Chapter 6
Chemical and Biological Characterization

Part A: Chemical Study

6.A.1 INTRODUCTION

Elemental analysis is an experiment that determines the amount (typically a weight percent) of an element in a compound. Just as there are many different elements, there are many different experimental methods for determining elemental composition. The most common type of elemental analysis is for carbon, hydrogen, and nitrogen (CHN analysis). This type of analysis is especially useful for organic compounds (compounds containing carbon-carbon bonds). The elemental analysis of a compound enables one to determine the empirical formula of the compound. The empirical formula is the formula for a compound that contains the smallest set of integer ratio for the elements in the compound that gives the correct elemental composition by mass. If one prepares or isolates a new compound, the determination of the molecular formula for the compound is an important goal. This determination typically involves two steps: (1) elemental analysis of the compound and (2) determination of the molecular mass. The elemental analysis permits determination of the empirical formula, and the molecular weight and elemental analysis permit determination of the molecular formula. Apart from Elemental Analysis, Molar Conductivity of material was found by appropriate mathematics formula
6.A.2 THEORY

If electrodes are immersed in a solution of say sodium chloride in water, the conductivity can be measured using a conductivity meter[1,2]. This conductivity will depend on the type and concentration of ions present, the solvent[1-7], the area of the electrode, and the distance between the electrodes. The measurement of the conductivity of an electrolytic solution begins with the measurement of the resistance for that solution using a conductivity cell. The resistance measurements must be accomplished using alternating current (AC) to avoid changes in concentrations and product build up on the electrodes which in turn would effect the measurement. Usually, Platinum electrodes, coated with colloidal Pt to absorb any gas products, are used to in order to reverse changes occurring during phases with reverse polarity. After the resistance is determined, the resistivity is determined using equation (6.1). Since the geometry of the electrodes can change during their use through physically deforming, the ratio L/A could change, therefore it is necessary to determine the value of L/A by using a solution with known conductivity to calibrate the conductivity cell by determining a cell constant.

Specific conductance $\sigma$ is the reciprocal of the specific resistance. If a cell could be constructed with electrodes of exactly 1 cm$^2$ area exactly 1 cm apart, the reciprocal of the cell resistance in reciprocal ohms would be numerically equal to the specific conductance in reciprocal ohms per centimeter since $L/A = 1\text{cm}^{-1}$. Conductance cells do not satisfy these conditions, and so it is convenient to define a constant factor $k$ determined by the cell geometry and called the cell constant, such that
where R is the measured resistance of the actual cell. The numerical value of k for a particular cell is determined experimentally by use of a standard solution of known specific conductance.

The specific conductance will clearly depend on the concentration of the electrolyte\([4-9]\). In general, if the concentration doubles, the conductivity will double. The measurement of conductance is put on an per ion basis by defining the equivalent conductance \(\Lambda\):

\[
\Lambda = kV
\]

where \(V\) is the volume of solution containing 1 g equiv. of solute. In the cgs system, \(V\) is in cubic centimeters and \(L\) is in square centimeters per ohm per equivalent. For ions with a single charge, the equivalent conductivity is equal to the molar conductivity, \(\Lambda_m\), obtained by dividing the conductivity by its molar concentration, \(m\).

\[
\Lambda_m = k/m
\]

### 6.A.3 KOHLRAUSCH’S LAW

Before proceeding, let’s stop for a moment and think about the conductivity of ions on a simple qualitative basis. Suppose the compound AB dissolves in water to produce the ions \(A^+\) and \(B^-\). The conductance of ionic solutions is the result of the movement of ions through the solution to the electrodes. When two electrodes in the solution are made part of a complete electrical circuit, the cations (+)
are attracted to the negative pole (cathode) and the anions (-) are attracted to the positive pole (anode). Changes in the equivalent conductance of an electrolyte solution with changes in concentration may result from changes in both the number and the mobility of the ions present. If both anion and cation are monovalent, the overall electrical neutrality of the soluble solution assures that equal numbers of the two ions are present. They will not in generally have the same mobility, however, and thus do not share equally in the conduction of current.

The solution conducts electricity through motion of the ions under the effect of an electric field. At high concentrations, each ion is surrounded by other ions, both positive and negative. The field affecting any particular ion changes slightly because of these surrounding ions. At infinite dilution, the distance between nearest neighbor ions is large, and only the effect of the applied electric field is felt by individual ions. This is the reason for extrapolating the data to infinite dilution.

