CONNECTING CORE CONCEPTS
WITH EVERYDAY CHEMISTRY

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By

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ABSTRACT

The rationale for this project is based on the recognition that chemistry courses tend to be taught too much from a theoretical standpoint, with little reference to everyday life. This is one of the reasons that a majority of students think that chemistry is difficult, boring, tedious, and uninteresting (Worthy, 1982). If they have the choice, many students would rather not take a chemistry course, and if they do, it will probably be their last course in Chemistry.

It is the intent of the Ontario Curriculum Guidelines to provide some science-technology-society connections. The aim of this project is to provide supplemental science-technology-society connections, and selected concrete examples of practical, everyday chemistry for teachers, so that they may enrich their classes, motivate their students, and put theory into an appropriate context. If classes are more interesting and relevant to the world of the students, then more students could be motivated to take chemistry courses and consider continuing to more advanced classes. A second purpose for this project is to stimulate a typical non-science student's interest in chemistry and science. It is even more necessary to motivate these students by providing interesting connections with the real world and suitable applications of theory and principles. These connections with the real world

are important for such students, so that they will be better able to make informed decisions as scientifically literate citizens, managers, or politicians, not only for themselves, but for the benefit of society as a whole.

To accomplish the aims of this project, two or three short hand-outs of practical everyday chemistry were prepared for each of the core topics in the Grade 11 (SCH 3A) and Chemistry OAC (SCH OA) courses. A few of the examples included Dental Chemistry, Culinary Chemistry, Insect Pheromones, and Teflon.

Results of the survey taken from chemistry teachers showed that these hand-outs would better motivate students to study chemistry. Teachers think it is useful for their classes. They would like a compilation of these examples, if one were to be made available.

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CHAPTER I

INTRODUCTION AND BACKGROUND

The high school introductory chemistry course is very important because it has the potential of affecting the attitudes of students towards chemistry for the rest of their lives. As is shown in the literature, the prevailing attitude of most students now is that chemistry is difficult, boring, and only for the intellectually-motivated person (Laurie, 1993). This is a major reason why fewer students take the course, especially if it is optional, and even fewer continue into more advanced chemistry courses. The purpose of this project is to enrich the high school chemistry courses, SCH 3A (Grade 11 Chemistry) and SCH OA (Ontario Academic Credit Chemistry) with several examples of interesting, practical, everyday chemistry - chemistry that touches the lives of everybody, chemistry of the real world - in an effort to encourage more students to take chemistry and/or continue into more advanced courses.

Another purpose of the project is to expose non-science students who take the introductory chemistry course to enough chemistry and its applications in everyday life that they will be able to make rational decisions about science and technology in the future. It is important to achieve this, to enable non-scientists to "overcome fears that might prevent them from launching a lifetime learning experience about science and technology." (Mooney, 1985)

Non-scientists, such as lawyers, MBA's, managers, and politicians, play an important role in running the country. Since science and technology contribute many solutions to the problems of the country, as well as cause some problems, it is important that leaders of the country or those that make laws and decisions about how the country is run, need to know about scientific principles and their applications in everyday life.

Civilization "has always been limited by technology, and can only rise to a level that is limited by the state of technological achievement at any particular time" (Westheimer, 1985); therefore, it is important that our lawyers, businessman, writers, and leaders of the country ought to be able to understand science and technology, and "make informed decisions with respect to technological matters." This is very important to the welfare and security of the people in the country that these leaders serve.

HISTORICAL BACKGROUND

When Charles Eliot became president of Harvard University in 1869, he made high school science one of the requirements for admission to Harvard. In 1886, Josiah Cooke published a pamphlet containing 83 chemistry experiments, 60 of which had to be completed and reported by high school students. Cooke's pamphlet developed standards for chemistry as a laboratory subject in high school. Due to Eliot and Cooke's initiatives, the nature of high school chemistry was changed from primarily a lecture course, with occasional demonstrations, to a laboratory course (Walford, 1983).

In 1932, the National Society for the study of education suggested that science be taught in the framework of human affairs. In 1939, physicist J. D. Bernal wrote that "the effectiveness of any scheme of scientific education is shown by the place science takes in everyday life." (Lagowski, 1988).

In 1957, the Soviet Union launched SPUTNIK, the first satellite in space. This accomplishment ushered in a period of soul-searching and questioning by the United States. The country's leaders reacted by putting some of the blame for falling behind in space science on the schools, particularly the mathematics and science curricula.

The American Chemical Society, in response to the criticism by the government of the math and science curricula, funded a committee which came up with the three general deficiencies of the high school chemistry curricula (Walford, 1983). They were:

1. Preoccupied with the memorization of history, descriptive detail, and technology.
2. Not emphasizing the major unifying concepts and principles of modern chemistry.
3. Devoid of meaningful laboratory work.

The committee, in 1959, also developed a new course known as Chemical Education Materials Study (CHEM Study), which used the "inquiring approach in developing concepts and in laboratory investigation." Although this course was popular in the 1960's and 1970's, its popularity eventually diminished.

Curricular reforms made by the impact of SPUTNIK were found to be too difficult for a majority of students, since they were too theoretical and abstract. Science became less interesting to most students, and fewer students took the courses. Bill Aldridge, executive director of the National Science Teachers' Association, observed that the curricular reforms of the 60s were "purist and elitist," and were "far too difficult for the majority of students," since it was "too heavy on theory and abstraction, and applications were eliminated." (Walsh, 1980)

The 1970's saw more and more young people aspiring to have a college or university education, and to earn a degree. The long period of relative prosperity in North America had made it possible for more students to enter college. These students began to appreciate the financial value of an education more than its intellectual value. Increased immigration also brought about the increasing number of minorities who wanted access to higher education as a means of improving their socioeconomic status.

These students encountered a science curriculum developed during the 1960's that assumed a high degree of student motivation, and had little connection to the real world that the students were familiar with. They were fed a diet of formal treatments of such theory as reaction kinetics, thermodynamics, and valence, with little application in everyday experience. Students who were highly intellectually motivated succeeded, but average students started to regard chemistry courses as a "series of artificial and unpleasant hurdles which for obscure reasons they are required to surmount," (Walter, 1982) in order to earn their degrees, certifications, or as a prerequisite for university.

Reacting to this scenario, Robert I. Walter wrote in 1972, that the approach to teaching introductory or elementary chemistry should be changed to make it more meaningful and useful to a large number of students whose interest and educational objectives lie elsewhere. He suggested that teachers should increase motivation by using more demonstrations and by establishing connections of chemistry to the real world. He added that instead of keeping our students busy mastering information and theory, that they should have an opportunity to appreciate chemistry and leisurely contemplate it (Walter, 1982).

In June, 1978, high school, college, and university teachers from the United States, Canada, and several countries held an international conference on Introductory Chemistry at McMaster University in Hamilton, Ontario, Canada. Their main concern was that the introductory courses had too many complex abstract principles and theories, and that this was encouraging a widespread negative attitude toward the subject.

Their main consensus after the meetings was to "reintroduce significant amounts of descriptive chemistry on which the theories were constructed." (Benfey, 1980).

They recognized that there was an imbalance in the introductory chemistry curriculum at both the secondary and post-secondary level, and agreed that the high school curriculum should be designed to "emphasize the social relevance of the subject and give students an understanding of the properties of the materials they might encounter in domestic and industrial situations." (Gillespie and Humphreys, 1980).

The period between 1980 to the present has been characterized as the third critical period in the history of science education. It is critical for several reasons: the shortage of competent math and science teachers, low enrollments in math and science, and increasing public ignorance of science and technology-related topics (Worthy, 1982).

Shortage of competent math and science teachers.

The shortage of high school math and science teachers in the 1980's was attributed to lack of incentive. One reason for this is that 1970 predictions of a teacher glut in the future have been taken seriously by a lot of college students, and fewer have been studying to be teachers of any kind.

Sarah Klein, (Worthy, 1982) then retiring president of the National Science Teachers Association (NSTA) in 1982, cited a survey that indicated a critical shortage of chemistry teachers in 10 states and a shortage in 27. Another survey (Worthy, 1982) also indicated that in 1981, five times as many science and math teachers left the schools to non-teaching jobs than left to retire; and that the average age of the science/math teacher was 41.

The question of competence and quality of science and math education, which surfaces at times, is due to the fact that science teachers face budget cuts for supplies, equipment, workshops, and in-service training. According to Klein, about 40% of teachers have never attended a workshop since they began teaching, 51% say their undergraduate training gave them no preparation to teach science, and 71 % have never had in-service training in science and had no science consultants in their schools. Klein also contends that government support for science programs has declined steeply.

Low enrollments in math and science.

Low enrollments in traditional science courses was attributed to the "new" curricula initiated after the SPUTNIK era, that concentrated heavily on pure science, and appealed mainly to the highly intellectual students. It had little relevance to everyday life.

The amount of material to be learned increased dramatically, and during the 1960's chemistry was regarded, as Ronald Ratney (Ratney, 1968) put it, as an "ivory tower enterprise in which they (students) did not see themselves." When young people come to college "expecting that they will learn to cope with the world, how to improve it, and make a living in it," and not do find what they want in science courses, they will desert science for other fields.

Davenport suggested in 1968 that chemistry courses placed "too much emphasis on math and not enough chemistry itself," hence suiting only 10% of the students. He later observed that the students had too much theory and were out of touch with reality (Lloyd, 1992).

In 1980, Aaron J. Ihde (Ihde, 1980) suggested that thousands of chemistry students find no relationship between chemistry and their lives, because it was "taught as if it is a mental exercise."

Another reason proposed for the low enrollments in the science is that many of the courses are not mandatory. Students perceive that science and math courses are harder than other options, and they simply choose the path of least resistance or the easier way out in the absence of coercion, initiative, or motivation. A majority of high school students think science course are too boring, have a lot of unfamiliar terms, place undue emphasis on memorization of unrelated facts, and are irrelevant to everyday life (Worthy, 1982).

Increasing scientific illiteracy.

The 1970's showed a 10% decline in science knowledge and a 16% drop in basic mathematics skills. A 10-point drop in the average SAT scores in 1975 was the largest reported ever. Public interest in science, high at the beginning of the 1960's, petered out in the 1970's (Worthy, 1982). In 1980, Lippincott (Lippincott, 1980) suggested that the increased complexity in science caused this increased scientific illiteracy. He also added that society was now more interested in a pleasure-seeking lifestyle, to the detriment of intellectualism. This factor caused a decreased interest and skill in chemistry.

This decreased scientific literacy was just an effect of the previous factors - decreased enrollments in science courses, and lack of competent science teachers. A basic understanding of science is necessary to be scientifically literate. Scientific literacy is increasingly important in all areas of public concern. Although these are studies done in the United States, it is assumed that they would also apply to the Canadian context.

This decrease in scientific literacy among the general public is perceived to be harmful. The National Academy of Sciences lists the harmful effects as follows: 1) weakened national security; 2) lessened ability to compete in the technological world; and 3) increased unemployment (Heylin, 1982).

CHAPTER 2

EVIDENCE OF IMBALANCE IN THE CURRICULUM IN THE 1990'S

The general chemistry curriculum has been the subject of several papers, conferences, and symposia over the past thirty years. Among the pitfalls of the introductory chemistry course were: boring lectures, little relevance to everyday life, poor to mediocre quality of teaching, and lack of discussion of chemistry-related issues prominent in the media. It was pointed out by J. N. Spencer (Spencer, 1992) that never before "has there been such a consensus movement toward the reconsideration of the general chemistry curriculum."

A lot of chemistry students are confused, and their confusion lies in the fact that they must work in four different worlds: a macroscopic world in which they do their experiments; a molecular world in which they interpret their data; a symbolic world, where one symbol may have different shades of meaning, for example, "Na" stands for a shiny metal which reacts vigorously with water, and an infinitesimally small particles which contains 11 protons, 11 electrons, and 12 neutrons; and the world students are aware of in their everyday life, that many times has no relationship to what they learn in chemistry (Spencer, 1992).

So what is perceived to be wrong about the general chemistry courses today? George Bodner (Bodner, 1992) of

Purdue University states plainly that "something is wrong with the way science is taught, and we need to restructure science education." He proposes that it might be useful to consider the following approaches: (1) restructure the curriculum; (2) increase efforts to attract young children to science; and (3) convince teachers to change the way science is taught at the elementary and secondary levels.

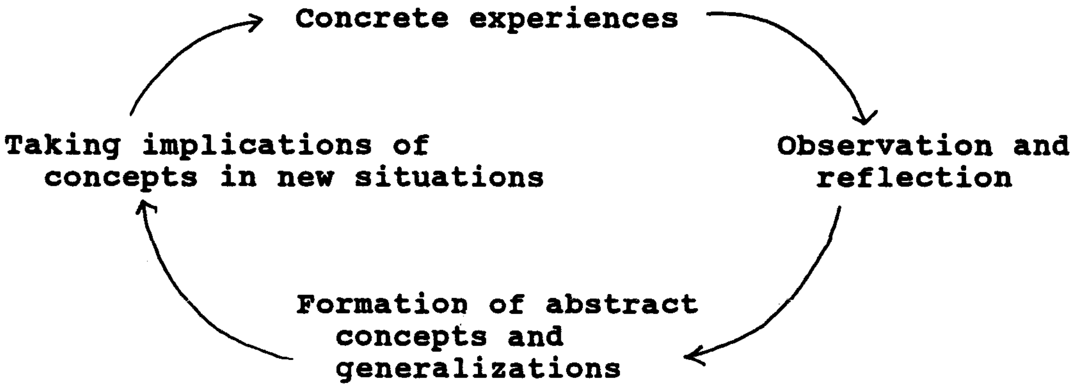
Bodner also enumerates general rules for determining the optimum psychological order for presentation of material:

1. Start with a topic closest to the student's experience.
2. Build from their experiences toward more abstract ideas when a student senses a need for some way to explain an observed phenomenon.
3. Teach from specific to general.
4. Start with systems that have relatively few parameters toward more complex systems.

David A. Kolb and associates (Kolb, Rubin, and McIntyre, (1986), portray learning as a four-stage cycle: (1) concrete experience, (2) observation and reflection, (3) formation of abstract concepts and generalizations, and (4) hypotheses to be tested in future action, which in turn leads to new experiences. This model of the learning process is continuously recurring. Kolb also states that we "test our concepts in experience and modify them as a result of our observation of the experience," therefore, "all learning is relearning and all education is reeducation."

On the other hand, Kolb also recognizes that learning is governed by individual needs and goals, and the learning process is highly individualized in the direction learning is to take place and in the process one chooses to pursue.

The following illustration shows the pattern that Kolb emphasizes:



Kolb suggests that an effective learning experience should include the complete cycle and that it is better to begin with concrete experiences than with abstractions and generalizations. The concrete experiences that practical, everyday chemistry offers are important in the learning cycle, and help to reinforce the formation and understanding of abstract concepts.

Ronald J. Gillespie of McMaster University (Gillespie, 1991) takes the view that high school and first-year college chemistry courses must take the blame for the current state of affairs. He believes that chemical or science literacy depends on improvements in science education at the elementary and high school level, since it seems that these introductory courses, instead of exciting students' interest and improving motivation, are killing any interest, and are discouraging students from taking more chemistry courses, even preventing them from being chemistry majors.

Gillespie further outlines what in his opinion is wrong with the introductory chemistry course. He says the course contains too much material; too much emphasis is placed on physical chemistry and solving numerical problems; there is an overabundance of difficult and abstract theory; and its content is geared towards chemistry majors and does not fulfil the needs of the majority of students in the course. He recommends that an introductory chemistry course should deal with properties, reactions, and uses of substances, and should stress that "chemical reactions are the basis of life and the basis of modern civilization." He further adds that there should be a balanced treatment of facts and applications with appropriate concepts, principles, and theories.

Thomas Shiland (Shiland, 1995) writes that introductory chemistry textbooks are filled with too much abstract material. He refers to Pauling's belief that the material is being presented "at an advanced yet superficial level, which makes understanding by the average student virtually impossible." Pauling also felt that the abstract material in textbooks turns students away from chemistry. Abstract here means that it is not related to sufficient concrete phenomena. Shiland reflects, "How many talented students have we lost because they gave up trying to make sense out of pages of abstraction?"

The American Chemical Society (Sutnam and Bruce, 1992), taking into account the general concern that present high school chemistry textbooks are "encyclopedic" in nature and that traditional courses have little relationships between science and technology, developed through its Education Division a year-long chemistry course called Chemistry in the Community (ChemCom).

This program was developed over a period of eight years at a total cost of 1.5 million dollars. It was designed for high school students who have little interest in more theoretical aspects of the subject, but who would benefit from "varied experiences with some level of higher order cognitive processes in approaching both science and significant issues facing them personally and facing the nation." ChemCom is also intended to motivate students to learn more chemistry through addressing issues that affect them personally and society as a whole. In ChemCom, the societal issues are used as a vehicle for understanding chemical principles, which is opposite to that of a traditional chemistry class which studies mainly the concept and theory first. The ChemCom method is consistent with Kolb's learning cycle, which starts with concrete experience.

The evaluation of ChemCom (Sutnam and Bruce, 1992), conducted by five independent researchers over five years revealed some pertinent observations that will probably affect the teaching of high school chemistry in the future. Two student groups from an inner-city science-oriented high school

- one which had already completed a traditional course, and one which had no formal chemistry instruction whatsoever - both asked for "chemistry experiences" that could be applied to resolve environmental issues. The evaluation also gave an indication that ChemCom motivates students to pursue the next level of advanced study in chemistry and other sciences. The study also may indicate that the ChemCom approach can adequately supply the needs of both non-college and college-bound students, as well as majors or non-majors alike. It was concluded (Sutnam and Bruce, 1992) that ChemCom gives students an opportunity to construct their own world view of chemistry and its applications, thus providing them with better motivation to undertake further study in the sciences.

Robert E. Laurie (Laurie, 1992) writes that "it can be argued that the introductory high school chemistry course is the most important of all chemistry courses." Many grade 11 students will either drop out, not attend university, or choose another area of study. The introductory high school chemistry course is probably the first and last chemistry course for a fairly significant number of students. Since most students perceive chemistry to be "hard, boring, and useless," it is extremely important that any high school introductory chemistry course be made relevant and down-to-earth so that it may become interesting. Laurie reiterates what and others (Gillespie, Bodner, etc) have observed - that the emphasis of applications of chemistry and numerous examples of everyday chemistry which students can relate to in their daily lives, rather than abstract theories and mathematical operations, should be a major part of an introductory chemistry course.

