Adult Basic Education

Science

Chemistry 3102A

Thermodynamics & Rates

Curriculum Guide

Prerequisite: Chemistry 2102C

Credit Value: 1

Chemistry Concentration

Chemistry 1102
Chemistry 2102A
Chemistry 2102B
Chemistry 2102C
Chemistry 3102A
Chemistry 3102B
Chemistry 3102C

Table of Contents

To the Instructor

I. Introduction to Course

Chemistry 3102A introduces students to the ways that energy changes are involved in physical and chemical changes. This information is then further developed in a study of the factors affecting reaction rates and an examination of what is happening at a molecular level.

Students taking this course need to know how to solve for unknowns and use a scientific calculator. Instructors should ensure that students have these prerequisite skills. Chemistry 3102A, along with Chemistry 3102B and C, are equivalent to Chemistry 3202 in the current high school program. **Chemistry 2102C is a prerequisite to this course.**

II. Curriculum Guides

Each new ABE Science course has a Curriculum Guide for the instructor and a Study Guide for the student. The Curriculum Guide includes the specific curriculum outcomes for the course. Suggestions for teaching, learning, and assessment are provided to support student achievement of the outcomes. Each course is divided into units. Each unit comprises a **two-page layout of four columns** as illustrated in the figure below. In some cases the four-column spread continues to the next two-page layout.

Curriculum Guide Organization:
The Two-Page, Four-Column Spread

Unit Number - Unit Title	
Outcomes	**Notes for Teaching and Learning**
Specific curriculum outcomes for the unit.	Suggested activities, elaboration of outcomes, and background information.

Unit Number - Unit Title	
Suggestions for Assessment	**Resources**
Suggestions for assessing students' achievement of outcomes.	Authorized and recommended resources that address outcomes.

III. Study Guides

The Study Guide provides the student with the name of the text(s) required for the course and specifies the sections and pages that the student will need to refer to in order to complete the required work for the course. It guides the student through the course by assigning relevant reading and providing questions and/or assigning questions from the text or some other resource. Sometimes it also provides important points for students to note. (See the *To the Student* section of the Study Guide for a more detailed explanation of the use of the Study Guides.) The Study Guides are designed to give students some degree of independence in their work. Instructors should note, however, that there is much material in the Curriculum Guides in the *Notes for Teaching and Learning* and *Suggestions for Assessment* columns that is not included in the Study Guide and instructors will need to review this information and decide how to include it.

IV. Resources

Essential Resources

Chemistry: Mustoe, Jansen, et al; McGraw-Hill Ryerson, 2004.
McGraw-Hill Chemistry Teacher's Resource (including CD-ROM)

Recommended Resources

Chemistry 3202 Curriculum Guide:
http://www.ed.gov.nl.ca/edu/sp/chem_3202.htm

Chemistry 11/12 Computerized Assessment Banks.
Textbook website:
http://www.mcgrawhill.ca/school/booksites/chemistry/index.php

Other Resources

Center for Distance Learning and Innovation: http://www.cdli.ca/

Access Excellence Resource Center:
http://www.accessexcellence.org/RC/chemistry.html

Virtual Chemistry: http://neon.chem.ox.ac.uk/vrchemistry/

To the Instructor

V. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam *(entire course)*	50%
	100%

The overall pass mark for the course is 50%.

Thermodynamics & Rates

Unit 1 - Temperature Change and Heat

Outcomes

1.1 Explain temperature and heat using the concept of kinetic energy and the particle model of matter.

1.1.1 Define thermochemistry.

1.1.2 Distinguish between system and surroundings.

1.1.3 State the First Law of Thermodynamics.

1.1.3 Define open, closed, and isolated systems.

1.1.4 Define temperature as a measure of the average kinetic energy of the particles of the system.

1.1.5 Identify and describe the changes to particle movement in systems in which the energy change is accompanied by a change in temperature of the system.

1.1.6 Describe heat as a transfer of kinetic energy from a system of higher temperature (higher average kinetic energy) to a system of lower temperature (lower average kinetic energy) when each is in thermal contact with the other.

Notes for Teaching and Learning

Instructors should make sure that students review the terms energy, kinetic energy and potential energy.

