This course supports the assessment for Physical Chemistry. The course covers 5 competencies and represents 3 competency units.

Introduction

Overview

Physical Chemistry introduces the study of chemistry in terms of physical concepts.
It includes thermodynamics, reaction kinetics, chemical equilibrium, electrochemistry, and matter.

Getting Started

Welcome to Physical Chemistry! The study of physical chemistry will help you answer questions such as, why does a heater warm us? Why does water in a teapot get hot? Why does mercury in a barometer vary with air pressure? Through successfully completing this course, you will be prepared to enter a secondary classroom and lead students in an organized and meaningful learning experience in their study of physical chemistry.

Teaching Dispositions Statement

Please review the WGU Statement of Teaching Dispositions.

You will complete three tasks as you work through the course.

Competencies and Objectives

The information in this section is provided to detail the resources available for you to use as you complete this course.

Competencies and Objectives

This course provides guidance to help you demonstrate the following competencies:

Competency 208.2.1: First Law of Thermodynamics

The graduate applies the first law of thermodynamics to analyze heat transfers associated with chemical processes and changes in state.

Objectives

- Determine the heat of solution for a given ionic compound in water using a simple laboratory-made calorimeter.
- Use chemical principles and symbols to determine how photosynthesis is an endothermic reaction.
- Calculate calorie, heat capacity, specific heat, and latent heat for a given substance.

Competency 208.2.2: Second Law of Thermodynamics

The graduate applies concepts of the second law of thermodynamics and free energy to predict the spontaneity of a process and analyze chemical equilibrium.

Objectives

- Calculate and interpret entropy changes when the temperature of a given substance changes.
- Evaluate absolute entropy from given data.
- Calculate the total entropy change of reaction from given data.
- Use total entropy changes to predict whether a given reaction is spontaneous.
- Use free energy and free energy changes to predict the stability of a given substance and the spontaneity of changes.
- Calculate the free energy change that occurs when the temperature of a given gas changes.

Competency 208.2.4: Real Gases
The graduate applies models and equations of state to analyze properties of real gases.

Objectives

- Use a simulation to solve for the volume, temperature, amount (number of moles), or pressure of a given ideal gas.
- Solve a given problem using Avogadro's law, Dalton's law, or the Maxwell-Boltzmann distribution law.
- Solve a given problem using Charles' law, Boyle's law, or Gay-Lussac's law.
- Solve a given problem using the Van der Waals equation.
- Carry out a specified laboratory procedure using the appropriate scientific techniques and equipment.

Competency 208.2.7: Electrochemistry
The graduate applies concepts of thermodynamics and electrochemistry to analyze the interchange of chemical and electrical energy.

Objectives

- Solve a given problem involving oxidation and reduction.
- Balance a given redox equation.
- Use the concepts of electrodes, salt bridges, half-cell reactions, and net cell reaction and cell diagrams to demonstrate the operation of a galvanic (voltaic) cell.
- Use Faraday's laws to calculate the quantity of chemical change produced by a given amount of electric charge.
- Explain how the pH meter measures the electrical potential difference between a sample and a reference solution.

Competency 208.2.8: Chemical Kinetics
The graduate uses experimental data and kinetic models to analyze reaction rates and reaction mechanisms.

Objectives

- Determine through laboratory activities what factors can affect reaction rates in a given situation or problem.
- Calculate the average rate of reaction over a period of time in a given situation or problem.
- Use plots of log concentration vs. time and reciprocal concentration vs. time to determine the order of reaction in a given situation or problem.
- Use the Arrhenius equation to relate rate constant to temperature and activation energy.
- Explain how reaction rates, energy, bond strength, catalysis, and equilibrium relate to each other.
- Determine the order and rate of a reaction using a laboratory experiment.

Preparing for Success

The information in this section is provided to detail the resources available for you to use as you complete this course.

Learning Resources

The learning resources listed in this section are required to complete the activities in this course. Read the full instructions provided to ensure that you have access to all of your resources in a timely manner.

Order and Sign Up for Your Resources

The learning resources listed below are required to complete the activities in this course. For many resources, WGU provides access through links in your courses. However, the below resources are a bit different and require you to register and order. Please follow the instructions carefully.

Chemistry: Content Knowledge in OWL

This web-based resource provides access to videos, Mastery questions, End of Chapter (EOC) questions, and the following e-text:

- E-text: Zumdahl, S., & Zumdahl, S. (2013). *Chemistry* (9th ed.). Belmont, CA: Brooks/Cole. ISBN: 1-133-61109-5

Please follow these registration steps carefully in order to access your resource.

