

# **CURRICULUM OF CHEMISTRY FOR OTHER DEPARTMENTS**

**BS Program  
(4-Year, 8-Semester)**



**Department of Chemistry**  
Shaheed Benazir Bhutto Women University  
Peshawar

## SCHEME OF STUDIES

<b>Department of Biochemistry</b>		
<b>Course Code</b>	<b>Course Title</b>	<b>Credit Hours</b>
<b>Semester – I</b>		
CHM-301	Fundamental Inorganic Chemistry	4 (3 + 1)
<b>Semester – II</b>		
CHM-302	Fundamental Physical Chemistry	4 (3 + 1)
<b>Semester – III</b>		
CHM-401	Fundamental Organic Chemistry	4 (3 + 1)
<b>Semester – IV</b>		
CHM-403	Fundamental Analytical Chemistry	4 (3 + 1)

<b>Department of Microbiology/Department of Physics/ Other (excluding Biochemistry/Zoology) Departments (if they require this course for their academic program(s))</b>		
<b>Course Code</b>	<b>Course Title</b>	<b>Credit Hours</b>
<b>Semester – I</b>		
CHM-300	General Chemistry	4 (3 + 1)

<b>Department of Zoology</b>		
<b>Course Code</b>	<b>Course Title</b>	<b>Credit Hours</b>
<b>Semester – II</b>		
CHM-301	Fundamental Inorganic Chemistry	4 (3 + 1)
<b>Semester – III</b>		
CHM-401	Fundamental Organic Chemistry	4 (3 + 1)
<b>Semester – IV</b>		
CHM-402	Environmental Chemistry	4 (3 + 1)

## Details of Theory/Practical Courses of Chemistry for BS (4-Years) Other

### Department of Biochemistry

#### BS 1<sup>st</sup> Year (Semester-I)

##### CHM-301 Fundamental Inorganic Chemistry (Cr. 3)

**The Periodic Law and Periodicity:** Development of Periodic Table; Classification of elements based on *s*, *p*, *d* and *f* orbitals, group trends and periodic properties in *s*, *p*, *d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electronegativities and redox potential.

**Principles of Chemical Bonding:** Types of chemical bonding; Lewis structures and prediction of shapes using VSEPR model, the localized bond approach: VB theory, hybridization and resonance; the delocalized approach to bonding: molecular orbital theory as applied to diatomic and polyatomic molecules, three center bonds, bonding theory of metals and intermetallic compounds; conductors, insulators and semiconductors; bonding in electron deficient compounds; hydrogen bonding.

**Acids and Bases:** Concepts of acids and bases including SHAB concept, relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions. Theory of indicators, solubility, solubility product, common ion effect and their industrial applications.

**Chemistry of p-block Elements:** Chemistry and structure of *p*-block elements; main emphasis on the chemistry and structure of noble gases and their compounds, chemistry and structure of interhalogens, pseudohalogens and polyhalides.

##### **Recommended Books**

1. Cotton, F. A., Wilkinson, G. and Gaus, P. L., "*Basic Inorganic Chemistry*", 3<sup>rd</sup> Ed., Wiley, New York, 1995.
2. Huheey, J. E., Keiter, E. A. and Keiter, R. L., "*Inorganic Chemistry: Principles of Structure and Reactivity*", 4<sup>th</sup> Ed., Harper and Row, New York, 2001.
3. Clyde Day, M. & Selbin, J., "*Theoretical Inorganic Chemistry*", 2<sup>nd</sup> Ed., Van Nostrand Reinhold, 1969.
4. Lee, J.D., "*Concise Inorganic Chemistry*", Chapman and Hall, 5<sup>th</sup> Ed., 1996.
5. Shriver, D. F., Atkins, P. W. and Langford, C. H., "*Inorganic Chemistry*", Oxford University Press, 2<sup>nd</sup> Ed., 1994.
6. Bassette, J., Denney, G. H. and Mendham, J., "*Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis*" English Language Book Society, 4<sup>th</sup> Ed., 1981.

### **CHM-301 Fundamental Inorganic Chemistry Lab. (Cr. 1)**

1. **Laboratory Ethics and Safety Measures:** Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations.
2. **Qualitative Analysis:** Analysis of four ions (two anions and two cations) from mixture of salts.
3. **Quantitative Analysis:**
  - i) Volumetric Analysis: Practical exercises will be based on Redox, Iodometric and Iodimetric, Precipitation and Complexometric Reactions.
  - ii) Gravimetric Analysis: Estimation of  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ . Determine percent of P and  $\text{P}_2\text{O}_5$  in a sample of ammonium phosphomolybdate.

