

## Contents

NO.	Titles	Pages
<i>Appendices</i>		
	<i>Abstract</i> .....	<i>VIII</i>
	<i>Summary</i> .....	<i>IX</i>
	<i>List of Abbreviations</i> .....	<i>XVI</i>
	<i>List of Figures</i> .....	<i>XVIII</i>
	<i>List of Tables</i> .....	<i>XXVI</i>
 <i>Chapter 1</i> 		
<i>General Introduction and Literature Survey</i>		
	<i>1.1 Historical Overview of Nano</i> .....	<i>1</i>
	<i>1.2 Definition of Nanometer Scale, Nanoscience, and Nanotechnology</i> .....	<i>1</i>
	<i>1.3 Classification of Nanomaterials Based on Dimensions</i> .....	<i>2</i>
	1.3.1 Zero-Dimension (0-D) Nanomaterials .....	<i>3</i>
	1.3.2 One-Dimension (1-D) Nanomaterials .....	<i>4</i>
	1.3.3 Two-Dimension (2-D) Nanomaterials.....	<i>4</i>
	1.3.4 Three-Dimension (3-D) Nanomaterials.....	<i>5</i>
	<i>1.4 Properties of Nanomaterials</i> .....	<i>6</i>
	1.4.1 Surface Energy of Nanomaterials.....	<i>6</i>
	1.4.2 Quantum Size Effect of Nanomaterials .....	<i>7</i>
	1.4.3 Mechanical Properties of Nanomaterials.....	<i>9</i>
	1.4.4 Magnetic Properties of Nanomaterials .....	<i>11</i>

1.4.5 Optical Properties of Nanomaterials .....	14
<i>1.5 Preparation of Nanomaterials</i> .....	<i>16</i>
1.5.1 Top-Down Method .....	17
1.5.2 Bottom-Up Method.....	17
1.5.3 Fabrication of Metal Nanoparticles .....	19
1.5.4 Fabrication of Magnetic Nanoparticles .....	20
<i>1.6 Applications of Nanotechnology</i> .....	<i>20</i>
1.6.1 In Agriculture and Food .....	20
1.6.2 In Medicine .....	21
1.6.3 In Energy .....	22
1.6.4 In Water Remediation.....	22
1.6.4.1 Filtration.....	23
1.6.4.2 Photocatalysis.....	23
<i>1.7 Literature Survey</i> .....	<i>24</i>
<i>1.8 Aims of the Thesis</i> .....	<i>30</i>

## ***Chapter 2***

### ***Theoretical Consideration***

<i>2.1 Introduction of Light Radiation</i> .....	<i>32</i>
2.1.1 Electromagnetic (EM) Radiation.....	32
<i>2.2 UV-Visible Spectroscopy</i> .....	<i>34</i>
2.2.1 The Concept of UV-Visible Spectrometer .....	34
2.2.2 The Absorption and Beer-Lambert's Law.....	35

2.2.3 Theory of Ultraviolet-Visible Electronic Spectroscopy .....	37
2.3 Transmission Electron Microscopy (TEM) .....	39
2.3.1 The Principle of Transmission Electron Microscope Technique .....	40
2.4 Theory of X-Ray Diffraction .....	43
2.4.1 Bragg's Law.....	43
2.5 Infrared (IR) Spectroscopy .....	45
2.5.1 Theoretical Basics of Infrared Radiation.....	45
2.5.2 Mathematical Consideration of Absorbing Infrared Spectra .....	47
2.5.3 Hook's Law for Stretching Vibrations .....	49
2.5.4 Number of Vibration Modes in Infrared Spectra .....	52

### Chapter 3

#### Methodology and Instruments

3.1 Materials.....	54
3.1.1 Gold (III) Chloride Hydrate ( $\mathbf{HAuCl_4 \cdot H_2O}$ ) .....	54
3.1.2 Silver Nitrate ( $\mathbf{AgNO_3}$ ) .....	54
3.1.3 Sodium Dodecyl Sulfate ( $\mathbf{C_{12}H_{25}NaO_4S}$ ) .....	55
3.1.4 Iron (II) Chloride Tetrahydrate (Ferrous Chloride) ( $\mathbf{FeCl_2 \cdot 4H_2O}$ ).....	55
3.1.5 Iron (III) Nitrate Nonahydrate (Ferric Nitrate) ( $\mathbf{Fe(NO_3)_3 \cdot 9H_2O}$ ) .....	56
3.1.6 Chitosan ( $\mathbf{C_6H_{11}NO_4}_n$ ).....	56
3.1.7 Acetic Acid ( $\mathbf{C_2H_4O_2}$ ).....	57
3.1.8 Sodium Hydroxide ( $\mathbf{NaOH}$ ).....	57
3.1.9 Absolute Ethanol ( $\mathbf{C_2H_5OH}$ ) .....	58

