(1) **Example 3.10** Calculate the resultant pH of 700 ml of steel plant effluent with pH 6.5 and the 800 ml of power plant effluent with pH 4.3.

Solution. $[H^+]$ ion steel plant effluent

$= 10^{-6.5}$ *mols/lit* $= 10^{-6.5} \times 0.7$ *mols.*

$[H^+]$ ion from power plant effluent

$= 10^{-4.3}$ *mols/lit* $= 10^{-4.3} \times 0.8$ *mols.*

Total number of moles of H^+ *ion*

$= 10^{-6.5} \times 0.7 + 10^{-4.3} \times 0.8$

The volume of resultant mixture= 0.7 + 0.8 = 1.5 litre

Resultant $[H^+]$ concentration of mixture

$$= \frac{total\ moles\ of\ H^+}{Volume\ of\ mixture} = \frac{10^{-6.5} \times 0.7 + 10^{-4.3} \times 0.8}{1.5} = 2.688 \times 10^{-5}\ mol/lit$$

pH= 5-log 2.688 = 4.57

pH = −log[H+]
= −log(2.688×10^−5)
= −log 2.688 + log 10^−5
= −log 2.688 + (−5) log 10
= −log 2.688 + 5 × 1
= −log 2.688
= 4.57

(2) **Example 3.13** Calculate various hardness of the water simple containing Ca^{2+}, Mg^{2+} and $HCO\bar{3}$ as 60 *mg/L*, 29.3 *mg/L* and 122 *mg/L*, respectively.

Solution. Hardness due to Ca^{2+} *in mg/L as* $CaCO_3$

Equivalent mass of $CaCO_3$ = 100/2 = 50

$$= concentration\ (mg/L) \times \frac{50}{Eq.wt.of\ metal\ ion} = 60 \times \frac{50}{20} = 150 mg/L\ as\ CaCO^3$$

Hardness due to $Mg^{2+} in \frac{mg}{L} CaCO^3 = 29.3 \times \frac{50}{12.2} = 120 mg/L\ as\ CaCO^3$

Hardness due to $HCO\bar{3}\ as\ CaCO^3 = 122 \times \frac{50}{61/2} = 200 mg/L\ as\ CaCO^3$.

$HCO\bar{3}$ ions are only considered for bivalent cations of Ca and Mg.

Hence equivalent mass of $HCO\bar{3}$ is taken as molecular mass/2.

Total hardness (TH) = 150+120= *270mg/L as* $CaCO^3$

Carbonate hardness (CH) = *200 mg/L as* $CaCO^3$

Non-carbonate hardness = 270-200 = *70 mg/L as* $CaCO^3$

(3) **Example 3.14** Calculate different types of hardness of a given water simple with the following analysis.

$Ca^{2+} = 60\ mg/L$

$Mg^{2+} = 12\ mg/L$

$Na^+ = 10\ mg/L$

$HCO\bar{3} = 122\ mg/L$

Solution. Calcium hardness in meq. $= \frac{60}{20} = 3\ meq.$

= 3 x 50 = 150 mg/L as $CaCO^3$

Magnesium hardness $= \frac{12}{12} = 1\ meq$

= 1 x 50 = 50 mg/L as $CaCO^3$

Sodium does not contribute towards hardness.

Total hardness = Ca hardness = Mg Hardness = 200 mg/L as = 3 x 50 = 150 mg/L as $CaCO^3$

Carbonate hardness is due to carbonate and biocarbonate only

$$HCO\bar{3} = 122\ mg/L = \frac{122}{61} = 2meq$$

= 2 x 50 = 100 mg/L as $CaCO^3$

mass of HCO_3^- = 61 g/mol

Non carbonate hardness = 200 - 100 = 100 mg/L as $CaCO^3$ due to $[OH]^-$.

There shall be non-carbonate hardness.

4) A fabric filter is to be constructed using bags of 0.25m in diameter and 6.0m long. The bag house is to receive 15 m³/s of air. Given the filtration rate of 2.2 m/min, determine the number of bags required in the bag house.

Solution. Total filtration area $= \dfrac{\text{flow rate}}{\text{filtering rate}} = \dfrac{15 \times 60\ m^3/min}{2.2\ m/min} = 409.1\ m^2$

Area of one bag $= \pi DH = 3.14 \times 0.25 \times 6 = 4.71\ m^2$

No. of bags $= \dfrac{409.1}{4.71} = 86.8 = 87$ bags required for the bag house.

No. of bags = $\dfrac{\text{Total area}}{\text{Area of one bag}}$

5) Compute the plate area of an ESP attached to a stack handling a flow of $3600\ m^3/min$, if the settling velocity of dust is 0.15 m/s. Take ESP efficiency as 99 %.

