CLASS TEST

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Environment Engineering

CIVIL ENGINEERING

Date of Test : 01/12/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. **(c)**

Nitrite : Color induced by addition of sulphonic acid and napthamine.
Nitrate: Color induced by addition of phenol di-sulphonic acid and KOH.
Fluoride: Color induced by addition of zirconium and alizarine.

2. **(c)**

Density before compaction = 110 kg/m^3

Area of landfill site = 1 m^3

Let thickness of waste before compaction = x m

$\therefore$ Total weight of waste = $110x$ kg

Total weight of waste after compaction = 400 × 1 × 0.14 = 56 kg

$\because$ Total weight of waste remains the same

$$\therefore \quad 110x = 56$$

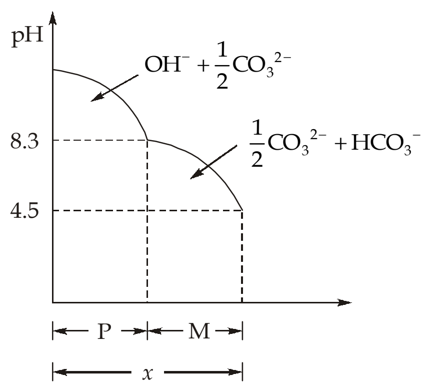
$$\Rightarrow \quad x = 0.509 \simeq 0.51 \text{ m}$$

3. **(a)**

Heterotrophs: Derive both energy and material from organic compounds.
Autotrophs: Derive both energy and mass from inorganic compounds.
Phototrophs: Derive energy from sunlight.

4. **(b)**

Titration curve



For caustic and carbonate alkalinity as predominant species, the following relation needs to be satisfied,

$$P > \frac{x}{2}$$

$$\Rightarrow \quad P > \frac{P+M}{2}$$

$$\Rightarrow \quad 2P > P + M$$

$$\Rightarrow \quad P > M$$

5. (c)

According to national board of fire under writers formula,

$$F_D = 4637\sqrt{P}\left(1-0.01\sqrt{P}\right) l/\text{min} \qquad \text{(where } P \text{ is in thousand)}$$

$$= 4637\sqrt{200}\left(1-0.01\sqrt{200}\right) = 56303\, l/\text{min}$$

$$= \frac{56303}{10^3 \times 60} = 0.938\ \text{m}^3/\text{s}$$

6. (d)

$$\text{Alkalinity} = \frac{500}{2}\ \text{mg}/l = 250\ \text{mg}/l$$

$$\text{Hardness} = \frac{450}{2}\ \text{mg}/l = 225\ \text{mg}/l$$

Carbonate hardness = min. {Alkalinity, Hardness}

= 225 mg/l

Non-carbonate hardness = Hardness – Carbonate hardness

= 225 – 225 = 0 mg/l

∴ Non-carbonate hardness is zero.

7. (d)

$$\text{SVI} = \frac{V_{ob}\,(\text{m}l/l)}{X_{ob}\,(\text{mg}/l)} = \frac{V_{ob}}{X_{ob}} \times 100\ \text{m}l/\text{g}$$

V_{ob} = Settled volume sludge per liter

$$= \frac{850}{2} = 425\ \text{m}l/l$$

$$V_{ob} = 3000\ \text{mg}/l$$

$$\text{SVI} = \frac{425}{3000} \times 1000 = 141.667 \simeq 142\ \text{m}l/\text{g}$$

8. (c)

Velocity gradient, $G = \sqrt{\frac{P}{\mu V}}$

Power input per unit volume $\left(\frac{P}{V}\right)$ = 600 W

∴ $G = \sqrt{\frac{600}{10^{-3}}}\ \text{sec}^{-1}$

⇒ $G = 774.597\ \text{sec}^{-1} = 774.597 \times 60\ \text{min}^{-1}$

⇒ $G = 46475.8\ \text{min}^{-1}$

9. (c)

Dilution ration	Treatment
1. > 500	No treatment required
2. 300 – 500	Plain sedimentation
3. 150 – 300	Sedimentation (SS < 60 ppm)
4. < 150	Complete treatment (SS < 30 ppm; BOD < 20 ppm)

10. (b)

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

Here concentration is in moles/litre

$$10^{7.4} = \frac{[\text{HOCl}]}{\left[10^{-7.4}\right]\left[\text{OCl}^-\right]}$$

$\Rightarrow$ $[\text{HOCl}] = [\text{OCl}^-]$

Free residual chlorine $= [\text{HOCl}] + [\text{OCl}^-]$

$\Rightarrow$ $$\frac{2\times10^{-3}}{2\times35} = [\text{HOCl}^-] + [\text{OCl}^-]$$

