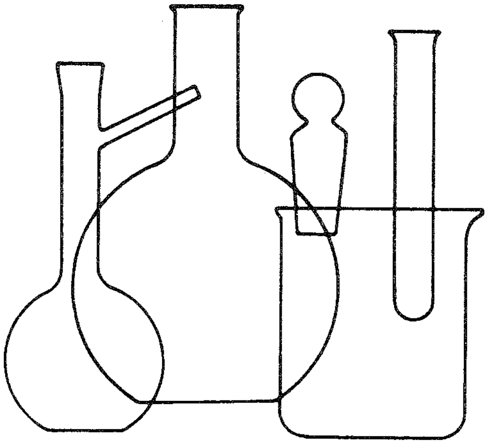

CHEMISTRY
IN THE
TWO-YEAR COLLEGE

VOLUME XXII SPRING 1981

2YC₃ COMMITTEE ON CHEMISTRY IN THE TWO-YEAR COLLEGE
DIVISION OF CHEMICAL EDUCATION • AMERICAN CHEMICAL SOCIETY

FORWARD

In this period of history when the need for scientists, engineers and technicians as well as a scientifically literate society has been increasing rapidly, we are observing a decline in the general understanding of science and technology among the citizens of our country. The quantity of science being taught and learned in our schools, particularly to students who are not planning science and technology careers, has actually become less. We note that our society has been pervaded by a lessening of commitment to literacy in science. Meanwhile, public fear of science, especially of "chemicals" has become commonplace. It is our responsibility as chemistry educators in community colleges to turn our attention to the quality and quantity of science education in our schools and to work diligently toward increasing public awareness, understanding, and appreciation of the need for literacy and excellence in science and technology. One of the goals of the Committee on Chemistry in the Two-Year College, division of Chemical Education, American Chemical Society, is to increase the participation of two-year college chemistry faculty and students in the affairs and programs of those interested in chemical education and to promote the articulation of two-year college chemistry programs with programs of senior institutions and high schools as well as with other disciplines and professional groups.

This issue of Chemistry in the Two-Year College reports on the proceedings of two-year college chemistry conferences which were held in 1980 and 1981. The articles in this issue include presentations on curriculum developments and new courses, innovations in teaching and alternative teaching strategies, some interrelationships among various areas of science, and special topics in chemistry. Sincere appreciation is expressed to members of each of the host institutions and to the conference personnel involved in the following meetings: Prairie State College, Chicago Heights, IL (Elliott Greenberg and James Herbach); City College of San Francisco, San Francisco, CA (Eugene Roberts and Bernard Coyle); Atlanta Junior College, Atlanta, GA (Marion Baker of Valencia Com. College, Orlando, FL and Tom Maier); and Oakland Community College, Southfield, MI(Tamar Susskins and Marvin Parent). We thank you for your dedication to the activities of the Two-Year College Chemistry Conference ($2YC_3$) and for your diligence in planning these conferences. Special gratitude is also extended to the editors of this publication, Jay and Ellen Bardole, Vincennes Univ., Vincennes.

The success of each two-year college chemistry conference must be measured in part by the number of participants who benefit from our activities. To assure continuation of $2YC_3$ conferences which provide a platform for the dissemination of information such as that contained in this publication and for related discussions, we must receive your active support. We urge you to attend our meetings, to participate in future $2YC_3$ programs and to subscribe to the journal by becoming a member of $2YC_3$ (annual 1982 membership $6.00/year). Each chemistry teacher is invited to become involved in the activities of the Division of Chemical Education which include sponsorship of the Committee on Chemistry in the Two-Year College; planning of biennial summer chemical education conferences, division meetings and special conferences; maintenance of a comprehensive ACS examination program; promotion of high school chemistry programs; sponsorship of task forces on chemical education for health professionals and computers in chemical education; and publication of the Journal of Chemical Education.

Katherine E. Weissmann
Chairperson, COCTYC

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TEACHING ENERGY TOPICS

PETROLEUM: Key Resources for Energy and Chemicals

Doris Kolb
Illinois Central College
East Peoria, IL 61635

Presented to a Symposium on Energy at the Sixty-Seventh, Two-Year Chemistry Conference. Prairie State College, Chicago Heights, Illinois 60411 April 25, 1980.

It is surely one of our most valuable natural resources. Not only does petroleum supply half of our energy in the U.S. (with another one-fourth coming from natural gas), but it also provides the raw materials for 95% of our organic chemicals, plus hydrogen for most of the ammonia that forms the base of our fertilizer industry.

Petroleum is at the very heart of our energy crisis, and it is probably the most important single factor contributing to our growing economic problems. Petroleum has been called "black gold", and that name has never seemed more appropriate than it does today.

Early History

Just how it originated no one knows. Petroleum is probably of marine origin, derived from organic matter that lived perhaps 500 million years ago. Even the most recent deposits are at least 50 million years old, according to radioactive dating.

Man's use of petroleum goes back at least 5000 years. Around 3000 BC asphaltic material that seeped from the ground was being used in Mesopotamia for paving roads, waterproofing ships, and making bricks (by blending with sand and fibers). As early as 1000 AD the Arabs were distilling petroleum to obtain an oil which they burned to produce light; and by 1200 AD Arab and Mongol armies were both using petroleum-fueled flame throwers. With the discovery of America came an interest in Cuban deposits of petroleum tar as caulking material to repair the big wooden ships.

The Age of Illumination

As the 19th century began the industrial revolution was causing urban areas to expand, and there was increased nighttime activity in the cities, giving rise to a greater need for lamps and illumination fuel. Animal fats and fish oils had been the traditional lamp fuels, but coal oil from coking ovens and pine oil distillate also came to be used as fuel for lanterns. Finally, because of the increased demand for illuminating fuels, Benjamin Silliman at Yale University made a study of the composition of petroleum, noting that it could be distilled to give as much as 50% of a liquid fuel similar to coal oil. Called *kerosene*, this fraction was a mixture of C_9 to C_{18} hydrocarbons, and it was very useful as lamp fuel.

It was to satisfy the ever growing demand for lighting fuel that Edwin Drake in 1859 drilled the first oil well at Titusville, Pennsylvania. The oil was distilled to produce a C_9-C_{18} kerosene fraction, a more volatile C_5-C_8 naphtha fraction, and a heavy, high boiling oil. The kerosene was used for lighting, the heavy oil for lubrication, and the residual asphaltic tar for paving streets and waterproofing roofs. The lighter naphtha fraction found limited use as a solvent (e.g. for paints), but the demand for it was low and excess naphtha was often dumped into rivers, which occasionally caught fire.

The Gasoline Age

The beginning of the 20th century marked a turning point in the history of petroleum because of two important technological developments-the electric light and the gasoline-powered automobile. Gasoline for autos was a mixture of C_5-C_{12} hydrocarbons, much the same mixture as the often surplus naphtha. Petroleum refiners could now sell kerosene for lighting and gasoline (or naphtha) for motor fuel. But by 1910 the demand for naphtha was skyrocketing, and there was a growing surplus of kerosene. Whereas a gallon of kerosene could provide light for an entire household for a week, a gallon of gasoline could be burned in minutes in a single automobile. Furthermore, kerosene lanterns were gradually being replaced by electric lights.

Since gasoline was now the primary product of the petroleum refinery, efforts were made to increase the percentage of gasoline that could be made from a barrel of crude oil. At the Standard Oil Company (Indiana) William Burton found that he could heat the kerosene distillate to high temperatures (600-700°C) and "crack" the C_9-C_{18} molecules into smaller fragments.

$$\underset{\text{a typical kerosene molecule}}{C_{16}H_{34}} \xrightarrow{700^\circ C} \underset{\text{octene}}{C_8H_{16}} + \underset{\text{octane}}{C_8H_{18}}$$

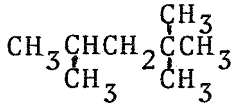
gasoline molecules

By 1913 Burton's "thermal cracking" had become a commercial process used by almost all oil refiners.

By 1920 the popularity of the automobile had grown, and both refiners and auto makers became concerned about gasoline quality, since some gasolines were causing excessive engine noise (along with reduced power and overheating). It was found that straight chain gasoline molecules caused considerable preignition or "knocking", whereas branched chain molecules burned much more quietly. An arbitrary "octane" scale (based on n-heptane = 0 and iso-octane = 100) was set up in order to rate "knock" performance.

$$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$$

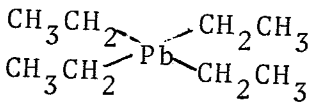
n-heptane (octane no. 0)



$$CH_3\underset{CH_3}{C}HCH_2\overset{CH_3}{\underset{CH_3}{C}}CH_3$$

iso-octane (octane no. 100)

Thomas Midgley (at the General Motors Chemical Co.) discovered in 1921 that a little tetraethyl lead added to gasoline would greatly reduce its tendency to "knock" or "ping".


tetraethyl lead

Eventually all refiners were using this "anti-knock" additive, so that by 1950 almost all gasolines on the market were "leaded".

Increasing concern about environmental pollution from automobile exhaust gas, however, has resulted in recent efforts to take the lead out of gasoline. As it turns out, the clean air standards set by the Environmental Protection Agency, requiring a reduction in the carbon monoxide and unburned hydrocarbons in auto exhaust, have necessitated catalytic converters as part of the exhaust system in automobiles built since 1974. Since lead poisons the catalyst in these converters, new cars cannot use leaded gasoline, and thus lead is already being phased out of motor fuel. Unleaded gasoline no longer has to cause engine kcnock because refiners over the years have learned to "reform" straight-chain gasoline molecules, altering their shapes so as to increase their octane numbers.

Composition of Petroleum

As obtained from the will petroleum is a thick dark liquid, mainly a mixture of hydrocarbons. It may contain several hundred different hydrocarbons, the composition varying according to the source of the crude oil. (Middle East oil is rich in lower boiling hydrocarbons, for example, while Mexican crude oil is high in heavy oils and residual material.) Straight chain alkanes are most abundant, just as the alkyl groups in fats and oils are mainly straight chains, (This supports the theory that petroleum is derived from fats and oils of prehistoric living matter.) Odd-numbered carbon compounds predominate, presumably as a result of decarboxylation of even-numbered fatty acids. Among the compounds with methyl branches, 2-methyl alkanes are most abundant. Cycloalkanes are mainly cyclohexanes and cyclopentanes, and aromatic hydrocarbons may be substantial or insignificant in quantity, depending on the source of the oil.

Modern Refining Processes

As petroleum reaches the refinery, it usually contains dissolved salts and naphthenic acids, which are removed by water washing. The crude oil is then vaporized and sent through fractionating towers, which separate the hydrocarbons according to boiling point. The process is a continuous fractional distillation.

Fractional Distillation

The purpose of the fractional distillation process is to separate the petroleum into hydrocarbon fractions of similar molecular size. There are usually at least five major fractions, such as those shown in the table on the next page. (Amounts and composition of the fractions will vary depending on the crude oil source.)

Volume Percent	Boiling Point, °C	Carbon Atoms (approx. range)	Common Names for Products
1-2%	up to 30	C_1-C_4	natural gas, methane ethane, propane, butane liquefied petroleum gas (LPG)
15-30%	30-200	C_4-C_{12}	naphtha straight-run gasoline ligroin, petroleum ether
5-20%	200-300	C_{12}-C_{15}	kerosene heater oil, jet fuel
10-40%	300-400	C_{15}-C_{25}	gas oil diesel oil, furnace oil lubricating oil
Undistilled	>400	$>C_{25}$	residual oil paraffin wax asphalt, tar

Vacuum distillation of the residual oil yields more heavy gas oil (plus paraffin wax), and the undistillable tar (asphalt) that remains after distillation is used for road paving, roof coating, etc.

Catalytic Cracking

In order to increase the yield of gasoline, some of the heavier oils are subjected to cracking, splitting larger molecules into smaller ones. The thermal cracking process of the 1920's has largely been replaced by catalytic cracking. The catalyst most often used is silica-alumina (SiO_2-Al_2O_3), often containing tungsten or nickel and used in a hydrogen atmosphere.

$$\underset{\text{(gas oil range)}}{\text{large molecules}} \xrightarrow[500°C]{\text{catalyst}} \underset{\text{(gasoline range)}}{\text{smaller alkanes + alkenes}}$$

Today more than a third of all crude oil is ultimately subjected to cracking.

Although thermal cracking using steam ("steam cracking") is the major process used in making alkene petrochemicals-ethene, propene, and the butenes.

Catalytic Reforming

The primary method increasing gasoline octane number is catalytic reforming, which can change the octane number of a straight-run gasoline from about 60 to over 100. This dramatic increase in octane number results mainly from the conversion of alkanes and cycloalkanes to aromatic compounds (all of which have octane numbers greater than 100).

$$\underset{\substack{\text{n-heptane}\\ \text{(octane no. = 0)}}}{CH_3CH_2CH_2CH_2CH_2CH_2CH_3} \xrightarrow[500°C]{\text{catalyst}} \underset{\substack{\text{toluene}\\ \text{(octane no. = 103)}}}{C_6H_5CH_3} + 4H_2$$

The major catalyst for this process is platinum on silica-alumina. Catalytic reforming was first commercialized during World War II to make high octane fuel for airplanes. It also provided toluene for making TNT explosives. Since 1952 this process has become the main source of benzene, toluene, and xylenes (BTX) for the chemical industry.

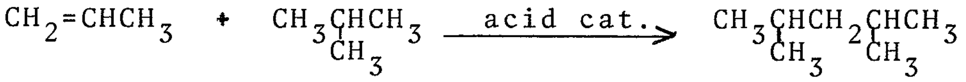
Besides producing high octane gasoline and BTX chemicals, catalytic reforming also procudes large amounts of by-product hydrogen. During the 1950's refiners started building plants fo combine this hydrogen with nitrogen (from the air) to make ammonia by the Haber process.

$$N_2 + 3H_2 \xrightarrow[400°C]{\text{catalyst}} 2NH_3$$

The vast ammonia industry that has grown up as a result of the catalytic reforming process has now become the base of our fertilizer industry and a key factor in our expanded food production capacity.

Alkylation

Alkylation is a method for making high octane gasoline from hydrocarbon gases. Used since the 1930's, the alkylation process combines alkenes (such as propene) with isobutane to yield branched molecules in the gasoline range.



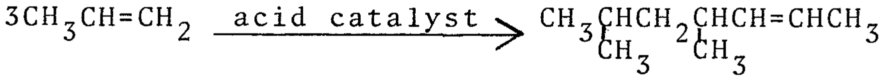
$$CH_2{=}CHCH_3 + CH_3\underset{CH_3}{CH}CH_3 \xrightarrow{\text{acid cat.}} CH_3\underset{CH_3}{CH}CH_2\underset{CH_3}{CH}CH_3$$

(plus other branched heptanes)

The catalyst used is HF or H_2SO_4, and the gasoline product has an octane number around 90.

Polymerization

Another way to convert smaller molecules to gasoline is to polymerize alkenes, such as propene, using a catalyst of H_2SO_4 or H_3PO_4.



$$3CH_3CH{=}CH_2 \xrightarrow{\text{acid catalyst}} CH_3\underset{CH_3}{CH}CH_2\underset{CH_3}{CH}CH{=}CHCH_3$$

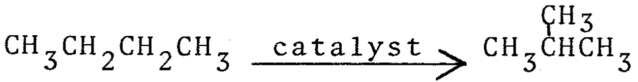
propene trimer

(dimers and tetramers also formed)

The product is usually a mixture of dimers, trimers, and tetramers. These compounds have good octane numbers, but they are gum formers because of the double bonds. They must be hydrogenated in order to give stable gasoline.

Isomerization

The isomerization process, which converts straight chain hydrocarbons to branched mixtures, is an important side reaction in catalytic cracking and reforming, gut it is of minor interest as a separate refining process. Probably its main use today is for converting n-butane to isobutane (needed in the alkylation process).



$$CH_3CH_2CH_2CH_3 \xrightarrow{\text{catalyst}} CH_3\overset{CH_3}{CH}CH_3$$

n-butane isobutane

Pentane and hexane mixtures can also be isomerized to increase their octane numbers from the 60's to the high 90's. The catalyst often used is a Pt-Al_2O_3 complex with $AlCl_3$.

Hydrotreating

Catalytic hydrogenation has become an important process for improving gasoline quality. Treatment with hydrogen can remove double bonds and sulfur from gasoline molecules. Sulfur compounds, which are usually mercaptans, give gasoline an unpleasant odor, and double bonds cause gum and varnish formation.

Current Use of Petroleum

Petroleum currently accounts for about half of our energy supply. In 1978 our primary energy sources were:

Petroleum	49%
Natural Gas	25%
Coal	18%
Hydroelectric	4%
Nuclear	4%

Our domestic oil production peaked in 1969 and has been diminishing since that time. Unfortunately our energy demands have continued to grow, so that we have been forced to import increasing quantities of foreign oil. Since 1973 when OPEC (Organization of Petroleum Exporting Countries) began its spiralling escalation of oil prices, oil imports have been contributing heavily to our world trade deficit. Today our economy has reached the point where we must cut back on our purchase of foreign oil. The trend toward smaller cars and other energy conservation efforts are helping a little, but we need to establish new energy sources.

At present only about 5% of the petroleum we use goes into petrochemicals. On a percentage basis that may not seem like very much, but in terms of tons of products the quantity is enormous. Ethylene production alone is about 25 billion pounds per year in this country. Petroleum is our dominant source of organic chemicals. It is the basic raw material from which we make synthetic fibers (nylon, orlon, polyesters, etc.), plastics (polyethylene, polystyrene, polyvinyl chloride, teflon, polyurethanes, etc.), synthetic rubber, detergents, pesticides, solvents, and many other products. Petroleum also provides most of the hydrogen from which we make ammonia, nitric acid, and nitrogen fertilizers. It even yields considerable amounts of sulfur (used to make sulfuric acid) and carbon black (used in rubber tires). The petroleum that goes into chemicals may amount to only about 5%, but it can be argued that this is the most important portion of our oil consumption.

Conclusion

Petroleum is a non-renewable natural resource, and the world's supply is limited. Estimates vary as to just how long the world's petroleum will last, but it is likely that reserves will be pretty well exhausted by the middle of the next century. We are going to replace petroleum with other energy sources. The only question is: When?

The ever-rising prices of OPEC oil have made this a critical question. The U.S. currently produces about 20% of the world's petroleum, but we use much more than we can produce, so that we are heavily dependent on foreign oil. This dependency has already proved to be disastrous for our economy. It is essential that we begin using other fuel sources to replace petroleum as soon as possible.

Some of the most obvious solutions to our problem of finding petroleum substitutes are:

removing the oil from tar sands,
extracting oil from shale,
hydrogenating coal to make liquid hydrocarb
synthesizing gasoline from producer's gas ($CO + H_2$), made by treating coal with steam,
converting plant or animal waste to fuels,
and making alcohol fuel by fermentation of plant material.

The important thing is that alternative fuels be made available quickly.

As petroleum grows more expensive and harder to get, its role as a source of chemicals should become more important. Within a few decades petroleum may become so treasured as a chemicals resource that its use as fuel will become secondary. Perhaps some day man will decide that this "black gold" is simply too valuable to burn.

U. S. SOURCES: Past, Present, and Future

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Presented to a Symposium on Energy at the Sixty-Seventh Two-Year Chemistry Conference, Prairie State College, Chicago Heights, Illinois 60411, April 25,1980.

U.S. Energy Use - Past Philosophy

A country's standard of living is based on such factors as: capital, labor, technology, mineral resources and energy. In many ways the U.S. has been uniquely blessed with an abundance of all of these as well as a political system that has allowed for their integrated use. Since the time of its industrial takeoff in the middle of the 19th century until the mid 1970's the U.S. had such an availability of energy in various forms that energy was used almost as if it were free. Thus a way of life developed in the U.S., in the industrial, commercial, residentail and transportation segments alike, where energy was used with little regard to conservation because it was so cheap. One result of this cheap energy is that the U.S. has the highest per capita energy consumption of any country in the world. Our evergy use is twice that of other industrial countries (Table 1). The U.S. with 6% of the world's population uses a third of the world's concentrated forms of energy! We should take note that there may be a global energy problem ahead that will be more challenging than our current energy concerns (Table 2). A little less than a third of the world's concentrated forms of energy. This leaves the vast majority of the world's population still relying on the energy of their own bodies, animals or wood. In the long run (which may not be that long) these peoples of the underdeveloped countries may well demand their "share" of the world's concentrated energy.

To understand our dependence on energy and how we as a society became accustomed to using it as if it had little economic value, let us consider our past uses of energy. Until this most recent decade our approach to energy use in the U.S. was to use more of it than anything else, since energy was cheaper, cheaper than capital, labor, or technology. The concept of cheap energy produced a mentality which entered all segments of our society.

Let us consider some common examples of energy waste that we all have experienced. Consider the typical U.S. home built with but little insulation. Excellent insulations such as fiberglass have been available since the 1930's but was not adequately used in the construction of most homes. To save a few hundred dollars in home construction larger furnaces and air conditioners were installed. Commercial buildings built since WW II (until quite recently) were built so as to require some type air conditioning the year round, since windows, if they existed, did not open. Waste heat was not utilized, just vented into the atmosphere. Perhaps all of us have been owners of autos whose manufacturers paid scant attention to fuel economy. It is an interesting fact that the weight of the typical U.S. auto increased by a thousand pounds during the 1960's. Little, if anything was gained by this 30% weight increase, but it forced us to use larger engines that burned more gasoline. Perhaps the height of wasteful energy use was achieved in the recent generation of refrigerators. These were sold as bigger on the inside but smaller on the outside because of the use of superior insulation. This instulation was so "superior" that electric resistance heaters had to be incorporated in the doors to warm the cold door to prevent moisture from condensing on its surface. In most cases the heaters were always on the year round since energy was cheap. Thus for us as a nation to change our way of life based on cheap energy will be a challenge. To maintain a high standard of living on a lower but wiser energy budget should be our goal.

U.S. Energy Source - Past and Present

In the U.S. we have used our mix of abundant energy sources in ever-increasing amounts since the Civil War (Table 3). Since 1850 energy use has grown from 2 to 78 Quads, a 39-fold increase. (A Quad is 10^{15}, or 1 quadrillion, BTU's.) In the same period our population has grown from 23 million to 220 million, or about tenfold. The mix has changed considerably during this period.

Wood was the dominant fuel in 1850 supplying 91% of our energy. Then coal began its rapid rise, peaking in 1920 at 15. Quads, 78% of our total energy. Only now in 1980 is the production of coal again approaching 15-16 Quads, but this is now only about 20% of our energy. Oil supplied only 2.4% of our energy in 1900 but it was providing half our energy by 1960. Gas was slower to grow, since it needed a system of pipelines criss-crossing the U.S. (mainly installed during WW II). By 1960 gas contributed 25% of our energy, and oil and gas togethe accounted for three quarters of our total energy.

In spite of huge federal projects, hydroelectric has contributed an almost constant 4% of U.S. energy since 1920. Nuclear power is a new energy source contributing only 0.3% in 1970 but about 4% of our total energy (or 12% of our electricity) by 1978.

All these sources have problems associated with them and all except hydropower are in limited supply. Coal, of which we have the greatest reserve is dirty, dangerous to mine, and environmentally damaging. (There is even a long range problem of possible harmful effects from increased carbon dioxide.)

Our present importation of about 45% of our oil needs is not only politically risky but economically threatening. We cannot continue for very long paying a bill of about 90 billion dollars a year for imported oil.

It would seem then that our energy problems involve both our total energy use and our mix of energy sources.

