3 Water Chemistry

Water Chemistry

Exercise 1: Find out the chlorine demand of a given sample of water with given bleaching powder

Exercise 2: Estimate the total hardness of given sample of water.

Exercise 3: Estimation of Ca hardness of given sample of water.

Exercise 4: Estimation of Mg hardness of water.

Exercise 5: Estimation of chlorides in given sample of water.

Exercise 6: Estimate sulphates in given sample of water.

Exercise 7: Estimate available chlorine in bleaching powder.

Exercise 1: Find out the chlorine demand of a given sample of water with given bleaching powder

Objective: To find out the chlorine demand of given water sample.

Apparatus

Horrock's apparatus containing:
1. 6 white cup measuring 200 ml capacity each
2. One black cup, 200 ml capacity
3. 2 metallic spoons measuring 2 gm each
4. 7 glass stirring rods
5. One special pipette
6. 2 droppers
7. One starch iodide/potassium iodide bottle

Principle

$H_2O + Cl_2 = HOCl + HCl$

$HOCl = H^+ + OCl^-$

$OCl^- + 2H^+ + 2I = I_2 + H_2O + Cl^-$, I_2 + Starch = Starch iodide (blue colour)

Procedure

Step 1: Prepare stock solution of bleaching powder with following steps:
   a. Take one level full of spoon (2 gm) of bleaching powder in black cup.
   b. Add some sample water to it to make a paste.
   c. Now fill the cup up to circular mark and stir it with a rod. Now stock solution is ready.

Step 2: Fill six white cups with sample water up to 1 cm below the rim, i.e. 200 ml.

Step 3: With the help of special pipette add one drop of stock solution in cup no. '1', two drops in cup no. '2', three drops in cup no. '3', four drops in cup no. '4', five drops in cup no. '5', and six drops in cup no. '6' after arranging cups in sequence.

Step 4: Stir each cup using separate rod for each cup.

Step 5: Wait for contact period (half hour for treated water and 1 hour for untreated water)

Step 6: Add 3 drops of starch iodide/potassium iodide solution in each white cup.

Step 7: Note the 1st cup showing blue colour in the series of 6 cups.

Step 8: Repeat the whole procedure (step 1 – 7) at least 2 times more.

Step 9: Take mode (maximum repeated) of observations.

Step 10: Calculate amount of bleaching powder for given sample water with formula.

Observations

S. no.	*No. of 1st cup showing blue colour*	*Mode of no. of 1st cup*
1.		
2.		
3.		

Calculations

$$\text{Amount of bleaching powder} = \frac{\text{No. of 1st cup showing blue colour}}{455} \times 2 \text{ gm/litre of water}$$

Amount of bleaching powder required (BP) = ________ gm/l of water

If, bleaching powder is having 25% strength, then

Amount of chlorine in ________ gm bleaching powder is = BP × 25/100

Result: Chlorine demand of water is ________ l

For super-chlorination, calculation is as follows:

Amount of bleaching powder for super-chlorination

$$= \frac{\text{No. of 2nd cup showing blue colour}}{455} \times 2\,\text{gm/l of water}$$

Exercise 2: Estimate the total hardness in given sample of water

Objective: To estimate the total hardness in given sample of water.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. EDTA (ethylenediaminetetraacetic acid)
6. Chrome black-T
7. Ammonium buffer (NH_4OH) to make pH 8.5 to 11.5).

*Principle

Water + Ammonium buffer + chrome black-T ⟶ Wine red colour compound with chrome black-T

↓ Titrated with EDTA

Pinkish blue colour (original colour of dye)
Colourless compounds with EDTA

Procedure

Step 1: With the help of a pipette, take 25 ml of sample water in a beaker.
Step 2: Add 1 ml of NH_4OH (ammonium buffer) in it.
Step 3: Add a pinch (5 ml) of chrome black-T to it.
Step 4: After observing wine red colour (due to chrome complexes with Ca and Mg), start titrating it with EDTA.
Step 5: Stop titration on appearing pinkish blue colour and note the reading.
Step 6: Repeat the whole exercise (step 1–5) at least two times more or uptill two reading coincides.
Step 7: Take mode of reading.
Step 8: Calculate the EDTA used for 25 ml sample water.
Step 9: Now calculate total hardness of sample water.