H. Eric Streitberger (Streitberger, 1988) outlines ways of integrating issues like nutrition and diet, drug abuse, pollution, toxic waste disposal, ozone depletion, and others in the classroom. He enumerates what other groups believe should be included as some of the goals of the high school chemistry curriculum:

1. To prepare students to use science and technology in understanding and improving (students') daily lives.
2. To apply scientific knowledge to everyday life; and to introduce social and environmental implications of scientific and technological development.
3. To use current societal issues and problems to meet the needs of our society and of students.
4. To emphasize at all levels the social and human relevance of chemistry.
5. To use attitudes and knowledge about science to live as an informed citizen in a scientifically developed nation.

The province of Alberta has initiated an ALCHEM program that integrates Science, Technology, and Society (STS approach). This program utilizes to the maximum local industries that apply various chemical concepts, procedures, and techniques (Sutnam and Bruce, 1992). ALCHEM recognizes the importance of "technological and industrial applications of chemistry, particularly the effect of chemistry on the student's day-to-day life (Bodner and Heron, 1980). Alberta Education has provided a model that other schools all over

Canada should look into and try to emulate.

In response to the 1989 National Science Foundation (NSF) call for "broad curricular change in chemical education," the American Chemical Society's Division on Chemical Education formed a Task Force in 1990 for the revision of the general chemistry curriculum. The general chemistry curriculum is very similar to the Chemistry OAC curriculum. One of the recommendations to the change in the curriculum was to "make apparent the link among the topics of the course and between the topics and the life experience of the students" (Lloyd and Spencer, 1994).

To provide more time to introduce and study various applications of chemistry, abstract topics like thermodynamics, quantum mechanics, molecular orbital theory, and free energy are to be left out of the introductory chemistry course. These topics could be introduced in later courses for chemistry majors.

To help teachers implement the recommendations of the Task Force, a monograph on the new curricular change was published (Lloyd, 1994). The document includes historical changes in chemistry teaching through the years, different ways of translating Task Force recommendations into action, new and innovative methods of teaching core topics, and ways of linking real problems into student assignments and laboratory sessions. If these changes will make chemistry relevant and interesting to students, they are worth doing.

CHAPTER 3

SOLUTIONS TOWARDS RESTORING THE BALANCE IN THE CURRICULUM:

THE TEACHER'S ROLE

In 1988, the National Assessment of Educational Progress compared the educational achievements of students in thirteen of the most industrialized nations of the world. Eva M. Ogens cited that more than 300 national reports since 1983 have pointed to the low level of scientific literacy in America, and said that the problem begins early in the educational process (Ogens, 1991). One begins to wonder if teachers had any part to play in this problem, or if the problem is caused by a multitude of or combination of several factors.

Most suggestions for improving science teaching deal with the classroom atmosphere and how it affects the students, consideration of the students' developmental levels, and the role of the teacher as an organizer and facilitator of the learning environment.

The teacher's role has traditionally been one who is the source of knowledge. The teacher imparts from the fountain of knowledge - the students fill themselves by drinking from the fountain. However, in an effort to "cover" as much material as possible, the teacher often resorts to the lecture method. Teachers sometimes place too much emphasis on delivering content rather than on the students learning it.

The teacher communicates verbally and non-verbally, and can generate enthusiasm for the subject by being enthusiastic about the subject. A teacher could also capitalize on the interests of the students by encouraging student curiosity. This may be accomplished by using practical applications associated with the students' existing interests.

Robert Walter of the University of Illinois (Walter, 1972), writes that teaching has come to be carried only through formal lectures, hence the "loss of the inspirational stimulus." This factor, although not widely accepted, may be affecting enrollments in the chemistry courses, particularly the introductory ones. Walter adds that teachers should change their approach to teaching chemistry by having more demonstrations to motivate students, and by "establishing the connection of chemistry to the world which is real to them."

Edward Walford of Cheyenne Mountain High School in Colorado, suggests that chemistry should be taught "through the reactions and properties of real materials, particularly materials which might be encountered in real-life situations." (Walford, 1983). In this way the high school chemistry course will be of maximum benefit to students preparing for the future.

Ronald Gillespie of McMaster University says that teachers should emphasize chemistry that deals with properties and reactions of substances, and that "chemical reactions are the basis of life and the basis of modern civilization." (Gillespie, 1991)

Robert Laurie of Ecole Sainte-Anne in Fredericton, New Brunswick (1992), states that teachers should emphasize various applications of chemistry in daily lives instead of abstract theories. He stresses that each teacher should have the freedom to include relevant examples from daily life so students will be motivated and their interest will be increased.

Carole Stearns (Stearns, 1988) of Horace Mann School in Bronx, New York writes that in order to make science more interesting to students, environmental chemistry topics should be incorporated in the curriculum. Although students may already be politically aware of issues like acid rain, the ozone layer, and smog; taking these in science courses help them develop a scientific appreciation for current issues and problems, as well as bring to them the real-life applications of their own chemistry lessons. Stearns has compiled an environmental chemistry bibliography (Stearns, 1988) which could be of good use to high school chemistry teachers.

Another excellent resource for teachers is an exhaustive reference list of science demonstrations and resources stressing practical applications of science prepared by David Katz of the Community College of Philadelphia (Katz, 1991). Teachers who are really interested in producing a spark of interest and motivation in their science classes would at least take a look at this wealth of information for use in their classes.

George, Wystrach, and Perkins (George, Wystrach, and Perkins, 1987) state that "teachers have an important influence on the attitudes that the students have toward the subject." It is then important that the teacher be a co-discoverer rather than a giver of knowledge, and strive to maintain an environment that is conducive to applying the scientific method. It is also very helpful if the teacher knows sufficient chemistry to be at ease with the course and to be enthusiastic about it.

Lois Fruen, (Fruen, 1992) a high school chemistry teacher who has received several awards from private corporations and two National Science Teachers Association awards for excellence in teaching, is convinced that significant changes in chemistry teaching are long overdue. The frequency of students asking her, "Why do we have to know this stuff?" caused her to modify her course content to convince students that chemistry is meaningful.

She left out most traditional content and put together her own texts. She tried to make the subject "contextually significant" to her students, and tried to show how relevant chemistry is to the world they live in by including examples of practical, everyday chemistry in her classes. Some of her examples were chemistry of hair conditioners and make-up, memory metals, love, and exercise. She decided that no topic would be taught without some practical aspect being discussed.

She also assigned several take-home experiments and activities. Students were allowed to choose the activities they were interested in. Some of the experiments involved: making silly putty, rates of reactions of alka seltzer tablets, removing tarnishes, making hot and cold packs, and others. She also assigned students to work in cooperative learning groups to research a topic of their choice on a certain societal issue like lead poisoning, aluminum in soda cans, mercury in dental fillings, etc. These reports not only helped students see connections and relevance of chemistry to daily life, but also improved writing and information retrieval skills.

Lois Fruen reports that students in her classes now, especially girls, are more interested in pursuing careers in science, than those students in the honours courses or students in traditional classes that she has taught in the past. Fruen concludes that what is missing from most high school and general college chemistry classes is the practical, interesting, everyday chemistry.

She says, not all reaction to her teaching is positive, since she has been accused of teaching "peanut-brittle" chemistry - her students are having too much fun and they are not learning "rigorous chemistry." She also says that there are teachers who are more used to "weeding students out of chemistry than making it accessible to students who are not traditionally attracted to chemistry." She concludes that:

> "It takes time to apply every aspect of chemistry, because existing texts, for the most part, do not do that, but it can be done. Let's change the way chemistry is taught. Let's attract the non-traditional chemistry major into the subject. Let's all be accused of teaching "peanut-brittle" chemistry - chemistry that captivates students, holds their attention, and enriches their lives." (Fruen, 1992)

Baird Lloyd of Emory and Henry College in Virginia has this to say about the teacher's role:

> "The way teachers interpret course goals, lay out the learning objectives for students, evaluate their progress, and imbue the students with a sense of wonder and excitement for learning chemistry affects the outcomes of the course for students." (Lloyd, 1992).

It seems that the teacher has a major role to play when it comes to enhancing and maintaining interest and motivation levels in the students. A teacher could improve science teaching by improving the atmosphere in the classroom, adjusting his or her level to match the student's level of mental development, introducing and using topics that provide adequate connections to everyday life to make the subject more "down to earth" and interesting, and giving students several opportunities to actively participate in the learning cycle.

To accomplish this, teachers should have variety, interest, humour, and contagious enthusiasm. Class should be fun, yet not sacrificing curriculum objectives. Stefan Schindler offers some final advice to teachers: "Start anywhere, as long as you generate amazement, puzzlement, interest, and awe...." (Schindler, 1991).

CHAPTER 4

SELECTION OF TOPICS AND FORMAT OF EXAMPLES

Selection of Topics.

At the start of the project, this researcher informally asked her students what topics in chemistry they wanted to know most about, and what they were most interested in. From this initial list gleaned from the students, I prepared a few mini-lectures about certain topics of interest that had technology-society connections.

Format of the examples.

The write-ups start with a catchy topic sentence, a description of the example, how it works, chemical reactions, and other applications, if any. Curriculum applications of the particular example are pointed out. A list of references are provided at the end of each report. These are intended for teachers, to help them look into the topic in greater detail, or for students, who could use the resources as starting points for independent study units.

This researcher sent a questionnaire (see Appendix B) to several chemistry teachers. The questionnaire aimed to gather more ideas for possible topics, to enlist evaluations of the examples, and to gather suggestions for the project. Several examples accompanied the questionnaire. The questionnaire also asked for input from teachers on the suitability of the hand-outs, and how the teachers would use them. More mini-lectures were prepared using some of the topics that the teachers suggested.

SCH 3A and SCH OA Curriculum.

The latest Ontario Ministry of Education Curriculum Guidelines for Grade 11 Chemistry, Advanced Level (SCH 3A) and Chemistry, OAC (SCH OA) were also consulted. The examples cited were correlated as much as possible to the core units of these two courses. An attempt was made to provide at least two examples for each core unit. Some examples utilized overlapping concepts in the different core units.

A summary of the core units for SCH 3A and SCH OA are given below.

I. SCH 3A - Chemistry, Grade 11, Advanced Level
    A. Matter
    B. Elements and Chemical Bonding
    C. Gases
    D. Chemical Reactions
    E. Chemical-Reaction Calculations
    F. Solutions
    G. Industry and Society

II. SCH OA - Chemistry OAC

  A. Organic Chemistry
  B. Atomic Structure and Molecular Architecture
  C. Energy and Rates in Chemical Reactions
  D. Equilibrium - Introduction
  E. Equilibrium - Applications
  F. Redox and Electrochemistry
  G. Independent Investigations

A summary of the correlation of examples presented and the core units of both chemistry courses is shown in Appendix D.

CHAPTER 5

INTERESTING EXAMPLES OF PRACTICAL, EVERYDAY CHEMISTRY

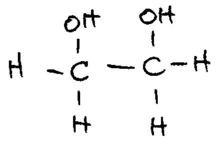
The following pages include short hand-outs of practical, everyday chemistry examples that are intended to supplement the curriculum of Grade 11 Chemistry, Advanced (SCH 3A) and Chemistry OAC (SCH OA). It is hoped that teachers will find these useful in their teaching of chemistry, especially to initiate interest and to motivate their students.

ANTI-FREEZE

The insect world has fascinating examples of creatures that can endure extreme cold. How can insects survive temperatures of up to 40 degrees below zero to live through the winter, and then be able to start a new population when the growing season starts?

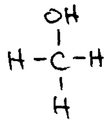
Insects begin to give off water as the temperature begins to drop in the fall. The increased concentration of body fluids helps them to withstand freezing temperatures without damage to their tissues brought about by the freezing of water. As temperatures dip to several degrees below zero, some insects produce their own anti-freeze to protect them from the extreme cold. Ethylene glycol, a chemical used for anti-freeze solutions in car radiators, and glycerin, have been found in insect bodies.

More than 95% of the anti-freeze on the market has ethylene glycol as the major constituent. Methyl alcohol is also used.



$$\mathrm{H-\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}-H}$$

ethylene glycol



$$\mathrm{H-\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}-H}$$

methyl alcohol

Anti-freeze protects water-cooled vehicle engines. Although water is a good coolant, is cost effective and readily available, it freezes at relatively high freezing point and is corrosive under certain conditions. Anti-freeze corrects these problems by preventing water from freezing at 0 degrees centigrade, but allowing it to freeze at lower than zero temperatures.

This is called freezing point lowering, and is proportional to the concentration of solute, but nearly independent upon the nature of solute.

The phenomena can be expressed in this relationship:

$$\Delta T = K_f m$$

where ΔT is the freezing point depression

Kf is the proportionality constant characteristic of each solvent

m is the number of moles of solute per 1000 grams of water

This relationship is used to obtain an estimate of the freezing point. The presence of an anti-freeze or any solute will lower the freezing point and increase the boiling point, because it lowers the vapour pressure of the solvent by interfering with solvent-solvent interactions. In freezing, it inhibits water from forming its normal hexagonal structure by forming hydrogen bonds with water molecules. This prevents water molecules from occupying their place in the crystal lattice - interfering with crystal formation. Hence, anti-freeze prevents freezing in the winter, and boiling over in the summer.

Anti-freeze may also prevent corrosion when mixed with substances like reducing agents, surface-active agents, and ion scavengers that are used to inhibit corrosion. Other radiator sealants include polystyrene spheres, which act to plug up a crack or leak. High temperature and pressure conditions in the engine fuse the plugs solid in the cracks.

Other applications of anti-freeze are de-icing fluids which melt ice and frost from aircraft wings and car windows. These may contain ethylene or propylene glycol, 2-propanol, denatured alcohol, anti-corrosion agents, and wetting agents.

CURRICULUM APPLICATIONS:

The discussion of anti-freeze and its various applications is a good example of practical uses of solutes and solutions in everyday life. This can also be used to illustrate the role of intermolecular forces and hydrogen-bonding on physical properties of solution and states of matter.

REFERENCES:

1. Mark Jones, David Johnston, John Netterville, James Wood, Melvin Jostein, Chemistry and Society, Fifth Edition, Philadelphia: Saunders Publishing Company, 1988, pp. 653-655.

2. R. L. Whitman, E. E. Zinck, R. A. Nalepa, Chemistry Today 1, Third Edition, Scarborough: Prentice-Hall, 1988, p. 318.

CULINARY CHEMISTRY

A cook - a chemist?

A cook may hardly consider himself a chemist, but the kitchen is an excellent example of where physical and chemical changes take place everyday.

Cooking may be divided into four basic methods: 1) dry heating, which includes baking and roasting; 2) wet heating - boiling and steaming; 3) hot-oil frying; and 4) microwaving. The changes brought about by these methods may either be physical, chemical, or microbiological.

Physical changes occur in boiling, enlargement of starch grains when boiled, and accompanying or a result of chemical changes. Chemical changes are involved in breaking of bonds and partial digestion during heating. Chemical and structural changes many be effected by small changes in temperature. The colour, texture, composition, moisture content, and taste of food are affected in various ways by the following factors: energy source, time, temperature, and cooking methods.

Baking,

Baking causes certain chemical reactions that release carbon dioxide gas, which causes breads, cakes, and pastries to rise. Carbon dioxide may be generated by yeast (microbiological change) by the following reaction:

$$\underset{\text{glucose}}{C_6H_{12}O_6} \xrightarrow[\text{from yeast}]{\text{zymase}} \underset{\text{carbon dioxide gas}}{2CO_2} + \underset{\text{ethanol}}{2C_2H_5OH}$$

Carbon dioxide is also produced from the decomposition of baking soda (sodium bicarbonate, $NaHCO_3$) and baking powders which contain a mixture of sodium bicarbonate and salts like potassium hydrogen tartrate, $KHC_4H_4O_6$, calcium dihydrogen pyrophosphate monohydrate, $Ca(H_2PO_4)_2.H_2O$, or sodium acid pyrophosphate, $Na_2H_2P_2O_7$.

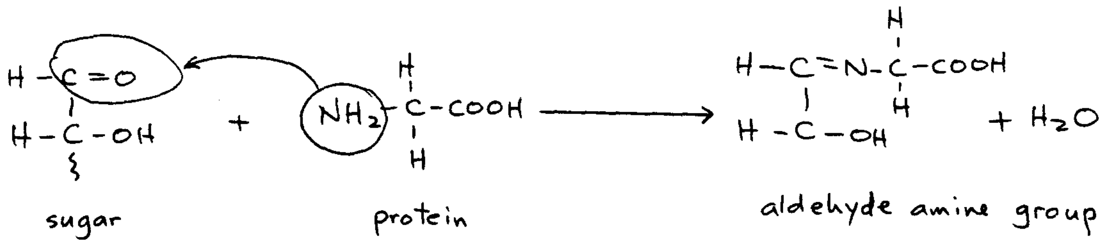
$$NaHCO_3 + H^+ \longrightarrow Na^+ + H_2O + CO_2\ (gas)$$

$$KHC_4H_4O_6 + NaHCO_3 \xrightarrow{water} KNaC_4H_4O_6 + H_2O + CO_2\ (gas)$$

Air trapped in bread dough also causes bread to rise as it expands due to heating. Steam generation in bread dough and other baked goods is also an important factor in leavening.

Toasting of Bread.

Non-enzymatic browning of toast and roasted cocoa beans was studied by Maillard in the early 1900s, and Kirk in the 1970s. In the Maillard Reaction, the aldehyde group of the sugar reacts with the amine of the acid to form an aldehyde amine group. This is really a complex chemical reaction between protein and starch.



Greening of egg yolk.