The Future-Energy Sources to 2000 A.D.

During the past decade national plans should have been formulated for our future energy needs, but little was done. Perhaps now in the 1980's we will get started on some long range every plans. The first question we need to ask is: How much energy will be needed at a given future date, such as the year 2000? Current U.S. usage is 78 Quads. How many Quads will we need in 2000? I might suggest a low but feasible 90 Quads for the year 2000. This would allow for a modest increase of 16% in energy use over the next two decades. The 90 was arrived at by taking the current usage of 78, substracting 12 Quads for energy that could reasonably be saved by conservation, and then multiplying the resulting 66 Quads by 1.26 to adjust for population increase (from 215 to 270 million) in 2000. The resulting value of 86 Quads of energy in 2000 is giben in Table 4. The following are comments on the figures suggested in Table 4:

1. Coal mining will need to increase about 75% by 2000 to meet these goals. This will be difficult, but an increase of 50-75% should be feasible. A significant part of this coal increase (at least half) will be needed to produce synthetic gas and oil, equivalent to about 2 million barrels of oil a day. More coal will be used to replace oil and gas for the generation of electricity in all but the most urban of power generating stations.

2. Oil usage must decrease by the year 2000, even including that derived from tar sands and shale. The U.S. can not afford to import 90 billion dollars of oil a year. The efficiency of the American auto fleet in 2000 should be at least 100% (or 200%) greater than it is today. The era of the small fuel-efficient car has finally arrived in the U.S.
3. Gas production is taken to be elastic enough that as the price maximum goes from the mid 1970's price of 52¢ per 1000 cubic feet to $5.00 in the 1980's, more gas will become available. The 18 Quad figure also includes imported LNG which will probablly grow during the remainder of this century.
4. Hydropower should be capable of a 50-60% increase if many small dams with hydroelectric plants are built during the next two decades. It is not likely that there will be any more huge dams, since there are only so many natural places available in the U.S.
5. Nuclear power in the form of the present U-235 fission reactor must continue to play a modest but real role in our energy supply if we are to avoid drastic economic dislocations. Since we have 72 nuclear power plants now supplying 2 Quads of energy with 90 more under construction, the goal of 5 Quads should be obtainable, unless antinuclear forces become unreasonable.
6. Geothermal as an energy source will grow in the next two decades by a factor of 4-6 but will remain a relatively small energy source, limited to a few specific areas of the country.
7. Solar energy in all its many forms of active and passive heating, biomass (including ethyl alcohol production), and solar cells offers much promise. How fast solar becomes a major energy source depends to a large degree on federal tax policies and the price of gas and oil, and technological breakthrough. With tax incentives solar heating of homes could provide 10-15% of the heating energy needed by 2000. Biomass conversion in the form of alcohol should play a small but significant role as a motor fuel and perhaps as a chemical feedstock. Trash, largely a solar product, may well constitute 2-5% of the feed used to fire large coal furnaces. Unless there is some technological breakthrough, such as a method for producing cheap, efficient amorphous silicon wafers, solar cells will provide relatively little energy by 2000. While windmills will contribute some energy by 2000, the total will be quite small.
8. Conservation of all new energy sources between now and 2000 the one "source" that can make the largest contribution is conservation. Of our present usage of 80 Quads about three quarters goes for uses other than generating electricity. Surely an average of about 20% of this energy used in autos, homes, factories,

and commercial business can be saved. Some use areas will increase their efficiency by more than 20%. For example autos by 2000 will be averaging 30 miles per gallon for city driving against the present 10-15. Industry which has already effected energy savings of as much as 15-20% may find it difficult to achieve another 20%, but certainly another 10% is not out of the question.

The Future - Energy Beyond 2000

One can be optimistic that by 2050 new energy sources and means of handling energy will be playing significant roles in our society. New technological breakthroughs on the energy front not only offer real hope of solving the need for energy but of also helping us obtain a better environment. For example:

1. Nuclear Fusion on a controlled basis may well be an economic reality. If so it will not be a panacea solving all energy problems, but it would be a valuable (though expensive) energy source for providing us with more electricity.
2. Solar Cells of reasonable price and efficiency for generating electricity should be available by 2000, and by 2050 they should be a really important source of modest amounts of electricity for homes in sunny regions. Perhaps appliances such as refrigerators will be run on solar cells, using batteries for electrical storage.
3. Hydrogen produced from water by the use of solar energy may well be more important than electricity per se from solar cells. Hydrogen has the advantage that it can be transported and used in a manner similiar to natural gas.
4. Electric Autos which should begin to appear by 1990 will probably be an important form of transportation in urban areas in the 21st century. The key to the electric auto will be a storage battery superior to the present batteries.
5. Efficiency of energy use will receive considerable attention. Super conducting metals may help us achieve much, more efficient transmission of electricity, and MHD (magneto hydrodynamics) will provide more efficient generation of electricity. New catalyst systems already lowering energy needs in 1980 will continue to cut industrial energy needs. Means will be found to utilize warm water, certainly more cogeneration plants will appear. Perhaps waste warm water will be used in agriculture to enhance plant growth.
6. Biomass will certainly be a significant source of organic chemicals which now utilize 6.5% of our oil and gas. For example certainly a greater percentage of rubber will again be "natural" coming from new plant sources. Lubricating oil may also be from plant origin.

An unknown in the future energy picture is the total impact of science and technology. We are confident they will play a major role in meeting the challenge. There are discoveries to be made that we have not even envisioned yet, science and technology will help meet this energy challenge of the 21st century.

Table I

ENERGY PER CAPITA PER DAY
(thousands of BTU's used)

United States	850
United Kingdom	430
U.S.S.R	350
Japan	200
Brazil	184
India	37

Table II

WORLD ENERGY DISTRIBUTION

Industrial Countries (29% of world population)	Non-Industrial Countries (71% of world population)
Use 77% of the coal	use 87% of the animal energy
Use 81% of the oil	use 73% of the wood energy
Use 95% of the natural gas	
Use 80% of the nuclear and hydro energy	

U.S. with 6% of world's population uses about 33% of world's energy.

Table III

U.S. Energy Use 1850 to 1978
Percent Contributed by Each Source

Year	Wood	Coal	Oil	Gas	Hydro	Nuclear	Total Quads
1850	90.7	9.3					2.4
1870	73.2	26.5	0.3				4.0
1900	21.0	71.4	2.4	2.6	2.6	-	9.6
1910	10.7	76.7	6.1	3.3	3.2	-	16.6
1920	0	78.4	13.5	4.2	3.9	-	19.8
1930	0	61.2	26.5	8.8	3.5	-	22.3
1940	0	52.5	32.3	11.4	3.8	-	23.9
1950	0	38.0	39.7	18.1	4.2	-	34.0
1960	0	22.7	45.1	28.5	3.7	-	44.6
1970	0	19.2	43.9	32.7	3.9	0.3	66.9
1978	0	18.0	48.6	25.3	4.2	3.8	78.2

Table IV

U.S. Energy Sources 1978 and 2000

Source	1978 Percent	1978 (Quads)	2000 Percent	2000 (Quads)
Coal (+coal gas & oil)	18.0	(14.1)	27.7	(25)
Oil (+shale, tar sands)	48.6	(38.0)	33.3	(30)
Natural gas	25.3	(19.8)	20.0	(18)
Hydropower	4.2	(3.3)	4.5	(4)
Nuclear	3.8	(3.0)	5.5	(5)
Geothermal	~	(0.1)	~	(0.3)
Solar (all forms)	~	~	8.9	(8)
Total Quads		(78.3)		(90.3)

"Achieveable" Conservation Quad Equivalents 12

RESEARCH TO INSTRUCTION
An Interactive Approach to Water Quality Investigations

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Presented as a Workshop at the Sixty-Seventh, Two-Year College Chemistry Conference, Prairie State College, Chicago Heights, Illinois 60411, Aril 26, 1980.

Although I will not claim that this approach is the optimum way to do reserch or to accomplish instruction, I believe that it has its own peculiar merits. The following is a sort of annotated outline of the process.

I. PLANNING - the logical and necessary first step
The booklet A Practical Guide to Water Quality Studies of Streams by F.W. Kittrell, U.S. Government Printing Office: 1970 0-368-814 has been a source of inspiration. It is rather hard to obtain. My last successful attempt was through the suspices of the E.P.A. Research Center in Cincinnati, Ohio.

A. Goals - most frequently redefined by practical considerations. Goals must be set in the light of the following:

1. Time available
    - a. Duration of the project
    - b. Man hours available - no. of people x hours per person
    - c. Supervisory time available
2. Facilities available - equipment and commodities often dictate whats feasible
3. Instruction vs. Research priorities - Clear instructional objectives often take precedence over desired research objectives

Although both our instructional and research objectives have been stated in numerous quises, they fundamentally boil down to the following:

INSTRUCTION - Provide students with practical experience and a conceptual understanding of the common field and laboratory techniques used in the analysis of water.
RESEARCH - investigate the composition and dynamics of stream systems in terms of the viability of the systems rather than the potential uses of the systems as water sources or effluent sinks.

B. THE STREAM SYSTEM - choice of the right system to study
  1. What to look for
    a. Accessibility is often a dominate factor
    b. Variety - ponds or a short reach of a stream may be very dull subjects. Preferable a stream stretch over somewhat varied terrain with some tributaries and effluent sources (not too many).
    c. Predictability - too much variety (e.g.the Cal Sag Canal) makes interpretation very difficult.
  2. How to look for it
    a. maps and aerial photographs
    b. field survey - increasing detail

C. THE SAMPLING PLAN - once a system is chosen, research it
  1. Background Research - water chemistry is influenced by many factors
    a. geology of the area - determines many of the natural components
    b. man's impact - talk to the people who live along it. (Note: you will want to get to know them or you may be regarded as trespassers)
    c. effluent sources - sewage disposal plants, agricultural run-offs etc. provide predictable influences
    d. know water chemistry - study the composition and interactions in aquatic systems
  2. Choice of Parameters to Measure - it begins to come together
    a. results of background research
    b. goals of the study
    c. equipment and facilities
    d. time
  3. Site Selection and Sampling Schedule - REMEMBER, no. of sites x no. of sampling times x no. of parameters = no. of analyses to be performed!
  4. Auxilary Data on weather, physical conditions, and general field observations are important aides to interpretation. Plan to record them.

The final details of the sampling plan (e.g. sample sizes, types of pretreatment and/or preservation) depend on the Analysis Procedures.

D. Analysis Procedures - feasibility strikes again
The following are valuable references on procedures. The ultimate authority is <u>Standard Methods for the Examination of Water and Waste Water</u>, APHA, EPA, and others, Washington, APHA. New editions are published

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The most important step is the preparation of clear procedures in terms of the actual equipment and materials you will be using. No procedure can be made idiot proof but the closer you come the more dependable the data obtained.

II. IMPLEMENTATION - Here I will describe what we have done. The 1979 Water Quality Research class collected and analyzed samples from ten sites along the Rock Creek System on ten sampling dates in May - August 1979. Data was measured on twenty parameters - THAT'S 2,000 MEASUREMENTS! Acutally we only succeeded in getting 1,994 measurements. Anyone can have a bad day.

A rough map on the Rock Creek System is attached. This system lies withing the southern part of Will County and northern part of Kankakee County running from just north of Peotone, IL to the Kankakee River at the Kankakee State Park. The upstream portion of the system consists of two roughly parallel stretches. The North branch runs exclusively through agricultural areas while the South branch originates in three parts from the Black Walnut Creek, Marshall Slough, and the actual South branch of Rock Creek. There are two sewage treatment plants along the South Branch system including one serving Peotone on the Black Walnut stretch and on serving Manteno on the combined South Branch. Near the mouth on the Kankakee River the stream flows through a deep canyon cut by glacial runoff. The system is unusual in that its gradient is small in the upstream stretches but increased markedly near the mouth.

The parameters tested are as follows. These are broken down according to where they were measured.

IN SITU

temperature
  air
  water
dissolved oxygen
(electrode method)

MOBILE LAB

pH
alkalinity
dissolved oxygen
(Winkler Method)
hardness
color
conductivity
Biochemical Oxygen
Demand (BOD) initial
residue- initial

GSU LABORATORY

BOD - final
Residue - final
chloride
nitrate
nitrite
ortho phosphate
total phosphorous
calcium
magnesium

The procedures used included gravimetric (residues), volumetric (Winkler D.O. and hardeness), electrometric (pH, alkalinity, chloride), colorimetric (color, nitrate, nitrite, ortho and total phosphorous), and atomic absorption (calcium and magnesium).

All data was logged into a computer for storage and ease of obtaining current printouts and well as for later statistical analysis.

Organizational details were based on consideration of the following:

- rotation of student assignments
- flexible scheduling to allow for contingencies caused by weather and equipment failures
- people problems, teamwork is necessary and student leadership by both assistants and participants is necessary

Considerable attention to detail is essential to avoid loss of date through carelessness or lack of understanding of procedures.

The overall schedule of activities was approximately as follows:

- preliminary class presentations on the scope and organization of the project and on the nature of stream systems
- laboratory preparation of reagents and equipment (this provides an opportunity to sort out student abilities)
- demonstration of field techniques
- initial sampling runs including collection of samples and field analysis in the mobile laboratory
- begin lectures on the procedures to provide background
- continue sampling runs on a regular basis
- introduce GSU laboratory procedures
- begin analysis of data at approximately midpoint of season
- continue sampling and laboratory work while controlling data quality
- complete sampling then laboratory work
- input all remaining data and clean up data problems
- data analysis and interpretation

III. EVALUATION - the most important step

A. Procedures - before serious analysis of results can begin, you must have a notion of the limits of the data accuracy.

B. Analysis of the clarity of procedures and the organizational details while it is fresh in everyones mind helps prepare for the next season.

C. Once systematic errors in the data have been evaluated, the analysis begins - graphical techniques are the most powerful.

D. Finally, interpretation of results in terms of the goals of the project.

ADVANCED BATTERIES FOR ELECTRIC VEHICLES

— A Look at The Future

William J. Walsh
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Presented to a Symposium on Energy at the Sixty-Seventh, Two-Year College Chemistry Conference, Prairie State College, Chicago Heights, Illinois 60411, April 25, 1980.

One of the most serious energy problems faced by our natio during the remainder of this century will be liquid fuel shortages. Partial "fixes" for this problem include (A) development of downsized, more-efficient gasoline powered vechicles, (B) reductions in the amount of non-essential travel, (C) production of synthetic fuels from coal or biomass feedstocks, and (D) exploitation of oil shales and tar sands. However, serious liquid fuel shortages are possible, even with dramatic success in each of these areas.

Another partial solution to this problem would be the introduction of electric vehicles into the national transportation fleet. Dramatic improvements in electric vehicles will occur within 10 years as a result of intensive government and industry efforts to develop systems capable of acceptable performance and range. These advanced electric vehicles will incorporate efficient motor/controller systems, improved aerodynamics, rolling resistance, transmission efficiency, etc. along with extensive use of light-weight components. However, the major obstacle to the successful development and commercialization of the electric vehicles is the present lack of a battery of suitable performance, ruggedness, and cost.

The very real possibility of an immense transportation market has created a technological "race" to develop a suitable electric vehicle battery. Dozens of industrial developers in the USA, Western Europe, and Japan have entered this competition, and the net result appears to be a world-wide "renaissance" in battery technology. This paper describes the technical/economic prospects of various advanced batteries, and explains why there is an electric vehicle industry emerging in this country in the 1980's.

CONVERSION OF COAL TO GASEOUS FUELS

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ABSTRACT

The conversion of coal to gaseous fuels proceeds by many different reactions which occur simultaneously to provide different products. The coal organic matter is thermally decomposed to small molecules. The process developer will choose process conditions and catalysts to favor certain types of products to meet particular needs, for example, substitute natural gas, or industrial fuel gas, or a liquid fuel such as methyl alcohol or gasoline. This paper will describe the gasification chemistry and some of the more importnat processes either available or under development for producing gaseous and certain liquid fuels from coal.

INTRODUCTION

Coal in the United States is a plentiful solid fuel. This fuel is converted to gaseous fuels primarily because of the greater ease of transportation, flow control, and lack of solid wastes or undesirable gaseous contaminants. These advantages are always achieved at some cost of loss of energy and consequent increased cost of energy. The role of the chemist and engineer has been to try to minimize these costs by studying the reactions such that improved processes with minimal cost can be developed.

Coal is found widely in the United States. Figure 1 indicates the location of different types of coal deposits in this country. Four major types or ranks of coal are usually distinguished. Coal results from the conversion of plant matter under the effects of pressure, heat, and time progressively through lignite, subbituminous, bituminous, and anthracite coal in the process called "coalification". The lignite deposits are located primarily in North Dakota and in the Gulf Coast region. Subbituminous deposits are found primarily in the Montana-Wyoming region. Bitumionous coal is found extensively through the Middle West and anthracite is found primarily in Pennsylvania.

In the process of coalification the average composition of the original plant material changes. The net effect is as if the original cellulosic material lost water and a small amount of methane. Therefore, the youngest coals have the highest oxygen contents. Table 1 indicates some typical analytical results for samples of these coals. The more mature coals tend towrd pure carbon as in graphite, however, no coal is pure carbon. The oxygen content is high for the "younger" coals. Besides the organically bound heteroatoms, (S, N, O), there is also a considerable amount of ash material, typically about 15 wt% for the bituminous coal burned in the usual electric utility boiler.

The desired fuels such as substitute natural gas, gasoline, or methyl alcohol have significantly higher hydrogen contents than the majority of coals which have a hydrogen-to-carbon ratio that is frequently near 0.8. The production of synthetic fuels will, therefore, involve the addition of hydrogen from some external source to achieve the desired composition. The usual source of hydrogen is water. Since the hydrogen in water is no reactive enough with coal at normal temperatures and pressures, some high temperature processes must be devised to bring about the desired change. Table 2 gives some coal and gas compositions for comparison. There are some chemical fuels besides those indicated above that are very useful, not only for fuels but also for chemical building blocks. One of these is carbon monoxide. Because of its toxicity, it has had limited fuel application recently, although it was one of the constituents of town gas which was distributed earlier in this century. Producer gas is one name given to carbon monoxide or a gas which is primarily carbon monoxide. Synthesis gas or syngas is a mixture of hydrogen and carbon monxide which may be used in a chemical process to provide some new material such as methane, methyl alcohol, or a hydrocarbon liquid.

In general, the conversion of coal into gaseous fuels occurs in two steps. When the plant is intended to provide one or more particular products, the initial step is a conversion of the coal to a mixture of low molecular weight gaseous products; the final step includes an adjustment of a gas composition and a catalytic conversion to one or more particular products that are desired. Therefore, the overall process can be considered as starting with coal, producing intermediates, and finally, converting to final products.

GASIFICATION CHEMISTRY

Some of the gasification processes are exothermic and provide heat to drive other steps. Some steps are endothermic and require the exothermic reactions in order to take place. The overall processes are then arranged to balance the heat effects of exo- and endothermic reactions. Table 3 lists a number of carbon gasification reactions and the associated heat effects in btu's. Data are given for carbon since the heat effects are constant. These effects vary for coal with the composition. Essentially, coal approaches carbon in composition and releases significant amounts of heat energy as the reaction of coal and oxygen is carried out. The temperature of a reactor would rise rapidly and possibly reach much higher temperatures than desirable unless the endothermic carbon-steam reactions were allowed to take place. Proper combinations of oxygen and steam gasification permit the temperature control of a gasifier. Still another exothermic reaction involves the direct combination of hydrogen with carbon to prepare methane. This heat may be used to help drive the overall process. Another reaction of importance is the gasification with carbon dioxide. This reaction will reduce the carbon dioxide to monoxide, providing a very useful fuel, but since it is endothermic will also reduce the reactor temperature.

In order to produce a useful industrial fuel gas in a continuous fashion, heat-balanced gasification must be carried out. Table 4 gives an example of this concept. The heat required in the endothermic steam-carbon reaction is just balanced by the heat released from the exothermic carbon oxidation. The overall reaction is one of carbon reacting with both steam and oxygen to provide a mixture of hydrogen and carbon monoxide. The molar ratios of the reactants are given and are useful in comparing processes for economic evaluations.

When a gasifier is operated under higher pressures, the direct reaction of hydrogen with carbon to form methane can take place to a significant extent. The product methane is a desirable fuel because of the higher heat content compared with the alternatives. For example, the product gases are sometimes referred to as "high-Btu" gas (methane with a heating content of 1000 Btu/cu. ft., "medium-Btu" gas with a heating content of 80 to 180 Btu/cu. ft.). The varying heat contents reflect the lower heat content of hydrogen or carbon monoxide (322-325 Btu/cu. ft.) compared to methane and the possible dilution with nitrogen or carbon dioxide which add nothing to the heat content of the gas. Methane has become the standard gaseous heating fuel because of its high heat content, availability, and low toxicity. It can be transported great distances economically. The transportation costs for the other fuel gases with lower heat contents would rise roughly proportionately with the decrease in heating content.

Heat-balanced gasification can take place with methane production as shown for example in Table 5. The heat energy released in the methane production is used to help drive the overall process. As a result, a greater amount of carbon is gasified for a given amount of water or steam and a lower amount of oxygen is consumed. A somewhat greater heating value is obtained from the products.

The hydrogen to CO ratio can vary depending on the process conditions. The most desirable hydrogen-to-CO ratio will depend on the product which is to be produced from the plant. Some important conversions are indicated below:

Methane: $CO + 3H_2 = CH_4 + H_2O$

Methyl Alcohol: $CO + 2H_2 = CH_3OH$

Hydrocarbons: $nCO + 2nH_2 = (CH_2)_n + nH_2O$

From these reactions, it may be seen that a ratio of 2 or $3H_2$ per CO would be desirable for these catalytic conversions. Table 6 indicates some gas composition adjustments which are used to bring about the desired composition and change. The first is the so-called shift reaction in which carbon monoxide is essentially traded for hydrogen with the release of some heat energy. The shift reactor essentially adds steam, reduces the CO and increases the hydrogen content and also produces some CO_2 which must be removed or scrubbed out.

Since coal has a number of impurities in it, some other reactions of significance takes place. Sulfur is found either organically combined or present in some inorganic form, such as pyrite with the formula, FeS_2. Under the conditions of most gasification reactions, a significant amount of the pyrite or organic sulfur will be converted to hydrogen sulfide. Since H_2S is a toxic gas and also a catalyst poison, it is necessary to remove this before final processing. Carbon dioxide contributes nothing to the heating value of the product, and will represent some penalty if the process hydrogen combines with it. For this reason, both hydrogen sulfide and carbon dioxid are usually removed at the same time in a step called "acid g removal" or "scrubbing". Typically, an alkaline or amine solution will be used to contact a gas and permit the removal. The solution which has removed the acid gases is usually rege erated by applying heat. In this way the solution may be use repeatedly. The carbon dioxide may be vented directly to the atmosphere since it is not toxic. The hydrogen sulfide is fu ther processed to provide elemental sulfur. The Claus reacti

$$2H_2S + SO_2 = 3S + 2H_2O$$

is used to accomplish the conversion. The SO_2 is provided by the combustion of some of the product sulfur.

After the gas composition has been adjusted and the acid gases have been removed, a catalytic conversion step follows, to provide either gaseous or certain liquid fuels. The catalysts commonly used include nickel for preparation of methane copper or zinc to make methyl alcohol, and iron to make hydrocarbons.

