# *HCS Curriculum: Science 6 – 12*
## IB Chemistry, 12th grade
## Hoover City Schools Secondary Curriculum
Science, 2006-07

Course Information:

| | |
|---|---|
| Course Title: | Chemistry 12, IB |
| Grade Level: | 12 |
| Course Description: | This course continues the study of International Baccalaureate Chemistry. Students will finish the study of inorganic chemistry with an authentic assessment of Transition Metal Chemistry and will study basic Organic Chemistry and Spectroscopy. Students will engage in additional laboratory exercises, complete the Group IV Project, prepare their Experimental Portfolio for internal assessment, and review for the IB Exam. |
| State COS Correlate: | None |
| Calendar Type: | Year |
| Pre-requisite: | IB Chem. 12 |
| Co-requisite: | Calculus |
| Textbook Title: | Chemistry: The Central Science (AP Edition) |
| Textbook Publisher: | Prentice Hall |
| Textbook ISBN: | 0-13-193719-7 |
| Textbook Copy Year: | 2006, 10th ed |
| Accountability Standards: | None |
| LEA Curriculum Authors: | Jane Mahon |
| Date of LEA Approval: | Spring 2006 |

**Topical Scope and Sequence**: The unit numbers continue where the IB 11 unit numbers ended.

| Unit # | 1st Nine Weeks |
|---|---|
| 10 | Buffers and Titrations |
| 11 | Electrochemistry |
| 12 | Advanced Periodicity |
| 13 | Transition Metal Chemistry |

| Unit # | 2nd Nine Weeks |
|---|---|
| 14 | Alkanes and Alkenes: Names, properties, reactions, and mechanisms. |
| 15 | Naming of Functional Groups and Isomerism |
| 16 | Reactions of Functional Groups Containing C, H, and O |

| Unit # | 2nd Nine Weeks |
|---|---|
| 14 | Alkanes and Alkenes: Names, properties, reactions, and mechanisms. |
| 17 | Reactions of Benzene and its Derivatives |

| Unit # | 3rd Nine Weeks |
|---|---|
| 18 | Acid Base properties of Organic Molecules and Other Reactions |
| 19 | Analytical Techniques and Principles of Spectroscopy |
| 20 | Study of Visible, Ultraviolet, Infrared Spectroscopy, Nuclear Magnetic Resonance and Chromatography |
| 21 | Group IV Project |

| Unit # | 4th Nine Weeks |
|---|---|
| 22 | Portfolio Prep and Review |

Units and Outcome-Based Objectives:

## Unit 10- Buffers and Titrations

Essential Questions:

- *How are exact concentrations of mixtures of chemical achieved?*
- *How are these concepts applied to everyday life?*

Conceptual Connections:

- Control
- Ratio
- Life

Experimental Activities:

| # | Unit 10 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Is There a Buffer HERE? | 1 | Inquiry |
| 2 | Make Your Own Buffer (ASIM) | 2, 10 | Inquiry |
| 3 | Determination of $K_a$ by Half-titration (ASIM) | 5, 16 | Experiment |
| 4 | NaOH Standardization with KHP (ASIM) | 15 | Experiment |
| 5 | Titration of a Weak Acid with Standardized NaOH to find the Molar Mass and $K_a$ of the Acid | 17 | Experiment |

Outcome-Based Objectives:

| # | Unit 10 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Describe a buffer solution in terms of its composition and behavior. | Mastery | NA | NA |
| 2 | Describe two ways to make a buffer solution. | Mastery | NA | NA |
| 3 | Draw and explain a graph, showing pH against volume of titrant for titrations involving strong acids and bases. | Mastery | NA | NA |
| 4 | Draw and explain the general shapes of graphs showing pH against volume of titrant for titrations any kind of monoprotic acid and any base. | Mastery | NA | NA |
| 5 | State the equations of the reaction of any weak acid or weak base with water, and hence derive the ionization constant. | Mastery | NA | NA |
| 6 | Derive the expression $K_a$ x $K_b$ = $K_w$ and use it to solve problems for a weak conjugate acid/base pair. | Mastery | NA | NA |
| 7 | State and explain the relationship $K_a$ and $pK_a$ and between $K_b$ and $pK_b$. | Mastery | NA | NA |
| 8 | Determine the relative strengths of acid or their conjugate bases from $K_a$ or $pK_a$ values. | Mastery | NA | NA |
| 9 | Apply $K_a$ or $pK_a$ in calculations. | Mastery | NA | NA |
| 10 | Calculate the pH of a specified buffer system. | Mastery | NA | NA |
| 11 | State and explain whether salts form acidic, alkaline or neutral aqueous solutions. | Mastery | NA | NA |
| 12 | Describe qualitatively how an acid-base indicator works. | Mastery | NA | NA |
| 13 | State and explain how the pH range of an acid-base indicator relates to its $pK_a$ value. | Mastery | NA | NA |
| 14 | Determine an appropriate indicator for a titration given the equivalence point of the titration and $K_a$ or $pK_a$ for possible indicators. | Mastery | NA | NA |
| 15 | Standardize a solution of NaOH using KHP and pH meters. | Mastery | NA | NA |
| 16 | Find the $K_a$ of a weak acid by the half-titration method (using NaOH prepared in #15.) | Mastery | NA | NA |
| 17 | Find the molar mass and $K_a$ of an | Mastery | NA | NA |