$\Rightarrow$ $2.857 \times 10^{-5} = 2[\text{OCl}^-]$

$\Rightarrow$ $[\text{OCl}^-] = 1.429 \times 10^{-5}$ moles/litre

$\Rightarrow$ $[\text{OCl}^-] = 1.429 \times 10^{-5} \times 51 \times 10^3$ mg/l

$\Rightarrow$ $[\text{OCl}^-] = 0.729$ mg/l

11. (b)

General equation of kinetics is

$$\frac{dC_A}{dt} = -kC_A^n$$

Order = 2

$\therefore$ $$\int_{C_o}^{C_t} \frac{dC_A}{C_A^2} = \int_o^t -k\,dt$$

$\Rightarrow$ $$\left(\frac{1}{C_o} - \frac{1}{C_t}\right) = -kt$$

Given, $C_o = 0.25$ mg/l, $k = 0.5$ per day, $t = 2$ days

$\Rightarrow$ $$\frac{1}{C_t} = \frac{1}{0.25} + 1$$

$\Rightarrow$ $C_t = 0.2$ mg/l

12. (b)

Given: $P = 30000$, $R = 1$

Quantity of domestic sewage produced per day

$$= \frac{30000 \times 130}{1 \times 10^6} = 3.9 \text{ MLD}$$

Total BOD of sewage = 3.9 × 250 = 975 kg/day

Out of this BOD, 36% is already removed in PST.

∴ BOD to be removed in filter = 0.64 × 975 = 624 kg/day

$$\text{Volume of filter media required} = \frac{\text{Total BOD to be removed}}{\text{Organic loading}} = \frac{624}{10000}\times 10^4 = 624 \text{ m}^3$$

$$\text{Recirculation factor,} \quad F = \frac{1+R}{(1+0.1R)^2} = \frac{1+1}{(1+0.1\times 1)^2} = 1.65$$

Efficiency of this filter is given by

$$\eta = \frac{100}{1+0.44\sqrt{\dfrac{Q_o y_1}{V\times F}}} = \frac{100}{1+0.44\sqrt{\dfrac{624}{624\times 1.65}}} = 74.5\%$$

13. (a)

Critical oxygen deficit is given by,

$$\left(\frac{L_o}{D_c f}\right)^{f-1} = f\left[1-(f-1)\frac{D_o}{L_o}\right]$$

$$f = \frac{k_R}{k_D} = \frac{0.05}{0.03} = \frac{5}{3}$$

$$\left(\frac{12}{D_c\times\frac{5}{3}}\right)^{2/3} = \frac{5}{3}\left[1-\frac{2}{3}\times\frac{5}{12}\right]$$

$$\Rightarrow \quad D_c = 5.45 \text{ mg}/l$$

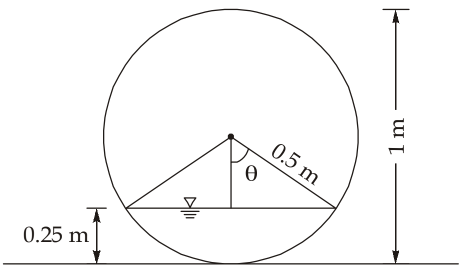
$$D_c = \frac{k_D L_o}{k_R} e^{-k_D t_C}$$

$$\Rightarrow \quad \frac{5.45\times 0.05}{0.03\times 12} = e^{-0.03 t_C}$$

$$\Rightarrow \quad 0.03 t_C = 0.2784$$

$$\Rightarrow \quad t_C = 9.28 \text{ days}$$

14. (b)



$$\cos\theta = \frac{0.5-0.25}{0.5} = \frac{0.25}{0.5} = \frac{1}{2}$$

$$\Rightarrow \qquad \theta = \frac{\pi}{3}$$

Cross-sectional area of flow, $A = r^2\left[\theta - \frac{\sin 2\theta}{2}\right]$

$$\Rightarrow \qquad A = (0.5^2)\left[\frac{\pi}{3} - \left\{\sin\left(2\times\frac{\pi}{3}\right)\right\}\frac{1}{2}\right]$$

$$\Rightarrow \qquad A = \frac{1}{4}\left[\frac{\pi}{3} - \frac{\sqrt{3}}{4}\right]$$

$$A = 0.1535 \text{ m}^2$$

Wetted perimeter of flow $= r\,(2\theta)$

$$= 0.5\times 2\times\frac{\pi}{3} = 1.047 \text{ m}$$

$\therefore$ Hydraulic radius $= \frac{A}{P} = \frac{0.1535}{1.047} = 0.147$ m

15. (c)