COMMERCIAL GASIFICATION PROCESSES

The most widely used commercial coal gasification proces today is the Lurgi process. This is used extensively in the Republic of South Africa in large plants to provide synthetic fuels. Gasifiers of this design may also be found in Europe and scattered other places in the world, however, none are operational in the United States at this time. A schematic diagram of this gasifier system is shown in Figure 2. In this type of descending bed gasifier, which is representative of one of three major types, the coal flows slowly through a pre sure vessel. The coal is initially heated, then gasified and finally burned to release the ash residue. The coal enters a the top through a pressurizing device called a "lockhopper". This permits the coal to enter at the operating pressures in the range of 350-450 psi. In the uppermost zone of the bed, the coal is heated to release volatile matter including gases light oils, and tars. In the central region of the bed, the devolatilized coal contacts a mixture of carbon monoxide, hydrogen, and steam at high temperatures to gasify the coal. the lower region of the bed, the partially reacted coal or ch contacts oxygen and steam to burn the carbon to provide heat for the process. The steam also reacts to moderate the temp ature and provide hydrogen.

The Koppers-Totzek is another commercially available ga ifier. A schematic diagram of the gasifier system is given Figure 3. A mixture of steam and oxygen entrains the pulver coal which is swept into the atmospheric pressure gasifier. extremely high temperatures (up to about 3300°F) crack all o the larger molecular species and provide a mixtrue of CO, H_2 CO_2, and H_2O. The high temperatures melt the coal ash which flows from the bottom of the reactor as a molten slag. The synthesis gas is cooled and then processed. Typically, the gases (H_2S and CO_2) will be removed. The synthesis gas is m often used to make ammonia. Plants are located in India, Tu

Greece, and South Africa.

DEVELOPING GASIFICATION PROCESSES

The HYGAS Process is one example of the newer processes being developed to produce high-Btu gas or methane under Department of Energy and Gas Research Institute sponsorship. A schematic diagram of the pilot plant is shown in Figure 4. In each of these processes many of the steps remain the same. The coal is initially crushed and will be pulverized if an entrained reactor is used. A bituminous coal will be pretreated by surface oxidation to eliminate the tendency to agglomerate when heated. After gasification, the gases are cooled, the composition is adjusted, the acid gases are removed, and the catalytic conversion to methane is accomplished. The HYGAS reactor was designed to accomplish several process steps within the same pressurized enclosure to maximize the efficiency and initial production of methane. A coal mixture is fed into the reactor with a modified oil field pump in the form of a slurry or mud. In the upper stage of the reactor the slurry is dried, and the dry coal descends to contact a hot rising gas stream, rich in hydrogen. The high pressure (typically 1000 psi) favors the exothermic reaction to form methane in the temperature range of 1200 to 1300°F. Then that reacted coal is separated and descends into a fluidized bed, which is kept in vigorous motion by the gases rising from the lowest part of the reactor. The fluidized bed temperatures are usually in the range of 1400 to 1500°F and the residence times average about 45 minutes. The gas pressure for all of these stages is essentially about the same, near 1000 psi. The unreacted coal char from the fluidized bed dexcends to the lowest stage called the "steam-oxygen gasifier". Here, oxygen contacts the char to burn it producing CO_2 and releasing major amounts of heat energy. Steam is added to control the temperature and provide a source of hydrogen for the gasification reaction. The coal ash falls from the bottom of the reactor through a valve opening and is periodically removed.

Another example of a developing process is IGT's U-GAS Process, also being developed under Department of Energy sponsorship. Synthesis gas or industrial fuel gas is the intended product. This can also be catalytically converted to liquid fuels. Operation at lower pressure is planned to avoid methane formation. A schematic diagram of the reactor is shown in Figure 5. Raw coal or char is injected at high velocities into the lower part of the fluidized bed. Gasification takes place with steam and air or oxygen. Product gases and the fine unreacted coal pass through cyclone separators which return the coal to the gasifier. The fine coal is returned via a venturi. This unique modification to the fluidized bed provides a higher temperature region to complete the conversion of the coal char and permit the agglomeration of the ash particles. The agglomerates are discharged through the throat with ash compositions up to 95% ash which represents about 99% carbon utilization. The product gases are cooled and treated to remove the acid gases prior to their intended application as either a fuel gas or chemical intermediate.

A commerical plant is planned for the Memphis Light, Gas and Water Division in Memphis, Tennessee.

Table 1

SOME TYPICAL COAL COMPOSITIONS IN % (DRY, ASH-FREE)

	C	H	O	N	S
Lignite	70.59	4.47	23.13	1.04	0.74
Subbituminous	77.2	5.01	15.92	1.30	0.51
Bituminous	80.2	5.80	7.53	1.39	5.11
Anthracite	92.7	2.80	2.70	1.00	0.90

Source: Marks, M.E. Handbook and IGT data.

Table 2

COAL AND GAS COMPOSITIONS

wt%	COAL (Ash and Moisture-Free	PRODUCER GAS (CO)	SYNGAS ($2H_2$ + CO)	SNG (Methane)
C	70-88	43	37.5	75
H	6-4	--	12.5	25
O	22-2	57	50.0	--
N	1-2	--	----	--
S	1-4	--	----	--

Table 3

GASIFICATION CHEMISTRY

CARBON GASIFICATION

$$C + 1/2O_2 \rightarrow CO + 47600 \text{ Btu}$$

$$C + O_2 \rightarrow CO_2 + 169{,}300 \text{ Btu}$$

$$C + H_2O(g) \rightarrow H_2 + CO - 56{,}500 \text{ Btu}$$

$$C + 2H_2O(g) \rightarrow 2H_2 + CO_2 - 38{,}800 \text{ Btu}$$

$$C + 2H_2 \rightarrow CH_4 + 32{,}200 \text{ Btu}$$

$$C + CO_2 \rightarrow 2CO - 74{,}200 \text{ Btu}$$

Table 4

GASIFICATION CHEMISTRY

HEAT BALANCED GASIFICATION

$$C + H_2O(g) \rightarrow H_2 + CO - 56{,}500 \text{ Btu}$$

$$1.2C + 0.6O_2 \rightarrow 1.2CO + 56{,}500 \text{ Btu}$$

$$2.2C + H_2O(g) + 0.6O_2 \rightarrow H_2 + 2.2CO$$

$O_2/C = 0.27$ $H_2O/C = 0.45$

Table 5

GASIFICATION CHEMISTRY

HEAT BALANCED GASIFIER

$$C + H_2O(g) \longrightarrow H_2 + CO - 56{,}500 \text{ Btu}$$

$$0.5C + H_2 \longrightarrow 0.5CH_4 + 16{,}100 \text{ Btu}$$

$$0.85C + 0.425O_2 \longrightarrow 0.85CO + 40{,}400 \text{ Btu}$$

$$2.35C + H_2O + 0.425O_2 \longrightarrow 1.85CO + 0.5CH_4$$

$$O_2/C = 0.18 \qquad H_2O/C = 0.43$$

Table 6

GAS COMPOSITION ADJUSTMENTS

$$CO + H_2O(g) \longrightarrow H_2 + CO_2 + 17.700 \text{ Btu}$$

$$CO + 3H_2 \longrightarrow CH_4 + H_2O + 88{,}700 \text{ Btu}$$

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O + 71{,}000 \text{ Btu}$$

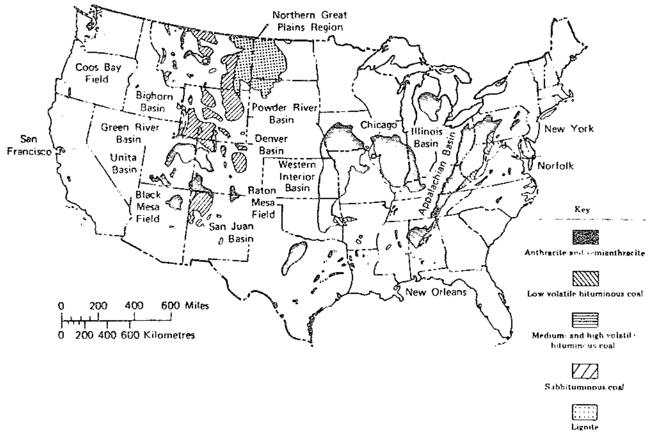

Figure 1. Coal Fields of the Conterminous United States

Source: Averitt, 1975

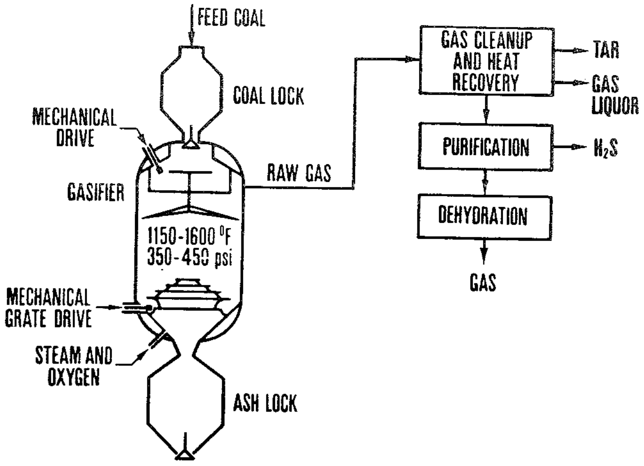

Figure 2. The Lurgi Gasifier System

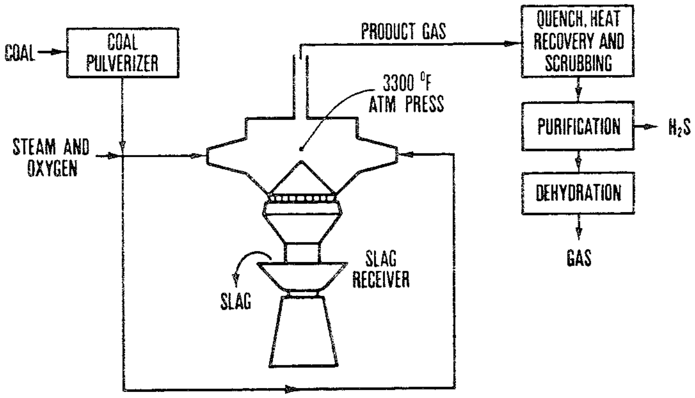

Figure 3. The Koppers-Iotzek Gasifier System

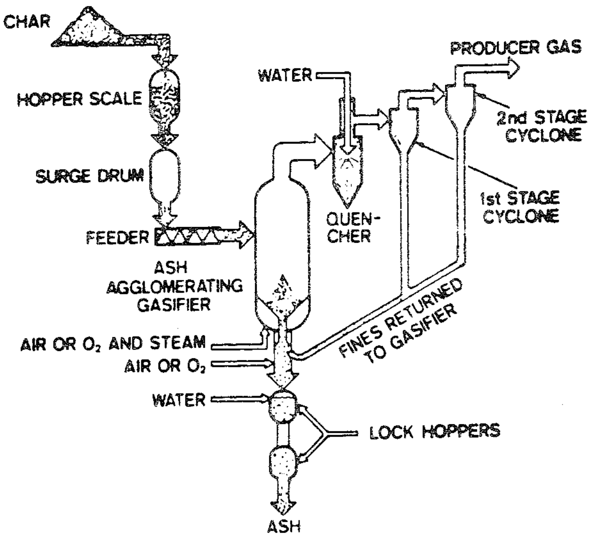

Figure 5. Flow Diagram of the IGT Ash-Agglomerating Gasifier

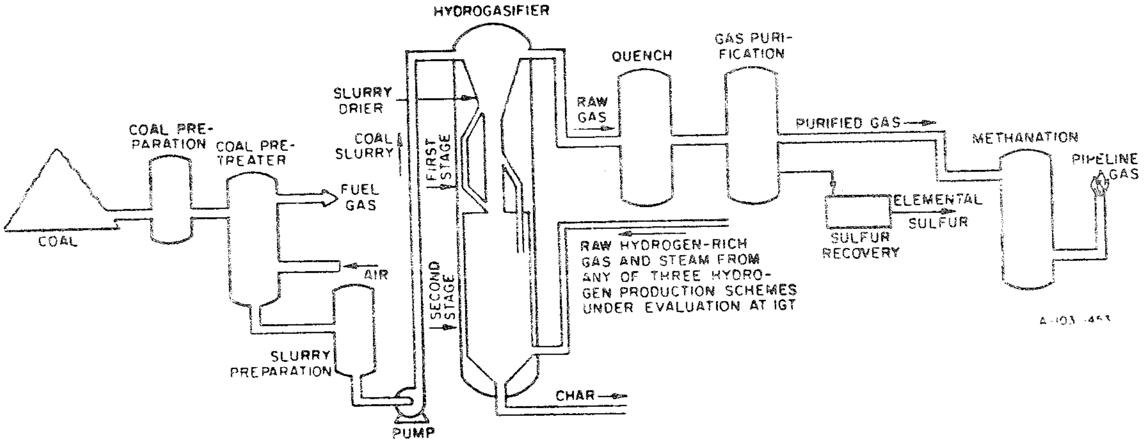

Figure 4. Simplified Flow Diagram of the IGT HYGAS Pilot Plant

AN OVERVIEW OF COAL CONVERSION

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This nation is under ever-increasing pressure to produce energy from its own resources. One of the most abundant and most frquently mentioned sources of energy currently obtainable by present technology is the utilization of coal. While coal conversion technology is not new, efficient methods of converting coal fall in the realm of current research and development. The utilization of coal to produce transportation fuels and other commodities depends very much on the development of methods which are efficient and competitive with the ever-increasing prices of natural petroleum. Unfortunately, the current state of research in coal chemistry is in its infancy stage. With today's knowledge, the design of plants for the conversion of coal is very empirical. In fact, I attended a conference only a few weeks ago which dealt with the problem of the need to know more physical and chemical data in order to make correlations necessary to design a plant on the basis of understood principles rather than a "fly by the seat of your pants" principle. In addition to the need to understand the physics and chemistry associated with the conversion of coal, it is very important that we understand the effects of the coal conversion industry on human health and on the environment. I am part of a large program at Oak Ridge which is involved in studying this very problem. Work which is conducted among biologists, environmental scientists, and analytical chemists is aimed toward the elucidation of the kinds of compounds associated with coal conversion, which may be important from a health and environmental viewpoint.

In this paper we will survey in a rather abbreviated fashion some of the aspects of coal conversion chemistry and gasification and liquefaction technologies, with a few historical observations ot provide background in both of these areas. The references found at the end of this paper provede additional information and starting points for more detailed information in all of the subjects that we'll be touching on in this paper.

Overview of Coal Conversion

Coal conversion in this nation is not a new activity. We have been using coal quite extensively for direct combustion, thereby converting it to carbon dioxide and water in an ideal combustion situation. Approximately 20% of all the electrical power generated in this nation is generated today by the combustion of coal. Most energy scenarios indicate that it is likely that we will continue to use coal in a direct combustion mode for many decades to come. And while we will continue to improve this technology with better cleanup methods and with more efficient boilers, etc., there will still be significant need to convert coal into liquids and, in particular, into transportation fuels.

The abundance of coal in this nation is demonstrated by the map, which is shown in Figure 1, of the known coal fields across the continental part of the United States. In this figure it is evident that we have two large areas of obtainabl coal, the area in the Eastern part of the United States which contains most of the known deposits of the bituminous coals, and a large area in the Western part of the United States whic contains sub-bituminous coals. Smaller amounts of other types of coal, e.g., anthracite deposits in Pennsylvania and lignite deposits across the Southeastern part of the United States add to the coal inventory to some extent. The estimates of mineab coal available by today's technology vary considerably, but al estimates indicate that 100% use of coal for all of our energy needs would still provide sufficient energy for this country fo at least the next several centuries. In addition to the anthracite, the sub-bituminous and bituminous coals and various lignites, this nation possesses very large deposits of economicall mineable oil shale with the principal concentration of the richest mineable shale in the corner of Wyoming, Utah, and Colorado While we will not be discussing the oil shale industry in this paper, I do wish to point out that many people feel this industry is nearer to commercialization than any large-scale conversion of coal, especially into liquid transportation fuels. Among the coal deposits in the United States, the Western coals are being scrutinized with great interest because of the plentifulness of the deposits, the thickness of the seams (some as thick as 70 ft) and the shallow overburden making strip-mining an attractive method of removing this resource. One subject which I will not dwell on in this paper, but which deserves mentioning, is the question of coal mining itself. Obtaining coal is not as simple as one may first imagine; there are a vast number of legal questions and applications for various permits which are involved in the production of coal. In fact, the number of requirements has increased so substantially that it is estimated that to bring a new mine into production has approximately the same time scale as the licensing of a nuclear power plant, that is, in the neighborhood of 7-10 years.

Let's focus our attention now on the problems associated with the conversion of coal into various products. One of the first questions we need to ask in "What is coal"? We need to address this question as extensively as possible if the design of coal conversion processes is to be put on any kind of a firm scientific basis. Unfortunately, the answers to this question are few and the chemical makeup of coal is only partially understood. Some of the facts that are known are: (1) coal is a variable material, varying in physical and chemical composition from seam to seam and even within a given seam; (2) there is no such thing as a coal molecule, rather, the various kinds of chemical functionalities which constitute coal can be represented as in Figure 2; (3) the organic and inorganic components of coal are highly variable from one type of coal to another. In general, the sub-bituminous coals of the Western regions of the United States are low sulfur and high moisture, whereas the more frequently used bituminous coals of the Eastern part of the United States are high sulfur, highest BTU content, and lower moisture. Focusing on Figure 2, we see that a typical representation of a coal molecule indicates a highly aromatic type of structure containing various bridging links among aromatic ring systems which can be oxygens, disulfide bonds, or aliphatic chain linkages, and others. We also notice other heteroatom structures which incorporate nitrogen, oxygen, and sulfur within the ring systems. One of the most noteworthy features of a model of this type is that the hydrogen of carbon ratio is quite similar to that found in the most simple aromatic molecule, benzene. This ratio is, of course, 1:1. Figure 3 is a representation of the kinds of molecular fragments we might obtain going from the low BTU content lignite to the almost pure carbon, anthracite. Note that the hydrogen to carbon ratio is continuously decreasing as we go up in coal rank from lignite through anthracite. The representation for lignite contains a number of chemical functionalities which are associated with wood, i.e., lignin structures.

Our current knowledge of coal structure leads us to several important objectives in designing a method for the conversion of coal:

(1) maximize the hydrogen to carbon ratio in the coal product,
(2) minimize both sulfur and nitrogen contents in the coal products,
(3) remove the mineral matter,
(4) do all of the above at a cost competitive with producing fuels from petroleum.

The most expensive step among all the above in the addition of hydrogen to the coal in order to produce high-octane fuels for transportation and feedstocks for the production of synthetic materials. Obtaining hydrogen is an expensive process and is a step which must be carefully scrutinized in obtaining an economic balance in a coal conversion process. The desire to minimize sulfur and nitrogen contents in a coal product are important both from a refinery viewpoint and a utilization viewpoint. Most refineries contain catalytic units which cannot tolerate even trace amounts of sulfur compounds. The presence of nitrogen compounds is correlated with instabilities of stored products and the formation of gums. There is also significant evidence now that the heteroatom content of a product is related to the likely hazardousness of the material in terms of its effect on health and/or the environment. The removal of mineral matter is a rather obvious necessity; solids simply cannot be tolerated in transportation fuels and must be removed at some stage even for stationary power combustion.

Several important products are sought from the coal liqu faction technologies. Among the products most frequently men tioned are low-sulfur fuel oils, chemical feedstocks, and syn thetic crudes for refining to transportation fuels. The meth ology for producing materials of each of these types will be discussed later in this paper.

At this point we turn our attention to some of the chemis involved in coal conversion. As has been mentioned, one of th main objectives in a coal conversion process is to produce a product that has an enriched hydrogen to carbon ratio. Examin ation of Table 1 information shows that the hydrogen to carbon ratios for various fossil fuels range from nearly zero for the nearly pure carbon, anthracite, to the high hydrogen/carbon ratio found in methane or natural gas. Gasoline is a material which has a hydrogen/carbon ratio of approximately two. If on examines the hydrogen/carbon ratios among most of the large coal deposits, we find that this ratio can range anywhere from approximately .5 to .75; thus, it is apparent that a great dea of hydrogen would have to be added to a coal product in order to produce a gasoline. There are several ways of obtaining this goal which will be treated in turn.

Overall reactions which describe coal conversion processes can be written. In Figure 4 there are several categories of reaction types which describe chemistry occurring under various coal conversion conditions. The group of reactions which describe the pyrolysis process show the production of acetylene, benzene, and methane and carbon in a reaction which is essentially a disproportionation. We can see in this group of reactions, especially in reaction 3, that the hydrogen/carbon ratio can be upgraded at the expense of removing hydrogen from other entities in the coal. Many coal conversion processes are designed for the addition of hydrogen directly as a gas to a coal liquid or to a gas in the presence of a catalyst. This overall reaction is shown under the direct hydrogenation category. More practical in an economic sence is the addition of hydrogen by indirect hydrogenation as is shown under that category in Figure 4. We see in this pair of reactions that hydrogen for increasi hydrogen/carbon ratios is obtained from water. In the second of these reactions we can see that hydrogen gas is a product and and it is this type of reaction which is proposed to produce hydrogen gas necessary as a reactant in a commercial conversion scheme. The last generalized reaction shown, that is the production of synthesis gas, is perhaps the most important type of reaction in coal conversion. Synthesis gas is an excellent starting material to build either fuels or simple molecules as building blocks for synthetic materials now produced by the petrochemicals industry.

Gasification

Coal gasification has been an important source of fuel for at least two centuries. A very small amount of coal gas is still produced in this country. This technology has been one of the most successful although many of the fundamental reactions which occur are not well understood. The ideal reaction for the conversion of coal into methane is shown in Figure 5. While this reaction is thermodynamically very favorable, kinetically there are some severe hindrances in that no coal conversion process is successful in converting coal and water to methane and carbon dioxide directly. A more realistic approach is illustrated by the series of equations also shown in Figure 5. A coal, steam, and oxygen or air mixture is first reacted to produce varying amounts of carbon monoxide, hydrogen, small amounts of methane, carbon dioxide and other products not shown, such as low-molecular weight hydrocarbons. The relative amounts of the products depend a great deal on the type of coal, the steam feed rate, and whether or not oxygen or air is used as the oxidant. The important products are carbon monoxide and hydrogen gas. In the usual conversion operation insufficient amounts of hydrogen are produced from the coal-steam-oxygen reaction alone; additional hydrogen is produced through the water shift reaction by causing some of the carbon monoxide to be converted through a reaction with water into carbon dioxide and hydrogen gas; this reaction is carried out in the presence of a catalyst. Finally, we have adjusted the proportion of carbon monoxide to hydrogen to make a useful synthesis gas. If the object of the coal gasification plant is to produce a pipeline-quality gas similar in BTUs to the natrual gas we now have available, then the reaction of hydrogen and carbon monoxide is carried out catalytically to produce methane and water as shown in the last reaction.