The greenish discoloration around yolk occurs if eggs are boiled too rapidly or too long. Careful attention to rate of boiling and slow cooking, plus placing eggs in cold water to stop the cooking process prevents discoloration. If precautions are not taken, iron reacts with sulphide ions in the egg white to produce the green iron (II) sulphide:

$$Fe^{+2} + S^{-2} \longrightarrow FeS$$

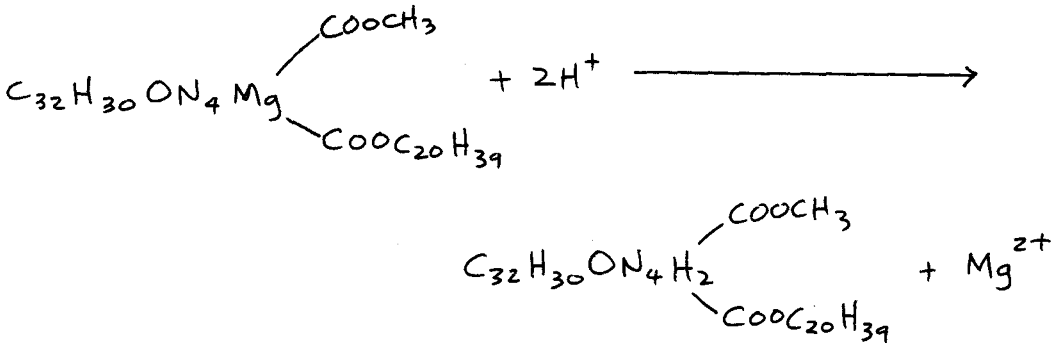
Sizzling steaks.

One of the joys of summer is the sound and aroma of sizzling steaks over the backyard barbecue. This gustatory delight is produced by the chemical changes produced in meat fat during the cooking. Glycerol in fat decomposes to acrolein and water. Acrolein produces the strong odour.

$$\underset{\text{glycerol}}{C_3H_5(OH)_3} \longrightarrow \underset{\text{acrolein}}{CH_2{=}CHCHO} + \underset{\text{water}}{2H_2O}$$

Vegetable Dishes.

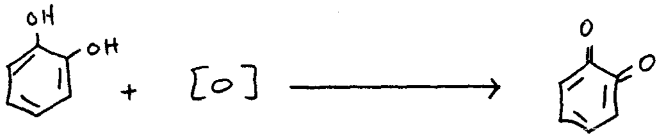
Stir frying is becoming more popular these days due to the influence of the Chinese in our midst. It is also popular because it preserves the bright green colour and the nutrients of vegetables, so long as the dish is eaten right away. Vegetables have to be cooked as fast as possible to preserve their bright green colour. The chlorophyll molecule, responsible for greenness, is very unstable during heating. Magnesium is replaced by hydrogen during heating to produce olive-green pheophytins in a process called pheophytinization.



$$C_{32}H_{30}ON_4Mg\begin{cases}COOCH_3\\COOC_{20}H_{39}\end{cases} + 2H^+ \longrightarrow C_{32}H_{30}ON_4H_2\begin{cases}COOCH_3\\COOC_{20}H_{39}\end{cases} + Mg^{2+}$$

Browning of fruit.

Fruit is used in a variety of desserts and salads. One problem encountered is the browning of fruit. Browning is an enzymatic reaction - it occurs when chemicals in the fruit skins become oxidized in an enzyme-catalyzed reaction.



To prevent and minimize browning, the pH of the fruit must be lowered by adding lemon juice to it. Citrus fruit, strawberries, and tomatoes do not brown since they don't have the browning enzyme. There is still much to be understood and much that is not known about enzymatic browning.

Pre-cooking and Digestion.

Cooking involves partial digestion or breakdown of proteins and carbohydrates by heat and hydrolysis. These macromolecules in vegetable cell walls and meat connective tissue need to be broken down for cooking to be effective.

Pre-cooking additives, like meat tenderizers, are now routinely used. These are enzymes which catalyze bond breaking at room temperature, thereby reducing cooking time. Meat tenderizers include protein-splitting enzymes from plants like papain, or microbial protease enzymes from bacteria and fungi.

Heat also plays a major role in food breakdown. The rate of chemical breakdown is directly proportional to the amount and length of time the food is heated. Pressure cookers achieve temperatures above the boiling point of water (Charle's Law), and so allow for faster cooking.

Microwave Cooking.

Just beyond infrared and at the beginning of the shortwave radio waves are very short wavelengths called microwaves. They are used for radar, to transmit television and FM signals, and to cook with. In microwave cooking, no energy is wasted in heating pots, since microwaves travel directly to the food. A magnetron vacuum tube inside the top of the oven converts household current into high-frequency microwaves. A stirrer-fan distributes the microwaves evenly throughout the oven. Microwaves are waves of energy, not heat. Metals reflect microwaves; glass, pottery, paper, and most plastics allow waves to pass through. Food absorbs microwaves, and the absorbed microwave energy causes the food molecules to vibrate rapidly against each other, inducing friction, which in turn produces heat in food. Microwaves penetrate the food from the outside. The interior of the food then cooks by conduction. Microwaves also reheat and defrost with excellent results.

CURRICULUM APPLICATIONS.

Chemistry in the kitchen may be discussed in conjunction with physical and chemical changes in the study of the properties of matter. Enzymatic reactions may be mentioned in chemical kinetics, especially the effect of catalysts and heat on rates of chemical reactions. Bread leavening is a good application of the gas laws. Leavening contributions may be estimated by calculating volume changes of air trapped in dough, using the ideal gas equation.

REFERENCES:

1. Harriet G. Friedstein, "Basic Concepts of Culinary Chemistry," Journal of Chem. Ed., 60, 12 (December, 1983), pp. 1037-1038.

2. Mark Jones, David Johnston, John Netterville, James Wood, and Melvin Joesten, Chemistry and Society, 5th Edition, Philadelphia: Saunders College Publishing, 1988, pp. 571-572.

3. Ben Selinger, Chemistry in the Marketplace, Sydney: Harcourt Brace Ivanovich, Publishers, 1986, pp. 69-70.

4. William R. Stine, Chemistry for the Consumer, Boston, Allyn and Bacon, Inc., 1978, pp. 243-250.

"GREEN THUMB" CHEMISTRY

A "green thumb" is not the only necessary factor for success in the garden. Chemicals, natural or otherwise, have played a very important role in household as well as worldwide food production. The use of chemical fertilizers, herbicides, fungicides, and pesticides have resulted in increased productivity of food.

Fertilizers.

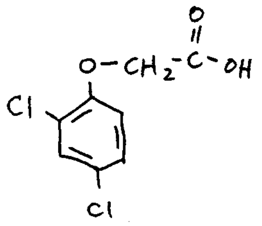
Plants, like any other living organisms, need nutrients in order to grow. The three basic nutrients that plants need are nitrogen for leaf growth and synthesis of plant proteins, phosphorus for bulbs and plants that produce fruits, and potassium for controlling acidity of the soil. These basic nutrients are called macronutrients, and are commonly present in fertilizer bags or containers in varying percentages depending on the purpose of the fertilizer. A bag of fertilizer labelled 32-3-5, for example, contains 32% nitrogen, 3% phosphorus, and 5% potassium.

Other nutrients, called micronutrients, are in the form of water soluble salts of copper, manganese, iron, zinc, or molybdenum. These micronutrients are part of plant enzymes that are involved in various processes like nitrogen fixation, photosynthesis, and respiration.

For the organic gardening enthusiast, composting of organic matter by bacterial action produces nutrients by decomposition. Not to be forgotten as a source of nitrogen are nitrogen-fixing bacteria that convert nitrogen from the air to nitrates.

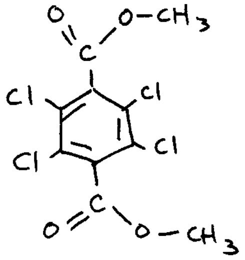
Herbicides.

Herbicides are weed killers. Weeds lower crop quality and quantity. A widely-used weed killer is the chlorophenoxy compound known as 2,4 - D (Agent Orange in the Vietnam War), which is a growth regulator that attacks dandelions and broadleaf weeds, but is harmless to grass species like cereals and lawn grass. The structure of 2,4-D and Dacthal are shown below.



2,4 -D

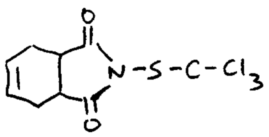
(2,4 - dichlorophenoxy acetic acid)



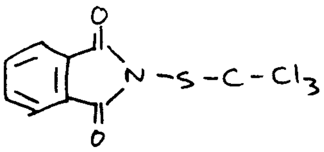
Dachtal

Fungicides.

Fungicides are used to control diseases that wither leaves of fruit trees and vegetables. Fungicides are also used to treat seeds to prevent them from rotting. The most common and safest fungicides are Captan and Folpet.



Captan



Folpet

Insecticides.

Insects comprise about 76% of the total world animal mass. It has been said that insects consume one-third of everything that grows or stored, and cause one-half of all human deaths and deformities due to disease (malaria being the biggest killer). Two make matters worse, insects multiply at a dizzying rate. For example, a single pair of houseflies could produce an estimated 1.9 x 10^{20} descendants in a single summer. If all the offspring of each generation were to survive and breed, the earth would be covered with flies to the depth of 14 m!

Early Egyptian writings tell about frightening locust swarms that can reach masses of 15,000 tonnes. Insect larvae underground account for a lot more insect mass. Insects have short lifespans, but can exist in different forms (metamorphosis), hence are highly resistant to attempts to eradicate them.

The groups of chemical insecticides are: inorganic, organochlorines, organophosphorus, organocarbamates, and plant extracts.

Inorganic insecticides include lead arsenate ($PbHAsO_4$), for ticks, sodium fluoride (NaF) and Borax ($Na_2B_4O_7$) for cockroaches and ants, copper compounds and elemental and lime sulphur. These type of insecticides are mainly stomach poisons which are restricted to chewing insects, and are not effective against aphids or mosquitoes.

Organochlorine compounds were the first among the insecticides. DDT, diclorodiphenyltrichloroethane, the most famous, was discovered by J. R. Geigy, who received the Nobel Prize in 1948 for his work. It, together with some of its analogs, are now banned in the United States and other countries due to environmental concerns like bioconcentration, and its being a carcinogen in laboratory animals.

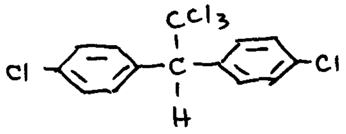
Organochlorine compounds were replaced by organophosphates. They were toxic to vertebrates. The most popular is Diazinon, which is used for houseplants, roaches and ants. Other organophosphates are used to treat fruit fly infestations, and are used in flea and tick collars.

Organocarbamates also replaced many organochlorine compounds. The most common are Sevin and Baygon, used in gardens, flea and tick collars, and used against household ants and roaches, respectively.

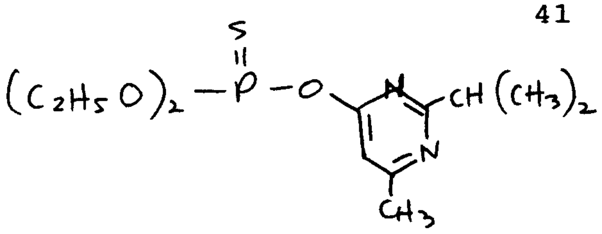
Another group, called pyrethins, are either man-made or natural. They are among the safest and rapidly-acting insecticides. Now, more stable synthetic pyrethins are used due to the instability of natural pyrethins.

The harmful side-effects of chemical insecticides has produced a search for alternatives. Pheromones and juvenile hormones, natural enemies like ladybugs, have been used to some extent. They are biodegradable and non-polluting.

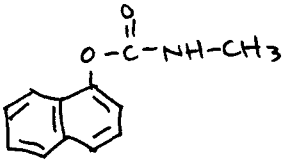
The structures of the most commonly used chemical insecticides are given.



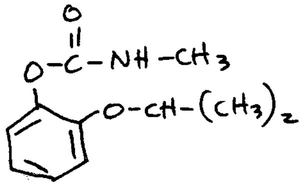
DDT



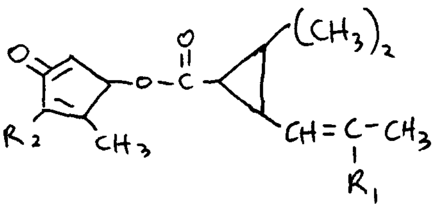
Diazinon



Sevin



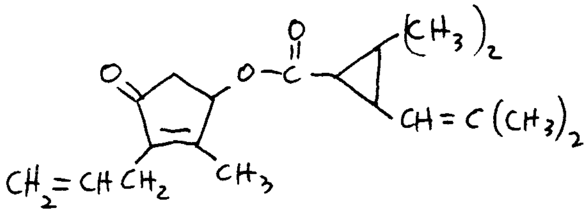
Baygon



Pyrethin I (Natural pyrethin)

$R_1 = -CH_3$

$R_2 = -CH_3CH{=}CHCH{=}CH_2$



Allethrin (synthetic pyrethin)

CURRICULUM APPLICATIONS.

Discussion of garden chemistry can be done in conjunction with introductory organic chemistry, citing the value of organic synthesis for better living conditions. This could also be used in the Industry and Society Unit. The topic may also be assigned as an Independent Study Unit.

REFERENCES:

1. Ronald Gillespie, Donald Eaton, David Humphreys, and Edward Robinson, Atoms, Molecules, and Reactions, Englewood Cliffs, New Jersey: Prentice-Hall, International Inc., 1994, p. 245.

2. Edward Maslowsky, Jr., "Agricultural Chemicals for Consumer Use," Journal of Chem. Ed., 62, 8 (September, 1985), pp. 774-776.

3. Ben Selinger, Chemistry in the Marketplace, Sydney: Harcourt Brace Ivanovich Publishers, 19186, pp. 116-144.

4. William R. Stine, Chemistry for the Consumer, Boston: Allyn and Bacon, Inc., 1978, pp. 152-187.

DISPOSABLE FLASH BULBS

Have you ever used disposable flash bulbs to take pictures? What causes the sudden bright flash? Disposable flash bulbs are made of enclosing very fine meshes of magnesium wire in an atmosphere of oxygen in the bulb. When you click the camera, electric current passes through the thin wire, raising the temperature high enough to ignite. As soon as it does, it burns explosively in the oxygen-rich atmosphere and produces a very bright white light, characteristic of burning magnesium. The reaction is also instantaneous because magnesium is present as a fine mesh, and has greater surface area. After use, the interior of the bulb is coated with a white film of magnesium oxide.

The chemical reaction involved is oxidation. The magnesium metal reacts with oxygen to produce magnesium oxide. The chemical reaction is:

$$2Mg \quad + \quad O_2 \quad \text{------------>} \quad 2MgO$$

Other metals may react with oxygen at a slower rate. Zinc reacts with oxygen to produce ZnO (zinc oxide), which is a thin film coating that prevents unexposed surface from further corrosion. Rust is a form of oxide, Fe_2O_3. The process may be speeded up by heat, and has applications in welding.

CURRICULUM APPLICATIONS:

This chemical reaction is a good application of the study of oxidation, combination reactions, oxidation-reduction, and rates of reaction. It may also be used as an example of incandescence.

REFERENCE:

1. American Chemical Society, ChemCom: Chemistry in the Community, Dubuque, Iowa: Kendal/Hunt Publishing Co., 1988, p. 100.

HOW IS FROSTED GLASS MADE?

Have you ever wondered how beautiful patterns are made in glass? Since glass is very fragile, one cannot use a chisel to make patterns. Decorative windows and frosted glass are made by etching the glass with hydrogen fluoride or hydrofluoric acid.

Hydrogen and fluorine react explosively when mixed, so hydrofluoric acid is made by the action of concentrated sulfuric acid on fluorspar or calcium fluoride. The chemical reaction is:

$$CaF_2 + H_2SO_4 \longrightarrow 2HF + CaSO_4$$

Since HF has a boiling point of 19.5 degrees Celsius, near room temperature, it may be easily condensed. It is sold and packaged in special vessels lined with wax or polyethylene, or in cylinders made of alloy steel or polyethylene. Glass cannot be used, since hydrofluoric acid dissolves glass.

The ability of hydrofluoric acid to attack glass is made use of in etching patterns in glass, decorative glassware, and the manufacture of frosted glass. Frosted glass is used in bathroom or shower doors and some windows to achieve greater privacy. Interiors of some types of light bulbs are also frosted to reduce glare. Hydrofluoric acid is sprayed on the glass to achieve the effect.

The reaction of hydrofluoric acid with glass is a two-stage process. First, silicon tetrafluoride is formed.

$$SiO_2 + 4HF \longrightarrow SiF_4 + 2H_2O$$

Silicon tetrafluoride then reacts with the excess hydrofluoric acid.

$$SiF_4 + 2HF + 2H_2O \longrightarrow 2H_3O^+ + SiF_6^{-2}$$

CURRICULUM APPLICATIONS:

Hydrohalic acids react as typical acid-base reactions. They form salts with basic oxides. They also act as Lewis bases, and may form complex ions. This example may be used in acid-base chemistry as well as in the study of the properties of halogens. The explosive reaction of hydrogen and fluorine is also a good example of predicting reactivity based on position of elements in the periodic table.

REFERENCE:

1. P. W. Atkins, M. J. Clugston, M. J. Frazer, and R. A. Y. Jones, Chemistry: Principles and Applications, New York: Longman Inc., 1988, pp. 353-354.

INSECT "AFTER-BITE" PRODUCTS

A walk in the woods is a great experience - if there are no insects lurking in the shadows waiting for their next victim. But if you still want to take a hike in the woods in spring or early summer, be prepared. Take along some insect repellant and a tube of an insect "after-bite" product to minimize the effects of the inevitable.

Insect bites may be relieved by creams or "after-bite" products. These products ease or relieve the pain caused by the stings. The relieving effect of these creams may be explained by acid-base chemistry.

Blood and cell fluids in tissues have an almost neutral pH of 7.4, which is very close to that of pure water, 7.0. When nerve endings are exposed to more acidic solutions, they sense the change in pH. Their response causes the sensation of pain or irritation. That's why if you spill something sour or acidic on a cut or break in the skin, you will feel a sharp sting.

Insects inject a solution of formic acid into the skin. Formic acid comes from the Latin word for ants, the source from which the compound was originally extracted. Since formic acid has a pH value of between 2 and 3, this results in the sting or irritation one feels when an insect bites. If the acidic solution causing pain is neutralized, then pain can be relieved.

Creams or "after-bite" products contain slightly basic solutions. Ammonia, a base, is used in "after-bites". The resulting acid-base reaction brought about by the application of these remedies neutralizes the acid and relieves pain.

The chemical reaction is as follows:

NH_4OH + $HCOOH$ -----------> H_2O + NH_4COOH
(Aqueous solution of ammonia)

CURRICULUM APPLICATIONS:

This reaction may be used to illustrate practical applications of acid-base reactions.

