DETAILS EXPLANATIONS

CE : Paper-2 (Paper-6) [Full Syllabus]

[PART : A]

1. The vernier, invented by Piere vernier, is a device for measuring the fractional part of the smallest divisions of a graduated scale.
2. It is equal to the meridian distance of the preceding line plus half the departure of preceding line plus half the departure of the line itself.
3.
   - The road users
   - Vehicles
   - The road and it's condition
   - Environmental factors-traffic, weather etc.
4.
   - Roman-roads where built regardless the gradient.
   - They were built after removing soil and reaching hard stratum.
5. It should be hard, durable, free from impurities, properly rounded and should have a density of about 1600 kg/m^3.
6. The ratio of reservoir capcity to the total inflow in it, is known as capacity-inflow ratio.
7. It is caused by the bacteria and living organisms, which multiply rapidly in a pool water.
8. It is test for residual chlorine and it uses BDH chlorotex reagent, provided with standard colour matching card.
9. It is defined as the ratio of available oxygen to the required oxygen satisfying first stage BOD.
10.
    - Chemical precipitation
    - Gas transfer
    - Adsoption
    - Disinfection
    - Combustion
    - Ion-exchange
    - Electrodialysis
11. A 'Trap' is a bent fitting which, when provided remains full of water, thus maintaing a water seal.
12.
    - It can work under small beds.
    - It can be operated without exposing sewage effluent to view.
13.

$$(DO)_{mix} = \frac{(9.1\times 25)+(0\times 2)}{25+2}$$

$$= 8.426 \text{ mg/lit}$$

14. The evaluation of the shape of particles by shape-test is made in the form of following :

- Angularity number
- Elongation index
- Flakiness index

15. These bricks are used to bear high temperature and low thermal conductivity.

16. Shear stress $(\tau_0) = 0.0225\rho U^2\left(\frac{\mu}{\rho U\delta}\right)^{1/4}$

17. It is defined as the ratio of the area of the jet at vena contracta to the area of the orifice.

18. Uniform flow is the type of flow in which properties of fluid do not change with space.

19. River training works are required to stabilize the river channel along a certain alignment and with a certain cross-section.

20.
- Baby siphon
- Joggle
- Hinged steelplate
- Clear overfall
- Priming weir
- Volutes

[PART : B]

21. D = Horizontal distance, l = Measured length

(i) $D = l\cos\theta = 428\cos 8^\circ = 423.82$ m

(ii) $D = \sqrt{l^2 - h^2} = \sqrt{428^2 - 62^2} = 423.48$ m

(iii) $\tan\theta = \frac{1}{4} = 0.25$

$\therefore \theta = 14^\circ 2'$

$D = l\cos\theta = 428\cos(14^\circ 2') = 415.23$ m

22. We have,

Sensitivity = Angular value of one division = α'

$$\alpha' = \frac{S}{nD} \times 206265 \text{ seconds} = 35''$$

Here, D = 100 m

n = Number of divisions = 1.5

S = Staff intercept

$$S = \frac{\alpha' nD}{206265} = \frac{35 \times 1.5 \times 100}{206265} = 0.025 \text{ m}$$

23. ***Tubewell development by Surging :***

In this method, a plunger is worked up and down in the well, so that water is alternately forced out into the surrounding formation and then allowed to flow back into the well. A surge block or surge plunger is the tool, which is used for this purpose.

The above action loosens the fine sand or gravel particles near the screen and carries fine particles into the well, from where they are removed.

24. This pan is 90 cm square in plan and 45 cm deep. It is supported by drum floats in the middle of a raft of size 4.25 m × 4.87 m. The pan is set afloat in a lake to simulate the characterstics of a large reservoir. The water level in the pan is kept the same as that of the lake.

