# Introduction to Chemistry Connections

**Introduction**

As a student attempting to successfully complete senior level secondary school chemistry, you will find this exciting 50-part series extremely effective. It will help you develop the major concepts in Thermochemistry, Electrochemistry, Chemical Equilibrium and Acid-Base Chemistry. In addition, you will discover that this series connects science, technology and society to the themes of matter, change, energy, systems, equilibrium and diversity.

Your presenters will be senior high school chemistry teachers, fellow students, college and university professors, or professionals in technologies with strong chemistry connections. They will work with you to provide instruction by illustrating chemistry concepts in the form of demonstrations, laboratory experiments, technological applications and examinations of the impact of science and technology on society.

**Prerequisite Knowledge**

To achieve the objectives in this series of programs, you should already have an understanding of the basic chemical principles taught in an introductory high school chemistry course. These prerequisite chemistry topics should include the following:

- Classifying matter, elements and the Periodic Table
- Atomic theories and chemical bonding theory
- Classifying compounds and chemical nomenclature
- Writing, balancing and classifying chemical reaction equations
- Classifying solutions, and the concentration and solubility of solutions
- Kinetic Molecular Theory and the behavior of solids, liquids and gases
- Mole calculations and stoichiometry calculations for chemical reactions
- S.I. (Système International d'unités) unit conversions, scientific notation and significant digits

**What's in This Course**

This course consists of the following materials and activities:

- A series of 50 video programs
- Three Activity Guides to help you work through the video materials

# Introduction to Chemistry Connections

In general, you will read the **Program Synopsis**, **Prerequisite Knowledge**, and **Learner Expectations** sections for the assigned video program. Then you will watch the video and do the activities listed for that program to help you work with and remember the concepts. This will help you gain the maximum benefit from this series and lead to success in writing unit or external examinations. You should supplement the questions and problems explained in the programs with reading and practice exercises on related topics found in senior level secondary school textbooks.

As you work through the materials, you'll use the following study aids:

- Prerequisite Knowledge
- Learner Expectations
- Additional Information
- Video Pause Point Icons

**Prerequisite Knowledge**

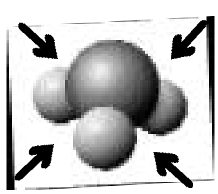
This section lists the knowledge you should have before you view the video and work through the material in your resources.

**Learner Expectations**

This section lists the things you should be able to do after you have viewed the video and worked through the associated materials.

**Additional Information**

Additional Information sections provide material which reviews specific ideas or problems from the video or is supplementary to the video program, but which will aid in your understanding of concepts. Additional Information may contain definitions, examples, solutions to problems, or discussions of concepts. Not every program will have an Additional Information section.



In some of the video programs, the icon to the left will be displayed in the lower part of your television screen to indicate a pause point. When you see this icon, check the unit to see what activities you should do before you continue the program. In some programs, some pause points will refer to material in the Additional Information section.

# Introduction to Chemistry Connections

## Suggestions for Classroom Learners

Your teacher will assign all or part of the *Chemistry Connections* material to you. The programs and activities may be used to:

- Supplement classroom instruction by either viewing a program in its entirety (with appropriate pauses) or by viewing selected segments appropriate to your lesson.
- Assist you in working independently or in an individualized mode.
- Enable you to "catch up" if you have been absent from classes.
- Review for examination preparation.

Follow your teacher's instructions for using the materials.

## General Guidelines

### Significant Digits and Manipulation of Data

The rules of significant digits used throughout this series are those commonly adhered to in scientific fields or studies. These rules address the apparent inconsistencies that may arise from time to time when you do a series of calculations. The rule you should follow is to do all calculations with the calculator running. Then round the final answer to the same number of significant digits contained in the quantity (given or measured) with the fewest number of significant digits.

When you write intermediate results, or print them in graphics, round the results to the appropriate number of significant digits. But remember, don't carry an intermediate result forward, and don't use it when you verify calculations. Instead, use the running calculator quantity.

# Nuclear Changes

**Program Synopsis**

In Program 13, the presenters:

- Compare the energy of phase changes, chemical changes and nuclear changes.
- Explain the conversion of mass to energy using Einstein's equation, $E = mc^2$.
- Trace the path from the discovery of radioactivity to the development of the fission bomb.
- Explain the concepts of radiation, fission and fusion within an STS context.

**Prerequisite Knowledge**

To achieve the objectives of this course, you should have an understanding of the basic chemical principles taught in an introductory chemistry course as specified in the Introduction to this course. To achieve the objectives of this program, you should also be familiar with the following specific concepts and skills from an introductory chemistry course(s) or from preceding programs:

- Atomic theory
- Chemical bonding
- Potential energy graphs and heating curves

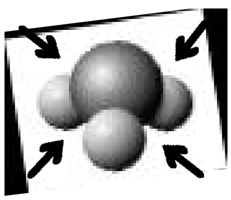
**Learner Expectations**

After you view this program and complete the activities, you should be able to:

- Write balanced reaction equations that include the energy change.
- Use and interpret change in enthalpy notation for communicating energy changes.
- Define molar enthalpy of nuclear change.
- Compare phase, chemical, and nuclear changes in terms of the magnitude of the energy involved.
- Provide simple qualitative explanations based on intermolecular forces, chemical bonds, and nuclear forces for the energy changes that occur during phase, chemical, and nuclear changes to matter.
- Recognize nuclear fission and a fusion reaction.

