Chemistry – Part 2

Michigan State Science Content Expectations

Course Description

Course Description

Chemistry Part 2 will continue exploring many chemistry topics in depth. The learner will begin by investigating chemical reaction, stoichiometry, and the states of matter. The learner will then explore the behavior of gases, aqueous systems, and solutions. The learner will then continue onto Thermochemistry, reaction rates and equilibrium. Finally the learner will analyze acid and base theories and oxidation-reduction reactions.

Text Book

Wilbraham, Antony C., Dennis D. Staley, Michael S. Matta, Edward L. Waterman. *Prentice Hall Chemistry,* Upper Saddle River: Prentice Hall, 2005

Unit 1 Description

The learner will describe chemical reactions by recognizing the types of chemical reactions and then predicting the products of a reaction. This unit will also introduce the learner to stoichiometry by having the learner calculate the amount of reactant needed or product formed in a chemical reaction. In addition the unit will explore the nature of the solid state and discuss how atoms of some elements are arranged in more than one way in nature. Finally, the unit will discuss the conditions needed for a substance to be in a particular state of matter.

Essential Content and Skills

The learner will:

- Describe how to write a word equation and a skeleton equation.
- Describe the steps for writing a complete chemical equation.
- Describe the five general types of reactions and predict the products of the five general types of reactions.
- Describe the information found in a net ionic equation.
- Predict the formation of a precipitate in a double-replacement reaction.
- Calculate the amounts of reactants required or product formed in a nonchemical process.
- Interpret balanced chemical equations in terms of interacting moles, representative particles, masses, and gas volume at STP.

- Construct mole ratios from balanced chemical equations and apply these ratios in mole-mole stoichiometric calculations.
- Calculate stoichiometric quantities from balanced chemical equations using units of moles, mass, representative particles, and volumes of gases at STP.
- Identify and use the limiting reagent in a reaction to calculate the maximum amount of product(s) produced and the amount of excess reagent.
- Calculate theoretical yield, actual yield or percent yield given appropriate information.
- Describe the assumptions of the kinetic theory as it applies to gases and interpret gas pressure in terms of kinetic theory.
- Define the relationship between Kelvin temperature and average kinetic energy.
- Evaluate how the way particles are organized and explain the properties of solids.
- Identify the factors that determine the shape of a crystal.
- Explain how allotropes of an element are different.
- Describe how equilibrium conditions are represented in a phase diagram.
- Investigate how chemical reactions are limited by the amount of reactants present.

Unit 1 Michigan State Content Expectations

Click here to view the Michigan DOE Curriculum Content Standards.

Unit 1 Lesson 1: Describing Chemical Reactions

State Standard	Description
C4.2B	Given the name, write the formula of simple binary compounds.
C4.2d	Given the name, write the formula of ionic and molecular compounds.
C5.2A	Balance simple chemical equations applying the conservation of matter.
C5.6b	Predict single replacement reactions.

Unit 1 Lesson 2: Types of Chemical Reactions

State Standard	Description
C2.1b	Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).
C2.2B	Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.
C5.2A	Balance simple chemical equations applying the conservation of matter.
C5.2B	Distinguish between chemical and physical changes in terms of the properties of the reactants and products.

Unit 1 Lesson 3: Reactions in Aqueous Solution

State Standard	Description
C5.3a	Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).
C5.3b	Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).

Unit 1 Lesson 4: The Arithmetic of Equations

State Standard	Description
C5.2A	Balance simple chemical equations applying the conservation of matter.
C5.2B	Distinguish between chemical and physical changes in terms of the properties of the reactants and products.
C5.2d	Calculate the mass of a particular compound formed from the masses of starting materials.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.
C5.2g	Calculate the number of atoms present in a given mass of element.

Unit 1 Lesson 5: Chemical Calculations

State Standard	Description
C4.6a	Calculate the number of moles of any compound or element given the mass of the substance.
C4.6b	Calculate the number of particles of any compound or element given the mass of the substance.
C5.2d	Calculate the mass of a particular compound formed from the masses of starting materials.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.
C5.2g	Calculate the number of atoms present in a given mass of element.

Unit 1 Lesson 6: Limiting Reagent and Percent Yield

State Standard	Description
C4.1a	Calculate the percent by weight of each element in a compound based on the compound formula.
C4.1b	Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.
C5.2e	Identify the limiting reagent when given the masses of more than one reactant.

