Environmental Engineering

GATE Questions and Solutions

Module : Water Requirement: Quality Standards

By

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1. Some of the water quality parameters are measured by titrating a water sample with a titrant.

   Group-I gives a list of parameters and Group-II gives the list of titrants.

Group-I	Group-II
P.Alkalinity	1. N/35.5 AgNO3
Q.Hardness	2. N/40 Na2S2O3
R.Chloride	3. N/50 H2SO4
S.Dissolved Oxygen	4. N/50 EDTA

   The correct match of water quality parameters in Group-I with titrants in Group-II is:

   (A)P-1,Q-2,R-3,S-4 (B)P-3, Q-4, R-1, S-2

   (C)P-2,Q-1,R-4,S-3 (D) P-4, Q-3, R-2, S-1

   Ans:

   a) Alkalinity : H2SO4 : N/50 (Because alkalinity is expressed as $CaCO_3$ whose equivalent weight is 50)

   b) Chloride : AgNO3 : N/35.5 (Chlorine equivalent weight is 35.5)

   c) Hardness : EDTA : N/50 (Because alkalinity is expressed as $CaCO_3$ whose equivalent weight is 50)

   d) Dissolved oxygen : Na2S2O3 : N/40

2. A water sample has a pH of 9.25. The concentration of hydroxyl ions in the water sample is

   (A) $10^{-9.25}$ moles/L

   (B) $10^{-4.75}$ mmoles/L

   (C) 0.302 mg/L

   (D) 3.020 mg/L

Ans:

Hydrogen ions (H^+) are $10^{-9.25}$ moles/L and Hydroxyl Ions (OH^-) are $10^{-4.75}$ moles/L

$\therefore$ Hydroxyl ions = $10^{-4.75}$ moles/L X 17 gr/mole

$= 3.02 \text{ X } 10^{-4}$ g/L = 0.302 mg/L

3. Anaerobically treated effluent has MPN of total coliform as 10^6/ 100 mL. After chlorination, the MPN value declines to 10^2/ 100 mL. The percent removal (%R) and log removal (log R) of total coliform MPN is

(A) %R = 99.90; log R = 4
(B) %R = 99.90; log R = 2
(C) %R = 99.99; log R = 4
(D) %R = 99.99; log R = 2

Ans:

$\%R = (10^6 - 10^2)/10^6 X\ 100 = 99.99$

$log_{10} R = log_{10} 10^6 - log_{10} 10^2 = 4$

4. Chlorine gas (8 mg/L as Cl_2) was added to a drinking water sample. If the free chlorine residual and pH was measured to be 2 mg/L (as Cl_2) and 7.5, respectively, what is the concentration of residual OCl- ions in the water? Assume that the chlorine gas added to the water is completely converted to HOCI and OCl-. Atomic Weight of Cl: 35.5

Given: $OCl^- + H^+ \rightleftharpoons HOCl$ k = $10^{-7.5}$

(A) 1.408 x 10^{-5} moles/L
(B) 2.817 x 10^{-5} moles/L
(C) 5.634 x 10^{-5} moles/L
(D) 1.127 x 10^{-4} moles/L

Ans:

$$k = \frac{[H^+][OCl^-]}{[HOCl]}$$

$$10^{-7.5} = \frac{[H^+][OCl^-]}{[HOCl]}$$

$$\frac{10^{-7.5}}{[H^+]} = \frac{[OCl^-]}{[HOCl]}$$

$$1 + \frac{10^{-7.5}}{[H^+]} = \frac{[HOCl]+[OCl^-]}{[HOCl]}$$

But PH =7.5. i.e $[H^+] = 10^{-7.5}$

$$1+\frac{10^{-7.5}}{10^{-7.5}} = \frac{[HOCl]+[ocl^-]}{[HOCl]}$$

$$2 = \frac{[HOCl]+[ocl^-]}{[HOCl]}$$

$$0.5 = \frac{[HOCl]}{[HOCl]+[ocl^-]}$$

$$\therefore 0.5 = \frac{[ocl^-]}{[HOCl]+[ocl^-]}$$

Residual Chlorine is 2 mg/L (as Cl_2) that is $\frac{2}{1000\,x\,35.5}$ moles/l = 5.634 x 10^{-5} moles/l . But concentration of $[OCl^-]$ is 0.5 times of total concentration.

$\therefore$ 0.5 x 5.634 x 10^{-5} = 2.817 x 10^{-5} moles/l

5. Ion concentrations obtained for a groundwater sample (having pH = 8.1) are given below

Ion	Ca^{2+}	Mg^{2+}	Na^+	HCO_3^-	SO_4^{2-}	Cl^-
Conc.	100	6	15	250	45	39

a) Total hardness (mg/L mg/l as $CaCO_3$) present in the above water sample IS

(A) 205 (B) 250 (C) 275 (D) 308

Ans:

Total Hardness is due to Calcium and Magnesium.

Molecular weight of Ca^{2+} = 40

Molecular weight of Mg^{2+} = 24

Molecular weight of $CaCO_3$ = 100

$$100\ X\ \frac{100}{40} + 6\ X\ \frac{100}{24} = 275\ mg/l$$

6. Ion concentrations obtained for a groundwater sample (having pH = 8.1) are given below

Ion	Ca^{2+}	Mg^{2+}	Na^+	HCO_3^-	SO_4^{2-}	Cl^-
Conc.	100	6	15	250	45	39

Carbonate hardness (mg/l as $CaCO_3$) presentin the above water sample is

(A) 205 (B) 250 (C) 275 (D) 289

Ans:

Alkalinity is due to HCO_3^-

Molecular weight of HCO_3^- = 61

$$250\ X\ \frac{100}{61} = 410\ mg/l$$

Carbonate hardness is lesser of total hardness or alkalinity. So it is 250 mg/l

7. Following chemical species were reported for water sample from a well:

Species	Concentration (milli equivalent/L)
Chloride (Cl^-)	15
Sulphate (SO_4^{2-})	15
Carbonate (CO_3^{2-})	05
Bicarbonate (HCO_3^-)	30
Calcium (Ca^{2+})	12
Magnesium (Mg^{2+})	18
pH	8.5

Total hardness in mg/L as $CaCO_3$ is

(A)1500 (B) 2000 (C) 3000 (D) 5000

Ans:

Total Hardness is due to Calcium and Magnesium.

Equivalent mass of Ca^{2+} = 20

Equivalent mass of Mg^{2+} = 12

Equivalent mass of $CaCO_3$ = 50

$$12\ X\ 20\ X\ \frac{100}{40} + 18\ X\ 12\ X\ \frac{100}{24} = 1500\ mg/l$$

8. Following chemical species were reported for water sample from a well:

Species	Concentration (milli equivalent/L)
Chloride (Cl^-)	15
Sulphate (SO_4^{2-})	15
Carbonate (CO_3^{2-})	05
Bicarbonate (HCO_3^-)	30
Calcium (Ca^{2+})	12
Magnesium (Mg^{2+})	18
pH	8.5

Alkalinity present in the water in mg/L as $CaCO_3$ is

(A) 250 (B) 1500

(C) 1750 (D) 5000

Ans:

Alkalinity is due to CO_3^{2-} and HCO_3^-

Equivalent mass of CO_3^{2-} = 30

Equivalent mass of HCO_3^- = 31

$$5\ X\ 30\ X\ \frac{100}{60} + 30\ X\ 31\ X\ \frac{100}{62} = 1750\ mg/l$$

9. A wastewater sample contains $10^{-5.6}$ m mol /l of OH^- ions at 25°C. The pH of this sample is

(A) 8.6 (B)8.4 (C) 5.6 (D) 5.4

Ans:

OH^- Concentration = $10^{-5.6}$ mmol /l = $10^{-8.6}$ mol /l

H^+ Concentration = $10^{-14-(-8.6)} = 10^{-5.4}$ mol /l.

∴PH = 5.4

10. Group I lists estimation methods of some of the water and wastewater quality parameters. Group II lists the indicators used in the estimation methods. Match the estimation method (Group I) with the corresponding indicator (Group II).

Group I		Group II	
P.	Azide modified Winkler Method for dissolved oxygen	1.	Eriochrome Black T
Q.	Dichromate method forchemical oxygen demand	2.	Ferrion
R.	EDTA titrimetric method for hardness	3.	Potassium chromate
S.	Mohr or Argentometric method for chlorides	4.	Starch

(A) P-3, Q-2, R-1, S-4 (B) P-4, Q-2, R-1, S-3

(C) P-4, Q-1, R-2, S-3 (D) P-4, Q-2, R-3, S-1

Ans:

1.Modified Winkler Test : Titrant - Sodium thiosulphate :Indicator - Starch

2.COD : Titrant - potassium dichromate : Indicator- ferroin

3.EDTA (Hardness) : Titrant – EDTA : Indicator - Eriochrome Black T

4.Chlorides (Mohr's) : Titrant Silver Nitrate : Indicator - Potassium chromate

11. The presence of hardness in excess of permissible limit causes
    (a) Cardio vascular problems
    (b) Skin discolouration
    (c) Calcium deficiency
    (d) Increased laundry expenses

Ans: Consume more soap therefore increases laundry expenses.

12. The alkalinity and hardness of a water sample are 250 mg/L and 350 mg/L as CaCO3, respectively. The water has

    (a) 350 mg/L carbonate hardness and zero non-carbonate hardness.
    (b) 250 mg/L carbonate hardness and zero non-carbonate hardness.
    (c) 250 mg/L carbonate hardness and 350 mg/L non-carbonate hardness.
    (d) 250 mg/L carbonate hardness and 100 mg/L non-carbonate hardness.

Ans :

As alkalinity is less than Total hardness, the carbonate hardness is equal to alkalinity.

i.e 250 mg/l and non-carbonate hardness is equal to total hardness-carbonate hardness

i.e 350-250=100 mg/l

13. A synthetic sample of water is prepared by adding 100 mg Kaolinite (a clay minerla), 200 mg glucose, 168 mg NaCI, 120 mg $MgSO_4$, and 111 mg $CaCI_2$ to 1 liter of pure water. The concentrations of total solids (TS) and fixed dissolved solids (FDS) respectively in the solution in mg/L are equal to

    (a) 699 and 599
    (b) 599 and 399
    (c) 699 and 199
    (d) 699 and 399

Ans:

Total solids = 100 + 200 + 168 + 120 + 111 = 699 mg/l

Dissolved solids= Except Kaolinite all are dissolved solids. Hence 699-100 =599 mg/l

14. A water sample contains the following dissolved ions.

[Na^+] = 56 mg/L;

[Ca^{2+}] = 40 mg/L;

Mg^{2+}] = 30mg/L;

[$A1^{3+}$] = 3mg/L;

[HCO_3^-] = 190 mg/L;

[Cl^-] = 165 mg/L;

Water Ph is 7

Atomic weights : Ca:40; Mg: 24;AI:27;H:1, C:12; O:16; Na:23; CI:35.5

The total hardness of the sample in mg/L as $CaCO_3$ is

(a) 484 (b) 450 (c) 242 (d) 225

Ans:

Total Hardness is due to Calcium and Magnesium.

