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Environmental Engineering

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 23/10/2019

ANSWER KEY ➤ Environmental Engineering

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

DETAILED EXPLANATIONS

1. (b)

Number of air changes required per hour = 30

Volume of air in the room needed to be changed = 24 m^3

Total volume of air required to be changed per hour = 24 × 30 = 720 m^3/hr

Hence, the minimum required capacity of the exhaust ton = 720 m^3/hr

2. (b)

$$S_y = n - S_R$$
$$= 40 - 15 = 25\%$$
$$= 0.25$$
$$\text{Change in storage} = S_y \times \text{Area} \times \text{Drop in the level of water}$$
$$= 0.25 \times 32 \times 1.2$$
$$= 9.6 \text{ ha-m}$$

3. (c)

Expanded depth of filter bed, $D_e = \dfrac{(1-n)D}{(1-n_e)}$

$$D_e = \frac{(1-0.5)\times 0.6}{(1-0.6)}$$
$$= 0.75 \text{ m}$$

4. (d)

$$\text{Energy content on an ash free basis} = \frac{100}{100 - mc\% - \text{ash}\%} \times \text{energy discarded}$$

$$= \frac{100}{100 - 16 - \text{ash}\%} \times 15000 = 18750$$

$$\text{Ash}\% = 4\%$$

6. (a)

$$Q = 4637\sqrt{P}\left[1 - 0.01\sqrt{P}\right]$$

where, P is population in thousand

$$P = 169000 = 169 \text{ thousand}$$

$$\therefore \quad Q = 4637\sqrt{169}\left[1 - 0.01\sqrt{169}\right]$$
$$= 4637 \times 13\,[1 - 0.01 \times 13]$$
$$= 52444.47 \text{ litres/day}$$

7. (c)

Two sections are hydraulically equivalent when

$$Q_1 = Q_2 \text{ for full discharge condition on the same slope}$$
$$\therefore \quad Q_{cir} = Q_{sq}$$
$$\Rightarrow \quad \frac{\frac{\pi}{4}D^2}{n}\left(\frac{D}{4}\right)^{2/3}\sqrt{s} = \frac{1}{n}\times B^2 \times \left(\frac{B}{4}\right)^{2/3}\sqrt{s}$$

$$\Rightarrow \quad D^{8/3} = \frac{4}{\pi}B^{8/3}$$

$$\Rightarrow \quad D = 1.095\text{ B} \simeq 1.1\text{ B}$$

8. (c)

Amount of chlorine required daily = $0.3 \times 30000 \times 150$

$= 1.35 \times 10^6$ mg = 1.35 kg

Amount of bleaching powder required daily = $\dfrac{1.35 \times 100}{30}$ = 4.5 kg

∴ Annual consumption of bleaching powder = 4.5×365

= 1642.5 kg

= 1.64 tonnes

9. (d)

$$\because \quad Q = CAS$$

$$20 \times 10^{-3}\text{ m}^3\text{/sec} = \frac{0.6}{60 \times 60} \times \left(\frac{\pi D^2}{4}\right) \times 3$$

$$D = 7.14\text{ m}$$

12. (c)

$$Al_2(SO_4)_3 \cdot 18H_2O + 3Ca(HCO_3)_2 \rightarrow 3CaSO_4 + 2Al(OH)_3(\downarrow) + 6CO_2$$

Each mole of alum (mol. mass = 666) is supposed to produce 2 moles of [$Al(OH)_3$] precipitate. In other words, 666 kg of alum produces 2×78 kg of sludge precipitate as $Al(OH)_3$.

∴ 1 kg alum will produce = $\dfrac{2 \times 78}{666}$ = 0.234 kg of sludge

∴ 500 kg alum produces sludge = 0.234×500 = 117 kg ≃ 120 kg

13. (a)

In this disinfection process, we have the relationship,

$$tC^n = k$$

where, t = time required to kill all pathogenic organisms

C = concentration of disinfectant

n = dilution coefficient

k = constant

$$\therefore \quad t_1C_1^{\,n} = t_2C_2^{\,n} \qquad \text{...(i)}$$

In our case, $n = 1$

$$t = \frac{L}{V}$$

L = length of pipe, V = velocity of flow

$$\therefore \quad t = \frac{L}{Q/A} = \frac{L \times A}{Q}$$

$$C = \frac{W}{Q}$$

where, W = weight of disinfectant per day

Q = discharge per day

Substituting C and t in equation (i),

$$\frac{L\times A}{Q_1}\times\frac{W_1}{Q_1} = \frac{L\times A}{Q_2}\times\frac{W_2}{Q_2}$$

$$\Rightarrow \quad W_2 = \frac{Q_2^2}{Q_1^2}\times W_1 = \left(\frac{28}{22}\right)^2\times 40\text{ kg/d} = 64.79\text{ kg/day}$$

14. (a)

Quantity of ferrous sulphate = $\frac{12\times16\times10^6}{10^6} = 192$ kg

Chemical reaction:

$FeSO_4\cdot 7H_2O + Ca(OH)_2 \rightarrow Fe(OH)_2 + CaSO_4 + 7H_2O$

and $Ca(OH)_2 \rightarrow CaO + H_2O$

(Molecular weight of $FeSO_4\cdot 7H_2O$ = 278, Molecular weight of CaO = 56)

∴ 278 kg of ferrous sulphate will react with 56 kg of lime.