Unit 1 Lesson 7: Inquiry Activities

State Standard	Description
C5.2A	Balance simple chemical equations applying the conservation of matter.
C5.2B	Distinguish between chemical and physical changes in terms of the properties of the reactants and products.
C5.2C	Draw pictures to distinguish the relationships between atoms in physical and chemical changes.

Unit 1 Lesson 8: The Nature of Gases

State Standard	Description
C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.
C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.
C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.

Unit 1 Lesson 9: The Nature of Liquids

State Standard	Description
C4.3A	Recognize that substances that are solid at room temperature have stronger attractive forces than iquids at room temperature, which have stronger attractive forces than gases at room temperature.
C4.3B	Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.
C4.4a	Explain why at room temperature different compounds can exist in different phases.
C5.3a	Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).

Unit 1 Lesson 10: Nature of Solids and Changes of State

State Standard	Description
C2.2f3.4.12 A	Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.
C3.3A	Describe how heat is conducted in a solid.
C3.3B	Describe melting on a molecular level.
C4.3A	Recognize that substances that are solid at room temperature have stronger attractive forces than iquids at room temperature, which have stronger attractive forces than gases at room temperature.
C4/3B	Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.
C4.3c	Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.
C4/3d	Compare the strength of the forces of attraction between molecules of different elements. (For example, at room temperature, chlorine is a gas and iodine is a solid.)
C4.3e	Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table.
C4.3h	Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.
CC4.3i	Explain why ionic solids have higher melting points than covalent solids. (For example, NaF has a melting point of 995°C, while water has a melting point of 0° C.)

Unit 2 Description

The learner will describe the behavior of gases by demonstrating the relationships among the temperature, pressure, and volume of a gas. This unit also analyzes water and aqueous system by describing water and its properties, homogeneous aqueous systems, and heterogeneous aqueous systems. This unit will also explore how the solution process occurs and the factors that influence the process. The learner will demonstrate how to calculate solution concentrations. Finally the learner will discover how a solute can change the freezing point of a solution.

Essential Content and Skills

The learner will:

- Explain why gases are easier to compress than solids or liquids are.
- Describe the three factors that affect gas pressure.
- Describe the relationships among the temperature, pressure, and volume of a gas.
- Use the combined gas law to solve problems.
- Compute the value of an unknown using the ideal gas law.
- Compare and contrast real and ideal gases.
- Relate the total pressure of a mixture of gases to the partial pressures of the component gases.
- Explain the high surface tension and low vapor pressure of water in terms of the structure of the water molecule and hydrogen bonding.
- Explain that water's unique characteristics result from the structure of the water molecule.
- View an experiment using a Hoffman apparatus and discover that water can be decomposed.
- Distinguish between a solvent and a solute and describe what happens in the solution process.
- Explain why all ionic compounds are electrolytes.
- Demonstrate how the formula for the hydrate is written.
- Distinguish between a suspension and a solution.
- Identify the distinguishing characteristic of a colloid.
- Identify the units usually used to express the solubility of a solute.
- Identify the factors that determine the mass of solute that will dissolve in a given mass of solute.
- Solve problems involving the molarity of a solution.
- Define percent by volume [%(v/v)] and percent by mass [%(m/m)] solutions
- Identify three colligative properties of solutions.
- Describe why the vapor pressure, freezing point, and boiling point of a solution differ from those properties of the pure solvent.
- Describe how the freezing point depression and boiling-point elevation are related to molality.

Unit 2 Michigan State Content Expectations

Unit 2 Lesson 1: Properties of Gases and the Gas Laws

State Standard	Description
C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.
C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.
C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.
C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.

Unit 2 Lesson 2: Ideal Gases

State Standard	Description
C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.
C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.
C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.
C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.

Unit 2 Lesson 3: Gases: Mixtures and Movements

State Standard	Description
C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.
C4.6a	Calculate the number of moles of any compound or element given the mass of the substance.

Unit 2 Lesson 4: Lab

State Standard	Description
C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.
C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.
C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.

Unit 2 Lesson 5: Water and Its Properties

State Standard	Description
C4.7a	Investigate the difference in the boiling point or freezing point of pure water and a salt solution.
C4.7b	Compare the density of pure water to that of a sugar solution.
C5.4c	Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane).
C5.4d	Explain why freezing is an exothermic change of state.

Unit 2 Lesson 6: Homogeneous Aqueous Systems

State Standard	Description
C4.4b	Identify if a molecule is polar or nonpolar given a structural formula for the compound.