The conductivity of any particular ion will also be affected by the ease with which the ion can move through the water. Hence different ions should contribute differently to the total measured conductivity. The ease with which any ion moves through the solution depends on considerations such as the total charge and the size of the ion; large ions offer greater resistance to motion through the water than small ions.

Suppose we now consider the compound CB, which dissociates on solution to produce C\(^+\) and B\(^-\), where the ion B\(^-\) is the same as the B\(^-\) produced by the compound AB discussed above. One expects the contribution of the anion B\(^-\) to the total conductivity of the solution to be
independent of the nature of the cation at infinite dilution.

Friedrich Kohlrausch (1840-1910) found that the molar conductivity varied as the square root of the concentration for many solutions [1-9].

\[ \Lambda_m = \Lambda_m^0 - k c^{1/2} \]

6.4

This basic relationship is one of Kohlrausch’s law where the limiting molar conductivity at infinite dilution, \( \Lambda_m^0 \), is a constant which depends on the electrolyte. The constant, \( k \), depends more on stoichiometry of the electrolyte than its nature. The molar conductivities of several electrolytes are plotted as a function of the square root of concentration in Figure 5 to illustrate that concept.

The increase of the equivalent conductance of solutions of strong electrolytes in the low-concentration range is not due to an increase in dissociation, because the dissociation is already complete, but to an increased mobility of the ions. In a concentrated solution of a highly ionized strong electrolyte, the ions are close enough to one another so that any one of them in moving is influenced not only by the electrical field impressed across the electrodes but also by the field of the surrounding ions. The ionic velocities are, then, dependent upon both forces. Arrhenius attempted to treat the electrolytic-conductance behavior of the strong electrolytes in the way in which he had successfully treated the weak electrolytes; such a treatment is, however, inconsistent with the experimental fact, discovered by Kohlrausch, that a plot of the equivalent conductance of a strong electrolyte against the square root of the concentration is very nearly linear. Debye and Hückel and Onsager have been able to calculate the effect of the surrounding ions on the 201

Chapter 6 Chemical and Biological Characterization
mobility of any given ion and, for dilute solutions, have obtained results entirely consistent with the experimental facts. Complete dissociation is here assumed.

The conductivity of a solution is then given by the conductivities of the anion and the cation:

$$\Lambda^o = \Lambda_{+}^o + \Lambda_{-}^o$$

Equation (6.7) describes the true state of affairs and states Kohlrausch’s law of independent mobilities of ions in infinitely dilute solutions[1-11]. It is amenable to easy verification, since the difference in $\Lambda^o$ for pairs of salts with a common ion should be the same regardless of the common ion.

### 6.A.4 WEAK ELECTROLYTES

A factor which affects the equivalent conductance of a solution that was not considered above is the possible limited dissociation of the electrolyte. Some electrolytes, known as weak electrolytes, do not dissociate completely in solution. Instead, there is an equilibrium between ions and associated electrolyte. Acetic acid is a typical weak electrolyte. The apparent equilibrium constant for dissociation may be calculated as[9,10]

$$K = \frac{\alpha^2 c^2}{(1 - \alpha)c}$$

where $\alpha$ = degree of dissociation

c = concentration of the solute

According to the Arrhenius theory, the equivalent conductance at any
concentration is related to the degree of dissociation by
\[
\alpha = \Lambda / \Lambda^0
\]
where \( \Lambda \) = equivalent conductance at concentration \( c \)
\( \Lambda^0 \) = equivalent conductance at infinite dilution

In the case of a weak electrolyte the value of \( \Lambda^0 \) cannot be obtained by
the extrapolation to infinite dilution of results obtained at finite
concentration, because \( \Lambda \) is a rapidly varying and nonlinear function of
\( \Lambda_c \). Instead, \( \Lambda^0 \) is obtained by the of the law of Kohlrausch:
The apparent equilibrium constant \( K_a \), is equal to the true equilibrium
constant, which is expressed in terms of activities, only for ideal solutes.