#### **Recommended Book**

1. Vogel, A. I., "A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis" Longman Green & Co., 1995.

### **BS 1<sup>st</sup> Year (Semester-II)**

#### **CHM-302 Fundamental Physical Chemistry (Cr. 3)**

**Physical Properties of Matter:** Concept of ideal and real gases, state variables, equations of states (ideal gas equation and van der Waals equation). Kinetic model of gases; Collision diameter, mean free path, collision frequency. Properties of liquids; Surface tension, viscosity, refractive index, polarity, homogeneous and heterogeneous solutions, types of interactions in liquids, van der Waals interactions, dipole-dipole interactions, hydrogen bonding. Unit cell, crystal lattice, crystal systems, Miller indices, amorphous and crystalline solids. **Thermodynamics:** Thermodynamic system, surrounding, zeroth law of thermodynamics, concept of equilibrium, first law of thermodynamics, concept of internal energy, enthalpy, thermodynamic processes under different conditions (isothermal, adiabatic, reversibility concept), second law of thermodynamics, concept of entropy, Gibbs free energy. **Chemical Kinetics:** Rate of reactions, order of reactions, molecularity, extent of reaction, rate law, rate laws of zero-order and first-order reactions and differential and integrated forms, examples, concept of half-life and mean-life, factors affecting rates (Arrhenius equation). **Electrochemistry:** Introduction of electrochemistry (ions in solution, conductance, resistance); Ohm's law, Kohlrausch law, electrode potential, electrochemical cell (galvanic cell, electrolytic cell).

**Pre-requisite:** CHM-301

#### **Recommended Books**

1. P.W. Atkins, and J. de Paula. *Physical Chemistry*, 8<sup>th</sup> ed., Freeman & Co., New York (2006).
2. R.A. Alberty and R.J. Silby. *Physical Chemistry*, John Wiley, New York (1995).
3. I. N. Levine. *Physical Chemistry*, McGraw Hill, New York (2002).

### **CHM-302 Fundamental Physical Chemistry Lab. (Cr. 1)**

1. Determination of viscosity and parachor values of liquids.
2. Determination of percent composition of liquid solutions viscometrically.
3. Determination of refractive index and molar refractivity.
4. Determination of percent composition of liquid solutions by refractive index measurements.
5. Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method).
6. Determination of heat of solution by solubility method.
7. Determination of heat of neutralization of an acid with a base.

#### **Recommended Books**

1. Jaffar M., "*Experimental Physical Chemistry*", University Grants Commission, 1989.
2. Levitt B.P., "*Findlay's Practical Physical Chemistry*", 9<sup>th</sup> Ed., Longman Group Limited, 1978.
3. Shoemaker D., "*Experiments in Physical Chemistry*", 5<sup>th</sup> Ed., McGraw Hill Publishing Company Limited, 1989.

### **BS 2<sup>nd</sup> Year (Semester-III)**

#### **CHM-401 Fundamental Organic Chemistry (Cr. 3)**

**Introduction to Organic Chemistry:** Organic chemistry—the chemistry of carbon compounds; the nature of organic chemistry— a historical perspective. Localized and delocalized chemical bonding, concept of hybridization and shapes of organic molecules; resonance; aromaticity; tautomerism; hyperconjugation; hydrogen bonding.

**Classes and Nomenclature of Organic Compounds:** Classification of organic compounds; development of systematic nomenclature of organic compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups including polycyclic system and compounds containing more than one functional groups.

**Functional Group Chemistry:** A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives.

**Applications of Chemistry:** Use of organic compounds in industries, like medicinal, pharmaceutical, cosmetics, paints and pigments, polymers etc.

**Pre-requisite:** CHM-301

#### **Recommended Books**

1. L.G. Wade, *Organic Chemistry*, 8<sup>th</sup> Ed., Pearson's, 2012.
2. T.W. Graham Solomons and Graig B. Fryhle, *Organic Chemistry*, 10<sup>th</sup> Ed., John Wiley & Sons, 2011.
3. J.G. Smith, *Organic Chemistry*, 3<sup>rd</sup> Ed., McGraw-Hill Companies, 2012.