| # | Unit 10 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | unknown weak acid by titration with the standardized NaOH. | | | |

## Unit 11- Electrochemistry

Essential Questions:

- *How is chemical energy (potential energy) transformed into electrical work?*

Conceptual Connections:

- Change
- Power
- Time

Experimental Activities:

| # | Unit 11 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Zn/Cu Voltaic Cell | 14 -17 | Demo |
| 2 | Making a Chart of Reduction Potentials | 9, 13, 14 | Inquiry |
| 3 | Puddle Electrolysis | 16 - 18 | Experiment |
| 4 | Electrolysis of Aqueous KI Solution: Determination of Faraday's Constant and Avogadro's Number | 19 - 23 | Experiment |

Outcome-Based Objectives:

| # | Unit 11 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Define oxidation and reduction in terms of electron loss and gain. | Mastery | NA | NA |
| 2 | Introduce the concept of the half-equation (half-reaction.) | Mastery | NA | NA |
| 3 | Calculate the oxidation number of an element in a compound. | Mastery | NA | NA |
| 4 | State and explain the relationship between oxidation numbers and the names of compounds. | Mastery | NA | NA |
| 5 | Identify whether an element is oxidized or reduced in simple redox equations, using oxidation numbers. | Mastery | NA | NA |
| 6 | Define the term oxidizing agent (oxidant) and reducing agent (reductant.) | Mastery | NA | NA |

| # | Unit 11 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 7 | Balance redox equations in acid solutions using half-reactions. | Mastery | NA | NA |
| 8 | Examine the properties of common oxidants and reductants. | Mastery | NA | NA |
| 9 | Deduce a reactivity series based upon the chemical behavior of a group of oxidizing agents and reducing agents. | Mastery | NA | NA |
| 10 | Deduce the feasibility of a redox reaction from a given reduction potential series. | Mastery | NA | NA |
| 11 | Describe and explain a how a redox reaction is used to produce electricity in a voltaic cell. | Mastery | NA | NA |
| 12 | Describe the standard hydrogen electrode. | Mastery | NA | NA |
| 13 | Define the term standard electrode potential and explain the measurement of standard electrode potentials to produce an electrochemical series. | Mastery | NA | NA |
| 14 | Define the term cell potential and calculate cell potentials using standard electrode potentials. | Mastery | NA | NA |
| 15 | Predict whether a reaction will be spontaneous using standard electrode potentials. | Mastery | NA | NA |
| 16 | Draw a diagram showing the essential components of an electrolytic cell. | Mastery | NA | NA |
| 17 | Describe how current is conducted in an electrolytic cell. | Mastery | NA | NA |
| 18 | Deduce the products for the electrolysis of a molten salt. | Mastery | NA | NA |
| 19 | Distinguish between the use of a spontaneous redox reaction to produce electricity in a voltaic cell and the use of electricity to carry out a non-spontaneous redox reaction in an electrolytic cell. | Mastery | NA | NA |
| 20 | Describe and explain the use of electrolysis in electroplating Cu. | Mastery | NA | NA |
| 21 | List and explain the factors affecting the products formed in the electrolysis of aqueous solutions. | Mastery | NA | NA |
| 22 | List the factors affecting the amount of | Mastery | NA | NA |

| # | Unit 11 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | product formed during electrolysis. | | | |
| 23 | Determine the relative amounts of the products formed during the electrolysis of an aqueous solution. | Mastery | NA | NA |
| 24 | Know the definition of ampere, the Faraday and the volt, and be able to use these concepts in solving problems about voltaic cells and electrolytic cells | Mastery | NA | NA |