Molecular weight of Ca^{2+} = 40

Molecular weight of Mg^{2+} = 24

Molecular weight of $CaCO_3$ = 100

$$40\ X\ \frac{100}{40} + 30\ X\ \frac{100}{24} = 225\ mg/l$$

15. A water sample contains the following dissolved ions.

[Na^+] = 56 mg/L;

[Ca^{2+}] = 40 mg/L;

Mg^{2+}] = 30mg/L;

[$A1^{3+}$] = 3mg/L;

[HCO_3^-] = 190 mg/L;

[Cl^-] = 165 mg/L;

Water Ph is 7

Atomic weights : Ca:40; Mg: 24;AI:27;H:1, C:12; O:16; Na:23; CI:35.5

The non-carbonate hardness of the sample in mg/L as $CaCO_3$ is

(a) 225 (b) 156

(c) 86 (d) 0

Ans:

Alkalinity is due to HCO_3^-

Molecular weight of HCO_3^- = 61

$$190\ X\ \frac{100}{61} = 311\ mg/l$$

Carbonate hardness is lesser of total hardness or alkalinity.
So it is 225 mg/l

Non-carbonate hardness = Total hardness – carbonate hardness.

i.e. 225-225=0

16. 1 TCU is equivalent to the colour produced by

(a) 1 mg/L of chlorplatinate ion
(b) 1 mg/L of platinum ion
(c) 1 mg/L Platinum in form of chlorplatinate ion
(d) 1 mg/L of organo-chlorplatinate ion

Ans:

One true colour unit (TCU), or platinum-cobalt unit, corresponds to the amount of colour exhibited under the specified test conditions by a standard solution containing 1.0 mg of platinum per litre.

17. Most of the turbidity meters work on the scattering principle. The turbidity value so obtained is expressed in

(a) CFU (b) FTU
(c) JTU (d) NTU

Ans: NTU Naphelometric Turbidity Units

18. Hardness of water is directly measured by titration with ethylene-di-amine-tetracetic acid (EDTA) using

(a)eriochrome black T indicator
(b) ferroin indicator
(c) methyl orange indicator
(d) phenolphthalein indicator

Ans: Eriochrome black T indicator

19. The organism, which exhibits very nearly the characteristics of an ideal pathogenic indicator is

(a) Entamoeba histolytica
(b) Escherichia coli
(c)Salmonellatyphi
(d) Vibrio comma
Ans: Escherichia coli

20. The present population of a community is 28000 with an average water consumption of 4200m^3/d. The existing water treatment plant has a design capacity of 6000 m^3/d. It is expected that the population will increase to 44000 during the next 20 years. The number of years from now when the plant will reach its design capacity, assuming an arithmetic rate of population growth, will be

(a) 5.5 years (b) 8.6 years
(c) 15.0 years (d) 16.5 years
Ans:

Per capita demand = 4200/28000 = 0.15 m^3/d

6000 m^3/d will be sufficient for 6000/0.15 = 40000 population

Increase in population per year = (44000-28000)/20 = 800

No of years to reach maximum capacity = (40000-28000)/800 = 15 years

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

Sample Size (ml)	No. of +ve results out of 5 tubes	No. of-ve results out of 5 tubes
1.0	4	1
0.1	3	2
0.01	1	4

MPN Index and 95% confidence limits for combination of positive results when five tubes used per dilutions (10 ml, 1.0 ml, 0.1 ml)

Combination Ofpositives	MPN Index per 100 ml	95% confidence limit	
		L	Up
4-2-1	26	12	65
4-3-1	33	15	77

Using the above MPN Index table, the most probable number (MPN) of the sample is

(a) 26 (b) 33 (c) 260 (d) 330

Ans:

No of positive results are 4-3-1 and corresponding MPN is 33. The multiplication factor is 10 because standard sample size is 10 ml, 1 ml, 0.1 ml which is 10 times of present sample size. Therefore MPN is 33 X 10 = 330

22. Chlorine gas used for disinfection combines with water to form hypochlorous acid (HOCl). The HOCl ionizes to form hypochlorite (OCl^-) in a reversible reaction :

$HOCl \Leftrightarrow H^+ + OCl^-$ (k= 2.7×10^{-8} at 20°C),

the equilibrium of which is governed by PH. The sum of HOCl and OCl^- is known as free chlorine residual and HOCl is the more effective disinfectant. The 90% fraction of HOCl in the free chlorine residual is available at a pH value

(a) 4.8 (b) 6.6 (c) 7.5 (d) 9.4

Ans:

$$k = \frac{[H^+][OCl^-]}{[HOCl]}$$

$$2.7\ X\ 10^{-8} = \frac{[H^+][OCl^-]}{[HOCl]}$$

$$\frac{2.7\ X\ 10^{-8}}{[H^+]} = \frac{[OCl^-]}{[HOCl]}$$

$$1+\frac{2.7\ X\ 10^{-8}}{[H^+]} = \frac{[HOCl]+[OCl^-]}{[HOCl]}$$

$$\left[1 + \frac{2.7\ X\ 10^{-8}}{[H^+]}\right]^{-1} = \frac{[HOCl]}{[HOCl]+[OCl^-]}$$

$$\left[1 + \frac{2.7\ X\ 10^{-8}}{[H^+]}\right]^{-1} = 0.9$$

$$[H^+] = 2.43\ X\ 10^{-7}$$

$$PH = -log_{10} 2.43\ X\ 10^{-7} = 6.6$$

23. The results of analysis of a raw water sample are given below

Turbidity	:	5 mg/l
pH	:	7.4
Fluorides	:	2.5 mg/l
Total Hardness	:	300 mg/l
Iron	:	3.0 mg/l
MPN	:	50 per 100 ml

From the data given above, it can be inferred that water needs removal of

(a) Turbidity followed by disinfection
(b) Fluorides and Hardness
(c)Iron, followed by disinfection
(d) Both (b) and (c)

Ans:

Flourides allowable limit is 1 mg/l s. it needs to be removed. MPN is 50 and disinfection is required. Hard ness desirable limit is 300 mg/l so no treatment required. Turbidity limit is 5 NTU so no treatment required. Iron limit is 0.3 mg/l so it should be removed.

24. Results of a water sample analysis are as follows:-

Cation	Concentration (mg/l)	Equivalent Weight
Na^{+}	40	23
Mg^{+2}	10	12.2
Ca^{+2}	55	20
K^{+}	2	39

(milliequivalent weight of $CaCO_3$ = 50 mg/meq).

Hardness of the water sample in mg/1 as $CaCO_3$ is

(a) 44.8 (b) 89.5
(c) 179 (d) 358

Ans:

Total Hardness is due to Calcium and Magnesium.

$$10\ X\ \frac{50}{12.2} + 55\ X\ \frac{50}{20} = 178\ mg/l$$

25. In natural water, hardness is mainly caused by

(A) $Ca^{++}$and Mn^{++} (B) $Na^{+}$and K^{+}

(C) Ca^{++}andFe^{++} (D) $Ca^{++}$and Mg^{++}

Ans: $Ca^{++}$and Mg^{++}

26. The Ca^{++}concentration and Mg^{++}concentration of a water sample are 160 mg/lit and 40 mg/lit as their ions respectively. The total hardness of this water sample in terms of in $CaCO_3$ mg/lit is approximately equal to

(A)120 (B) 200 (C) 267 (D) 567

Ans:

Total Hardness is due to Calcium and Magnesium.

Molecular weight of Ca^{2+} = 40

Molecular weight of Mg^{2+} = 24

Molecular weight of $CaCO_3$ = 100

$$160\ X\ \frac{100}{40} + 40\ X\ \frac{100}{24} = 567\ mg/l$$

27. Temporary hardness in water is caused by the presence of

(A) Bicarbonates of Ca and Mg (B) Sulphates of Ca and Mg

(C) Chlorides of Ca and Mg (D) Nitrates of Ca and Mg

Ans: Bicarbonates of Ca and Mg

28. Blue baby disease (methaemoglobinemia) in children is caused by the presence of excess

(A) Chlorides (B) Nitrates

(C) Fluoride (D) Lead

Ans: Nitrates

29. Two samples of water A and B have pH values of 4.4 and 6.4 respectively. How many times more acidic sample A is than sample B?

(A) 0 (B) 15

(C) 100 (D) 200

Ans:

Concentration of H^+ ion in Sample A = $10^{-4.4}$

Concentration of H^+ ion in Sample B = $10^{-6.4}$

$$\frac{Concentration\ of\ sample\ A}{Concentration\ of\ sample\ B} = \frac{10^{-4.4}}{10^{-6.4}} = 100$$

30. If a solution hydroxide solution is $1.52\times 10^{-4}M$, than the PH of solution is?

(A) 9.18 (B) 11.18

(C) 8.18 (D) 10.18

Ans:

$$-\log(1.52 \times 10^{-4}) = 3.8186$$

$$P[OH^-] = 3.8186$$

$$P[H] = 14 - 3.8186 = 10.182$$

31. If a solution of hydrochloric acid is $1.0\times 10^{-2}M$, then the PH of the solution is?

(A) 9 (B) 12

(C) 2 (D) 10

Ans:

$$-\log\ (1.0 \times 10^{-2}) = 2$$

32. In a water treatment plant PH value of incoming and outgoing water are 7.2 and 8.4. assuming a linear variation of PH with time. Determine the average value of PH?

(A) 7.234 (B) 7.474

(C) 7.784 (D) 7.346

Ans:

$$\text{Average value of PH}=\log_{10}\left(\frac{10^{-7.2}+10^{-8.4}}{2}\right) = 7.4745$$

33. Calculate the PH of 0.02mol/L H_2SO_4?

(A) 1.4 (B) 7.4

(C) 7.7 (D) 7.3

Ans:

$$PH = -\log(0.02 \times 2) = 1.39 \approx 1.4 \quad [2\ moles\ H_2SO_4]$$

34. Calculate the PH of NaoH 0.5mol/L?

(A) 1.4 (B) 13.7

(C) 7.7 (D) 7.3

Ans:

$$[OH^-] = -\log(0.5) = 0.3010$$
$$PH = 14 - 0.3010 = 13.699 \approx 13.7$$

35. The product of H^+ and OH^{-1} ions in a stronger acid is 10^{-4}. Determine resultant PH value of one with PH=6 and PH=8 find resultant.

(A) 1.4345 (B) 6.2967

(C) 7.7456 (D) 7.3123

Ans:

$$Resultant\ PH = -\log_{10}[\frac{10^{-6}+10^{-8}}{2}]$$
$$= 6.2967 \approx 6.3$$

36. The threshold odour number for a water sample at 40 ml diluted to standard 200ml mixture in which odour is barely detectable to the sense of smell is?