Settling velocity, $V_s = \sqrt{\frac{\frac{4}{3}gd(G-1)}{C_D}} = \sqrt{\frac{\frac{4}{3}\times 9.81\times 0.6\times 10^{-3}\times 1.4}{5}} = 0.0469$ m/s

Head loss through the original medium =Head loss through the expanded medium

$\therefore$ Head loss through original medium =$(G - 1)\,(1 - n)\,d$

$$= 1.4 \times (1 - 0.55) \times 0.54$$

$$= 0.3402 \text{ m} \simeq 0.34 \text{ m}$$

16. (d)

η = 60%

Moisture content = 96%

$\therefore$ Solids content = 4%

S_{solid} = 1.2

$$\therefore \qquad \frac{100}{S_{sludge}} = \frac{\%\,\text{solid}}{S_{solid}} + \frac{\%\,\text{water}}{S_{water}}$$

$$\Rightarrow \qquad \frac{100}{S_{sludge}} = \frac{4}{1.2} + \frac{96}{1}$$

$$\Rightarrow \qquad S_{sludge} = 1.0067$$

Volume of sludge produced, $V = \frac{100}{100-P}\times\frac{M}{\rho_{sludge}} = \frac{100}{100-96}\times\frac{0.6\times 300\times 10}{1006.7}$

$$= 44.7 \text{ m}^3$$

17. (c)

$$\text{Concentration of gas} = 2.8 \text{ ppm}$$

$\Rightarrow 10^6$ m^3 air holds 2.8 m^3 gas

$\Rightarrow 1$ m^3 air holds 2.8×10^{-6} m^3 gas

$\because$ Ideal gas law is valid, $\therefore \quad PV = nRT$

$$P = 2 \text{ atm}$$
$$V = 2.8 \times 10^{-6} \text{ m}^3$$
$$T = 294 \text{ K}$$
$$R = 82.05 \times 10^{-6} \text{ atm m}^3/\text{mol. K}$$

$$\therefore \quad 2 \times 2.8 \times 10^{-6} = n \times 82.05 \times 10^{-6} \times 294$$
$$n = 2.32146 \times 10^{-4} \text{ mol}$$

(Note: The concentration is asked in 1 m^3 of air)

$$\therefore \quad n = 2.32146 \times 10^{-4} \times (10^{-2} \times 10^{2})$$
$$\Rightarrow \quad n = 2.32146 \times 10^{2} \ \mu \text{ mol}$$
$$\Rightarrow \quad n = 232.146 \ \mu \text{ mol} \simeq 232.15 \ \mu \text{ mol/m}^3$$

$\Rightarrow 1$ m^3 of air has 232.146 ($\simeq$ 232.15) μ mol of gas.

18. (a)

$$G = 2.5, \ h_L = 0.6 \text{ m/m}$$

η_e is the porosity of expanded bed

$$h_L = D(1 - \eta_e)(G - 1)$$
$$\Rightarrow \quad \frac{h_L}{D} = (1 - \eta_e)(2.5 - 1)$$
$$\Rightarrow \quad \frac{0.6}{1.5} = 1 - \eta_e$$
$$\Rightarrow \quad \eta_e = 0.6$$

Now,
$$\eta_e = \left(\frac{V_B}{V_S}\right)^{0.22}$$
$$\Rightarrow \quad V_B = (0.6)^{1/0.22} \times V_s$$
$$V_B = 0.392 \text{ cm/s} \simeq 3.92 \text{ mm/sec}$$

19. (a)

Component	**% by mass**	**% Moisture**	**Energy (kJ/kg)**	**Dry (mass (kg))**	**Total Energy (kJ)**
Food waste	20	70	4650	6	93000
Paper	40	6	16750	37.6	670000
Card board	15	5	16300	14.25	244500
Plastics	7.5	2	32600	7.35	244500
Garden trimming	7.5	60	6500	3	48750
Wood	5	20	18600	4	93000
Tin cans	5	3	700	4.85	3500
Total				77.05	

$$\text{Moisture content} = \left(\frac{100-77.05}{100}\right)\times 100 = 22.95\%$$

$$\text{Unit energy content} = \frac{\text{Total energy}}{\text{Total weight}} = \frac{1397250}{100} = 13972.50 \text{ kJ/kg}$$

$\therefore$ Energy content on ash-free dry basis

$$= 13972.50\left(\frac{100}{100-22.95-5}\right) = 19392.78 \text{ kJ/kg}$$

20. (c)

