produced in the digestion of the sludge from 2000 m^3 of sewage are in 3:2 ratio. If the fuel value of methane is 36000 kJ/m^3. Find the fuel value of gas produced (Assume gas production is at the rate of 0.9 m^3/kg of volatile) in MKJ.

(A) 26.3 (B) 31.4
(C) 48.5 (D) 34.8

Answer Keys

1. B	**2.** A	**3.** B	**4.** D	**5.** C	**6.** A	**7.** B	**8.** B	**9.** D	**10.** A
11. A	**12.** C	**13.** D	**14.** D	**15.** B	**16.** A	**17.** D	**18.** B	**19.** C	**20.** B
21. C	**22.** B	**23.** D	**24.** D	**25.** D	**26.** C	**27.** A	**28.** C	**29.** B	**30.** D

Hints and Explanations

1. SO_x are measured by West and Gack method.
Choice (B)

2. In zone of degradation, degradation just begins and all aquatic organisms disappear except fish. Choice (A)

3. Circular man hole covers are convenient to easy entry at times of repair. Choice (B)

4. Factors affecting sludge digestion are
1. Temperature
2. pH
3. Seeding of sludge
4. Mixing and stirring of raw sludge. Choice (D)

5. Primary clarifies is aimed to remove settleable organic solids of large size in waste water. These organic solids are similar to flocculent particles and influence other particles surrounding them and all of them settle together. This is called hindered/Type-III settling.
Choice (C)

6. Cl_2 added = 0.5 + 0.1 = 0.6 mg/l

$$\text{Bleaching powder} = \frac{Cl_2 \text{ added}}{\%\text{ of } Cl_2}$$

$$= \frac{0.6}{0.32} = 1.875 \text{ mg/l.}$$ Choice (A)

7. $$\text{Carbonate hardness} = \text{least of} \begin{pmatrix} \text{Alkalinity} \\ (\text{or}) \\ \text{Total hardness} \end{pmatrix}$$

∴ When Alkalinity > Total hardness
Carbonate Hardness = Total Hardness

∴ "Methyl Orange Alkalinity" indicates use of methyl orange indicator is titration, adopted for determining Alkalinity which changes its color from orange at pH = 4.6 to pink at pH = 4.
Choice (B)

8. Minimum/Balancing storage capacity of reservoir = maximum surplus + maximum deficit = $b + a$.
Choice (B)

9. Rapid sand filters are less efficient in removing bacteria (80 to 90%) but efficient in removing color and suspended solids.
Helminths are worms, which naturally would get removed in rapid sand filters. These are larger than bacteria. Choice (D)

10. Discharge $Q = KIA$
I = Hydraulic gradient
K = permeability coefficient
A = c/s area of well. Choice (A)

12. $L_{eq} = 10 \log_{10} \Sigma 10^{\frac{Li}{10}} \times T_i$

$$T_i = \frac{t_i}{\Sigma t_i}$$

$$\therefore \quad T_2 = \frac{10}{10+80+5} = 0.105$$

$$T_2 = \frac{80}{95} = 0.842$$

$$T_3 = \frac{5}{95} = 0.053$$

$$L_{eq} = 10 \log_{10} \left[\left(10^{\frac{80}{10}} \times 0.10.5 \right) + \left(10^{\frac{60}{10}} \times 0.842 \right) + \left(10^{\frac{100}{10}} \times 0.053 \right) \right]$$

= 87.33 dB. Choice (C)

13.

Year	Population	Increase in Population	Incremental Increase
1970	2,37,98,624	2,12,79,701	(+) 1,09,71,594
1980	4,50,78,325	1,03,08,107	(+) 34,92,702
1990	5,53,86,432	1,38,00,809	
2000	6,91,87,241		
Total		4,53,88,617	1,44,64,296
Average per decade		$\bar{x}$ = 1,51,29,539	$\bar{y}$ = 48,21,432

Expected population at the end of year 2020 (after 2 decades from 2000)

$$P = P_o + 2\bar{x} + \frac{2\times(2+1)}{2}.\bar{y}$$

$$= 69187241 + 2(15129539) + \frac{2\times3}{2} \times (4821432)$$

$$= 11,39,10,615$$

∴ Water requirement in 2020 @ 200 l/head/day

$$= \frac{200\times11,39,10,615}{10^6}\text{MLD}$$

= 22,782 MLD. Choice (D)