4. Brown and Foote, *Organic Chemistry*, 6<sup>th</sup> Ed., Pearson Publishers, 2011.
5. Stanley H. Pine, *Organic Chemistry*, 5<sup>th</sup> Ed., McGraw-Hill, 2007.
6. D. Hellwinkel, *Systematic Nomenclature of Organic Chemistry*, Springer Verlag, 2001.

### **CHM-401 Fundamental Organic Chemistry Lab. (Cr. 1)**

1. Qualitative organic analysis: Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives.
2. Preparation of the following compounds: Suphanilic acid, dibenzyl acetone, methyl orange, dinitrobenzene from benzene, isolation of caffeine.
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation methods).
4. Equivalent weight of an acid (neutralization).
5. Identification of organic functional groups by I.R. spectroscopy.

#### **Recommended Books**

1. K.N. Williamson and K.M. Masters, *Macroscale and Microscale Organic Experiments*, published by Cengage learning, 2011.
2. J.J. Li, C. Limberakis and D.A. Pflum, *Modern Organic Synthesis in Laboratory*, Oxford University Press, 2007.
3. J. Leonard, B. Lygo and G. Procter Nelson, *Advanced Practical Organic Chemistry*, Thomas Ltd. UK, 2001.

### **BS 2<sup>nd</sup> Year (Semester-IV)**

#### **CHM-403 Fundamental Analytical Chemistry (Cr. 3)**

**Introduction to Analytical Chemistry:** Chemical analysis, analytical processes, sampling and applications.

**Measurements and Chemical Analysis:** Concentration units, stoichiometric calculations.

**Data Handling:** Experimental errors, precision, accuracy and limits of detection, evaluation of data, quality of results, quality assurances and calibration methods.

**Chemical Equilibria:** Basic approach to chemical equilibria (acid-base, redox, complexation, precipitation), solubility and solubility product, ionic strength and activity coefficient, analysis by acid-based chemistry and titration curves.

**Pre-requisite:** CHM-301

#### **Recommended Books**

1. Christian, G.D., "*Analytical Chemistry*", 6<sup>th</sup> Ed., John Wiley & Sons, New York, 2003.
1. Harris, D.C., "*Quantitative Chemical Analysis*", 8<sup>th</sup> Ed., Freeman, W.H. and Company, New York, 2011.
2. Skoog D.A., West D.M., and Holler F.J., "*Fundamentals of Analytical Chemistry*", 8<sup>th</sup> Ed., Thomson, 2004.

### **CHM-403 Fundamental Analytical Chemistry Lab. (Cr. 1)**

1. Lab safety and precautions
2. Introduction and calibration of glassware and instruments
3. Determination of Cations and anions (mass measurement)
4. Acid-base titrations
5. Redox titrations
6. Complexation titrations

#### **Recommended Books**

1. Vogel A.I., "A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis", Longman Green & Co., 1995.
2. Jaffar M., "Experimental Physical Chemistry", University Grants Commission, 1989.

### **Department of Microbiology/Department of Physics/Other (excluding Biochemistry/Zoology) Departments (if they require this course for their academic program(s))**

#### **BS 1<sup>st</sup> Year (Semester-I)**

### **CHM-300 General Chemistry (Cr. 3)**

**The Periodic Law and Periodicity:** Development of Periodic Table; Classification of elements based on *s*, *p*, *d* and *f* orbitals, group trends and periodic properties in *s*, *p*, *d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electronegativities and redox potential.

**Principles of Chemical Bonding:** Types of chemical bonding; Lewis structures and prediction of shapes using VSEPR model, the localized bond approach: VB theory, hybridization and resonance; the delocalized approach to bonding: molecular orbital theory as applied to diatomic and polyatomic molecules, three center bonds, bonding theory of metals and intermetallic compounds; conductors, insulators and semiconductors; bonding in electron deficient compounds; hydrogen bonding.

**Acids and Bases:** Concepts of acids and bases including SHAB concept, relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions. Theory of indicators, solubility, solubility product, common ion effect and their industrial applications.

**Thermodynamics:** Thermodynamic system, surrounding, zeroth law of thermodynamics, concept of equilibrium, first law of thermodynamics, concept of internal energy, enthalpy, thermodynamic processes under different conditions (isothermal, adiabatic, reversibility concept), second law of thermodynamics, concept of entropy, Gibb's free energy.

