Description of BSc. Program Courses:

CHEM 101: General Chemistry (1)

Stoichiometry: SI units, chemical formulae, the mole, methods of expressing concentration, calculations based on chemical equations.
Gases: Laws, kinetic theory, deviation and Van der Waals equation.
Thermochemistry: Types of enthalpy changes, Hess Law and its applications, First Law of Thermodynamics.
Solutions: Type of solutions and laws related, colligative properties.
Chemical Kinetics: Law of reaction rate, reaction order, factors affecting the reaction.
Chemical Equilibrium: Reaction between K_c & K_p, Le-Chatelier's principle and factor affecting equilibrium. Ionic equilibrium: Acid and base concepts, pH calculations of acid, base and buffer solutions

Practical General Chemistry

Eleven experiments dealing with: Physical properties of mater, Hess's law, chemical kinetics, volumetric analysis.

CHEM 201: General Chemistry (2)

Bohr's atomic theory, Electronic structure of atoms, The periodic table, Chemical bonding (Lewis symbols and structures, oxidation numbers, ionic and covalent bonding, resonance, bond enthalpy), Molecular geometry and hybridization of atomic orbitals, Intermolecular interactions, Chemical Kinetics, Chemical equilibrium, Acid-bases equilibria. Practical part: the student performs 10 experiments in the lab concerning the above topics by two hours a week.

CHEM 223: Chemistry of Main Groups

Summary of modern atomic theory, Periodic Table, Periodicity effect, Group I elements: (Li-Cs), Group II elements (Be-Ba), Group III elements: Boron (Al-Tl), Group IV elements: Carbon (Si-Pb), Group V elements: Nitrogen (P-Bi), Group VI elements: Oxygen (S-Po), Group VII elements: (F-At), Group VIII elements: (Noble gases). Ionic bond compounds – Covalent bond compounds - Chemical forces.

CHEM 232: Chemical Thermodynamics

Importance and terminologies, Work and Heat, Zeroth Law, First Law, Thermochemistry, The second and Third Laws, Free energy, partial molar quantities. Chemical potential. Mixing ideal and true solutions, Chemical and physical equilibrium, Statistical thermodynamic.

CHEM 240: Organic Chemistry (1)

Introduction: (Carbon Compounds), Chemical Bonds (ionic, Covalent), Atomic and Molecular orbitals, Hybridization, Polarity and Inductive effect, Alkanes, Cycloalkanes (Alkyl groups, IUPAC nomenclature, Physical properties, Sources off, Synthesis. Reactions (Combustion, Halgenation, Ring opening. Configuration, Cyclohexanes, Alkenes and Alkynes (IUPAC nomenclature, Physical properties, Synthesis (Dehydrohalogenation, from vicinal di-halides, Dehydration of alcohols). Reactions (Acidity of terminal alkynes, Addition reactions (Reduction, Halogenation, Addition of HX – Markovnikov rule, Carbonium ions and their stability, Reaction mechanism), Addition in the presence
of peroxides, Hydration, Halohydrin formation), Oxidation of Alkenes ($KMnO_4$, Peroxides and Ozonolysis), Conjugated Dienes (Allyl radical and stability, Allyl cation, 1,3-Butadiene-electron delocalization, Resonance and the Stability of conjugated dienes, 1,4-Addition and 1,4-Cycloaddition reactions of diene), Stereochemistry (Structural isomers and Stereoisomerism, Enantiomers, Diastereomers and Chirality, D and L, The R-S system, Resolution, Molecules with more than one chiral carbon, Reactions of chiral molecules: Inversion , Racemization, Aromatic Compound (Aromatic character, Hukel rule, Nomenclature, Electrophilic substitution reactions (Alkylation, Acylation, Halogenation, Sulphonation, Nitration; reaction mechanism), Side chain halogenation and oxidation, Reactivity and Orientation in substituted benzene, Poly-nuclear aromatics).

CHEM 241: Organic Chemistry (2)

Organic halides (IUPAC nomenclature, Physical properties, Synthesis, Grignard reagents, Nucleophilic substitution SN1, SN2. E1, E2 mechanism). IUPAC nomenclature, Classification, Physical properties, Synthesis, Reactions of the following organic classes: Alcohols and Thiols; Ethers, Epoxides and Sulfides; Phenols, Aldehydes and Ketones; Carboxylic acids and Their Derivatives, Amines.