After defining temperature the instructor could use temperature differences in the classroom to illustrate differences in particle movement and heat. For example, ask students to place a hand on their desk. The desk will feel cool. What's happening? The temperature of the hand is higher than the temperature of the desk, therefore the kinetic energy (E_K or KE) (particle movement) in the hand is higher than the E_K (particle movement) in the desk. The result is a transfer of E_K from the particles in the hand to particles in the desk as collisions occur in the interface. This is heat transfer from the hand to the desk.

Students may still confuse heat and temperature. Instructors should make sure they understand that temperature is a measure of the average thermal energy of a substance, while heat describes the transfer of thermal energy.

Whenever a temperature change occurs, the change in E_K involved can be determined from experimentally obtained data or from data provided, using the First Law of Thermodynamics.

Suggestions for Assessment

Students could be asked to distinguish between temperature and heat by relating these to the energy of the atoms and molecules.

Students could respond to the following questions:

Explain why, on a hot, summer day at the beach, the sand can be unbearably hot on bare feet yet the water is very cold.

What happens when direct sunlight is blocked by a cloud? How does this affect the temperature of the sand versus that of the water ?

Why is it helpful to fill your thermos bottle with hot water before filling it with a hot beverage?

Students could be told they can use a balance to find the mass of a substance only when it is at room temperature. They should explain this statement.

They should be able to give an example of an experiment to show that two objects at the same temperature do not necessarily have the same thermal energy.

The CDLI (Center for Distance Learning and Innovation) website was developed for distance delivery of selected high school courses. It contains lots of materials that could useful in the delivery of ABE courses.

Note: You will need a username and password to enter the CDLI site.

Resources

MGH Chemistry, pages 624 - 638.

Teacher's Resource for MGH Chemistry pages 236-259 (including CD-ROM).

Website for the text: http://www.mcgrawhill.ca/school/booksites/chemistry/index.php

Department of Education website: http://www.ed.gov.nl.ca/edu/science_ref/chem3202.htm

The centre for distance learning and innovation website: http://www.cdli.ca/

Outcomes

1.2 Calculate and compare the energy involved in changes of temperature.

1.2.1 Define the terms: joule, heat capacity and specific heat capacity.

1.2.2 Identify that the amount of heat lost or gained by an object is dependent upon; type of material, change in temperature of material, and mass of material.

1.2.3 Perform calculations involving heat capacity, C, and specific heat capacity, c.

1.2.4 Calculate the heat gained or lost from a system using the formulas $q = mc\Delta T$ or $q = C\Delta T$ where c is the specific heat capacity, C is the heat capacity and ΔT is the change in temperature.

Notes for Teaching and Learning

Students can achieve outcome 1.1.6 by completing ***ThoughtLab - Factors in Heat Transfer***.

Students need to understand that the change in temperature depends on the type of material and the mass, which should be illustrated through the concepts of heat capacity (C) and specific heat (c). For example, you wish to boil water for a cup of tea. Why would it be faster to place 250 mL of water in the kettle rather than 2000 mL of water? This reinforces the concept of the importance of mass to energy lost or gained.

It requires more energy to raise the temperature of a 1 kg aluminium frying pan by 200ºC than it does to raise the temperature of a 1 kg iron frying pan 200ºC. Why? This reinforces the concept of the importance of the type of matter to energy lost or gained. This leads into the explanation of specific heat and related calculations.

A 20.0 g piece of iron has a heat capacity of 8.88 J/ºC. Calculate the specific heat of iron. The specific heat of aluminium is 0.890 J/gºC. Calculate the heat capacity of a 500 g aluminium saucepan. Refer to the table of specific heat values for comparison. The previous calculation can quickly lead to calculation of heat lost or gained using the formula
$q = mC\Delta T$.

Practise using this formula for calculating one of *q, m, c,* or ΔT given the other three variables. Instructors should note that math skills in rearranging formulas may be weak for some students.

For example, how much energy is lost when an aluminium mailbox, with a mass of 400.0 g, cools from 26.2 ºC to 12.4 ºC ?

Suggestions for Assessment

Instructors should use question 1.10 of the Study Guide, Completion of the Though Lab, for assessment of outcome 1.2.2. Answers to *Procedure* questions and *Analysis* question can be found in the *Teacher's Resource*.