Unit 2 Lesson 7: Heterogeneous Aqueous Systems

State Standard	Description
C4.4a	Explain why at room temperature different compounds can exist in different phases.

Unit 2 Lesson 8: Properties of Solutions and Concentrations of Solutions

State Standard	Description
C4.6a	Calculate the number of moles of any compound or element given the mass of the substance.
C4.6b	Calculate the number of particles of any compound or element given the mass of the substance.

Unit 2 Lesson 9: Colligative Properties of Solutions

State Standard	Description
C4.6a	Calculate the number of moles of any compound or element given the mass of the substance.
C4.7a	Investigate the difference in the boiling point or freezing point of pure water and a salt solution.
C4.7b	Compare the density of pure water to that of a sugar solution.

Unit 2 Lesson 10: Calculations involving Colligative Properties

State Standard	Description
C5.4c	Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane).
C5.4d	Explain why freezing is an exothermic change of state.

Unit 3 Description

The learner will demonstrate his knowledge of Thermochemistry by classifying processes as exothermic or endothermic, measuring and expressing enthalpy changes by constructing thermochemical equations, and solve for enthalpy changes in chemical reactions by using heats of reaction. The learner will also describe rates of reaction by identifying four factors that influence the rate of a chemical reaction. In addition the learner will describe reversible reactions and equilibrium by identifying the stresses that can change the equilibrium position of a chemical system.

Essential Content and Skills

The learner will:

- Explain the relationship between energy, heat, and work.
- Distinguish between exothermic and endothermic processes.
- Distinguish between heat capacity and specific heat.
- Construct equations that show the heat changes for chemical and physical processes.
- Calculate heat changes in chemical and physical processes.
- Classify the enthalpy changes that occur during melting, freezing, boiling, and condensing.
- Calculate enthalpy changes that occur during melting, freezing, boiling, and condensing.
- Apply Hess's law of heat summation to find heat changes for chemical and physical processes.
- Calculate heat changes using standard heats of formation.
- Describe how to express the rate of a chemical reaction
- Identify four factors that influence the rate of a chemical reaction.
- Describe how the amounts of reactants and products change in a chemical system at equilibrium.
- Identify three stresses that can change the equilibrium position of a chemical system
- Explain what the value of K_{eq} indicates about the position of equilibrium.
- Describe the relationship between the solubility product constant and the solubility of a compound
- Predict whether precipitation will occur when two salt solutions are mixed.
- Identify two characteristics of spontaneous reactions.
- Describe the role of entropy in chemical reactions.
- Define Gibbs free-energy change.
- Describe the general relationship between the value of the specific rate constant, k, and the speed of a chemical reaction.

Unit 3 Michigan State Content Expectations

Unit 3 Lesson 1: The Flow of Energy-Heat and Work

State Standard	Description
C3.4A	Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.
C3.4B	Explain why chemical reactions will either release or absorb energy.

Unit 3 Lesson 2: Measuring and Expressing Enthalpy Changes

State Standard	Description
C3.4c	Write chemical equations including the heat term as a part of equation or using ΔH notation.
C3.4d	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.

Unit 3 Lesson 3: Heat in Changes of State

State Standard	Description
C3.4A	Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.
C3.4B	Explain why chemical reactions will either release or absorb energy.
C3.4c	Write chemical equations including the heat term as a part of equation or using ΔH notation.
C3.4d	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.

Unit 3 Lesson 4: Calculating Heats of Reaction

State Standard	Description
C3.1a	Calculate the ΔH for a given reaction using Hess's Law.
C3.1d	Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.

Unit 3 Lesson 5: Lab 16: The Specific Heat of a Metal

State Standard	Description
C3.3A	Describe how heat is conducted in a solid.
C3.3B	Describe melting on a molecular level.

Unit 3 Lesson 6: Rates of Reaction

State Standard	Description
C5.r1a	Predict how the rate of a chemical reaction will be influenced by changes in concentration, and temperature, pressure. (recommended)
C5.r1b	Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. (recommended)

Unit 3 Lesson 7: Reversible Reactions and Equilibrium

State Standard	Description
C5.3a	Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).
C5.3b	Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).
C5.3c	Predict the extent reactants are converted to products using the value of the equilibrium constant.

Unit 3 Lesson 8: Solubility Equilibrium

State Standard	Description
C5.3c	Predict the extent reactants are converted to products using the value of the equilibrium constant.