## Unit 12- Advanced Periodicity

Essential Questions:

- *How does the Periodic Table reflect the structure and properties of matter?*

Conceptual Connections:

- Structure
- Bonding
- Organization

Experimental Activities:

| # | Unit 12 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Thermite Reaction | 6 | Demo |
| 2 | Students will design an experiment which demonstrates any of the periodic properties of the elements and compounds we have in the stockroom. | 7 - 10 | Inquiry |

Outcome-Based Objectives:

| # | Unit 12 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Describe the arrangement of elements in the Periodic Table in order of increasing atomic number. | Mastery | NA | NA |
| 2 | Distinguish between the terms group and period. | Mastery | NA | NA |
| 3 | Deduce the relationship between the | Mastery | NA | NA |

| # | Unit 12 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | electron configuration of elements and their position in the Periodic Table. | | | |
| 4 | Describe and explain periodic trends in atomic radii, ionic radii, ionization energy, and electronegativity. | Mastery | NA | NA |
| 5 | Describe and explain the trends in melting points of the alkali metals, halogens and period 3 elements based on attraction between nucleus and electrons and based upon electron repulsions | Mastery | NA | NA |
| 6 | Discuss the change in nature, from metallic to nonmetallic, of the elements across period 3. | Mastery | NA | NA |
| 7 | Describe the similarities in chemical nature of elements in the same group. | Mastery | NA | NA |
| 8 | Explain the physical properties of the chlorides and oxides of the elements in the third period in terms of their bonding and structure. | Mastery | NA | NA |
| 9 | Describe the chemical trends for the chlorides and oxides in terms of acid-base properties and the reactions of the chlorides and oxides with water. | Mastery | NA | NA |
| 10 | Remember that oxides in which the metal has a high oxidation state are covalent and acidic, whereas those in which the metal has a low oxidation state are ionic and basic. | Mastery | NA | NA |

## Unit 13- Transition Metal Chemistry

Essential Questions:

- *Where is the color in the Periodic Table?*

Conceptual Connections:

- Structure
- Charges
- Beauty

Experimental Activities:

| # | Unit 13 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Demo of a reaction of the complex ions of copper: $Cu(H_2O)_4^{+2} + NH_{3(aq)} \rightarrow Cu(NH_3)_{6(aq)}^{+2}$ | 12 | Demo |
| 2 | Adopt a Transition Metal – Student Project with a paper and a presentation/demo (Authentic Assessment) | 6-12, 15 | Inquiry |

Outcome-Based Objectives:

| # | Unit 13 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | List the characteristics properties of transition (d block) elements. | Mastery | NA | NA |
| 2 | Identify which elements are considered to be typical d-block elements. | Mastery | NA | NA |
| 3 | Identify which elements are considered to be atypical d-block elements. | Mastery | NA | NA |
| 4 | Describe the existence and reason for variable oxidation states in the d-block elements. | Mastery | NA | NA |
| 5 | Define the term ligand and give several examples. | Mastery | NA | NA |
| 6 | Be able to name complex ions and coordination compounds from their formulas. | Mastery | NA | NA |
| 7 | Be able to write the formulas and draw the structural formulas of complex ions and coordination compounds from their names. | Mastery | NA | NA |
| 8 | Describe the Valence Bond Model for complex ions and coordination compounds. | Mastery | NA | NA |
| 9 | Discuss the limitations of the Valence Bond Theory. | Mastery | NA | NA |
| 10 | Describe the Crystal Field Model (Ligand Field Theory) for complex ions and coordination compounds. | Mastery | NA | NA |
| 11 | Be able to calculate the crystal field splitting for a specific ion or compound. | Mastery | NA | NA |
| 12 | Know that the factors that affect the color of a transition metal complex ion are the identity of the metal and its oxidation number. Be able to explain octahedral complexes in aqueous | Mastery | NA | NA |

| # | Unit 13 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | solution. | | | |
| 13 | Describe the effect of different ligands on the splitting of the d orbitals in transition metal complexes. Know specifically the differences between $NH_3$, $H_2O$ and $Cl^{1-}$. | Mastery | NA | NA |
| 12 | Be able to use the Spec 20 to find the maximum absorbance of a colored complex ion or coordination compound, and from this measurement calculate the amount of energy released to form the color. | Mastery | NA | NA |
| 13 | Explain the difference between a homogeneous catalyst and a heterogeneous catalyst and give a specific example of each. | Mastery | NA | NA |
| 14 | Outline the catalytic behavior of d-block elements and their compounds: $MnO_2$ in the decomposition of $H_2O_2$, $V_2O_5$ in the Contact process, Fe in the Haber process, and Ni in the conversion of alkenes to alkanes. Mechanisms are not required. | Mastery | NA | NA |
| 15 | Complete an authentic assessment by completing a laboratory project called "Adopt a Transition Metal." Complete details are included in a separate handout. | Mastery | NA | NA |