REFERENCE:

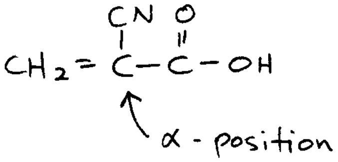
1. Jack Candido, Edward James, Ronald Phillips, Bryan Kaufman, and Glen Wiley, Heath Science Connections 10, Canada: D. C. Heath Canada Ltd., 1988, p. 390.

2. William F. Kieffer, Chemistry Today, San Francisco: Canfield Press, 1976, pp. 422-423.

INSTANT ADHESIVES

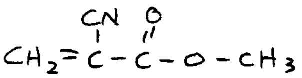
You are doing the dishes, and mother's best china bowl slips from your hands and breaks into to pieces. Don't despair, it's not the end of the world. Instant glues can now repair almost everything from china to toys. Go to the nearest hardware store, and pick up a tube of SuperGlue. Your mom will never know what happened, though I suppose you should tell her.

Instant adhesives, chemically known as alpha-cyanoacrylates, have assumed an important place in industry, and now are also readily available to the homeowner and the hobbyist. The major component of alpha-cyanoacrylate adhesives consists of alkyl esters of alpha-cyanoacrylic acid, whose structure is:



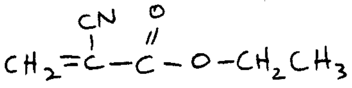
$$CH_2=\overset{\overset{CN}{|}}{C}-\overset{\overset{O}{\|}}{C}-OH$$

The most common esters used are methyl, ethyl, and isobutyl esters, whose structures are shown below:



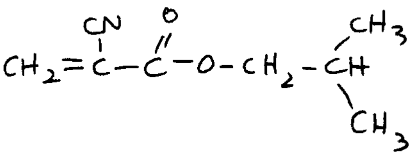
$$CH_2=\overset{\overset{CN}{|}}{C}-\overset{\overset{O}{\|}}{C}-O-CH_3$$

methyl-2-cyanoacrylate



$$CH_2=\overset{\overset{CN}{|}}{C}-\overset{\overset{O}{\|}}{C}-O-CH_2CH_3$$

ethyl-2-cyanoacrylate



$$CH_2=\overset{\overset{CN}{|}}{C}-\overset{\overset{O}{\|}}{C}-O-CH_2-\overset{CH_3}{\underset{CH_3}{CH}}$$

secondary butyl-2-cyanoacrylate

When alpha-cyanoacrylates spread on surfaces that are to be joined, polymerization occurs. This readiness to polymerize is due to two very strongly electron-attracting groups attached to the same carbon atom, the cyanide group, and the oxygen-rich carboxyl group. This distorts the electron distribution in the carbon-carbon double bond, -C=C-, and makes it very reactive; hence, polymerization proceeds quickly. Presence of traces of water and alcohol makes the glue form chemical bonds with surfaces to be bonded.

The popularity of alpha-cyanoacrylate adhesives is due to two factors. First, they are very simple to use. The liquid adhesive is merely applied as a small drop to one of the surfaces to be bonded. Sufficient force is applied to keep them together. Adhesion occurs within seconds. Secondly, these adhesives will bond anything - metal, glass, rubber, plastic, china, and even human skin!

Generically known as "instant glues" or "superglues," cyanoacrylates have widespread applications. They are used in the electronics industry for bonding small electronic parts. In the auto industry, they bond everything from dashboard knobs, identification tags, to outside trim. They have generated a great deal of interest in medicine where they are used as replacement sutures in eye and skin surgery, and to repair spleen, liver, and kidney tissues where sutures are unsatisfactory. They are used to close blood vessels, bronchial tubes, bond bones, and prevent cerebrospinal fluid leakage during brain surgery. They are also useful for securing medical devices to the skin.

Super glues are used for cosmetic purposes, too. Broken and cracked fingernails are mended using this glue, and morticians use it to seal once and for all the eyes and lips of their clients. But, woe unto you, if you get it on your skin! The glue sticks hard to skin, and if it bonds your fingers to each other, you may need medical attention!

CURRICULUM APPLICATIONS.

Instant adhesives and their applications may be used in a units on polymerization and industrial chemistry. It could also be used in chemical bonding, especially showing the effect of different functional groups on the carbon-carbon double bond.

REFERENCES:

1. Henry Lee (editor), Cyanoacrylate Resins - Instant Adhesives: A Monograph of Their Applications and Technology, Pasadena California: Pasadena Technology Press, 1981, pp. 1-7, 143-164.
2. P. W. Atkins, Molecules, New York: Scientific American Library, 1987, p. 76.

THE HOLE IN THE SKY - OZONE DEPLETION

There is bad news for sun-lovers out there. Excessive sun-bathing may increase your chances of getting skin cancer. Recently, news of the hole in the ozone layer has been capturing the headlines. The degree of ozone depletion and the "ultraviolet index" is now part of some weather reports. What causes the ozone hole, and why is it of so much concern these days?

The earth has a protective ozone layer in the stratosphere, which is responsible for filtering out most of the sun's deadly ultraviolet radiation from the earth. Scientists speculated in the seventies that the relatively-inert chlorofluorocarbons (CFCs), were making their way to the stratosphere.

Freon, CCl_2F_2, the most significant of the CFCs, is used in refrigerators and air-conditioning units. Other CFCs are used as spray propellants in spray cans used for deodorants, hair sprays, and many other applications.

CFCs are inert in the lower atmosphere, but rise to the stratosphere where they are decomposed by ultraviolet radiation to atomic chlorine. Atomic chlorine is thought to destroy the atmospheric ozone by the following reactions.

1. $CF_2Cl_2 + uv \longrightarrow CF_2Cl\cdot + Cl$
2. $Cl\cdot + O_3 \longrightarrow ClO + O_2$
3. $O_3 + hy \longrightarrow O_2 + O\cdot$
4. $ClO + O\cdot \longrightarrow Cl + O_2$

The last step results in the formation of another chlorine atom that can break down another molecule of ozone. Since the last two to four steps can be repeated many times, the decomposition of one molecule of chlorofluorocarbons can destroy several molecules of ozone. It is estimated that one molecule of CFC can destroy 10,000 or more ozone molecules.

Another threat to the ozone layer are supersonic transport airplanes (SSTs). These aircraft cruise in the stratosphere where they emit nitric oxide as a product of combustion. Nitric oxide reacts with ozone to produce nitrogen dioxide and oxygen. The reaction may proceed in these steps.

1. $NO + O_3 \longrightarrow NO_2 + O_2$

2. $NO_2 + O \longrightarrow NO + O_2$

Since the regeneration of nitrogen dioxide produces another molecule of NO, one No may destroy many ozone molecules.

The preceding reactions have been simulated in the laboratory. The National Academy of Science estimates that a 10% decrease in the ozone layer would cause a corresponding 8000 increase in skin cancer cases per year. Because of this, CFCs have been banned from most products, but not all nations are doing this. Each one of us can do our part in lessening the effects of ozone depletion by not using products with CFCs.

CURRICULUM APPLICATIONS:

The discussion of the ozone hole can be integrated with environmental chemistry, free-radical reactions, and rate of reactions.

REFERENCES:

1. Stanley E. Manahan, Environmental Chemistry, Second Edition, Boston, Massachusetts: Willard Grant Press, 1975, p. 403.
2. John W. Hill, Chemistry for Changing Times, Third Edition, Minneapolis, Minnesota: Burgess Publishing Co., 1980, pp. 276-277.

3. World Resources Institute, World Resources, 1990-1991: A Guide to the Global Environment, New York: Oxford University Press, 1990, pp. 62-63 and Teacher's Guide, p. 14.

INSECT PHEROMONES

Have you ever wondered how insects attract their mates? Did you know that some insects used "aphrodisiacs" to induce mating? Pheromones are chemicals released by organisms into an environment where they serve as messages to others of the same species. These chemicals are commonly secreted by the exocrine glands of insects, and may serve several functions like marking a trail, bringing insects together for increased defense against predators, sending an alarm to stimulate escape, or attracting members of the opposite sex.

Chemical dispersion within air is attributed to diffusion due to the Brownian movement. Passive transport, which is attributed to the movement or flow of the medium (like air), may also be responsible. Sex attractants and trail markers are the most common, since the behaviours they stimulate are easy to monitor and observe. Insect pheromones are simpler than those of other animals, since chemical composition is well-defined and generally consistent from individual to individual within the species.

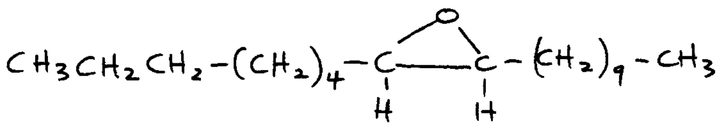
Sex attractants are simple. Some common sex attractants are:

COMMON HOUSEFLY:

$$CH_3(CH_2)_7CH=CH-(CH_2)_{12}-CH_3$$

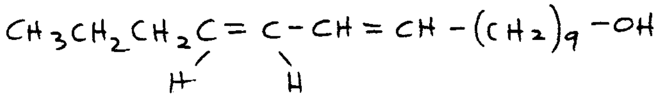
This molecule contains 23 carbon atoms with a double-bond between the ninth and tenth. It is fairly easy to synthesize.

GYPSY MOTH:



A team from the US Dept. of Agriculture used 87,000 female gypsy moths to isolate a very small amount in 1967. Its structure was determined using sophisticated instruments, and three years later it was synthesized in the laboratory. The pheromone was effective in concentrations as low as 10 grams in traps.

SILKWORM MOTH:



$$CH_3CH_2CH_2\underset{H}{C}=\underset{H}{C}-CH=CH-(CH_2)_9-OH$$

trans-10-cis-12-hexadecadienol

This is one of the pheromones released by the silkworm moth. In the order Lepidoptera, female pheromones have been identified in over 100 species. Some moths release pheromones that stimulate females to fly upwind to enable them to locate males.

Identification of pheromones is not easy, since pheromones are secreted in such minute amounts. Research is expensive and time-consuming, but through chemical research, a pheromone may be identified and its structure determined.

This makes it possible to manufacture pheromones in large quantities in the laboratory for use in pest control.

Pheromones may be used to misdirect insect behaviour and prevent reproduction. They are used in three specific ways in agriculture and forest management. First, they are used to detect and monitor pest populations. Second, they are used to attract and remove pests by use of pheromone traps. Males are attracted to the pheromone in the trap, and once trapped are unavailable for breeding. Pheromones are also sprayed over infested areas to confuse and disorient males, who detect females, but can't find them; hence, making it difficult for them to mate and breed. This is an effective way of controlling pests without damage to the environment.

CURRICULUM APPLICATIONS:

The study of pheromones may be used as an example of Brownian movement, diffusion, passive transport, and the synthesis of organic compounds for the benefit of man. It is also an excellent application of environmental chemistry.

REFERENCES:

1. William Agosta, "Using Chemicals to Communicate," Journal of Chem. Ed., 71, 3 (March 1994), pp. 242-246.
2. M. C. Birch and K. F. Haynes, Insect Pheromones, London Edward Arnold, 1982, pp. 1-14.
3. John W. Hill, Chemistry for Changing Times, Second Edition, Minneapolis, Minnesota: Burgess Publishing Co., 1972, pp. 224-225.
4. H. H. Shorey, Animal Communication by Pheromones, New York: Academic Press, 1976, pp. 14-15.

OLESTRA: A NON-CALORIC DIETARY FAT SUBSTITUTE

Haven't you eaten a bag of potato chips and felt guilty afterward for ingesting a high-fat food? Won't it be nice not to have to worry about excess fat in one's diet, and just enjoy our food?

Fats are needed by the body to enhance taste of foods, for insulation, and for protection of vital body organs. Excess fat, especially animal fat, has been linked to cardiovascular diseases like strokes and heart attacks and some forms of cancer - breast, colon, and even lung cancer. In the typical North American diet, fats account for approximately 37% of the calories in the diet. In countries where rice is the staple, less than 10% of the total calories consumed is fat. Fats are the most concentrated energy food source.

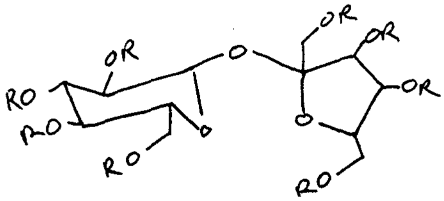
The food industry has responded to concerns about fat in the diet. Crisco introduced in 1911 an all-vegetable cottonseed oil-based product as a replacement for lard. Vegetable oils with low levels of saturated fats and high levels of unsaturated fats began to be widely marketed. Margarines, which replaced butter, contained less than 20% saturated fatty acids. Lowfat or "lite" foods are now common in the supermarkets. A new development is the processing of egg white or milk protein to form spherical particles of approximately 1 micrometers in diameter. These particles give the mouth the feeling of a creamy emulsion. Recent developments include calorie-reduced and non-caloric dietary fat substitutes. These are called "engineered fats". They are supposed to provide all the advantages of conventional fats without contributing calories or saturated fats, which are the main culprits in atherosclerosis, heart disease, and other health problems.

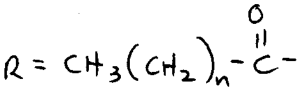
Fat in the body is stored as triglycerides. These are broken down by lipase enzymes to produce fatty acids, which are further enzymatically oxidized to release energy, carbon dioxide, and water. Overabundance of triglycerides is not healthful. There is experimental evidence that all fat is hydrolyzed before it is absorbed by the body.

Fat digestion involves lipase-catalyzed hydrolysis to diglycerides and free fatty acids which are transported to the intestinal wall and are absorbed by diffusion. Once out of the intestinal wall, they recombine to form triglycerides.

Unhydrolyzable fats then offer a potential for society to enjoy high-fat foods without suffering ill-health, since these cannot be absorbed by the body. With this premise in mind, Proctor and Gamble developed a fat substitute known as OLESTRA. Olestra is a common name for a mixture of octa-, hepta, and hexaesters formed from the sugar sucrose and long-chain fatty acids isolated from vegetable oils.

The structural formula of olestra is shown below.





$R = CH_3(CH_2)_n-\overset{O}{\overset{\|}{C}}-$

OLESTRA, Sucrose esterified with 6 or more fatty acids

Olestra can be used with or substituted for triglyceride fats and oils in any food, and for baking and frying. It is currently being reviewed by the FDA. Maybe we can now enjoy potato chips without feeling guilty.

CURRICULUM APPLICATIONS:

The development and synthesis of olestra illustrates the role organic chemistry plays in synthesizing various macromolecules for the benefit and needs of modern society. This is an excellent example of societal implications of introductory organic chemistry, which is one of the core subjects in SCHOA (Chemistry OAC).

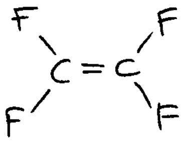
REFERENCE:

1. R. J. Jardacek, "The Development of Olestra, a Non-caloric Substitute for Dietary Fat," Journal of Chemical Education, Vol. 68, No. 6, June 1991, pp. 476-479.

TEFLON - NON-STICK COOKING SURFACES

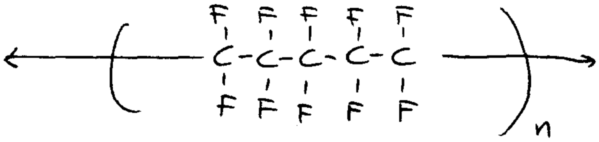
Perhaps you have experienced the frustration of having pancakes stick to the cooking pan, and resulting in such a mess that you won't want to eat them. With non-stick cooking surfaces in cookware these days, food sticking to pots and pans is a thing of the past.

Teflon, a Dupont trade name, is a non-stick coating for cooking utensils. It is also used for electrical insulation, sealing tape for pipe fittings, and laboratory utensils. Teflon, also know as polytetrafluoroethylene, is a polymer of tetrafluoroethylene, whose structural formula is:



Tetrafluoroethylene is a colourless, odourless, and tasteless gas, which polymerizes to form Teflon.

A polymer is made up of stringing together many identical smaller molecular units called monomers. The Teflon polymer is a very long chain, composed of about 50,000 -CF2- groups with very little cross-linking. Its structure is:



Teflon is an extremely tough plastic which is very little affected by other chemicals or high temperature. The presence of fluorine atoms makes the resulting polymer relatively inert just like other fluorocarbons such as Freon.

Teflon's chemical and thermal stability is attributed to two factors. First the strength of the C-C and C-F bonds are considerable, and this keeps the molecules from decomposing when heated. Second, the match between the sizes of the fluorine and carbon atoms form a strong backbone completely covered by fluorine atoms. The fluorine atoms form a continuous sheath around the carbon chain, protecting it from chemical attack.

This is the reason that grease and oil do not form bonds with Teflon, giving it a "non-stick" coating. Since molecules are so densely packed, it does not absorb water, making it an excellent electrical insulator.

CURRICULUM APPLICATIONS:

The polymerization of tetrafluoroethylene to Teflon, and properties of Teflon, give an excellent example of addition polymers. This is also a good example of the relationship of bonding and structure to physical and chemical properties of a substance, i.e. - strength, toughness, and reactivity.

REFERENCES:

1. Peter Williams Atkins, Molecules, New York: W. H. Freeman and Company, 1987, pp. 71-72.

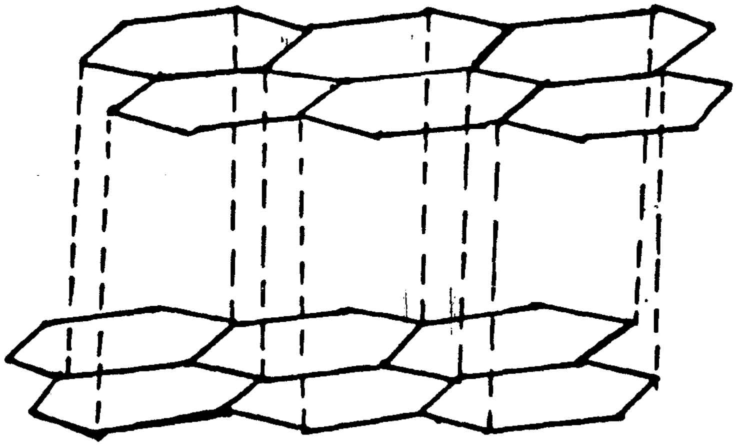
2. William F. Kieffer, Chemistry Today, San Francisco: Canfield Press, 1976, pp. 615-517.