(A) 15 (B) 10

(C) 20 (D) 5.0

Ans:

$$= \frac{200}{40} = 5$$

37. The carbonate and non-carbonate hardness of water having a total alkalinity of 200mg/lit as $caco_3$ and 120mg/lit of ca^{++} and 60mg/lit of mg^{++}. What is total hardness? And carbonate hardness?(as $caco_3$)

(A) 550,200 (B) 750,200

(C) 650,200 (D) 550,250

Ans:

$$Total\ hardness = 120 \times \frac{100}{40} + 60 \times \frac{100}{24} = 550\ mg/lit$$
$$Alkalinity = 200\ mg/lit$$
$$Alkalinity < Total\ Hardness$$
$$\therefore Carbonate\ Hardness = 200\ mg/lit$$

38. The concentration of OH^- ions in water sample is measured as 17mg/l at 25^{0}C. what is PH of water sample

(A) 15 (B) 10

(C) 11 (D) 5.0

Ans:

$$[OH^-] = 17\frac{mg}{lit} = 17 \times \frac{10^{-3}gm}{lit}$$
$$= 10^{-3} moles/lit$$

$$P[OH] = 3$$

$$PH = 14 - 3 = 11$$

39. Total suspended particulate matter TSP concentration in an ambient air is to be measured using high volume sampler. The filter used for the purpose had on initial dry weight of 9.787gm. the filter was mounted in sampler and the initial air flow rate through filter was set at $1.5m^3/min$. Sampling continued for 24hours. The air flow after 24hours was measured to be $1.4m^3/min$. The dry weight of the filter paper after 24hours sampling was 10.283gms. Assume a linear decline in air flow rate during sampling what is the 24hour average TSP concentration in ambient air.

a) $592\mu g/m^3$
b) $118.6\mu g/m^3$
c) $237.5\mu g/m^3$
d) $574.4\mu g/m^3$

Ans:

$W_1 = 9.787gm$
$Q_1 = 1.5\ m^3/min$
$Q_2 = 1.4\ m^3/min$
$W_2 = 10.283\ gm$

$$Change\ in\ weight = W_2 - W_1 = 10.283 - 9.787$$
$$= 0.496\ gm = 0.496 \times 10^6 \mu gm$$

$$Average\ air\ flow\ rate = \frac{Q_1+Q_2}{2} = \frac{1.5+1.4}{2} = 1.45\ m^3/min$$

$$Total\ time\ of\ sampling = 24\ hours = 1440\ min$$
$$= 1.45 \times 1440 = 2088\ m^3$$

$$Average\ TSP\ concentration = \frac{weight}{Air\ flow\ rate} = \frac{0.496 \times 10^6}{2083}$$
$$= 237.55\ \mu g/m^3$$

40. Ion concentration obtained for ground water sample PH=8.1 are given below.

Ion	ion concentration
ca^{++}	100
mg^{2+}	6
Na^+	15
HCO_3^-	250

SO^{2-} 45

Cl^{-} 39

Totalhardness (mg/l as $caco_3$) Present in water sample and carbonate hardness (mg/l as $caco_3$) present is

(A) 275, 275 (B) 750,200

(C) 650,200 (D) 550,250

Ans:

$$Total\ hardness = 100 \times \frac{100}{40} + 6 \times \frac{100}{24} = 275\ mg/lit$$
$$Alkalinity = 250 \times \frac{100}{61} = 409.83 \approx 410\ mg/lit$$
$$Alkalinity > Total\ Hardness$$
$$\therefore Carbonate\ Hardness = 275\ mg/lit$$

41. Waste water sample contains $10^{-5.6}$ milli mol/lit of OH^- ions what is PH

a) 8.6
b) 8.4
c) 5.6
d) 5.4

Ans:

$$[OH^-] = 10^{-5.6} \text{ milli mol/lit}$$
$$= 10^{-5.6} \times 10^{-3}\ moles/lit$$
$$= 10^{-8.6}$$
$$14 - 8.6 = 5.4$$

42. $[Na^+]$=56mg/l, $[Mg^{2+}] = 30mg/l$, $[ca^{2+}] = 40mg/l$,$[AL^{3+}] = 3mg/l$, $[Hco_3^-] = 190mg/l$, $[Cl^-]$=$165mg/l$ water PH=7. Find total hardness, alkalinity& carbonate hardness as$caco_3$.

(A) 275, 275, 225 (B) 225, 311, 225

(C) 650,200, 225 (D) 550,250, 225

Ans:

$$[ca^{2+}] = 40mg/l$$
$$[Mg^{2+}] = 30mg/l$$
$$[Hco_3^-] = 190mg/l$$
$$Total\ hardness = 40 \times \frac{100}{40} + 30 \times \frac{100}{24} = 225\ mg/lit$$
$$Alkalinity = 190 \times \frac{100}{61} = 311.475 \approx 311\ mg/lit$$
$$Alkalinity > Total\ Hardness$$
$$\therefore Carbonate\ Hardness = 225\ mg/lit$$

Environmental Engineering

GATE Questions and Solutions

Module : Basic unit processes and operations for water treatment. Drinking water standards, water requirements

By

Asst. Prof. Puja Kadam

1. A water treatment plant is designed to treat 1 m^3/s of raw water. It has 14 sand filters. Surface area of each filter is 50 m^2. What is the loading rate in $m^3/(day m^2)$ with two filters out of service for routine backwashing?

   a) 144 b) 288 c) 72 d) 36

   Ans :

   Volume of water per day = 1 X 60 X 60 X 24 = 86400 m^3/day

   Number of filters in operation = 14-2 = 12

   Total area of filters = 12 X 50 = 600 m^2

   Loading rate = 86400/600 = 144 $m^3/(day m^2)$

2. A settling tank in a water treatment plant is designed for a surface overflow rate of 30 $m^3/(day m^2)$. Assume specific gravity of sediment particles = 2.65, density of water (ρ) = 1000 kg/m3, dynamic viscosity of water (μ)=0.001 N.s/m^2, and *Stokes' law* is valid. The approximate minimum size of particles that would be completely removed is:
   (A) 0.01mm (B) 0.02 mm (C) 0.03 mm (D) 0.04 mm

   Ans:

   Settling velocity = 30 /86400 = 3.47 X 10^{-4} m/s

   Drag force = $\frac{1}{2} C_d \rho A v^2$ where $C_d = \frac{24}{R_e} = \frac{24}{\frac{\rho v d}{\mu}}$

   $= \frac{24 X 0.001}{1000 X 3.47 X 10^{-4} Xd} = 0.06916/d$

   $$F_d = 0.5 X \frac{0.06916}{d} X1000 X \frac{1}{4}\pi d^2(3.47 X 10^{-4})^2$$

   $$= 3.27 X 10^{-6} d$$

Submerged weight $=1000\ X\ 9.81X\ (2.65-1)X\frac{4}{3}X\pi\ \left[\frac{d}{2}\right]^3 =$

$8476\ d^3$

Equating drag force =submerged weight

$3.27\ X\ 10^{-6}\ d\ = 8476\ d^3$

d= 1.96 X $10^{-5}\ m = 0.02\ mm$

3. A town is required to treat 4.2 m^3/min of raw water for daily domestic supply. Flocculating
particles are to be produced by chemical coagulation. A column analysis indicated that an overflowrate of 0.2 mm/s will produce satisfactory particle removal in a settling basin at a depth of 3.5 m.The required surface area (in m^2) for settling is
(A) 210(B) 350 (C) 1728 (D) 21000
Ans:

Overflow rate = 0.2/1000 ×86400 = 17.28 $m^3/(day m^2)$

Per day water requirement = 4.2 X 60 X 24 =6048 m^3/day

Area required = $\frac{\text{water required per day}}{\text{over flow rate}} = \frac{6048}{17.28} = 350\ m^2$

4. Consider the following unit processes commonly used in water treatment; rapid mixing (RM),flocculation (F), primary sedimentation (PS), secondary sedimentation (SS), chlorination *(C)* andrapid sand filtration (RSF). The order of these unit processes (first to last) in a conventional watertreatment plant is
(A) PS --- RSF --- F --- RM --- SS --- C
(C) PS --- F --- SS --- RSF --- RM --- C
(B) PS --- F --- RM --- RSF --- SS --- C
(D) PS --- RM --- F --- SS --- RSF --- C
Ans: PS --- RM --- F --- SS --- RSF --- C

5. A horizontal flow primary clarifier treats wastewater in which 10%, 60% and 30% of particles have settling velocities of 0.1mm/s, 0.2mm/s, and 1.0mm/s respectively. What would be the total percentage of particles removed if clarifier operates at a Surface Overflow Rate (SOR) of 43.2m^3/m^2.d?

(A) 43% (B) 56%
(C) 86% (D) 100%

Ans:

Critical settling velocity = 43.2 X 1000/86400 = 0.5 mm/s

The particles whose settling velocities more than 0.5 m/s will settle 100%. But the particles whose settling velocities less than 0.5 m/s

will settle the fraction of the particles only. This fraction is ratio of settling velocity of the particles and critical settling velocity.

$$\text{Total \% of particle removed} = 30 + \frac{0.1}{0.5} X\ 10 + \frac{0.2}{0.5} X\ 60 = 56\ \%$$

6. A water treatment plant is required to process 28800 m^3/d of raw water (density = 1000 kg/m^3, kinematic viscosity = $10^{-6}m^2$/s). The rapid mixing tank imparts a velocity gradient of $900s^{-1}$ to blend 35mg/l of alum with the flow for a detention time of 2 minutes. The power input (W) required for rapid mixing is

(A) 32.4 (B) 36 (C) 324 (D) 32400

Ans:

$$G' = \left[\frac{P}{\mu V}\right]^{1/2} \text{ where}$$

$G' = velocity\ gradient,$

P = Power,

$\mu = viscosity,$

$V = Volume\ of\ raw\ water\ in\ m^3$ per detention time = $28800/(24\times60)\times2 = 40m^3/s$

$$\mu = 10^{-6}\ X\ 1000 = 10^{-3}\ N\frac{s}{m^2}$$

$$900 = \left[\frac{P}{10^{-3}\ X\ 40}\right]^{1/2}$$

$$P = 32400\ \text{W}$$

7. A plain sedimentation tank with a length of 20m, width of 10 m, and a depth of 3 m is used in a watertreatment plant to treat 4 million litres of water per day (4 MLD). The average temperature of water is 20°C. The dynamic viscosity of water is 1.002 x 10^{-3} N.s/ m^2 at 20°C. Density of water is 998.2 kg/ m^3. Average specific gravity of particles is 2.65. What is the surface overflow rate in the sedimentation tank ?

(a) 20 m^3/ m^2/day (b) 40 m^3/ m^2/day

(c) 67 m^3/ m^2/day (d) 133 m^3/ m^2/day

Ans: Surface overflow rate = $\frac{Q}{A} = \frac{4\times1000}{20\times10} = 20m^3/m^2/day$

8. A plain sedimentation tank with a length of 20m, width of 10 m, and a depth of 3 m is used in a water treatment plant to treat 4 million litres of water per day (4 MLD). The average temperature of water is 20°C. The dynamic viscosity of water is 1.002 x 10^{-3} N.s/ m^2 at 20°C. Density of water is 998.2 kg/ m^3. Average specific gravity of particles is 2.65. What is the minimum diameter of the particle which can be removed with 100% efficiency in the above sedimentation tank?

(a) 11.8×10^{-3}mm (b) 16.0×10^{-3} mm
(c) 50×10^{-3} mm (d) 160×10^{-3}mm

Ans:

Settling velocity $v_s = \frac{g}{18}(G-1) \times \frac{d^2}{\vartheta}$

From overflow rate settling velocity = 20 /86400

$= 0.2315 \times 10^{-3}$ m/s

Kinematic viscosity $= 1.002 \times 10^{-3} / 998.2 = 1 \times 10^{-6}$ m$^{2/s}$

$0.2315 \times 10^{-3} = \frac{9.81}{18}(2.65-1) \times \frac{d^2}{1 \times 10^{-6}}$

$d = 1.6 \times 10^{-5}$ m $= 1.6 \times 10^{-2}$ mm $= 16 \times 10^{-3}$ mm

9. In a rapid sand filter, the time for reaching particle breakthrough (T_B) is defined as the time elapsed from start of filter run to the time at which the turbidity of the effluent from the filter is greater than 2.5 NTU. The time for reaching terminal head loss (T_H) is defined as the time elapsed from the start of the filter run to the time when head loss across the filter is greater than 3m.

The effect of increasing the filter depth (while keeping all other conditions same) on T_B and T_H is

(a) T_B increases and T_H decreases
(b) both T_B and T_H increase
(c) T_B decreases and T_H increases
(d) Both T_B and T_H decreases

Ans: T_B increases and T_H decreases

10. In a rapid sand filter, the time for reaching particle breakthrough (T_B) is defined as the time elapsed from start of filter run to the time at which the turbidity of the effluent from the filter is greater than 2.5 NTU. The time for reaching terminal head loss (T_H) is defined as the time elapsed from the start of the filter run to the time when head loss across the filter is greater than 3m.