## Unit 14- Alkanes and Alkenes: Names, Properties, Reactions, and Mechanisms

Essential Questions:

- *Why is life carbon based?*
- *Why is carbon the only element on the periodic table that can form chains and rings?*

Conceptual Connections:

- Change
- Speed
- Symmetry
- Beauty

Experimental Activities:

| # | Unit 14 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Model Making | 3 | Experiment |
| 2 | Relative Volatility of Alkanes | 2 | Inquiry |
| | NEW Blue Bottle Demo | 20 | Demo |
| 3 | Relative Rates of Nucleophilic Substitution Reactions | 20 | Experiment |
| 4 | Reaction to Produce and Verify the Presence of Alkenes | 7 | Experiment |

Outcome-Based Objectives:

| # | Unit 14 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Describe the features of a homologous series. | Mastery | NA | NA |
| 2 | Predict and explain the trends in boiling points of members of a homologous series. | Mastery | NA | NA |
| 3 | Draw and state the name of any alkane or alkene with up to 12 carbon atoms in the structure. | Mastery | NA | NA |
| 4 | Explain the relative inertness of alkanes in terms of the inertness of C-H and C-C bonds. | Mastery | NA | NA |
| 5 | Describe complete and incomplete combustion of hydrocarbons. | Mastery | NA | NA |
| 6 | Know that the combustion of hydrocarbons is exothermic. | Mastery | NA | NA |
| 7 | Outline the reaction of symmetrical alkenes with hydrogen, bromine, hydrogen halides and water. | Mastery | NA | NA |
| 8 | Describe and explain the electrophilic addition reactions of symmetrical alkenes. | Mastery | NA | NA |
| 9 | Write a stepwise mechanistic approach with such reacting species as halogens, mixed halogens, and hydrogen halides. | Mastery | NA | NA |
| 10 | Apply Markovnikov's rule to predict the outcome of electrophilic addition reactions of asymmetrical alkenes. | Mastery | NA | NA |
| 11 | State that alkanes can react with | Mastery | NA | NA |

| # | Unit 14 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | halogens and distinguish between homolytic and heterolytic fission. | | | |
| 12 | Describe and explain the structure of benzene using chemical and physical evidence. Explain its special stability. | Mastery | NA | NA |
| 13 | Write the free radical substitution reactions and mechanism which occur in the gas phase between alkanes and methylbenzene. | Mastery | NA | NA |
| 14 | Describe how the gas phase reactions of chloroalkanes affect the level of ozone in the upper atmosphere. | Mastery | NA | NA |
| 15 | Distinguish between primary, secondary, and tertiary halogenoalkanes. | Mastery | NA | NA |
| 16 | Describe and explain the $S_N1$ mechanism in nucleophilic substitution. | Mastery | NA | NA |
| 17 | Describe and explain the $S_N2$ mechanism in nucleophilic substitution. | Mastery | NA | NA |
| 18 | Write a stepwise mechanism knowing that some examples of nucleophiles are –CN, -OH, and $NH_3$. | Mastery | NA | NA |
| 19 | Describe and explain the moleculaity for the $S_N1$ and $S_N2$ mechanisms | Mastery | NA | NA |
| 20 | Describe how the rate of nucleophilic substitution in halogenoalkanes depends on both the identity of the halogen and whether the halogenoalkane is primary, secondary or tertiary. | Mastery | NA | NA |
| 21 | Outline how the relative rate of nucleophilic substitution is affected by different nucleophiles. | Mastery | NA | NA |
| 22 | Describe and explain inductive and steric effects of substituents on substitution reactions. | Mastery | NA | NA |
| 23 | Outline the polymerization of alkenes. | Mastery | NA | NA |

## Unit 15-Naming of Functional Groups and Isomerism

Essential Questions:

- *Why are there so many organic compounds?*

Conceptual Connections:

- Change
- Symmetry

- Asymmetry
- Charges

Experimental Activities:

| # | Unit 15 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Model Making | 1,4,5,6,7,10,13 | Experiment |
| 2 | Are there differences in the reactions or reaction rates of enantiomers if all other conditions are held constant? | 8,9,10 | Inquiry |