Efficiency of trickling filter,

$$\eta = \frac{250-100}{250}\times 100 = 60\%$$

Now, as per NRC equation,

$$\eta = \frac{100}{1+0.44\sqrt{OLR}} \qquad \text{(OLR is in kg/m}^3\text{/day)}$$

$$\Rightarrow \quad 60 = \frac{100}{1+0.44\sqrt{OLR}}$$

$$\Rightarrow \quad 1+0.44\sqrt{OLR} = \frac{100}{60}$$

$$\Rightarrow \quad \text{OLR} = 2.2957 \text{ kg/m}^3\text{/d}$$

But $$\text{OLR} = \frac{\text{kg of BOD entering the filter/day}}{\text{Volume of the filter (V)}}$$

$$\Rightarrow \quad V = \frac{250 \text{ mg}/l \times 20 \times 10^6 \, l/d}{2.2957 \text{ kg/m}^3/\text{d} \times 10^6 \text{ mg/kg}} = 2177.98 \text{ m}^3 \simeq 2178 \text{ m}^3$$

21. (c)

$$d = 0.05 \text{ mm} = 0.05 \times 10^{-3} \text{ m}$$
$$G_s = 2.65$$
$$\eta = 88\%$$
$$\nu = 10^{-6} \text{ m}^2/\text{s}$$

Settling velocity as per Stoke's law is,

$$V_s = \frac{g}{18}(G_s - 1)\frac{d^2}{\nu}$$

$$\Rightarrow \quad V_s = \frac{9.81}{18}\text{m/s}^2\,(2.65-1)\times\frac{(0.05\times 10^{-3}\text{m})^2}{10^{-6}\text{m}^2/\text{s}}$$

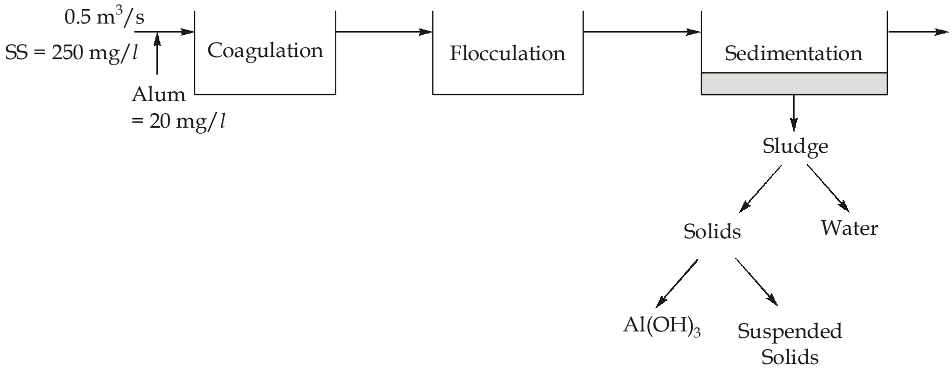
$$= 2.248 \times 10^{-3} \text{ m/s} = 2.248 \text{ mm/s}$$

$$\eta = \frac{V_s}{V_0}\times 100$$

$$\Rightarrow \quad 88\% = \frac{2.248}{V_0}\times 100$$

$$\Rightarrow \quad V_0 = 2.5545 \text{ mm/s} \simeq 2.55 \text{ mm/s}$$

22. (b)



Quantity of suspended solids settled per day

$$= \frac{(250\,\text{mg}/l \times 0.75) \times 0.5\ \text{m}^3/\text{s} \times 86400\,\text{s/d} \times 10^3\ l/\text{m}^3}{10^6\ \text{mg/kg}}$$

$= 8100$ kg/d

1g of alum produces 0.234 g of $Al(OH)_3$ precipitation

$\Rightarrow$20 mg/l of alum will produce = $\frac{0.234}{1} \times 20 = 4.68\,\text{mg}/l$ of $Al(OH)_3$ precipitate

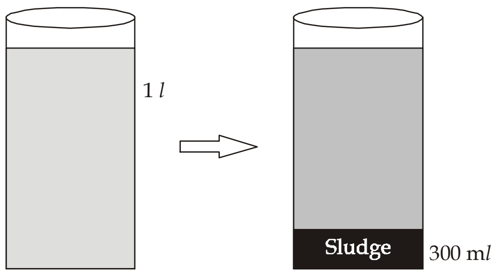
Quantity of $Al(OH)_3$ settled/day = $\frac{4.68\,\text{mg/l} \times 0.5\text{m}^3/\text{s} \times 86400\,\text{s/d} \times 10^3\,\text{l/m}^3}{10^6\ \text{mg/kg}}$

$= 202.176$ kg/d

$\therefore$Total quantity of solids settled/day = 8100 + 202.176 = 8302.176 kg/d $\simeq$ 8300 kg/d

23. (d)

When 300 ml of sludge is dried it is found to have a mass of 3.2 g.