The effect of increasing the filter loading rate (while keeping all other conditions same) on T_B and T_H is

(a) T_B increases and T_H decreases
(b) Both T_B and T_H increases
(c) T_B decreases and T_H increases
(d) Both T_B and T_H decreases

Ans: Both T_B and T_H decreases

11. A city is going to install the rapid sand filter after the sedimentation tanks. Use the following data.

Design loading rate to the filter 200 m^3/m^2d

Design flow rate 0.5 m^3/s

Surface area per filter box 50m^2

The surface area required for the rapid sand filter will be

(a) 210 m^2 (b) 215 m^2

(c) 216 m^2 (d) 218 m^2

Ans:

$$\frac{(0.5\ X\ 86400)}{200} = 216\ m^2$$

12. A city is going to install the rapid sand filter after the sedimentation tanks. Use the following data.

Design loading rate to the filter 200 m^3/m^2d

Design flow rate 0.5 m^3/s

Surface area per filter box 50m^2 The number of filters required shall be

(a) 3 (b) 4 (c)6 (d)8

Ans:

$$\frac{(0.5\ X\ 86400)}{200} = 216\ m^2$$

Number of filters$=\frac{216}{50} = 4.32 \approx 6$

13. The design parameter for flocculation is given by a dimensionless number G t, where G is the velocity gradient and t is the detention time. Values of G t ranging from 10^4 to 10^5 are commonly used, with t ranging from 10 to 30 mm. The most preferred combination of G and t to produce smaller and denser floccus is

(a) large G values with shortt

(b) large G values with long t

(c) small G values with short t

(d) small G values with long t

Ans: (d)

14. Zero hardness of water is achieved by

(a) Lime soda process

(b) Excess lime treatment

(c) Iron exchange treatment

(d) Excess alum and lime treatment

Ans: Iron exchange treatment

15. An ideal horizontal flow setting basin is 3m deep having surface area 900m^2. Water flows at the rate of 8000 m^3/d, at water temperature 20^{0}C (m=10^{-3} kg/m.s) and p= 1000 kg/m^3). Assuming Stokes law to be valid, the proportion (percentage) of spherical sand particles (0.01 mm in diameter with specific gravity 2.65), that will be removed, is

(a) 32.5 (b) 67

(c) 87.5 (d) 95.5

Ans. Critical settling velocity = $\frac{8000}{900\times86400} = 1.029 \times 10^{-4}\ m/s$

$$v_s = \frac{g}{18}(G-1) \times \frac{d^2}{\vartheta}$$

$$v_s = \frac{9.81}{18}(2.65-1) \times \frac{0.00001^2}{1X10^{-6}} = 9 \times 10^{-5}\ m/s$$

% particle removed = $\frac{9\times10^{-5}}{1.029\times10^{-4}} \times 100 = 87.5\ \%$

16. Match the following:

Group I (Type of water impurity)

P	Hardness
Q	Brackish water from sea
R	Residual MPN from filters
S	Turbidity

Group II (Method of treatment)

1. Reverse Osmosis
2. Chlorination
3. Zeolite Treatment
4. Coagulation and Flocculation
5. Coagulation, Flocculation and Filtration

Codes:

	P	Q	R	S
(a)	1	2	4	5
(b)	3	2	2	4
(c)	2	1	3	5
(d)	3	1	2	5

Ans:

Hardness - Zeolite Treatment

Brackish water from sea - Reverse Osmosis

Residual MPN from filters – Chlorination

Turbidity - Coagulation, Flocculation and Filtration

17. A water treatment plant treating 10 mld of water requires 20mg/l of filter Alum, $Al_2(SO_4)_3$. 18 H_2O. The water has 6 mg/l of alkalinity as $CaCO_3$ (Al = 26.97, S=32, O=16, H=1, Ca=40, and C=12).
Total alkalinity requirement (10^6 mg per day as $CaCO_3$) matching filter Alum, shall be

(a) 180 (b) 120
(c) 90 (d) 60

Ans:

Alum dose = 20 mg/l
Discharge Q=10 MLD
Alkalinity = 6 mg/l

$$Al_2(SO_4)_3 18\,H_2O + 3\,Ca\,(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3Ca\,SO_4 + 18\,H_2O + 6CO_2$$

(666) (162)

Alkalinity required as $Ca\,(HCO_3)_2$ = 20 × 162/666 =4.864 ×3 = 14.592 mg/l

Alkalinity as $Ca\,CO_3$ =14.592 ×100/162 = 9 mg/l

Total alkalinity requirement = $9 \times 10 \times 10^6 = 90 \times 10^6 \frac{mg}{day} as\ CaCO_3$

18. A water treatment plant treating 10 mld of water requires 20mg/l of filter Alum, $Al_2(SO_4)_3$. 18 H_2O. The water has 6 mg/l of alkalinity as $CaCO_3$ (Al = 26.97, S=32, O=16, H=1, Ca=40, and C=12).
Quantity of Quick Lime required (10^6 mg per year as CaO) shall be

(a) 2132 (b) 3000
(c) 4132 (d) 6132

Ans:

$$Ca\,(HCO_3)_2 \rightarrow CaO + H_2O + 2CO_2$$

(162) (56)

Quick lime required = 14.592 ×56/162 = 5.04 mg/l
Existing alkalinity =6×56/100 =3.36 mg/l
Deficiency =5.04-3.36=1.68 mg/l
Total quick lime required per year= 1.68×10=16.8×365 =6132Kg

19. In disinfection, which of the following forms of chlorine is most effective in killing the pathogenic bacteria?

(A) Cl (B) OCl (C) NCl (D) HOCl

Ans: HOCl

20. For a water treatment plant having a flow rate of 432/hr, what is the required plan area (m^2) of a Type I setting tank to remove 90% of the particles having a settling velocity of 0.12 cm/sec is

(A) 120 (B) 111 (C) 90 (D) 100

Ans:

$Q = 432\frac{m^3}{hr}$ $v_s = 0.12\ cm/sec$

$v_s = 0.9 \times v_0$

$v_0 = 0.133\ cm/sec = 0.13 \times 10^{-2} m/sec$

$A = \frac{432}{0.133 \times 10^{-2} \times 60 \times 60} = 90.226 \approx 90 m^2$

21. Aeration of water is done to remove

(A) Suspended impurities (B) Colour

(C) Dissolved Salts (D) Dissolve Gases

Ans: Dissolved Gases

22. The following chemical is used for coagulation

(A) Ammonium Chloride

(B) Aluminium Chloride

(C) Aluminum Sulphate

(D) Copper Sulphate

Ans:

Aluminium Sulphate $Al_2(SO_4)_3\ 18\ H_2O$ – Alum

Ferrous Sulphate $Fe\ SO_4\ 7\ H_2O$ - Copperas

Chlorinated copperas

Sodium Aluminate $Na_2Al_2O_4$

23. A town has an existing horizontal flow sedimentation tank with an overflow rate of 17 m^3 /day/m^2, and it is desirable to remove particles that have settling velocity of 0.1mm/sec. Assuming the tank is an ideal

sedimentation tank, the percentage of particles removal is approximately equal to

(A) 30% (B) 50% (C) 70% (D) 90%

Ans:

Critical settling velocity = 17×1000/86400 = 0.2 mm/s

% of particles remove that have settling velocity 0.1 mm /s =0.1 /0.2 x 100 = 50 %

24. Use of coagulants such as alum

(A) Results in reduction of pH of the treated water.

(B) Results in increase of pH of the treated water.

(C) Results in ho change in pH of the treated water

(D) May cause and increase or decrease of pH of the treated water.

Ans: Results in reduction of pH of the treated water.

25. The disinfection efficiency of chlorine in water treatment

(A) Is not dependent on pH value.

(B) Is increase by increased pH value.

(C) Remains constant at all pH value.

(D) Is reduced by increased pH value.

Ans:

Is reduced by increased pH value. Because if PH is less than 7 then chlorine is in the form of HOCl which has high disinfection efficiency whereas if PH is more than 7 HOCl dissociate into H^+ *and* OCl^- *ions* in which OCl^- has less disinfection efficiency.

26. The following characteristics pertain to the sand filters used in water industry.

I. Filtration rate is 1 to 4 m^3/day/m^2

II. Typical duration of operation in one run is 24 to 72 hours.

III. Operating cost is low.

Which of the above characteristics pertain to slow sand filters?

(A) I, II and III (B) I and II (C) II and III (D) I and III

Ans:

Slow sand filters

: Filtration rate is 2 to 4 $m^3/day/m^2$
: Cleaning interval 1 to 3 months
: Operating cost is low.

Rapid sand filters

: Filtration rate is 60 to 120 $m^3/day/m^2$
: Cleaning interval 1 to 3 days.
: Operating cost is high.

27. A solids sphere (diameter 6 mm) is rising through oil (mass density 900 kg/m^3, dynamic viscosity 0.7 kg/ms) at a constant velocity of 1 cm/s. What is the specific weight of the material from which the sphere is made? (Take g = 9.81 m/s^2)

(a) 4.3 kN/m^3 (b) 5.92kN/m^3
(c) 8.7 kN/m^3 (d) 12.3kN/m^3

Ans:

$d = 6mm = 0.006m$
$\gamma = 900\ kg/m^3$
$\mu = 0.7\ kg/ms$
$v = 1cm/s = 1 \times 10^{-2} m/s$
$g = 9.81 \qquad G = ?$
$-v_s = \frac{g}{18}(G-1)\frac{d^2}{v}$ (-ve Since sphere is rising)
$-1 \times 10^{-2} = \frac{9.81}{18} \times (G-1) \times \frac{0.006^2}{\frac{0.7}{900}}$
$G = 0.6036$
$= 0.6036 \times 9.81 = 5.92\ kn/M^3$

28. A soil is composed of solid spherical grains of identical specific gravity and diameter between 0.075 mm and 0.0075 mm. If the terminal velocity of the largest particle falling through water without flocculation is 0.5 mm/s, that for the smallest particle would be

(A) 0.005 mm/s (B) 0.05 mm/s
(C) 5 mm/s (D) 50 mm/s

Ans:

$v_s = \frac{g}{18}(G-1)\frac{d^2}{v}$
$v_s \propto d^2$
$\frac{v_{s1}}{v_{s2}} = \frac{d_1^2}{d_2^2}$
$\frac{0.5}{v_{s2}} = \frac{0.075^2}{0.0075^2}$
$v_{s2} = 0.005mm$

29. A settling tank in a water treatment plant is designed for a surface overflow rate of 30 $\frac{m^3}{day.m^2}$. Assume specific gravity of sediment

particles = 2.65, density of water (ρ) = 1000 kg/m3, dynamic viscosity of water (μ) = 0.001 N.s/m2, and *Stokes' law* is valid. The approximate minimum size of particles that would be completely removed is:

(A) 0.01mm (B) 0.02 mm
(C) 0.03 mm (D) 0.04 mm

Ans:

$$v_s = 30\frac{\frac{m^3}{m^2}}{day} = \frac{30}{24\times60\times60} = 0.347\times10^{-3} m/s$$

$$G = 2.65 \qquad \rho = 1000\ kg/m^3\ \mu = 0.001\ Ns/m^2$$

$$v_s = \frac{g}{18}(G-1)\frac{d^2}{v}$$

$$0.347\times10^{-3} = \frac{9.81}{18}\times(2.65-1)\times\frac{d^2}{1\times10^{-6}}$$

$$d = 1.964\times10^{-5} m = 0.0196\ mm = 0.02mm$$

Environmental Engineering

GATE Questions and Solutions

Module : Basic unit operations and unit processes for surface water treatment, distribution of water.