CHEM 247: Identification of Organic Compounds

Introduction: (Safety, Laboratory Equipment, Gas cylinders), Solubility, Extraction, Distillation.
Physical constants: melting point, boiling point
Chromatography: Paper (PC), Column (CC), Thin layer Chromatography(TLC)
Functional groups: Alkane, Alkene, Aromatic, Organic halides, Hydroxy-Compounds, Nitro and amine compounds, Aldehydes and Ketones, Carbohydrate, Carboxylic acids and their derivatives. Elemental Analysis.

CHEM 252: Fundamentals of Analytical Chemistry

Concentrations of solutions. Types of equilibrium. Factors affecting equilibrium constant. Precipitation equilibrium and the introduction to quantitative analysis. Acid-base titration. Titration curves. Indicators. Complexiметric titrations. Precipitation titrations. Redox and potentiometric titrations. Gravimetric analysis. Gravimetric calculations.

Practical: Acid-base titrations - Precipitation titrations - Complexiметric titrations- Redox titrations. Some experiments on gravimetric analysis.

CHEM 256: Spectroscopic Analytical Methods

I) Spectrometric methods:

General introduction – the electromagnetic radiation (particle model & wave model) – Absorption of radiation by atoms and molecules – Beers Law (Instrumental dev., chemical dev. And Spectrum. Error) – Instrumentation (source of radiation, mono-chromator, detector, … etc.) – single-beam spectrometer vs. double-beam spectrometer.

II) Molecular Spectrometric Methods: MolecularAbsorptionSpectrometry(MAS)– MethodsofAnalysisandtheirapplications

– Flow Injection Analysis (FIA) – FIA- Spectrometry and some applications – Fluoremetery and Phosphorimetry – FIA - Fluorometry – FIA-Chemiluminescence.

III) Atomic Spectrometric Methods:

Absorption, emission and fluorescence of radiation by atoms in vapor phase – types of flames, burners and nebulizers – Atomic Emission Spectrometry (AES) – Hollow-cathode lamp – Single-beam vs. double-beam atomic absorption spectrometers – Atomic Fluorescence Spectrometry (AES) – Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) – Arc Spark Emission Spectrography.

Practical section:

Experiments on molecular spectrometry and atomic spectrometry methods.

CHEM 310: Computer Applications in Chemistry

It is a course that aims at enabling students from conducting mathematical calculations using Microsoft Excel. The course will discuss the program's instructions and basic concepts, as well as hands-on training weekly exercises taken from chemistry using Excel software on computers. Through which students learn about the many ways in which Excel can be used as a calculator and an analytical tool for scientific problems and exercises in chemistry.

CHEM 323: Chemistry of Transition Elements

Definition of transition elements. Theories of bonding (Warner›s Theory, the effective atomic number, the Valence Bond Theory, the Crystal Field Theory, Molecular Orbital Theory, Ligand Field Theory).

Energy levels for the transition metal ions. The magnetic properties of the transition metal complexes. Role of transition metal ions in the biological system. Role of transition metal ions in catalysis.

CHEM 320: Quantum Chemistry (1)

Historical Background: black body radiation, Electromagnetic effect, atomic spectra, Bohr Theory, de Broglie Principle, Heisenberg Uncertainty Principle.

Mathematical review: differentiation, integration, coordinate system, complex numbers, vectors, operators, Eigen functions, odd and even functions, differential equations.

Particle in a box: Interpretation of the wave function, particle in one-dimensional box, normalization of the wave function, orthogonality, energy and wave function of a particle in a box, Correspondence Principle, postulates of quantum mechanics, application of the postulates of quantum mechanics, particle in three-dimensional box, degeneracy.

Simple harmonic motion: view of classical mechanics of the simple harmonic motion, quantum chemistry view of the simple harmonic motion, some mathematical relationships of the simple harmonic motion wave function.

Hydrogen atom: solution of the Schrodinger equation of the hydrogen-like atoms, Schrodinger equation and separation of variables, equation of the F function, equation of the T function, equation of the R function, wave function of the hydrogen-like atoms.

Angular Momentum: View of classical mechanics of the angular momentum, commutation and measuring more than property at the same time, commutation and the angular momentum, Eigen values and Eigen functions of the angular momentum, representation of the angular momentum.