$\therefore$ 3.2g solids are present in 300 ml sample.

$\therefore$ SDI (Sludge Density Index) = $\frac{1}{\text{Sludge volume index (SVI)}}$

$$= \frac{3.2}{300}\ \text{g/mL}$$

$$= \frac{3.2}{300} \times 10^3\ \text{mg/mL}$$

$= 10.67$ mg/mL

24. (c)

From Chick Waston model,

$$t_1 C_1^{n_1} = t_2 C_2^{n_2}$$

Given, $n_1 = n_2 = 1$

t_1 and t_2 → Time of contact

C_1 and C_2 → Concentration of chlorine

For one day, $C_1 = \dfrac{30\,\text{kg}}{20\text{ M}l} = \dfrac{30 \times 10^6 \text{ mg}}{20 \times 10^6\, l} = 1.5 \text{ mg}/l$

∴ $10 \text{ min} \times 1.5 \text{ mg}/l = 12 \text{ min} \times C_2$

⇒ $C_2 = 1.25 \text{ mg}/l$

∴ Total quantity of chlorine required = $1.25 \text{ mg}/l \times 30 \times 10^6\ l/\text{d} = 37.5$ kg/d

25. (d)

DO of diluted sample at $t = 0$

$$= \frac{4 \times 0.5 + 96 \times 4}{100} = 3.86 \text{ mg/lt}$$

$$BOD_5 = (3.86 - 0.8) \times \frac{100}{4} = 76.5 \text{ mg/lt}$$

$$L_0 = \frac{L_t}{1 - 10^{-k_D t}} = \frac{76.5}{1 - 10^{-0.12 \times 5}} = 102.16 \text{ mg/lt}$$

26. (c)

$y_2 = 100 \text{ mg}/l$; $t_2 = 2$ days

$y_4 = 175 \text{ mg}/l$; $t_4 = 4$ days

$k_D = ?$

$$y_2 = y_0\left(1 - e^{-k_D t_2}\right)$$

$$y_4 = y_0\left(1 - e^{-k_D t_4}\right)$$

$$\frac{y_2}{y_4} = \frac{1 - e^{-k_D 2}}{1 - e^{-k_D 4}}$$

$$\frac{100}{175} = \frac{1 - e^{-2k_D}}{1 - e^{-4k_D}}$$

$$1.75 - 1.75x = 1 - x^2$$

$$x^2 - 1.75x + 0.75 = 0$$

$$x = 1, 0.75$$

when $x = 1$

$$e^{-2k_D} = 1$$

⇒ $k_D = 0$

when, $x = 0.75$

$$e^{-2k_D} = 0.75$$

$$k_D = 0.1438 \text{ day}^{-1}$$

27. (d)

28. (a)

$$\text{Percentage removal} = \frac{V_s'}{V_s} \times 100$$

Given,

$$V_s' = 0.92\, V_s$$
$$= 0.92 \times \text{Overflow rate}$$
$$V_s' = \frac{0.92 \times 35}{86400} \text{ m/s}$$
$$\frac{(G-1)gd^2}{18\nu} = \frac{0.92 \times 35}{86400}$$
$$d = \sqrt{\frac{0.92 \times 35 \times 18\nu}{86400 \times (G-1) \times g}} = \sqrt{\frac{0.92 \times 35 \times 18 \times 1.1 \times 10^{-6}}{86400 \times 1.7 \times 9.81}}$$
$$= 2.1035 \times 10^{-5} \text{ m}$$
$$= 21.035\ \mu\text{m} \simeq 21.04$$

29. (c)

$$\text{Minimum chimney height} = h = 14(Q_s)^{1/3}$$

where, Q_s = SO_2 emission in kg/hr

$$\therefore \quad Q_s = \frac{4536 \text{ kg}}{7 \times 24} = 27 \text{ kg/hr}$$
$$\therefore \quad h = 14 \times (27)^{1/3}$$
$$= 14 \times 3$$
$$= 42 \text{ m}$$

30. (b)

This is a case of confined aquifer. Using Theim's formula

$$Q = \frac{2\pi KH(S_1 - S_2)}{2.3\log_{10}\frac{r_2}{r_1}}$$
$$\Rightarrow \quad 0.2 = \frac{2 \times 3.14 \times K \times 15 \times (5-3)}{2.3 \times \log_{10}\left(\frac{50}{10}\right)}$$
$$\Rightarrow \quad K = 1.7077 \times 10^{-3} \text{ m/sec} \simeq 1.7 \times 10^{-3} \text{ m/sec}$$

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