One of the oldest gasifier designs and the only design used extensively in a commercial mode today is the Lurgi gasifier shown in Figure 6. A gasifier of this type is very simple. Coal feed is added through a lock hopper at the top of the gasifier while ash is removed through another lock hopper at the bottom of the gasifier. The coal bed in between consists of a top layer of coal which is in the drting stages; immediatly beneath that is a zone which is in the neighborhood of several hundred degrees centigrade in which carbonization is occurring; gasification is occurring in the next level; and in the bottom level a small amount of the coal is combusted to provide the heat necessary to drive the gasification reactions. A simple analogy to the gasifier behavior is that of a burning cigarette. There is unburned material, followed by a heated zone, followed by a flame zone, followed by an ash zone. The zone continuously moves as a cigarette is burned. The only difference in the analogy is that in the gasifier the flame front remains stationary while ash is being removed and fuel is being added at opposite ends of the gasifier. The product of this gasifier is the synthesis gas we have mentioned before, i.e., a mixture of carbon monoxide and hydrogen. The synthesis gas is a useful product because there are several options for the use of this material in the construction of other compounds. One of the most promising uses is the direct catalytic conversion of CO and H_2 to methanol. Methanol is an especially valuable building block for other chemicals that can be used as chemical feedstocks; in addition, methanol can be used as a fuel or can be converted directly to gasoline by a method patente by the Mobil Corporation called the M-Gasoline Synthesis. I South Africa, Lurgi gasifiers produce synthesis gas which is catalytically converted to a gasoline fraction via the Fisch Tropsch synthesis. That nation, in fact, supplies more than one-half of all of its gasoline needs through the Lurgi gasifier to produce synthesis gas in the Fischer-Tropsch synthes to produce gasoline. Other products possible from synthesis gas are ammonia and urea.

In Figure 7 is shown a simplified schematic of the low pressure-low temperature Lurgi methanol process for the dire conversion of synthesis gas to methanol. Conceivably this p cess could be used in tandem with the Mobil M-Gasoline proce to produce gasoline. This process is illustrated in simple diagrammatic form in Figure 8. While details of the process are not available, it is known that the M-Gasoline Process utilizes zeolite catalysts which have pore sizes comparable to the molecular dimensions of decane and other gasoline co pound constituents. The process is expecially attractive b cause of its high efficiency and low temperatures for the p duction of a nearly ideal gasoline.

Liquefaction

To conclude this paper we turn briefly to a discussion coal liquefaction technology. Liquefaction technology is b on one of two methods; (1) direct liquefaction, and (2) ind liquefaction. Indirect liquefaction methods have been allu to before and are exemplified by the South African producti of gasoline by the Fischer-Tropsch conversion of the synthe gas to gasoline. The disadvantage of this method is that i a poor efficiency of only about 35%. The advantage of this thod is that it is a proven technology and could be utilize this country were the cost of petroleum-derived gasoline to crease dramatically. In the United States, direct liquefac appears more attractive because of the higher conversion ef ciencies that are calculated. These efficiencies run in th range of 60-80%. The characteristics that direct liquefact plant designs have in common are these: (1) a coal/oil slu is involved, (2) hydrogen is added directly to the slurry, liquid products are separated and deashed in subsequent pro steps, (4) hydrogen necessary for the process is manufactur from the reaction of heavy residuals, i.e., char and steam high temperature and pressure. Current processes under dev ment in the United States are: (1) H-Coal, (2) Exxon Donor vent, and (3) SRC-II (solvent refined coal). Pilot plants currently in operation for both the H-Coal and the Exxon Do Solvent processes. Preliminary conversion efficiencies cal ated for the operation at the H-Coal plant are meeting or e ceeding expectations.

Figure 9 shows a simple block diagram of the H-Coal pi plant which is located in Catlettsburg, KY. The main featu of all liquefaction processes are illustrated in this block diagram. These are: (1) a coal preparation area, (2) a li faction reactor, (3) a separation module, (4) a hydrogen manufacturing module, (5) a desulfurization module, (6) a gas cleanup system, and (7) a wastewater treatment facility. The Exxon Donor Solvent Process pilot plant is illustrated in Figure 10, and here we see similar process units as we find in the H-Coal plant. The main difference between the two plants is that the EDS plant adds hydrogen to a coal-produced solvent which is recycled and makes contact with the coal/oil slurry rather than adding hydrogen gas directly to the slurry in a reactor.

Conclusions

While coal conversion technology is not likely to provide a significant amount of synthetic fuel within the next several years, there is a clear interest both in government and private sectors in the development of this technology to hedge against ever-diminishing petroleum supplies, especially from foreign sources. We have seen from this rather cursory survey that there is some old technology that is highly reliable, while new technology is being developed but at the present state of development, is not ready for commercialization. The area of coal conversion is ripe for exploration both on the applied and basic research levels. A great deal more must be understood about the reactions of coal, the reactions of coal products, and the physics and chemistry involved in the various stages of coal conversion processes in order to make this technology economically viable.

References for Additional Information:

1. O.H. Hammond and R.E. Baron, "Synthetic Fuels: Prices, Prospects, and Prior Art," Am. Scientist, 64, 407 (1976).
2. S. Kasper, "Coal Conversion Chemistry--See It in Common Terms", Ind. Res. and Dev., (Jan. 1981) 164.

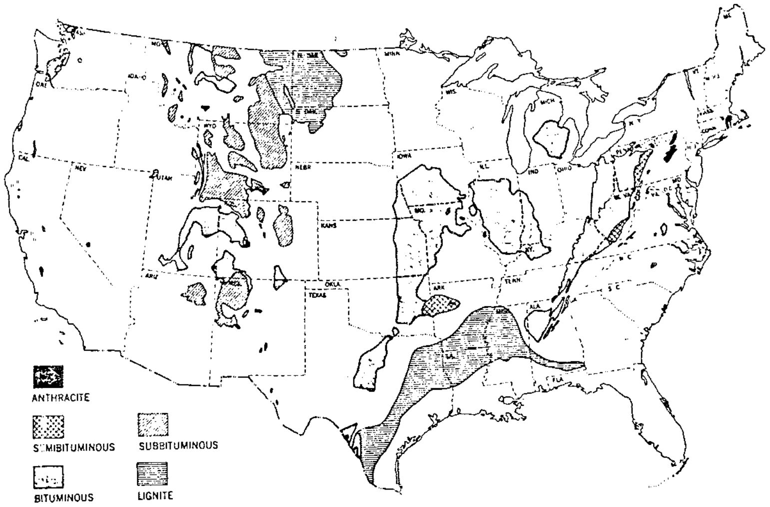

Fig. 1. Coal fields of the United States.

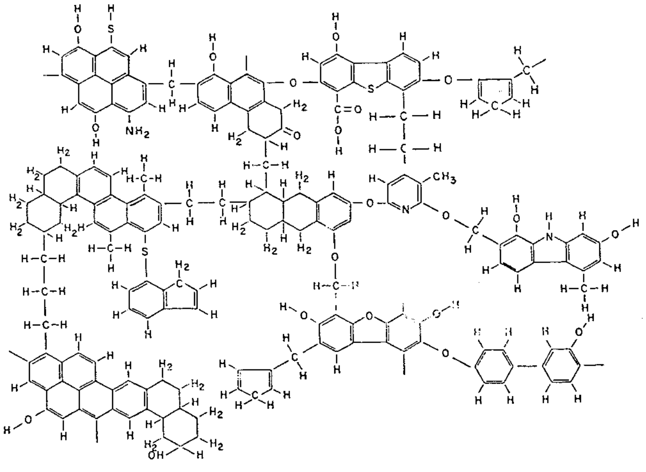

Fig. 2. Schematic representation of structural groups and connecting bridges in bituminous coal.

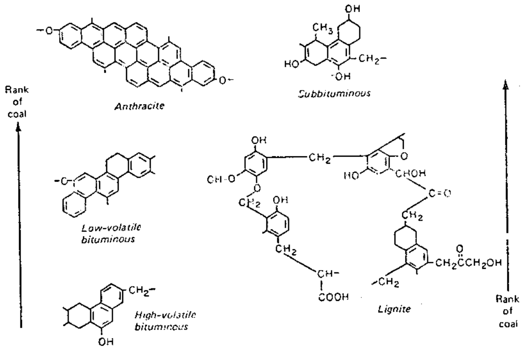

Fig. 3. Representative partial structure of different ranks of coal. [From I. Wender, Catalytic Synthesis of Chemicals from Coal, Catalysis Reviews Science and Engineering. 14(1): 101, Fig. 2 (1976)].

SOME TYPICAL REACTIONS IN COAL CONVERSION
(COAL = CH)

PYROLYSIS

$2CH \longrightarrow C_2H_2$

$6CH \longrightarrow C_6H_6$

$4CH \longrightarrow CH_4 + 3C$

DIRECT HYDROGENATION

$CH + 3/2H_2 \longrightarrow CH_4$

INDIRECT HYDROGENATION

$2CH + H_2O \longrightarrow CH_4 + CO$

$CH + H_2O \longrightarrow CO + 3/2H_2$

SYNTHESIS GAS PRODUCTION

$2CH + O_2 \longrightarrow 2CO + H_2$

Fig. 4

COAL GASIFICATION

IDEAL REACTION:

$$\mathrm{COAL + WATER} \longrightarrow \mathrm{CH_4 + CO_2}$$

ACTUAL PROCESS REACTIONS TO PRODUCE PIPELINE GAS:

$$\mathrm{COAL + STEAM + O_2} \longrightarrow \mathrm{CO + H_2 + CH_4 + CO_2}$$

$$\mathrm{CO + H_2O} \longrightarrow \mathrm{CO_2 + H_2} \quad \text{(WATER SHIFT REACTION)}$$

$$\mathrm{CO + 3H_2} \longrightarrow \mathrm{CH_4 + H_2O}$$

Fig. 5

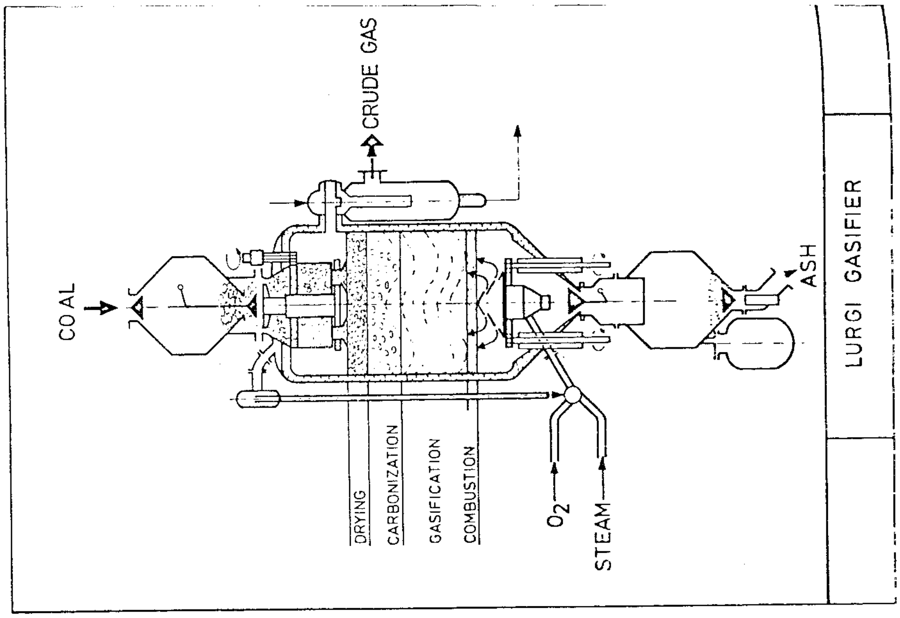

Fig. 6

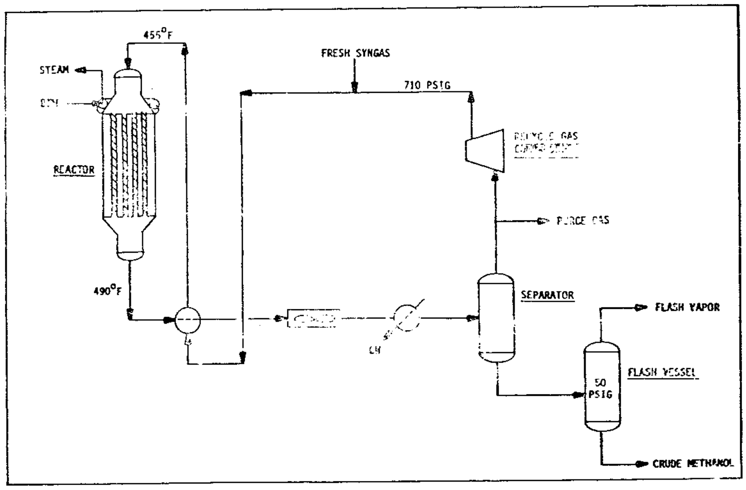

Fig. 7 Flow diagram--Lurgi LP/LT methanol process

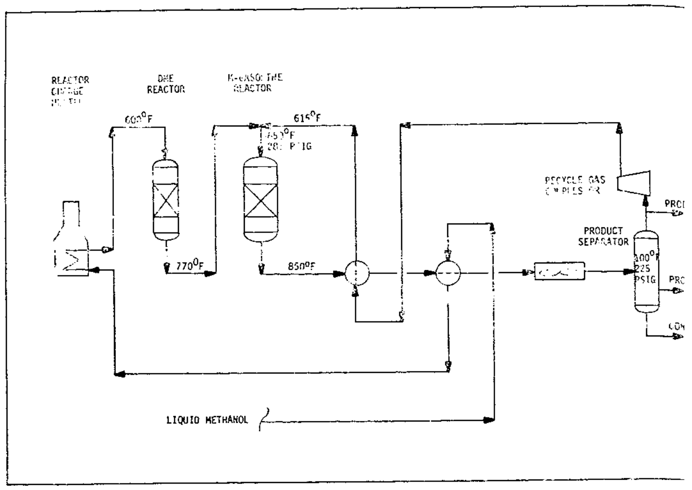

Fig. 8. Flow diagram M-gasoline process

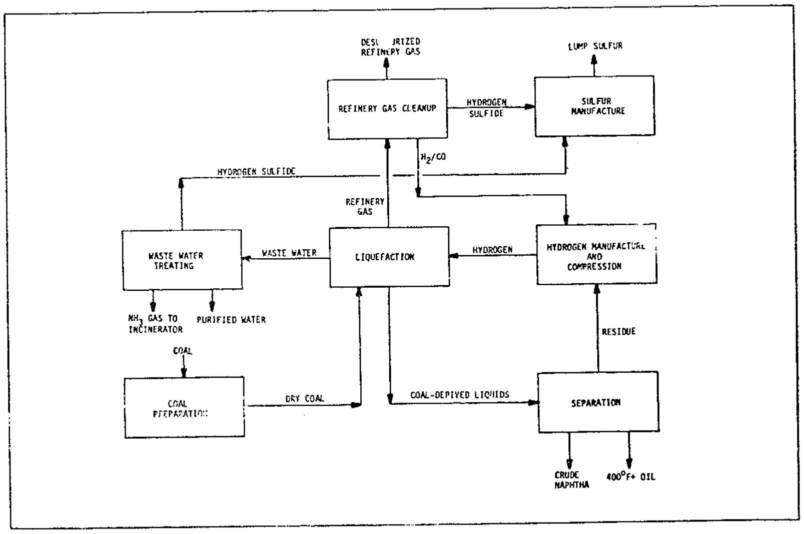

Fig. 9. Block flow diagram of H-Coal plant

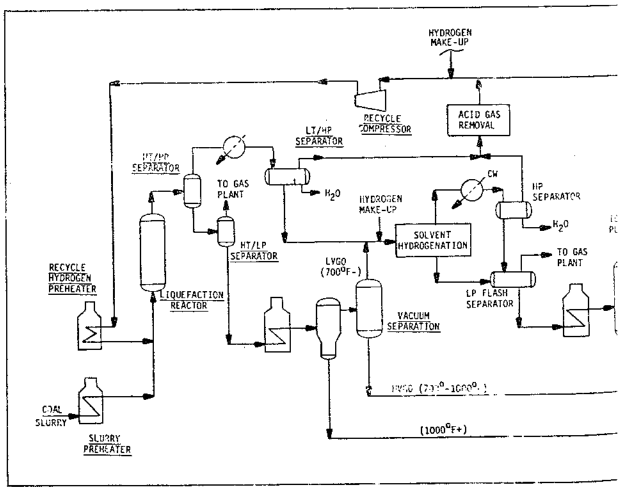

Fig. 10. Flow diagram of EDS liquefaction and product separation

TABLE 1

HYDROGEN/CARBON ABUNDANCES IN SOME FOSSIL-DERIVED MATERIALS

FOSSIL-DERIVED MATERIAL	H/C ATOM RATIO
METHANE - CH_4	4
GASOLINE - $(CH_2)_n$	2
COLORADO SHALE OIL	1.6-1.9
ATHABASCA TAR SANDS	1.5-1.75
BITUMINOUS COAL	0.6-0.75
SUB-BITUMINUOS COAL	0.5
LIGNITE	0.25
ANTHRACITE	0.05

DEVELOPMENTAL CHEMISTRY INSTRUCTION

GUIDED DESIGN: A Motivational Tool

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Presented to a Session on Inovations in Chemistry Instruction at the Seventieth, Two-Year Chemistry Conference, Atlanta Junior College, Atlanta Georgia 30310, March 27, 1981.

Guided Design is an educational strategy developed by Charles Wales and Robert Stager[1] in which students work together in small groups to solve openended problems designed to provide experience applying the subject matter content of a course. Although originally used by Wales in the freshman engineering program at the University of West Virginia, it has been adapted by others to such diverse disciplines as English, Nursing, Philosophy, Political Science, Drama, Business, and Chemistry. It has been used at all levels from secondary schools to graduate and professional schools.

In Guided Design, students are presented a problem and are guided in their search for a solution by a set of instructions which imitate the problem-solving strategies of professionals in the discipline. The solution of the problem requires the use of portions of the subject matter for the course. This provides the motivation for learning the subject matter of the course. Guided Design is most practical for classed of less than 40 students. Groups of four to six students work on the projects during the class period. Homework assignments in the subject matter parallel the project content. The assignments, which may include readings, questions and problems, provide background information necessary to the solution of the problem addressed in the project. (All of the subject matter assignment need not be used directly, but some of the ideas should be pertinent to the project.) The relevance of the projects to the students' interests and experiences is an essential feature of a successful project. Project topics must be chosen carefully to necessitate application of the subject matter as well as be timely. If the students do not see the relevance of the project, interest wanes and the motivation to learn the subject matter, which in my opinion is one of the strongest feature of this instructional method, is lost.

Through the appropriate design of the projects and through the guidance given the groups as they work on the projects, the instructor models the approach of a professional in problem solving in the discipline. This is also an important feature of Guided Design. The steps must be carefully and clearly outlined so that students can model the strategies of successful problem solvers. Although the order of steps will vary depending on the project, there are several essential elements which should be included in guiding students to a successful solution.

(1) Identify the Problem and State the Goal. Although this seems obvious, it is surprising how frequently students fail to recognize the importance of this step. Because of unclear or confusing goals, much effort can be spent in unproductive endeavors. Developing a clear and concise statement of purpose is essential to problem solving and should be the first step in the project.

The order of the next four steps will vary depending on the project.

(2) Gather Information. Examples of this would be reading question/problem assignments pertinent to the project, the collection of data from a lab experiment, and obtaining data from references.

(3) Generate Possible Solutions. Better known as brainstorming, this step involves thinking of possible approaches or solutions without regard to their practicality. Prejudging ideas may result in overlooking good solutions which on the surface appear inappropriate.

(4) State Constraints, Assumptions and Facts. The constraints, the bounds within which one must work to achieve a solution, will affect the choices of solution. Assumptions simplify the problem and make it amenable to solution. The facts are the known quantities. They may be derived from the problem statement or obtained from the information gathering step.

(5) Evaluate and Make a Decision. Considering the constraints, assumptions and facts, evaluate the possible solutions. Decide which approach seems most likely to yield a solution to the problem.

After making a decision concerning the method of approach, implementation of the method, developing and reporting the solution ensue.

(6) Analysis. Generate a step-wise plan for the solution chosen. Gather the necessary information and implement the plan.

(7) Synthesis. Create a unified solution based on the solutions to the steps used in the analysis.

(8) Evaluate Solution. Carefully consider the proposed solution to insure that it satisfies the goal and is consistent with the constraints. Economics, safety, legality and morality of the solution should also be examined at this point.

(9) Report the Results. Write a final report describing the solution and the approach used in achieving a solution. Make recommendations based on the solution. (For chemistry projects, a good format for reports is given by Wittcoff in his book on Industrial Organic Chemistry and College Science Teaching.[2])

When Guided Design is used in the class, the role of the instructor changes from the "oracle from which all information and truth springs" to "professional consultant helping find the solution to a problem". This can be quite a shock to students and a difficult adjustment for the instructor as well. The primary role of the instructor is to prepare written instructions to guide the students through each step of the project so that they can find the solution for themselves.

The instructor needs to be available to clarify instructions and to keep students working toward the goal they have established while at the same time allowing them as much freedom as possible to pursue different paths to the solution. Sometimes students learn more from their mistakes than from a "correct" solution. As instructor, your responsibility is to guide them to see the error of incorrect approaches rather than simply tell them that another approach works while theirs will not. As you might imagine, this is initially difficult for both instructor and students; but as students recognize that most problems they face have no unique solution, they develop self-confidence in their ability to solve the problem and depend less on the instructor for help.

Another important characteristic of Guided Design has already been alluded to, the lack of a unique solution to complex problems. Although most, if not all, students in a class will arrive at the same conclusion concerning the solution to a problem, this is not necessarily so. In some projects the probability of reaching different conclusions is quite large. Initially students find this disquieting. Being accustomed to a "black and white world", particularly where science is concerned, they find it difficult to accept that different conclusions can be drawn from the same data. This is, of course a characteristic of complex problems and provides the opportunity to discuss how alternative interpretations of data con lead to different conclusions and how constraints and assumptions affect the interpretation of data.

As mentioned earlier, Guided Design has been used by several people in the instruction in chemistry courses from the preparatory and general chemistry levels to physical chemistry and industrial chemistry at the junior-senior level. Although my experience using Guided Design has been limited to physical chemistry, I feel it would be of more interest to participants in the 2YC$_3$ to describe its use in preparatory and general chemistry courses.

Dr. Patricia Redden has been using Guided Design for 3 years in the preparatory science course at St. Peter's College in Elizabeth, NJ.[3] Since a large number of students had been unsuccessful in their beginning chemistry and biology courses, a program to develop study skills appropriate to these areas was instituted. Dr. Redden felt that Guided Design would be an effective instructional method for their Developmental Natural Science course. She developed 5 projects which involved study skills and concepts from both biology and chemistry. The titles of the projects and subject matter or description of content are given in Table 1.

Dr. Patrick Hoggard of the Polytechnic Institute of New York has been using Guided Design in his General Chemistry Course for several years.[4] He has continued to develop projects so that he now has 11 projects on a variety of topics (see Table 2).

TABLE 1. GUIDED DESIGN Projects for Developmental Natural Science (Dr. Patricia Redden, St. Peter's College, Elizabeth, NJ)

Project Titles	Subject Matter/Descriptio
Study Skills	Investigate own problems; find available services
The Scientific Method	Students attempt to solve commuting problem
The Case of the Decaying Statues	Air pollution and stoichiometry; acid rain
Human Resources and Water Pollution	pH, Henry's Law
To React or Not to React	Atomic structure, nuclear chemistry

TABLE 2. GUIDED DESIGN Projects for General Chemistry (Dr. Patrick Hoggard, Polytechnic Institute of New York, Brooklyn, NY)

Project Titles	Subject Matter
Oklahoma Story	Stoichiometry
Is Salt the Proper Seasoning for the Streets of New York?	Colligative properties
Element from Outer Space	Periodic properties
Disintegrating Statues	Gases, air pollution
Distant Object	Atomic spectroscopy and the hydrogen atom

Table Continued

Table 2 Continued

Project Titles	Subject Matter
The Smell of Things to Come	Molecular structure
Would you Like to Come Up and See me Etching?	Electrochemistry
Bloody Equilibrium	pH, ionic equiligrium
Water for Abu Kutar	Thermodynamics (desalination)
Ammonia Mania	Kinetics, equilibrium
Candy Man	Equilibrium

Dr. J.C. Norman has used Guided Design in an interdisciplinary chemistry-physics course at the University of Wisconsin at Green Bay.[5] He has a project entitled "Wood Alcohol" which utilizes concepts in thermodynamics and equilibrium. (His other projects primarily involve concepts from physics.)