**Chemical Kinetics:** Rate of reactions, order of reactions, molecularity, extent of reaction, rate law, rate laws of zero-order and first-order reactions and differential and integrated

forms, examples, concept of half-life and mean-life, factors affecting rates (Arrhenius equation).

**Functional Group Chemistry:** A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives.

### Recommended Books

1. Ralph H. Petrucci, R.H., Herring, F.G., Madura, J.D., Bissonnette, C., “*General Chemistry: Principles and Modern Applications*”, 11<sup>th</sup> Ed., Pearson Education, 2017.
2. Cotton, F. A., Wilkinson, G. and Gaus, P. L., “*Basic Inorganic Chemistry*”, 3<sup>rd</sup> Ed., Wiley, New York, 1995.
3. Huheey, J. E., Keiter, E. A. and Keiter, R. L., “*Inorganic Chemistry: Principles of Structure and Reactivity*”, 4<sup>th</sup> Ed., Harper and Row, New York, 2001.
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7. L.G. Wade, *Organic Chemistry*, 8<sup>th</sup>Ed., Pearsons, 2012.
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### CHM-300 General Chemistry Lab. (Cr. 1)

1. **Laboratory Ethics and Safety Measures:** Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations.
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3. **Qualitative Organic Analysis:** Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives
4. Determination of heat of neutralization of an acid with a base.

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# Department of Zoology

## BS 1<sup>st</sup> Year (Semester-II)

### CHM-301 Fundamental Inorganic Chemistry (Cr. 3)

**The Periodic Law and Periodicity:** Development of Periodic Table; Classification of elements based on *s*, *p*, *d* and *f* orbitals, group trends and periodic properties in *s*, *p*, *d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electronegativities and redox potential.

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4. Lee, J.D., "*Concise Inorganic Chemistry*", Chapman and Hall, 5<sup>th</sup> Ed., 1996.
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### CHM-301 Fundamental Inorganic Chemistry Lab. (Cr. 1)

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2. **Qualitative Analysis:** Analysis of four ions (two anions and two cations) from mixture of salts.

### 3. Quantitative Analysis:

- i) Volumetric Analysis: Practical exercises will be based on Redox, Iodometric and Iodimetric, Precipitation and Complexometric Reactions.
- ii) Gravimetric Analysis: Estimation of  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ . Determine percent of P and  $\text{P}_2\text{O}_5$  in a sample of ammonium phosphomolybdate.

#### Recommended Book

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## BS 2<sup>nd</sup> Year (Semester-III)

### CHM-401 Fundamental Organic Chemistry (Cr. 3)

**Introduction to Organic Chemistry:** Organic chemistry—the chemistry of carbon compounds; the nature of organic chemistry— a historical perspective. Localized and delocalized chemical bonding, concept of hybridization and shapes of organic molecules; resonance; aromaticity; tautomerism; hyperconjugation; hydrogen bonding.

**Classes and Nomenclature of Organic Compounds:** Classification of organic compounds; development of systematic nomenclature of organic compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups including polycyclic system and compounds containing more than one functional groups.

**Functional Group Chemistry:** A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives.

**Applications of Chemistry:** Use of organic compounds in industries, like medicinal, pharmaceutical, cosmetics, paints and pigments, polymers etc.

**Pre-requisite:** CHM-301

#### Recommended Books

1. L.G. Wade, *Organic Chemistry*, 8<sup>th</sup>Ed., Pearsons, 2012.
2. T.W. Graham Solomons and Graig B. Fryhle, *Organic Chemistry*, 10<sup>th</sup>Ed., John Wiley & Sons, 2011.
3. J.G. Smith, *Organic Chemistry*, 3<sup>rd</sup>Ed., McGraw-Hill Companies, 2012.
4. Brown and Foote, *Organic Chemistry*, 6<sup>th</sup>Ed., Pearsons Publishers, 2011.
5. Stanley H. Pine, *Organic Chemistry*, 5<sup>th</sup>Ed., McGraw-Hill, 2007.
6. D. Hellwinkel, *Systematic Nomenclature of Organic Chemistry*, Springer Verlag, 2001.

### CHM-401 Fundamental Organic Chemistry Lab. (Cr. 1)

1. Qualitative organic analysis: Systematic identification of organic compounds (monofunctional and simple bifunctional) and preparation of their derivatives.

