APPENDIX: EXAMPLE STUDENT LEARNING OBJECTIVES

This appendix provides examples of student learning objectives that are organized according to Marzano's taxonomy. These learning objectives are a preliminary set that will be extended and revised to match the Pitt General Chemistry curriculum.

Marzano's Learning Taxonomy:

1) *Retrieval* (perform a procedure, produce information on demand, determine if information is accurate, inaccurate or unknown)

2) *Comprehension* (construct symbolic representation of information, identify basic structure of information)

3) *Analysis* (Specifying, Generalizing, Error Analysis, Classify, Matching)

4) *Knowledge Utilization* (Investigate, Experiment, Problem Solve, Decision Making)

Unit 1: Atoms, Molecules, and Compounds

1.1 Atoms

1) Identify the number of protons, neutrons, and electrons in an atom or ion based on the mass number, atomic number, and the overall charge

2) Draw a model or appropriate symbol to accurately represent a particular element, ion, or isotope

3) Convert quantities representing mass, numbers of atoms, or moles of an element

4) Decide the most appropriate way to express the amount of matter based on how the information will be used

1.2 Compounds

1) Identify whether a compound is ionic or molecular based on the type of elements that make up their composition

2) Draw an appropriate microscopic representation depicting both the chemical composition and phase (solid, liquid, gas)

3) Specify the name and symbolic notation representing an ionic or molecular binary compound using an appropriate microscopic or symbolic model

4) Decide what type of microscopic composition should be selected based on a desired observation or application of the material.

1.3 Solutions

1) Identify whether a compound is soluble or not based on the solubility rules

2) Represent a solution both qualitatively through an appropriate microscopic representation and quantitatively in terms of molarity

3) Identify all species present at any point upon the addition of a series of aqueous ions to the same beaker and their concentration in terms of molarity

4) Describe an appropriate procedure to make a solution based on available materials and intended use

Unit 2: Fundamentals of Chemical Reactions and Heats of Reaction

2.1 Reactions

1) Identify appropriate molar quantities based on chemical formulas and reaction equations

2) Represent a balanced chemical reaction symbolically and draw an appropriate microscopic representation illustrating the effect of a limiting reactant

3) Calculate specific quantities representing mass, numbers of atoms, or moles for a chemical reaction

4) Propose the most likely scenario that would generate a particular observation resulting from a chemical reaction

2.2 Bond Energy

1) Define what is meant by enthalpy of atom combination and the terms exothermic and endothermic in terms bond making or breaking processes

2) Draw a reaction energy diagram based on energies of atom combination data and describe how it relates overall energy of reaction

3) Analyze and compare individual molecular bond energies and overall reaction energies based on bond order, bond length or enthalpies atom combination

4) Select the best compound for a reaction based on an assessment of the amount of energy absorbed or released.

2.3 TBD

Unit 3: Origins of Properties in Quantum Mechanics

3.1 Shell Model

1) Identify the key terms of Coulomb's law and describe how it is used to assess the amount of attraction or repulsion between two particles

2) Describe the relationship between potential energy, ionization energy, core charge, and distance. Use these concepts to create an appropriate shell model representation of an atom

3) Analyze and compare properties of elements in terms of their ionization energy based on core charge and number of shells

4) Decide what element best fits the properties described based on experimental data provided and justification according to Coulomb's Law

3.2 Electronic Configuration

1) Define what each specific quantum number is used to represent about an electron in an atom

2) Describe the experimental evidence justifying each of the four quantum numbers and the general region of space an electron would most likely be found (or not) based on this information

3) Appropriately represent and analyze features of the electron configuration or photoelectron spectra of any element

4) Select the best element for an application based on the energy and configuration of its electrons

3.3 TBD

Unit 4: Nature of Chemical Bonding

4.1 Molecular Bonding

1) Define what is meant by electronegativity and how it relates to ionization energies or AVEE trends.

2) Illustrate how to determine the partial charge for one particular atom type in a molecule

3) For a given skeletal structure, draw the "best" Lewis structure based on formal charges and describe any resonance effects on properties such as bond length and bond strength.

4) Propose a particular arrangement of elements that would most likely form a molecule

4.2 Molecular Structure

1) List the different molecular geometries and identify corresponding bond angles & hybridization

2) Describe valence bond theory and why hybrid orbitals are defined for atoms in a molecule

3) Assign molecular geometries, number of pi and sigma bonds, and assess the overall magnitude and direction molecular dipole moments

4) Select the best molecule for an application based on its 3D structure and polarity

4.3 MO Theory & Valence Bond Theory

1) Identify the types of hybrid and unhybridized orbitals associated with a type of bond and bond angle

2) Characterize the region of space electrons occupy in molecules based on either molecular orbital theory or valence bond theory

3) Compare the properties of molecules (e.g., spin, bond order, pi & sigma bonds) using an appropriate bonding theory

4) TBD

Unit 5: Intermolecular interactions

5.1 Ideal Gases

TBD

5.2 Molecular Forces

1) Define and list different types of intermolecular forces that exist between molecules

2) Draw a graph and describe differences in the system due to changes in temperature and intermolecular forces and clearly describe the types of bonds broken

3) Analyze and compare properties of molecules based on the types of intermolecular forces present

4) Select the best molecule for a desired property or application based on intermolecular forces