When you look at the number of projects used by Redden and Hoggard, you may feel that Guided Design is beyond your reach because of limited time to develop projects for use in your classroom. Although that might be true if you converted your entire course to the Guided Design format, one of the desirable features of Guided Design is that this is not necessary. In fact, many people use only one or two projects in their course, the remainder being a more traditional lecture format.

If you are interested in using Guided Design, I would recommend starting with a single short project, either one written by yourself or one written by an experienced Guided Design user. In that say you can learn how Guided Design works in your classroom without a large expenditure of either your effort or instructional time. (By using only one project, you will not need to make the extensive preparation required of those who convert their entire course to Guided Design-preparing self-study materials in addition to the Guided Design projects.)

If you are interested in using Guided Design or want to learn more about Guided Design (how it works, how to write projects, etc.), I would strongly recommend your obtaining a copy of "Guided Design" by Charles E. Wales and Robert A. Stager.[6] This is the Guided Design users' handbook. Several Guided Design projects are included in the book along with detailed information about how to write projects and how to organize a Guided Design course. This book can help you decide whether Guided Design is appropriate for your course. At the end of the book is a list of users of Guided Design compiled by Wales and listed by discipline. Most Guided Design users would be happy to answer specific questions you may have concerning Guided Design. The references cited earlier[3,4] will give more specific information about the use of Guided Design in introductory chemistry courses. If you would like a copy of a specific Guided Design project, please contact the author concerning the availability of a copy of the project.

Personally, I have enjoyed using Guided Design in my physical chemistry course. Although it has been hard work for both the students and myself, most students have felt that they profited from the Guided Design format. Guided Design allows the instructor to fill a different role in the lives of students, the role we in theory espouse--colleagues in the quest for knowledge. Guided Design also encourages a discussion of the significance of assumptions and constraints in the interpretation of data. Additionally an opportunity is provided for appreciation of the interrelation of science and such diverse disciplines as economics, ethics, social values and how these areas affect the interpretation of scientific data. Most students indicated that the Guided Design format demanded more time, energy and self-discipline than a lecture course. In spite of this, most students felt that seeing the applicability of the subject matter and working with other students had been a valuable experience.

Footnotes

1. Wales, C.E., and Stager, R.A., Engineering Educ., 62, 456(1972
2. Witcoff, H., "Industrial Organic Chemistry and College Science Teaching", 1978. (Manual for NSF Chautauqua Short Courses taught by Dr. Wittcoff).
3. Redden, P.A., and Petriello, R.P., J. Chem. Educ., 57, 712(198
4. Hoggard, P.E., J. Chem. Educ., 57, 299 (1980).
5. Norman, J.C., and C.R. Rhyner, "Energetics", University of Wisconsin-Green Bay, Green Bay, 1976.
6. Wales, C.E., and Stager, R.A., "Guided Design," West Virginia University, Morgantown, 1977. (Available from Dr. Charles Wales, Director of Freshman Engineering, University of West Virginia, Morgantown, WV 26506 at a cost of $5.)

A PHILOSOPHY FOR TEACHING PREPARATORY CHEMISTRY

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Presented to a Symposium on the Philosophies of Teachin
at the Seventieth, Two-Year Chemistry Conference, Atlant
Junior College, Atlanta, Georgia, March 28,1981.

The construction of an effective preparatory course in chemistry presents us with a formidable set of problems. Specificall how do we go about doing the job in keeping with the high standards that ought to characterize college education while the open-door policies (which I endorse) typical of state and community colleges presents us with a mind-boggling variety of student type and backgrounds? Obviously, we cannot have separate courses for veterans, repeaters, career-changers, and the temporarily jobless.

The financial restrictions on the proliferation of courses also precludes the variety of preparatory courses we might like for those ethnic and racial minorities who are described as economically and socially underpriviledged. And one might wonder about those students who had no high school chemistry or if they have an experience, it is remembered as a dismal encounter.

It seems to me that our primary job in this area of preparatory chemistry is to identify those needs that are common to the whole spectrum of student types. This may be an impossible objective, but no one has ever suggested easy solutions. If may be that we are dealing with a problem for which there is no solution, but rather we will have to be content with a steady evolution from bad to better.

The preparatory chemistry philosophy as I envision it and try to implement it can be described in three parts: A mutual respect between instructor and students, the remediation of basic skills, and realistic expectations in terms of course content.

RESPECT:

Assuming that we are humane beings (if not amateur psychologists), it would seem to me that we ought to be concerned with some self-image building or damaged-ego repair for many of our students who come in with a feeling of hopelessness and little or no self-esteem. After all, we can't do much with students who tend to give up before they start. With an attitude toward our students that encompasses gentleness, humor, and an insistence on their intrinsic worth and human dignity we can generate the optimal climate for learning. We need to balance criticism with praise when possible. We should encourage and reassure with unflagging patience. And we need to be accessible to students who would come to us for help and understanding.

REALISM:

We need to re-evaluate our objectives periodically so that we can distinguish between the ideal and the realistic. We should constantly remind ourselves whom we are teaching and what we are preparing them for. Realistic goals probably lie somewhere between the extremes of high standards (flunk 'em if they can't hack it) and the dispensation of an oversimplified pablum that is not quite honestly called "college chemistry". A partial answer might be found in the use of individualized and self-paced programs.

My own approach has been effective to such an extent that I would like to share it with you. The students are provided with a list of learning objectives so that they know what is expected of them in terms of content mastery in a chapter. Questions and problems are assigned as a loosely constructed pretest. Then all students take an exam at an announced time.

While the exam is not open-book, the students are permitted to bring a 5" x 7" card to the exam on which they have written any information they deem essential. The advantage of the legalized "crib-sheet" is that it forces the students to study, organize, and identify gaps in their understanding of concepts and capability to solve problems. I've found that open-book exams, by contrast, encourage poor preparation and a frantic riffling of pages in an effort to find answers that are usually not there.

Preparatory chemistry programs must be selective, necessarily. Even general freshman chemistry often smacks of being unrealistic when it attempts to cover the whole spectrum of topics commonly associated with general chemistry. Furthermore, we should constantly strive to weave-in anecdotal events from "real life" in an effort to help students conceptualize that which may be abstract in terms of their own limited experiences. If our experimental anecdotes and demonstrations are "relevant", so much the better.

REMEDIATION:

On the basis of their individual results, the students can identify their specific problems and remedy them by additional study. When the student has achieved a more solid mastery, he or she can arrange a re-test and demonstrate their improvement. The re-test opportunity has been a tremendously positive force in student learning. It makes the exam more truly a learning instrument as opposed to a mere grading device. The slower learner is not penalized in this way. I call this repetetive process "calculated redundancy".

In order to make the re-test a less time-consuming operation, I require the students to retake only those problem types that need improvement. Hence, a student who scores 80% may need to take only two problems of a type that were incorrectly done in the first exam.

The enormous improvement often shown by students on the re-test is gratifying to them and their teacher. I think we can teach a lot more chemistry outside the shadow of the guillotine. If we diminish tension, and the grim, humorless preoccupation the student tends to have toward grades, we are taking a giant step in the direction of humanizing our craft.

Grade consciousness can be diminished further, if we can justify to the students why they should expose themselves to the rigors of a particular scientific descipline. Most importantly, our rationale must include reasons quite apart from the practical necessity of science courses for students pointing toward a career in a science related profession. Pragmatic justification is really sine qua non, but justification in terms of moral and cultural values is the challenge to our imaginations.

One reason is that students, as citizens, have a responsibility to become literate in science. It is a concern for truth and accuracy (if not self-preservation) to be able to evaluate critically the claims made by scientific industries in popular magazines and newspapers. Perhaps, more importantly, scientific literacy can help our citizens cope with the exalted status of science often granted by people who have only a vague notion of what constitutes scientific activity. We need to learn about the historical forces at work in the theoretical-experimental interplay that led, and still leads us today, to meaningful scientific constructions. Structures that are aesthetically pleasing and useful to mankind. Structures that are unique insofar as much of the beauty inherent in them lie in their tentativ nature -- an amalgamation of hypotheses, theories, physical laws and bold assumptions. In effect, scientific literacy, in addition to providing the knowledge to make sensible decisions in the area of commerce and government, may enable us to distinguish between science and scientism.

There seem to be four outstanding areas of need for the remediation of basic skills: reading speed, reading comprehension, study habits, and mathematics. We have all seen examples of students reading at a junior high (or lower) level. They read slowly and comprehend with difficulty. The fact that they also must read and re-read for a number of hours that for exceeds our expectations creates a demoralizing condition -- if not a nearly impossible hurdle for them to leap. Students who read chemistry problems and fail to identify clearly what they are trying to solve and who are unable to organize the data available need help desparately.

Our college has a Learning Center equipped with the hardware and software designed to help these students. It is staffed with specialists in the field of reading and study. And we direct our students to these specialists. Periodically, free short courses in reading and study are provided and they are advertised. It seems to me that this is the only reasonable say to handle the problem. As long as we maintain an open-door admissions policy, the availability of reading and study specialists and programs are essential for students prior to, or concurrent with, preparatory courses. This not a redundant operation although it may seem to be so.

Remedial work in mathematics requires patience and reinforcement. The "new math" is an easy scapegoat when we choose to envision it as it was in its early days. But the "new math" is changing toward a more practical oreintation and we should agreeabley move toward a fuller cooperation with mathematics teachers. We cannot, and should not, expect them to function as servants to the sciences. Mathematics teachers are starting to realize, as Keith Laidler (University of Ottawa) says, that "Mathematics may be the Queen of the Sciences, but she should be prepared to mingle with her subjects".

In our effort to bridge the gap between pure and applied math, our remedial work could profitably concentrate on percentage calculations, graph construction and interpretation, basic algebraic operations, dimensional analysis, scientific notation, and the proper use of significant figures. I would suggest further that we emphasize the quantitative aspects of our laboratory exercises so that numerical data are constantly moved from the realm of the abstract to the concrete.

There is no magic method and there are no perfect tools. But if we are realistic and if we care, each of us operating in an environment of mutual respect, we can do the job. While we may not be preparing many or most of our students to be scientists, we can communicate an enthusiasm for intellectual pursuit, increase their scientific literacy, and pique their latent curiosity.

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Five years ago the authors organized and wrote curricular materials for an introductory college chemistry course to help students who were not motivated for college science, who had a poor knowledge of physical science and weak math skills but who chose a college major which required General College Chemistry. California State University Dominguez Hills is a commuter school with a very heterogeneous student body in Los Angeles.

Most of the students who take our General Chemistry course have had high school biology, chemistry, and at least two years of high school algebra but no physics, trigonometry or pre-calculus as indicated by a survey given to all entering Chemistry students. In spite of this, 60% of these students do not achieve more than 55% on a basic algebra/arithmetic/reasioning test. After talking with these students, it is clear that there are several valid reasions for these relatively low test scores.

1) Many students have had the necessary high school courses but not enough was required of the students in those courses, and the students believed that they would not need to retain the subject matter for their college work.
2) Many students had a good high school preparation but they have been out of school for at least ten years and have not used their math skills.

The students showed us the need and interest for some "remedial" work in our General Chemistry course because of the high attrition rate.

We carefully planned the Introductory course with the following emphasis:

1) review of basic math skills
2) exposure to some physical science principles in lecture and laboratory
3) exposure to some principles of chemistry in lecture and laboratory

A detailed outline of each component of the course follows:

REVIEW OF BASIC MATH SKILLS

The basic math skills useful for our General Chemistry course were agreed to be

1) fractions
2) scientific or exponential notation
3) percentage
4) logarithms
5) logarithmic evaluation
6) exponents and square roots
7) linear and literal equations and

8) quadratic equations

The texts for the mastery-learning review of math are:

"Programmed Reviews of Mathematics" By Flexer and Flexer published by Harper and Row, 1967. (This is now out of print but copies were places on reserve in the library)

and "Developing Skills in Algebra", 2nd edition by J.L. Nannery and J.L. Cable, Allyn and Bacon, 1976.

There are numerous programmed and modularized math review books currently available, and it is truly a buyers market. However, we found it necessary to write some additional modules on percentage because percentage is covered so poorly in the math review tests.

A lab room is open for at least ten hours per week and staffed with the course instructor and one student assistant for the purpose of tutoring and testing students. Ten different versions of ten-problem tests are available for each of the eight math review topics. Students can chose any math area for testing. A passing score of eight out of ten is required for each test. The tests are not multiple choice, and the students have to show all their work. If a student gets only five or less, he is told to leave the test room and to study the test for another day before being retested on the same math topic. However, he could choose a different topic for additional testing on the same day. If a student gets between five and seven, he is given another version of the test after some tutoring over concepts missed on the test. The instructor makes every effort to be consistent with algorithms, to motivate the students and to reduce anxieties as much as possible.

Detailed records are kept of each students' progress since students must pass at least three tests by the end of the third week of the class.

LECTURE

The lecture part of the course has the following schedule;

week	topic
1	fundamental concepts of math
2	movie - "Powers of Ten" significant figures dimensional analysis
3	Metric and American Systems of measure
4	density, specific gravity, percentage, functions and graphs graphs of linear relations (density, mass versus volume) (temperature, °F versus °C)
5	calculations involving heat
6	logarithms and pH

week	topic
7	movie - "Elements, Mixtures and Compounds''
	atoms, molecules and the periodic table
	movie - "Chemical Families"
	valence, writing formulas and naming compounds
8	writing and balancing chemical equations
	the mole method
9	percent composition
	empirical formulas and molecular formulas
10	stoichiometry

The text is "Chemical Problem-Solving by Dimensional Analysis", 2nd edition by A. Loebel, Houghton Mifflin Co., 1978. Since the text is programmed with little discussion of the periodic table and graphing techniques, detailed clear lectures are a must. However to keep students motivated and interested, active dialoging is a must, and had been found to work well.

Four exams are given during the quarter in weeks 2, 4, 6, 8, and 10. A comprehensive final exam is given at the end of the quarter.

The emphasis is on algorithmic approaches, especially the factor-label method, drill and dialoging. Also special topics like graphing and logarithms need lecture discussion as well as self-programmed reviews. By emphasizing the factor-label method, students can build up security and confidence to solve new problems in Chemistry.

The more formal concepts of atomic structure and chemical bonding are completely left out of this course. We feel it is more important to dwell on the development of math skills and physical science concepts and some descriptive chemical concepts. This approach is following in our General Chemistry course where we begin with the gas laws and stoichiometry before discussing atomic structure and bonding.

LABORATORY

The laboratory schedule is a follows:

week	exercise
1	check-in
	movie- "Piaget's Developmental Theory: Formal Thought", Five-Solution Problem
2	Equilibrium in the Balance
3	Mass, Volume and Density Measurements
4	Density by a Graphical Mithod
5	Temperature, Heat and Specific Heat
6	Changes of State, Freezing Point and Cooling Curve for p-dichlorobenzene
7	Classification and Properties of Matter
8	Solubility of Compounds
9	Elements and Atomic Masses

These exercises were selected because we feel they illustrate important concepts for beginning Chemistry student and can be used to develop students' reasoning through carefully worded questions during and at the end of each exercise. Such concepts as proportional reasoning, separation and control of variables, classification, correlation, seriation, reversibility and such skills as reading, language useage, clear and precise descriptions of observations, organization, graphing, weighing, volume measure, etc. can be developed.

A brief description of each exercise and some sample questions follows.

Five-Solution Problem:

Students are given five solutions, A, B, C, D, and E which they mix pair-wise and record observations for each pair. Typically there are precipitates of various color, size and shape as well as no reaction. The same five solutions are given as unknowns but scrambled and numbered 1, 2, 3, 4 and 5. Pair-wise mixing of the solutions and observations and correlations allow the students to match up the numbered and lettered solutions. Typically students are not careful enough with their descriptions to be complete and precise. Some students comments are:

"There was white precipitation along with a couple coagulations."

"A white precipitate went along with coagulation on the bottom and thin flake-like particles floating."

Often students can go no further than the observations and the correlation completely eludes them, or their descriptions are so confusing and incomplete a one to one correspondence between pairs of known and unknown solutions cannot be made.

Equilibrium In The Balance:

Using an equal arm balance and various masses, students determine whether the relation between masses and distances from the fulcrum point when the balance beam is horizontal are inversely or directly related. After struggling with their data, students cannot solve the exercise unless told to check for $\frac{M_1}{M_2} = \frac{D_1}{D_2}$ or $\frac{M_1}{M_2} = \frac{D_2}{D_1}$

After the exercise, students are led through discussions about how to tell whether a relation is direct or indirect given an equation relating the variables. Also the general properties of inverse and direct proportions are discussed.

Mass, Volume and Density Measure:

Three different objects are weighed on triple beam, centigram and top loading balances. The volumes on these three objects are determined by volume displacement, and water overflow as well as calculated from measured dimensions. Finally students calculate densities using the mass and volume quantities with the most significant figures and compare their results with the densities from specific grafity-water immersion determinations. Each measure is made several times and averaged.

Emphasis in this exercise is on measuring the same quantity several times and averaging the runs, significant figures, calculations of volumes of spheres, cones, frustrums, rectangular solids, and cubes, determining densities of irregular objects and on using density as an intensive property to identify substances.

Density By The Graphical Method:

Given a set of mass-volume data for a metal, students are asked to determine the density by the graphical method and to identify the metal. The questions with this exercise ask students to generate data tables, graphs and equations of lines, slopes, intercepts, etc. for the case where $100 is divided equally among different numbers of students. If P is the amount per student and Q the number of students, P versus Q is not linear, but P versus 1/Q is linear.

Temperature, Heat and Specific Heat:

This is the traditional calorimetry experiment in which the students determine the specific heat of a given metal. Students have to be careful to assign variables carefully to the metal and the water. Generally this is the most difficult exercise because of the concepts of heat and temperature and the difficulty in separating variables especially since the students are directed to calculate the specific heat as follows:

1) For each metal used, calculate the amount of heat absorbed by the water.
2) Give the amount of heat given up by the metal block.
3) Calculate the amount of heat released per gram of metal.
4) Calculate the specific heat of the metal.

Students confuse the temperature change with the temperature, the temperature change for the metal with the temperature change for the water, and often they can't even determine the temperature change for the metal since the initial temperature of the metal (100°C) is not explicitly stated.

Changes of State:

Students carefully heat up a beaker of ice to the boiling point of water and record the temperature of the beaker contents versus time and draw the heating curve for water. A thermometer immersed in molten para-dichlorobenzene allows for temperature and time measure so that the cooling curve and melting point of para-dichlorobenzene can be determined.

Students are asked to sketch the cooling curve for water, and ponder why the temperature of boiling water remains constant and why the temperature of the melting ice remains "constant".

Classification And Properties Of Matter:

Students learn the meaning of the terms: mater, substance, compound, element, mixture, physical change, chemical change, solid , liquid, gas, homogeneous, heterogeneous, physical property, chemical property, reversible, irreversible and the conservation laws. They then examine carefully and describe several mixtures, observe the effect of heat on substances and the solubility of a series of compounds in water as will as to use data tables to obtain specific information.

Some questions asked are:

1) A piece of silver and a piece of platinum are both shiny, silvery-white metals. What physical property could be used to distinguish easily silver from platinum?
2) Explain how it is possible to have a heterogeneous mixture and still have only one pure substance present. Give an example.
3) Explain how it is possible to have a homogeneous mixture of two different compounds. Give an example.

Students have trouble distinguishing when sulfur melts and burns and determining which is a physical and which is a chemical change. Language skills and observation skills are stressed.

Solubility Of Compounds:

The relationship between temperature and solubility for two substances, $K_2Cr_2O_7$ and KNO_3 are determined. Solubility is defined as the number of grams of solid that will dissolve in 100 grams of water. Since students begin with 10 ml of water, a given weight of salt, and add specified amounts of water to get the soubility data, it is a real challenge for them to use proportional reasioning to obtain the solubility of salt in each test solution.

The student decides whether the proportion between solubility and temperature is direct or inverse.

Elements And Atomic Mass:

The atomic mass of magnesium is determined from data obtained by heating magnesium turnings carefully in a covered crucible. From the data, students also determine combining weights, percent composition, empirical formulas, molecular formulas (given the gram-molecular weight) and the balanced equation for the reaction between magnesium and oxygen.

As a conclusion, our observation of the success rate and the outcome of students is reported.

Generally between 40% and 60% of the students who pass the Introduction to College Chemistry course go onto our General Chemistry course; 10% to 15% finish the full three quarters of the General Chemistry; and 2% to 5% finish the full year of organic chemistry which follows our General Chemistry.

Students from the Introductory course who have completed the following General Chemistry sequence are grateful for the second (or greater) chance to learn the basics of chemistry. Retesting with the placement test at the end of the Introductory course always shows marked improvement in the students' performance and the students are full of praise for the course structure and become confident in their other science and math courses as well.

The faculty see the improvement in the students and agree that the separation of students between the Introductory couse and the General course results in a better general course since the students with similar abilities are grouped together.

Finally the success of the Introductory course not only depends on the content, carefully chosen programmed materials, good overall organization, clearly defined goals and objectives but also on a faculty person who is patient and can motivate and encourage students to do their best. Also, we cannot overlook the positive benefits of having a highly motivated and verbal student in the class. This student often sets the pace for learning and understanding in the entire class.

RESEARCH IN THE TEACHING OF CHEMISTRY

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The teaching of general chemistry was a lot easier twenty-five years ago. At that time, chemists believed in a natural distribution of mental abilities and that only the more mentally facile students could have any hope of comprehending the formal logic of chemistry. This theory, as expounded by the chemist, Wallace R. Brode, excused the teachers from any responsibility for the students that failed their courses. This view, of course, had to be abandoned with the development of open-door admission policies in the drive to keep college classrooms filled. In order to justify letting anyone and everyone into college, we needed a new paradigm, one that allowed for the educability of all potential students. The learning mechanistic approaches of Gagne and Ausubel and the cognitive development theory of Piaget do not place any limitations on learning or mental development and have there fore been adopted as the model for the eighties.

It should be noted that the theory of Piaget has been adopted not because it demonstrated that all students are educable, but because it does not preclude their educability. There is, to our knowledge, no evidence to prove that all people can be taught to comprehend the type of formal logical reasoning that makes up a large part of a modern course in general chemistry. As scientists, the views of Brode seem to be more reasonable because we see distributions in all of the properties that we measure. With regards to people, we know for a fact that we cannot all become quarterbacks or long distance runners. If there is a distribution in our physical abilities, why not also a distribution in our mental abilities? Even if it is true that reasoning abilities follow a fixed pattern of development in all people, there is no evidence to justify the belief that all people are capable of attaining the highest level of reason ability. In fact, the statistics that have been collected in the past five years on the reasoning abilities of college students could be said to justify the conclusion that there is a natural distribution of reasoning abilities among people.

To make a long story short, we do not believe that there is yet an answer to the question of elitism versus egalitarianism in the teaching of chemistry. This means then, that the question why some students can, and others can't, do chemistry is still wide open for research. Only when our paradigms are founded upon empirical observations, and not fanciful speculations, can we hope to develop fruitful techniques for the teaching of general chemistry.