Hence quantity of lime corresponding to 192 kg of ferrous sulphate = $\frac{56}{278}\times 192 = 38.68$ kg

15. (a)

$$\text{Total hardness} = [Mg^{2+}]\times\frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } Mg^{2+}} + [Ca^{2+}]\times\frac{\text{Eq. wt of } CaCO_3}{\text{Eq. wt of } Ca^{2+}}$$

$$= \left(24\times\frac{50}{12}\right)+\left(80\times\frac{50}{20}\right) = 100 + 200 = 300\text{ mg}/l$$

16. (b)

Flow velocity, v = 0.4 m/s

Flow velocity, $v = \frac{Q}{BH}$

where, H = Depth of waste water at peak flow = 0.95 m

B = Width of grit chamber

$$\therefore \quad \frac{Q}{B} = v\times H$$

$$\Rightarrow \quad \frac{Q}{B} = 0.4\times 0.95 = 0.38\text{ m}^3\text{/s/m}$$

Settling velocity, $V_s = \frac{Q}{BL} = \frac{0.38}{8.5} = 0.045$ m/s

Settling velocity for 85% removal efficiency,

$$V_s' = 0.85\times V_s$$

$$\Rightarrow \quad V_s' = 0.85\times 0.045 = 0.038\text{ m/s}$$

$$V_s' = \frac{\gamma_w}{18}\left(\frac{G_s-1}{\mu}\right)d^2$$

$$\Rightarrow \quad 0.038 = \frac{10000}{18}\left(\frac{2.5-1}{1.002\times10^{-3}}\right)\times d^2$$

[γ_w = unit weight of water = 1000 kg/m^3 × 10 m/s^2 = 10^4 N/m^3]

$$\Rightarrow \quad d^2 = 4.57\times10^{-8}$$

$$\Rightarrow \quad d = 2.14\times10^{-4}\text{ m} = 0.214\text{ mm} \simeq 0.21\text{ mm}$$

17. (a)

The computation of increase in population per decade and incremental increase is shown below in table.

Year	Population	Increment per decade	Incremental Increase
1940	200000		
1950	380500	180500	– 65800
1960	495500	115000	– 44800
1970	565700	70200	14400
1980	650300	84600	
Total		450300	(–) 96200
Average		$\frac{450300}{4} = 112575$	$-\frac{96200}{3} = -32067$

We know that population after *n* decade by incremental increase method will be,

$$P_n = P + nI + \frac{n(n+1)}{2}\times r$$

Here, I = 112575, $r = -32067$ and $n = 2$

Expected population in the year 2000 AD (i.e. after 2 decades) is

$$P_{2000} = 650300 + 2(112575) + \frac{2(2+1)}{2}\times(-32067)$$

$$= 779249$$

Hence water requirement in 2000 AD @ 225 litres/head/day

$$= 779249\times225$$

$$= 175.33\times10^6 \text{ litres/day}$$

$$\simeq 175.3 \text{ MLD}$$

18. (a)

(i) Lime (CaO) required for alkalinity ($CaCO_3$)

Molecular weight of CaO = 40 + 16 = 56

Molecular weight of $CaCO_3$ = 40 + 12 + 3 × 16 = 100

$$\text{CaO required for 150 mg/}l\text{ alkalinity} = 150\times\frac{56}{100} = 84\text{ mg/}l$$

$$= \frac{84\times10^{-6}\text{ kg}}{l} = \frac{84\text{ kg}}{10^6 l}$$

(ii) Lime required for $MgSO_4$

Molecular weight of $MgSO_4$ = 24 + 32 + 4 × 16 = 120

CaO required for 90 mg/l of $MgSO_4$

$$= 90\times\frac{56}{120} = 42\text{mg/}l = \frac{42\text{kg}}{10^6 l}$$

∴ Total lime required = 84 + 42 = 126 kg/$10^6 l$

Total lime required to treat 10^6 litres of water = 126 kg

19. (a)

Bacterial growth is logarithmic and is described by the equation,

$$N_t = N_0 e^{\mu t}$$

$$\Rightarrow \quad 10^8 = 20 e^{0.02 \times t}$$

$$\Rightarrow \quad t = 771.247 \text{ minute} = \frac{771.247}{60} \text{hrs} = 12.85 \text{hrs}$$

20. (a)

Total green house gases produced by 150g of MSW

= 60g of CO_2 + 30g of CH_4 = 90 gm

600 tonnes of MSW will produce green house gases

$$= 600 \times 10^6 \times \frac{90}{150} = 360 \times 10^6 \text{ g/day}$$

Per capita average production of green house gases

$$= \frac{360 \times 10^6}{20 \times 10^5} = 180 \text{ g/day/capita}$$

21. (d)

$$\text{Surface loading rate} = \frac{720}{12 \times 1.5} = 40 \text{ m}^3/\text{hr/m}^2$$

$$\text{Detention time} = \frac{V}{Q} = \frac{12 \times 1.5 \times 0.8}{720} \times 60 = 1.2 \text{ minutes}$$