14. Since the volume of samples is 10 times more than specified sample size, the *MPN* from table is divided by 10 to get actual *MPN* of the sample

$$MPN = \frac{330}{10} = 33.$$ Choice (D)

15. The equations involved are

$$Fe\,SO_4.7H_2O + \underset{\text{(hydrated lime)}}{Ca(OH)_2}$$

$$\rightarrow Ca\,SO_4 + F_e(OH)_2 + 7H_2O$$

$$Ca(OH)_2 \rightarrow Ca\,O + H_2O$$

Q = 20 MLD

Dosage of copperas = 12 mg/l

$Fe\,SO_4.7H_2O = 56 + 32 + 64 + 7(2 + 16) = 278$

$Ca\,O = 56$

Total quantity of ferrous sulphate consumed

= 20 × 12 = 240 kg/day

278 parts of copperas = 56 parts of Ca O

$$1 \text{ part of copperas} = \frac{56}{278}\ Ca\,O$$

$$12 \text{ mg/l of copperas} = \frac{56}{278} \times 12 \text{ as } Ca\,O$$

= 2.42 mg/l as Ca O

∴ Ca O required = 2.42 × 20

= 48.4 kg/day. Choice (B)

16. Volume of water filtered between backwashing

= *R.O.F* × time of filtration × area of filter

$$= 5 \times \left(24 - \frac{15}{60}\right) \times 200 = 23750\ m^3.$$ Choice (A)

17. Volume of water used in backwashing

= (Rate of backwashing × time of backwashing × area of filter)

$$= (5 \times 5) \times \frac{15}{60} \times 200 = 1250\ m^3.$$ Choice (D)

18. Concentration of soda ash required

$$\underset{\text{(m.eq/lt)}}{Na_2CO_3} = \underset{\text{(m.eq/lt)}}{Ca^{2+}} + Mg^{2+} - \text{Alkalinity}$$

$$Ca^{2+} = \frac{44}{40/2} = 2.2 \text{ m.eq/lt}$$

$$Mg^{2+} = \frac{18}{24/2} = 1.5 \text{ m.eq/lt}$$

$$HCO_3 = \frac{122}{61/1} = 2 \text{ m.eq/lt}$$

$Na_2CO_3 = 2.2 + 1.5 - 2 = 1.7$ m.eq/lt

Soda ash = soda ash in m.eq/lt × eq. wt of Na_2CO_3

$$= 1.7 \times \frac{2(23)+12+3(16)}{2} = 90.1 \text{ mg/l}$$

Total soda ash required

= 2 × 90.1 = 180.2 kg/day. Choice (B)

19. Sodium sulphate is not a dechlorinating agent whereas sodium thisulphate, sodium meta bisulphate, sodium sulphite, sodium bisulphate, ammonia, sulphur dioxide gas are dechlorinating agents. Choice (C)

20. Total demand = 1,00,000 × 120 = 12 MLD

Volume of water demand in a day = 12 ML

$$\text{Rate of supply} = \frac{12}{8} = \frac{3}{2}\text{ML/hr}$$

Time	Demand % of total	Demand (ML)	Supply (ML)	Cumulative demand (ML)	Cumulative supply (ML)	Deficit (ML)	Surplus (ML)
6am-10am	50	6	$\frac{3}{2} \times 4 = 6$	6	6	–	–
10am-12pm	10	1.2	–	7.2	6	1.2	–
12pm-6pm	5	0.6	–	7.8	6	1.8	–
6pm-12am	30	3.6	$\frac{3}{2} \times 4 = 6$	11.4	12	–	0.6
12am-6am	5	0.6	–	12	12	–	–

∴ storage capacity

= Maximum surplus + Maximum deficit

= 0.6 + 1.8 = 2.4 ML. Choice (B)

21. D = diameter of server = 30 cm = 0.3 m

Area of sewer $A = \frac{\Pi}{4}D^2 = \frac{\Pi}{4} \times (0.3)^2 = 0.07 m^2$

$$R = \frac{A}{P} = \frac{\frac{\pi}{4}.D}{\pi.D} = \frac{D}{4} = \frac{0.3}{4} = \frac{3}{40}$$

$$S = \frac{1}{400}$$

$N = 0.015$

Use Mannings equation

$$V = \frac{1}{N} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$= \frac{1}{0.015}\left(\frac{3}{40}\right)^{\frac{2}{3}}\left(\frac{1}{40}\right)^{\frac{1}{2}}$$