25.
$$\text{Efficiency of plant} = \frac{\text{Generated Power}}{\text{Design Capacity}}$$

$$\eta = \frac{10\times10^4}{1.23\times10^5}\times100 = 81.3\%$$

(i) Plant Capacity = 1.60 × Design capacity

$$= 1.60 \times 1.23 \times 10^5$$

$$= 1.97 \times 10^5 \text{ kW}$$

(ii) $\text{Plant factor} = \frac{\text{Average Output}}{\text{Plant Capacity}} = \frac{10\times10^4}{1.97\times10^5}$

= 0.51 = 51%

(iii) Total energy produced in a year :

$$= (10 \times 10^4) \times (365 \times 24)$$

$$= 8.76 \times 10^8 \text{ KWh}$$

26. Let width of gate = b

$$\text{Area} = b \times d \text{ m}^2$$

Depth of C.G. from free surface :

$$\bar{h} = P$$

Let h* be the depth of center of pressure from free surface, which is given by-

$$h^* = \bar{h} + \frac{I_G}{A\bar{h}} = \left\{\frac{(bd^3/12)}{b.d.p.}\right\} + p$$

$$h^* = p + \frac{d^2}{12P}$$

Where, $I_G = \dfrac{bd^3}{12}$

27. ***Displacement Pumps :***

The displacement pumps or positive displacement pumps, works on the principal of mechanically inducing vaccum in a chamber and thus, sucking in a certain volume of water, which is then mechanically displaced and forced out of the chamber.

Types of displacement pumps :

- Reciprocating pump and
- Rotary pumps

28. Power is function of :

- Head, (H)
- Discharge, Q
- Specific weight, w

$\therefore$ $$p = KH^a.Q^b.w^C$$

K = Non-dimensional constant

Substituting the dimensions :

$$ML^2L^{-3} = KL^a(L^3T^{-1})^b(ML^{-2}T^{-2})^C$$

Equating the powers of M, L and T on both sides:

$$C = 1$$
$$b = 1$$
$$a = 1$$
$$p = KH^1Q^1w^1$$
$$p = KHQw$$

29. ***The Facts are as follows :***

- In each layer, an air space of about 25 mm should be maintained between adjacent members.
- The crosses/spacers should be of sound wood.
- The ends of all members should be coated with suitable material to prevent end cracking.
- The platform of stack should be made atleast 150 mm higher than ground.
- There should be a minimum distance of atleast 300 mm between adjacent stacks.

30. ***Grading of Aggregates :***

In order to obtain concrete of denser quality, the fine and coarse aggregates are poorly graded. The grading of find aggregates is expressed in terms of BIS test seives numbers 480, 240, 120, 60, 30 and 15. The grading of coarse aggregates may be varied through wider limits than those of sand without appreciable effect on workability of concrete.

31. Expansion $\Delta l = \delta' = \dfrac{2.5}{2} = 1.25 \text{ cm}$

$$\Delta T = T_2 - T_1$$
$$= 54^\circ - 10^\circ = 44^\circ C$$

$\therefore$ $\Delta l = l\ \alpha\ \Delta T$

$$l = \frac{\Delta l}{\alpha . \Delta T}$$
$$= \frac{1.25}{100 \times 10 \times 10^{-6} \times 44}$$
$$= 28.5 \text{ m}$$

32. ***Parking Space Inventory :***

The area under study is fully surveyed and a map is prepared showing all places where kerb parking and off street parking faciltities can be provided to meet the parking demands. The traffic engineers has to strike a balance between capacity and parking demands and to design proper facilities for parking.

[PART : C]

33. Length of dowel bar, L

Assume the diameter of the dowel bar,

$$d = 2.5 \text{ cm}$$
$$P = 5000 \text{ kg}$$
$$H = 25 \text{ cm}$$
$$l = 80 \text{ cm}$$
$$\delta = 2 \text{ cm}$$
$$F_s = 1000 \text{ kg/cm}^2$$
$$E = 1400 \text{ kg/cm}^2$$
$$F_b = 100 \text{ kg/cm}^2$$