Solution. Efficiency $(\eta) = 1 - \exp\left(-\dfrac{Aw}{Q}\right)$

where $Q = 3600\ m^3/min = 60\ m^3/s$

$\eta = 0.99,\ w = 0.15\ m/s$

$$0.99 = 1 - exp\left(-\frac{Aw}{Q}\right) = 1 - exp\left(-\frac{0.15A}{60}\right)$$

or $A = 1842.1\ m^2$

6) Determine the daily requirement of water treatment chemicals in kg for a water treatme plant (WTP) handling a flow of $500\ m^3/hour$. Dosage requirement from jar test for 1 litre as :

5 ml of 10 gm/L alum solution

2.2 ml of 5 gm/L lime solution

1 ml of 1 gm/L polyelectrolyte solution

2 ml of 5 gm/L chlorine solution

Solution. Alum solution strength 10 gm/L

5 ml contains 50 mg

∴ Alum dosage is 50 mg/L. Similarly lime dosage is $2.2 \times 5 = 11\ mg/L$

Polyelectrolyte dosage $1 \times 1 = 1\ mg/L$. Chlorine dosage $2 \times 5 = 10\ mg/L$

∴ Daily requirement of alum.

$$\frac{500 \times 1000 \times 24 \times 50}{10^6} = 600\ kg$$

Daily lime requirement

$$\frac{500 \times 1000 \times 24 \times 11}{10^6} = 132\ kg$$

Polyelectrolyte daily requirement

$$\frac{500 \times 1000 \times 24 \times 1}{10^6} = 12\ kg$$

Daily chlorine requirement

$$\frac{500 \times 1000 \times 24 \times 10}{10^6} = 120\ kg$$

To prevent the formation of dichloramine, ammonia should be dosed in the ratio. $Cl_2 : NH_3 \simeq 4 : 1$

∴ Ammonia requirement $120 \times 0.25 = 30\ kg/day$

6.0m long. The
umber of bags

area
one bag

(7) Calculate the amount of sludge solid generated in a Water Treatment Plant (WTP) for the following data water flow 50,000 m^3/day.

Inlet Suspended Solid (SS) concentration 420 mg/L. Alum dosage 50 mg/L. WTP efficiency 85%

Mount of suspended solid to be removed as sludge from WTP with 85% efficiency

$$= \frac{50{,}000 \times 420 \times 0.85 \times 1000}{10^6} = 17850\ kg/day = 17.85\ Ton\ per\ day$$

One mole of alum $Al_2(SO_4)_3\ 14\ H_2O$ produces two moles of $Al(OH)_3$ *floc*

594 kg of alum → 2×78 kg of $Al(OH)_3$

(molecular mass of alum) (molecular mass of $Al(OH)_3 \sim 78$)

i.e., 1 kg of alum produces 0.26 kg of chemical sludge.

Alum requirement in a day

$$= \frac{50{,}000 \times 1000 \times 50}{1000 \times 1000} = 2500\ kg/day$$

Generation of chemical sludge $= 2500 \times 0.26 = 650\ kg/day$

Total sludge generation $= 17850 + 650 = 18500\ kg/day = 18.5\ Tons/day$

(8) Calculate the waste water flow and characteristic (in BOD mg/L) for serving a population of 75,000.

Solution. Assume per capita cousumption 135 litre/day, waste generation (80%) $= 135 \times 0.8 = 108$ litre/day

Assume BOD loading 50gm/capita/day.

Wastewater generation $= \dfrac{75000 \times 108\ L/day}{1000} = 8100\ m^3/day$

Wastewater characteristic BOD in mg/L

$$\frac{\text{BOD loading in mg per day}}{\text{wastewater generation in litre/day}} = \frac{75000 \times 50 \times 1000\ mg}{75000 \times 108} \approx 463\ mg/L$$

~ X/

(9) Calculate the population equivalent of a city, given average sewage 95×10^6 lit/day and average BOD_5 as 300 mg/L. Assume BOD loading 50 gm/capita/day.

Solution. Sewage flow $= 95\times10^6\ l/day$, BOD loading 300 mg/L

Total BOD/day $= 95\times10^6\times300\ mg/day$

$$\text{Population equivalent} = \frac{95\times10^6\times300}{50{,}000} = 570{,}000$$

(10)

(i) 3 mL of wastewater is taken in a standard 300 mL BOD bottle. Initial DO for diluted sample is found to be 8.8 mg/L. Then final DO after 5 days in BOD incubator is found to be 4.5 mg/L. Find BOD_5 in mg/L.