In our opinion, the direct contact between teachers of chemistry at two-year colleges and their students provides an excellent opportunity for these teachers to conduct research on the teaching of chemistry. The personal interaction that exists between the students and these experienced master teachers can lead to insights that are not as readily accessible in the large university teaching situation. Therefore, we would like to see teachers of chemistry at two-year colleges become more involved in getting the answers we all need to teach more effectively.

Over the past ten years at the University of Wisconsin Center at Waukesha we have conducted a number of studies and educational experiments in an attempt to find our why Johnny and Joanie can't do chemistry. Some of the studies were quite simple, others more complex, but in all cases we believe that we learned something that has helped to shape our current views on the teaching and the learning of chemistry. We prepared this paper for presentation today to share with, and get the reactions of, other teachers of chemistry to the results of our studies. I want to present these studies in a systematic manner and I am going to do this by presenting, for each study, a hypothesis, the test of the hypothesis, the results of the test, and the conclusion that we drew from the results.

1. Hypothesis: Students do poorly on examinations because they cannot remember all of the mathematical equations that we have in a modern general chemistry course. Test: Allow the students to provide themselves with one 3 x 5 card of any information they want for the examination. Result: The comparison of exam grades for different years and for different exams for the same class of students did not reveal any significant effect on the average exam grade. Conclusion: The memorization of mathematical equations is not the obstacle to learning chemistry. We should add that the greatest benefit to the use of 3 x 5 cards is that the teacher no longer has to proctor the exams with an eagle eye. As we see it, this procedure just extends to the honest students an exam aid that the dishonest students always had.

2. Hypothesis: Students do poorly on examinations because they do not know what to expect on the examinations. Test: Give copies of the previous years exam to the students as a study aid, and them give the exact same exam to them as their examination. Result: Well within a reasonable estimate of the possible grading difference, the exam results were the same for the two years in our general chemistry course. However, using this procedure in quantitative analysis, the average grade went from 74 to 95. Conclusion: Knowing what to expect on examinations is not the obstacle to learning general chemistry, but a lack of motivation

may be the obstacle.

3. Hypothesis: The accomplishments of students are independent of the test vehicle used to measure their accomplishments. Test: For two exams, one semester, complete multiple choice exams were given rather than the usual exams which contain about 60 per cent subjective numberical problem questions and the remainder multiple choice questions. The multiple choice questions are graded either correct or incorrect whereas partial credit is given in the grading of the more lengthly numerical problem questions. Result: The average exam grade dropped about 30 points in using only multiple choice questions. Conclusion: The lack of partial credit in trading was responsible for the dramatic drop in grades since subsequent exams again resulted in the normal average grades. Further, the instructor must give serious consideration to the nature of his exams and their evaluation relative to his philosophy and objectives for the course. We prefer to give exams that result directly in an acceptable grade distribution rather than to demoralize students with exams that result in low averages which are then curved to get a reasonable grade distribution. The latter process does not have the nice neat relationship to the level of mastery of the material that the former process has.

4. Hypothesis: Students do poorly in general chemistry because they have not yet developed sufficiently mentally to handle the formal logical reasoning of chemistry. Test: Give the students a paper and pencil Piagetian test of their stages of cognitive development. Result: All of the students tested were found to be either formal operational or in the transitional stage between concrete operational and formal operational. Conclusion: The students in our course have developed sufficiently mentally to cope with the formal reasoning of chemistry.

5. Hypothesis: So much is expected of students in general chemistry in so short a period of time that it is impossible for all but the especially talented to be successful. Test: Set up an almost guaranteed work and pass system so that students willing to work can achieve at least a D in the course. Out of a total of 1000 points for the semester, 200 were given for turning in the homework on which they could get all the help they needed. 200 were given for the laboratory reports on which they could get all the help they needed, 60 points were given for just turning in a two page theme on some personally relevant aspect of chemistry, 20 points for the completion of a gackground survey, and 20 points for paying a visit to the instructor in his office and asking any kind of question about the course. Thus, a student willing to work could get 500 points and needed only 100 more out of the 500 on exams to get a D, 200 more to get a C, etc. Result: With this system we had more drops and failures, especially failures, than before or after the use of this system. Conclusion: The inability to cope with the course is not what prevents students from succeeding in the study of chemistry.

6. Hypothesis: Students do poorly in chemistry when they are not sufficiently motivated to attend classes. Test: Keep records of attendance in the discussion sections. Results: Students that drop or fail have very poor attendance records

whereas most A students never miss even one class. Conclusion: Poorly motivated students do poorly in the study of chemistry.

7. Hypothesis: Students do poorly in chemistry because they either do not study sufficiently or have poor study habits. Test: Analyze chemistry exams for the degree of success in pure memorization questions versus the degree of success in problems that require more advanced cognitive processes such as application, analysis, and synthesis. Result: A very strong correlation was found between the grades on pure memorization questions and the grades for questions that involved higher cognitive skills. Conclusion: The students are failing in the processes they use to study and learn the basic concepts of chemistry, and failing this, cannot use the concepts in more mentally advanced problems.

8. Hypothesis: Failure to memorize and understand the basic concepts and other fundamental information is the cause of doing poorly on chemistry examinations. Test: To tabulate student results for all questions on all examinations for a semester and to analyze the results in terms of the nature of the questions. Results: Students did the poorest job on questions that required them to memorize a number of isolated chemical facts or reactions or on problems that required the memorization of a body of facts or information which they then had to use in an analysis or synthesis cognitive operation. Students on the average got the highest marks for problems that involved the straight forward application of principles or on what we call, one step numerical problems. If students can recognize a problem as a simple filling in of numbers in one particular mathematical equation, them they do very will. Conclusion: Many students are failing to memorize the basic concepts and procedures of chemistry, and of those that do memorize them, some students see them only as isolated facts and do not see their relationship to the total structure of chemistry. This inability to study and to memorize in a meaningful way prevents them from working problems in which they have to integrate and correlate rules or procedures with bodies of chemical information.

9. Hypothesis: There are some students in our course that need an even greater challenge than is offered by our general chemistry course. Test: Set up an honor's program for honors credit in which the students are given a number of more difficult problem assignments to complete. Result: Approximately 5 per cent of the students sign up for the honors credit. Conclusion: The use of additional honors work provides a means of teaching general chemistry to students of widely varying abilities and, at the same time, providing sufficient challenge to the best students.

10. Hypothesis: Students are aware of the nature of their problems and are a useful source of information in solving the problems. Test: A survey on the system and attitudes of the students was conducted towards the end of the semester in which we make the study of the work and pass system. Results: An overwhelming majority of the students were in favor of the system as it was and saw no need for any changes in the system. Conclusion: The system was similar to procedures used in the high schools and lulled the students into believing that the same lax standards would be applied as in high school. The majority of

the students were not aware of the failure of the system to motivate them into satisfactory levels of achievement.

11. Hypothesis: When an examination covers many different kinds of numerical problems, students are unable to cope with the situation and do poorly on the examination. Test: In the last quarter of the second semester of general chemistry only one type of numerical problem was presented. Students were advised that a numerical problem would appear on the fourth hour examination. Result: Essentially all of the students solved the problem correctly. Only two out of 75 students were not motivated sufficiently to learn how to solve the problem. Conclusion: The study procedures employed by most students do not equip them with a sound enough grasp of basic concepts to allow them to recognize problem types and to recall the solution procedures when a large variety of problem types has been presented to them. This could be the result of a lack of motivation since proper study methods involve very hard work.

12. Hypothesis: Motivation is the primary factor in the attainment of success in the study of chemistry. Test: Compare completion statistics for two different modes of teaching our Chemistry 100 course, a short introductory, that is, remedial, course in chemistry. One teaching method consist of three hours of discussion per week and the other is the audio-tutorial program of Paul Santiago, in which the students are basically on their own to pursue the program. Result: All of the students that start the discussion course complete the course since all they have to do is show up for class three times a seek. For the A-T program, the completion figures have varied from 7 to 50%. Conclusion: The discussion program allows a student to get credit just by showing up for class. The A-T program requires them to do some work. Since no exams are given and since the students can get help as required, success in the A-T program means to do the work. Because doing the work requires a degree of motivation, it seems to us that we have a direct correlation between success and motivation.

Now, any chemistry professor worth his or her sodium chloride, should be able to take the results of each of our studies and come up with at least seven other conclusions. Nevertheless, what strikes us, is that all of our data can be explained in terms of a lack of motivation on the part of the students. Recent developments at the high school level make it particularly difficult to motivate beginning freshman students in general chemistry. They all know that all you have to do is show up for class and as a result of the curve you are sure to pass the course. The elimination of entrance requirements to get into college has done little to motivate high school teachers to maintain high standards.

We are in the process of making a study of what is being done around the country to motivate chemistry students. The next hypothesis we hope to test is that we can salvage some students by the incorporation of known motivational techniques into our teaching. We trust that these will be successful and plan to report our results upon completion of these studies. If you don't hear from us again then you can safely assume that we failed the test. Thank you.

CONSUMER CHEMISTRY

Chemistry in Everyday Life

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Presented to a Session on Inavation in Chemistry Instruction at the Seventieth, Two-Year College Chemistry Conference, Atlanta Junior College, Atlanta, Georgia, March 28, 1981.

Newspaper headlines, editorials, as well as cartoons constantly bombard the general public with fact, opinion and fiction about science. Chemistry, the science which studies matter and the changes it undergoes, becomes an important area of study in order to understand the vast amount of material that is presented. There has also been an increase in the number of science magazines designed for the reader who has a little background in science. Examples include Omni and Science 81.

Chemistry, a science in which mathematics plays an important role, is largely avoided by the student who is not majoring in science. These student tend to enroll in a biological science course so that lack of a mathematics background will not hinder the learning process.[1]

Valencia Community College has an open door policy which allows students over 18 years of age to enroll with or without a high school diploma and those under 18 years of age to enroll with a high school diploma, a high school equivalency diploma or with early admission - dual enrollment status. Therefore, the mathematics background varies tremendously from student to student.

To accommodate the students who did not have the mathematics background for even an introductory chemistry course, a chemistry course for non-science majors was developed. The course, Chemistry in Everyday Life, is designed to present some of the basic concepts in the fields of inorganic, organic, and biochemistry so that students may gain a background in order to "analyze, discuss, and make decisions on chemically related problems that affect everyday life".[2] Only basic arithmetic skills are necessary for success.

Chemistry in Everyday Life was developed during the 77-78 school year and was put on the schedule for the fall semester in 78-79. The enrollment for that first offering was a grand total of four students. Needless to say, the course was cancelled. Faced with an enrollment problem, the chemistry teachers decided to fill the class in the winter term. We had to face several problems. First, students tend to fear the word chemistry. Second, students always like to know just what is expected of them in a course, and there were no students to pass along this information. Third, the students needed to know that the course existed. (It was not included in the catalog descriptions for that year.)

We tried a new approach for recruitment. We went directly to the students and ran five minute "commercials". The students we contacted were those who were enrolled in the biological science courses designed for non-science majors. With the permission of the course instructors, we presented the ideas of the new chemistry course with the aid of overheads and handouts as well as a question - answer period. As a measure of the success of our program, the class filled to a maximum of thirty-five students for our second semester. We have not had to recruit students since that first time possibly because the students now have the student to student network established to answer questions concerning the course.

Once we had students enrolled, the success or failure of the course really depended on maintaining the interest of the students. This is not a required course so student demand keeps it going. What should the content of such a course be?

Basic concepts of chemistry including periodic properties, nuclear structure, kinetic molecular theory, acid-base theory, nuclear reactions, kinetics, and electronic structure are presented throughout the course. Some of these topics are developed at the beginning of the course, while others are developed throughout applications of chemistry to such areas as drugs, food, and evergy.

Since this is a course designed for students other than science majors, I developed a course outline that allows students to make use of their other talent and skills. Along with testing, students must complete a project during the semester. For the current year the Projects that were suggested were:

<u>Project 1</u>: Write <u>3</u> well-researched "letters to the editor" to inform citizens of your opinion on a present day issue concerning chemistry in their everyday lives. (Each letter should be about 1 page.) Mention any reference material in the body of your letter. Include a separate sheet which lists your complete bibliography.

<u>Project 2</u>: Conduct an in-depth survey on a controversial topic concerning one of the topics in our course. Contact at least 10 people of as widely-varying backgrounds as possible. Include in your report about one page of background material (with a bibliography), the survey topic, the responses of your contacts, and any conclusions you may have reached.

<u>Project 3</u>: Pick one of the topics covered in your textbook and develop a collection of articles, cartoons, TV show summaries, etc., which are concerned with the topic. Try to get started early in the semester on this so you can keep an eye out for current material. Evaluate your collection either individually or as a whole as to their validity as factual information. Your evaluation should be at least one page in length.

If students were interested in completing another type of project (other than a term paper) permission was obtained from the instructor.[3]

To keep the student interest high, several techniques are used. The easiest one to employ is to keep abreast of current topics of interest to the general public. The first year this course was offered, both the Three Mile Island incident and the release of the film "The China Syndrome" occurred about the time the class was discussing nuclear fission. Publicity about toxic waste disposal, acid rain, and food additives allow for interesting and informative discussions.

Another method is to allow students to observe directly just what happens when chemical reactions occur. Use is made of hands-on materials developed by Marion Baker of Valencia Community College to illustrate chemical properties and reactions during the class lecture. The overhead is used frequently to demonstrate such topics as kinetics, surface tension, solution and acid-base titration. The students also make use of the chemistry laboratory facilities to analyze a hot dog,[4] prepare polymers, test for carbohydrates (starch) and protein, and to prepare esters and identify their odors.

A third method to keep student interest high is to present a chemistry "magic trick" approximately one every two weeks. These are not explained but observations are encouraged and questions are answered. Directions for many of the "magic tricks" I use are found in Entertaining and Educational Chemical Demonstrations by Philip S. Chen.[5] Many of the color change reactions are excellent as are the combustion reactions.

To encourage the students to make value judgements based on facts, I use both small group and large group discussion methods. A nonthreatening atmosphere is important for open discussion. Many topics including drugs, diet, natural foods, food additives, and nuclear reactors bring new information to the students as well as perhaps eliminating some "old wives tales". My knowledge is constantly updated as I research questions that students have asked. I try to act as a moderator during discussions, presenting facts as they are needed or requested. I try to refrain from imposing my "feelings" on the students although I may express them.

One technique that I use for small group discussion is to present them with a short story (written by the instructor). The story contains several characters involved in a situation concerned with chemistry and with moral judgements. The students are asked to work through at least one exercise with the story. Often they start by listing the characters in order of increasing dislike for the characters. They must give reasons for listing the characters as they do.

The course has maintained on the average about 30 students per class each semester. On the whole student reaction seems positive. Some of the comments on student evaluations from past semsters are:

1. "Excellent course for filling science requirement."
2. "I feel I learned a lot about chemistry and how it affects our lives in everyday situations."
3. "Things covered in this course were applicable and useful."
4. "It is a great course for non chemistry or science majors."
5. "I really liked this course but some stuff was difficult."[6]

Several students have gone on to take more chemistry including introductory chemistry and general chemistry. They have all received grades ranging from A to C with no failures.

Chemistry in Everyday Life removes some of the mystique surrounding chemistry so that students may learn enough factual information to make educated judgements in buying products, voting for issues or candidates, as well as evaluating articles presented in the popular press.

Chemistry, indeed, has a definite place in general education and should be made available to as many people as possible.

Footnotes

[1] During Session II, (1980-81) at the East Campus of Valencia Community College, six sections of non-science major biology were filled compared to one section of non-science major chemistry.

[2] Valencia Community College 1980-81 Catalog.

[3] CHM 1020 Course Outline and Syllabus (Jones).

[4] Eby, Denise and Tatum, Roger, "The Chemistry of Food Additives", A Consumer Chemistry Learning Activity Package," 1st ed., Unigraph, Seattle, Washington, 1977, pp. 18-20.

[5] Chen, Philip S., "Entertaining and Educational Chemical Demonstrations, 2nd printing, Chemical Elements Publishing Co., Camarillo, California.

[6] Anonymous contributions from Valencia Community College Student Evaluation of Instruction.

Applications of Chemistry Principles to Consumer Problems

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Chemistry and Baseball

Last year a journeyman baseball player was interviewed in the St. Paul Pioneer Press. "I went to (name deleted) to get a college degree but all I got was a baseball degree," he said. "Having to study Shakespeare and the rest of those literary figures wasn't going to help my batting average. The same with chemistry. What's chemistry going to do for you in life unless you're a chemist?"

The purpose of this paper is to explain to this young man -- and to everyone else -- that chemistry is indeed important to baseball players -- and to all who would be informed consumers and responsible citizens. I'd like to tell the baseball player about the chemistry of the rosin he uses for a better grip on the bat, about the chemistry of leathermaking form glove and ball cover, about the elastomers in the ball, the synthetic fibers in his uniform, and the plastic in his helmet. I'd like to tell him how a knowledge of chemistry could help him understand good nutrition and help him avoid the pitfalls of alcohol and drugs that have cut short many a promising career. I'd like to tell him how biochemistry could help him understand the physiology of exercise. In short, I'd like to get this young man in my chemistry class and teach him all this and much more. Perhaps after his short career is over, he would be willing to listen. For now, though, let's look at some principles and applications that are -- or ought to be -- of interest to everyone.

The Law of Conservation of Matter

Consider as a first example the law of conservation of matter. Nearly any general chemistry student can correctly state the law in one form or another. A few of the enlightened students will realize that this law is the basis for stoichiometry. Atoms are conserved; the law is well established and widely known, yet we hear scientists and engineers talk about getting rid of wastes as if matter simply could be obliterated. It can't; certainly not in meaningful amounts. If we have a waste -- chemical or nuclear or agricultural or whatever -- there are only three places to put it -- in the air, the water, or the land.

Matter can't be destroyed, but it *can* be changed from one form to another. That's what chemistry *is* about -- transformations of matter. It is possible to change matter, in some cases, to less harmful form. For example, we don't have to dump polychlorinated biphenyls on the ground or into the waters. We can incinerate them. Properly done, this transforms the PCBs into carbon dioxide, water, and hydrogen chloride. These are presumably less harmful forms of matter -- unless you live downwind, in which case you might wonder about the HCl.

Mercury is an element. If is toxic as the free metal and in all soluble combined forms. For years we thought mercury in the environment was no problem; it would be converted by nature to insoluble, harmless mercury (II) sulfide. Then we learned that certain bacteria can convert mercury compounds to extremely toxic methylmercury which is readily taken up by organisms. Chemists aren't the only organisms that can carry out chemical conversion.

Atoms are conserved. Present day detergents are biodegradable. Degradable to what? They don't degrade to nothingness. Matter is conserved. Barry Commoner claims that degradation leads to toxic phenols. I don't know whether or not that is true. The situation does lend credence to the old adage, "Out of sight, out of mind". Our rivers don't foam, so we have "solved" the detergent problem.

Entropy: The Second Law of Thermodynamics

If atoms are conserved, how can we ever run out of an element? How, for instance, can we ever run out of copper? The answer is that we won't run out. There will be very nearly the same number of copper atoms aboard Planet Earth a thousand years from now as there are today. However, we may have spread those copper atoms so widely in the environment that it will be too expensive to gather them again to useful concentrations.

Every consumer is affected by inflation. Why does copper always get more expensive? (There are periodic ups and downs in prices, but the general trend is always up). One pressure for inflation is that as resources get scarcer, we must obtain them from lower grade ores or from more distant areas. When Europeans first came to North America, there were areas where one could pick up nuggets of pure native copper. This copper was sufficient for the Indians to make implements and ornaments. Now we mine the tailings of former mines for their 0.5% copper content. It takes a lot of energy to get copper out of low grade ore, and it causes a lot of pollution. The pollution can be controlled, but that takes energy and materials. You can't get something for nothing. What can you do? You can look for a more efficient process. There is now a method for extracting copper from ore by using a chelating agent. This method presumably uses less energy than roasting the ore, and the formation of sulfur dioxide is avoided.

Even at the high school level -- or earlier -- we can introduce the concept of entropy as scattering. Scattering is spontaneous; it is easy to pollute. Just dump some PCBs anywhere. The material will scatter over the ground and wash into the rivers. Then let's see you get it out. Gathering requires evergy. Let a pollutant get scattered widely enough, and all the Queen's scientists can't get it back together again.

Let's talk about gold. At $25 or $30 a gram, it might be worthy of our consideration. Low entropy -- unscattered -- gold is useful, for jewelry and electronics, and money. High entropy -- widely scattered -- gold is useless. From time to time we hear about a scheme to extract gold from the sea. The energy cost -- or, alternatively, the time that it would take -- is prohibitive. And it will always be that way, unless energy becomes so very cheap that its cost is negligible.

There are more elegant, more mathematical, ways to treat entropy, but not at the introductory level. A qualitative approach, as outlined here, can be enormously useful to our students. And the simple but powerful concept of the conservation of matter, if properly applied, leads to a better understanding of recycling, pollution, concentration of ores and minerals, and many other contemporary problems.

Conservation of Energy: The First Law of Thermodynamics

Another important principle with interesting applications is the law of conservation of energy. If energy is conserved, why do we have an energy crisis? Energy is conserved, all right, but it can be changed from one form to another. In any spontaneous change, the energy winds up in a less useful form. And in every change some of the energy is lost as heat. Again, a simple yet powerful natural law has enormous practical applications. It places considerable restraint on what we can do to "solve the energy crisis". To convert coal to (more convenient) gaseous or liquid fuels requires that we forfeit a part of the energy of the coal. To use electricity to produce hydrogen for use as a fuel requires that we forfeit a part of the electrical energy as waste heat. And we have already surrendered a major part (ca. 60%) of the energy of the coal or uranium that we used to generate the electricity. We frequently hear scientists propose hydrogen as the fuel of the future, often without seriously considering where the energy will come from to produce the hydrogen. I'm sure those scientists know the laws of thermodynamics; they just don't seem to realize that they have practical application.

The law of conservation of energy is also of interest to those who diet to lose weight. Energy is conserved. There are dozens of books with "magic" methods for losing weight. (Money is also conserved: Dollars gained by the quacks equals dollars lost by the suckers). All weight-loss diets work if (and only if) the caloric intake is reduced to less than the calories used up.

Is exercise a good way to lose weight? Consider taking off a kilogram of fat.

$$1 \text{ kg fat} = 32{,}000 \text{ kJ}$$

Let's do it by running. Running at a moderate pace (about 5min/km) expends energy at a rate of about 400 kJ/km. How far would we have to run to burn off a kilogram of fat?

$$32{,}000 \text{ kJ} \times \frac{1 \text{ km}}{400 \text{ kJ}} = 80 \text{ km}$$

That's about two marathons! And without any food taken in! And yet you read advertisements of diets that promise a loss of a kilogram a day or more. Any such loss must be water loss. Even a combination of starvation and <u>vigorous</u> exercise can't take off more than about 0.5 kg per day. And most physicians recommend a loss rate of no more than 1 kg/week. Exercise does help, but it is quite slow.

How does dieting work? Induce an energy deficit and the body uses stored energy -- fat. Say your normal diet is about 10,000 kJ/day. You go on a weight loss diet of about 6000 kJ/day. That induces a deficit of 4000 kJ/day.

$$\frac{32{,}000 \text{ kJ}}{1 \text{ kg fat}} \times \frac{1 \text{ day}}{4000 \text{ kJ}} = 8 \text{ days/ } 1 \text{ kg fat}$$

That's about the right rate. Energy is conserved. If we take in more food energy than we expend, our bodies store the excess as fat. No amount of wishful thinking or advertising hyperbole can change the law of conservation of energy.

