DETAILED SOLUTIONS

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UPPSC AE 2019
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 1

Part Syllabus Test | Water supply, Water collection & treatment, Waste water characterization & treatment, Solid waste mgt., Environmental pollution

ANSWER KEY

1.	(c)	11.	(b)	21.	(a)	31.	(b)	41.	(a)
2.	(c)	12.	(c)	22.	(a)	32.	(d)	42.	(a)
3.	(d)	13.	(a)	23.	(b)	33.	(b)	43.	(c)
4.	(a)	14.	(c)	24.	(a)	34.	(b)	44.	(c)
5.	(a)	15.	(a)	25.	(d)	35.	(b)	45.	(c)
6.	(c)	16.	(d)	26.	(d)	36.	(c)	46.	(a)
7.	(c)	17.	(b)	27.	(a)	37.	(a)	47.	(b)
8.	(b)	18.	(d)	28.	(a)	38.	(c)	48.	(b)
9.	(c)	19.	(a)	29.	(b)	39.	(a)	49.	(b)
10.	(c)	20.	(c)	30.	(c)	40.	(a)	50.	(a)

DETAILED EXPLANATIONS

1. **(c)**

2. **(c)**

3. **(d)**

$$A + 113 = 200$$

∴ Volume of sample, $A = 87$ ml

and $$\text{TON} = \frac{A+B}{A} = \frac{87+113}{87} = 2.3$$

4. **(a)**

FTU measures scattered light from the water sample at 90° angle from the incident light.

JTU measures attenuation of light through water sample.

5. **(a)**

Each vehicle produces NO_X = 20000 × 2 g = 40 kg

50000 vehicle produces NO_X = 40 × 50000 = 2000 tonnes of NO_X

6. **(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 (molecular mass = 666 g/mole) produces 2 moles of aluminium hydroxide [$Al(OH)_3$] (molecular mass = 78 g/mole) precipitate.

In other words, 666 kg of alum produces 2 × 78 kg of sludge precipitate as $Al(OH)_3$.

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

∴ 500 kg alum will produce sludge = 0.234 × 500 = 117.12 kg ≃ 120 kg

7. **(c)**

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

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

8. **(b)**

Anaerobic bacteria developing in the composting process consume carbon 30 to 50 times faster than nitrogen.

9. **(c)**

By using electrostatic precipitator, very small particles can be collected, when it is dry or wet.

10. (c)

Fanning plume is encountered under strong atmospheric inversions in presence of very light winds. In this, horizontal mixing takes place.

11. (b)

12. (c)

Two sections are hydraulically equivalent when

$$Q_1 = Q_2 \text{ for full discharge condition on the same slope}$$

$$\therefore \quad Q_{cir} = Q_{sq}$$

$$\Rightarrow \quad \frac{\frac{\pi}{4}D^2}{n}\left(\frac{D}{4}\right)^{2/3}\sqrt{s} = \frac{1}{n}\times B^2\times\left(\frac{B}{4}\right)^{2/3}\sqrt{s}$$

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

$$\Rightarrow \quad D = \left(\frac{4}{\pi}\right)^{3/8}\cdot B = 1.095\text{ B} \simeq 1.1\text{ B}$$

13. (a)

Sewage consists of more than 99.9% of water and less than 0.1% of solids sanitary sewage is also called as 'Municipal waste".

14. (c)

$$V_1(100 - P_1) = V_2(100 - P_1)$$

$$V_1 = 200\text{ m}^3,\ P_1 = 95\%,\ P_2 = 90\%,\ V_2 = ?$$

$$\therefore \quad 200(100 - 95) = V_2(100 - 90)$$

$$\Rightarrow \quad V_2 = \frac{200\times 5}{10} = 100\text{ m}^3$$

15. (a)

16. (d)

Simple sugars and starch get rapidly degraded and will therefore have a very large BOD rate constant. Thus BOD rate constant depends on nature of waste.

Any given microorganism has its limited ability to utilize organic compounds.

17. (b)

Organic strength of waste is determined by BOD. The organic particles are volatile solids and they reduce dissolved oxygen of water. However measurement of dissolved oxygen is not necessary. Some of the organic matter is refractory (non-biodegradable) in nature. This can be measured by COD. COD is more than BOD.