(ii) If blank correction is to be taken into account given initial blank (diluted water) sample with DO 8.85 mg/L. Final DO of blank (Diluted water) after 5 days in BOD incubator is found to be 8.75 mg/L. Find corrected BOD in mg/L.

(iii) If seeding factor is given at 0.99, then find the corrected BOD in mg/L

Solution.

(i) Sample 3mL diluted to 300mL.

Dilution factor $p = 300/3 = 100$

$DO_i = 8.8\ mg/L,\ DO_f = 4.5\ mg/L$

$$BOD_5 = (DO_i - DO_f)\times p = (8.8-4.5)\times100 = 4.3\times100 = 430\ mg/L$$

(ii) $B_i = 8.85\ mg/L$

$B_f = 8.75\ mg/L$

$$BOD_5 = [(DO_i - DO_f) - (B_i - B_f)]\times p$$

$$= [(8.8-4.5)-(8.85-8.75)]\times100 = (4.3-0.1)\times100 = 4.2\times100 = 420\ mg/L.$$

(iii) Seeding factor = 0.99, then

$$BOD_5 = [(DO_i - DO_f) - (B_i - B_f)f]\times p = [(8.8-4.5)-(8.55-8.75)\times0.99]\times100$$

$$= (4.3-0.1\times0.99)\times100 = (4.300-0.099)\times100 = 4.201\times100 = 420.1\ mg/L$$

(11) A 10 ml of sewage diluted in 300 ml BOD bottle has an initial dissolved oxygen (DO) content 8.7 mg/L and final DO after 5 days is found to be 3.5 mg/L.If the BOD of the above sewage is known to be 200 mg/L neglecting the correction factor, comment upon the test result.

Solution. Dilution factor $\frac{300}{10} = 30$

$DO_i = 8.7\ mg/L.$

$DO_f = 3.5\ mg/L$

$BOD_5 = (8.7 - 3.5) \times 30 = 5.2 \times 30 = 156\ mg/L$

But the strength of sewage is more than the result . Hence sewage is to be more diluted so that the value can be measured in the range, if the dilution factor is increased to 60,

$BOD_5 = 5.2 \times 60 = up\,to 312\ mg/L$ can be measured.

So the sewage BOD can be measured with this dilution.

(12) If a sound source has a pressure of 3000 μPa at 10 m distance, compute :

(a) the sound pressure level in dB

(b) the sound intensity in W/m^2

(c) the sound power in W.

Solution. $P = 3000 \mu Pa$

$P_0 =$ (reference level) $= 20 \mu Pa$

(a) $SPL = 20\ log_{10} \frac{P}{P_0} = 20\ log \frac{3000}{20} = 20\ log\ 150 = 43.5\ dB$

(b) Sound intensity $I = \frac{p^2}{\rho C} = \frac{(3000 \times 10^{-6})^2}{1.185 \times 340} = 2.2 \times 10^{-8}\ W/m^2$,

$c =$ velocity of sound $= 340\ ms^{-1}$

(c) Sound power $= 4\pi r^2 I = 4 \times 3.14 \times 10^2 \times 2.2 \times 10^{-8} = 2.76 \times 10^{-5} W$ *Ans.*

(13) If an industrial fan generates a noise level of 65 dB for 10 minutes out of every hour compute the equivalent continuous level (L_{Aeq}) if the background level is 55 dB.

Solution. $L_1 = 65dB$ L_2 (background) = 55 dB. $\Delta T_1 = 10\,minutes$, $\Delta T_2 = 50\ minutes$. Total time 1hr

$L_{Aeq} =$ (Equvalent noise) $= 10 \log \left[\frac{1}{T} \left(10^{L_1/10} \times \Delta T_1 + 10^{L_2/10} \times \Delta T_2 \right) \right]$

Ans.

$= 10\ log \left[\frac{1}{60} \left(10^{6.5} \times 10 + 10^{5.5} \times 50 \right) \right] = 76.8\ dB.$

(14) Compute the landfill area requirement for 20 years for a city of population about 5 lakh.

Solution. Assume MSW generation as 500 gm per capita per day. Assume MSW density as $500\ kg/m^3$.

Solid waste generation in 20 years $= \dfrac{500{,}000 \times 0.5 \times 365 \times 20}{1000} = 1825000\ MT$

Volume of solid waste (density of $MSW = 0.5T/m^3$)

$= \dfrac{1825{,}000}{0.5} = 36{,}50{,}000\ m^3$. Taking height of dump site as $10m$.

Surface area required = 365000 m² = 36.5 Hectare.

Taking 50% area for free space, vehicle movement and other.

Total area requirement shall be $36.5 \times 2 = 73$ Hectares.

~~FA~~ ~~decimal places~~

~~Figure answer~~