Outcome-Based Objectives:

| # | Unit 15 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Draw and state the names of compounds containing up to 10 carbon atoms with one of the following functional groups: aldehyde, ketone, carboxylic acid, alcohol, amide, amine, ester, halogenoalkane, ether, and amino acids. | Mastery | NA | NA |
| 2 | Discuss the volatility, solubility in water and acid-base behavior of the functional groups: aldehyde, ketone, carboxylic acid, alcohol, amide, amine, ester, halogenoalkane, ether and amino acids. | Mastery | NA | NA |
| 3 | Explain that functional groups can exist as isomers. | Mastery | NA | NA |
| 4 | Draw functional group isomers from molecular formulas. | Mastery | NA | NA |
| 5 | Draw structural isomers (hydrocarbon chain isomers) for alkanes and alkenes. | Mastery | NA | NA |
| 6 | Draw positional isomers for compounds that contain a functional group. | Mastery | NA | NA |
| 7 | Draw geometric isomers for alkenes. | Mastery | NA | NA |
| 8 | Outline the existence of optical isomers (enantiomers.). | Mastery | NA | NA |
| 9 | Locate the chiral carbon in optical isomers | Mastery | NA | NA |
| 10 | Draw mirror images of optical isomers. | Mastery | NA | NA |
| 11 | Describe and explain geometrical isomerism (cis-, trans-) in non-cyclic alkenes. | Mastery | NA | |
| 12 | Explain the difference in physical and chemical properties of geometrical | Mastery | NA | NA |

| # | Unit 15 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | isomers. | | | |
| 13 | Describe geometrical isomerism in $C_3$ and $C_4$ cyclo-alkanes. | Mastery | NA | NA |
| 14 | Define plane-polarized light and describe how it interacts with enantiomers (optical isomers.) | Mastery | NA | NA |
| 15 | Define the term racemic mixture. | Mastery | NA | NA |
| 16 | Compare the physical and chemical properties of enantiomers. | Mastery | NA | NA |

## Unit 16- Reactions of the Functional Groups Containing C, H, and O

Essential Questions:

- *How are increasingly larger molecules prepared?*
- *How are molecules with different properties made from the most common or available compounds*

Conceptual Connections:

- Size
- Versatility
- Beauty

Experimental Activities:

| # | Unit 16 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Preparation and Purification of Aspirin | 1, 2 | Experiment |
| 2 | Preparation of Esters | 1,2 | Inquiry |
| 3 | Preparation of Nylon | 13 | Demo |

Outcome-Based Objectives:

| # | Unit 16 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Outline the condensation reaction of an alcohol with a carboxylic acid to form an ester. | Mastery | NA | NA |
| 2 | State the uses of esters. | Mastery | NA | NA |
| 3 | Prepare a variety of esters in the lab. | Mastery | NA | NA |
| 4 | Describe a natural way in which ethanol can be produced. | Mastery | NA | NA |

| # | Unit 16 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 5 | Describe the production of ethanol for industrial purposes. | Mastery | NA | NA |
| 6 | Describe the partial oxidation of an alcohol to an aldehyde. | Mastery | NA | NA |
| 7 | Describe the complete oxidation of an alcohol to a carboxylic acid. | Mastery | NA | NA |
| 8 | Describe the dehydration reaction of alcohols to form alkenes. | Mastery | NA | NA |
| 9 | Show the stepwise mechanism for the elimination of water from alcohols. | Mastery | NA | NA |
| 10 | Know the reaction conditions for formation of a symmetrical ether from an alcohol. | Mastery | NA | NA |
| 11 | Show the step-wise mechanism for the elimination of HBr from bromoalkanes to form an alkene. | Mastery | NA | NA |
| 12 | Know the reaction conditions for formation of an alcohol from a halogenoalkane. | Mastery | NA | NA |
| 13 | Deduce the condensation polymers formed by amines reacting with carboxylic acids. | Introduction | NA | NA |
| 14 | Outline the formation of peptides and proteins from 2-amino acids. | Introduction | NA | NA |

## Unit 17- Reactions of Benzene and its Derivatives

Essential Questions:

- *Why are these compounds referred to as aromatic?*

Conceptual Connections:

- Continuity
- Stability
- Functionality

Experimental Activities:

| # | Unit 17 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Vial Organic Chemistry - Dyes | 1 - 4 | Experiment |
| 2 | Making models of the directing power of | 7 - 10 | Experiment |

| # | Unit 17 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| | substituents on the benzene ring. | | |