# Nuclear Changes

- Draw and interpret energy diagrams based on experimental data, for example, heating curves and potential energy diagrams for phase, chemical, and nuclear changes.
- Express an interest in the energy transformations happening around you.
- Express a sense of responsibility toward the use of energy.



**Watch the video program now.**

## Additional Information

The relative magnitudes of energy available from phase, chemical and nuclear changes are summarized in the chart below.

| Change | Reaction Equation | Energy Released Per Mole of Hydrogen Atoms Involved |
|---|---|---|
| **PHASE** | $H_2O_{(l)} \rightarrow H_2O_{(s)}$ | 3.02 kJ |
| **CHEMICAL** | $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$ | 120.9 kJ |
| **NUCLEAR** | $4\ {}^{1}_{1}H \rightarrow {}^{4}_{2}He + 2\ {}^{0}_{1}e^{-}$ | $6.2 \times 10^{8}$ kJ or 620,000,000 kJ |

Another perspective on the magnitudes of energy available in chemical and nuclear changes is to consider that the nuclear energy released from the fusion of 1 mole (1.01 grams) of hydrogen-1 atoms is equivalent to the thermal energy released from burning nearly 20,000 liters of gasoline.

# Nuclear Changes

**Question**

Arrange the following reaction equations in order of increasing enthalpy change.

1. $CH_{4(g)} + 2O_{s}(g) \rightarrow CO_{2(g)} + 2H_2O_{(g)}$

2. $H_2O_{(g)} \rightarrow H_2O_{(l)}$

3. $^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$

4. $H_2O_{(l)} \rightarrow H_2O_{(s)}$

**Nuclear Fission**

In **fission**, a heavy nucleus absorbs a neutron and breaks apart to give much lighter nuclei plus two or more neutrons, and much energy.

The energy released by the fission of 1 kg of uranium-235 is approximately $8 \times 10^{13}$ J. This is enough energy to keep a 100-watt light bulb burning for 3,000 years. This amount of energy is equivalent to the energy released by burning 3,000 tons of coal or 13,200 barrels of oil.

**Nuclear Fusion**

At sufficiently high temperatures, light atomic nuclei will **fuse** together to give a heavier nucleus and much energy.

The energy released by fusion to produce 1 kg of helium-4 is approximately $6.8 \times 10^{14}$J. This is enough energy to keep a 100-watt light bulb burning for 25,500 years. This amount of energy is equivalent to the energy released by burning 25,500 tons of coal or 112,200 barrels of oil.

Both fission and fusion reactions are exothermic. As nuclear reactions proceed, the observed masses are always a trifle smaller than the calculated nuclear masses. The mass difference represents mass converting to energy according to the Einstein equation $\Delta E = \Delta mc^2$. $\Delta E$ is the change in energy, $\Delta m$ is the mass difference, and $c$ is the velocity of light.

# Nuclear Changes

**Radioisotopes**

Radioisotopes are used in medicine largely in the treatment of cancer. Radioisotopes are involved in two types of therapeutic applications: teletherapy (external exposure) and in internal radiation treatments. A few examples of therapeutic applications follow.

### Teletherapy

Teletherapy has been used to treat Cushing's disease. This disease is often caused by the overproduction of a hormone produced by the pituitary gland. Doctors direct a source of X-rays or gamma rays at the pituitary to slow down the production of the hormone.

### Internal Radiation

Some radioisotopes are selectively absorbed by organs in the body. For example, radioactive iodine goes only to the thyroid. As a consequence, its radiation is concentrated and may destroy tumors located there.

### Brachytherapy

A partially radioactive wire is implanted at the site of a tumor.
The radiation then attacks the tumor.

### Boron-10 Neutron Capture

Boron-10 (a non-radioactive isotope) is administered to a patient. This is followed by external irradiation with neutrons. Boron-10 becomes radioactive when hit by neutrons, and produces cell-killing alpha particles only at the site of the tumor.

Radioisotopes are also used in:

- Medicine to diagnose diseases.
- Agriculture to test the effects of herbicides, pesticides and fertilizers.
- Chemical analysis of trace elements in samples.
- Chemistry and biochemistry to study chemical reactions and molecular structures.

If you want more information on radioisotopes, read the following sources:

- *Addison-Wesley Chemistry* (SI Edition). Antony C. Wilbraham, Dennis D. Staley, Candace J. Simpson, and Michael S. Matta. USA: Addison-Wesley Publishing Company, Inc., ©1993. ISBN 0-201-60202-4.
- *Fundamentals of Chemistry General*, Organic and Biological. Joseph DeLeo. USA: Scott, Foresman and Co., ©1988. ISBN 0-673-16591-4.
- *ChemCom Chemistry in the Community*. W.T. Lippincott, American Chemical Society Principal Investigator. USA: Kendall/Hunt Publishing Co., ©1988. ISBN 0-8403-4423-6.
- *Foundations of Chemistry* (2nd Edition). Ernest R. Toon, George L. Ellis, Larry Doyle, John Ivanco, and Stan Percival. Toronto, Canada: Holt, Rinehart and Winston of Canada, Limited, ©1990. ISBN 0-03-922287-X.
- *Chemistry* (3rd Edition). Steven S. Zumdahl, University of Illinois. USA and CANADA: D.C. Heath and Company, ©1993. ISBN 0-669-32462-0.
- *Chemistry* (5th Edition). Raymond Chang, Williams College. USA: McGraw Hill, Inc., ©1994. ISBN 0-07-011003-4.