18. (d)

$$G = \sqrt{\frac{P}{\mu V}} = \sqrt{\frac{1250}{1.0 \times 10^{-3} \times 5}}$$

$$\Rightarrow \quad G = 500 \text{ sec}^{-1}$$

19. (a)

Efficiency of oxidation ditch is close to 98%
Efficiency of oxidation pond is up to 90%
Efficiency of aerated lagoon ranges between 65% to 90%
Efficiency of trickling filter is between 80 - 90%

20. (c)

$$\text{Total BOD in sewage} = 300 \times 10^6 \text{ mg/day}$$

$$\text{Population equivalent} = \frac{\text{Total 5 day BOD in kg/day}}{0.08} = \frac{300 \times 10^6 \times 10^{-6}}{0.08}$$

$$= 3750$$

21. (a)

$$\text{Organic loading} = \frac{Q \cdot y_0}{V}$$

where, Q = Sewage flow into the aeration tank; y_0 = BOD_5 in mg/l
V = Aeration tank volume in m^3

$$\therefore \quad \text{Organic loading} = \frac{(50 \times 1000 \text{ lt}) \times 300 \text{ mg/lt}}{(5 \times 1000)\text{lt}}$$

$$= 3000 \text{ mg/lt}$$
$$= 3 \text{ g/lt}$$
$$= 3000 \text{ g/m}^3$$

22. (a)

Looping plume occurs in super adiabatic condition.
i.e. ELR > ALR
Coning plume occurs in sub-adiabatic condition i.e. ELR < ALR.

23. (b)

$$t_d = \frac{V}{Q} = \frac{2500}{25 \times 10^3} = 0.1 \text{ day} = \frac{24}{10} \text{ hours}$$

24. (a)

$KMnO_4$ or $K_2Cr_2O_7$ is used for COD test. Starch as an indicate is used for DO determination in water (Winkler's method).

25. (d)

26. (d)

$$V_1\,(100 - p_1) = V_2\,(100 - p_2)$$

$$\Rightarrow \quad \frac{V_2}{V_1} = \frac{100 - p_1}{100 - p_2} = \frac{100 - 99}{100 - 95} = \frac{1}{5}$$

27. (a)

$$\text{Total hardness} = 140 \times \frac{50}{20} + 80 \times \frac{50}{12}$$

$$= 350 + 333.33$$

$$= 683.33 \text{ mg}/l \text{ as } CaCO_3$$

Carbonate hardness = Lesser of (Total hardness, alkalinity = Lesser of (200 mg/l, 683.33 mg/l) = 200 mg/l

So, $$\text{Non carbonate hardness} = 683.33 - 200$$

$$= 483.33 \text{ mg}/l$$

28. (a)

$$\text{Volume of primary sludge solids} = \frac{M_s}{1000 G_{si} P_s} = \frac{600}{1000 \times 1.01 \times 0.05} = 11.88 \text{ m}^3$$

$$\text{Fixed solids} = 600\,(1 - 0.5) = 300 \text{ kg}$$

$$\therefore \quad \text{Total solids in digested sludge} = \text{Fixed solids} + \text{Volatile solids}$$

$$= 300 + 600 \times 0.5 \times 0.1 = 330 \text{ kg}$$

$$\therefore \quad \text{Volume of digested sludge} = \frac{330}{1000 \times 1.04 \times 0.1} = 3.17 \text{ m}^3$$

$$\therefore \quad \text{Percentage reduction in volume} = \frac{11.88 - 3.17}{11.88} \times 100 = 73.32\% \simeq 73\%$$

29. (b)

For the smaller population served (less than 50000) the peak factor can be taken as 2.5, and as the population served increases the value of peak factor reduces. For large cities it is can be considered about 1.5 to 2.0.

30. (c)

Activated sludge sedimentation follows Type III or zone sedimentation. In zone sedimentation the particles are at a high concentration (greater than 1000 mg/l) such that particles tend to settle as a mass and distinct clear zone and sludge zone are present.

