Unit 2 Solutions & Gases - Basic Training Part 2

Content Area:	**Science**
Course(s):	**AP Chemistry**
Time Period:	**September**
Length:	**6 weeks**
Status:	**Published**

Transfer Skills

Review of basic concepts from first year chemistry, solutions, colligative properties, & gases, with additional focus on the depth required for Advanced Placement curriculum and laboratory experiments.

Enduring Understandings

Adding solute to a pure solution will have an effect on the properties

The kinetic molecular theory can conceptually predict, analyze, and explain the properties of gases.

The gas laws can predict, analyze and explain many everyday occurrences involving gases

Essential Questions

How can you quantify the concentration of a solution?

How are Colligative properties useful?

How can we predict the behavior of gases?

To what extent can a gas be classified as ideal?

Content

Root mean square velocity, oxidation, reduction, oxidizing agent, reducing agent, solution, colloid, suspension, saturation, colligative properties, rates of solubility, molarity, molality, mole fraction, Boyle's Law, Charles' Law, Avogadro's Law, Gay-Lussac Law, diffusion, effusion, Dalton's Law Partial Pressure, Van't hoff factor, Raoult's Law

Skills

Determine the formation of a precipitate in a reaction and write the net ionic reaction.

Calculate concentration using Molarity, molality, mole fraction and mass %

Perform calculations relating freezing point depression and boiling point elevation.

Relate the Kinetic molecular theory to pressure, temperature and volume relationships and effusion properties of an ideal gas.

Use Gas Laws to calculate unknown gas variables.

Resources

Standards

Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.
Essential knowledge 1.A.2: Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity.
c. Because pure compounds have a specific mass percent of each element, experimental measurements of mass percents can be used to verify the purity of compounds.

1.A.2 Learning Objectives:
LO 1.2 The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. [See SP 2.2]

Essential knowledge 1.A.3: The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.
a. Atoms and molecules interact with one another on the atomic level. Balanced chemical equations give the number of particles that react and the number of particles produced. Because of this, expressing the amount of a substance in terms of the number of particles, or moles of particles, is essential to understanding chemical processes.

d. Thus, for any sample of a pure substance, there is a specific numerical relationship between the molar mass of the substance, the mass of the sample, and the number of particles (or units) present.

1.A.3 Learning Objective:
LO 1.4 The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. [See SP 7.1]

Essential knowledge 1.D.3: The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration.
c. The amount of light absorbed by a solution can be used to determine the concentration of the absorbing molecules in that solution, via the Beer-Lambert Law.

1.D.3 Learning Objectives:
LO 1.15 The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [See SP 4.1]

LO 1.16 The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [See SP 4.2, 5.1]

Enduring understanding 1.E: Atoms are conserved in physical and chemical processes. Essential knowledge 1.E.1: Physical and chemical processes can be depicted symbolically; when this is done, the illustration must conserve all atoms of all types.
a. Various types of representations can be used to show that matter is conserved during chemical and physical processes. 1. Symbolic representations 2. Particulate drawings

b. Because atoms must be conserved during a chemical process, it is possible to calculate product masses given known reactant masses, or to calculate reactant masses given product masses.

c. The concept of conservation of atoms plays an important role in the interpretation and analysis of many chemical processes on the macroscopic scale. Conservation of atoms should be related to how nonradioactive atoms are neither lost nor gained as they cycle among land, water, atmosphere, and living organisms.

1.E.1 Learning Objective:
LO 1.17 The student is able to express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings. [See SP 1.5]

Essential knowledge 1.E.2: Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.
c. The coefficients in a balanced chemical equation represent the relative numbers of particles that are consumed and created when the process occurs.

d. The concept of conservation of atoms plays an important role in the interpretation and analysis of many chemical processes on the macroscopic scale.

f. Titrations may be used to determine the concentration of an analyte in a solution. The titrant has a known concentration of a species that reacts specifically with the analyte. The equivalence of the titration occurs when the analyte is totally consumed by the reacting species in the titrant. The equivalence point is often indicated by a change in a property (such as color) that occurs when the equivalence point is reached. This observable event is called the end point of the titration.

1.E.2 Learning Objectives:
LO 1.18 The student is able to apply conservation of atoms to the rearrangement of atoms in various processes. [See SP 1.4]

LO 1.20 The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1]

Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.
Enduring understanding 2.A:
a. Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of

attraction among them.

2.A Learning Objectives:
LO 2.1 Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views. [See SP 6.4, 7.1]

Essential knowledge 2.A.2: The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently.
a. Ideal gases exhibit specific mathematical relationships among the number of particles present, the temperature, the pressure, and the volume.

b. In a mixture of ideal gases, the pressure exerted by each component (the partial pressure) is independent of the other components. Therefore, the total pressure is the sum of the partial pressures.

c. Graphical representations of the relationships between P, V, and T are useful to describe gas behavior.

d. Kinetic molecular theory combined with a qualitative use of the Maxwell-Boltzmann distribution provides a robust model for qualitative explanations of these mathematical relationships.

e. Some real gases exhibit ideal or near-ideal behavior under typical laboratory conditions. Laboratory data can be used to generate or investigate the relationships in 2.A.2.a and to estimate absolute zero on the Celsius scale.

f. All real gases are observed to deviate from ideal behavior, particularly under conditions that are close to those resulting in condensation. Except at extremely high pressures that are not typically seen in the laboratory, deviations from ideal behavior are the result of intermolecular attractions among gas molecules. These forces are strongly distance-dependent, so they are most significant during collisions.

g. Observed deviations from ideal gas behavior can be explained through an understanding of the structure of atoms and molecules and their intermolecular interactions.