The Law of Constant Composition

Another law of considerable importance is that of constant composition and some of its corollaries. Upon electrolysis, water always forms two parts by volume of hydrogen and one of oxygen. But the law of constant composition is more than just the basis for chemical formulas. Compounds also have constant properties. Water is always wet. Pure water freezes at 273 K and boils at 373 K (under 1 atm of pressure). You can put a little carbon dioxide and a few minerals in it and call it Perrier's and sell it for a lot of dollars. You can put other substances in it, but the basic stuff is still water.

Organic Chemistry: Structure/Property Relationships

A given composition and structure define a set of properties. Nitrate ions have certain properties. We could discuss its oxidizing potential, solubility parameters, etc. We could discuss its role as a plant nutrient. It matters not whether nitrate ions come from a chemical factory or cow manure. The formula NO_3^- not only designates a certain composition, if also represents a set of properties. These properties are as invariant as the composition. Structure/property relationships are perhaps moss evident in organic chemistry. Vitamin C is ascorbic acid, a chemical compound. Its properties do not depend on its source, advertising claims, or our wishes. Aspirin is acetylsalicylic acid. It has a nice set of desirable properties -- antipyretic, analgesic, anti-inflammatory, and anticoagulant -- and some that are undesirable -- it promotes bleeding and causes allergic reactions in some people. The desirable and undesirable properties are inseparable. Indeed, the anticoagulant action may be desirable -- it may decrease the chance of a second stroke or heart attack -- or undesirable -- promoting bleeding from a wound or aggravating an ulcer -- depending on the circumstances. In more basic terms, knowing that aspirin is aspirin can save the consumer a lot of money.

Reproducibility of Evidence

Another principle is that of the reproducibility of evidence, a cornerstone of experimental science. Anyone in the worldwide scientific community can demonstrate the properties of water or aspirin or vitamin C. What about Laetrile, the supposed anticancer drug. Ernst Krebs, Sr., patented a substance with the molecular formula $C_{14}H_{15}NO_7$ as Laetrile in 1958 (British patent no. 788,855). The claim was make that the substance selectively released cyanide in cancer cells, killing the cancerous grouth. No one has ever been able to make Laetrile by the method described in Krebs' patent. The stuff sold today has the molecular formula $C_{20}H_{27}NO_{11}$ and is properly called amygdalin. Further, it releases cyanide in the liver and not preferentially in cancer cells. So much for reproducibility. The warning signals of quackery ought to be clear to any chemist -- even to an introductory chemistry student.

Summary and Conclusions

These are but a few of the applications of chemical principles to consumer problems. I'm sure you can think of many others. I believe we must include such applications in all our courses, even those for science students, in order to make the subject meaningful. Chemistry might not improve that baseball player's batting average -- although the possibility exists that it could -- but it will certainly improve his quality of life and make him a better informed citizen.

In summary, we can gain a lot by teaching our students, by using a few examples, how to apply important chemical principles to their everyday lives. (That students generally have difficulty applying principles is evident on nearly every examination; they learn best by practicing applications). We can show them that chemistry is not just an abstract science that serves as a hurdle to be cleared on the way to graduation. Rather, chemistry serves not only as enriching cultural experience which can be pursued for pure enjoyment, but also as a practical preparation for life.

TEACHING SECOND YEAR CHEMISTRY

A Philosophy of Teaching Organic Chemistry

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1. Our full-year organic chemistry course should meet the needs and stimulate the interest of all the students who take it. We can do this by providing early and frequent examples of the applications of organic chemistry to biology, medicine, biochemistry, and to chemical industry. If we choose them with care our examples will not only stimulate interest, but they can also help teach the fundamentals of the subject as well.
2. Our approach to the subject should be unified and logical. My own experience has shown me that an organization based on functional groups, rather than reaction types, is the one that beginning students find nost accessible. One major disadvantage of the traditional functional group approach to organic chemistry, however, is that too much of the first part of the course is devoted to the chemistry of hydrocarbons. The chemistry of the biologically (and industrially) important functional groups is delayed.
3. A way around this problem is to give an early presentation of all of the important functional groups. By doing this we can give our students a brief overview of what is yet to come. We can bring in, as examples, simple but interesting molecules from ecology or industry. We can introduce some of the rudiments of nomenclature, and if we want, we can also present examples of the basic reaction types. All of this will make what follows in the course much broader, more logical, and more interesting.
4. What we do early in the course is most important. One thing we must do is pay special attention to the language of the science. We must carefully define and illustrate each new term when it is first presented. We must also develop a coherent internal order out of the basic concepts so that, as our students progress from chapter to chapter, they will be able apply the knowledge they have gained to new situations. We should also resist the temptation to devote the first portion of our course entirely to the structures of organic molecules by treating spectroscopy and stereochemistry in the first few weeks. Our students need time to become familiar with the structures and conformations of molecules first. They need to get their feet solidly on the ground before they

can tackle these more difficult topics.
Also, devoting the first portion of the course to structures neglects the true magic of chemistry - the chemical reaction. Of course, in organic chemistry we understand reactivity by relating it to the structures of moles, but as much as possible, however, I think we should integrate these two aspects for our students. They should see structure and reactivity side-by-side, not structure first and reactions later.

5. We can make early and effective use of cyclic molecules in illustrating the stereochemical consequences of chemical reactions. Some of the most basic ideas of stereochemistry are beautifully and simply demonstrated when we use a cyclic molecule to illustrate the reaction. Consider the S_N2 reaction, for example. Traditionally, we have delayed discussion of this reaction until we have given our students a rigorous treatment of molecular chirality, optical activity, R- and S- designations and the like. The reason: we want to be able to show that when an S_N2 reaction takes place, an inversion of configuration takes place at the carbon that is the focus of the nucleophilic attack. However, if we introduce cyclic molecules early, we can illustrate this idea in a very simple way. We simply show, for example, that when <u>trans</u>-3-methylcyclopentyl bromide undergoes an S_N2 reaction the product is a <u>cis</u>-cyclopentyl derivative. There is no need at this point for relating configurations, for R-,S-, for (+)-, (–), etc. All of this can come later, as reinforcement of our ideas, after our rigorous introduction to stereochemistry is complete. Other important reactions where the use of cyclic molecules simplifies the introductory treatment are syn and anti additions. With cyclopentene, for example, a syn addition yield a <u>cis</u> (or Z) product. An anti addition yields a <u>trans</u>-(or E) product. This is so much simpler as a first exposure, than showing that cis-2-butene yields a meso compound when it is subjected to syn-hydroxylation, but that it yields a racemate when it is subjected to anti-hydroxylation. We can show this later, but not as first.
6. We must also give our students some insight into how we know what we know about chemistry - about how we formulate our theories from experimental results. We cannot teach our subject as though it were dogma. To do this would no doubt make our courses simpler but it would do our students a serious disservice.
7. We must get our students to work problems and many of them. The problems we give them should provide ample opportunities for drill and review but some of them use be challenging problems that will give them the opportunity to reason and think.
8. We must limit what we attempt to do in the first year. We cannot teach our beginning students everyting that we know about organic chemistry. I would rather my students understand a few basic principles thoroughly, than have them c casually and perhaps eroneously acquainted with a multitude of somewhat esoteric topics. At the same time we should

find ways for our brighter students to go beyond the limits of basic course as their interests lead them. In my book I have provided a series of special topics as one method for accomplishing this.

9. Finally, I think we must take our teaching very seriously. The opportunity to make truly significant contributions to our field by discovery in research is not given to many of us. In any given decade the number of momentous discoveries are few. With our students, if we teach them well and inspire them, we have the opportunity to multiply our odds significantly.

The Use of a Microprocessor-Controlled, Video Output Atomic Absorption Spectrometer as an Educational Tool in a Two—Year Technical Curriculum

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Analysis for metals by atomic absorption spectroscopy is a techmique which is becoming more and more ubiquitous in environmental and technical fields. It is increasingly necessary in technical education to teach students how to use the atomic absorption spectrophotometer (AA). This trend brings to mind several questions about educating and training students in the use of AA. At Charles County Community College, CHE 255, Instrumental Analysis, teaches the basic principles and operation of several instruments, including the AA. The class is usually comprised totally of students in either the Pollution Abatement Technology program which deals with water and wastewater treatment, or Estuarine Resource Technology which deals with natural water body ecology. Both two-year degree programs require the course.

In order to plan a successful program dealing with AA, it is first necessary for educators to pinpoint the specific goals at which they will aim in any course covering AA. It is obvious that the student who is well-prepared for work as an analyst will be versed in AA, and that this training will include some practice in the use of an AA, as well as a basic understanding of the physical and chemical principles behind AA. In an attempt to satisfy these two goals, it is useful to choose an instrument which will afford students the opportunity to gain competence in the use of the AA, as well as one which will satisfactorily show students the theory on which atomic absorption spectroscopy is based. The instrument should afford the student fast and easy access to the skills and principles which are desired for him/her to gain. At Charles County Community College, a microprocessor-controlled, Instrumentation Laboratories (IL) Model 551 AA with a video output is used for training in AA. This instrument has many attributes which suit it well to the purpose of instruction in AA in a two-year technical curriculum.

In order to consider the positive educational aspects of the use of a microprocessor-controlled AA, the procedures involved in student use of the two types of AA must be considered, in order to identify several differences which surface when use is made of this type of instrument.

In the use of both types of AA, there are several steps involved. These include instrument set-up and electrical "zeroing," running of standards for the calibration curve, calibration, and sample measurement. Consideration of each of these steps individually allows for evaluation of each one's efficiency in achieving the goals mentioned above.

The instrumental set-up and electrical zeroing are valuable procedures, both in terms of skills gained and understanding of the principles of operation of the AA. The choice of the proper wavelength is necessary and instructional, but access to the data involves consultation of a table, and flame conditions, bandwidth, and other parameters must also be found in a reference source. Setting zero frequently involves "fiddling" with knobs for some time, especially at a very high gain where the adjustment controls are very sensitive or when the signal is noisy. When a microprocessor with video output is part of the system, the analysis conditions may be permanently stored, allowing immediate recall and display. Microprocessor-controlled AA instruments frequently have one controlwhich will automatically assign an absorbance value (ABS) of zero to a "blank" standard. Both of these features serve to eliminate time spent on the initial set-up of the AA. This time can be spent more profitably in actual operation of the instrument, rather than in time spent doing tedious mechanical tasks.

The procedure of running calibration standards, in order to generate a calbration curve, is central in both attainment of skills and understanding of AA analysis. In any AA analysis done in the future by the student, calibration standards will be run, and the assumption of a smooth, continuous calibration curve is the basic tent in the theory of AA. When an AA without a Microprocessor is used, absorbance readings must be observed, whether from a digital readout or a dial, and a guess at the average value must be made. This can be very problematic with noisy signals, or at low analyte concentrations. When a microprocessor is used, the instrument can read the ABS at specified time intervals, and display it, along with the current average ABS value, on the ABS readout. When the average value becomes constant, the student may be secure in the belief that the true average has been obtained. The microprocessor option also allows for instantaneous statistical analysis and display of standard deviation and RMS for the average ABS value so obtained. This can give the instrument operator a quantitative indication of the precision of the result.

During the calibration procedure, the microprocessor-controlled AA equipped with a video display can display a table of the calibration curve data entered up to that point with standard concentration and ABS value, or it can exhibit a cartesian coordinate plot ot the data entered to that point. This allows the student to actually see the calibration curve constructed and to spot any potentially bad data. Any points that seem to be questionable can then be remeasured and reentered with the new ABS reading. This obviates the need to consider poorly entered or read data as a source of student error.

After all standards have been run, and sufficient data is obtained for construction of a calibration curve, the microprocessor equipped with a video output can calulate the best fit curve to the data in seconds and display the resulting curve. In order to command the execution of this curve calculation and plotting, the student need only press one button. If an inflection point occurs in the curve, the calculation does not proceed and "FLEX CURVE" is displayed on the video screen. If this occurs, the student can again examine the data used and correct any bad entries, or evaluate the concentration range of the standards. After this, depression of one button then allows immediate calculation and display of the calibration curve generated by the new data.

The use of the microprocessor-controlled AA with video output in routine operation, contrasted with that of a "conventional" AA, shows that it is more efficient at presentation of material which students should retain. The principles of AA and requisite skills for routine use of the instrument are demonstrated in a short time period with a minimal amount of distraction of the students' attention to mechanical manipulations. These mechanical manipulations are simple enough so that if they are required in the future, they will be easily mastered. Omission of these tasks allows the students to more clearly focus attention of the important aspects of AA in the limited time allowed for study.

The sample measurement in a microprocessor-controlled AA is performed after generation of the calibration curve, and the answer is given in concentration units with standard deviation values, if desired. In AA instruments without microprocessors, the sample measurement is usually done before the student plots (or calculates) the "best fit" calibration curve. With the microprocessor's immediate feedback on the calibration curve, the student has the simple and convenient option of remeasurement of some standards in an attempt for more precision. If the student can actually see the calibration curve before the sample measurement, the process becomes more meaningful.

Aside from deleting many obfuscating tasks and focusing the student's attention on the central aspects of AA, the microprocessor-controlled AA equipped with a video screen for output can be modified slightly to become an extremely powerful educational tool by tapping the leads to the screen for videotape recording. This allows a direct recording of exactly what the student will see on the screen in the process of an analysis. Use of the videotape by students before performance of an AA experiment can be very valuable preparation. An AA without video output can also be used to record experimental procedure, but a camera must be used. This requires additional personnel, along with special lighting and editing, while an instructor can record his own videotape directly from the video output instrument if it is suitably modified.

Aside from a videotape demonstrating routine operation of the AA, other uses of this capability can be made. The video output of the IL 551 AA can be selected as a plot of absorbance vs. time for an arbitrary length of time. By operating in this output node, aspiration of a standard can be begun in the middle of the specified plot time, and the rapid rise in absorbance viewed. Deuterium background correction is available in the IL 551, and at suitable wavelengths, a plot of absorbance vs. time will display both the total absorbance and background absorbance. Time plots of flames at various fuel/osidant ratios can show the student the background effects due to very rich or very lean flames. By selecting and videotaping various expository demonstrations, the student can observe directly the effects of conditions like aspiration rate, flame stoichiometry, and others. This is in contrast to the oral or written presentation required without an actual plot of absorbance to witness.

Of special interest in the context of videotaping instrument output are the "flameless" techniques--cold vapor Hg analysis, and furnace methods. Both of these techniques involve discrete evanescent atom populations in the beam of the instrument, and videotape recording of a plot of absorbance vs. time can actually show the effects of various conditions on peak shape and height. For example, in the Hg cold vapor analysis, videotaping allows evaluation of the optimum flow rate for maximum sensitivity as well as display of the effects of slow purging of Hg into the beam. In furnace techniques, students can actually see any "spattering" of drops which may occur from heating at a rate slightly too high. In use of a furnace, a "bad" temperature program can be recorded on videotape to show exactly what happens when heating is too fast, or drying temperatures too high. In the case of furnace techniques, a simple and convenient method of recording a videotaped demonstration is very useful. Without this ability to directly record videotapes, the long and costly camera recording process must be used, and a plot of the actual absorbance as a function of time is not available without significant instrument modification or additional equipment purchase.

Above and beyond the capabilities of "conventional" AA instruments, a microprocessor-controlled AA with video output can be used as an extremely valuable educational tool. The ability to quickly and conveniently record the output of the instrument on a videotape cassette allows instructors to prepare material for student study before performance of an AA experiment. The video output capability gives students valuable insight into exactly what is occurring in both flame and flameless techniques through display of a plot of absorbance vs. time. These plots can be recorded to show students the variation of background signal intensity with various conditions such as wavelength, flame stoichiometry, etc., or, alternatively, to demonstrate the effect on peak height and/or shape of various experimental conditions. These concepts have been heretofore, very difficult to demonstrate through the use of a "conventional" atomic absorption spectrophotometer.

The previous discussions show how the inclusion of a microprocessor and video output on an AA forms a valuable educational tool. There are two general ways in which inclusion of a microprocessor in an AA increases the efficiency of learning the theory and operation of the AA. First, the microprocessor eliminates the tedium of educationally inefficient mechanical tasks like knobfiddling in calibration or standardization. Secondly, the microprocessor serves as an expository tool, by making the calibration curve easily accessible, and feedback on data immediate, for the student. By watching the construction of the calibration curve, the student gains a better understanding of the theory of AA, and inclusion of the video output facilitates this. Visual presentation of calibration curves is routinely done in teaching of AA, but presentation of these curves on video screen is even more efficient and meaningful for the student.

TECHNICAL WRITING AND CHEMICAL LITERATURE:

An Unified Approach

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Although most undergraduates in the chemical sciences are well trained in the theories and techniques of the discipline, many cannot effectively report their own ideas and results, nor can they readily locate the work of their predecessors. The first problem, the inability to write well, is not restricted to the chemical sciences. A decline in the quality of undergraduate writing has been documented extensively and lamented widely. [13,16, 17,20] The second problem, the inability to use the chemical literature, is less well recognized, but equally important. Despite the continued exponential increase in the size of the chemical literature and the proliferation of searching tools, including various computerized techniques, fewer and fewer colleges and universities offer formal instruction in the use of the chemical literature. [10, 14]

Technical Writing and the Chemical Literature, Chemistry 199, is a unique, interdisciplinary course designed to tackle both of these problems simultaneously. This one-semester, three-credit, technical elective is open to sophomores, juniors, and seniors in chemistry, biochemistry, and chemical engineering at the Urbana campus of the University of Illinois. Classes meet for two one-hour sessions each week, except during the last quarter of the semester when students schedule weekly individual conferences with the instructor. This article describes Chemistry 199 in detail, especially course materials and teaching techniques, and discusses its effectiveness based on two years of experience.[1]

Course Materials

The unusual, interdisciplinary nature of Chemistry 199 made development of course materials particularly challenging. Courses in technical writing, also common, are usually taught by the business faculty and are not science-oriented. Courses in the chemical literature are dwindling, and they have not previously included instruction in writing. As a result, direct borrowing from related fields was seldon possible.

Table 1 shows the topics included in the syllabus. As the lengths of the left and center columns suggest, instruction in writing and in literature searching are weighted equally. This balance is maintained throughout the design of the course, from structuring class time, to making reading and writing assignments, to establishing grading policies. Although public speaking is largely beyond the scope of the course, the topic is treated briefly, since skill in oral as well as in written communication is critical to many careers in the chemical sciences. Many topics useful to students entering industry are included, because half the undergraduates in the School of Chemical Sciences enter industry directly and the majority of those who pursue graduate training enter industry later.

A list of books used in the course appears in Table 2. Required texts include a grammar handbook, [7] a summary of the principles of composition, [18] a discussion of technical writing as it applies to the chemical sciences, [6] and a guide to the chemical literature. [21] Reading assignments from the books listed in Table 1 are supplemented by R. Schoenfeld's series of articles, "The Chemist's English", [15] and by a selection of scientific articles from scholarly and popular journals.

The 19 writing assignments forming the core of the course are listed in Table 3. Students may delete up to three assignments, not including those related to the term paper or those written in class. Examples of two of the five categories of assignments appear in Figure 1.

For the six regular writing assignments students obtain information on a single topic, which they subsequently present in a 1-2 page composition. Most of these assignments require the students to employ written formats widely used by professionals in the chemical sciences. In one instance, each student is asked to choose an article from a recent issue of <u>Science</u>, <u>Journal of the American Chemical Society</u>, <u>Journal of Biological Chemistry</u>, or <u>AIChE Journal</u> and to write an original abstract for it. In another assignment, "Safety Memorandum", shown in Figure 1, students must demonstrate their familiarity with the literature on safety and toxicology, their ability to pitch their writing to a specific audience, and their knowledge of acceptable style for memoranda and bibliographies. As part of the assignment of public speaking, each student located biographical information about a famous living scientist and prepares an introduction of this person to a seminar audience.

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[1] A very brief description of this course appears elsewhere. See L. Lee Melhado, <u>Journal of Chemical Education</u>, <u>57</u>: 128-128; 1980.

Four writing assignments are related to an 8-12 page term paper, which may be a review, a research report, a biographical sketch, or other approved format. To encourage students to approach the project at a steady pace and to maximize the opportunities for them to seek assistance, work on the term paper is divided into phases, each treated as a separate assignment. In the middle of the term, students write a 1-2 page proposal in which they specify a topic. Several weeks later, they prepare an outline and a tentative bibliography; and, at the end of the semester, they submit a final draft.

Three writing assignments are completed in class. These include a one-hour introductory assignment written during the second class meeting (two essays), a one-hour mid-term examination (an essay and an editing exercise), and a three-hour final examination (two essays, and editing exercise, and two short-answer sections). Most topics assigned for in-class writing do not require outside preparation: those few that do are declared in advance, as seen in Figure 1. Instead of testing factual knowledge, the in-class exercises provide an opportunity to practice writing in a spontaneous manner and a chance to demonstrate a working knowledge of selected references available during the in-class writing period.

Four assignments are short-answer exercises that require students to supply specific items (compound names, molecular formulas, etc.) obtained by consulting the indexes to Chemical Abstracts, the print-out from a computer search of the Bibliographic Retrieval Services data base, or reference works that the students have read about but not otherwise had a chance to use, such as Science Citation Index. Although these assignments do not provide practice in writing, they efficiently introduce students to important searching tools.

Teaching Techniques

It is impossible to understand how Chemistry 199 works by looking at content alone. At least five supporting techniques are critical to the success of the course.

The first technique, a combination of a case study and a laboratory approach, implicit in the writing assignments already described, pervades the entire course. The technique evolved from the philosophy that students learn more quickly and more thoroughly if they have to use information or concepts than if they passively absorb the material by reading or listening. Every reading assignment and every lecture is tied to a writing assignment, and every writing assignment but the revisions and editing exercises treats the library as a laboratory in which the students apply their searching skills. The six regular assignments, all in-class essays, and the assignments related to the term paper are posed as case studies. This technique focuses the students' thinking, infuses a sense of purpose and excitement into creating a solution, and approximates search problems students might reasonably expect to encounter on the job.

A second technique is for the instructor to schedule frequent individual conferences with students, which are held monthly during the first part of the semester and weekly during the last 4 weeks. These 5-15 minute conversations allow students to seek assistance with searching or writing problems before they become hopelessly confused or frustrated. Students having persistent difficulties are encouraged to arrange additional appointments, an invitation many of them take seriously.

Although the reason is not readily apparent, two years of experience with Chemistry 199 indicates that it is much harder to teach students how to write than how to use the chemical literature. Reflecting this fact, three techniques were developed especially to bolster instruction in writing.

One such technique is in-class discussion of selected samples of scientific writing. Approximately 30% of the time in class is devoted to this activity. Some of the samples are taken from the literature, but most are extracted anonymously from student papers, since interest is noticeably greater when student papers are discussed. Although students are encouraged to withhold their papers from circulation if they feel that they would be embarrassed by public criticism, no one has done so. Students are virtually unanimous in the opinion that class discussion of student papers is a vital part of learning how to improve their writing, and the majority recommend that more class time be set aside for this purpose.

Another technique is for the instructor to provide written comments, not just corrections, on every writing assignment. This technique allows the instructor to identify recurrent problems of the class in general and of individual students in particular, to praise each student for what he or she does well, and to suggest alternative means of improvement. Students report that this technique helps them understand their problems with writing, and they repeatedly emphasize that it helps them sustain their interest and effort even when they have not done well on a particular assignment.