Outcome-Based Objectives:

| # | Unit 17 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Describe and explain the structure of benzene using chemical and physical evidence. | Mastery | NA | NA |
| 2 | Discuss the stability of the benzene ring in comparison to that of cyclohexane or cyclohexene. | Mastery | NA | NA |
| 3 | Discuss the stability of the benzene ring in relationship to the types of reactions it undergoes as compared to compounds like alcohols. | Mastery | NA | NA |
| 4 | Give a stepwise mechanism for the nitration of benzene. This mechanism must include the reaction between nitric acid and sulfuric acid. | Mastery | NA | NA |
| 5 | Give a stepwise mechanism for the chlorination of benzene. This mechanism must show the formation of $Cl^+$ and the formation of the catalyst in the last step of the mechanism. | Mastery | NA | NA |
| 6 | Give a stepwise mechanism for the alkylation of benzene and methylbenzene in the presence of a halogen carrier. | Mastery | NA | NA |
| 7 | Describe and explain the directing effects and relative rates of reaction of different substituents on a benzene ring. | Mastery | NA | NA |
| 8 | Know that the substituents that make a molecule more reactive than benzene are $–CH_3$ and –OH. These substituents cause increased substitution on the $2^{nd}$ and $4^{th}$ carbon of the benzene ring. | Introduction | NA | NA |
| 9 | Know that –Cl makes the benzene ring less reactive and causes substitution on the $2^{nd}$ and $4^{th}$ carbon of the benzene ring. | Introduction | NA | NA |
| 10 | Know that $–NO_2$ and $–CO_2CH_3$ (or other esters) make the benzene ring less | Introduction | NA | NA |

| # | Unit 17 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | reactive and cause substitution to occur only on the 3rd carbon of the benzene ring. | | | |
| 11 | Describe and explain the relative rates of hydrolysis of halogenated benzene compounds compared to a halogenoalkane. | Introduction | NA | NA |

## Unit 18- Acid Base Properties of Organic Molecules and Other Reactions

Essential Questions:

- *How are organic acids and bases different from inorganic acids and bases?*

Conceptual Connections:

- Concentration
- Variety

Experimental Activities:

| # | Unit 18 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Student designed experiment to convert an alcohol to a carboxylic acid. | 1 and 2 | Inquiry |
| 2 | Arrange a group of organic compounds from the most acidic to the least acidic. | 3 - 5 | Inquiry |

Outcome-Based Objectives:

| # | Unit 18 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Describe and explain the acidic properties of phenol (benzene with an –OH attached) and substituted phenols in terms of bonding (delocalization of charge and polarity of molecules.) | Mastery | NA | NA |
| 2 | Describe and explain the acidic properties of substituted carboxylic acids in terms of bonding. | Mastery | NA | NA |
| 3 | Place acids in ascending or descending | Mastery | NA | NA |

| # | Unit 18 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | order of strength based on bonding principles, $K_a$ values, or $pK_a$ values. | | | |
| 4 | Describe acid properties in terms of the stability of the conjugate base. | Mastery | NA | NA |
| 5 | Compare and explain the relative basicities of ammonia, amines, and amides. | Mastery | NA | NA |
| 6 | Use bonding principles such as delocalization of charge to place bases in order from with most basic to least basic or vice versa. | Mastery | NA | NA |
| 7 | Use pH, $K_b$, or $pK_b$ to place bases in order. Keep in mind that when ammonia or an amine reacts with water an acid and $OH^{1-}$ are formed. Salts of these weak acids are basic, and the amine can be reformed by reaction with a strong base like NaOH. | Mastery | NA | NA |
| 8 | $-CH_3$ is an electron donating group so it tends to stabilize the O-H bond in acids; -Cl is an electron withdrawing group so it tends to weaken the O-H bond in acids, thus making them stronger acids. The reverse is true for bases. | Mastery | NA | NA |
| 9 | **(Nucleophilic Addition Reactions)** Describe and explain the mechanism for the addition of HCN to aldehydes and ketones, followed by hydrolysis to give carboxylic acids. | Mastery | NA | NA |
| 10 | **(Nucleophilic Addition-Elimination Reactions)** Describe and explain the reactions of 2, 4-dinitrophenylhydrazine with aldehydes and ketones. (No mechanism is required.) | Mastery | NA | NA |
| 11 | Be able to write simple syntheses starting with a given compound and using two or more reagents to prepare a new compound. (See #22 on p. 410, G& D.) | Mastery | NA | NA |