- Go to http://login.cengagebrain.com/course/E-24YE3Q87N3UZ8.
- Under New Students enter your WGU e-mail address using the @my.wgu.edu extension and click Create a New Account.
- Enter the required information to create an account: First Name, Last Name, Password creation, Security Question and Answer, and check the box to agree to the terms of the site.
- You will be logged in under your new account. Click the Open button next to your Chemistry 9th Edition resource listing.
- Please make note of the login credentials you created for this site.
- We recommend adding https://login.cengagebrain.com/cb/login.htm to your browser Favorites so you can easily login to the resource in the future.

After logging in, click the Assignments button. Complete the four "Intro" assignments to be sure your computer is compatible with this resource and you understand how to make use of this resource.

Virtual ChemLab
This inquiry-based lab simulation environment allows you to perform key chemistry labs accurately and efficiently, without costly equipment and cleanup. It stresses proper procedures and safety. This learning resource includes a downloadable computer program and a general chemistry lab manual.

Below are instructions for accessing the Virtual ChemLab resource. Please follow them carefully.

1. Go to http://www.pearsonhighered.com/thechemistryplace.
2. Click Login.
3. Underneath Virtual ChemLab, click on the "Woodfield, Virtual ChemLab: General Chemistry Student Workbook, 4e Woodfield ISBN: 0321875664" icon.
4. Login using the following credentials:
    1. Username: wgusciencestudent
    2. Password: wgu_student123
5. Click the VCL Download button for the type of computer you are using - PC or MAC.
6. Carefully follow the installation instructions.
7. This will install the lab onto your computer locally. You will now be able to enter the virtual lab using your Desktop link or Programs path on your system.
8. Last, download the lab manual.
   NOTE: This file may load slowly in some browsers. You may want to save the manual somewhere you will remember.

Chemistry LabPaq
The *Chemistry* LabPaq, sometimes referred to as a lab kit, from Hands-On Labs, is a physical shipment. This lab kit (LabPaq) is covered by your program's Science Lab Fee, and includes digital multi-meter, and all of the other equipment and chemicals necessary to complete experiments covering a wide variety of chemistry topics. The experiments reinforce science content and teach laboratory techniques.

1. Use these instructions to order your LabPaq: Chemistry LabPaq Ordering Instructions.

2. Use this lab manual throughout your course and assessment where applicable: Chemistry LabPaq Manual. You may want to save the manual somewhere you will remember.

Pacing Guide and Study Plan

The pacing guide suggests a weekly structure to pace your completion of learning activities. It is provided as a suggestion and does not represent a mandatory schedule. Following the pacing guide will help you complete the course in the suggested timeframe.

Week 1

- Learning Resource Enrollment
- Behavior of Gases
- Phase Diagrams

Week 2

- Energy and Its Conservation
    - Energy and Heat
- Start Thermochemistry Performance Task

Week 3

- Energy and Its Conservation
    - Spontaneity
    - Complete Thermochemistry Performance Task

Week 4

- Equilibrium

Week 5

- Electrochemistry
- Complete Electrochemistry Performance Task

Week 6

- Kinetics
- Complete Kinetics Performance Task

Course Instructor Assistance

For course instructor assistance, please schedule an appointment using the following link to the course instructor calendar:

- Physical Chemistry Team Calendar

Physical Chemistry Team e-mail:

- chemistry@wgu.edu

As you prepare to demonstrate competency in this subject, remember that course instructors stand ready to help you reach your educational goals. As subject matter experts, instructors enjoy and take pride in helping students become reflective learners, problem solvers, and critical thinkers. Course instructors are excited to hear from you and eager to work with you.

Successful students report that working with a course instructor is the key to their success.

Course instructors are able to share tips on approaches, tools, and skills that can help you apply the content you're studying. They also provide guidance in assessment preparation strategies and troubleshoot areas of deficiency. Even if things don't work out on your first try, course instructors act as a support system to guide you through the revision process. You should expect to work with course instructors for the duration of your coursework, so you are welcome to contact them as soon as you begin. Course instructors are fully committed to your success!

Behavior of Gases

Matter exists as a gas, liquid, or solid. In this section, gases and their behaviors will be discussed. Gases have many important applications. For example, everyone on Earth is at the bottom of a gas ocean consisting of nitrogen, oxygen, and a small percentage of other elements. This atmospheric ocean supports life on Earth in a number of ways. Because of its importance, a lot of time, effort, and money are directed towards the study of the atmosphere, the effects humans have on the atmosphere, and the effects the atmosphere has on humans.