CHEM 328: Quantum Chemistry (2)

The Variation Method: Variation Principle, extension of the Variation Method to include the excited states, linear variation functions.

Perturbation Method: Perturbation Method for non-degenerate states, treatment of the Perturbation Method of the helium atom, treatment of the Variation Method of the helium atom.

Electron spin and the Pauli principle: electron spin, Pauli Principle, the helium atom, the lithium atom, Slater determinant.

Angular momentum of multi-electron atoms: Hamiltonian Operator of multi-electron atoms, the total electronic angular momentum, the angular momentum of multi-electron atoms, state symbol, equivalent and non-equivalent electrons, fine structure of the electronic spectrum of the hydrogen atom, electronic spectrum of the helium atom.

Huckel Molecular Orbital Method: Huckel Molecular Orbital Method, application of the Huckel Molecular Orbital Method to hydrocarbons with conjugate double bonds, delocalization energy, charge density and bond order.

CHEM 329: Inorganic Compounds Spectroscopy

Introduction: characterization of electromagnetic radiation, quantization of energy, regions of spectrum, representation of spectrum, basic elements of practical spectroscopy, signal-to-noise, resolving power, width and intensity of spectral lines.

Microwave spectroscopy: rotation of molecules, rotational spectra, diatomic molecules.

Infra-red spectroscopy: vibrating diatomic molecule, diatomic vibrating rotator, vibration-rotation spectrum of carbon monoxide, breakdown of the Born-Oppenheimer approximation, interaction of rotations and vibrations.

Electronic spectroscopy of atoms: structure of atoms, electronic angular momentum, multi-electron atoms, angular momentum of multi-electron atoms.

Spin resonance spectroscopy: spin and applied field, nuclear magnetic spectroscopy, electron magnetic spectroscopy.

Group Theory: Molecular symmetry and the symmetry groups, symmetry point groups, representation of groups, applications.

CHEM 330: Physical Chemistry of Polymers:

Introduction, Definitions, classification of polymers, Polymerization and copolymerization techniques, Characterization and determination of molecular weight, Configuration of polymers chains (structure and microstructure), Solubility of polymer and miscibility, Determination of thermal properties of polymers.

Practical:

- Solubility and precipitation of polymers
- Techniques of purification of monomers, catalysts and polymers
- Polymerization of suitable monomer using free radical
- Polymerization of suitable monomer using anionic or cationic polymerization
- Polymerization of suitable monomers using poly condensation method
- Copolymerization using free radicals and characterizations
- Determination of molecular weight by viscosimetry
- Grafting of polymer using free radical.
- Determination of structure and microstructure of polymer using spectroscopic techniques

CHEM 333: Industrial Chemistry

Physical Processes in Chemical Industry, Mass and Energy Balance in Industrial Processes, Industrial Thermo-chemistry, Chemical Conversion Processing, Main Catalysts used in Chemical Industry, Industrial Applications of Electrochemical Cells and Electrolysis, Corrosion Phenomenon and its industrial solutions.

CHEM 334: Nuclear and Radiation Chemistry

Part One: Nuclear chemistry, Introduction, atomic nuclei, radioactive decay process, nuclear reaction, equations of radioactive decay and growth, interaction of radiation with matter, radiation detection and measurement, techniques in nuclear chemistry, radiochemical applications and beneficial uses of isotopes, sources of nuclear bombarding particles, reactor safety and radiation protection and control.

Part Two: Radiation chemistry, reaction dosimetry, radiolysis of water and aqueous solution, radiolysis of organic systems, radiolysis of gases, applications of radiation chemistry.

CHEM 335: Chemical Kinetics

Reaction rate, concentration and time, rate expression, reaction order, half time, rate-concentration plot, experimental methods, kinetics of simple reactions with different orders, determination of rate and orders, reaction rate and temperature, Arrhenius equation, Activation energy calculation, Complex reaction and mechanism. Introduction to catalysis, solid-gas and solid-liquid heterogeneous catalysis, chemical kinetics of heterogeneous catalysis, types and preparation of catalysts, major industrial reactions

CHEM 336: Physical Chemistry of Solutions

Some notions on the liquid properties;