## Unit 19-Analytical Techniques and Principles of Spectroscopy

Essential Questions:

- *What is inside those little black boxes?*

Conceptual Connections:

- Mystery
- Light
- Structure

Experimental Activities:

| # | Unit 19 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Find the concentration of $Fe^{2+}$ in an unknown | 1,2 | Inquiry |
| 2 | View an animation of how a double beam spectrometer operates | 10 | Demo |

Outcome-Based Objectives:

| # | Unit 19 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | State the reason for using analytical techniques: structure determination, analysis of composition, determination of purity. | Mastery | NA | NA |
| 2 | Outline the information that can be obtained from analytical techniques, singly or on combination. | Mastery | NA | NA |
| 3 | Know that visible and ultraviolet spectroscopy can be use for assaying of metal ions, organic structure determination and detections of drug metabolites. | Mastery | NA | NA |
| 4 | Know that infrared (ir) spectroscopy can be used in the determination of organic structures, information on strengths of bonds, in the determination of the secondary structure of proteins, and measuring degree of unsaturation of oils and fats. | Mastery | NA | NA |
| 5 | Know that mass spectrometry can be used to determine organic structure, determine isotopic abundance in a naturally occurring element, and isotopic or carbon-14 dating. | Mastery | NA | NA |
| 6 | Know that gas chromatography and mass spectrometry are used in drug and food testing and in forensic science. | Mastery | NA | NA |
| 7 | Describe the electromagnetic spectrum. | Mastery | NA | NA |

| # | Unit 19 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | Be able to identify x-ray, uv, visible, ir and radio (including microwave) should be identified. Be able to explain the difference in wavelength, frequency, and energy across the spectrum. | | | |
| 8 | Distinguish between absorption and emission spectra and how each is produced. | Mastery | NA | NA |
| 9 | Describe the atomic and molecular processes in which absorption of energy takes place, for example vibrations, rotations and electronic transitions. | Mastery | NA | NA |
| 10 | Describe the operating principles of a double-beam infrared spectrometer. Be able to draw a simple double beam spectrometer, even though modern spectrometers process signals by Fourier transformation. | Mastery | NA | NA |

## Unit 20-Study of Visible, Ultraviolet, Infrared, Nuclear Magnetic Resonance, Mass Spectroscopy and Chromatography

Essential Questions:

- *How do the black boxes yield data?*

Conceptual Connections:

- Mystery
- Light
- Structure

Experimental Activities:

| # | Unit 20 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Determination of Structure of Organic Molecules using an IR Spectrophotometer | 6 - 9 | Inquiry |
| 2 | View an animation of how the FTIR produces a spectrum and how one analyses it | 6 - 9 | Demo |

Outcome-Based Objectives:

| # | Unit 2O Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Know that organic molecules containing | Mastery | NA | NA |

| # | Unit 2O Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | a double bond absorb ultraviolet radiation. | | | |
| 2 | Describe the effect of the conjugation of double bonds in organic molecules on the wavelength of absorbed light as in retinol and phenolphthalein. | Mastery | NA | NA |
| 3 | Predict whether or not a particular molecule will absorb ultraviolet or visible light. | Mastery | NA | NA |
| 4 | State the Beer-Lambert Law. | Mastery | NA | NA |
| 5 | Construct a calibration curve and use the Beer-Lambert law to determine the concentration of an unknown solution. See Unit 20, Investigation 1. | Mastery | NA | NA |
| 6 | Describe what occurs at a molecular level during the absorption of infrared radiation by molecules. | Mastery | NA | NA |
| 7 | Know that the polarity of the molecule MUST change in order to absorb infrared radiation. | Mastery | NA | NA |
| 8 | State that the relationship between wavenumber and wavelength is inverse. High wavenumber means high energy. | Mastery | NA | NA |
| 9 | Deduce the functional groups in an organic molecule from its infrared spectrum. The following functional groups MUST be recognized: alcohol, carboxylic acid, ketone, aldehyde, alkene, and alkyne. | Mastery | NA | NA |
| 10 | Know that atoms with an odd mass number can be detected by NMR spectroscopy. Emphasis is on $^{1}H$. | Mastery | NA | NA |
| 11 | Analyze simple NMR spectra including: number of peaks, chemical shift, area under each peak, splitting pattern such as doublet, triplet, and quartet. The environment of a H can change its chemical shift. | Mastery | NA | NA |
| 12 | Outline how NMR is used in body scanners. (Water in the body gives 3-d pictures of organs and other structures.) | Mastery | NA | NA |
| 13 | Discuss how the molecular mass and molecular formula of a compound may be obtained from the molecular ion | Mastery | NA | NA |