For equal capacity of dowel bar in bending and bearing

$$L_d = 5 \times 2.5 \left[\frac{1400}{100} \times \frac{L_d + 1.5 \times 2}{L_d + 8.8 \times 2} \right]^{1/2}$$

$$= 12.5 \left[14 \times \frac{L_d + 3}{L_d + 17.6} \right]^{1/2}$$

Solution of this equation by trail method is simple. therefore as a first trial assume

$$L_d = 45 \text{ cm}$$

$$L_d = 12.5 \left[14 \times \frac{45 + 3}{45 + 17.6} \right]^{1/2} = 40.95$$

Which is less than 45

Assume $L_d = 40.5$

$$L_d = 12.5\left[14 \times \frac{40.5+3}{40.5+17.6}\right]^{1/2} = 40.47$$

Therefore total length of embedment,

$$L'_d = 40.5 \text{ cm}$$

Minimum length of dowel bar required,

$$L = L_d + \delta$$
$$= 40.5 + 2.0 = 42.5$$

Therefore provide 2.5 cm diameter dowel bar of length 45 cm.

Load transfer capacity of single dowel bar, P'

$$P'(\text{shear}) = 0.785\ d^2F_s$$
$$= 0.785 \times 2.5^2 \times 1000 = 4906 \text{ kg}$$

Actual value of $L_d = 45.0 - 2.0 = 43$ cm

$$P'(\text{bending}) = \frac{2d^3F_t}{L_d + 8.86} = \frac{(2 \times 2.5^3 \times 1400)}{(43 + 8.8 \times 2)} = 722 \text{ kg}$$

$$P(\text{bearing}) = \frac{F_b L_d^3 . d}{12.5(L_d + 15\delta)}$$

$$= \frac{100 \times 43^2 \times 2.5}{12.5(43+3)} = 804 \text{ kg}$$

Taking the lowest of the three values, for design, load capacity of a dowel bar, P'(design) = 722 kg

Required load capacity factor

Load capacity of the dowel group = 40% of

$$P = 0.4 \times 5000 = 2000 \text{ kg}$$

Required capacity factor for dowel group

$$= \frac{2000}{722} = 2.77$$

Spacing of dowel bars

Effective distance upto which there is load transfer

$$= 1.8\, l = 1.8 \times 80 = 144 \text{ cm}$$

Assuming a trial spacing of 35 cm between the dowel bars, the capacity factor available for the group.

$$= 1 + \frac{144-35}{144} + \frac{144-70}{144} + \frac{144-105}{144} + \frac{144-140}{144}$$

$$= 5 - \frac{350}{144} = 2.57$$

This value of capacity factor available is less than the capacity factor required, i.e., 2.77. Therefore assuming a closer spacing of 30 cm, capacity factor available.

$$= 1+\frac{144-30}{144}+\frac{144-60}{144}+\frac{144-90}{144}+\frac{144-120}{144} = 2.92$$

As this is greater than the required capacity factor of 2.77, the spacing of the dowel bars is adequate. therefore provide 2 - 5 cm diameter dowel bars of total length 45 cm at 30 cm spacing.

34. Domestic sewage = $(150 \times 40000)10^{-3} = 6000$ m³/day

Industrial wastewater = 0.25×10^6 litres/day = 250 m³/day

Total BOD of domestic sewage

$= (150 \times 40000 \times 200)10^{-6}$

$= 1200$ kg/day

Total BOD of industrial wastewater

$= (0.25 \times 10^6 \times 600)10^{-6}$

$= 150$ kg/day

∴ Total BOD of combined flow

$= 1200 + 150 = 1350$ kg/day

Hence BOD applied to the filter is

$w = 1350 \times 0.65 = 877.5$ kg/day

∴ Filter volume $V = \dfrac{\text{Total BOD removed}}{\text{Permissible organic loading}}$

$$V = \frac{877.5}{8000}\times 10^4 = 1096.9 \text{ m}^3$$

Also, total volume of wastewater influent,

$Q = 6000 + 250 = 6250$ m³/day

Now total inflow, including recirculation

$= (1 + R)Q$

$= (1 + 1)Q = 2 \times 6250$

$= 12500$ m³/day

∴ Filter area $= \dfrac{\text{Total volume of flow}}{\text{Permissible surface loading}}$

Here, permissible surface loading per day = 160 mL/hec

$$= \frac{(160\times 10^6)\times 10^{-3}}{10^4} = 16 \text{ m}^3/\text{m}^2$$

∴ Filter area $= \dfrac{12500}{16} = 781.25$ m²

Hence, diameter of filter $= \sqrt{\dfrac{781.25\times 4}{\pi}} = 31.54$ m

However, provide a tank of 32 m diameter.