3.1.10 Sodium Diphosphate Monobasic ( $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ ).....	58
3.1.11 Disodium Hydrogen Orthophosphate Anhydrous ( $\text{Na}_2\text{HPO}_4$ ) .....	58
3.1.12 Ammonium Hydroxide ( $\text{NH}_4\text{OH}$ ) .....	59
3.1.13 Cobalt (II) Chloride 6-Hydrate (Cobaltous Chloride) ( $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ )59	
3.1.14 Hydrazine Hydrate ( $\text{N}_2\text{H}_4 \cdot \text{H}_2\text{O}$ ).....	60
3.1.15 Nickel (II) Nitrate Hexahydrate ( $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ) .....	60
3.2 <i>Experimental Methods</i> .....	60
3.2.1 Green Synthesis of Gold and Silver Nanoparticles .....	60
3.2.1a Preparation of Gold Nanoparticles with Different Concentrations of Lemon Extract .....	61
3.2.1b Preparation of Silver Nanoparticles with Different Concentrations of Silver Nitrate.....	62
3.2.2 Synthesis of Iron and Cobalt as a Magnetic Nanoparticles.....	64
3.2.2a Preparation of Iron Nanoparticles Capped by Chitosan at Different Concentrations of Iron .....	65
3.2.2b Preparation of Cobalt Nanoparticles with Different Concentrations of Sodium Hydroxide.....	67
3.3 <i>Instrumentation Techniques</i> .....	70
3.3.1 Ultraviolet/Visible Spectrophotometer Technique (UV-Vis) .....	70
3.3.2 High-Resolution Transmission Electron Microscopy (HR-TEM) .....	72
3.3.3 X-Ray Diffraction Spectrometer Technique (XRD) .....	74
3.3.4 Fourier Transform Infrared Spectroscopy (FTIR).....	76

## Chapter 4

### Results and Discussion

4.1 Ultraviolet-Visible Spectroscopy.....	79
4.1.1 Ultraviolet-Visible Spectra of Gold Nanoparticles Prepared at Different Concentrations of Lemon .....	79
4.1.2 Ultraviolet-Visible Spectra of Silver Nanoparticles Prepared at Different Molar Ratio of Silver Nitrate.....	83
4.1.3 Ultraviolet-Visible Spectra of Iron Nanoparticles Prepared at Different Molarity of Iron Salt .....	85
4.1.4 Ultraviolet-Visible Spectra of Cobalt Nanoparticles Prepared at Different Concentrations of Sodium Hydroxide .....	86
4.2 High-Resolution Transmission Electron Microscopy .....	88
4.2.1 HR-Transmission Electron Microscopy of Gold Nanoparticles Prepared at Different Concentrations of Lemon Extract .....	88
4.2.2 HR-Transmission Electron Microscopy of Silver Nanoparticles Prepared at Different Molar Ratio of Silver Nitrate .....	91
4.2.3 HR-Transmission Electron Microscopy of Iron Nanoparticles Prepared at Different Molarity of Iron Salt .....	93
4.2.4 HR-Transmission Electron Microscopy of Cobalt Nanoparticles Prepared at Different Concentrations of Sodium Hydroxide .....	96
4.3 X-Ray Diffraction Pattern.....	99
4.3.1 X-Ray Diffraction for Iron Nanoparticle Prepared at Different Concentrations of Iron Salt.....	99

4.3.2 X-Ray Diffraction of Cobalt Nanoparticles Prepared at Different Concentrations of Sodium Hydroxide .....	100
<i>4.4 Fourier Transform Infrared Spectroscopy .....</i>	<i>103</i>
4.4.1 Fourier Transform Infrared Spectroscopy of Gold Nanoparticle Capped with Different Concentrations of Lemon Extract .....	103
4.4.2 Fourier Transform Infrared Spectroscopy of Silver Nanoparticle Capped by Lemon Extract .....	106
4.4.3 Fourier Transform Infrared Spectroscopy of Iron Nanoparticle Prepared at Different Concentrations of Ion Salt.....	109
4.4.4 Fourier Transform Infrared Spectroscopy of Cobalt Nanoparticles Prepared at Different Concentrations of Sodium Hydroxide .....	112
<i>4.5 Applications of Nanoparticles in Water Purification.....</i>	<i>115</i>
4.5.1 UV-Visible Spectroscopy with Different Concentrations of Nickel Nitrate .....	115
4.5.2 Study the Alternating in Nickel Salt Concentrations Dissolved in Water After Passing through Imbibed Filter by Gold Nanoparticles.....	117
4.5.3 Study the Alternating in Nickel Salt Concentrations Dissolved in Water After Passing through Imbibed Filter by Silver Nanoparticles .....	120
4.5.4 Study the Alternating in Nickel Salt Concentrations Dissolved in Water After Passing through Imbibed Filter by Iron Nanoparticles .....	123
4.5.5 Study the Alternating in Nickel Salt Concentrations Dissolved in Water After Passing through Imbibed Filter by Cobalt Nanoparticles .....	125
<i>Conclusions.....</i>	<i>130</i>
<i>References.....</i>	<i>132</i>

*Arabic Summary*.....148