By

Asst. Prof. Puja Kadam

1. The suitable layout of distribution system for a city with roads of rectangular pattern is

   a) Grid iron system
   b) Dead end system
   c) Ring system
   d) Radial system

   Ans: (a)

2. Coincident draft is

   a) Maximum hourly demand + fire demand
   b) Maximum daily demand + fire demand
   c) Maximum daily demand + public demand
   d) Maximum hourly demand + industrial demand

   Ans: (b)

3. The valve which allows uni directional flow of water in a pipe is called

   a) Reflux valve
   b) Gate valve
   c) Sluice valve
   d) Washout valve

   Ans: (a)

4. In water distribution system at consumers end, the minimum residual gauge pressure should be

   a) 0.7 kg/cm^2
   b) 1.0 kg/cm^2
   c) 1.4 kg/cm^2
   d) 5.0 kg/cm^2

   Ans:(c)

5. For internal water distribution system within building, the most suitable material among the given four is

   a) Steel pipes
   b) C.I. pipes
   c) R.C.C. pipes
   d) G.I. pipes

   Ans: (d)

6. The joints on cast iron pipes for water supply are generally

a) Flanged
b) Welded
c) Spigot and socket (turned and bored)
d) Spigot and socket (lead)

Ans: (d)

7. As per Is : 1172 the water consumption per head for domestic purposes for average conditions is taken as

a) 75 lit/day
b) 100 lit/day
c) 135 lit/day
d) 155 lit/day

Ans: (c)

8. The water mains are provided usually of cast iron as

a) It is very desirable
b) It is able to resist very high pressure
c) It is resistant to corrosion
d) Its discharge remains unaffected with the service time

Ans: (c)

9. The distribution system in water supplies is designed on the basis of

a) Average daily demand
b) Peak hourly demand
c) Coincident draft
d) Greater of b) and c)

Ans: (d)

10. The peak flow factor in water demand in relation to average daily demand

a) 1.8
b) 1.5
c) 2.7
d) 2.0

Ans: (c)

Environmental Engineering

GATE Questions and Solutions

Module : Sewage and sewerage treatment, quantity and characteristics of wastewater.

By

Asst. Prof. Puja Kadam

1. A student began experiment for determination of 5-day, 20°C BOD on Monday. Since the 5thday fell on Saturday, the final DO readings were taken on next Monday. On calculation, BOD (i.e. 7 day, 20°C) was found to be 150 mg/L. What would be the5-day, 20°C BOD (in mg/L)? Assume value of BOD rate constant (k) at standard temperature of 20°C as 0.23/day (base *e*).

(A) 128 (B) 475
(C) 271 (D) 190

Ans:

$$Y_7 = L\,[1 - 10^{-K_d t}]$$
$$150 = L\,[1 - 10^{-0.1\times 7}]$$
$$L = 187.39\ mg/l$$
$$Y_5 = 187.39\,[1 - 10^{-0.1\times 5}] = 128\ \text{mg/l}$$

2. A sample of domestic sewage is digested with silver sulphate, sulphuric acid, potassium dichromate and mercuric sulphate in chemical oxygen demand (COD) test. The digested sample is then titrated with standard ferrous ammonium sulphate (FAS) to determine the un-reacted amount of
(A) Mercuric sulphate
(B) Potassium dichromate
(C) Silver sulphate
(D) Sulphuric acid

Ans: Potassium dichromate

3. **Assertion [a]:** At a manhole, the crown of the outgoing sewer should not be higher than the crown of the incoming sewer.
Reason [r]: Transition from a larger diameter incoming sewer to a smaller diameter outgoing sewer at a manhole should not be made.
The **CORRECT** option evaluating the above statements is:

(A) Both **[a]** and **[r]** are true and **[r]** is the correct reason for **[a]**
(B) Both **[a]** and **[r]** are true but **[r]** is not the correct reason for **[a]**
(C) Both **[a]** and **[r]** are false
(D) **[a]** is true but **[r]** is false

Ans : (B)

4. If the BOD_3 of a wastewater sample is 75 mg/L and reaction rate constant k. (base e) is 0.345 per day. the amount of BOD remaining in the given sample after 10 days is

(A) 3.21 mg/L (B) 3.45 mg/L
(C) 3.69 mg/L (D) 3.92 mg/L

Ans:

$$Y_3 = L\,[1 - 10^{-K_d t}]$$
$$K_d = \frac{0.345}{2.3} = 0.15\ /day$$
$$75 = L\,[1 - 10^{-0.15\times 3}]$$
$$L = 116.25\ mg/l$$
$$Y_{10} = 116.25\,[1 - 10^{-0.15\times 10}] = 112.56\ mg/l$$

BOD remaining = 116.25-112.56=3.69 mg/l

5. The 5-day BOD of a wastewater sample is obtained as 190 mg/l (with k = $0.01h^{-1}$). The ultimate oxygen demand (mg/I) of the sample will be

(A) 3800 (B) 475
(C) 271 (D) 190

Ans:

$$Y_5 = L\,[1 - 10^{-K_d t}]$$
$$K_d = \frac{0.01 \times 24}{2.3} = 0.1043\ /day$$
$$190 = L\,[1 - 10^{-0.1043\times 5}]$$
$$L = 271\ mg/l$$

6. Match Group I (Terminology) with Group II (Definition/Brief Description) for wastewater treatment systems

Group I		Group II	
P.	Primary treatment	1.	Contaminant removal by physical forces
Q.	Secondary treatment	2.	Involving biological and / or chemical reaction
R.	Unit operation	3.	Conversion of soluble organic matter to business
S.	Unit process	4.	Removal of solid materials from incoming waste water

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

Ans:

Primary treatment - Contaminant removal by physical forces

Secondary treatment - Involving biological and / or chemical reaction

Unit operation - Conversion of soluble organic matter to business

Unit process - Removal of solid materials from incoming wastewater

7. To determine the BOD_5 of a wastewater sample, 5, 10 and 50 mL aliquots of the wastewater were diluted to 300 mL and incubated at 20°C in BOD bottles for 5 days.

Sl. No.	Wastewater Volume,	Initial DO, mg/L	DO After 5 days, mg/L
1.	5	9.2	6.9
2.	10	9.1	4.4
3.	50	8.4	0.0

Based on the data, the average BOD_5 of the wastewater is equal to

(a) 139.5 mg/L (b) 126.5 mg/L
(c) 109.8 mg/L (d) 72.2 mg/L

Ans:

$300/5\times(9.2-6.9) = 138$

$300/10\times(9.1-4.4) = 141$

Average = (138+141)/2=139.5 mg/L

Third sample should not be considered as the DO after 5 days is zero.

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

Component	Percent by Weight	Specific Weight (kg/m^3)
Food waste	50	300
Dirt and Ash	30	500
Plastics	10	65
Wood and Yard waste	10	125

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

(a) 319 (b) 217 (c) 209 (d) 199

Ans:

$300 \times 0.5 + 500 \times 30 + 65 \times 0.1 + 125 \times 0.1 = 319\ kg/m^3$

9. In aerobic environment, nitrosomonas convert

(a) NH_3 to NO_2 (b) NO_2^- to NO_3^-
(c) NH_3 to N_2O (d) NO_2^- to HNO_3

Ans: NH_3 to NO_2

10. Total kjeldahl nitrogen is a measure of

(a) Total organic nitrogen
(b) Total organic and ammonia nitrogen
(c) Total ammonia nitrogen
(d) Total inorganic and ammonia nitrogen

Ans:

Total organic and ammonia nitrogen

11. Group 1 contains some properties of water / wastewater and group 2 contains list of some tests on water/waste water. Match the property with corresponding test.

Group1	Group 2
P. Suspended solids concentration	1. BOD
Q. Metabolism of biodegradable organics	2. MPN
R. Bacterial concentration	3. Jar test
S. Coagulant dose	4. Turbidity

(a) P-2, Q-1, R-4, S-3 (b) P-4, Q-1, R-2,S-3
(c) P-2, Q-4, R-1, S-3 (d) P-4, Q-2, R-1, S-3

Ans:

Suspended solids concentration : Turbidity
Metabolism of biodegradable organics : BOD
Bacterial concentration : MPN
Coagulant dose : Jar test

12. In a certain situation, wastewater discharged into a river, mixes with the river water instantaneously and completely. Following is the data available:

Wastewater :
DO = 2.00 mg/L
Discharge rate = 1.10 m^3/s

River water
DO = 8.3 mg/L
Flow rate = 8.70 m^3/s
Temperature = 20° C

Initial amount of DO in the mixture of waste and river shall be

(a) 5.3 mg/L (b) 6.5 mg/L
(c) 7.6 mg/L (d) 8.4 mg/L

Ans:

$$\frac{2 \times 1.1 + 8.3 \times 8.7}{1.1 + 8.7} = 7.6\ mg/l$$

13. An analysis for determination of solids in the return sludge of activated sludge process was done as follows : (1) A crucible was dried to a constant mass of 62.485 g. (2) 75 ml of a well-mixed sample was taken in the crucible. (3) The crucible with the sample was dried to a constant mass of 65.020 g in a drying oven at 104° C. The crucible with the dried sample was placed in a muffle furnace at 600° C for an hour. After cooling, the mass of the crucible with residues was 63.145 g. The concentration of organic fraction of solids present in the return sludge sample is

(a) 8800 mg/l (b) 25000 mg/l
(c) 33800 mg/l (d) 42600 mg/l

Ans:

$$\frac{65.020-63.145}{75} X1000 = \frac{25g}{l} = 25000\ mg/l$$

14. Water samples (X and Y) from two different sources were brought to the laboratory for the measurement of dissolved oxygen (DO) using modified Winkler method. Samples were transferred to 300 ml BOD bottles. 2 ml of $MnSO_4$ solution and 2 ml of alkaliodide-azide reagent were added to the bottles and mixed. Sample X developed a brown precipitate, whereas sample Y developed a white precipitate.
In reference to these observations, the correct statement is

(a) Both the samples were devoid of DO
(b) Sample X was devoid of DO while sample Y contained DO
(c)Sample X contained DO while sample Y was devoid of DO
(d) Both the samples contained DO

Ans:

Sample X contained DO while sample Y was devoid of DO

15. A portion of wastewater sample was subjected to standard BOD test (5 days, 20□C), yielding a value of 180 mg/l. The reaction rate constant (to the base 'e') at 20°C was taken as 0.18 per day. The reaction rate constant at other temperature may be estimated by $k_r = k_{20}\ (1.047)^{T-20}$. The temperature at which the other portion of the sample should be tested, to exert the same BOD in 2.5 days, is

(a) 4.9 °C (b) 24.9 °C
(c) 31.7 °C (d) 35.0 °C

Ans:

$$Y_5 = L\ [1 - 10^{-K_d t}]$$

$$K_d = \frac{0.18}{2.3} = 0.078\ /day$$

$$180 = L\ [1 - 10^{-0.078 \times 5}]$$

$$L = 303.7\ mg/l$$

$$180 = 303.7\,[1 - 10^{-K\times 2.5}]$$

$$K = 0.156$$

$$0.156 = 0.078 \times (1.047)^{T-20}$$

$$T = 35°C$$

16. Match the following:

Group I (Characteristics of sewage discharged into inland waters)	Group II (Allowable limit, mg/L)
P BOD_5	1. 50
Q COD	2. 30
R Oil and Grease	3. 20
S Total Suspended Solids	4. 10
	5. 5
	6. 3

Codes

	P	Q	R	S
(a)	2	5	4	2
(b)	4	1	6	4
(c)	3	1	4	2
(d)	2	1	6	3

Ans:

BOD_5 : 30 mg/L

COD : 250 mg/L

$Oil\ and\ grease$: 10 mg/L

$Total\ Suspended\ Solids$: 100 mg/L

17. In a domestic wastewater sample, COD and BOD were measured. Generally which of the following statement is true for their relative magnitude?