Observations

S. no.	*Sample water + NH_4OH + Chrome black-T*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

Total hardness of water = EDTA used × 40 mg/l of water

Result: Total hardness of given sample, water is ______________ (mg/l)

*Principle

1. NH_4OH is used to make pH suitable (8.5 to 11.5) for reaction of Ca, Mg, etc. with chrome black-T.
2. Chrome black-T forms wine red colour complexes with Ca, Mg, etc. as hardness.
3. EDTA forms more durable colourless complexes of Ca and Mg, etc. for which EDTA extracts Ca and Mg from Ca, Mg complexes of chrome black-T, then wine red colour slowly gets converted to pinkish blue, which is the original colour of dye itself.

**Calculations

25 ml of water needs = E ml of EDTA to utilize Ca and Mg present in water.

$$1 \text{ ml of water needs} = \frac{\text{E ml of EDTA to utilize Ca and Mg present in water}}{25}$$

$$1000 \text{ ml of water needs} = \frac{\text{E (EDTA used)} \times 1000 \text{ mg}}{25}$$

1 Liter of water needs = E (EDTA used) × 40 mg

Total hardness = E (EDTA used) × 40 mg/l of water

Exercise 3: Estimation of Ca hardness in given sample of water

Objective: To estimate the Ca hardness of given sample of water.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. EDTA
6. Murexide
7. NaOH (2 ml)

*Principle

Water + Sodium buffer (NaOH) + Murexide ⟶ Pink-coloured complex with murexide

↓ Titrated with EDTA

Purple colour (original colour of dye)
Colourless complex with EDTA

Procedure

Step 1: Take 25 ml of sample water in beaker with the help of pipette.
Step 2: Add 1 ml of sodium buffer to it to make pH about 12.
Step 3: Add a pinch of murexide to it.
Step 4: After observing pink colour of complex, titrate it with EDTA.
Step 5: Stop titration on appearing purple colour and note the reading.
Step 6: Repeat whole process two times more.
Step 7: Take mode of reading of EDTA.
Step 8: Calculate Ca hardness with the help of formula.

Observations

S. no.	*Sample water + NaOH + Murexide*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

Calcium hardness of water = EDTA use × 40 mg/l of water

Result: Calcium hardness of given sample water is ______________ (mg/l)

*Principle

1. Murexide makes complexes with Ca not with Mg.
2. NaOH is used to make pH suitable (12) for reaction of Ca with murexide.
3. Murexide makes pink colour complexes with calcium as hardness.
4. EDTA form more durable colourless complexes of Ca for which EDTA extract Ca from calcium complexes of murexide.
5. Then pink colour slowly is converted to purple which is the original colour of dye itself.

**Calculations

25 ml of water need E ml of EDTA to use Ca present in given sample of water

$$1 \text{ ml of water need} = \frac{\text{E ml of EDTA to use}}{25}$$

$$1000 \text{ ml of water need} = \frac{E \times 1000}{25} = \text{E 40 mg/L of Ca hardness}$$

Exercise 4: Estimation of Mg hardness in given sample of water

Objective: To estimate the Mg hardness in given sample of water.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. EDTA
6. Chrome black-T
7. Murexide
8. NaOH
9. Ammonia buffer (NH_4OH)

*Principle

Total hardness – Ca hardness = Mg hardness

Procedure: Same as that of exercise ‘2’ and ‘3’

Observations

For Total Hardness ‘A’

S. no.	*Sample water + NH_4OH + Chrome Black-T*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

For Calcium Hardness 'B'

S. no.	*Sample water + NaOH + Murexide*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

Total hardness of water = EDTA used in exercise 'A' × 40 mg/l

Calcium hardness of water = EDTA used in exercise 'B' × 40 mg/l

Total hardness – Ca hardness = Mg hardness

or Mg hardness = (EDTA used 'A' – 'B') × 40 mg/l of water

Result: Magnesium hardness of given sample of water is ________________ (mg/l)

*__Principle:__ Same as that of exercise '2' and '3'.