STRUCTURAL DIFFERENCES BETWEEN CARBON AND GRAPHITE

Did you know that diamond is the hardest substance that can be found in nature? It is because of this property that diamond is used as an important tool in drills, saws, bearings for watches, and other precision instruments - not to mention why it is the most highly-valued of gems. Its hardness, refractivity, and chemical stability make it very valuable as a gem. Not all diamonds are cut and polished for jewelry because few meet high quality standards. What meets the standards is very rare - therefore, extremely expensive and valuable. Because of this, methods for synthesizing diamonds have been developed.

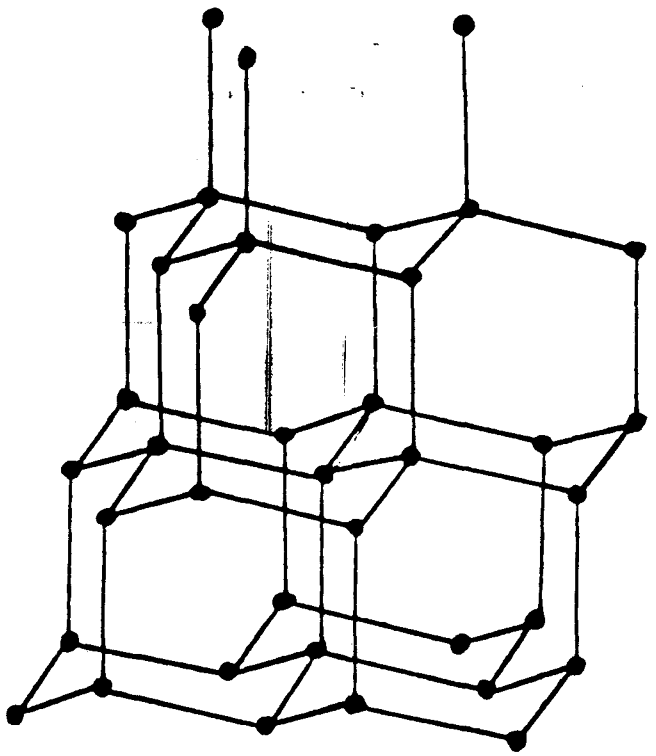
Diamond is an allotropic form of carbon. An allotrope is one of the two or more physical forms in which an element can exist. There is another natural form of carbon called graphite. This substance is not rare, and is the most important constituent of pencil lead. Although graphite is make up of the same carbons atoms that make up diamond, it has completely different characteristics. Graphite is greyish-black in colour, soft, has a metallic sheen, and conducts electricity. These differences in properties are due to differences in crystal structure.

In graphite, the carbon atoms are arranged in layers consisting of interlocking honey-comb-like hexagons which extend into two dimensions. The -C-C-C- bonding angles in the hexagon are 120 degrees, and the distance between carbon atoms is 0.141 nm (10^{-4} m). Distance between layers is 0.334 nm. The carbon atoms in graphite are connected to only three other C-atoms by overlap of sp^2 orbitals, which leaves free unbonded electrons. This accounts for graphites metallic sheen and electrical conductivity. Since the layers of carbon atoms are not bonded, they are held together by weak Vanderwaals forces. This explains the softness of graphite and its usefulness as a lubricant. The "lead" of pencils is actually graphite, whose layers rub off from the pencil on to the paper.



Graphite

The greater density of diamond (3.5 g/cm^3) compared to graphite (2.26 g/cm^3) is attributed to the more tightly-packed carbon molecules. In diamond, every carbon atom is bonded with sigma overlaps of sp^3 orbitals to form a tetrahedron. The distance between two carbon atoms is 0.154 nm. A three-dimensional structure is formed with no layers that can be displaced and no free or loosely-held electrons. This completely-different bond arrangement and spatial geometry results in totally different properties of diamond compared with those of graphite.



Diamond Lattice

Graphite is more abundant in nature than diamond. It is also economically synthesized from coke. Chemists have made many unsuccessful attempts since the 19th century to synthesize diamond. They have tried to induce transformation of graphite to diamond by using very high temperatures and pressures. Today, pressures and temperatures used range from 5000 MPa and 40,000 MPa, and 500-4000 degrees Celsius, respectively. Synthesis at high pressures and temperatures require considerable investment in both apparatus and buildings. For instance, in the former Soviet Union, very high pressure installations are the size of a ten-storey building.

Recently (1985), a third form of pure carbon, informally called buckeyball, was proposed. This form consisted of C-60 clusters shaped like a sphere, geodesic dome, or hollow soccer ball. Applications range from plastics, electrochemistry, to superconductors.

CURRICULUM APPLICATIONS:

The study of allotropic forms of carbon is useful in showing relationships between atomic/molecular structure, physical properties, and applications. Looking into the structure of the forms helps students understand the physical properties of the substances, and how these physical properties are used for various practical applications. This topic may also be applied in units of carbon chemistry, industrial chemistry, bonding, and intermolecular forces.

REFERENCES:

1. Alfred Neubauer, Chemistry Today: The Portrait of a Science, New York: Arco Publishing, Inc. 1983, pp. 60-65.

2. Donald A. McQuarrie and Peter A. Rock, Descriptive Chemistry, New York: W. H. Freeman and Company, 1985, pp. 53-55.

WHY ARE ROOFS OF OLD BUILDINGS GREEN?

A tour of Quebec City or any city with a lot of history reveals an interesting observation. Many roofs of old buildings - like the Hotel Frontenac in Quebec City - have green roofs. The Statue of Liberty, which is 46 m tall and 128 tonnes, is also green. What does it have in common with the Hotel Frontenac in Quebec City? The hotel has a copper roof. The Statue of Liberty, which is 46 metres tall and 128 tonnes, is made up of 300 copper plates. When exposed to weathering, the copper acquires a blue-green patina, which is $Cu_2(OH)_2CO_3$.

Although it is fairly resistant to corrosion, copper slowly oxidizes in air, and when carbon dioxide is also present, its surface becomes coated with a green film $Cu_2(OH)_2CO_3$. This compound is formed by the gradual corrosion of the statue's copper skin. The layer of patina protects the copper underneath it from further corrosion.

The chemical reaction is:

$$Cu + CO_2 + H_2O \longrightarrow Cu_2(OH)_2CO_3$$

CURRICULUM APPLICATIONS:

This illustration is an example of corrosion, the chemistry of copper, and oxidation-reduction reactions.

REFERENCE:

1. James E. Brady and John R. Holum, <u>Fundamentals of Chemistry,</u> Third Edition, Toronto: John Wiley and Sons, 1988, p. 912.

DRAIN OPENER

There is nothing more irritating than a clogged drain, especially if you have to do the dishes in the kitchen, or brush your teeth in the morning. But if it happens, it's DRANO to the rescue.

DRANO is a commercial drain cleaner. It is a mixture of sodium hydroxide and flakes of aluminum.

The most common substances that clog drains are fats in the kitchen and hair in the bath and shower. Sodium hydroxide reacts with fats to form soap, which is soluble in water. A possible chemical reaction is:

$$C_{17}H_{35}COOH \quad + \quad NaOH \quad \text{--------->} \quad C_{17}H_{35}COONa$$

Aluminum reacts with sodium hydroxide in the presence of water. The reaction produces heat and hydrogen gas. The heat speeds up the reaction between sodium hydroxide and fats. The hydrogen gas produced fizzes and agitates the liquid to break up the clog.

Hair is made up of proteins which also react with sodium hydroxide. The reaction loosens the clog, and as soon as the material becomes loose, it passes through the pipe as water is flushed down the drain. The chemical reaction of sodium hydroxide and aluminum is:

$$2Al \ + \ 2NaOH \ + \ 2H_2O \ \text{----->} \ 3H_2 \ + \ 2NaAlO_2 \ + \ \text{heat}$$

Aluminum dissolves in the process of the reaction. This is one reason why oven cleaners that contain sodium hydroxide should not be used in aluminum pots and pans. NaOH attacks aluminum and dissolves it.

Other examples of drain openers are <u>Liquid Drano</u>, which contains NaOH solution, and <u>Liquid Plumber</u>, which contains KOH and hypochlorite.

CURRICULUM APPLICATIONS:

This particular reaction may be used in conjunction with the following topics: Redox principles, rates of reaction, amphoteric nature of aluminum.

REFERENCE:

1. James Brady and John Holum, <u>Fundamentals of Chemistry,</u> Third Edition, Toronto: John Wiley and Sons, 1988, p. 899.

DENTAL CHEMISTRY - The Importance of Fluoride

Most brands of toothpaste in the market widely advertise their fluoride (F^-) content. What role does fluoride play in dental hygiene?

Tooth enamel, the hard protective covering that protects out teeth, extends about 2 mm into the tooth. Enamel consists of a complex, three-dimensional structure - a lattice composed of calcium, phosphate, and hydroxide ions called hydroxyapatite, $CO_2(PO_4)_3OH$. Hydroxyapatite may be dissolved or reformed in the mouth according to the following reaction:

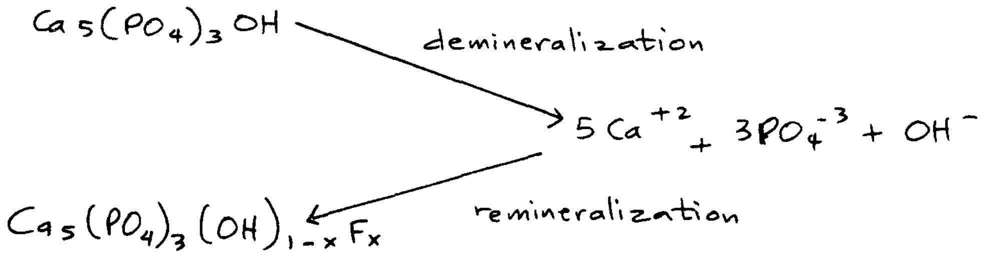
$$Ca_5(PO_4)_3OH \underset{\text{remineralization}}{\overset{\text{dimineralization}}{\rightleftharpoons}} 5Ca^{+2} + 3PO_4^{-3} + OH^-$$

The remineralization is the favoured reaction, thus maintaining the enamel; but dimineralization is favoured more and more as acidity is increased. What causes an increase in acidity?

Plaque is made up of a mass of microorganisms (oral flora), traces of food, and a base material of complex carbohydrates. The anaerobic bacteria in plaque cause fermentation of carbohydrates to organic acids, particularly lactic and acetic acid. Sucrose is particularly harmful, for it may penetrate the plaque and ferment to acids. The more sugar eaten, the more acid is produced. The hydrogen ions in the acid neutralize the hydroxide ions, and drive the reaction to the right, therefore favouring dimineralization. Also, as pH is lowered, the phosphate ions are converted to HPO_4^{-2} and $H_2PO_4^-$, leaving less phosphate, PO_4^{-3}, available for remineralization. The dimineralization reaction will also produce more calcium and phosphate ions which nourish the bacteria, resulting in more plaque.

For better dental health, and to effect dimineralization and favour remineralization, diet is an important factor. A steady stream of sugar increases the formation of acids to favour dimineralization. Sticky sweets adhere to the teeth and in-between teeth, and packs into pits and fissures, then hastening dental carries between teeth and gums. A diet rich in calcium and phosphorus may also slow down dimineralization. Finally, good dental hygiene is important to lessen plaque build-up and minimize acid production.

Fluoride helps prevent dental caries by increasing remineralization. The free fluoride ion relaces the hydroxide ion in the hydroxyapatite lattices forming a tougher mineral. This shifts the equilibrium to the left favouring remineralization.



The resulting fluoridated hydroxyapatite is less soluble in acid solutions, and thus prevents tooth decay.

CURRICULUM APPLICATIONS

This is an excellent practical chemical application of the Le Chatelier's equilibrium principle. This illustration may be used in the unit on Equilibrium in Chem OAC.

REFERENCES:

1. Ben Selinger, Chemistry in the Market Place, Third Edition, Sydney: Harcourt Brace Jovanovich, Publishers, 1986, pp. 250-251.
2. William Stine, Applied Chemistry, Second Edition, Boston: Allyn and Bacon, Inc. 1981, pp. 407-410.

INSTANT SUNGLASSES

Instant sunglasses! They do exist - you probably know at least one person who wears them. As soon as sunlight strikes the lenses, they begin to darken. Within a few minutes, these glasses look more like sunglasses; but as soon as the wearer returns to a room without sunlight, they return to their original clear shade. What causes this change?

Reactive particles embedded in the glass absorb light energy to reach to produce a substance that causes darkening by absorbing and reflecting some of the light that passes through the lens. The reaction reverses, and the class clears when light intensity decreases.

This unusual behaviour under the influence of light is due to submicroscopic silver halide particles in the glass. This glass is called photochromic glass. Silver halides are deposited in a structural region of glass which lies between the appearance of true crystals down to the point where particles are so small they probably contain too few atoms to form a crystal. Silver halides are light sensitive substances that absorb light energy when exposed to light. They then produce particles of silver which account for the darkening of the glass. The reaction is similar to what happens in the emulsion on photographic film.

$$n\,AgCl \longrightarrow n\,Ag + n\,Cl$$

$$n\,Ag \longrightarrow (Ag)_n$$

While photodecomposition of silver halides in photographic film is irreversible, what occurs in photochromic glass is reversible. When light strikes the glass, silver halides decompose, depositing finely-divided silver. The glass then darkens as silver particles absorb light. When light is removed the glass quickly returns to its original state, since the silver atoms recombine with chlorine to form the silver halide compound. This reversible reaction has been found to continue indefinitely with no loss of activity. The system does not photodegrade, since no decomposition products build up to the destroy the chemical activity of the silver chloride. Why is this so?

This interesting behaviour of silver halides in glass was first discovered by scientists studying the basic structure of glass. Researchers were studying effects on various substances dissolved in molten glass as the glass was allowed to harden. Molten glass, or silica, is an extremely viscous, or syrupy liquid. Its structure is composed of a network of interconnected silicon dioxide molecules arranged in tetrahedral form.

These tetrahedral units are then joined together by oxygen bonds in a random manner. In the molten state, the bonds are continually breaking and reforming. Molten silica is a powerful universal solvent. While some atoms may become part of the structural network, others may become an "ionic plasma" moving through holes in the network. In the molten state these ions of dissolved solutes are free to move about, but become locked in place as glass hardens at room temperature. Reactions that occur upon absorption of light are a result of electron shifting and not molecular rearrangement.

In photochromic glass, the solute ions are silver (Ag^+) and chloride (Cl^-) ions. These ions, called microcrystals, are embedded in the holes of the chemically inert glass network. There are about $8x10^{15}$ silver chloride crystals per cubic centimeter of glass. The diameter of the individual crystals is 50 angstrom (1 A is 10^{-8} cm), and the crystals are 500 A apart. There are two factors why the photodecomposition of silver chlorides is reversible: the small size of the crystals and the relatively large distance between them. One chemist says, "photolytic colour centres cannot diffuse away, or grow into stable silver particles, or react chemically to produce an irreversible decomposition of silver halide."

Tests were conducted using mixtures of metals. Regardless of composition, reactions were reversible because light-absorbing particles are not free to move about and clump together into a mass of metal. The rigid glass structure holds them in place, and as a result, light absorption produces only a darkening of glass.

CURRICULUM APPLICATIONS:

This example is an excellent practical application of the chemistry of silver; it could also be used as an application of oxidation-reduction reactions. The concept may also be mentioned as an application of Ksp in the Equilibrium Unit. This can also be used as an example of how structural relationships affect physical properties of materials.

REFERENCE:

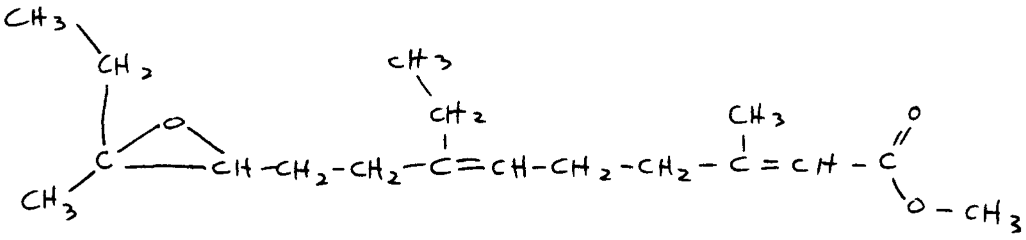
1. A. H. Drummond, Jr., Molecules in the Service of Man, New York: J. B. Lippincott Company, 1972, pp. 66-74.

JUVENILE HORMONES

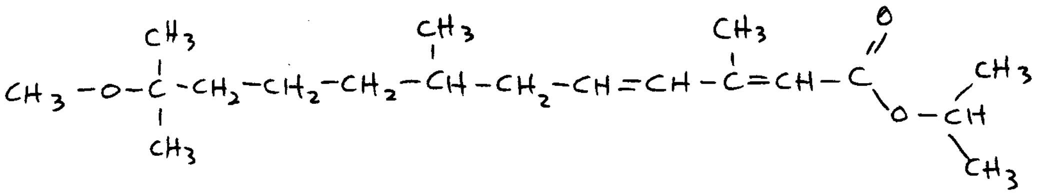
How would you like to remain forever young? For ages men have been searching for the "fountain of youth." Nobody really wants to grow old. If someone came up with a hormone that would keep the human race forever young, that person would surely become a millionaire.

Insect metamorphosis is controlled by a small gland behind the insect's brains called corpus allatum. During the larval stage, the gland secretes a hormone called juvenile hormone that controls the rate of development of the young. Under the influence of this hormone, larval characteristics are retained. When secretion of the hormone stops, adult characteristics are developed and metamorphosis progresses. The hormone is stored in the insects' abdomens. A single insect's abdomen yields enough hormone to block development of 10 pupae.

A variety of insect juvenile hormones have been isolated by chemists. Once the structures have been determined, chemists can synthesize hormones in the laboratory. A mosquito juvenile hormone has been isolated. Its structure was determined to be:



When this hormone is applied to mosquitoes in the larval stage, they will not mature, hence cannot reproduce. By replacing certain groups in a structure, chemists have been able to synthesize more potent and effective compounds. These compounds are called analogs. The following compound, whose structure is given below, has been found to be nearly 2000 times as effective as the above natural hormone.