22. (b)

Sewage produced = 1200000 litres/day

5 day BOD of sewage = 210 ppm = 210 mg/litre

BOD of effluent = 22 mg/litre

∴ BOD removed by pond = (210 – 22) = 188 mg/litre

∴ BOD removed per day = 1200000 × 188 = 225.6 × 10^6 mg = 225.6 kg

It is given that organic loading = 60 kg/ha/day

$$\therefore \quad \text{Required area} = \frac{\text{Sewage consumed}}{\text{Organic loading}} = \frac{225.5}{60} = 3.76 \text{ ha}$$

23. (a)

Total water filtered in a day = 1 × (24 × 60 × 60) = 86400 m^3/day

$$\text{Total surface area of filter required} = \frac{86400 \text{m}^3/\text{day}}{140 \text{m}^3/\text{day/m}^2} = 617.14 \text{ m}^2$$

Area of one filters required = 6 × 8 = 48 m^2

$$\text{Total number of filter} = \frac{617.14}{48} = 12.86 \simeq 13$$

As three filters are out of service, number of filters working = 13 – 3 = 10

Total surface area of ten filters = 48 × 10 = 480 m^2

$$\text{New loading rate} = \frac{86400 \text{ m}^3/\text{day}}{480 \text{ m}^2} = 180 \text{ m}^3/\text{day/m}^2$$

26. (b)

Sludge solid removal in sedimentation tank = 0.7 × 300 = 210 mg/l

$$\therefore \text{ Mass of total solids removed per 8 million litres} = \frac{210 \times 8 \times 10^6}{1000} = 1.68 \times 10^6 \text{ gm}$$

$$\therefore \quad \text{Sludge volume} = \frac{28 \times 10^6}{1} = 28 \times 10^6 \text{cc}$$

$$= 28 \times 10^6 \text{ m}l$$

$$= \frac{28 \times 10^6}{1000} \text{litres} = 28000 \text{ litres}$$

27. (b)

$$\text{Intensity level} = 10\log\left(\frac{I}{I_0}\right)$$

In first source, $\frac{I}{I_0} = 4$

$$\therefore \quad \text{Thus increased intensity level} = 10\log\left(\frac{I}{I_0}\right) = 10\log(4) = 6\text{dB}$$

and in second source, $\frac{I}{I_0} = 8$

$$\therefore \quad \text{Thus increased intensity level} = 10\log\left(\frac{I}{I_0}\right) = 10\log(8) = 9\text{dB}$$

28. (b)

If waste water sample is mixed with pure distilled water and incubated for 5 days, then BOD_5 of sewage sample

$$= \text{DO consumed}$$

$$= \left(\text{DO}_{\text{initial}} - \text{DO}_{\text{final}}\right) \times \left[\frac{\text{Volume of diluted sample}}{\text{Volume of undiluted sewage sample}}\right]$$

However, when pure distilled water is not used for dilution of the sewage sample, then BOD_5 of sewage sample can be calculated by using modified equation as,

$$= \left[(D_1 - D_2) - (B_1 - B_2)\cdot f\right] \text{Dilution factor}$$

where, B_1 = Initial DO of dilution water

B_2 = DO of dilution water after incubating for 5 days in a coperate BOD bottle

f = Ratio of dilution water volume in wastewater test to the dilution water volume in BOD test on dilution water

D_1 = 7.5 mg/l

D_2 = 2.1 mg/l

B_1 = 8.0 mg/l

B_2 = 6.8 mg/l

$$\text{Dilution factor} = \frac{400\text{mL}}{20\text{mL}} = 20$$

$$\therefore \quad \text{BOD}_5 \text{ of sewage} = \left[(7.5-2.1)-(8.0-6.8)\times\frac{380}{400}\right]\times 20$$

$$= [5.4 - 1.2 \times 0.95] \times 20 = 85.2 \text{ mg}/l$$

29. (a)

$$Q = 4230 \text{ m}^3/\text{d}$$

$$N_t = N_0 \, e^{-0.156t}$$

Let x be the no. of microorganisms present initially.

97% kill of micro-organisms implies that at time 't' 3% of micro-organisms are still surviving.

$\therefore$ Micro-organisms surviving at time 't' $= \frac{3}{100}x$

$$\therefore \quad \frac{3}{100}x = x \cdot e^{-0.156t}$$

$$\therefore \quad t = 22.48 \text{ min}$$

$$t = 0.0156 \text{ days}$$

$$\therefore \quad \text{Volume} = Q.t$$

$$= 4230 \times 0.0156$$

$$= 65.99 \text{ m}^3$$

30. (c)

$$Q = \frac{2\pi T(s_1 - s_2)}{l\text{n}\left(\frac{r_2}{r_1}\right)}$$

$$T = \frac{55\times10^{-3}\times24\times60\times60\times\ln\left(\frac{120}{12}\right)}{2\times\pi\times(3.5-0.75)}$$

$$= 633.25 \text{ m}^2/\text{day}$$

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