| # | Unit 2O Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| | peak. | | | |
| 14 | Analyze molecular mass spectra. Isotopes can be identified, too. For example $^{13}C$ is $(M+1)^+$; chlorine is $(M+2)^+$; bromine is $(M+4)^+$. Other peaks which help interpret the mass spectrum are $(M_r - 15)^+$ loss of $CH_3$; $(M_r - 29)^+$ loss of $C_2H_5$ or CHO; $(M_r - 31)^+$ loss of $CH_3O$; $(M_r - 45)^+$ loss of COOH. | Mastery | NA | NA |
| 15 | State the reasons for using chromatography. | Mastery | NA | NA |
| 16 | State that all chromatographic techniques require a stationary phase and a mobile phase. | Mastery | NA | NA |
| 17 | Explain how the phenomena of adsorption and partition can be used in chromatographic techniques. | Mastery | NA | NA |
| 18 | Outline the use of paper chromatography, thin-layer chromatography (TLC), gas-liquid chromatography (GLC) and high performance liquid chromatography (HPLC). | Mastery | NA | NA |
| 19 | Deduce which chromatographic technique is most appropriate in a particular mixture. | Mastery | NA | NA |

## Unit 21- End of Year Essentials

Essential Questions:

- *Do we have to do all of this to receive an IB diploma?*

Conceptual Connections:

- Hard work
- Time
- Conclusion

Experimental Activities:

| # | Unit 21 Investigations | Unit Obj Correlation | Type (Dem, Exp, Inq) |
|---|---|---|---|
| 1 | Group IV Project | IB Syllabus | Inquiry |

Outcome-Based Objectives:

| # | Unit 21 Objectives | Mastery Level (Int, Rev, Mas) | COS Alignment | Accountability Alignment |
|---|---|---|---|---|
| 1 | Perform and write a complete Lab Report for the Group IV Project. | Mastery | NA | NA |
| 2 | Prepare Laboratory Portfolios for Internal Assessment. | Mastery | NA | NA |
| 3 | Review for the IB Exam | Mastery | NA | NA |

## Alabama Course of Study Correlation: **Science**

| COS Title | Not applicable | Bulletin 2005, No. 20 |
|---|---|---|
| # | COS Objectives | HCS Unit-Objective |
| | Note: *This locally developed elective course is part of a continuum of courses offered within the International Baccalaureate Programme.* | |

## EXPLORE / PLAN / ACT Standards for Transition Correlation: **Science**

| Score Range | EPAS Standard | HCS Unit-Objective |
|---|---|---|
| **28 - 32** | Identify or use a complex mathematical relationship that exists between data | 20.4 |
| | Extrapolate from data points in a table or graph | 13.13,21.5 |
| | Compare or combine given text with data from tables, graphs, or diagrams | 20.1, 20.2, 20.9 |
| | Understand complex lab procedures | Inv13.2, Inv 12.4 |
| | Determine the hypothesis for an experiment | 19.1 |
| | Understand moderately complex experimental designs | Inv13.2, Inv 12.4 |
| | Identify an alternate method for testing a hypothesis | Inv 20.1 |
| | Select a complex hypothesis, prediction, or conclusion that is supported by a data set or viewpoint | Group IV Project |
| | Select a set of data or a viewpoint that supports or contradicts a hypothesis, prediction, or conclusion | Group IV Project |
| | Predict the most likely or least likely result based on | Group IV |

| Score Range | EPAS Standard | HCS Unit-Objective |
|---|---|---|
| | a given viewpoint | Project |
| **33 - 36** | Compare or combine data from two complex data sets | Inv 13.2 |
| | Combine new, complex information (data or text) with given information (data or text) | Inv 13.2 |
| | Understand precision and accuracy issues | Inv 13.2 Group IV Project |
| | Predict how modifying an experiment or study (adding a new trial or changing a variable) will affect results | Post-lab discussions of Inv 13.2, 12.4, 20.1 |
| | Identify new information that could be collected from a new experiment or by modifying an existing experiment | Post-lab discussions of Inv 13.2, 12.4, 20.1 |
| | Select a complex hypothesis, prediction, or conclusion that is supported by two or more data sets or viewpoints | Post- lab discussions of Inv 12.4, 13.2, 20.1 |
| | Determine why given information (data or text) supports or contradicts a hypothesis or conclusion | Group IV Project |