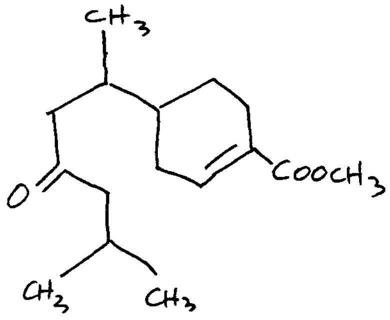


$$CH_3-O-\underset{CH_3}{\overset{CH_3}{C}}-CH_2-CH_2-CH_2-\overset{CH_3}{CH}-CH_2-CH=CH-\overset{CH_3}{C}=CH-\overset{O}{\overset{\|}{C}}-O-\underset{CH_3}{\overset{CH_3}{CH}}$$

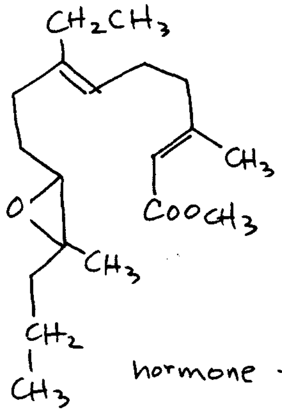
The hormone is very stable, resistant to heat, dilute acids and bases. Active hormone has been extracted from museum insects dead for eight years. The hormone is also effective when applied to the skin. It penetrates the insect cuticle.

Although expensive and difficult to synthesize, juvenile hormones are an environmentally safe pesticide, and would be cost-effective in the long run. They are a truly perfect insecticide, because insects cannot develop resistance to their own hormones. Juvenile hormones are mainly effective for insects which are pests in the adult stage. Keeping a voracious caterpillar in the larval stage will have devastating effects.

Some evergreens, the balsam fir, in particular, have built-insecticides. This was discovered quite by accident. A scientist brought some bugs called <u>Pyrhocoris apterus</u> from Czechoslovakia, which had been reared in Prague. The bugs died without reaching sexual maturity. It was found that the bugs had access to juvenile hormones from paper towelling made from balsam fir. This effect was observed only with American paper, but not with European or Japanese paper. Pulp and paper products in the US and Canada use balsam fir. The hormone analog from the balsam fir has a structure very similar to the juvenile hormone of the caecropia moth.



hormone analog
from
balsam fir



hormone from
caecropia moth

Cosmetic scientists have dreamed up another use for the juvenile hormone. They want to put it in their potions. Could this be a secret to looking forever young and beautiful in the future? Only time will tell.

CURRICULUM APPLICATIONS:

The study of juvenile hormones can be integrated into the study of organic chemistry, and the important role of organic synthesis in improving the quality of life. It is an excellent example of preservation of the environment by chemical manipulation of natural organic compounds. It can also be applied in the study of diffusion and Brownian movement.

REFERENCES:

1. John Hill, Chemistry for Changing Times, Third Edition, Minneapolis, Minnesota: Burgess Publishing Co., 1980, pp. 208-209.

2. V. B. Wigglesworth, "Metamorphosis, Polymorphism, Differentiation, Scientific American, Feb, 1959, Vol. 199, No. 2, pp. 100-104.

3. Carrol Williams, "The Juvenile Hormone," Scientific American, February 1958, Vol. 199, No. 2, pp. 67-68.

4. Carrol Williams, "Third Generation Pesticides," Scientific American, July 1967, Vol. 217, No. 1, pp. 13-17.

PERSONAL CARE PRODUCTS

For ages men and women have used chemicals to improve their appearance. Did you know that way back centuries ago, ancient Egyptian women used green eye shadow and eye liner? They used malachite, a copper ore, as eye shadow, and galena, a lead ore, as eyeliner. Women in colonial America used common garden products as beauty aids. Lavender, rose water, and cucumber cream were used as perfumes; beat juice as lipstick; and burnt cork as an eyelash darkener. Today, the personal care products industry is a billion-dollar undertaking. There is a wealth of chemistry involved in personal care products.

Deodorants.

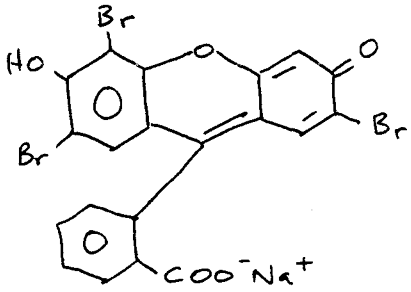
The human body has 2,000,000 sweat glands which regulate body temperatures by evaporation of water. This evaporation leaves residues like sodium chloride and other organic compounds like amines and fatty oils. Bacterial action on these products and hydrolysis of fatty oils cause body odour. There are three kinds of deodorants: anti-perspirants or astringents, odour-maskers, and those which remove odorous compounds by combining with them.

Anti-perspirants contain mainly aluminum, zinc and zirconium compounds, the most common of which are hydrated aluminum chloride, $AlCl_3.6H_2O$; and aluminum chlorohydrate, $Al_2(OH)_3Cl.2H_2O$. It is postulated, although the mode of action is not clear, that aluminum salts close up openings of the sweat glands by affecting the hydrogen bonds that hold protein molecules together or by coagulating skin proteins.

Lipstick.

Our lips are covered by a thin corneal layer that is fat-free and prone to drying. Lipstick is a beauty aid as well as a moisturizer to help prevent dryness. Lipstick should be uniform, shiny but not too greasy, stable to light and temperature changes, non-toxic, non-irritating, and neutral in taste.

It consists of colouring agents, an anti-oxidant, preservative, perfume, colouring agent, and high molecular weight esters called "lake," which is a precipitate of a metal ion like Fe, Ni, or Co with an organic dye. One of the dyes used is the sodium salt of tetrabromofluorescien, whose structure is shown below:



TETRABROMOFLUORESCIEN (Fosin)

The other ingredients in lipstick are:

Dye	Colouring Agent	4-8%
Castor oil or other paraffins	Dissolves dye	50%
Lanolin	Emollient	25%

Carnauba wax or beeswax	Raises melting point and stiffens stick	18%
Perfume	Imparts pleasant odour	small amt.

Face Powder.

Face powder gives the skin a smooth, silky appearance by covering up oily secretions which make the skin look shiny. It should also have good spreading and sticking ability. Its absorbing qualities are derived from calcium carbonate, formed by precipitating aqueous solutions of chloride and sodium carbonate.

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + NaCl$$

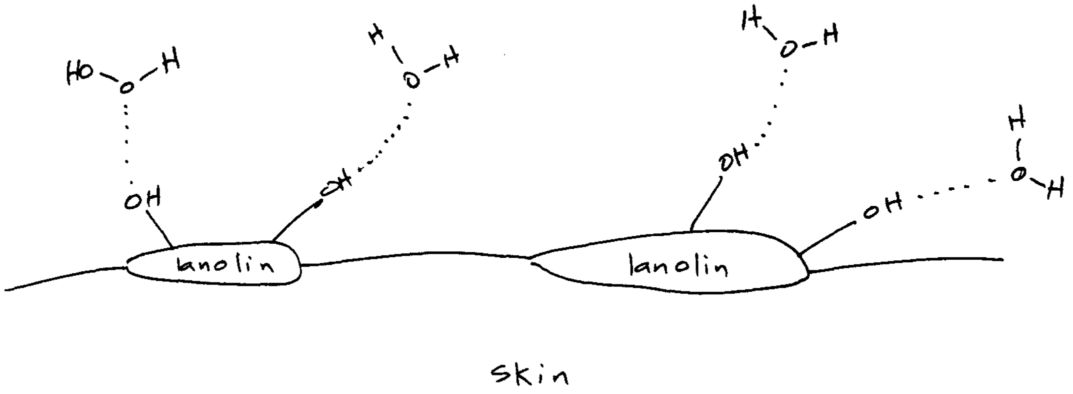
Other ingredients are:

Talc	56%
Zinc oxide	20%
Zinc stearate	6%
Perfume and dye	trace

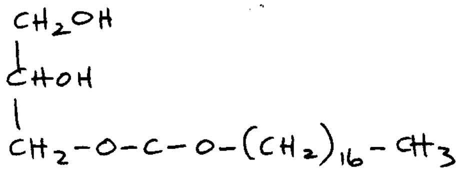
Facial Creams.

Skin must have a moisture content of around 10% to maintain a healthy look. A higher moisture content encourages bacterial growth, and a lower content precipitates dry skin. Washing skin removes natural fats that retain optimum amount of moisture. This necessitates treating the skin with a fat to allow natural fats to be regenerated.

Facial creams are emulsions (colloidal dispersions of one liquid in another) of oil and water. Lanolin is a component of many skin softeners and moisturizers. It is a mixture of esters, hydrated fat, and cholesterol - an alcohol. The skin is kept moist by the hydrogen bonding of alcohol groups to water. The fat parts of the molecule are "soluble" in the protein and fat layers of the skin, forming a protective layer.

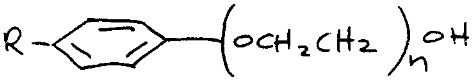


The structural formulas for some common emulsifiers used in cosmetics are:



$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2-O-C-O-(CH_2)_{16}-CH_3 \end{array}$$

glycerol monostearate



polyoxyethelene alkyl phenol

Other skin-care creams are cleansing creams and lotions which dissolve or take away more easily the grease that hold pigments, grime, and make-up on the skin; cleansers for oily skin, which remove excessive oil flow; and moisturizers that replace lost water and protects skin from dryness by slowing evaporation of water from the outer layer of the skin.

CURRICULUM APPLICATIONS:

Personal care products chemistry can be discussed in conjunction with solutions and their properties. This is also a good example of the relationship between organic structures and properties.

REFERENCES:

1. Mark Jones, David Johnston, John Netterville, James Wood, and Melvin Joesten, Chemistry and Society, 5th Edition, London: Saunders College Publishing, 1988, pp. 611-616.

2. Mark Jones, et. al., Chemistry, Man, and Society, London: W. B. Saunders Company, 1972, pp. 548-549.

3. David Newton, Consumer Chemistry Projects for Young Scientists, Toronto: Franklin Watts, 1991, pp. 52-53.

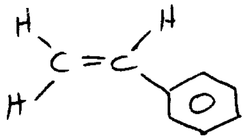
4. Ben Selinger, Chemistry in the Market Place, Sydney: Harcourt Brace Jovanovich, Publishers, 1986, pp. 91-101.

POLYSTYRENE FOAM

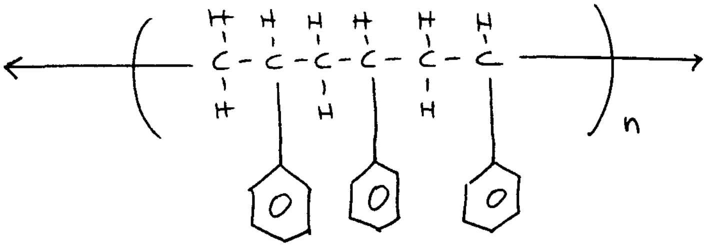
How does a sunken ship get raised out of the depths of the water? Traditionally, sunken vessels were raised by pumping them full of air. This was found to be an expensive procedure since it required sealing the whole ship to prevent air from leaking out, which would cause the salvage operation to be futile. The development of polystyrene foam solved this problem.

A few years ago, a freighter full of sheep sank in the Kuwait harbour. It was pumped full of polystyrene beads. The air bubbles trapped in the polystyrene foam gave the ship the buoyancy it needed to rise to the surface. Several underwater salvage operations have been successful using this technique.

Many polymers can be made by substituting an atom or group of atoms for one of the hydrogen atoms in the ethene (ethylene) molecule. Styrene is formed by substituting a benzene ring for hydrogen as shown below:



Polymerization of the styrene molecule results in polystyrene.



During the polymerization of styrene, the material changes from liquid to solid form. While in the liquid form, other chemicals are added that are capable of decomposing into gases. The gas bubbles form during the process, and are trapped into a solid foam as the polymer solidifies. This makes polystyrene rigid, yet very light. The product is called styrofoam, and is used as light-weight containers. Because benzene groups on the chain obstruct movements of chains past each other, polystyrene is less flexible than polyethylene.

Styrofoam softens when heated slightly, and can be moulded into any desired shape. This property of polystyrene foam makes it useful in making light-weight supports for broken fingers and sprained joints, and for making movie sets, props, and costumes. Armour breastplates and helmets may be moulded directly to the actors' bodies. Authentic-looking spears, swords, and other props can be made. This process also saves money and the environment, because props may be recycled and re-used simply by reheating and remolding.

CURRICULUM APPLICATIONS.

This topic is useful in units in polymerization, industrial chemistry, and environmental chemistry. It may also be used to illustrate the relationship of molecular structure to physical properties and practical applications.

REFERENCES:

1. James A. Corrick, Recent Revolutions in Chemistry, New York: Franklin Watts, 1986, p. 34.
2. William F. Kieffer, Chemistry Today, New York: Canfield Press, 1976, pp. 514-516.

ARCTIC BOMBS

Have you ever wondered what causes weather fluctuations and severe storms, putting dampers on some of the best of our plans, and inflicting havoc not only on our schedules, but also on lives and properties?

Factors like elevation, cloud cover, land terrain, nearness to water bodies, to name a few, affect the rate of cooling and temperatures reached at night. Extremely cold weather systems could develop if air becomes trapped. In situations like this, the temperature reaches record lows and the atmospheric pressure reaches record highs. This is called the "arctic bomb." One such bomb developed over Siberia and lasted for two weeks, achieving record-breaking lows of -66 degrees Centigrade and highs of 809 torr pressure. These systems are monitored closely since they are important in plotting long-range weather forecasts.

This phenomenon may be explained using ideal gas laws, but there appear to be contradictions to the pressure-temperature relationships in the ideal gas law, $PV = nRT$, which shows that the pressure of air rises with increased temperature or vice versa. In an arctic bomb, atmospheric pressure increases as temperature plummets. How can this apparent contradiction be explained?

As the air cools, the volume decreases. Since we are dealing with an open system which allows matter to enter and exit, air from the surroundings is brought over the cool, shrinking air, and the mass of the atmosphere over the affected area is increased. This combined effect produces simultaneously high pressure and colder temperature. Gases tend to spontaneously flow from high pressure to low pressure. Atmospheric pressure decreases with altitude, but air near the surface does not flow to higher altitude due to the force of gravity. The ideal gas law works for closed systems, but the atmosphere is an open system that allows matter to enter and leave.

Why pressure is inversely proportional to temperature in an arctic bomb, as opposed to what is predicted by the ideal gas law may be explained quite simply. Picture the atmosphere as a gigantic sea of fluid air with waves like the oceans. Crests correspond to areas of high pressure, while valleys correspond to low pressure areas. The jet stream may trap these areas. Since the column of air of high pressure has more mass than that of low pressure, it is a better thermal conductor than its surroundings of low pressure. Cooling therefore occurs faster in these high pressure regions. Air is drawn into the cooler regions to replace the air that is cooling and shrinking. This causes further increases in the atmospheric pressure, and more rapid cooling. The cycle continues as long as the air column is trapped by the jet stream, and will continue to intensify until an "arctic bomb" is formed. A simple mathematical derivation for the conditions of an arctic bomb is shown in the reference given.

CURRICULUM APPLICATIONS.

This phenomenon may be used as an application of ideal gas laws. This is a good example of how a valid scientific principle may be in direct conflict with experience; but will help the student analyze, understand, and question the conditions why this happens, and apply the law to open systems like our atmosphere.

REFERENCE:

1. Earl F. Pearson, "Revealing the Secret of the Arctic Bomb," Journal of Chem. Ed., 70, 4 (April 1993), pp. 315-317.

TITANIC CHEMISTRY

Does chemistry have anything to do with the Titanic? It sure does. The Titanic was the great "unsinkable" ocean liner, which ironically sank on its maiden voyage after sideswiping an iceberg about 95 miles south of the Grand Banks of Newfoundland.

The Titanic, the world's largest ship then, was built by 17,000 workers, and had the latest in design and technology. When she sailed from Southhampton, England with 2,227 passengers, she had the elite of the industrial society, including Thomas Andres, the ship's builder. Builders claimed she was "unsinkable," and even in a worst-case situation, it would take from one to three days to sink. History has shown us otherwise. Just after 11:30 p.m., on that fateful day of April 12, 1912, an iceberg sliced the Titanic around the waterline, splitting it like a 300-foot zipper, and at 2:20 a.m. of the next day, it sunk beneath the surface, carrying with it 1500 passengers. It had sunk in less than three hours,

In 1991 tests were done by scientists that were part of the IMAX team that was to film the wreck. Lead scientist was Steve Blasco, a geologist with Canada's Department of Natural Resources. Using as Charpy machine to test brittleness, the team found out that the Titanic's hull was very brittle. The steel plates were not ductile, they fractured. This brittleness was due to high sulphur content. The Titanic's hull was full of sulphide occlusions called "stringers," and its sulphur content was high even for the time it was built. That type of steel would never get out of the yard today.

Blasco says, "shipbuilding technology has outstripped metallurgy technology." Canadians call the Titanic "the 1912 Challenger," after the space shuttle that exploded in mid-air, since "both disasters resulted from a failure to understand how a material - whether brittle steel plate or brittle rubber seal - would behave."

Chemistry has also played a vital role in restoring the various artifacts that have been retrieved from the ocean floor. There is very little corrosion down there. The cell structure, grain, and chemical composition of the steel is virtually identical to steel from a souvenir slug from a rivet hole that somebody took as a souvenir before the ship sailed. Some explanations offered are: complete absence of light, temperature of zero degrees Centigrade, very little oxygen, and a combination of temperature and pressure, which researchers cannot somehow explain quite well yet. Many artifacts have suffered biological and chemical corrosion, and erosion by sand and water currents.

Researchers at Michrochem and the Geological Survey of Canada in Nova Scotia showed that rapidly-multiplying sulphate-reducing anaerobic bacteria promoted growth of rusticles, a type of corrosion. Chlorides and sulphates from seawater have also weakened some artifacts. Corrosion is accelerated if they are brought up and exposed to oxygen, so they have to be kept in water.

Artifacts are analyzed by a powder x-ray diffractometer and a scanning electron microscope (SEM), equipped with x-ray spectrometer to find out the composition of alloys and corrosion products. With this information, the best possible treatment for the relics can be determined. Copper-based materials were found to corrode to form copper hydroxychlorides, and silver artifacts formed silver chloride at a slower rate of corrosion than copper.