2.A.2 Learning Objectives:
LO 2.4 The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors. [See SP 1.4, 6.4]

LO 2.5 The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [See SP 1.3, 6.4, 7.2]

LO 2.6 The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. [See SP 2.2, 2.3]

Essential knowledge 2.A.3: Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.
a. In a solution (homogeneous mixture), the macroscopic properties do not vary throughout the sample. This is in contrast to a heterogeneous mixture in which the macroscopic properties depend upon the location in the mixture. The distinction between heterogeneous and homogeneous depends on the length scale of interest. As an example, colloids may be heterogeneous on the scale of micrometers, but homogeneous on the scale of centimeters.

b. Solutions come in the form of solids, liquids, and gases.

c. For liquid solutions, the solute may be a gas, a liquid, or a solid.

d. Based on the reflections of their structure on the microscopic scale, liquid solutions exhibit several general properties: 1. The components cannot be separated by using filter paper. 2. There are no components large enough to scatter visible light. 3. The components can be separated using processes that are a result of the intermolecular interactions between and among the components.

f. Distillation is used to separate chemical species by taking advantage of the differential strength of intermolecular interactions between and among the components and the effects these interactions have on the vapor pressures of the components in the mixture.

h. Generally, when ionic compounds are dissolved in water, the component ions are separated and dispersed. The presence of ions in a solution can be detected by use of conductivity measurements.

i. Solution composition can be expressed in a variety of ways; molarity is the most common method used in the laboratory. Molarity is defined as the number of moles of solute per liter of solution.

j. Understanding how to prepare solutions of specified molarity through direct mixing of the components, through use of volumetric glassware, and by dilution of a solution of known molarity with additional solvent is important for performing laboratory work in chemistry.

2.A.3 Learning Objectives:
LO 2.8 The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent. [See SP 1.1, 1.2, 6.4]

LO 2.9 The student is able to create or interpret representations that link the concept of molarity with particle views of solutions. [See SP 1.1, 1.4]

LO 2.10 The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [See SP 4.2, 5.1]

2.B.2 Learning Objectives:
LO 2.12 The student can qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions. [See SP 5.1, 6.5, connects to 2.A.2]

Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
3.A Learning Objective:
LO 3.1 Students can translate among macroscopic observations of change, chemical equations, and particle views. [See SP 1.5, 7.1]

Enduring understanding 3.A: Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. Essential knowledge 3.A.1: A chemical change may be represented by a molecular, ionic, or net ionic equation.
a. Chemical equations represent chemical changes, and therefore must contain equal numbers of atoms of every element on each side to be “balanced.”

b. Depending on the context in which it is used, there are different forms of the balanced chemical equations that are used by chemists. It is important not only to write a balanced molecular, ionic, or net ionic reaction equation, but also to have an understanding of the circumstances under which any of them might be the most useful form.

c. The balanced chemical equation for a reaction is capable of representing chemistry at any level, and thus it is important that it can be translated into a symbolic depiction at the particulate level, where much of the reasoning of chemistry occurs.

d. Because chemistry is ultimately an experimental science, it is important that students be able to describe chemical reactions observed in a variety of laboratory contexts.

3.A.1 Learning Objective:
LO 3.2 The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. [See SP 1.5, 7.1]

Essential knowledge 3.A.2: Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.
a. Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations that apply the mole concept; the most important place for this type of quantitative exercise is the laboratory. 1. Calculate amount of product expected to be produced in a laboratory experiment. 2. Identify limiting and excess reactant; calculate percent and theoretical yield for a given laboratory experiment.

b. The use of stoichiometry with gases also has the potential for laboratory experimentation, particularly with respect to the experimental determination of molar mass of a gas.

c. Solution chemistry provides an additional avenue for laboratory calculations of stoichiometry, including titrations.

3.A.2 Learning Objectives:
LO 3.3 The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. [See SP 2.2, 5.1]

LO 3.4 The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. [See SP 2.2, 5.1, 6.4]

Essential knowledge 3.B.3: In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.
a. In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced.

b. Oxidation numbers may be assigned to each of the atoms in the reactant and products; this is often an effective way to identify the oxidized and reduced species in a redox reaction.

c. Balanced chemical equations for redox reactions can be constructed from tabulated half-reactions.

d. Recognizing that a reaction is a redox reaction is an important skill; an apt application of this type of reaction is a laboratory exercise where students perform redox titrations.

3.B.3 Learning Objectives:
LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer. [See SP 6.1]

Enduring understanding 3.C: Chemical and physical transformations may be observed in several ways and typically involve a change in energy. Essential knowledge 3.C.1: Production of heat or light, formation of a

gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred.
a. Laboratory observations are made at the macroscopic level, so students must be able to characterize changes in matter using visual clues and then make representations or written descriptions.

b. Distinguishing the difference between chemical and physical changes at the macroscopic level is a challenge; therefore, the ability to investigate chemical properties is important.

c. In order to develop the ability to distinguish experimentally between chemical and physical changes, students must make observations and collect data from a variety of reactions and physical changes within the laboratory setting.

d. Classification of reactions provides important organizational clarity for chemistry; therefore, students need to identify precipitation, acid-base, and redox reactions.

3.C.1 Learning Objective:
LO 3.10 The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions. [See SP 1.4, 6.1, connects to 5.D.2]