Unit 6 Electrochemistry & Nuclear/Organic - Get Charged Up

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

Transfer Skills

Get Charged Up: Electrochemistry & Nuclear/Organic: The transfer of electrons during chemical reactions requires or produces electricity that has commercial and everyday applications

Enduring Understandings

There are beneficial and practical uses for radioisotopes.

Hydrocarbons with the same molecular formula but different molecular structures have different properties.

The addition of functional groups to carbon chains affects the intermolecular forces present and the properties of molecules.

Many chemical changes involve the transfer of electrons.

Essential Questions

What happens when an unstable nucleus decays?

Why are carbon based molecules versatile as chemical building blocks?

How will the addition of a functional group affect a molecule?

How can chemical changes be produced or caused by electrical energy?

Content

Vocabulary:

Voltaic cell, galvanic cell, anode, cathode, salt bridge, cell notation, EMF, electrolytic cell, electrolysis, anode, cathode, alkane, alkene, alkyne, alcohol, ester, ether, esterification, mass defect, nuclear binding energy, half-life

Skills

Use Einstein's relationship to calculate the energy or mass changes of a reaction.

Predict the type of decay that a nucleus will undergo based on its composition.

Use the half life of a substance to predict the amount of the radioisotope present after a given period if time.

Distinguish among the structure and properties of alkanes, alkenes, alkynes and aromatic

hydrocarbons.

Explain the relationships between the properties and structures of compounds with various functional groups.

Use standard electrode potential to calculate cell voltage and draw cell diagrams.

Differentiate between products from voltaic, and electrolytic cells.

USE the Nernst equation to calculate emf under non-standard conditions

Diagram a simple electrolytic cell- including appropriate labels. Use Faraday Law to determine the amount produced by an electrolytic cell.

Draw, label and analyze voltaic cells for cell potential

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.
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.

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]

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.B: Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature. Essential knowledge 2.B.1: London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules.
a. A temporary, instantaneous dipole may be created by an uneven distribution of electrons around the nucleus (nuclei) of an atom (molecule).

b. London dispersion forces arise due to the Coulombic interaction of the temporary dipole with the electron distribution in neighboring atoms and molecules.

c. Dispersion forces increase with contact area between molecules and with increasing polarizability of the molecules. The polarizability of a molecule increases with the number of electrons in the molecule, and is enhanced by the presence of pi bonding.

2.B.1 Learning Objective:
LO 2.11 The student is able to explain the trends in properties and/or predict properties of samples consisting of particles with no permanent dipole on the basis of London dispersion forces. [See SP 6.2, 6.4]

Essential knowledge 2.D.4: Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.
a. Molecular solids consist of nonmetals, diatomic elements, or compounds formed from two or more

nonmetals.

b. Molecular solids are composed of distinct, individual units of covalently bonded molecules attracted to each other through relatively weak intermolecular forces. 1. Molecular solids are not expected to conduct electricity because their electrons are tightly held within the covalent bonds of each constituent molecule. 2. Molecular solids generally have a low melting point because of the relatively weak intermolecular forces present between the molecules. 3. Molecular solids are sometimes composed of very large molecules, or polymers, with important commercial and biological applications.

2.D.4 Learning Objectives:
LO 2.31 The student can create a representation of a molecular solid that shows essential characteristics of the structure and interactions present in the substance. [See SP 1.1]

LO 2.32 The student is able to explain a representation that connects properties of a molecular solid to its structural attributes and to the interactions present at the atomic level. [See SP 1.1, 6.2, 7.1]

Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.
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]

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.

e. There are a number of important redox reactions in energy production processes (combustion of hydrocarbons and metabolism of sugars, fats, and proteins).