(A) COD = BOD

(B) COD > BOD

(C) COD < BOD

(D) Nothing can be said

Ans: COD > BOD

18. The theoretical oxygen demand of a 0.001 mol/L glucose solution is

(A) 180 mg/L (B) 192 mg/L

(C) 90 mg/L (D) 90 mg/L

Ans:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6H_2O$$

Molucular weight of $C_6H_{12}O_6$ = 180 g /mol

Molucular weight of 6 O_2 = 192 g /mol

$$\text{Glucose } 0.001 \text{ mol/L} = 0.001 \times 180 = 0.18 \text{mg/L}$$

$$\text{Oxygen quantity} = 0.18 \times \frac{192}{180} = \frac{0.192g}{L}$$
$$= 192\ mg/L$$

19. A wastewater sample has an initial BOD of 222 mg/L. The first order BOD decay coefficient is 0.4/day. The BOD consumed (in mg/L) in 5 days is

(A) 150 (B) 192 (C) 30 (D) 50

Ans:

$$Y_5 = L\,[1 - 10^{-K_d t}]$$

$$K_d = \frac{0.4}{2.3} = 0.174/day$$

$$Y_5 = 222\,[1 - 10^{-0.174 \times 5}] = 192\ mg/l$$

BOD consumed in 5 days = 192 mg/l

20. If the $BOD_{5,20}$ of waste is 150 mg/L and the reaction rate constant (to the base 'e') at C is 0.35/day, the ultimate BOD in mg/L is

(A) 97.5 (B) 181.5 (C) 212.9 (D) 230.5

Ans:

$$Y_5 = L\,[1 - 10^{-K_d t}]$$

$$K_d = \frac{0.35}{2.3} = 0.152/day$$

$$150 = L\,[1 - 10^{-0.152 \times 5}]$$

$$L = 181.5 \text{ mg/l}$$

21. The BOD removal efficiency, in percentage, during primary treatment, under normal conditions is about

(A) 65% (B) 85% (C) 30% (D) Zero

Ans: 30%

22. Standard 5-day BOD of a waste water sample is nearly x% of the ultimate BOD, where x is

(A) 48 (B) 58 (C) 68 (D) 78

Ans: 68 %

23. The minimum dissolved oxygen content (ppm) in a river necessary for the survival of aquatic life is

(A) 0 (B) 2 (C) 4 (D) 8

Ans: 4 ppm

24. In a BOD test, 5 ml of waste is added to 295 ml of aerated pure water. Initial dissolved oxygen (D.O.) content of the diluted sample is 7.8 mg/l. After 5 days of incubation at 20°C, the D.O. content of the sample is reduced to 4.4 mg/l. The BOD of the waste water is

(A) 196 mg/l (B) 200 mg/l

(C) 204 mg/l (D) 208 mg/l

Ans:

$300/5 \times (7.8-4.4) = 204$ mg/l

Environmental Engineering

GATE Questions and Solutions

Module : Primary Treatment of wastewater

By

Asst. Prof. Puja Kadam

1. A circular primary clarifier processes an average flow of 5005 m^3/d of municipal wastewater. The overflow rate is 35 $m^3/ m^{2/}d$. The diameter of clarifier shall be

(a) 10.5 m (b) 11.5 m (c) 12.5 m (d) 13.5 m

Ans:

Area=5005/35 =143 m^2

$$\frac{\pi d^2}{4} = 143\ m^2$$

$$d = 13.5\ m$$

2. The following data are given for a channel-type grit chamber of length 7.5 m, flow-through velocity = 0.3 m/s, the depth of wastewater at peak flow in the channel = 0.9 m, specific gravity of inorganic particles = 2.5

g = 9.80 m/s^2, $\mu = 1.002\ X\ 10^{-3}\ Ns/m^2$ at 20 °C, γ_w = 1000 kg/m^3. Assuming that the Stokes is valid, the largest diameter particle that would be removed with 100 percent efficiency is

(a) 0.04 mm (b) 0.21 mm
(c) 1.92 mm (d) 6.64 mm

Ans:

Detention period = Length/velocity =7.5/0.3 =25 s

Settling velocity = depth/time = 0.9/25 = 0.036 m/s

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

$$0.036 = \frac{9.81}{18}\frac{(2.5-1)d^2}{1.002 \times 10^{-6}},$$

$$\therefore d = 2.1 \times 10^{-4} m = 0.21\ mm$$

Environmental Engineering

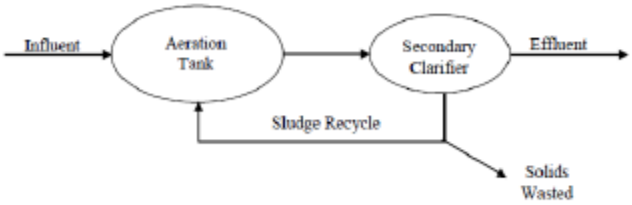
GATE Questions and Solutions

Module : Secondary Treatment of wastewater

By

Asst. Prof. Puja Kadam

1. An activated sludge system (sketched below) is operating at equilibrium with the following information. Wastewater related data: flow rate = 500 $m^3/hour$, influent BOD = 150 mg/L, effluent BOD = 10 mg/L. Aeration tank related data: hydraulic retention time = 8 hours, mean-cell-residence time = 240 hours, volume = 4000 m3, mixed liquor suspended solids = 2000 mg/L.



The food-to-biomass (F/M) ratio (in kg BOD per kg biomass per day) for the aeration tank is

A) 15 (B) 0.210 (C) 0.225 (D) 0.240

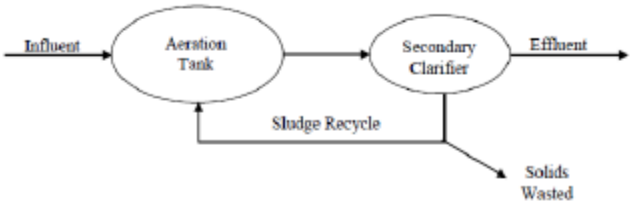
Ans:

$$\frac{F}{M} = \frac{Q \times Y_0}{V \times X_t}$$

$$= \frac{500 \times 24 \times 150}{4000 \times 200}$$

$$= 0.225$$

2. An activated sludge system (sketched below) is operating at equilibrium with the following information. Wastewater related data: flow rate = 500 $m^3/hour$, influent BOD = 150 mg/L, effluent BOD = 10 mg/L. Aeration tank related data: hydraulic retention time = 8 hours, mean-cell-residence time = 240 hours, volume = 4000 m3, mixed liquor suspended solids = 2000 mg/L.



The mass (in kg/day) of solids wasted from the system is

(A) 24000 (B) 1000 (C) 800 (D) 33

Ans:

$$SRT = \frac{V \times X_T}{Q \times X_E}$$

$$= \frac{4000 \times 2000}{500 \times X_E} = 8$$

$$X_E = 2000\ mg/l = 2kg/m^3$$

Per day $2 \times 500 \times 24 = 24000\ kg/day$

3. The sludge from the aeration tank of the activated sludge process (ASP) has solids content (by weight) of 2%. This sludge is put in a sludge thickener, where sludge volume is reduced to half. Assume that the amount of solids in the supernatant from the thickener is negligible, the specific gravity of sludge solids is 2.2 and the density of water is 1000 kg/ m^3.
What is the density of the sludge removed from the aeration tank?

(A) 990 kg/ m^3 (B) 1000 kg/ m^3
(C) 1011 kg/ m^3 (D) 1024 kg/ m^3

Ans:

$2200 \times 0.02 + 1000 \times 0.98 = 1024$ kg/ m^3

4. The sludge from the aeration tank of the activated sludge process (ASP) has solids content (by weight) of 2%. This sludge is put in a sludge thickener, where sludge volume is reduced to half. Assume that the amount of solids in the supernatant from the thickener is negligible, the specific gravity of sludge solids is 2.2 and the density of water is 1000 kg/ m^3.
What is the solids content (by weight) of the thickened sludge?
(A) 3.96% (B) 4.00%
(C) 4.04% (D) 4.10%

Ans:

$$\frac{V_1}{V_2} = \frac{100 - P_2}{100 - P_1}$$

$$2 = \frac{100 - P_2}{100 - 98}$$

$$P_2 = 96$$

Here P_1, P_2 *are moisture contents.*

Therefore solids content is 100-96 =4 %

5. **Column I** **Column II**

P. Grit chamber 1. Zone settling

Q. Secondary settling tank

2. Stoke's law

R. Activated sludge process

3. Aerobic

S. Trickling filter

4. Contact stabilisation

The correct match of Column I with Column II is

(A) P-1,Q-2,R-3,S-4

(B) P-2,Q-1,R-3,S-4

(C) P-1,Q-2,R-4,S-3

(D) P-2,Q-1,R-4,S-3

Ans:

Grit chamber : zone settling

Secondary settling tank: Stoke's law

Activated sludge process: Aerobic

Trickling filter : Contact stabilisation

6. A completely mixed activated sludge process is used to treat a wastewater flow of 1 million litres per day (1MLD) having a BOD_5 of 200 mg/L. The biomass concentration in the aeration tank is 2000 mg/L and the concentration of the net biomass leaving the system is 50 mg/L. The aeration tank has a volume of 200 m^3.

What is the hydraulic retention time of the wastewater in aeration tank ?

(a) 0.2 h (b) 4.8 h (c) 10 h (d) 24 h

Ans:

$$\frac{V}{Q} = \frac{200}{1000}$$

$$= 0.2\ day$$

$$= 0.2 \times 24 = 4.8\ h$$

7. A completely mixed activated sludge process is used to treat a wastewater flow of 1 million litres per day (1MLD) having a BOD_5 of 200 mg/L. The biomass concentration in the aeration tank is 2000 mg/L and the concentration of the net biomass leaving the system is 50 mg/L. The aeration tank has a volume of 200 m^3. What is the average time for which the biomass stays in the system.

(a) 5 h (b) 8 h (c) 2 days (d) 8 days

Ans:

$$SRT = \frac{V \times X_T}{Q \times X_E}$$

$$= \frac{200 \times 2000}{1000 \times 50}$$

$$= 8\ days$$

8. Which of the following sewage treatment methods has inherent problem of odour, ponding, and fly nuisance?

(a) UASB system
(b) Activated sludge process
(c) Trickling filters
(d) Stabilization ponds

Ans. Trickling filter

9. A trickling filter is designed to remove

(A) Settleable Solids

(B) Colloidal Solids

(C) Dissolved Organic Matter

(D) None of the above

Ans: Dissolved Organic Matter

10. Critical factors for the activated sludge treatment process are

(A) Maximum hourly flow rate.

(B) Maximum and minimum flow rate.

(C) Maximum hourly flow rate and maximum daily organic load.

(D) Minimum hourly flow rate and minimum daily organic load.

Ans: Maximum hourly flow rate and maximum daily organic load.