It is interesting to note that the study of gases typically focuses on a hypothetical concept called an ideal gas. In reality, there is no such thing as an ideal gas. As you progress through this section, think about why so much attention is given to ideal gases and how it relates to the study of real gases.

Gases and Gas Laws

Like most areas of science, the study of gases will start with a review the properties and laws that describe gases. As you progress through the material, pay attention to how observations have led to natural laws that describe gases and how models have been created to help visualize and understand these laws. Complete the activities within this topic to gain an understanding of gases and their behaviors.

The Gas Laws

The gas laws explain the behavior of gases. These laws hold true for real or ideal gases. In this section, you will be discovering the relationships that exist between two variables as they apply to gas behavior, focusing on the variations of temperature, volume, pressure, or amount.

Read

- OWL Chapter 5 ("Gases")

Watch

- The Gas Laws (10 min.)
- The Ideal Gas Law (9 min.)
- STP Gas Calculations (6min.)
- Partial Pressure and Dalton's Law (10 min.)
- Kinetic Molecular Theory, Effusion, and Diffusion (6 min.)
- Real Gases (5 min.)

Practice Problems

Complete

- Problem groups 1–14 in OWL Chapter 5: Mastery

Watch

- Using OWL in Physical Chemistry (6 min.)

Complete

- Virtual ChemLab experiment 5-4 ("Derivation of the Ideal Gas Law.")
- Virtual ChemLab experiment 5-6 ("Ideal vs. Real Gases")

Phase Diagrams

A phase diagram is a graph that shows the relationship between the phase of a substance and its temperature and pressure. Every substance has a unique phase diagram. Can you draw a simple phase diagram showing the relationship between the temperature and phase of water?

Phase Change Diagram

Complete the activities within this topic to gain an understanding of phase diagrams. This is a very hands-on concept. Make sure you practice drawing and interpreting phase diagrams.

Phase Diagrams

Phase diagrams are used to graphically explain if a molecule exists as a solid, liquid, or gas at any given temperature and pressure. In this section, you will discover how to interpret phase diagrams.

Read

- OWL section 10.8 ("Vapor Pressure and Changes of State")
- OWL section 10.9 ("Phase Diagrams")

Watch

- Phase Diagrams (18 min.)

Practice Problems

Complete

- Problem groups 17, 19, and 20 in OWL Chapter 10: Mastery

Review

- Using Owl in Physical Chemistry (6min.)

Energy and Its Conservation

Energy is used in almost everything people do. It is an important component of all science disciplines. Energy sources can be divided into two groups: renewable and nonrenewable. Currently, only about 7% of the nation's energy supply comes from renewable sources. About half of this percentage comes from biomass, a third comes from hydropower, and the rest comes from wind, geothermal, or solar sources. You will begin your study with an overview of energy and then move into a more chemistry-focused analysis of energy.

Energy and Heat

There is an interesting and important relationship between energy, work, and heat. But be careful; this relationship and an understanding of the definition of heat are often misunderstood. It is usually best to think of heat as energy transferred because of a difference in temperature.

Types and Sources of Energy

In this section, you will be learning about the different types of energy, the process of heat transfer, and how this is defined by the first law of thermodynamics. There are several definitions covered in this section that will be important to comprehend as you continue studying thermochemistry and thermodynamics.

Read

- OWL Chapter 6 (Thermochemistry)

Watch

- The Nature of Energy (13 min.)
- The First Law of Thermodynamics (11 min.)
- Thermochemistry Definitions (7 min.)
- Calorimetry Introduction and Coffee Cup Calorimeter Problems (19 min.)

Practice Problems

Complete

- Problem groups in OWL Chapter 6: Mastery

Review

- Using OWL in Physical Chemistry (6min.)

Complete

- Virtual ChemLab 3-1 ("Endothermic vs. Exothermic") on pages 80–81
- Virtual ChemLab 3-6 ("Heat of Combustion: Sugar") on pages 81–82

- Virtual ChemLab 3-8 ("Heat of Formation: Ethanol") on pages 85–86

Bomb Calorimetry in the Virtual ChemLab for Task 1

Heats of Combustion of Gasoline Components

Now that you have learned what information that can be determined by using a calorimeter and you have used the bomb calorimeter within the Virtual ChemLab (VCL), you are ready to complete an experiment within the VCL. You will be discussing this experiment in your performance task on thermochemistry, so be sure to take detailed notes.