2. Preparation of the following compounds: Suphanilic acid, dibenzyl acetone, methyl orange, dinitrobenzene from benzene, isolation of caffeine.
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation methods).
4. Equivalent weight of an acid (neutralization).
5. Identification of organic functional groups by I.R. spectroscopy.

#### **Recommended Books**

1. K.N. Williamson and K.M. Masters, *Macroscopic and Microscopic Organic Experiments*, published by Cengage learning, 2011.
2. J.J. Li, C. Limberakis and D.A. Pflum, *Modern Organic Synthesis in Laboratory*, Oxford University Press, 2007.
3. J. Leonard, B. Lygo and G. Procter Nelson, *Advanced Practical Organic Chemistry*, Thomas Ltd. UK, 2001.

### **BS 2<sup>nd</sup> Year (Semester-IV)**

#### **CHM-402 Environmental Chemistry (Cr. 3)**

**Atmospheric Chemistry:** The air around us, atmospheric temperature and pressure profile, Temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, radioactivity, atmospheric aerosols, Acid rain –major sources, mechanism, control measures and effects on buildings and vegetation, Global warming – major green house gases, mechanism, control measures and global impact, The stratospheric ozone – the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

**Water Pollution and Water Treatment:** Sources of water pollution-industrial sources and agricultural sources, heavy metals contamination of water, Eutrophication, detergents and phosphates in water, water quality criteria, Water purification – primary, secondary and advanced treatment, Removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition.

**Soil Pollution:** Soil and mineral resources, general principles of metal extraction, heavy metals contamination of soil, toxicity of heavy metals, bio-accumulation of heavy metals, organic matter in soil, macro- and micro-nutrients in soil, ion-exchange in soil, soil pH and nutrients availability.

**Energy Production and Environment:** Liquid and gaseous fuel, hydrogen economy.

#### **Recommended Books**

1. Baird, C., “*Environmental Chemistry*”, W. H. Freeman and Company, New York, 1995.
2. Moore, J.W., Moore, E.Z., “*Environmental Chemistry*”, Academic Press Inc., New York, 1976.
3. Neill, P.O., *Environmental Chemistry*, Chapman and Hall, London, 1993.
4. Elsom, D.M., “*Atmospheric Pollution, Blackwell Publishers*”, Oxford, 1992.
5. Lean, G., Hinrichsen, D., “*Atlas of the Environment*”, Helicon Publishing Ltd., Oxford, 1992.
6. De, A.K., “*Environmental Chemistry*”, Wiley Eastern Ltd. New Delhi, 1989.

7. Manahan, S.E., “*Fundamentals of Environmental Chemistry*”, 3<sup>rd</sup> Ed., CRC Press, Taylor & Fancis Group, New York, 2008.

**CHM-402 Environmental Chemistry Lab. (Cr.3)**

1. Safety Rules and Regulations, Techniques in solution preparation.
2. The pH and Buffer Capacity of Environmental Waters.
3. Inorganic and Organic Profiles of Soil and Sediment Cores.
4. Alkalinity of Water Samples.
5. Conductivity of Various Water Samples
6. Metals Determination in water samples by Electrogravimetry.
7. Determination of Chloride Ion in Natural Waters.
8. Determination of the Temporary and Permanent Hardness of Waters by Complexometric and Precipitation Titration respectively.
9. Determining Iron and Manganese in Natural Waters and Sediments.
10. Determination of the DO, BOD and Chemical Oxygen Demand of Natural Water and Waste water Using Standard Method.
11. Introduction to Air Sampling: Particulates in Urban Air.
12. Determination of the Concentration of Carbon Dioxide in the Atmosphere.

**Recommended Books**

1. Weiner, E.R., “*Applications of Environmental Chemistry: A Practical Guide for Environmental Professionals*”, CRC Press, 2010.
2. Vowles, P.D., Connell, D.W., “*Experiments in Environmental Chemistry A Laboratory Manual Book*”, Elsevier, Vol. 4, 2013.
3. Gopalan, R., Anand, A., & Sugumar, R.W., “*A Laboratory Manual for Environmental Chemistry*”, IK International Pvt Ltd., 2010.
4. Bleam, W.F., “*Soil and Environmental Chemistry*”, Academic Press, 2<sup>nd</sup> Ed., 2016.