**__Calculations:__ Same as that of exercise '2' and '3'.

Exercise 5: Estimation of chlorides in given sample of water

Objective: To estimate the chlorides in given sample of water.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. $AgNO_3$
6. Potassium chromate (K_2CrO_4)

*Principle

Chlorides of water + Potassium chromate ($K_2Cr\ O_4$) ⟶ Silver chlorides (colourless complex)

↓ Titrated with $AgNO_3$

Silver Chromate (brick red colour complex)

$CaCl_2 + 2\ AgNO_3 = 2\ AgCl$ (colourless complex) $+ Ca(NO_3)_2$

$MgCl_2 + 2\ AgNO_3 = 2\ AgCl$ (colourless complex) $+ Ca(NO_3)_2$

K_2CrO_4 (yellow colour) $+ 2\ AgNO_3 = 2\ KNO_3 + Ag_2CrO_4$ (brick red colour)

Procedure

Step 1: Take 25 ml of water in a beaker with the help of pipette.
Step 2: Add a few drops of potassium chromate into it.
Step 3: Titrate it with $AgNO_3$ after a few minutes.
Step 4: Titrate it until the whole chlorides of water converted to $AgCl_2$
Step 5: Stop titration on appearance of brick red colour of silver chromate.
Step 6: Note the reading.
Step 7: Repeat the whole process (steps 1 to 5) at least for two times more.
Step 8: Take mode of reading of $AgNO_3$.
Step 9: Calculate amount of chloride in water with the help of formula.

Observations

S. no.	Sample water + K_2CrO_4	$AgNO_3$ used	Final reading
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

Chlorides in sample water = Amount of $AgNO_3$ used × 40 mg/l

Result: Chlorides in given sample water is ________________ (mg/l)

*Principle

1. Potassium chromate (K_2CrO_4) is yellow coloured compound.
2. When $AgNO_3$ titrates it makes AgCl (colourless complexes) with chlorides present in water.
3. As soon as whole chloride in water is used by $AgNO_3$ (forming AgCl), potassium chromate (K_2CrO_4) titrated with $AgNO_3$ it makes red colour complexes of silver chromate.

**Calculations

25 ml of water need 'A' ml of $AgNO_3$ use chlorides present in given sample of water

$$1 \text{ ml of water need} = \frac{\text{'A' ml of } AgNO_3}{25}$$

$$1000 \text{ ml of water need} = \frac{A \times 1000}{25} = \text{A 40 mg of chlorides}$$

Exercise 6: Estimate sulphates in given sample of water

Objective: To estimate sulphates in given sample of water.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. $BaCl_2$
6. Ammonium buffer
7. Chrome black-T
8. EDTA

***Principle:** Principle for total hardness is given in exercise no '2'.

****Calculations:** Total hardness–hardness except SO_4 = SO_4 hardness

Principle for Hardness Except SO_4

Water + $BaCl_2$ + Ammonium buffer + Chrome black-T ⟶ Wine red colour complex with chrome black-T

↓ $BaSO_4$ PPT — Titrated with EDTA

Blue colour (original colour of chrome black-T)

$CaSO_4$ (in water) + $BaCl_2$ = $BaSO_4$ (wine red colour) + $CaCl_2$

$MgSO_4$ (in water) + $BaCl_2$ = $BaSO_4$ (wine red colour) + $MgCl_2$

Procedure: Procedure for total hardness is given in exercise '2'.