\[
K_a = \frac{c_{H^+} c_{R^-}}{c_{HR}} \quad K = \frac{\gamma_{H^+} c_{H^+} \gamma_{R^-} c_{R^-}}{\gamma_{HR} c_{HR}} \quad 6.7
\]

where \( \gamma_i \) is the activity coefficient of species \( i \). Since \( \gamma_i \to 1 \) for infinitely
dilute solutions,

\[
\text{Lim} \ K_a = K \quad 6.8
\]

Arrhenius noted that the molar conductivities of electrolytes decreased
with increasing concentration. He considered a solution of the salt \( AB \) to
consist partly of unionized \( AB \) molecules and partly of cations and
anions. He attributed the decrease in conductivity to the decrease in the
degree of ionization of the electrolyte. Suppose that a solution of \( AB \) is
prepared with \( n \) molecules of \( AB \) per cubic centimeter of solution. The
degree of ionization, \( \alpha \), is determined by the number of positive ions per
cubic centimeter, \( n_+ = \alpha \ n \), or the number of negative ions, \( n_- = \alpha \ n \).
Suppose that the velocities with which the ions move through the water
are \( v_+ \) and \( v_- \). The total current carried across a unit area is then
\[ I = n_+ e \nu_+ + n_- (-e) (-\nu_-) = ne(\nu_+ + \nu_-) \alpha \] \hspace{1cm} 6.9

where the negative sign for \( \nu_- \) arises because the two different ions move in opposite directions; the electron charge is denoted by \( e \).

The *mobility* \( \mu \) of an ion is defined as the velocity per unit field strength, or

\[ \mu_+ = \frac{\nu_+}{E} \quad \text{and} \quad \mu_- = \frac{\nu_-}{E}. \]

From Ohm’s law and the definition of conductivity, then \( \kappa = \frac{I}{E} \), where \( I \) is the current across a unit area and \( E \) is the electric field. The specific conductivity of the solution is

\[ \kappa = ne(\mu_+ + \mu_-) \] \hspace{1cm} 6.10

The equivalent conductivity is then

\[ \Lambda = N_o e(\nu_+ + \nu_-) \alpha \] \hspace{1cm} 6.11

where \( N_o \) is the Avogadro number. Since \( N_o e \) is the charge on a mole of electrons, or the Faraday constant \( F \), (15) can be written as

\[ \Lambda^0 = F(\mu_+ + \mu_-) \] \hspace{1cm} 6.12

It is here that Arrhenius made the critical assumption that at infinite dilution ionization is complete, that is, as \( m \to 0 \), \( a \to 1 \). In the limit,

\[ \Lambda = F(\mu_+ + \mu_-) \alpha \] \hspace{1cm} 6.13

and by combining Equations (6.13) and (6.14) we get the expression for the degrees of ionization,
\[ \alpha = \Lambda / \Lambda^0 \]

This model accomplishes two things. First, it enables the calculation of the degree of ionization of electrolytes from conductivity data, and secondly it provides an explanation of Kohlrausch's law of independent migrations. The mobilities of the ions are independent of the chemical constitution and the terms in eq. 18 can be interpreted by taking
\[ \Lambda^+_o = F \mu_+ \text{ and } \Lambda^-_o = F \mu_- \]

The concentrations of the various species at equilibrium have been written in terms of \( c \) and the degree of dissociation [9-11]. Shortly after Arrhenius first proposed his ionic dissociation theory, Ostwald applied the law of mass action to a partially ionized substance. For HAc:
\[ K = \frac{[H^+][Ac^-]}{[HAc]} = \frac{c^2 \alpha^2}{c(1 - \alpha)} \]

where the brackets indicate molar concentrations.

Measurements of \( K_a \) over a range of concentrations thus provide a way of estimating \( K \) and the activity coefficient factor \( \gamma_{H^+} \gamma_{A^-} / \gamma_{HA} \) at the various concentrations. To a good approximation \( \gamma_{HA} \) may be considered to be unity [11]. The value of the product \( \gamma_{H^+} \gamma_{A^-} \) is, by definition, \( \gamma^2_\pm \) the square of the mean ionic activity coefficient for the weak electrolyte HA.
6.A.5 EXPERIMENT

Figure 6.1: C-H-N-S-O Analyzer at SICART, V.V.Nagar, Gujarat

Make Model: Perkin Elmer, U.S.A 2400 Series II

CHNS/O Elemental Analyzer Perkin Elmer PE 2400 Absolute CHN, CHNS, O modes of operations; Accuracy: + 0.3%; 60 samples autosampler, Analysis/estimation of C, H, N, S, O in solid samples.