Acutal surface area $= \dfrac{\pi}{4}(32)^2 = 804.24$ m²

Hence filter depth $= \dfrac{1096.9}{804.25} = 1.364$ m

Provide the depth of media equal to 1.4 m.

Efficiency, $E = \frac{100}{1+0.44\sqrt{\omega/\gamma F}}$

Here, $\omega = 877.5$ kg/day

V = Volume of filter

$= 804.25 \times 1.4 = 1125.95 \text{ m}^3$

F = Recirculation factor

$= \frac{1+R}{(1+0.1R)^2} = \frac{1+1}{(1+0.1\times1)^2} = 1.653$

$\therefore \quad E = \frac{100}{1+0.44\sqrt{877.5/1125.95\times1.653}}$

$= 76.8\%$

BOD of effluent $= \left(\frac{100-76.8}{100}\right)\times877.5$

$= 203.6$ kg/day

Total volume of effulent = 6250 m^3/day

$\therefore$ BOD concentration $= \frac{203.6\times10^6 (mg)}{(6250\times10^3)(l)}$

$= 32.58$ mg/l

35. ***(i) Observation from A to C :***

$S = 2.425 - 0.765 = 1.66$ m

Distance $AC = K.S.\ \cos^2\theta$

$= 100 \times 1.66 \cos^2 10°12' = 160.8$ m

$V = \frac{K.S.\sin 2\theta}{2} = \frac{100\times1.66}{2}\sin 20°24'$

$= 28.931$ m

Let the elevation of A = 100.00 m

R.L. of C = 100 + 1.38 + 28.931 − 1.595

= 128.716 m

(ii) Observation from B to D :

$S = 2.860 - 0.820 = 2.040$ m

Distance $BD = K.S.\ \cos^2\theta$

$= 100 \times 2.04 \cos^2 12°30' = 194.4$ m

$V = \frac{K.S.\sin 2\theta}{2} = \frac{100\times2.040}{2}\sin 25°$

$= 43.107$ m

R.L. of B = 100 + 6.50 = 106.50 m

R.L. of D = 106.50 + 1.42 – 43.107 – 1.84

= 62.973 m

(iii) Length and Gradient of CD :

Length of AC = 106.8 m

R.B of AC = 546°30'ω

Hence AC is in the third quadrant.

Latitude of AC = –160.8 cos 46°31' = –110.7

Departure of AC = –160.8 sin 46°30' = –116.6

Length of BD = 194.4 m

R.B. of BD = N84°45'E

Hence BD is in the first quadrant.

Latitude of BD = 194.4 cos 84°45' = +17.8

Departure of BD = 194.4 sin 84°45' = +193.6

Now,

Total Latitude of A = +212.3 Total departure of A = –186.8

Add Latitude of AC = –110.7 Add departure of AC = –116.6

Total Latitude of C = +101.6 Total departure of C = –303.4

Similarly,

Total latitude of B = +102.8 Total departure of B = – 96.4

Add latitude of BD = +17.8 Add departure of BD = +193.6

Total latitude of D = +120.6 Total departure of D = +97.2

Thus, the total co-ordinates of the points C and D are known.

Latitude of line CD = Total latitude of D – Total

Latitude of C = 120.6 – 101.6 = +19.0

and Departure of line CD = Total departure of D – Total

Departure of C = 97.2 – (–303.4) = +400.6

The line CD is, therefore, in the fourth quadrant.