31. (b)

$$\text{Quantity of sewage produced during the detention period} = 150 \times 150 \times \frac{24}{24} = 22500 \text{ litres}$$

$$\text{The quantity of sludge deposited} = 30 \times 150 \times 1 = 4500 \text{ litres}$$

$$\text{Total required capacity of the tank} = 22500 + 4500 = 27000 \text{ litres}$$

$$= 27000 \times 10^{-3} \text{ m}^3$$

$$= 27 \text{ m}^3$$

32. (d)

Chlorine required for 200 ml water = $\frac{0.1 \times 200}{1000}$ mg

Amount of bleaching powder solution needed = $\frac{\text{Chlorine requirement}}{\text{Available chlorine content}}$

$$= \frac{0.1 \times 200}{1000 \times 0.3} = 0.067 \text{ ml}$$

33. (b)

Tularemia (Deer fly fever, rabbit fever) is caused by bacterium francisella tularensis.

34. (b)

Maximum rate of effluent application,

$$q = \frac{204}{\sqrt{t}} = \frac{204}{\sqrt{9}} = 68\ l/\text{d/m}^2$$

$$\therefore \quad \text{Area of field required} = \frac{136 \times 100}{68} = 200 \text{ m}^2$$

35. (b)

Storage coefficient is also known as "Storativity".

36. (c)

$$\text{Relative stability, } s = 100\left[1 - (0.630)^{t_{37}}\right]$$

where, t_{37} = time in days to decolourise methylene blue solution at 37°C

So, $$s = 100\left[1 - (0.630)^{2}\right] = 60.31\%$$

37. (a)

Since ion exchange method provides water with zero hardness so assuming that x MLD of water is by-passed then

$$100 \text{ mg}/l = \frac{x \times 500 \text{ mg}/l + (10 - x) \times 0}{10}$$

$$\Rightarrow \quad x = 2 \text{ MLD}$$

38. (c)

39. (a)

Aerobic digestion is energy intensive since contineous supply of air has to be maintained.

40. (a)

For new cities, geometric increase method is more suitable for population forecasting.

41. (a)

Nitrification { Nitrosomonas Bacteria : NH_3 to NO_2^-
Nitrobecter Bacteria : NO_2^- to NO_3^-

Denitrification { Paracoccus Denitrificans : NO_3^- to N_2

42. (a)

43. (c)

44. (c)

45. (c)

Typhoid fever is caused by bacterium salmonella typhi and is thus not a viral infection where as infectious hapatitis is caused by virus and not by bacteria.

46. (a)

Assume rate of filtration = $q\, l/\text{d}/\text{m}^2$

Given the side(l) of square filter becomes two times and thus the area will become ($l' \times l' = 2l \times 2l = 4l^2$) four times.

So, amount of water filtered = Rate of filtration × Area
= $q \times 4A = 4 \times (q \times A)$
= 4 times the initial amount of water filtered

47. (b)

$$\text{Recirculation factor, } F = \frac{1+\dfrac{R}{I}}{\left(1+0.1\dfrac{R}{I}\right)^2} = \frac{1+1.4}{(1+0.1\times1.4)^2} = 1.85$$

48. (b)

BOD = Oxygen consumed × Dilution factor

$$\text{Dilution factor} = \frac{100}{0.5}$$

$$\therefore \quad BOD_5 = 2\times\frac{100}{0.5} = 400 \text{ mg}/l$$

49. (b)

$$\text{Temperature of the mix, } T = \frac{Q_w T_w + Q_s T_s}{Q_w + Q_s}$$

$$= \frac{8640\times25+1.2\times24\times60\times60\times15}{8640+1.2\times24\times60\times60}$$

$= 15.77°\text{C}$

50. (a)

$$\text{SPL} = 20\log_{10}\left(\frac{P}{P_{ref}}\right)$$

$$P_{\text{ref}} = 20\ \mu\text{Pa}$$

$$P = 0.0002\ \mu\ \text{bar}$$

$$= 0.0002 \times 10^5\ \mu\text{Pa} \qquad (\because\ 1\ \text{bar} = 10^5\ \text{Pa})$$

$$\therefore \quad \text{SPL} = 20\log_{10}\left(\frac{0.0002\times10^5}{20}\right)$$

$$= 20\log_{10}(1) = 0$$

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