- Used for determination of Carbon, Hydrogen, Nitrogen, Sulphur and Oxygen contents in organic compounds and their presence if any in inorganic compounds
- Fastest technique to analyze C, H, N, S & O
- The analysis time is around 8 to 10 minutes per sample
- Auto sampler achieves unattended automatic sampling of 60 samples.
• CHNS/O analyzer PE-2400 series II works on frontal chromatography technique for separation and estimation of C, H, N, S and O elements in a sample.
• The analyzer has three mode of operation namely CHN, CHNS and O for respective elemental analysis
• Typical analysis accuracy of 0.3% and analysis time of 8 to 10 minutes per sample

Specifications:

• Analyzed Elements: Carbon, Hydrogen, Nitrogen, Sulfur and Oxygen
• Operating Mode: CHN, CHNS and OXYGEN
• Accuracy: 0.3% abs
• Analysis Time: 6 to 8 minutes per sample
• Automatic Weight Transfer
• Sample Size: 1 to 200 mg
• Multiple Sample Mode if required: 60 samples
• Sample Combustion Temperature: Around 2000 º c.

Applications:

• Used for knowing the concentration & percentage of C,H,N,S & O in newly synthesized compounds, quality control, metallurgical samples, catalysts, petrochemicals etc depending upon the values of these, products can be identified
• The best solution for the analysis of Organic compounds, Pharmaceuticals, Petrochemicals, Gasoline & Flues, Coal &Coke, Graphite, Carbides & Nitrides, Polymers
The original analysis method is based on the complete and instantaneous oxidation of the sample by "flash combustion" which converts all organic and inorganic substances into combustion products. The resulting combustion gases pass through a reduction furnace and are swept into the chromatographic column by the carrier gas which is helium. The gases are separated in the column and detected by the thermal conductivity detector which gives an output signal proportional to the concentration of the individual components of the mixture. The results are comparable to those obtained by traditional methods, such as Kjeldahl and Dumas, but it offers faster analysis time with greater reproducibility and accuracy. An extra benefit of the flash combustion method is that no hazardous waste is created other than the spent columns that can be used for hundreds of samples. The sample to be analyzed is weighed into a tin container and loaded into the autosampler. The sample is then deposited into the combustion reactor which is maintained at 1020 degrees C. The sample and container melt and the tin promote a violent reaction in a temporarily enriched atmosphere of oxygen. Under these conditions even thermally resistant substances are completely oxidized. The mixture of combustion products pass first through an oxidation catalyst of chromium trioxide in the reaction/combustion tube. The combustion products, those of interest being CO2, N2 and NOx, along with some water, then pass through a second tube known as the reduction reactor. It contains metallic copper kept at 650C. The excess of oxygen is removed and at
this temperature the nitrogen oxides are reduced to elemental nitrogen, which together with CO2 and water pass to the magnesium perchlorate tube which removes the water. The helium stream then flows through a chromatographic column separating the nitrogen and carbon. From there the gases flow through the thermal conductivity detector which generates an electrical signal proportional to the concentrations. Analyzing a standard of known composition under the same conditions makes it possible to calibrate the instrument and quantify the content of nitrogen and carbon.

6.A.6 RESULTS AND DISCUSSION

(1) Elemental Analysis Study

The analytical data of the crystals are presented in Table: 6.1 indicates 1:2 stoichiometry. The general equation for the formation of binary crystals is shown as below:

\[ M + H_2L \rightarrow ML + 2H^+ \]  

6.17

Where M = Cr(VI) or Co(II), L = Schiff Base

All crystals are colored and possess high decomposition points. All are amorphous and stable in air. The crystals are soluble in acetone and DMF, sparingly soluble in ethanol, insoluble in water and other organic solvents like methanol, benzene, chloroform, carbon tetrachloride.