Instructors could use Practice Problems, Section Review and Unit Review questions to assess students' understanding of the concepts covered in Unit 1.

Students may check the answers to the Practice Problems in the text by referring to page 659. Instructors should make sure that students are using the correct procedures to arrive at these answers.

Instructors should check students' answers to all questions assigned in the Study Guide for this unit.

Resources

ThoughtLab - Factors in Heat Transfer, MGH Chemistry page 631.

The centre for distance learning and innovation website: http://www.cdli.ca/ Chemistry 3202: Unit 03: Section 02

Unit 2 - Enthalpy Changes

Outcomes

2.1 Understand enthalpy changes for physical and chemical changes.

2.1.1 Define the terms: enthalpy, molar enthalpy change (ΔH), exothermic reaction and endothermic reaction.

2.1.2 Use and interpret change in enthalpy (ΔH) notation for communicating energy changes.

2.1.3 Identify and explain that chemical changes and phase changes involve changes in potential energy only.

Notes for Teaching and Learning

Students should write thermochemical equations to represent enthalpy notation.

The sign of ΔH is negative for exothermic processes (energy is a product in the reaction) and positive for endothermic processes (energy is a reactant in the reaction).

Unit 2 - Enthalpy Changes

Suggestions for Assessment

Ask students to explain what is happening in terms of potential energy for physical and chemical changes when (a) heat is lost by a process or (b) heat is gained by a process. Similarly ask them what is happening if the process is *exothermic* or *endothermic.*

The Chemistry Teacher's Resource has some good suggestions (see pages 241-242) to demonstrate the concepts introduced in this unit.

Resources

MGH Chemistry pages: 639-640.

Unit 2 - Enthalpy Changes

Outcomes

2.2 Illustrate changes in energy of various chemical reactions, using potential energy diagrams.

2.2.1 Draw and interpret potential energy diagrams based on experimental data for chemical changes.

2.2.2 Label enthalpy diagrams given either the ΔH for a process, or a thermochemical equation.

2.2.3 Identify exothermic and endothermic processes from the sign of ΔH, from thermochemical equations, or from labelled enthalpy diagrams.

2.2.4 Write thermochemical equations, including the quantity of energy exchanged, given either the value of ΔH or a labelled enthalpy diagram.

Notes for Teaching and Learning

Emphasize understanding of Figures 16.11 and 16.12 of text as these are fundamental to understanding activation energy diagrams in Unit 4.

Instructors could ask students for everyday examples involving endothermic and exothermic changes. Examples might include heating and freezing of ice, hot and cold packs, evaporation and condensation of water, and production and decomposition of ammonia.

Unit 2 - Enthalpy Changes

Suggestions for Assessment

Use the data in Table 16.2 and ask students to represent the information as (a) thermochemical equations (b) separate expressions or (c) enthalpy diagram. Problem 2 on page 657 of text covers these representations.

Resources

MGH chemistry pages 641-643.

Unit 2 - Enthalpy Changes

Outcomes

2.3 Calculate and compare the energy involved in changes of state and in chemical reactions.

2.3.1 Use the formula $q = n \cdot \Delta H$ to calculate the heat absorbed or released by a process.

2.3.2 Explain that energy is required by a system whenever attractive forces between particles are broken and that energy is released from a system whenever new attractive forces form between particles (bond-breaking vs. bond-forming)

2.3.3 Identify and explain that energy changes are observed during phase changes and chemical changes where forces of attractions between particles are formed or broken yet no change in the temperature of the system occurs.

2.3.4 Calculate heat changes for changes of state.

2.3.5 Calculate heat changes when a substance changes temperature.

2.3.6 Calculate total heat absorbed or released by a system.

Notes for Teaching and Learning

It is very important for students to understand that during chemical and phase changes there is no change in temperature of the ***system*** although temperature changes may be observed in the ***surroundings***.

For example, a candle burns and releases energy equal to the change in potential energy between the reactants (candle wax and oxygen) and the products (CO_2 and H_2O). This energy is observed as it warms up the surrounding air and unburned candle wax (melted wax). This concept is more easily understood in phase changes because, for example, everyone is familiar with pure water freezing at 0 ºC, and at 0 ºC only (at 1 atm).