$$\text{Length CD} = \sqrt{(19.0)^2 + (400.6)^2} = 401.1 \text{ m}$$

Gradient of CD = (128.716 – 62.973) ÷ 401.1

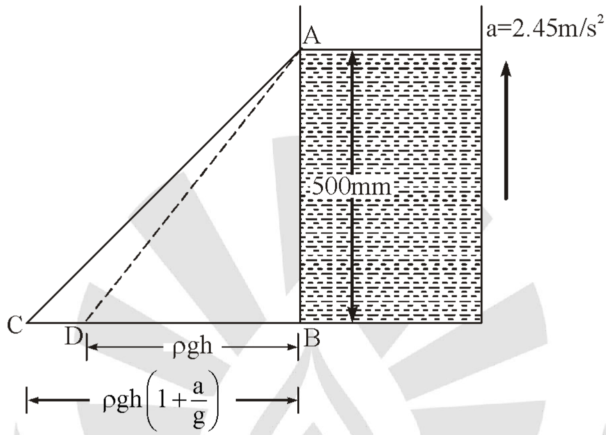
= 1 in 6.1 (Falling)

36. Given, Depth of water, h = 500 mm = 0.5 m

Vertical acceleration, a = 2.45 m/s^2

Width of tank, b = 2 m

To find the force exerted by water on the side of the tank when moving vertically upward, let us first find the pressure at the bottom of the tank.



The guage pressure at the bottom (i.e., at point B) for this case is given by equation as

$$PB = \rho gh\left(1+\frac{a}{g}\right) = 1000\times9.81\times0.5\left(1+\frac{2.45}{9.81}\right)$$

$$= 6131.25 \text{ N/m}^2$$

This pressure is represented by line BC.

Now the force on the side AB = Area of triangle ABC × Width of tank.

$$= \left(\frac{1}{2}\times AB\times BC\right)\times b = \left(\frac{1}{2}\times0.5\times6131.25\right)\times2$$

($\because$ BC = 6131.25 and b = 2 m)

$$= 3065.6 \text{ N}$$

(i) Force on the side of the tank, when tank is moving vertically downward :

The pressure variation is shown in figure for this case, the pressure at the bottom of the tank (i.e., at point B) is given by equation as

$$P_b = \rho gh\left(1-\frac{a}{g}\right) = 1000\times9.81\times0.5\left(1-\frac{2.45}{9.81}\right)$$

$$= 3678.75 \text{ N/m}^2$$

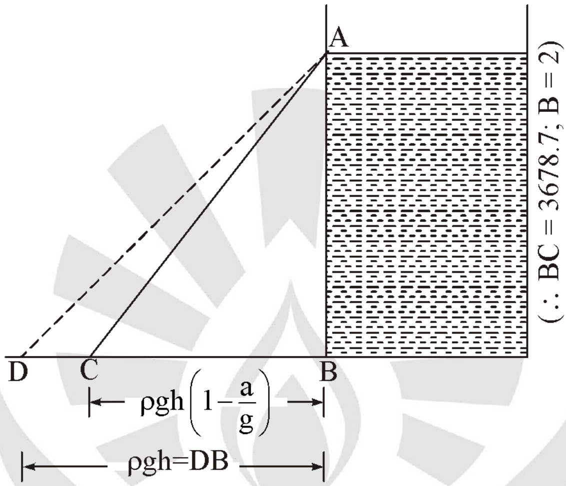
This pressure is represented by line BC.

Now the force on the side AB = Area of triangle AB × Width

$$= \left(\frac{1}{2} \times AB \times BC\right) \times b$$

$$= \left(\frac{1}{2} \times 0.5 \times 3678.75\right) \times 2$$

$$= 1839.37 \text{ N}$$



(ii) Force on the side of the tank, when tank is stationary :

The pressure at point B is given by,

$$P_B = \rho g h = 1000 \times 9.81 \times 0.5 = 4905 \text{N/m}^2$$

The pressure is represented by line BD in figure. force on the side AB = Area of triangle ABD × width

$$= \left(\frac{1}{2} \times AB \times BD\right) \times b$$

$$= \left(\frac{1}{2} \times 0.5 \times 4905\right) \times 2 = 2452.5 \text{ N}$$

For this case, the force on AB can also be obtained as

$$F_{AB} = \rho g A \bar{h}$$

Where, $A = AB \times \text{width} = 0.5 \times 2 = 1 \text{ m}^2$

$$\bar{h} = \frac{AB}{2} = \frac{0.5}{2} = 0.25 \text{ m}$$

$$= 1000 \times 9.81 \times 1 \times 0.25 = 2452.5 \text{ N}$$

37. CAST - IRON :

The cast-iron is manufactured by re-melting pigiron with coke and limestone. This re-melting is done in a furnace known as the cupola furnace. It is more or less some as the blast furnace, but it is simaller in size. Its shape is cylindrical with diameter of about I m and height of about 5 m figure. 10 - 2 shows a typical cupola furnace.