(2) Molar Conductance Study

The conductivity of crystals was measured in DMF as solvent using conductivity meter model, Systronic 361 μ digital. All the crystals showed the molar conductance values for \(10^{-3}\)M concentration in range 209
2 to 78 ohm\(^{-1}\)cm\(^2\) mol\(^{-1}\). It is suggesting that all crystals are nonelectrolyte in nature\[12\]. The molar conductance values of all the crystals are listed in Table: 5.1
Table: 6.1

Analytical Data and Some Physical Properties of Metal Crystals

<table>
<thead>
<tr>
<th>Crystals</th>
<th>Molecular Formula</th>
<th>colour</th>
<th>Formula weight</th>
<th>Yield</th>
<th>Analysis of elements (%) found (calculated)</th>
<th>Molar Conductance</th>
<th>D.P. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Co·L₂]·6H₂O·Cl₂</td>
<td>CoC₃₀H₄₆N₆O₆Cl₂</td>
<td>Green</td>
<td>714.933</td>
<td>78</td>
<td>M: 8.24, C: 50.40, H: 6.43, N: 11.74, O: 13.41, Cl: 9.93</td>
<td></td>
<td>8.58 &gt;300</td>
</tr>
</tbody>
</table>

D.P. = Decomposition point
Part B. Antibacterial Assay of Crystals

6.B.1 INTRODUCTION

The preparation and study of inorganic compounds containing biologically important ligand is made because certain metal ions are active in many biological processes.

Antibiotics, phenolic compounds and organic solvents are known for their negative effects on growth of microorganisms, like Bacteria, Yeast and Fungi. Organic carbons like glucose, fructose and sucrose and organic nitrogen like yeast extract fermentation process and also in environments where they are vital in nature. The growth of microorganisms is also enhanced by presence of macronutrients and micronutrient is otherwise called trace elements in appropriate condition. If these concentrations are increased or decreased as compared to the optimum level growth of microorganisms is adversely effected. The required concentration of macronutrients in the growth media must be greater than $10^{-4}\text{mol.L}^{-1}$. Many scientists have standardized the required concentration to satisfy the growth of microorganisms at concentration less than $10^{-4}\text{mol.L}^{-1}$.

6.B.2 MATERIALS AND METHOD

The biological activity of ligand (Schiff base) and derived crystals were checked with to their impact on the growth of bacteria (Escherichia coli and Bacillus megaterium) at Department of Biology, Hemchandracharya North Gujarat University, Gujarat, India.

6.B.3 COLLECTION OF CULTURE

The microbial strains Escherichia coli (ACCT 1642), Bacillus megaterium were collected from IMTECH, Chandigarh, India.
6.B.4 MAINTENANCE OF CULTURE

The culture of bacteria Bacillus subtilis and Escherichia coli were grown on nutrient agar with following composition

- Peptone 10 g/ml.
- Meat extract 03 g/ml.
- NaCl 05 g/ml.
- Agar agar 30 g/ml.
- pH 7.4

The volume was made to 1000 ml with distilled water. The mixture was mixed and heated to boiling to dissolve the medium completely. Sterilization was carried at 15 lbs pressure (121°C) for 15 minutes.

6.B.5 INOCULUM PREPARATION

One loop full growth of Bacillus subtilis and Escherichia coli were inoculated in 50 ml of Nutrient broth containing all the component of N agar shown above except agar in 250 ml of Erlenmeyer flask and incubated overnight on rotary shaker adjusted at 120 rpm, 37°C.

6.B.6 ANTIBACTERIAL ASSAY

The synthetic heterochelates were explored in the range of (0.1 to 10 µg/ml) for its antimicrobial potential against E. coli and Bacillus megaterium by disc diffusion method [13]. Besides that antimicrobial activity of Schiff base was evaluated in the similar range (0.5 to 10 µg/ml). Various metal salts like CoCl₂·6H₂O and CrO₃ were also examined for their antimicrobial activity in the range of (2000 to 10000 µg/ml).
6.B.7 RESULTS AND DISCUSSION

The effect of synthesized crystals on the growth of E. coli and B. subtilis was investigated. Antibacterial activity was investigated in selected range of 2000 to 10000 (µg/ml). Antimicrobial activity was recorded in variable manner for all the metal salts included in present study for a given set of concentrations. Highest activity was recorded for Cr(VI) salt followed by Co(II) salts respectively for E. coli while in case of B. megaterium again Cr(VI) oxide salt showed highest activity followed by Co(II) chloride salts. The zones of inhibition were comparatively greater in case of the E. coli in comparison to B. megaterium as per the results presented in Table: 6.21 and 6.3.