It is often valuable to get students to heat a beaker of ice and measure the temperature during the process. Students are often astonished that as long as there is ice present, there is no change in temperature. Similarly as long as the liquid is boiling the temperature stops rising.

Break energy changes for systems e.g. ice at -35ºC steam at 110ºC into its various separate steps for the students. Ask them to identify how they would calculate the heat required for each step.

Suggestions for Assessment

Instructors should check student answers to all study guide questions.

Additional questions such as the following can be used:

How much heat is released as 150 g of steam at 125ºC is cooled to water at 25ºC?

How much heat is required to convert 15 g of ice at -40ºC to water at 6.5ºC?

Instructors could also select questions from the Section Review, Chapter Review, or Unit Review to assign for assessment of students' understanding of the concepts covered in this unit. Full solutions for all problems in the text are provided on the Teacher's Resource CD-ROM. The CD-ROM also provides chapter tests with solutions. Instructors could select questions from the chapter tests and/or the computerized assessment bank for use as assessment and/or evaluation tools.

Resources

MGH Chemistry: pages 643-647; 653-655.

MGH Chemistry, Teacher's Resource CD-ROM.

MGM Chemistry 11/12, Computerized Assessment Bank CD-ROM.

Unit 3 - Calorimetry and Hess's Law

Outcomes

3.1 Understand how to measure heat changes

3.1.1 Identify the basic instrument for measuring heat transfer and the assumptions made in heat transfer experiments.

3.1.2 Apply the equation $q_{system} = -q_{surroundings}$ to determine heat transfer.

3.1.3 Calculate heat changes for simple processes.

3.1.4 Measure the enthalpy of neutralization for the reaction of hydrochloric acid and sodium hydroxide.

Notes for Teaching and Learning

Students commonly forget to change the sign for heat. If the temperature of the system rises in a coffee cup they generally think of this as the ***reaction*** being endothermic.

Remind them that the contents of the coffee cup is increasing in temperature because the ***system*** is releasing heat ***to*** the ***surroundings***. The reverse happens for an endothermic process. The system absorbs heat from the surroundings and the measured temperature drops.

Investigation 17-A is easy to perform. If HCl is not available, acetic acid (vinegar) could be used. If NaOH is not available, solid baking soda ($NaHCO_3$) can weighed and used. You may have to experiment with quantities to determine what gives a reasonable temperature change.

Consult the MGH Chemistry Teacher's Resource for safety precautions and tips on carrying out the lab and for answers to all the lab questions.

Suggestions for Assessment

Questions similar to the Sample Problem on page 663-664 can be given using different metals.

Also, other acid -base reactions similar to that done in the lab, can be used as examples for practice. Blackline Master 17-1 can be used here.

Students must complete and submit the Core Lab for grading. If they have not submitted lab report to you before, they will need guidelines.

Resources

MGH Chemistry pages 660-664.

Core Lab:
Investigation 17-A, "Determining the Enthalpy of a Neutralization Reaction", pages 668-669.

BLM 17-1, "Enthalpy of Neutralization".

Outcomes

3.2 Understand Hess's Law of Heat Summation.

3.2.1 State Hess's law of heat summation.

3.2.2 Draw enthalpy diagrams to show how the enthalpy for a reaction can be determined from several separate enthalpy changes.

3.2.3 Determine the enthalpy change of an overall process using the method of addition of chemical equations and corresponding enthalpy changes.

Notes for Teaching and Learning

Keep the problems used here to two step processes. Students frequently find that using enthalpy diagrams gives them a better understanding of Hess's law applications.

If time and equipment permit, try Investigation 17-C. Completing this investigation will give students further experience in calorimetry calculations as well as a two-step Hess's law calculation. Consult the Teacher's Resource for safety precautions and tips for carrying out the investigation.

Instructors should point out that Hess's law is a method of determining ΔH for reactions that are too difficult, too expensive, too slow, or too dangerous to measure experimentally (eg. using calorimetry).

An analogy is useful here to illustrate that Hess's Law is based on the concept that the energy involved in a chemical reaction is independent of the path taken to change reactants into products. An example might be to suggest the whole class meet at a a particular spot later in the day. Each person may take a different route but the outcome is the same.

Suggestions for Assessment

Study Guide questions 3.9 and 3.10 cover outcome 3.2. Instructors could assign problems similar to practice problems 11 and 12 on page 681 for extra practice.