Artifacts are treated by frequent washing out of surface salts by electrolysis, or treatment with complexing-reducing agents. In electrolysis, the object is the cathode, a stainless steel plate is the anode, and electrolytes may be dilute sodium hydroxide or sodium carbonate. The weak current draws out chloride ions from the metal and hydrogen bubbles formed loosen the corrosion products. Electrolysis also stops further corrosion. A clear wax protective coating is then put over the relic.

Complexing agents like oxalic acid are also used to remove iron corrosion products. The iron oxalate formed is easily removed by washing. Conditions like the right temperature and humidity have to be meticulously maintained to prevent further corrosion.

The valuable information derived from the scientific examinations of the wreck and the artifacts provide a wide range of important insights for scientists. Long-term deterioration rates are better understood, and may be applied to pipeline maintenance and construction and containment of radioactive wastes from sunken nuclear submarines.

CURRICULUM APPLICATIONS.

A wide range of chemical principles are involved in the study of why the Titanic sunk, and of its relics. Some of the basic concepts are rate of reactions, oxidation-reduction, Le Chatelier's equilibrium principle (the effects of temperature, pressure, and other factors on the rate of corrosion), complexation, and molecular-structural considerations. This could very well be expanded and assigned as an independent study unit. The student could go into several chemical procedures, details, and specific chemical reactions in the study.

REFERENCES:

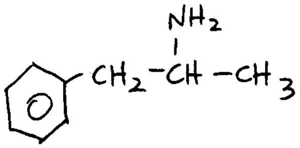
1. Michael Freemantle, "Chemical Techniques Help Conserve Artifacts Raised From Titanic Wreck," Chemical and Engineering News, October, 17, 1994, pp. 49-52.

2. Robert Gannon, "What Really Sank the Titanic," Popular Science, February 1995, pp. 49-55, 83.

007 CHEMISTRY

Many of us have enjoyed at one time or another the series of James Bond - secret agent 007 movies, based on the novels of Ian Fleming. Even today, new movies featuring James Bond are still being produced. Many references to chemicals and chemistry are mentioned in James Bond movies.

Ethyl alcohol in its various forms is mentioned most frequently in Fleming's books. Organic compounds mentioned frequently in Bond novels are benzedrine and chloral hydrate. Benzedrine or amphetamine (1-phenyl-2-propanamine), is a primary amine whose structure is shown below. It is a central nervous system stimulant, and its use is relatively common in Fleming's novels.



1-phenyl-2-propanamine

Chloral hydrate is sometimes referred to as "knock-out drops" or a "Mickey Finn" in many fiction novels. In <u>From Russia with Love</u>, Bond's female ally is given by his adversary, Grant, some chloral hydrate in her wine to sedate her. Chloral hydrate is produced by adding water to the stable yellow solid of trichloroacetaldehyde, as shown in the chemical reaction below.

$$Cl-\underset{Cl}{\overset{Cl}{C}}-\underset{O}{\overset{}{C}}-H + H_2O \longrightarrow Cl-\underset{Cl}{\overset{Cl}{C}}-\underset{OH}{\overset{OH}{C}}-H$$

The combination of the compound with alcohol could very well be fatal.

In Goldfinger and Octopussy, aqua regia is used. Aqua regia, a 3:1 mixture of concentrated hydrochloric acid and nitric acid dissolves all metals, including gold and platinum. In Octopussy, Bond is given a fountain pen containing aqua regia, which he uses to dissolve the metal bars of his cell. In Goldfinger, the first name of the villain is Auric, and he has a license plate AU1 (AU3 would have been more appropriate due to the oxidation state of gold. The chemical reaction of gold and aqua regia is:

$$Au_{(s)} + 4Cl^-{}_{(aq)} + 3NO_3^-{}_{(aq)} + 6H^+{}_{(aq)} \longrightarrow AuCl_4^-{}_{(aq)} + 3NO_{2\,(g)} + 3H_2O_{(l)}$$

Moonraker includes a discussion of possible fuels like oxygen and ethanol, hydrogen and fluorine, and hydrogen peroxide and potassium permanganate, which is a good example of a redox equation.

$$2MnO_4^-{}_{(aq)} + 6H^+{}_{(aq)} + 5H_2O_{(aq)} \longrightarrow 2Mn^{+2}{}_{(aq)} + 8H_2O_{(l)} + 5O_{2\,(g)}$$

Other references to chemicals and chemistry in Bond stories include the use of hydrogen cyanide, phosgene, TNT, several aspects of nuclear chemistry and radioactivity, diamonds, use of helium and oxygen mixture for divers, and bauxite deposits in the Caribbean. Fleming also refers to industrial chemistry when he mentions how the guano business went into decline with the development of artificial chemical manure, and when Bond poses as an agent and approaches a Japanese firm for the purchase of monosodium glutamate (MSG). MSG is prepared synthetically by AJINOMOTO, which produces 1000 tonnes of it per month.

References are also made to natural products. In _You Only Live Twice_, an extensive list of plants that produce alkaloids and other poisonous substances is given. In _Moonraker_, a structure of the substance that Drax proposes to use to destroy human life is flashed on the screen.

A mixture of copper acetate and dark nigrosine dye is used to repel sharks in _Live and Let Die_. This was used in the survival gear of the US Navy in World War II. The uses of neurotoxin and tetrodoxin are also mentioned. These chemicals are used by sorcerers to create zombies.

CURRICULUM APPLICATIONS.

The wealth of chemistry-related references in Ian Fleming's books offer a wide-range of curriculum applications from organic chemistry, natural products chemistry, inorganic chemical reactions, and industrial chemistry. Teachers can stimulate students' interest in chemistry by referring to these examples in their discussions and lectures. This could also be a starting point in an independent study investigation for an OAC Chemistry course, where chemistry trivia can be gleaned from other popular culture sources, like other novels and movies aside from the 007 Series.

REFERENCES:

1. Arthur M. Last, "Chemistry and Popular Culture," Journal of Chem. Ed., 69, 3 (March 1992), pp. 206-208.

2. J. McKetta, Editor, Encyclopedia of Chemical Processing and Design, Vol. 3, New York: Marcel Dekker, 1977, pp. 230-231.

SWIMMING-POOL CHEMISTRY

Welcome, summer! Enter hot and humid days! At these times, people who are fortunate to have a swimming pool in their backyards retreat to them to escape the heat and humidity of the Ontario summer. Little do most people know the amount of chemistry that goes into the operation and maintenance of a backyard swimming pool.

The major chemical used in pools is chlorine. Pool water must be free of disease-producing organisms. Pool water also accumulates body excretions, garden debris, and other wastes as it is used over and over again. Chlorine is used as a strong oxidizing agent to sterilize the water and make it safe for continued use. It is necessary to maintain chlorine levels to prevent the danger of ear, eye, and throat infections.

When chlorine is added to water, hypochlorous acid is produced, which forms the principal disinfecting action of chlorine.

$$Cl_2(aq) + 2H_2O \rightleftharpoons HOCl + Cl^- + H_3O^+$$

At pH levels above 4, the equilibrium is displaced towards the right, and very little free chlorine is in solution. Hypochlorous acid dissociates in water to form hydrogen and hypochlorite ions. The reaction is reversible depending on pH and temperature.

$$H_2O + HOCl \rightleftharpoons H_3O^+ + OCl^-$$

An optimum pH of 7.2 and 7.6 needs to be maintained in pool water if an equilibrium between HOCl and OCl^- is to be maintained. HOCl is much more effective in killing bacteria than OCl^- because the negative charge or the ion hinders it from entering bacteria; however, at low pH levels corrosion of various pool components is increased. An indicator is used to measure pH levels in a swimming pool. The one chosen, phenol red, has the same pKa as hypochlorous acid.

At certain intervals, usually, weekly or lesser, if there is heavy pool usage, the pool needs to be "shocked" or superchlorinated. Chlorine reacts with sweat or body fluids to form chloramines. Additional chlorine is necessary to oxidize these chloramines to nitrogen gas and nitrates. This additional chlorine treatment is known as superchorination.

Adjusting pool pH involves adding chemicals to increase or decrease pH. pH of natural water is about 6 due to dissolved carbon dioxide. In most cases, a "ph UP" is used, which consists of sodium bicarbonate or sodium carbonate. The hydrolysis of these salts produce basic solutions that raise the pH.

Chlorine is rapidly lost from pool water in the presence of sunlight, by the reaction:

$$OCl^- \xrightarrow[uv]{\qquad\qquad} Cl^- + \tfrac{1}{2}O_2\,(g)$$

Because of photolysis, chlorine stabilizers are added to pool water to prevent the loss of chlorine.

Other chemicals added to pool water are clarifiers, to produce crystal clear water. Alum is an ingredient in these clarifiers. It causes coagulation of tiny colloidal particles that cause water to appear cloudy. The coagulated material then settles at the bottom of the pool where it can be vacuumed, or becomes large enough to be filtered.

The amount of chemicals to be used have to be measured, taking into consideration the capacity of the pool or the volume of water in the pool.

CURRICULUM APPLICATIONS.

Since most students, if not all, enjoy swimming, swimming-pool chemistry can be used effectively to motivate interest in such curriculum concepts like pH, acids and bases, buffers, equilibrium, oxidation-reduction, electrolysis, photochemistry, and mole concept. This topic could also be researched in greater detail in an independent study unit, which is part of the core curriculum in OAC Chemistry.

REFERENCES:

1. Ben Selinger, Chemistry in the Marketplace, Third Edition, Sydney: Harcourt Brace Jovanovich, Publishers, 1986, pp. 144-155.
2. Various commercial pool care pamphlets from pool chemical suppliers.

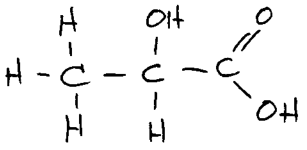
PICKLE CHEMISTRY

Pass the kimchi, please! Even today, fermented vegetable products form an important part of the diets of many cultures, not only in Asia and Europe, but also in North America, which is a melting pot of cultures.

For centuries, vegetables have been preserved by fermentation. It still is a primary method of preservation in countries where canning or freezing is not widely used. This process is more energy efficient compared to other methods, and the product can be stored for at least one year.

In fermentations, microorganisms convert sugars to acids, lowering the pH and thus preventing organisms that cause spoilage from thriving. Added salt and the absence of carbohydrates further contribute to preservation by inhibiting yeast formation.

Lactic acid bacteria are primarily accountable for chemical reactions responsible for preservation. The chemical processes causing these changes are brought about by enzymes produced by the lactic acid bacteria. The formula for lactic acid is $CH_3CHOHCOOH$, and the structure is:



The growth of lactic acid bacteria inhibits acid-sensitive spoilage organisms that are found in fresh vegetables. A rapid decrease in pH levels allows the lactic acid bacteria to overwhelm the others. Acidity and buffer capacity both influence the growth rate of lactic acid bacteria. The rate of fermentation is affected by several factors, namely: salt concentration, temperature, chemical additives, exposure to air and light, amount of carbohydrates, and other ingredients.

Lactic acid bacteria deter spoilage in several ways. They produce hydrogen peroxide that inhibits spoilage organisms. They produce carbon dioxide that flushes out the oxygen, thus preventing growth of other bacteria. They also produce antibiotic-like compounds that inhibit other bacteria. Nearly all known vegetables can be fermented by lactic acid bacteria, provided the right conditions are produced.

Four economically important fermented vegetables are cabbage, cucumbers, olives, and kimchi.

Cabbage.

Mature cabbage is picked in autumn and trimmed sparingly to avoid removal of the lactic acid bacteria. Salt is added using electronic salting machines. Salt extracts water from the cabbage by osmosis, suppressing growth of organisms that need water to survive. It also prevents softening of cabbage tissue. Respiration of the cabbage and microorganisms uses up the oxygen. An airtight seal is placed on the vat, and the sauerkraut is heated to kill gas-producing organisms that burst cans.

Cucumbers.

Pickles are the number one fermented product in North America. Pickles are fermented in brine, 5-8% NaCl solution, in fibreglass and plastic fermentation tanks, and sealed with a plastic sheet, covered with water. Rates of reaction are dependent on the temperature of brine and the concentration of salt. After 10 days, the lactic acid bacteria, which are the only ones present then, lower the pH to prevent further spoilage.

Olives.

Canned, ripe olives, minimally fermented, are popular in the United States, and account for 70% of the olive market. The olives are washed, soaked in lye (1-2% NaOH solution) to remove bitterness caused by oleuropein. Oleuropein is hydrolyzed by lye. The olives are then vigorously aerated in water, rinsed, packed, heat processed, and marketed.

Sicilian-type olives are packed in 5-8% NaCl solution minus the lye treatment. They are needled so their surfaces do not shrivel in brine due to osmotic pressure differences. Fermentation is accomplished in about 30 days by lactic acid bacteria.

Kimchi.

Koreans consume 50-500 grams of kimchi per person per day. Kimchi is made by fermenting a combination of radishes, turnips, onions, and Chinese cabbage. Sometimes sweet and sour peppers are added to give more flavour. The mixture is immersed in 3% salt concentration, and temperature is maintained between 10-20 degrees Centigrade during fermentation. The finished kimchi has a pH of 4.2-4.5.

CURRICULUM APPLICATIONS.

Fermentation can be integrated in various concepts like chemical kinetics, particularly the effect of catalysts and temperature on reaction rates. The application is also valuable in discussing osmosis, passive and active transport, pH, and equilibrium.

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NUCLEAR MEDICINE - RADIOISOTOPES

Did you know that Canada is at the forefront of nuclear technology, and that the Atomic Energy of Canada Limited (AECL), a federal crown corporation, is the world's largest supplier of Cobalt 60?

Nuclear medicine, a more recent medical practice, dates back to the early 1950's. Today it is widely used in medical treatment, diagnosis, and research, saving millions of lives. It is also used to improve product quality and safety in numerous industrial activities. Hardly a single major hospital exists in an industrialized country which does not have radiology and nuclear medicine departments. A wide array of laboratory radiochemical methods are used for diagnosis, investigation, and treatment of many diseases. One of three patients in an industrialized country benefit from some type of nuclear medicine procedure.

All these applications in nuclear medicine owe their success to isotopes. Isotopes are atoms that differ from one another only by the number of neutrons in the nucleus. Isotopes represent a tool which can perform jobs better, easier, quicker, more simply and cheaper than other methods. Some measurements cannot be done at all without the use of isotopes, since no other methods are available. Using radioactive isotopes, the detection limit of an element is enhanced a million times.

Radioisotopes are used for cancer therapy and a multitude of other diagnostic procedures. When radioisotopes are given to a patient, its distribution, rate, and concentration can be traced by detectors. Using this technology, one can determine how well organs function and how the body absorbs certain substances. This technology can also be used to locate and delineate tumours, eliminating the need for exploratory surgery. Some of the important radioisotopes used in nuclear medicine, and produced in Canada, are discussed below.

Cobalt-60

Cobalt-60 is the most widely-used radioactive substance. It is a deliberately-manufactured, man-made isotope. It is the most-widely used radioactive substance for therapeutic applications, and is also widely used in the plastics industry, food irradiation, and in lumber and paper-making industries. Our very own Ontario Hydro's nuclear reactors, Canadian-made CANDU (Canada Deuterium Uranium) reactors, and the research reactor at AECL's Chalk River Plant provide eighty to ninety percent of the world's supply of Cobalt-60. The CANDU reactor's design has a specially built-in program for Cobalt-60. Cobalt-59 rods are irradiated in the reactor to absorb neutrons for about one year. The resulting Cobalt-60 is then removed and used for a broad variety of applications.

Cobalt-60 is used in cancer therapy machines all over the world, treating over a million people a year, and has been used to treat cancer patients for more than thirty years. This technology was developed in Canada by Dr. Harold Johns in 1951 at the University of Saskatchewan. The Cobalt-60 therapy machine was first used at the Victoria Hospital in London, Ontario. John's invention revolutionized cancer treatment around the world. Radiation therapy treats 50 % of cancer cases, and one out of two cancer patients cured owes their life to radiation therapy. An estimated 13,000,000 years of added human life have been made possible through Cobalt-60 therapy.

Cobalt-60 is also used to sterilize a wide range of medical products like syringes, surgical gloves, gowns, and masks, surgical instruments, catheters, sutures, lubricating jellies, and a host of other hospital supplies. It is also used to irradiate food products to destroy bacteria; sterilize cosmetic products like powders, artificial eyelashes, and mascara; sterilize female hygiene products; and irradiate human fluids and wastes before disposal.

AECL designed the first full-scale sterilizers to process large volumes of medical, pharmaceutical, and food products in 1964. Today, more than half of all large sterilizers in the world are designed and manufactured in Canada by the AECL.

Molybdenum-99

Molybdenum-99, which has a half-life of about 66 hours, is the most important diagnostic radioisotope being produced at Chalk River. It is used in more than seven million diagnostic procedures annually around the world.

Technetium-99

Technetium-99, the most important general purpose isotope in the diagnostic field, is produced at Chalk River and Kanata's Nordion International Incorporated (formerly the Radiochemical Company of AECL). It is used to"label" chemical compounds known to migrate to various parts of the body. With it, doctors can determine if an organ is functioning properly. This aids in diagnosis of ailments of most body parts including the brain, liver, lungs, thyroid gland, kidneys, and bones. At least five million people undergo technetium-99 diagnostic procedures annually.

CURRICULUM APPLICATIONS

This very interesting topic, with mostly Canadian involvement, could be used in the core unit of matter in the Grade 11 Chemistry (SCH 3A) course. It could also be used to supplement practical applications in a chapter of Nuclear Chemistry, and can be expanded and thoroughly researched on as a possible ISU project. An extension to this application would be other diagnostic scanning systems like positron emission tomography (PET), magnetic resonance imaging (MRI), and other scanning techniques.

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CHAPTER 6

EVALUATION AND CONCLUSIONS

EVALUATION

The results of the survey were very positive. They showed (see Appendix C) that all who returned the questionnaire, except one (Question # 3), strongly agreed or agreed with the statements in the questionnaire. The respondents indicated that the hand-outs were suitable for Grade 11 Chemistry (SCH 3A) and Chemistry OAC (SCH OA). They would consider using the hand-outs in their teaching, and assign some as independent study units, which are required in Chemistry OAC. All agreed or strongly agreed that the examples will increase the students' interest in chemistry. All surveyed indicated that a compilation of these examples will be very useful for teachers, and all responded affirmatively to the question of personally purchasing a compilation of these examples, if published. Everybody who handed back the questionnaires acknowledged that the examples would enrich the introductory chemistry curriculum.