Environmental Engineering

GATE Questions and Solutions

Module : Tertiary Treatment of wastewater

By

Asst.Prof. Puja Kadam

1. An aerobic reactor receives wastewater at a flow rate of 500m^3/d having a COD of 2000mg/L. The effluent COD is 400mg/L. Assuming that wastewater contains 80% biodegradable waste, the daily volume of methane produced by the reactor is

(A) 0.224m^3 B) 0.280m^3
(C) 224m^3 (D) 280m^3

Ans:

Oxygen quantity

$$= 0.8 \times (2000 - 400) \times 500 \times 1000$$
$$= 640 \text{ x } 10^6 mg$$

$$= 640 \text{ x } 10^3 \ g$$

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2H_2O$$

Molecular weight of $CH_4 = 16$ g /mol

Molecular weight of 2 $O_2 = 64$ g /mol

64 g of oxygen produces 16 g of methane.

$$\text{Methane quantity} = \frac{16}{64} \times 640 \text{ x } 10^3 \ g = 160 \text{ x } 10^3 \ g$$

16 g occupies 22.4 L. Therefore

$640 \text{ x } 10^3\ g\ occupies\ \frac{22.4}{16} \times 160 \text{ x } 10^3\ litres = \frac{22.4}{16} \times 160\ m^3$

$$\frac{22.4}{16} \times 160\ m^3 = 224\ m^3$$

2. 50 g of CO2 and 25 g of CH4 are produced from the decomposition of municipal solid waste (MSW) with a formula weight of 120 g. What is the average per capita green house gas production in a city of 1 million people with a MSW production rate of 500 ton/day ?

(a) 104 g/day (b) 120 g/day
(c)208 g/day (d) 313 g/day

Ans:

$\frac{500\times1000\times1000}{1000000} = 500 g/person$. 120 gm produces 75 gm of greenhouse gases

$\therefore$ 500 gm produces $500\ X\ \frac{75}{120} = 312.5\ g/day$

3. The unit in which both sedimentation and digestion processes of sludge take place simultaneously is

(A) Skimming Tank (B) Imhoff Tank

(C) Detritus Tank (D) Digestion Tank

Ans:

Skimming tank: to remove oil and grease

Imhoff tank: Sedimentation and digestion processes of sludge take place simultaneously

Detrious tank: To remove larger grit and to separate very fine sand particles.

Digestion tank: sedimentation and digestion processes of sludge take place simultaneously

Environmental Engineering

GATE Questions and Solutions

Module : Sludge Disposal, Effluent Discharge Standards

By

Asst.Prof. Puja Kadam

1. Bulking sludge refers to having

(a) $F / M < 0.3 / d$
(b) $0.3 / d < F / M < 0.6 / d$
(c) $F / M =$ zero
(d) $F / M > 0.6 / d$

Ans: $F / M < 0.3 / d$

2. Match the following

Group I		Group 2
P.Thickening sludge	of	1. Decrease in volume of sludge by chemical oxidation
Q.Stabilization sludge	of	2. Separation of water by heat or chemical treatment
S.Reduction sludge	of	3. Digestion of sludge
R.Conditioning sludge	of	4. Separation of water by flotation or gravity

(a) P-4,Q-3, R-1, S-2
(b) P-3, Q-2, R-4, S-1
(c) P-4, Q-3, R-2, S-1
(d) P-2, Q-1, R-3, S-4

Ans:

Thickening of sludge : gravity thickeners, floatation thickeners and centrifugal thickeners

Stabilization of sludge : Digestion of sludge is called stabilization

Reduction of sludge : Decrease in volume of sludge by chemical oxidation

Conditioning of sludge : Separation of water by heat or chemical treatment

3. Setting test on a sample drawn from Aeration Tank liquor of ASP (MLSS = 2800 mg/I) was carried out with 1 litre sample. The test yielded a settled volume of 200 ml. The value of Sludge Volume Index shall be

(a) 14.0 (b) 34.2
(c) 71.4 (d) 271

Ans:

Sludge Volume Index is defined as the volume occupied in ml by one gm of solids in mixed liquor after settling for 30 minutes.

SVI= 200 ml/2.8 gm =71.4 ml/gm

4. The sludge from the aeration tank of the activated sludge process (ASP) has solids content (by weight) of 2%. This sludge is put in a sludge thickener, where sludge volume is reduced to half. Assume that the amount of solids in the supernatant from the thickener is negligible, the specific gravity of sludge solids is 2.2 and the density of water is 1000 kg/ m^3. What is the density of the sludge removed from the aeration tank?

(A) 990 kg/m^3. (B) 1000 kg/m^3.

(C) 1011 kg/m^3. (D) 1022 kg/m^3.

Ans:

$Weight\ of\ solids = 2\%$

$Volume\ is\ reduced\ to\ half\ by\ putting\ into\ sludge\ thickener$

$G = 2.2 \qquad \gamma_w = 1000kg/m^3$

$Sludge\ weight = 2kg$

$Water\ weight = 98kg$

$Total\ weight = 98 + 2 = 100kg$

$Sludge\ density = G\gamma_w = 2.2 \times 1000 = 2200$

$Volume = \frac{2}{2200} + \frac{98}{1000} = 0.0989\ m^3$

$Density = \frac{M}{v} = \frac{100}{0.0989} = 1011.03\frac{kg}{m^3} \approx 1011kg/m^3$

5. The sludge from the aeration tank of the activated sludge process (ASP) has solids content (by weight) of 2%. This sludge is put in a sludge thickener, where sludge volume is reduced to half. Assume that the amount of solids in the supernatant from the thickener is negligible, the specific gravity of sludge solids is 2.2 and the density of water is 1000 kg/ m^3.
What is the solids content (by weight) of the thickened sludge?

(A) 3.96% (B) 4.00%
(C) 4.04% (D) 4.10%

Ans:

$$Weight\ of\ solids = 2\%$$

$$Volume\ is\ reduced\ to\ half\ by\ putting\ into\ sludge\ thickener$$
$$G = 2.2 \qquad \gamma_w = 1000kg/m^3$$
$$Sludge\ weight = 2kg$$
$$Water\ weight = 98kg$$
$$Total\ weight = 98 + 2 = 100kg$$
$$Sludge\ density = G\gamma_w = 2.2 \times 1000 = 2200$$
$$Volume = \frac{2}{2200} + \frac{98}{1000} = 0.0989\ m^3$$
$$Density = \frac{M}{v} = \frac{100}{0.0989} = 1011.03\ kg/m^3$$
$$New\ volume = \frac{0.0989}{2} = 0.04945\ m^3$$
$$\frac{2}{2200} + \frac{x}{1000} = 0.04945\ m^3$$
$$x = 48.541\ kg$$
$$\frac{2}{2+48.541} \times 100 = 3.96\%$$

Environmental Engineering

GATE Questions and Solutions

Module : Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment Unit operations and unit processes of domestic wastewater, sludge disposal.

By

Asst. Prof. Puja Kadam

1. Primary sewage treatment removes what percentage of the biochemical oxygen demand (BOD) from domestic sewage?

   a) 90
   b) 30
   c) 33
   d) 60
   Ans: (c)

2. The waste water coming from kitchens and bath rooms is known as

   a) Domestic sewage discharge
   b) Sludge discharge
   c) Drainage discharge
   d) None of these
   Ans: (b)

3. Activated sludge treatment plants are normally preferred for

   a) Towns and smaller cities
   b) Medium sized cities
   c) Large sized cities
   d) All of them
   Ans: (c)

4. A pipe installed in house drainage for ventilation purposes is called a

   a) Soil pipe
   b) Antisiphonage pipe
   c) Vent pipe
   d) None of these
   Ans: (c)

5. The pipe in buildings, through which human excreta flows is called

   a) Soil pipe
   b) Waste pipe
   c) Vent pipe
   d) None of these
   Ans: (a)

6. In house plumbing system, the leakage of different pipes is tested by

a) Smoke test
b) Air test
c) Water test
d) All of these

Ans: (d)

7. In one pipe system of plumbing, waste water is carried down in soil pipe from

a) Water closets
b) Kitchens and bath rooms
c) Wash basin and sinks
d) All of these

Ans: (d)

8. A pipe which is installed in house drainage, to preserve the water seal of trap is called

a) Vent pipe
b) Waste pipe
c) Soil pipe
d) Antisiphonage pipe

Ans: (d)

9. Two pipe system of providing building drainage consists of

a) Soil pipe, waste pipe, vent pipe and sullage pipe
b) Soil pipe, waste pipe and two vent pipes
c) Two Soil pipes and two waste pipes
d) Two soil pipes only

Ans: (b)

10. A nahani trap is provided

a) At the head of each house drain
b) At the outfall end of each house drain
c) At the junction of two house drains
d) None of these

Ans: (a)

Environmental Engineering

GATE Questions and Solutions

Module : Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.

By

Asst. Prof. Puja Kadam

1. Consider four common air pollutants found in urban environments, NO, SO_2, Soot and O_3. Among these which one is the secondary air pollutant?

(A) O_3 (B) NO (C) SO_2, (D) Soot

Ans:

Primary: Oxides of sulphur, oxides of carbon, oxides of Nitrogen, volatile organic compounds and SPM

Secondary: Sulphuric acid, Ozone, Formaldehydes and Peroxy-acyl –nitrate

2. Total suspended particulate matter (TSP) concentration in ambient air is to be measured using a high volume sampler. The filter used for this purpose had an initial dry weight of 9.787 g. The filter was mounted in the sampler and the initial air flow rate through the filter was set at 1.5 m^3/min. Sampling continued for 24 hours. The airflow after 24 hours was measured to be *1.4 m^3/min*. The dry weight of the filter paper after 24 hour sampling was 10.283 g. Assuming a linear decline in the air flow rate during sampling, what is the 24 hour average TSP concentration in the ambient air?

(A) 59.2$\mu g/m^3$ (B) 118. $\mu g/m^3$
(C) 237.5 $\mu g/m^3$ (D) *574.4* $\mu g/m^3$

Ans:

Average flow rate = (1.5+1.4)/2 = 1.45 m^3/min

Total volume of air per day = 1.45 x 60 x 24 =2088 m^3

Weight of TSP =10.283-9.787 =0.496 g

Concentration =0.496/2088 =2.375 x 10^{-4} g/m^3 =237.5g/m^3

3. An air parcel having 40°C temperature moves from ground level to 500 m elevation in dry air followving the "adiabatic lapse rate. The resulting temperature of air parcel at 500 m elevation will be

(A) 35°C (B) 38°C (C) 41°C (D) 44°C

Ans:

Dry adiabatic lapse rate = 9.8°C/km. Therefore per 500m, it is 4.9°C. So the temperature at that elevation is 40 – 4.9 = 35.1 °C

Wet adiabatic lapse rate is 6 °C/km

4. Particulate matter (fly ash) carried in effluent gases from the furnaces burning fossil fuels are better removed by

(A) Cotton bag house filter
(B) Electrostatic precipitator (ESP)
(C) Cyclone
(D) Wet scrubber

Ans:

Cotton bag house filter

5. Two primary air pollutants are

(A) Sulphur oxide and ozone
(B) Nitrogen oxide and Peroxyacetylnitrate
(C) Sulphur oxide and hydrocarbon
(D) Ozone and Peroxyacetynitrate

Ans:

Primary: Oxides of sulphur, oxides of carbon, oxides of nitrogen, volatile organic compounds and SPM

Secondary: Sulphuric acid, Ozone, Formaldehydes and Peroxy-acyl -nitrate

6. The dispersion of pollutants in atmosphere is maximum when

(a) Environmental lapse rate is greater than adiabatic lapse rate
(b) Environmental lapse rate is less than adiabatic lapse rate
(c) Environmental lapse rate is equal to adiabatic lapse rate
(d) Maximum mixing depth is equal to zero

Ans:

When ELR is more than ALR environment is said to unstable and dispersion is more

7. Two electrostatic precipitators (ESPs) are in series. The fractional efficiencies of the upstream and downstream ESPs for size dp are 80% and 65%, respectively. What is the overall efficiency of the system for the same dp?