The simple mixtures (the thermodynamic description of mixtures, the Partial molar quantities); The Chemical potential of liquids (ideal solutions, ideal-dilute solutions); Ideal and non-ideal solutions of non-electrolyte; Colligative properties (the common features of colligative properties, the elevation of boiling point, the depression of freezing point, the solubility, the osmosis); Activities of solvent and solute (ideal-dilute solutions, real solutes, activities in terms of molalities, the biological standard state); Activities coefficient (the activities of regular solutions, mean activity coefficients); Ionic solutions (the thermodynamic properties of ions in solution, the Born and Debye-Huckel models, solubility and dissociation, electrolytic conductance, ionic mobility, transport number); Phases diagrams of binary systems (vapor pressure diagrams, liquid- vapor phase diagrams, liquid-liquid phase diagrams, solid-liquid phase diagrams).

CHEM 341: Heterocyclic Organic Chemistry

Heterocycles, Nomenclature, Aromaticity, Five-membered heterocycles: Pyrroles, Indoles, Diazoles, Synthesis, Reactions, Cycloaddition Reactions, Six-membered heterocycles, Pyridine, quinoline, Basicity, Synthesis, Reactions. Heterocyclic compounds versus microbes, Antibiotics, antitumorsandas Dyes. Biologically important Heterocycles, Uracils and Purins. Carbohydrates, Definition, Nomenclature, Classification, Monosaccarides: absolute configuration, cyclic structures, oxidation, reduction, osazones, ascorbic acid, amino sugars. Oligosaccarides and Polysaccarides, Cellulose technology. Amino acids, Proteins, Natural amino acids: Properties, Synthesis and Reactions, Synthesis of Peptides, Protein classification. Lipids, Classification, Waxes, Oils and Fats (Glycerides), synthesis and properties of Glycerides, Glycolipids.

CHEM 342: Polymers and Petrochemicals

Classification of polymers, Chemical and Physical properties, General methods for polymer synthesis, Condensation and Addition polymerization, Copolymerization, Polymer technology and application, Degradation and Stabilization of polymers. Petrochemicals from natural gas, Benzene, Toluene and Xylene.

CHEM 344: Organic Reaction Mechanism

Introduction, Thermodynamic and Activation energy. Physical and Chemical Methods to identify a Reaction Mechanism, reaction kinetics, Isotope labeling, intermediate determination, stereochemistry, crossover experiments.
Reactions: Acids and Bases, Nucleophilic Substitution, Elimination Reactions, Electrophilic Addition to a double bond, Nucleophilic Addition to a carbonyl group, Rearrangements and free radicals.

CHEM 345: Organic Preparations

Introduction, Safety, Lab. Equipment, Spectroscopy, IR Identification of Unknown, Preparation of derivatives, Reports
Unknowns 1 – 5 Identification of Mixture components and separation.

CHEM 353: Methods of Electrical Analysis:

Electrochemical cell. Cell potential and Nernst Equation. Calculation of the cell potential. Types of electrodes- reference electrodes and working electrodes. Junction potential. Potentiometry and potentiometric methods. Ion selective electrodes. Electrogravimetric methods. Coulometric methods. Voltammetric methods of analysis. Polarography and stripping voltammetry.
Practical section: Selected experiments covering different electro analytical techniques.

CHEM 421: Organometallic Chemistry

Introduction (definition, classification and stability of organometallic compounds), classification, bonding and synthesis of main group organometallic compounds, organo-transition metal complexes, classification of ligands, EAN rule and its applications, nature of bonding in transition metal complexes, d and p-complexes, metal-carbon bond cleavage reactions, oxidative-addition reactions, applications in homogeneous and heterogeneous catalysis.

CHEM 422: Chemistry of Solid state

Types of solids, external structure of solids, introduction to point group symmetry, internal structure of solids, crystal systems and unit cell, lattice types, lattice plans and directions, basic crystallographic calculations, X-ray diffraction, crystal structure of elements and inorganic compounds, defects in solid, inorganic industries (Steel, cement, glass).

Experiments:

Study of crystal structure using computer programs: Metals and alloys, Inorganic compounds, Molecular compounds.