The sub component of crystal which is Schiff base was also investigated for the antibacterial activity in the range of 0.1 to 10.0 (µg/ml).

Inhibitory action recorded for Schiff base was at from 0.5 µg/ml and onwards in range of 4 to 18 mm for E. coli while in case of B. megaterium inhibition was recorded 0.25 µg/ml and onwards in range of 7 to 13 mm. in Table: 6.4 and 6.5.

In case of E. coli for the synthesized crystals, antibacterial activity was recorded at the lower concentration of 0.1 to 0.25 µg/ml, which were non inhibitory in case of individual application for Schiff base. Highest activity was recorded for compound containing Cr(VI) salt followed by other crystals. The results indicate that the highest activity was due to incorporation of Cr(VI) in the crystals.

From Table: 6.6 and 6.7 that is for antimicrobial activity of crystals against E. coli and B. megaterium respectively and Inhibitory effect is shown more by Cr(VI) & Co(II) crystals as compared to other crystals observed by K.R.Patel(School of Research, Suresh Gyan Vihar University). In all crystals
studied here as the concentration of crystals increase in both gram positive *B. megaterium* and gram positive *E. coli*. Inhibitory affect increases.

A perusal of Table: 6.6 and 6.7 reveals that at all concentration of crystals (0.1 to 10 µg/ml), Cr(VI) crystals shows maximum inhibition as compared to other crystals.

The difference in the antimicrobial pattern can be due to variation in the cell wall structure of gram positive Bacillus megaterium and gram negative E. coli.

A Similar study on crystals with Schiff base and Cu(II) is reported by Jian Gao [14]. Zone of inhibition in case of all crystals is having values in behavior w.r.t. the Schiff base. This shows that by incorporation of metal ion and due to the complexation the behavior has totally changed.

Enhancement of antimicrobial activity by complexation of a ligand like eatz with Cd(II) ion and formation of [Cd(eatz)₆](NO₃)₂ was observed by Xiao, Ke Zheng et.al [15]

### Table: 6.2
**Antibacterial Activity of Metal Salts against *E. Coli***

<table>
<thead>
<tr>
<th>Metal Conc. (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
<th>CrO₃</th>
<th>CoCl₂·6H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>4000</td>
<td></td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>6000</td>
<td></td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>8000</td>
<td></td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>10,000</td>
<td></td>
<td>30</td>
<td>17</td>
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</table>

215
Chapter 6 Chemical and Biological Characterization
### Table: 6.3
Antibacterial Activity of Metal Salts against *B. Megaterium*

<table>
<thead>
<tr>
<th>Metal Conc. (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CrO₃</td>
</tr>
<tr>
<td>2000</td>
<td>5</td>
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<tr>
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<tr>
<td>10,000</td>
<td>11</td>
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</table>

### Table: 6.4
Antibacterial Activity of Schiff Base against *E. Coli*

<table>
<thead>
<tr>
<th>Concentration (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
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</thead>
<tbody>
<tr>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>0.25</td>
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<tr>
<td>10.00</td>
<td>18</td>
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Table: 6.5  
**Antibacterial Activity of Schiff Base against B. Megaterium**

<table>
<thead>
<tr>
<th>Concentration (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
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<tbody>
<tr>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>0.25</td>
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<td>5.00</td>
<td>9</td>
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<tr>
<td>10.00</td>
<td>13</td>
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Table: 6.6  
**Antibacterial Activity of Synthesized Crystals against E. Coli**

<table>
<thead>
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<th>Conc. of Crystals (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Cr(VI) Crystal</td>
</tr>
<tr>
<td>0.1</td>
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<td>12</td>
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<td>10</td>
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Table: 6.7
Antibacterial Activity of Synthesized Crystals against *B. Megaterium*

<table>
<thead>
<tr>
<th>Conc. of Crystals (µg/ml)</th>
<th>Zone of inhibition (mm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cr(VI) Crystal</td>
<td>Co(II) Crystal</td>
</tr>
<tr>
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<td>-</td>
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<td>10</td>
<td>17</td>
<td>19</td>
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REFERENCES

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