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]

LO 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration. [See SP 4.2, 5.1]

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]

Essential knowledge 3.C.3: Electrochemistry shows the interconversion between chemical and electrical energy in galvanic and electrolytic cells.
a. Electrochemistry encompasses the study of redox reactions that occur within electrochemical cells. The

reactions either generate electrical current in galvanic cells, or are driven by an externally applied electrical potential in electrolytic cells. Visual representations of galvanic and electrolytic cells are tools of analysis to identify where half-reactions occur and the direction of current flow.

b. Oxidation occurs at the anode, and reduction occurs at the cathode for all electrochemical cells.

c. The overall electrical potential of galvanic cells can be calculated by identifying the oxidation half-reaction and reduction half-reaction, and using a table of Standard Reduction Potentials.

d. Many real systems do not operate at standard conditions; the electrical potential determination must account for the effect of concentrations. LeChâtelier's principle can be used to predict qualitatively the differences in electrical potential and electron flow compared to those at standard conditions.

e. The magnitude of the standard cell potential is proportional to ΔG° (standard Gibbs free energy) for the redox reaction from which it is constructed.

f. Faraday's laws can be used to determine the stoichiometry of the redox reactions occurring in an electrochemical cell with respect to the following: 1. Number of electrons transferred 2. Mass of material deposited or removed from an electrode 3. Current 4. Time elapsed 5. Charge of ionic species

3.C.3 Learning Objectives:
LO 3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/ or Faraday's laws. [See SP 2.2, 2.3, 6.4]

LO 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. [See SP 5.1]

Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.
Essential knowledge 4.A.2: The rate law shows how the rate depends on reactant concentrations.
c. The method of initial rates is useful for developing conceptual understanding of what a rate law represents, but simple algorithmic application should not be considered mastery of the concept. Investigation of data for initial rates enables prediction of how concentration will vary as the reaction progresses.

4.A.2 Learning Objective:
LO 4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. [See SP 5.1, connects to 4.A.3]

Essential knowledge 4.A.3: The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant.
e. For first-order reactions, half-life is often used as a representation for the rate constant because they are inversely proportional, and the half-life is independent of concentration. For example, radioactive decay processes provide real-world context.

4.A.3 Learning Objective:
LO 4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. [See SP 2.1, 2.2]

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.
Essential knowledge 5.D.3: Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.
a. In large biomolecules, noncovalent interactions may occur between different molecules or between different

regions of the same large biomolecule.

b. The functionality and properties of molecules depend strongly on the shape of the molecule, which is largely dictated by noncovalent interactions. For example, the function of enzymes is dictated by their structure, and properties of synthetic polymers are modified by manipulating their chemical composition and structure.

5.D.3 Learning Objective:
LO 5.11 The student is able to identify the noncovalent interactions within and between large molecules, and/or connect the shape and function of the large molecule to the presence and magnitude of these interactions. [See SP 7.2]

Essential knowledge 5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.
a. Electricity may be used to cause a process to occur that is not thermodynamically favored. Useful examples are charging of a battery and the process of electrolysis.

b. Light may also be a source of energy for driving a process that in isolation is not thermodynamically favored. Useful examples are as follows: 1. The photoionization of an atom, because although the separation of a negatively charged electron from the remaining positively charged ion is highly endothermic, ionization is observed to occur in conjunction with the absorption of a photon 2. The overall conversion of carbon dioxide to glucose through photosynthesis, for which $6\ CO_2(g) + 6\ H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6\ O_2(g)$ has $\Delta G^\circ = +2880$ kJ/ molrxn, yet is observed to occur through a multistep process that is initiated by the absorption of several photons in the range of 400–700 nm

5.E.4 Learning Objectives:
LO 5.15 The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. [See SP 6.2]

Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.
Enduring understanding 6.A: Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. Essential knowledge 6.A.1: In many classes of reactions, it is important to consider both the forward and reverse reaction.
b. Dissolution of a solid, transfer of protons in acid-base reactions, and transfer of electrons in redox reactions are important examples of reversible reactions.

6.A.1 Learning Objective:
LO 6.1 The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. [See SP 6.2]