The working of cupola furnace is also similar to that of blast furnace. The raw materials are fed from tap. The cupola furnace is worked intermittently and it is open at top. After the raw materials are placed, the furnace is fired and blast of air is forced through tuyers. The blase of air is cold as the impurities in pig-iron are removed by the oxidation.

The impurities of pig-iron are removed to some extent and comparatively pure iron is taken out in the molten stage from bottom of furnace the slag is also removed from top of cast iron at regular intervals. The molten cast iron is led into moulds of required shapes to from what are known as the cast-iron costing.

COMPOSITION OF COST IRON:

The cast iron contains about 2 to 4 percent of carbon. The magnese makes cast-iron brittle and hard.

The phosphorous increases fludity of cast iron it also makes cast iron. Brittle and when its amount is more than 0.30 percent, the resulting cast iron is lacking in toughness and workability. Its percentage is sometimes kept as about 1 to 1.5 to get very thin castings.

The silicon combines with part of iron and forms a solid solution. It also removes combined carbon from graphite from. If its amount is less than 2.50 percent, it decreases shrinkage and ensures softer and better castings.

the sulphur makes cast iron brittle and hard. It also does not allow smooth cooling in sand moulds. Its presence causes rapid solidification of cast-iron and it ultimately results in blow-holes and sand holes. The sulphur content should be kept below 0.10 percent.

Types of Cast-Iron :

- ***Grey Cast Iron :***

  This is prepared from grey pig. Its colour is grey with a coarse crystalline structure. It is soft and it melts readily. It is some what weak in strength. It is extensively used for making castings.

- ***White Cast Iron :***

  Its colour is silver white. It is hard and it melts with difficulty. It is not easily worked on machine. It cannot be used for delicate casting.

- ***Mottled Cast Iron :***

  It is an intermediate variety between grey cast iron hard and white cast iron. The fracture of this variety is mottled.

- ***Chilled Cast Iron :***

  The chilling consists of making some part of cart of cast iron hard. The interior portion of the body of casting is soft and it is made up of grey-iron.

- ***Melleable Cast Iron :***
- ***Spheroidal Graphite Iron or Ducitile Iron :***

  Malleable cast iron is being replaced by spheroidal graphite iron or ductile iron now-a-days. It's manufacturing is much easier than malleable cast iron.

- ***Toughened Cast Iron :***

  This variety of cast iron is obtained by melting cast-iron with wrought-iron scrap the proportion of wrought iron scrap is about $1/4^{th}$ to $1/7^{th}$ of weight of cast-iron.

Properties of Cast-Iron :

- If placed in salt water, it becomes soft.
- It can be hardned by heating and sudden cooling.
- It can not be magnetised.
- It does not rust easily.
- It is fusible.
- It is hard, but brittle also.
- It's specific gravity is 7.5.

Uses of Cast Iron :

- For making cisterns, water pipes, gas pipes and sewers.
- For making ornamental castings, such as brackets, gates, lamp posts, spiral staircases etc.
- For preparing rail-chairs, carriage wheels etc.
- For making parts of machines which are not subject to heavy shocks.
- For making compression memebers like colums, bars etc.

38. The 6-hour incremental depths of rainfall are calculated and entered in column(2) of table given below. The critical sequence of the rainfall excess increments is then obtained. In the column(5), the rainfall increments are arranged such that the largest increament is against the second largest ordinate and so on.

In the column (6), the sequence is reversed. In the column (7), the infilteration loss is calculated. Column (8) gives the required critical sequence of the rainfall excess.