- Thermal analysis and its applications.
- X-ray diffraction and its applications
- Applications of SEM and TEM
- Identification of solid materials:
  Manuals method, Computer programs method.
- Nano-synthesis and studies of :
  Alloy - MgO and $Mg(OH)_2$ - Perovskite $SrTiO_3$ - $BaTiO_3$ - Spinel $MgAl_2O_4$ - Glass

CHEM 425: Inorganic Reaction Mechanism

Introduction to inorganic reaction mechanisms, soft and hard acids and bases, Neuclophilic substitution reactions at four-coordinate Site, Mechanism of Oxidation-Reduction reactions, Bio-inorganic Chemistry including: Non red-ox metallic enzymes, Oxygen carriers and the weight of oxygen proteins, Proteins of the hemoglobin, Nitrogen fixation and sulfur, iron proteins, Heavy metal ion storage, Metals and non-metals in medicine and biological system.

CHEM 426: Bio – inorganic Chemistry

The alkali metals and alkaline earth cations in biosystems.

1) Non-redox metalloenzymes.
2) Oxygen carriers and oxygen transport proteins, electron transfer and photosynthesis.

3) Heam proteins and copper proteins in redox reactions, vitamin B12.
4) Nitrogen fixation and iron-molybdenum-sulphur proteins.
5) Metal ion transport and storage.
6) Metals and non-metals in biology and medicine
7) Physical measurements.

CHEM 427: Industrial – inorganic Chemistry

1 - Water
- a- Water quality.
- b- Fresh water treatment.
- c- Waste water treatment.
- d- Desalination of sea water.
- e- Water pollution.

2 - Metallurgy
- a- Ore dressing: sorting, magnetic separation, floatation.
- b- Pyrometallurgy: extraction of iron, lead, chromium, tin, antimony, etc.
- . c- Hydrometallurgy: extraction of gold, silver, mercury, etc.
- d- Electrometallurgy: extraction of aluminum and sodium.
- e- Thermite: extraction of vanadium and chromium.

3 - Ultra purification of metals. Electro refining, zone refining, chemicals refining, alloys.
4 - Ceramics: composites. Processing of ceramics, applications of ceramics, superconducting ceramics.
5 - Glass and quartz industry B_2O_3 glass (Pyrex and kimax glass)
6 - Cement industry
7 - Extraction of elements for semiconductors Ultrapure silicon, gallium, phosphorous, arsenic.
8 - Extraction of radioactive elements Ion exchange process, solvent extraction.
9 - Sulfuric acid, Nitric acid, Hydrochloric acid industries.
10- Inorganic fertilizers, Detergent and household cleaning stuff.
Practical: Visits to industrial sites.

CHEM 429: Practical Inorganic Chemistry (2)

The electromagnetic radiation – preparation of samples for I.R. measurements – Preparation of some organometallic compounds and measuring their spectra – titration for non-aqueous solutions – study of the spectra of complexes – study of the kinetics of isomeric transformation of inorganic compounds - study of the electronic structure and electronic spectra - study of U.V. spectra of some compounds and evaluating the absorption coefficient and concentration.

CHEM 430: Electrochemistry

Solid-liquid interfaces, electrochemical potential, electrochemical reactions and Nernst equation, liquid junction potential, electrode kinetics, rate of electrochemical reactions, Bulter-Volmer equation, Tafel equation, diffusion and electrochemical reactions, cyclic voltammetry and mechanism of electrodic reactions.

Practical:

Measurement of electrochemical cell- Application of Nernst Equation- Determination of mean activity coefficient by electrochemical method- Determination of Ksp of a sparingly soluble salt by electrochemical method- Determination of thermodynamic functions by electrochemical method- Difference between galvanic and electrolytic cell- Precipitation of metals as a protection from corrosion- Application of Tafel Equation- Application of Cyclic volatmogram in an electrochemical cell.

CHEM 432: Corrosion

Essential definitions and terminologies. Direct and indirect costs of corrosion. Classifications of corrosion (types of corrosion). Methods of corrosion rate measurements. Thermodynamics and kinetics of corrosion. Factors affecting corrosion. Methods of corrosion control.

Practical: A number of experiments on Corrosion.

CHEM 436: Surface Chemistry and Catalysis

Surface and interfaces: Types of interfaces, Surface free energy, Surface tension.

Solid-Gas interface: Physical adsorption, chemical adsorption, adsorption measurement methods, adsorption isotherms, adsorption applications.

Homogeneous Catalysis: Acid & base catalysis, oxidation-reduction catalysis, chain reaction catalysis, coordination catalysis.