Your experiment will compare the heats of combustion of ethanol (a representative of E-85 fuel) and of some component of unleaded gasoline that is available within the VCL. Watch the following video to learn how to access these components within the VCL:

- [redacted] (19 min.)

Go to the following web page to find the components of unleaded gasoline:

- [redacted]

Choose a component of gasoline from the list that is available within the VCL to use for the experiment.

Once you have completed the experiment for ethanol and your chosen component of gasoline, you will complete several items for your task:

1. Write the balanced chemical equation for the combustion of each molecule. (Remember, combustion reactions of gasoline components occur only when oxygen is present and must produce carbon dioxide and water.)
2. Calculate the heat of combustion of each molecule. (Be sure to follow the instructions for calculating Heat of Combustion from the Virtual ChemLab manual for lab 3-6.)
3. Calculate the heat of combustion per gram for each molecule. (Example 6.6 in your Zumdahl text will help with this.)

You will then compare the heat of combustion per gram ethanol and your chosen component of gasoline for your task on thermochemistry and argue the case for either or both components as fuel sources.

Spontaneity

A reaction is spontaneous if it does not require outside energy. In this topic, you should consider why reactions take place. You will also study the rate of these reactions.

Spontaneity and Entropy

The entropy of the universe is always increasing. In these first sections of this chapter, you will

learn about entropy within chemical reactions and how that relates to the spontaneity of the reactions.

Read

- OWL Chapter 17 (Spontaneity, Entropy, and Free Energy), Sections 1–5

Watch

- Spontaneous Processes (12 min.)
- Entropy and the Second Law of Thermodynamics (14 min.)
- Entropy and Temperature (14 min.)
- Gibbs Free Energy (11 min.)
- Entropy and Spontaneity (19 min.)

Practice Problems

Complete

- Problem groups 1–8 in OWL Chapter 17: Mastery

Review

- Using OWL in Physical Chemistry (6min.)

Spontaneity of Ethanol Combustion

The final piece of the Thermochemistry performance task is an explanation of when the combustion of ethanol is not spontaneous. Using the information you know about the combustion of ethanol and your understanding of the Gibbs Free Energy equation, determine the conditions under which the combustion of ethanol is not spontaneous and provide an explanation of why. You will include this information in your Thermochemistry performance task.

Thermochemistry Performance Task

You are now ready to complete the performance task. Review your notes and contact the course instructor if you have any questions as you work on the task.

BVT Task 1 Performance Task

Complete in Taskstream:

- Physical Chemistry: BVT Task 1: Thermochemistry

For details about the performance assessment, see the “Assessment” tab in this course.

For more in depth information about Task 1, view the Rubric Walk through Presentation.

Equilibrium

Chemical equilibrium is the point at which the quantity of the reactant and products remains constant. This does not, however, mean the reaction is complete, as equilibrium can be shifted depending on the stress that is applied to the reaction. In this section, you will learn about equilibrium, the equilibrium constant, and Le Chatelier's principle.

Chemical Equilibrium

While some reactions can take place only in one direction, other reactions can happen in either direction. Chemical equilibrium is the point at which the forward and reverse reactions take place at the same rate, resulting in no net change.

Equilibrium

Equilibrium is the point of a reaction when the disappearance of product and production of reactant is stabilized. However, equilibrium does not mean that the reaction has stopped. Equilibrium can be reestablished when a stress is applied to the system. In this section, you will be introduced to these concepts, which will aid your understanding of equilibrium concepts in the remainder of this chapter, but also in other circumstances (such as electrochemical cells, acid/base neutralizations, etc.).

Read

- OWL Chapter 13 (Chemical Equilibrium)

Watch

- The Concept of Equilibrium (11 min.)
- The Law of Mass Action and Types of Equilibrium (11 min.)
- Equilibrium (11 min.)
- Le Chatelier's Principle (6 min.)

Practice Problems

Complete

- Problem groups 1–10 in OWL Chapter 13: Mastery

Review

- Using OWL in Physical Chemistry (6 min.)

Electrochemistry

As the name implies, electrochemistry is the study of the interchange of chemical and electrical energy. Electrochemistry is an important example of the applications of chemistry. For example, a battery is designed specifically to convert chemical energy into electrical energy. Electrolysis is used to produce important materials, such as aluminum, that are used in society.

Electrochemistry

While batteries and electrolysis are typically the first items that come to mind when you think

about electrochemistry, corrosion is also an example of an oxidation-reduction reaction that transfers electrons.