The respondents to the questionnaire gave several ideas on how they would use the examples in their teaching. Several wrote that they would use them as starting points for independent research, especially for Chemistry OAC (SCH OA), where one of the core topics is an independent study unit (ISU). The teacher would furnish the students with ideas from the examples, and the students would do a laboratory-based independent study or research the topic in more detail, then do a presentation in class. The examples could also be used as reference points for group projects and presentations.

One teacher wrote that she would use the sheets as reading assignments, then turn them into test or quiz questions. Another use of the sheets would be to utilize them as reference sheets for short reports. They could also be reproduced and handed out to students at appropriate segments in the chapter to enrich and motivate them. They could be used as discussion starters for a specific unit or used as examples during a lesson to provide connections between theory and practice.

Solicited comments were very positive and encouraging. One respondent wrote that this system was a good idea to motivate students. Others wrote that the articles were very interesting, well-written, easy to understand, and had excellent references. These practical applications will indeed help students to understand chemical concepts and find chemistry relevant in their lives. A few teachers left addresses and telephone numbers to contact if we had a compilation to sell.

The questionnaire also requested feedback on possible topics to be included in the examples, many of which were incorporated in this project. Other topics suggested were iron and steel-making, chemistry of poisons and their treatment, chemistry of household products and specific drugs, fireworks, chemistry of cosmetic products, and others (See a more extensive list on Appendix C). One teacher suggested more advanced topics not usually covered in the curriculum, like flash photolysis, mass spectrometry, and liquid crystals. It was not possible to include all the suggested topics, since we limited ourselves to two or at most three examples for each core unit, and because of constraints of time. This project has the possibility of expanding into a more exhaustive compilation of examples of practical, everyday chemistry.

Since all the respondents indicated that they would consider purchasing a compilation, if one were made available, the possibility of including more examples and publishing a book seems a great idea and not too far-fetched. In the process of doing research for examples, this researcher has acquired a lot more information that was necessary for this project, and has gathered more ideas that would be suitable for a more exhaustive compilation in the future.

A follow-up telephone interview was conducted with the respondents who provided their telephone numbers in the questionnaire. A few teachers were able to use some of the examples in their teaching. One teacher interviewed said that the hand-outs were good discussion starters, and that they got the students to ask more questions about a certain topic. One teacher had been adding these examples to his lecture material, and found that students became really interested.

It encouraged the students to ask questions and try to get more information about the topics themselves. One teacher used the examples to suggest topics for independent study units (ISU's), and to provide initial references for whatever topics the students chose to expand and do further research on. Other teachers found the topics very helpful for themselves, since they had little time to research on examples to use in their lectures. One teacher said that he already put the few examples that came with the questionnaire in his OAC file for future use, and asked for any more that I may have. A couple of teachers said they are finding a lot of examples useful in their Environmental Science and Science in Society classes.

This researcher has used some examples in her own classes, and has found that the students who were not really interested when theory or calculations were discussed, perked up and listened when practical examples were given. The students then open up, volunteer their comments, ask more questions, and nod their heads to show better understanding. Students will also volunteer to ask about other practical applications. Some of the topics that were used as examples in this project were suggestions from students. Students also wanted to know the chemistry behind some of these experiences or applications: blue jeans, colour-changing thermochromatic shirts, fluorescent bands spectators wave in ball games or ice-skating shows, glowworms and fireflies, instant photography, and others, which we would need more time and resources to look into.

CONCLUSIONS

The results of the survey revealed that what this project set out to do - to provide teachers with practical, everyday examples of chemistry so that they could better motivate their students - was effective, at least from the standpoint of those who responded. It was shown that teachers want more of these hand-outs to use in their classes. This researcher is excited about the possibility of a published compilation of examples, and hopes, if time and circumstances are favourable, the pursue this activity in the future.

This activity is certainly not the only way to motivate students and interest them in chemistry. This is just one of the many other methods that a teacher could use. As the saying goes, "variety is the spice of life," so a teacher could use different methods from time to time. With all other resources available, a teacher could be creative, make the classroom come alive, and provide an atmosphere where learning is a productive and pleasurable experience.

Other Ideas to Motivate Students

An examination of the literature yielded some other ideas that teachers could use to motivate students. Students could collect articles dealing with chemical applications (health, industry, home, etc.) from newspapers, magazines, and other media. They would then write their own analysis of one or more of these articles (Kruse, 1983).

The teacher could have students examine labels for a specific number (five or ten seems ideal) of household products. They are then asked to identify the organic or inorganic compounds used in the product, including their symbols and formulas. Various products include cleansers, soaps, bleaches, oven cleaners, meat tenderizers, soft drinks, ant or rat poison, and others. This exercise acquaints the students with these chemicals, forms the basis of discussion, and also points out that several brands of the same item use identical active ingredients (Kozlowski, 1983).

Kaihui Shen (Shen, 1993) from China provides a list of suggestions for what he calls Happy Chemical Education (HCE). He suggests that the teacher can provide the key to spark the students' interest and motivation. He believes that stimulating interest and motivation will kindle deep thinking and reflection, and result in students' intellectual development. Some of his suggestions include: sense of humour, interesting experiments (like phosphorus burning in water), use of modern technologies like videotapes and computer-assisted instruction, conducting debates to hone students' creative abilities and communication skills, running contests (like writing all possible isomers of C_7H_{14}), and recreational chemistry activities (students holding hands to illustrate polymers, choreographed dances showing molecular motion).

Student participation in debates involving current issues; and involvement in science fairs, group projects, and chemistry week activities help increase chemical awareness and reinforce chemical principles better (Laurie, 1993).

Lois Fruen (Fruen, 1992) has students working in cooperative learning groups to research a societal issue of their choice. Examples of issues include: lead poisoning - plumbing, drinking fountains, paints, and potteries; mercury in dental fillings; and aluminum in soda cans. Students locate their own information from journals and media sources, and use special computer programs or their own artistic abilities to prepare their presentations. This activity encourages creativity and curiosity.

Teachers may also prepare a bulletin board with clippings from media sources on chemically related material and issues. Students can be encouraged to bring in items related to the topics they are studying. These may be reproduced, distributed in class, and discussed. All these emphasize chemistry as a current, useful, and living science, as opposed to abstract theory and dry calculations (Adams, 1991).

Other methods of motivation would include reports on specific elements - their history, early and present-day uses, processing, environmental concerns, properties, and significant reactions. Similar reports may be done on one of the top 50 chemicals - its use, production, environmental effects, and manufacture. Students may also interview a chemist - what he does, his research, etc. This activity helps in establishing career choices. Laboratory-based independent researches may be done, with results presented to the class by the student (White, 1991).

This researcher has used some other methods in her classes that she believes, have motivated students in one way or another. A list of the methods used are:

(1) Students are assigned to compile a media file of chemical and chemical-related applications from newspapers, news magazines, and other media sources. The file is limited to current sources (calendar year that the course is taken). Students may be asked to write a summary of any number of articles. A personal reaction to the article should be included in the summary. This will allow the student to relate to the article personally, and to see how it is connected to his daily life.

(2) Field trips to factories, industrial plants, water treatment centres, nuclear medicine department of a local hospital, waste management plants, and other local industries are organized once or twice during the course. Students enjoy these educational outings. It gives them an opportunity to watch first-hand how things are done, and how they relate to the life of the community. It also gives them an opportunity to ask questions and reinforce

concepts learned.

(3) Have a chemist come to the class and talk to students about his/her work or research. If you live close to a university, you have access to professors who would not mind coming to talk to your class. You could also invite a chemist from a government agency, industrial company, or a health-related facility like a hospital or diagnostic laboratory. Students can ask questions after a short talk.

(4) Use a variety of journals to gather specific ideas on certain concepts and principles. The _Journal of Chemical Education_ has a section devoted to secondary education. Newsletters like _ChemUnity_ by the American Chemical Society Office of High School Chemistry, _Chem 13 News_ by the University of Waterloo Chemistry Department, _Discover Canadian Chemistry_ by the University of Alberta have a wealth of examples of everyday chemistry. Another source of information on everyday chemistry examples are pamphlets published by industrial companies, drug companies, and government agencies.

(5) Various technological and electronic media sources like videotapes, videodiscs, and TV science programs have been used to supplement certain topics in the curriculum. This researcher has used

videos from the Hamilton Public Library, which has a good supply of videos on chemistry-related environmental issues like acid rain, the greenhouse effect, ozone depletion, metal processing and industrial applications, and others. Another useful resource is the National Film Board. They produce a catalogue of all their films.

(6) We have made good use of a wide variety of computer software. There are simulations on environmental issues, and other related material. We have also used the information highway to access information about chemical, environmental, and industrial issues. Some of my students who have access to the Internet, have used it extensively to prepare reports and presentations. Just this term, we went over in class information about ozone depletion and the greenhouse effect, accessed and downloaded from the Internet. This innovative learning tool is something new for a lot of students and whets their desire for more information on current scientific issues.

The undertaking of this project has convinced this researcher in more ways than one, that to make better progress in chemistry classes it is necessary to make more connections between the scientific and technological principles in the curriculum and the everyday activities that students are involved in. This project does not intend to downplay the importance of theory, for students need to appreciate the intelligent thinking and rigorous and intense work that have brought about the applications. Theory has its rightful place in the classroom; on the other hand, the classroom should not be separate from reality, but should be a place where information from the industrial, commercial, and scientific world can be discussed, understood, analyzed, and related to everyday life, so the students will have increased interest and awareness of the importance and ubiquity of chemistry.

For some students, an introductory chemistry course will be the only chemistry course that they will ever take. This is the time to make the connections between core concepts in the curriculum and reality. The responsibility for bringing these connections, the substance and spirit of chemistry, lies largely on the teachers. By addressing this obligation, we, as teachers, will help in increasing scientific literacy, and aid in producing better citizens who can react responsibly to the issues of science and society.

APPENDIX A

APPENDIX A

1481 Fiddlers Green Road South
Ancaster, Ontario
L9G 3L1
April 17, 1995

To: Chemistry Teacher

I am doing a project as one of my major requirements for a Master of Science in Teaching degree at McMaster University. My project title is: "Connecting Core Concepts with Everyday Chemistry."

The result of this project will be a compilation of two to three-page hand-outs of practical, everyday chemistry examples for teachers that could be used to enrich the curriculum of introductory courses like Grade 11 Chemistry and OAC Chemistry in Ontario or any introductory or advanced high school chemistry course. The hand-outs include references and ideas for where the examples could be integrated into the curriculum. These examples are intended to provide teachers with interesting everyday applications at their fingertips which they could use in motivating students' interest in chemistry. Suggested uses are: use as examples in lectures, discussion starters, independent study topics (to be expanded by student), etc.

Enclosed are samples of some of the examples I have prepared as part of my study and project. I have prepared two or three examples for every core topic in the Grade 11 and OAC Chemistry courses (Ontario Ministry of Education Curriculum Guidelines). I would like to request that you go through them and answer the enclosed questionnaire. Your input in this project will be greatly appreciated. Please mail the questionnaire to the above address in this self-addressed, stamped envelop by June 20, 1995. If you don't mind, please give me your telephone number, so I may do a telephone follow-up survey later. Thank you for your input.

Sincerely,

Ophelia M. Barizo

Ophelia M. Barizo

APPENDIX B

APPENDIX B

QUESTIONNAIRE:

Please rate the statements on the scale of 1 - 5:
5 - strongly agree
4 - agree
3 - neutral
2 - disagree
1 - strongly disagree

1. These hand-outs are suitable for SCH 3A and SCH OA or any high school introductory chemistry course.

   5 4 3 2 1

2. I would consider using these hand-outs in my teaching.

   5 4 3 2 1

3. I would consider assigning some of these examples as independent study units.

   5 4 3 2 1

4. These examples will increase the students' interest in chemistry.

   5 4 3 2 1

5. A compilation of several of these examples will be very useful for teachers.

   5 4 3 2 1

6. These examples will enrich the introductory chemistry curriculum.

   5 4 3 2 1

Please answer the following questions.

1. Please give us some feedback on how you would personally use these examples in your teaching.

2. What other topics would you like to see if a compilation were made of some current, practical, everyday examples of chemistry?

3. Would you personally purchase a compilation of these examples, if they were published?

4. Any other comments or suggestions.

APPENDIX C

APPENDIX C

SUMMARY of RESULTS OF QUESTIONNAIRE: (sent out about 10, 5 responded).

5 - strongly agree
4 - agree
3 - neutral
2 - disagree
1 - strongly disagree

STATEMENTS:	5	4	3	2	1
1. These hand-outs are suitable for SCH 3A and SCH OA.	5	5			
2. I would consider using these hand-outs in my teaching.	5	5			
3. I would consider assigning some of these examples as independent study units.	2	6		1	
4. These examples will increase the students' interest in chemistry.	2	8			
5. A compilation of several of these examples will be very useful for teachers.	5	5			
6. These examples will enrich the introductory chemistry curriculum.	5	5			

QUESTIONS:

1. Please give us some feedback on how you would personally use these examples in your teaching.

- reading assignments
- set questions
- act as starting point for independent research
- enlarge on the units by exploring in more detail
- independent study enrichment for Science in Society course, SSO OA1
- applications of principles in SCH 3A and SCH OA to enrich the connection between theory and practical applications
- independent study unit (ISU) ideas for SCH OA
- illustrate real-life aspect of the concept being taught
- hand-outs to students to enrich and motivate them
- very good for Organic Chemistry section of SCH OA where lab conditions limit the number of good experiments
- introductory remarks to specific units
- group projects and presentations

- starting point for a laboratory-based independent study unit
- use as examples during a lesson
- reference sheets for short reports
- used as enrichment and examples in environmental science courses

2. What other topics would you like to see if a compilation were made of some current, practical everyday examples of chemistry?

   - iron and steel-making
   - chemistry of poisons and their treatment
   - polymers
   - liquid crystals
   - flash photolysis
   - mass spectrometry and applications
   - toothpastes
   - specific drugs like Tylenol, Prozac, etc.
   - artificial sweeteners
   - fireworks
   - detergents
   - cosmetic products - hairspray, conditioners, etc.
   - sunscreen
   - coloured markers
   - bonding and structure
   - redox
   - thermodynamics
   - stoichiometry
   - equilibrium (Kw, Ksp, Le Chatelier's principle, etc.)
   - rates of reaction
   - heats of reaction
   - molecular geometry
   - nuclear reactions
   - preparation of soap, aspirin, etc.
   - carbon isomers
   - molecular shapes
   - electrochemistry - electroplating, redox titrations, Nernst equation

3. Would you personally purchase a compilation of these examples if they were published? Yes (9)
   No answer (1)

4. Any comments or suggestions.
   - good idea
   - good length
   - depth of information is good - new chemistry learned, but not too technical to be a turn-off
   - should include more advanced topics like flash photolysis, mass spectrometry applications, liquid crystals, etc.

- articles are very interesting!
- articles are just the right length to keep a student's interest
- well written and easy to understand
- practical applications will help students understand the concepts
- students will find chemistry relevant
- common practical applications can increase a student's awareness of the importance of chemistry in our lives
- excellent references
- contact me if you have a compilation to sell

APPENDIX D

APPENDIX D

CORRELATION BETWEEN CORE CONCEPTS IN THE CURRICULUM WITH EXAMPLES OF EVERYDAY CHEMISTRY

I. GRADE 11 CHEMISTRY (SCH 3A)

A. MATTER
  1. Culinary Chemistry
  2. Nuclear Medicine - radioisotopes
  3. Structural Differences Between Carbon and Graphite

B. ELEMENTS AND CHEMICAL BONDING
  1. Disposable Flash Bulbs
  2. 007 Chemistry
  3. Structural Differences Between Carbon and Graphite
  4. How is Frosted Glass Made?
  5. Drain Opener
  6. Instant Sunglasses

C. GASES
  1. The Hole in the Sky - Ozone Depletion
  2. Arctic Bomb
  3. Culinary Chemistry

D. CHEMICAL REACTIONS
  1. Drain Opener
  2. Insect "After-Bite" Products
  3. 007 Chemistry
  4. Culinary Chemistry
  5. Disposable Flash Bulbs
  6. How is Frosted Glass Made?

E. SOLUTIONS
  1. Anti-freeze
  2. Personal Care Products
  3. How is Frosted Glass Made?
  4. Pickle Chemistry

F. INDUSTRY AND SOCIETY
  1. Instant Adhesives
  2. Green Thumb Chemistry
  3. Personal Care Products
  4. 007 Chemistry

II. ONTARIO ACADEMIC CREDIT CHEMISTRY - SCH OA

A. ORGANIC CHEMISTRY

1. Juvenile Hormones
2. Insect Pheromones
3. Olestra: A Non-Caloric Dietary Fat Substitute
4. Culinary Chemistry
5. Green Thumb Chemistry
6. Instant Adhesives
7. 007 Chemistry

B. ATOMIC STRUCTURE AND MOLECULAR ARCHITECTURE

1. Structural Differences Between Carbon and Graphite
2. Teflon - A Non-stick Cooking Surface
3. Polystyrene Foam
4. Titanic Chemistry

C. ENERGY AND RATES OF REACTIONS

1. Titanic Chemistry
2. Pickle Chemistry
3. Culinary Chemistry
4. Swimming Pool Chemistry

D. EQUILIBRIUM: INTRODUCTION AND APPLICATIONS

1. Dental Chemistry - The Importance of Fluoride
2. Instant Sunglasses
3. Swimming Pool Chemistry
4. Pickle Chemistry
5. The Hole in the Sky - Ozone Depletion

E. REDOX AND ELECTROCHEMISTRY

1. Why Are Roofs of Old Buildings Green?
2. Titanic Chemistry
3. Swimming Pool Chemistry
4. Disposable Flash Bulbs

F. INDEPENDENT STUDY INVESTIGATIONS

* Any of the topics could be expanded and researched in greater detail, but the following topics have the best possibilities.

1. Titanic Chemistry
2. 007 Chemistry (can be expanded to include other movies or novels)
3. Personal Care Products
4. Green Thumb Chemistry
5. Nuclear Medicine - Radioisotopes

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