(a) 100% (b) 93% (c) 80% (d) 65%

Ans:

$$80 + 0.2 \times 65 = 93$$

8. The mean indoor airborne chloroform ($CHCl_3$) concentration in a room was determined to be 0.4 $\mu g/m^3$. Use the following data : T = 293 K, P = 1 atmosphere, R = 82.05 x 10^{-6} atm.m^3/ mol-K, Atomic weights : C = 12, H=1, CI= 35.5. This concentration expressed in parts per billion (volume basis, ppbv) is equal to

(a) 1.00 ppbv (b) 0.20 ppbv
(c) 0.10 ppbv (d) 0.08 ppbv

Ans:

From avagadro's law

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{22.4 * 1}{273} = \frac{V_2 * 1}{293}$$

$$V_2 = 24.04\ L/mol$$

Molecular weight of $CHCl_3$ = 119.5 gr/mole. Therefore 119.5 gr occupies 24.04 L.

1 L occupies 119.5/24.04 =4.97 gr/L =4.97 x 1000 gr/m^3

=4.97 x 1000 x 10^6 $\mu g /m^3$

= 4.97 x 10^9 $\mu g /m^3$

Therefore 1 ppb = 4.97 $\mu g /m^3$ and 0.4 $\mu g /m^3$ means 0.4/4.97 = 0.08 ppbv

9. Elevation and temperature data for a place are tabulated below:

Elevation, m	Temperature, °C
4	21.25
444	15.70

Based on the above data, lapse rate can be referred as:

(A) Super-adiabatic (B) Neutral
(C) Sub-adiabatic (D) Inversion

Ans:

$$ELR = \frac{21.25-15.70}{0.440} = 12.61$$

$$ALR = 10°/km$$

$ELR > ALR$. So super adiabatic.

Environmental Engineering

GATE Questions and Solutions

Module : Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

By

Asst.Prof. Puja Kadam

1. A coastal city produces municipal solid waste (MSW) with high moisture content, high organic materials, low calorific value and low inorganic material. The most effective and sustainable option for MSW management in that city is

(A) Composting (C) Incineration
(B) Dumping in sea (D) Landfill

Ans:

Landfill is effective and sustainable.
Composting is not suitable as high moisture content.
Incineration is not possible as low calorific value.
Dumping in sea is not sustainable.

2. Two biodegradable components of municipal solid waste are

(A) Plastics and wood
(B) Cardboard and glass
(C) Leather and tin cans
(D) Food wastes and garden trimmings

Ans: Food wastes and garden trimmings

Environmental Engineering

GATE Questions and Solutions

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By

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1. According to the Noise Pollution (Regulation and Control) Rules, 2000, of the Ministry of Environment and Forests, India, the day time and night time noise level limits in ambient air for residential areas expressed in dB(A) are

(A) 50 and 40 (B) 65 and 55

(C) 55 and 45 (D) 75 and 70

Ans:

Industrial area : 75 and 70

Commercial area : 65 and 55

Residential area : 55 and 45

Silence zone : 50 and 40

2. The reference pressure used in the determination of sound pressure level is

(A) 20μPa (B) 20db

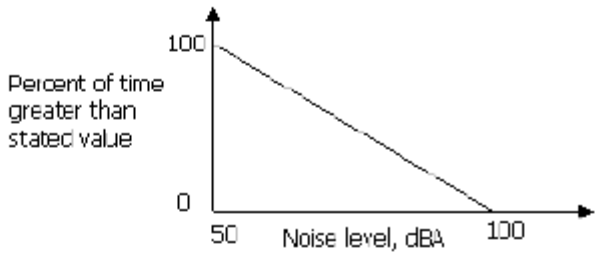
(C) 10μPa (D) 10db

Ans:

20μPa

$L_p \; in \; dB = 20 \; \log_{10} \frac{p_{rms}}{20 \; \mu \, Pa}$

3. The cumulative noise power distribution curve at a certain location is given below.

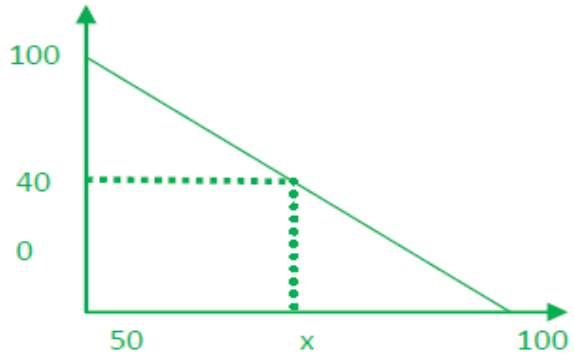


The value of L_{40} is equal to

(a) 90 dBA (b) 80 dBA

(c) 70 dBA (d) 60 dBA

Ans:



From similar triangle principle,

$$\frac{100-40}{x-50}=\frac{100}{100-50}$$

x = 80 dBA

4. If the distance from a noise source is doubled, find out the noise levels i.e. noise level will increase by _____dB.

(a) 6 dBA (b) 8 dBA

(c) 7 dBA (d) 9 dBA

Ans:

$$L_2 = L_1 - 20\ log_{10}\left(\frac{r_2}{r_1}\right)$$

$$20\ log_{10}\left(\frac{r_2}{r_1}\right) = 20\ log_{10}2$$

$$= 6\ \text{dB}$$

5. The noise level at a particular location is 65dB, 70dB and 78dB measured during an hour of the day. What are the average noise levels at the location?

a) 74.05dB b) 64.05dB

c) 50dB d) 40dB

Ans:

$$\overline{L_P}=10\log_{10}\frac{1}{N}\sum_{n=1}^{N}10^{\frac{L_n}{10}}$$

$$\overline{L_P}=10\log_{10}\frac{1}{3}\left[10^{\frac{65}{10}}+10^{\frac{70}{10}}+10^{\frac{78}{10}}\right]$$

$$=74.05\ \text{db}$$

6. The sound pressure level is measured at $5\times 10^{-4}\text{N}/m^2$. Find out the noise level in dB.

a) 27.95dB b) 30dB
c) 40dB d) 50dB

Ans:

$$20\log_{10}\frac{5*10^{-4}}{20*10^{-6}} = 27.95 \text{ db}$$

7. The three-hour day average values in dB are 48, 54,56,52,61 and three-hourly night average values in dB are 36, 42, and 48. What is day equivalent noise level, night equivalent and day-night equivalent noise level. In dB

a) 56.29, 44.41, 54.46
b) 55.68, 44.41, 56.29
c) 44.41, 56.29,55.68
d) 44.41, 55.68, 56.29

Ans:

$$\overline{L_P}=10\log_{10}\frac{1}{5}\left[10^{\frac{48}{10}}+10^{\frac{54}{10}}+10^{\frac{56}{10}}+10^{\frac{52}{10}}+10^{\frac{61}{10}}\right]$$

$$=56.29 \text{ db}$$

$$\overline{L_P}=10\log_{10}\frac{1}{3}\left[10^{\frac{36}{10}}+10^{\frac{42}{10}}+10^{\frac{48}{10}}\right]$$

$$=44.41\text{db}$$

$$\overline{L_P}=10\log_{10}\left[10^{\frac{56.29}{10}}*\frac{15}{24}+10^{\frac{44.41}{10}}*\frac{9}{24}\right]=54.46 \text{ db}$$

8. 60dB (A) re: 20MPa noise is accompanied with another 60dB (A) re: 20MPa. What will be the total noise?

a) 60dB b) 120dB
c) 63dB d) 66 dB

Ans:

$$60=20\log_{10}\left(\frac{P_{1,rms}}{20}\right)$$

$$60=20\log_{10}\left(\frac{P_{2,rms}}{20}\right)$$

$$\therefore P_{1rms}=20 \text{ Anti log}\frac{60}{20}=20000$$

$$P_{2,rms}=20 \text{ Anti log}\frac{60}{20}=20000$$

$$P_{rms}=\sqrt{P_{1,rms}^2+P_{2,rms}^2}=28284$$

$$L=20\log_{10}\left(\frac{P_{rms}}{20}\right)=63 \text{ db}$$

9. 50dB (A) noise lasting for 55 minutes is followed by 90dB (A) noise lasting for 5 minutes. What is leg of this noise

a) 79.2dB b) 7.92dB
c) 80dB d) 8dB

Ans:

$$\overline{L_{eq}}=10\log_{10}\left[10^{\frac{50}{10}}*\frac{55}{60}+10^{\frac{90}{10}}*\frac{5}{60}\right]=79.2\text{ db}$$

10. 10 decibel(dB) increase in sound level will increase the loudness of sound by

a) 2 times b) 5 times
c) 10 times d)none

Ans: (a)

11. Noise limit in silence zone as per Indian standard in a day and night in dB(A)

a) 50, 45 b) 40, 50
c) 60, 40 d) 70, 40

Ans: (a)

12. Units of frequency

a) Hz b) M c) N d) kg

Ans: (a)

13. I dB= _____bel's

a) $\frac{1}{10}$ b) $\frac{1}{100}$ c) 1 d) $\frac{1}{1000}$

Ans: (a)

14. Reference scale of sound pressure

a) $20\mu Pa$ b) $2Pa$
c) $20Pa$ d) $20MPa$

Ans: (a)

15. The maximum sound level which can be tolerated by human ear is

a) 180dB b) 18dB
c) 50dB d) 100dB

Ans: (d)

16. Sound level of jet aircrafts in dB

a) 100 b) 120 c) 140 d) 200

Ans: (a)

17. What is the average of 40, 50,62,72dB re:20MPa

a) 60 b) 56 c) 63 d) 70

Ans:

$$\overline{L_P}=20\log_{10}\frac{1}{N}\sum_{n=1}^{N}10^{\frac{L_n}{20}}$$

$$\overline{L_P}=20\log_{10}\frac{1}{4}\left[10^{\frac{40}{20}}+10^{\frac{50}{20}}+10^{\frac{62}{20}}+10^{\frac{72}{20}}\right]$$

$=63$ db

18. The sound pressure level for a jet plane on the ground with sound pressure of 2000μ bar should be

a) 60decibel
b) 100decible
c) 140decible
d) 180decible

Ans:

$$20\log_{10}\frac{2000*10^{-6}*10^{5}}{20*10^{-6}}=140 \text{ db}$$

19. A machine in a steel plant fabricating industry is found to be producing a sound level if 50dB. In the expansion plans one more such machine needs to be added. What will be the combined noise level?

a) 80-100dB
b) 101-150dB
c) 51-70dB
d) 40-50dB

Ans:

$$50=20\log_{10}\left(\frac{P_{1,rms}}{20}\right)$$

$$50=20\log_{10}\left(\frac{P_{2,rms}}{20}\right)$$

$$\therefore P_{1rms}=20 \text{ Anti log}\frac{50}{20}=6325$$

$$P_{2,rms}=20 \text{ Anti log}\frac{50}{20}=6325$$

$$P_{rms}=\sqrt{P_{1,rms}^2+P_{2,rms}^2}=8945$$

$$L=20\log_{10}\left(\frac{P_{rms}}{20}\right)=53 \text{ db}$$

20. Noise pollution in a road-side building can be reduced by
    a) Providing a ditch around the building and filling it with water
    b) Providing a thick bush around the building
    c) Providing a thick bush around the building
    d) Planting tall trees around the building and fencing them with barbed wires

    Ans: Providing a thick bush around the building

21. For noise measurement, formula for sound pressure level (SPL) is 20 $log \frac{p}{P_{ref}}$. What will be the resultant noise in dB if P is 0.0002μ bar?

    a) 0
    b) 60
    c) 90
    d) 100

    Ans: $20 \log_{10} \frac{0.0002*10^{-6}*10^{5}}{20*10^{-6}}$ =0 db