Redox Reactions

Review

- OWL section 4.9 ("Oxidation-Reduction Reactions")
- OWL section 4.10 ("Balancing Oxidation-Reduction Reactions")

Make sure you know how to balance a chemical equation.

Read

- OWL Chapter 18: "Electrochemistry"

Watch

- Reviewing Oxidation-Reduction Reactions (10 min.)
- Electrochemical Cells (9 min.)
- Standard Reduction Potentials (13 min.)
- Using Standard Reduction Potentials (13 min.)
- Electrochemical Determinants of Equilibria (10 min.)
- Equilibrium in Electrochemistry (5 min.)
- Batteries (11 min.)
- Electrolytic Cells (11 min.)
- Recharging a Battery (6 min.)

Practice Problems

Complete

- Problem groups 17–20 in OWL Chapter 4: Mastery
- Problem groups 1–17 in OWL Chapter 18: Mastery
- Problems 4 and 5 in OWL Chapter 18: EOC

Review

- Using OWL in Physical Chemistry (6min.)

Experiment: Electrochemical Cells and Cell Potentials

Complete

- Experiment 4 ("Electrochemical Cells and Cell Potentials ") CK-W LabPaq

Note: Take excellent lab notes as you complete the experiment. You will be asked to write a lab

report on this experiment as part of the performance assessment.

Review

- The Electrochemical Cells and Cell Potentials Lab

Electrochemistry Performance Task

You are now ready to complete the performance task. Review your notes and contact the course instructor if you have any questions as you work on the task.

Time to Recharge a Battery

The performance task on electrochemistry requires you calculate the time to recharge a battery that you design using the information obtained in the lab.

Watch

- Recharging a Battery (6min.)

BVT Task 2 Performance Task

Complete in Taskstream:

- Physical Chemistry: BVT Task 2: Electrochemistry

For details about this performance assessment, see the "Assessment" tab in this course.

For more in depth information about Task 2, view the Rubric Walkthrough Presentation

Kinetics

Chemical reactions are the application of chemistry. In order to fully understand these reactions, it is important to understand some of the underlying concepts that define chemical reactions. One of these concepts is reaction rate. Chemical kinetics is the study of reaction rates. Chemical equilibrium is the point at which the quantity of the reactants and products remains constant. As you will see during this section, this does not imply that chemical reactions have stopped.

Chemical Kinetics

Chemical kinetics is the study of the mechanisms that drive reactions and the rate of chemical reactions. You need to know how to use the equations given within this section. Make sure you work through the example problems in this section as well.

Reaction Rates

How fast a reaction occurs is the rate of the reaction. Reaction rates can be determined by looking at either the rate of disappearance of the reactant(s) or the rate of appearance of the product(s). In this section you will learn how to calculate the rate of reaction.

Read

- OWL Chapter 12 ("Chemical Kinetics")

Watch

- An Introduction to Reaction Rates (13 min.)
- Rate of Reaction (5 min.)
- Rate Laws: How the Reaction Rate Depends on Concentration (13 min.)
- Determining the Form of a Rate Law (9 min.)
- Kinetics - Rate Law Calculation (15 min)
- First-Order Reactions (13 min.)
- Second-Order Reactions (8 min.)
- The Collision Model (12 min.)
- The Arrhenius Equation (3 min.)
- Using the Arrhenius Equation (2 min.)
- Activation Energy (10 min.)
- Catalysts and Types of Catalysts (12 min.)

Practice Problems

Complete

- Problem groups 1–10 in OWL Chapter 12: Mastery

Review

- Using OWL in Physical Chemistry (6 min.)

Experiment: Reaction Order and Rate Laws

Complete

- Experiment 5 ("Reaction Order and Rate Laws") CK-W LabPaq

Note: Take excellent lab notes as you complete the experiment. You will be asked to write a lab report on this experiment as part of the performance assessment.

You will need to complete the experiment with an extra step—repeat a reaction well at a different temperature. You will need this information to determine the activation energy for the task.

Review

- The Reaction Order and Rate Laws Lab

Chemical Kinetics Performance Task

You are now ready to complete the performance task. Review your notes and contact the

course instructor if you have any questions as you work on the task.
BVT Task 3 Performance Task

Complete in Taskstream:

- Physical Chemistry: BVT Task 3: Kinetics

For details about the performance assessment, see the "Assessment" tab in this course.

For more in depth information about Task 3, view the Rubric Walk through Presentation.

Final Steps

Congratulations on completing the activities in this course! This course has prepared you to complete the assessment associated with this course. If you have not already been directed to complete the assessment, schedule and complete your assessment now.