Heterogeneous Catalysis: Solid-Gas heterogeneous catalysis, Solid-Liquid heterogeneous catalysis, main types of catalysts, preparations of heterogeneous catalysis, catalyst characterization.

CHEM 441: Organic Compounds Spectroscopy

Introduction, Structural elucidation by Spectroscopic Methods; Ultraviolet (UV) and Visible, Infrared (IR), ^{1}H and ^{13}C Nuclear Magnetic Resonance and Mass Spectrometry; Applications of these spectroscopic tools.

CHEM 442: Organic Industries

Production and uses of Petroleum and basic Petrochemicals and Inorganic chemicals, Downstream industries, Pioneers in the field of Chemical and Downstream industries in the Kingdom of Saudi Arabia.
Practical: Experiments include Preparation and Characterization of selected petrochemicals and non-petrochemicals.

CHEM 445: Chemistry of Natural Products

Introduction, Secondary metabolites, isolation, separation and structural identification. Isoprenoids: Terpenes, classification, monoterpenes and sesquiterpenes. Steroids: Triterpenoids and Sterols, Cardinolides, Biosynthesis of Terpenoids and Steroids (Acetate Pathway). Alkaloids, Classification, Examples:Pyrrolidines, Piperidenes, Isoquinolines, Quinolines, Indoles and Purines. Biosynthesis of Alkaloids(Amino acid Pathway).Alkaloids, Examples: Flavonoids, Anthraquinones, Coumarins, Xanthones, and Polyketide pathway.

CHEM 447: Advanced Practical Organic Chemistry

Introduction, Safety, Lab. Equipments
Preparation and study of some organic compound, spectroscopy, yield and its percentage
Examples of such Preparations and Reactions:

- Diels Alder Reaction - Oxidation of side chain - Reaction of S_N^1 K S_N^2, E^1 -Nitration of Organic compounds.
- Reduction of Nitorcompounds - Grignard Reaction - Perkin condensation - Friedel-Craffts alkylation -Alder Condensation, -Esterification - Polymerization - Polystyrene - Baekalite.

Isolation and Identification of Natural Products, using TLC and CC in purification of organic compounds.

CHEM 455: Statistical Treatment of Chemical Data

Errors in chemical analysis. Statistical evaluation of analytical data. Expressions of analytical results. Clinical chemistry. Application of analytical chemistry in industry.
Practical: Selected experiments on applied instrumental analysis.

CHEM 457: Environmental Analysis

Atmospheric composition, gaseous pollutants, water pollution, gaseous pollutants control, water pollutants, soil pollutants, medical pollutants, waste treatment and recycling.

Practical section:

Determination of metal (Mg, Cr, K, P, N ….) in plant sample, Hg in urine samples, Pb and Cd in paints…etc.

CHEM 458: Chromatographic Separation Methods

Principles and applications of solvent extraction. Ion exchange chromatography. Paper chromatography. Thin layer chromatography. Column chromatography.

Liquid chromatography. High performance liquid chromatography. Gas liquid chromatography.

Practical: Selected experiments on paper chromatography. Ion exchange chromatography. Column chromatography. High performance liquid chromatography and gas liquid chromatography.

CHEM 460: Green Chemistry

This course focuses on the study of Principles of Green Chemistry (pollution prevention, atom economy, less hazardous chemical synthesis, designing safer chemicals, safer solvents and auxiliaries, design for energy efficiency, use of renewable feedstock, reduce derivatives, catalysis, design for degradation, real-time analysis for pollution prevention, and inherently safer chemistry for accident prevention) Practical Part: 2 hours per week

-Compare a chlorinated cleaning product to a similar “green” product which uses no chlorine.

-Phosphates versus non-phosphate cleaning products.

CHEM 497: Instrumental Chemical Analysis Training

Student gain the ability to operate the scientific instruments common in use and knowing their components. Practical training on instrumental chemical analysis techniques: Spectroscopic techniques, separation techniques, thermal analysis, electrochemical techniques, sorption techniques. Student uses the instruments and knows how to analyze the different chemical samples.

CHEM 499: Research Project

The student undertakes a research project on a specific topic and submits a report at the end of the semester to be subjected to the departmental procedures and evaluated by a committee according to formal defined criteria.