$= 0.59$ m/s

$Q = A \times V$

$= 0.07 \times 0.59$

$= 0.0413$ m^3/s. Choice (C)

22. 1 liter of industrial waste water contains 1800 mg of suspended solids 50,000 liters of industrial water produce $= \frac{1800 \times 50000}{10^3}$ gm of suspended solids = 90000 gm

Standard percapita solid contribution of suspended solids = 100 gm

$\therefore$ Population equivalent $= \frac{90000}{100} = 900.$

Choice (B)

23. $L = 8$ m

$V_H = 0.4$ m/s

$H = 1$ m

Kinematic viscosity $\vartheta = \frac{\mu}{\rho}$

$$= \frac{1.002 \times 10^{-3}}{1000} = 1.002 \times 10^{-6} \text{ m}^2/\text{sec}$$

$\eta = 100\%$

$$\therefore \quad \frac{L}{V_H} = \frac{H}{V_S}$$

$$\frac{8}{0.4} = \frac{1}{V_S}$$

$V_S = 0.05$ m/s

$$V_S = \frac{g}{18}(S-1)\frac{d^2}{\vartheta}$$

$$0.05 = \frac{9.80}{18}(2.6-1) \times \frac{d^2}{1.002 \times 10^{-6}}$$

$d = 2.398 \times 10^{-4}$ m

$= 0.24$ mm. Choice (D)

24. Volume of sewage treated

= 5 M-liters/day

Mass of suspended solids in sewage = 300 × 5

= 1500 kg/day

As 60% solids are removed in sedimentation tank.

Mass of solids removed in sedimentation tank

$$= 1500 \times \frac{60}{100}$$

= 900 kg/day

When moisture content is 98%

2kg of solids → 100kg of wet sludge

900 kg of solids → $\frac{100}{2} \times 900$

= 45000 kg

Wet sludge produced per day = 45000 kg = 45 tonnes

Sp.gravity of wet sludge

= 1.02 × 1 t/m^3

= 1.02 t/m^3

Volume of wet sludge per day

$= \frac{45}{1.02} = 44.12$ m^3. Choice (D)

26. $y_5 = 150$ mg/l

Total BOD = 150 × 6 = 900 kg/day

= 9,00,000 gm/day

Volume of filter media required

$$= \frac{\text{Total BOD}}{\text{Organic loading rate}}$$

$= \frac{900000}{160} = 5625$ m^3. Choice (C)

27. Organic loading $u = 160$ gm/m^3/day

$= \frac{160}{1000} \times 10^4$ kg/ha-m/day

= 1600 kg/ha-m/day

$$\eta = \frac{100}{1 + 0.0044\sqrt{1600}}$$

$= \frac{100}{1+0.176} = 85.03\%$. Choice (A)

28. $\frac{100}{S_D} = \frac{\%A}{S_A} + \frac{\%B}{S_B} + \frac{\%C}{S_C}$

$$\frac{100}{S_D} = \frac{60}{250} + \frac{20}{400} + \frac{10}{70} + \frac{10}{130}$$

$S_D = 196.16$ kg/m^3 Choice (C)

29. $C_{mix} = \frac{Q_R + C_R + Q_W C_W}{Q_R + Q_W}$

$$= \frac{0 + (25 \times 10^6 \times 30)}{[25 \times 10^6 + (6 \times 1000 \times 60^2 \times 24)]} = 1.38 \text{ mg/l}$$

Rate of dissipation = Rate of removal = 0.13 mg/l/hr

Time to remove chemical from water $= \frac{1.38}{0.13} = 10.62$ hr

Distance travelled by river in 10.62 hr = 0.3 × 10.62 × 60^2 = 11469.6 m = 11.47 km Choice (B)

30. Total suspended solids in sewage = 300 mg/l
Suspended solids removed = 60% (300) = 180 mg/l
Volatile solids removed as sludge = 70% (180)
= 128 mg/l
Volatile solids are reduced by 70% in digestion tank
= 70% (128) = 89.6 mg/l

Volatile matter reduced in 20000 m^3 of sewage

$$= 89.6 \times \frac{(20000 \times 1000)}{10^6}$$

= 1792 kg

1kg volatile matter = 0.9 m^3 *G* as 1792 kg volatile matter = 0.9 × 1792 = 1612.8 m^3

Methane produce $= \frac{3}{3+2} \times 1612.8 = 967.68$ m^3

Fuel value of gas = 36000 × 967.68 = 34.8 MKJ
Choice (D)