For Hardness Except SO_4

Step 1: Take 25 ml water in a beaker with the help of burette.
Step 2: Add 10 ml $BaCl_2$ to it and keep it for a few minutes.
Step 3: Add 1 ml ammonium buffer and a pinch of chrome black-T to it.
Step 4: Titrate it with EDTA after observing wine red colour of $BaSO_4$.
Step 5: Stop titration when wine red colour disappears and blue colour of dye starts appearing.
Step 6: Note the reading of EDTA used.
Step 7: Repeat the whole process (steps 1–6) at least for two times more.
Step 8: Take final (mode) reading.
Step 9: Calculate SO_4 hardness as per principle with the help of formula.

Observations

For Total Hardness 'A'

S. no.	*Sample water + NH_4OH + Chrome black-T*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

For Hardness other than Sulphate 'B'

S. no.	*Sample water + $BaCl_2$+ NH_4OH + Chrome black-T*	*EDTA used*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

Total hardness of water = EDTA used in exercise 'A' × 40 mg/l

Hardness without sulphate (SO_4) of water = EDTA used in exercise 'B' × 40 mg/l

Total hardness – Hardness without sulphate (SO_4) = Sulphate (SO_4) hardness

Result: Sulphate (SO_4) hardness of given sample water is ___________ (mg/l)

*__Principle:__ Same as that of exercise '2'. Here $BaCl_2$ makes complexes with 'SO_4' which precipitates colourless.
**__Calculations:__ Same as that of exercise '2'.

Exercise 7: Estimate available chlorine in bleaching powder

Objective: To estimate available chlorine in bleaching powder.

Apparatus

1. Beaker
2. Pipette capacity 25 ml
3. Small pipette
4. Burette
5. Flask
6. Bleaching powder (sample)
7. Potassium iodide
8. Acetic acid
9. Starch solution
10. Sodium thiosulphate

*Principle

Bleaching P. soln + Pot. iodide +Acetic acid + Starch solution → Blue colour of starch iodide

↓ Titrated with sodium thiosulphate

Sodium thiosulphate complex (colourless)

Procedure

Step 1: Take 5 gm of bleaching powder in a flask.
Step 2: Dissolve it in 250 ml of distilled water.
Step 3: Take 25 ml of water in a beaker.
Step 4: Add 10 ml of 10% potassium iodide.
Step 5: Add 5 ml of acetic acid.
Step 6: Add a few drops of starch solution.
Step 7: Titrate it with sodium thiosulphate.
Step 8: Stop titration when blue colour disappears and note the reading.
Step 9: Repeat the whole process (steps 1–8) for at least two more times.
Step 10: Take final reading (mode of 3 readings).
Step 11: Calculate amount of chlorine available in given sample of bleaching powder with the help of given calculation.

Observations

S. no.	*Bleaching soln. + Pot. iodide + Acetic acid + Starch solution*	*Sodium thiosulphate*	*Final reading*
1.	25 ml		
2.	25 ml		
3.	25 ml		

**Calculations

% of chlorine available in bleaching powder = Sodium thiosulphate used × 200 × 0.00346

Result: Amount of chlorine in bleaching powder is ____________________%.

*Principle

*Chlorine in bleaching powder react with KI and starch as follows:

(R_1) Cl_2 + 2 KI + Starch = 2 KCl + Starch iodide (blue colour)

When Cl_2 consumed with KI and starch then starch react with sodium thiosulphate and makes colourless complex.

(R_2) $Na_2S_2O_3$ + Starch iodide = Colourless complex

**Calculations

250 ml of water contains 5 gm of bleaching powder

1 ml of water contains $\frac{5}{250}$ gm bleaching powder

25 ml of water contains = $\frac{5 \times 25}{250}$ gm = 0.5 gm of bleaching powder

0.5 gm bleaching powder requires '*S*' ml of sodium thiosulphate

1 gm of bleaching powder requires = $\frac{'S'}{0.5}$ ml of sodium thiosulphate.

100 gm of bleaching powder requires = $\frac{'S' \times 100}{0.5}$ ml of sodium thiosulphate

= 200 × '*S*' ml of sodium thosulphate.

(1 ml of thiosulphate = 0.003546 gm chlorine) (0.003546 is mol. wt. of chlorine)

= 200 × 0.003546 gm of chlorine.