Time (1)	Cumulative Rainfall Depth(mm) (2)	6-hr Incremental Depth (3)	Ordinates of Unit Hydrograph (Cumecs) (4)	Arrangement of Rainfall Increments (5)	Reversed Sequence of Increments (6)	Infiltration Loss (7)	Rainfall Excess (cm) (8)
0	0	0	0	–	0	0	0
6	15	15	16	–	1.5	0.6	0.9
12	22	7	45	–	2.0	0.6	1.4
18	28	6	85	1.0	4.0	0.6	3.4
24	32	4	110	3	7.0	0.6	6.4
30	35	3	125	6	15.0	0.6	14.4
36	37	2	140 (Largest)	15 (Largest)	6.0	0.6	5.4
42	38.5	1.5	138	7	3.0	0.6	2.4
48	39.5	1.0	122	4	1.0	0.6	0.4
54			102	2.0			
60			90	1.5			
66			75	0			
72			60				
78			45				
84			35				
90			25				
76			15				
102			10				
108			8				
114			4				
120			0				

- ***Procedure for design flood :***

  In this case, for the development of the design flood, eight unit hydrographs would be drawn, each lagging by 6-hours from the preceding one. The ordinates of the first unit hydrograph will be multiplied by the rainfall excess of 0.9 cm. Likewise, the ordinates of the second unit hydrograph by 1.4 cm, and so on.

  The direct run off hydrograph will be obtained by superposition of the respective ordinates.

  The flood hydrograph will be obtained from the direct runoff hydrograph by adding the base flow.

39. As we know;

1º french of hardness = 10 mg/lit of hardness as $CaCO_3$ Chemical reactions involved in lime-soda process are as under : (for example)

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$$

Carbonate hardness   Lime

A visual inspection of these reactions show that lime converts the entire magnesium hardness into calcium hardness in 1 : 1 mol-ratio and carbonate hardness of calcium finally uses lime in 1 : 1 mol-ratio. The original carbonate hardness of calcium and that of magnessium will, thus, required lime. The entire carbonate hardness thus requires lime, in addition to the lime required by the magnessium hardness (Mg^{++}).

The non carbonate hardness of calcium and that of magnessium (of course on conversion into calcium) require sods. hence, soda is required to remove the entire non-carbonate hardness.

As per the given question data :

Magnessium hardness = 9°F = 90 mg/lit
Carbonate hardness = 15°F = 150 mg/lit
Total hardness = 24°F = 240 mg/lit
(all as $CaCO_3$)

Total hardness =Carbonate hardness + Non-carbonate hardness

$\Rightarrow$ 240 = 150 + non-carbonate hardness

$\therefore$ Non-carbonate hardness = 90 mg/lit as $CaCO_3$

Lime required to remove the hardness

= Magnessium hardness + non-carbonate hardness

= 150 mg/lit + 90 mg/lit

= 240 mg/lit as $CaCO_3$

- Quantity of lime required to remove 240 mg/lit (as $CaCO_3$) of hardness is computed as follows :

  From molecular weights, we find that 100 parts of $CaCO_3$ require 56 parts of pure lime (CaO) for treatment, or

  100 mg/lit of $CaCO_3$ requires = 56 mg/lit of CaO (Quick lime)

  Hence Quick lime needed = 135 mg/lit.

  Since, 2 million litres of water is to be treated, total quick lime required.

  $$= 135 \text{ mg/lit} \times 2 \times 10^6 \text{ lit}$$

  $$= 270 \text{ kg}$$

- The quantity of soda required to react with non carbonate hardness of 90 mg/lit (a $CaCO_3$), is computed as :

  100 parts of $CaCO_3$ requires = 106 parts of Na_2CO_3

  $$\Rightarrow 90 \text{ mg/lit of } CaCO_3 \text{ requires} = \frac{106}{100} \times 90 \text{ mg/lit of } Na_2CO_3$$

  $$= 95.4 \text{ mg/lit of soda.}$$

  So, to treat 2 m*l* of water, soda required

  $\Rightarrow$ 95.4 mg/lit × 2 × 10^6 lit

  $\Rightarrow$ 190.8 kg

  Say 191 kg of soda.

❍❍❍