Instructors should check student answers to all study guide questions for this unit and provide extra practice if needed.

Resources

MGH Chemistry: pages 677-681.

Unit 4 - Collision Theory, Reaction Mechanisms, and Catalysts

Outcomes

4.1 Understand the meaning of rate of a reaction and the factors that affect reaction rate.

- 4.1.1 Define reaction rate.
- 4.1.2 Recognize that reaction rate can be measured by monitoring a variety of changing macroproperties including; mass, colour, volume and pH.
- 4.1.3 Identify the factors that affect reaction rate.

4.2 Describe collision theory and its connection to factors involved in altering reaction rates

- 4.2.1 State the Kinetic Molecular Theory (KMT) of matter.
- 4.2.2 State the collision theory.
- 4.2.3 Explain using collision theory how temperature, concentration/pressure, surface area and nature of reactants affect the rate of reaction.
- 4.2.4 Describe the effect of a catalyst on the rate of reaction.

Notes for Teaching and Learning

Instructors should introduce the topic of rates of reaction by using examples to point out to students that reactions proceed at varying rates and sometimes do not occur at all. They should make sure that students realize that rate of reaction is a measurement of a change in quantity over a change in time.

Instructors could demonstrate some of the macroproperties that can be observed to measure rate of reaction (see Resource Guide, p.187).

Explain to students that a balloon stays inflated due to the ideas of the KMT (Kinetic Molecular Theory). According to the KMT, the gas particles are in constant motion, moving as far apart as possible. The ideas of the KMT also apply to the diffusion of the scent of perfumes through a room.

Instructors should note that there are many generalizations regarding the effect of nature of reactants on reaction rate. Students should realize that the type of bonding within reactants and products has a profound impact on reaction rate.

It would be useful to provide students with the opportunity to visualize reactions occurring at the molecular level. Videos and the Internet are good sources for animations and simulations of collisions and reactions in 3-D.

Suggestions for Assessment

Instructors will find questions that may be used for review, reinforcement and/or assessment in the Section Review, Chapter Review and Unit Review in the text. There are *Additional Practice Problems* found on the *Teacher's Resource CD-Rom*.

Instructors could direct students to the text website. It contains Study Quizzes for Chapter 12 that students could use for self assessment.

Resources

MGH Chemistry, pages 460-481.

Teacher's Resource for MGH Chemistry (including CD-Rom).

Website for the text: http://www.mcgrawhill.ca/school/booksites/chemistry/index.php

Department of Education website: http://www.ed.gov.nl.ca/edu/science_ref/chem3202.htm

The centre for distance learning and innovation website: http://www.cdli.ca/

Unit 4 - Collision Theory, Reaction Mechanisms, and Catalysts

Outcomes

4.2.5 Define, draw, and label a potential energy diagram for exothermic and endothermic reactions (overall or one-step mechanism). Include:
(i) labelled axis
(ii) activation energy
(iii) activated complex site
(iv) ΔE
(v) reactants and products

Notes for Teaching and Learning

Full solutions for Practice Problems are in the *Solutions Manual* on the *Teacher's Resource CD-Rom.*

Suggestions for Assessment

Students should draw a potential energy diagram and they should correctly label it for an endothermic and exothermic reaction. Include the shape of the curve, correct labelling for activation energy and energies of reactants, products, and activated complex.

Students can be given BLM12-2, "Potential Energy Diagrams", for assessment of their skill level in drawing and interpreting potential energy diagrams.

Instructors should check student answers to all questions assigned in the study guide for this unit.

Instructors should choose appropriate Section Review, Chapter Review, and Unit Review questions to be completed for review, reinforcement and assessment of how well the student has achieved success in reaching the outcomes for the chapter.

BLM 12-3, "Chapter 12 Test" (or portions of it), can be used to assess student understanding of the concepts in Chapter 12.

A final comprehensive exam should be given for the course. The mark on the exam should comprise at least 50% of the final mark for the course.

Resources

" Web Links" referenced on the textbook's website under *Teacher Resources.*

CDLI website at www.cdli.ca/

Teacher's Resource CD-ROM, BLM 12-2, "Potential Energy Diagrams". BLM 12-3, "Chapter 12 Test".