Unit 3 Lesson 9: Entropy and Free Energy

State Standard	Description
C3.4e	Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.)
C3.4f	Explain why some endothermic reactions are spontaneous at room temperature.

Unit 3 Lesson 10: The Progress of Chemical Reactions

State Standard	Description
C5.3c	Predict the extent reactants are converted to products using the value of the equilibrium constant.
C5.r1a	Predict how the rate of a chemical reaction will be influenced by changes in concentration, and temperature, pressure. (recommended)
V5.r1b	Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. (recommended)

Unit 4 Description

In this unit the learner will demonstrate his knowledge of acids, bases, and salts by comparing and contrasting acids and bases as defined by the theories of Arrhenius, Bronsted-Lowry, and Lewis. The learner will also describe the strengths of acids and bases by defining strong acids and weak bases, and neutralization reactions. In addition to acids and bases the learner will describe the characteristics of a redox reaction and identify the oxidizing agent and reducing agent.

Essential Content and Skills

The learner will:

Define the properties of acids and bases.
Compare and contrast acids and bases as defined by the theories of Arrhenius, Bronsted-Lowry, and Lewis.
Classify a solution as neutral, acidic, or basic given the hydrogen-ion or hydroxide –ion concentration**.**
Convert hydrogen-ion concentrations into pH values and hydroxide-ion concentrations into pOH values.
Describe the purpose of an acid-base indicator.
Calculate an acid dissociation constant (Ka) from concentration and pH measurements.
Order acids by strength according to their acid dissociation constants (Ka).
Order bases by strength according to their base dissociation constants (Kb).
Define the products of an acid-base reaction.
Explain how acid-base titration is used to calculate the concentration of an acid or a base.
Explain the concept of equivalence in neutralization reactions.
Describe the relationship between equivalence point and the end point of a titration.
Describe when a solution of a salt is acidic or basic.
Define oxidation and reduction in terms of the loss or gain of oxygen and the loss or gain of electrons.
State the characteristics of a redox reaction and identify the oxidizing agent and reducing agent.
Determine the oxidation number of an atom of any element in a pure substance.
Define oxidation and reduction in terms of a change in oxidation number and identify atoms being oxidized or reduced in redox reactions.
Describe how oxidation numbers are used to identify redox reactions.
Balance a redox equation.
Explain how an unstable nucleus releases energy and describe the three main types of nuclear radiation.

Unit 4 Michigan State Content Expectations

Unit 4 Lesson 1: Acid-Base Theories

State Standard	Description
C5.7A	Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.
C5.7B	Predict products of an acid-base neutralization.
C5.7C	Describe tests that can be used to distinguish an acid from a base.
C5.r7i	Identify the Brønsted-Lowry conjugate acid-base pairs in an equation. (recommended)

Unit 4 Lesson 2: Hydrogen Ions and Acidity

State Standard	Description
C5.7D C5.7g	Classify various solutions as acidic or basic, given their pH. Calculate the pH from the hydronium ion or hydroxide ion concentration.

Unit 4 Lesson 3: Strengths of Acids and Bases

State Standard	Description
C5.7D C5.7g	Classify various solutions as acidic or basic, given their pH. Calculate the pH from the hydronium ion or hydroxide ion concentration.

Unit 4 Lesson 4: Neutralization Reactions

State Standard	Description
C5.7B C5.7f	Predict products of an acid-base neutralization. Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.

Unit 4 Lesson 5: Salts in Solution

State Standard	Description
C5.7D	Classify various solutions as acidic or basic, given their pH.

Unit 4 Lesson 6: Lab 27 Ionization Constants of Weak Acids

State Standard	Description
C5.7A	Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.

Unit 4 Lesson 7: The Meaning of Oxidation and Reduction

State Standard	Description
C5.6a C5.6b C5.6c	Balance half-reactions and describe them as oxidations or reductions. Predict single replacement reactions. Explain oxidation occurring when two different metals are in contact.

Unit 4 Lesson 8: Oxidation Numbers

State Standard	Description
C5.6a	Balance half-reactions and describe them as oxidations or reductions.

Unit 4 Lesson 9: Balancing Redox Reactions

State Standard	Description
C5.6a	Balance half-reactions and describe them as oxidations or reductions.

Unit 4 Lesson 10: Nuclear Radiation

State Standard	Description
C3.5a C2.r5b C2.r5c	Explain why matter is not conserved in nuclear reactions. Describe the potential energy changes as two protons approach each other. (recommended) Describe how and where all the elements on earth were formed. (recommended)