Twice during the semester students revise a previous assignment. The technique of revision was introduced during the second year the course was offered to insure that students would learn to examine their own writing critically. Editing exercises in which students rewrite another's work were also introduced because many students can learn to revise more readily if they can remove themselves from the task emotionally, which is easier to do with someone else's work than with one's own.

Results

As Table 4 demonstrates, the 36 students who have completed Chemistry 199 to date are a heterogeneous group. Juniors, chemists, and females are slightly more likely to have taken the course than enrollment figures for the School of Chemical Sciences would predict, but in most ways the students in Chemistry 199 are broadly representative of undergraduates in the School as a whole. In particular, the average Grade Point Average for students in Chemistry 199 is statistically indistinguishable from the average GPA for all sophomores, juniors, and seniors in the School. This comparison is noteworthy because it indicates that, even though the course is an elective, allowing skewed distribution by self-selection, Chemistry 199 students are not an elite group. If the course is successful with them, it should be successful with most students in the School.

Chemistry 199 is unquestionably popular among those who have taken the course. Class discussions are lively, and attendance is excellent, averaging better than 95%. Despite the heavy load of homework, 31 of the 36 students who have taken the course have completed all required writing assignments, while the remaining five students have completed all but one. Many students have recommended the course to their friends, causing the Main Office of the School of Chemical Sciences to receive an unprecedented number of inquiries regarding the availability of the course in future semesters.

Two years of experience also indicate that Chemistry 199 is an effective antidote to the problens it was designed to combat. Although it is difficult to judge objectively improvement in writing skills, at least half the students made noticeable progress. All of the students felt that they had markedly enhanced their literature searching skills. This claim was corroborated by the chemistry librarians, who frequently observed students from Chemistry 199 assisting other library patrons. Many students in the class also stated that their newly acquired facility with the literature gave them a competitive advantage in other technical courses. The results of the Instructor and Course Evaluation forms administered at the end of each semester have been equally encouraging. For two consecutive years, Chemistry 199 received the highest rating of any course in the School of Chemical Sciences and ranked within the top 20% of courses offered throughout the University.

In many ways the success of Chemistry 199 hinges in its interdisciplinary character. More than 85% of students polled in the School of chemical Sciences preferred Chemistry 199 to separate electives in writing and in literature searching. The most obvious advantage of an interdisciplinary approach is educational efficiency. In a crowded science curriculum, the opportunity to combine subjects appeals to students as well as professors. Another benefit of Chemistry 199 is that it draws many students who want to learn to use the chemical literature, but who are afraid to take a writing course, even though they feel they need and could profit from further instruction in writing. A third advantage of the interdisciplinary combination is realism. Integrating instruction in writing with instruction in literature searching greatly diminishes the artificiality of short-answer literature searches and of essays on topics outside the students' areas of interest and expertise. The assignments are sufficiently realistic that many students use the cover letters and resumes they write for the course in their searches for summer or permanent jobs, and one student is publishing his term paper.

A final, unexpected benefit of Chemistry 199 is the enhanced professional awareness among students taking the course. At the end of each semester, students have stressed that this course teaches them about professional journals, membership in professional societies, career opportunities, job hunting skills, and many other aspects of professional life that they had not encountered elsewhere as undergraduates, despite the existence on campus of a chemical fraternity, ACS and AIChE Student Affiliates, and an excellent local placement office. Many assignments helped students explore their plans for the future and the depth of their commitment to a career in the chemical sciences.

Acknowledgement: The author thanks Dr. Nelson J. Leonard and Dean Roger K. Applebee for their enthusiastic support of this course.

Table 1. Topics Included in the Syllabus

Technical Writing	Chemical Literature	Public Speaking
Abstracts	Abstracting Journals and Indexes	Introductions
Applications	Biographies, Directories,	Oral Presentations
Bibliographies	and Histories	Visual Aids
Footnotes	Compilations of Data	
Illustrations	Experimental Literature	
Letters	Guides to the Literature	
Manuals	Libraries	
Memoranda	Patents and Other Government Documents	
Outlines		
Proposals	Safety and Toxicology	
Recommendations	Searches (manual and computer, retrospective and current)	
Reports		
Resumes	Trade Literature	
Revisions	Translations	

Table 2. Required and Recommended Reading

	Title	Reference
Writing, General		
	Harbrace College Handbook[a]	[7]
	The Elements of Style[a]	[18]

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[a] Required texts.

Table 2 continued.

	Title	Reference
Technical Writing		
	Handbook for Authors[a]	[6]
	How to Write and Publish a Scientific Paper	[4]
	Reporting Technical Information	[8]
	Style Guide for Chemists	[5]
	Writing a Technical Paper	[12]
Guides to the Chemical Literature		
	A Guide to the Literature of Chemistry	[3]
	Chemical Publications	[11]
	Guide to Basic Information Sources in Chemistry	[1]
	How to Find Chemical Information	[9]
	How to Find Out in Chemistry	[2]
	The Use of Chemical Literature	[19]
	Using the Chemical Literature[a]	[21]

Table3. Writing Assignments

Regular

- Writing Abstracts
- *Beilsteins Handbuch*
- Safety Memorandum
- Launching Your Career
- Public Speaking
- Instruction Manual

Term Paper

- Proposal
- Annotated Bibliography
- Outline
- Final Draft

In-Class

- Letters (2)
- Essays (4)
- Editing Exercises (2)

Short-Answer

- *Chemical Abstracts*
- Patents
- Computer Search
- Library Practical

Revisions (2)

Table 4. Student Characteristics[a]

	Chemistry 199[b]	School of Chemical Sciences
Academic Status		
sophomore	17%	31%
junior	53	34
senior	28	36
other	3	--
Curriculum		
chemistry	60%	28%
biochemistry	12	20
chemical enginnering	25	52
other	3	--
Sex		
male	62%	79%
female	38	21
GPA (A = 5.0)	4.01	4.00

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[a] Average, 1978 and 1979.

[b] n = 36.

[c] n = 1444.

Figure 1. Sample Writing Assignments

Regular

Imagine that you are the supervisor of a research group whose members regularly use one of the materials listed on the attached sheet.[a] Write a 1-2 page memorandum describing specific hazards associated with this reagent and procedures for handling it safely. The memorandum should include a brief discussion of the type and extent of the danger(s) involved, any precautions which should be taken to minimize the risk(s), and the appropriate steps to be followed if an accident should occur. You may assume that all individuals to whom the memorandum is addressed have completed two or more years of college chemistry. Use any standard format for memoranda, citing references as endnotes.

[a] Not shown.

Figure 1. continued

In-Class

Describe the branch library (agriculture, biology, engineering, geology, library science, mathematics, or physics) that you visited in preparation for this in-class writing assignment. If you visited several branch libraries, describe only one. Two or three paragraphs should be sufficient.

References

1. Antony, A. Guide to Basic Information Sources in Chemistry. New York, NY. 1979.
2. Burman, C.R. How to Find Out in Chemistry. Pergamon, Oxford. 1966.
3. Crane, E.J., Patterson, A.M., and Marr, E.G. A Guide to the Literature of Chemistry, Second Edition. John Wiley, New York, NY. 1957.
4. Day, R.A. How to Write and Publish a Scientific Paper. Institute for Scientific Information Press, Philadephia, PA. 1979.
5. Fieser, L.F., and Fieset, M. Style Guide for Chemists. Krieger, New York, NY. 1972.
6. Handbook for Authors. American Chemical Society, Washington, D.C. 1978.
7. Hodges, J.C. and Whitten, M.E. Harbrace College Handbook, Seventh Edition, Harcourt, Brace and World, New York, NY. 1972.
8. Houp, K.W., and Pearsall, T.E. Reporting Technical Information, Third Edition. Glencoe Press, Beverly Hills, CA. 1977.
9. Maizell, R.E. How to Find Chemical Information. John Wiley, New York, Ny. 1979.
10. Martin, D.F., and Robinson, D.E. "Who's Teaching Chemical Literature Courses These Days?" Journal of Chemical Documentation 9: 95-99; 1969.
11. Mellon, M.G. Chemical Publications, Fourth Edition. McGraw-Hill, New York, NY. 1965.
12. Menzel, D.H., Jones, H.M., and Boyd, L.G. Writing a Technical Paper. McGraw-Hill, New York, NY. 1961.
13. "On Further Examination: Report of the Advisory Panel n the Scholastic Aptitude Test Score Decline." College Entrance Examination Board, New York, NY. 1977.
14. Sarkisian, J.E. "The Status of the Teaching and Use of Chemical Information in Academe." Abstracts of Papers, Part 1, 178th ACS National Meeting, CINF 1. American Chemical Society, Washington, D.C. 1979.
15. Schoenfeld, R. "The Chemist's English." Proceedings of the Royal Australian Chemical Institute. Series of articles, 1974-1979.

16. Sheils, M. Newsweek 86: 58; December 8, 1975.

17. Stacy, G.W. "Basic Communication Skills Crucial For Successful Professional Careers." Chemical and Engineering News 56: 29; September 18, 1978.

18. Strunk, W., Jr., and White, E.G. The Elements of Style, Third Edition. Macmillan, New York, NY. 1979.

19. The Use of Chemical Literature, Third Edition. R.T. Bottle, Editor. Butterworths, London. 1979.

20. Time 108: 77; November 8, 1976.

21. Woodburn, H.M. Using the Chemical Literature. Marcel Dekker, New York, NY. 1974.

PREPARATORY CHEMISTRY

HANDS—ON CHEMISTRY: Experiments For a Preparatory Course

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Presented at the Seventy-first Two-Year Chemistry Conference, Oakland Community College, Southfield, Michigan, May 1981.

Instructors in preparatory chemistry courses, especially in larger institutions, must face budget pressures of increasing severity. We must confront the hard fact that many of our "clients" will not go on to major in chemistry and thus will not in a large way "pay back" the department for its investment. Laboratory education is also expensive in instructor time, and thus is often eliminated from consideration in preparatory chemistry courses. In addition, few suitable published materials are available for the instructor who does wish to give preparatory students "hands-on" experience in chemistry.

This poster session will feature demonstrations of several experiments planned especially for a laboratory-oriented preparatory chemistry course. The experiments have been chosen to emphasize concrete experiences related to abstract concepts such as volume, density, chemical composition, electrochemical activity, concentration, and gas law relationships. Safety and economy of materials and apparatus are stressed. Students are encouraged to develop skills of observation, description, organization of time, manipulation of chemical apparatus, and data collection. Questions emphasizing understanding of concepts are posed throughout the experiments, and thought-provoking problems are the basis of report sheets.

Two general questions come most immediately to my mind as I focus efforts on science courses for non-majors and preparatory chemistry courses in particular. First, what kinds of things do we sant students to learn and be able to do when they finish such a course? Secondly, how can we as instructors help them along what can be a very difficult path to success in college science courses?

Although science courses for nonscience majors have waxed and waned in popularity at colleges and universities in the United States over the last decade, the concept of a college level course in preparation for college chemistry is who choose majors that require of them some depth of knowledge in traditional science areas but who do not bring with them to college the skills necessary to survive rigorous first courses in biology, chemistry, and physics. For whatever reasons, these students are not equipped with the reading, logical thinking, arithmetic, and synthesizing skills to allow them to succeed. Some of these students will not continue through a science curriculum to become research scientists, teachers, or health professionals, but the concept and practice of a preparatory course at least allows the door to be opened. Thus, one of the most important purposes of a preparatory chemistry course is to give students the background preparation for traditional college chemistry courses.

Students in a preparatory course are often characterized by a serious lack of confidence in their own abilities to think and function in foreign territory. A preparatory chemistry course should help students improve their abilities to ask questions more significant than, "What do I do now?' We want our students to gain confidence in manipulating apparatus, starting with simple (for us) translation from a laboratory manual illustration to a still-life complete with burner, ring stand, beaker, and so forth. Many students are unsure of their abilities to observe chemical phenomena, to make calculations, to draw conclusions, and to test out their own reasoning. A well-designed preparatory chemistry course should help to remedy these deficiencies.

It is often the case that students are perfectly capable of memorizing complicated bodies of knowledge, but their deep understanding cannot be built without patient experience with physical objects. A preparatory chemistry course should help students develop a physical intuition about such concepts as volume, density, concentration, pressure, and conservation of various quantities. In the laboratory, students should have time to design an experiment to answer a question. They should be able to try out some ideas that ultimately may not work in order to discover the consequences of their thoughts and actions.

With such experiences, although students may not be discovering concepts new to you and me, they are making progress toward many of the formal reasoning abilities vital to real success in science. It should not be a surprise to your that many college-age students are not consistently able to isolate and control variables in an experiment, to translate easily between word and symbol, to understand the difference between observation and conclusion, to work with proportional reasoning, or to construct models or hypotheses about concepts. It is vital for us all to realize that these students are not dumb. Reasoning processes that we may have developed almost unconsciously at a very early age are not yet part of the tool boxes of many of our students. Yes, working with such students is frustrating, but I have gained much deep insight into a number of concepts I understood superficially from interactions with students we would all describe as "high-risk".

What, then, can we do other than to provide many concrete experiences and allow time for students to develop? It is probably impossible to define exactly the kinds of experiences that allow students the most room to grow. Students will learn to survive even without our care and concern, but let me share with you some ideas that have helped me enjoy rather then dread courses in preparatory chemistry.

The less "proof-by-loud-voice" you do, the longer your voice will last and the calmer your students will stay. Verbal arguments simply do not carry the weight with concretely-reasoning students that they do with fully-formal thinkers. You can try to draw pictures and simple diagrams, but be aware that the analogies we use to tie chemical concepts to ordinary life may not be very helpful for a student who lacks the same experiences we have had and who has not developed the mental apparatus for making the connentions. When encourage students to do the same. Ask students, "What kind of evidence would convince you?" By all means, let them work with and talk with each other during laboratory periods. Groups of two or sometimes more, especially when the groups contain a sceptic, demonstrate an amazing synergy. Be sure to listen to your students' questions; their ways of asking a question may be clues to how they are thinking. Insist that students state their questions clearly and in complete sentences. Don't be afraid to answer questions with other questions, although you must be aware of the limits of students' frustrations. Circulate and ask students "What is happening in the beaker? What did you expect to see? Why are you doing X? How did you decide that?" Let students hear you reasoning, see you making mistakes, find out that you are real. Try to remember when you had trouble understanding the mole concept or gas laws or statistical mechanics or whatever.

"But," you say, "I am too busy. My classes are too large for all that interaction." I know, I know! I really <u>do</u> understand the problems of not having enough energy to go around, but there are many tricks for coping. Here are a few ideas.

Before the laboratory period, set up a display of the appropriate apparatus in an easily-visible place. Students need to see a three-dimensional example, especially if there are small changes to be make to accommodate your local variety of clamp or ring stand. Another problem with large classes is the difficulty in showing particular techniques to everyone at the same time. We have used an "each one teach one" method for skills such as pipet, buret, and balance use. Choose no more than 4 or 5 students and teach them the skill. Divide the class into teams for each of your new experts. Make sure that everyone knows the name of his or her teacher and insist that questions be directed back to that person. It is amazing how much people can absorb when they know that they will have to teach someone else!

Even in small classes, it is difficult to answer all the questions. I have often resorted to written communication for simple questions that do not require an immediate response. Ask students to submit questions, in writing, about an experiment procedure or calculation or other problem the day before lab and return your written answers to them. You may be able to post a large sheet of paper somewhere in or near your laboratory room and hang a pencil nearby. As well as questions about chemistry, you will find grafitti of amazingly high quality, and students will also help answer each others questions. Sometimes only a fellow student can translate to me the problem someone is having. Unless students object, I prepare a list of their names, addresses, and phone numbers to be handed out so that they can get to know each other.

Finally, evaluating and responding to laboratory reports can be overwhelming. While it is certainly possible to streamline reports to single-answer forms, I would not recommend emphasis on numerical results in order to speed up grading tasks. You may find that talking with students about their work can be faster than checking notebooks or reports. If you ask students to stay in the laboratory to finish writing reports before they leave, you may be able to look over reports or notebooks from the students who finished early.

Working with students in preparatory chemistry laboratories can be a very high entropy process, but I hope that your overall free energy change is favorable.

CHEMISTRY IN LOW WITH SHIFTED GEARS

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Presented to a Symposium of Authors View of New Developments in Chemical Education at the Seventy-First Two-Year College Chemistry Conference, Oakland, Community College, Southfield, Michigan, May 8, 1981.

Introduction

In a recent trip to Wisconsin a chemist who had just adopted my (JDH) text for a newly instituted prep course remarked that the decision wasn't difficult since it is the only book on the market that was written for a preparatory course. I admit I was pleased, but wondered whether Hein, Peters, Seese and Daub or the authors of other books would agree!

I am sure that the gentleman form Wisconsin was not entirely wrong, simply because of publishers.

The prep market is small and publishers don't like small markets. Consequently, they try to pool markets. Prep courses, courses for students in allied health fields, and courses for humanities majors have been pooled by publishers as a single market for "low-level" Chemistry. Pedogogically, this is wrong; the educational needs of the three groups are very different.

Unlike most texts used in prep courses, Understanding Chemistry was written with only the prep course in mind. Neither the publisher nor I are proud; we'll sell to any body, but the book was clearly designed for the prep market. What does this mean in terms of the book?

Aptitude. The prevailing notion of intelligence among chemists is that "some's got it, and some don't; there isn't much you can do with the latter group." The view of intelligence -- academic aptitude, if you will -- undergirding my book is that aptitude is a measure of the rate at which students can learn.

It is assumed that every college student can understand chemistry, though the time required for some to master the ideas may be great. (For some, the time is longer than you and I could justify encouraging the student to spend.)

Nature of deficiencies. Well, if anybody can understand, why don't they? Let me ignore some of the obvious answers: poor reading, lack of effort, poor study habits, lack of organization, and puppy love. I do not wish to suggest that such matters are unimportant, but they are problems that aren't addressed very well in a text, mine included.

When a student who wants to learn and who knows how to learn, doesn't learn, it is likely to be because of lack of prerequisite information or lack of intellectual development.

Most instructional materials and many instructors have ignored the latter problem when teaching a preparatory course. The focus has been on presenting information; in reality, presenting words. Virtually every topic in a general introductory course is covered, but covered superficially. Emphasis is on drill and rote memory. (Frankly, I think the approach is often a reflection of a belief that "dumb" students can never understand chemistry; the purpose of a prep course is to get them through a requirement.)

I happen to believe that colleges are in business to educate, and that is what I hope my book will be used to do.

In Understanding Chemistry, the number of topics has been deliberately limited so that there will be time to understand the limited number of concepts presented. Attention is given to the reasoning used in science, and an attempt is make to gradually develop some of the reasoning patterns -- particularly proportional reasoning.

The "unary rate"* is used to describe proportional relationships and factor-label is taught as a tool to keep track of the reasoning used to solve problems involving proportions. Examples are worked through using reasoning commonly understood by students who have not developed proportional reasoning, and the treatment develops through out the book, ending with a formal treatment of proportions in a late chapter dealing with gases.

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*The term was coined by Madaline Goodstein to describe the ratio of two quantities where the denominator has a numerical value of one. For example, \$2.98/lb is a unary rate; \$5.96/2 lb is not.

Gradual development of skills is found in other areas as well. Nomenclature of binary compounds, for example, is introduced and practiced. Nomenclature of more complicated compounds is introduced in a later chapter where additional practice is provided.

Concrete experience. What we know about learning and intellectual development strongly suggests that learning is enhanced by beginning with experience that can be sensed directly and introducing the theory that enables us to organize vast amounts of data only when we have data to organize. Understanding Chemistry is organized on thes premise. Lecture demonstrations and laboratory work are strongly encouraged as an integral part of the course.

How demonstrations and laboratory exercises are used is very important. More often than not, they are used only to illustrate what we have told the students they must believe. Valuable as this may be, we ask students to do more. We ask them what they consider sensible to believe, base on what they have seen. We believe that this is a necessary step in fostering the intellectual development that many students need to make in preparation for the normal introductory course.

Laboratory experiences

From my (JSC) point of view, laboratory experiences for a preparatory chemistry course are a non-negotiable demand. Not even the most complex thinker can understand new areas without some hands-on practice. In considering the efforts needed to manage a successful laboratory program for a preparatory chemistry course, let us focus in turn on students, on skills, and on teachers.

Problems students have. Some students are simply fearful of laboratory experiences. They are afraid to light a burner, afraid to mix chemicals, afraid to follow even explicit directions without considerable assistance from others. For a few students (for example the student who witnessed a pressure cooker explosion as a child) these fears are legitimate, but in general, instructors need to help students overcome their reluctance to dig into laboratory experiments. Other students are not prepared for the day's work. Specific assignments that are checked at the beginning of a laboratory period can be helpful in encouraging these students to read through the assignment before they come. Still other students rely too much on a lab partner for every detail of the experiment. Working with one or more laboratory partners is often extremely helpful, especially when considerable discussion is part of the experiment. In these cases, it is important for each member of the investigation team to have specific tasks to perform and reports to make to the larger group.

Laboratory skills students need. We all know that one important purpose of a preparatory chemistry course is to enable students to survive in "regular" general chemistry courses later in their careers. Laboratory skills vital to success in later courses include observation of physical and changes and understanding differences between significant and trivial changes.

Students need also to learn to describe their observations in clear language and to use data to come to appropriate conclusions about chemical processes. Organization of time in the laboratory is vital to being able to accomplish the (often substantial) tasks assigned in science courses for majors. Finally, students need to learn to be comfortable with manipulating equipment that is commonly used in chemistry laboratories. Hands-on Chemistry, the laboratory manual developed for use with Understanding Chemistry, establishes a firm skills base for students who will go on to further chemistry courses.

Problems teachers have. How can mortal instructors make time to challenge their students to think about laboratory tasks and results, to support students' growth through the significant emotional changes that often accompany learning new ways of thinking, as well as to field questions about procesures and results throughout the laboratory period, to say nothing of grading laboratory reports?! There is no doubt that the process of good teaching violates all principles of energy conservation, but the rewards must offset the costs or we couldn't continue with what we're doing year after year. And one of the most satisfying rewards is a former prep chemistry student who goes ahead to succeed infurther courses, perhaps not simply because if our efforts, but because at least we have offered a significant shove in the right direction.

THE CHEMISTRY PREPARATORY COURSE:

How Much Damage Does It Do?

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Presented to a General Session of the Seventy-First, Two-Year College Chemistry Conference. Oakland Community College, Southfield, Michigan, May 9, 1981.

Two distinct groups of students are served by one term basic chemistry courses: those whose curricula require only one or two semesters of chemistry (Group A), and those who subsequently intend to enroll in standard two-semester sequences in general and organic chemistry, but who are not sufficiently prepared to do this (Group B). It is a common practice to teach essentially the same basic survey-type course for both Group A and Group B students.

Typically, basic survey type courses possess one or more of the following features, each of which is a major liability for students who are attempting to prepare themselves for a further study of chemistry: (1) Reinforcement of inappropriate approaches to problem solving and insufficient attention to helping students improve their problem-solving skills, (2) Grossly oversimplified, confusing, and misleading treatments of many topics, (3) Approaches that encourage students to merely accept statements rather than deepen their conceptual understanding, (4) Overemphasis on theoretical models and/or insufficient attention to the connection between models and experimental facts, and (5) Reinforcement of students' feelings of inadequacy and anxiety about studying chemistry.

Many students find that working quantitative problems is the most difficult part of a standard introductory chemistry course. One common reason for this is the mistaken belief that for any problem there is a set standard procedure that one can simply use in an unthinking manner. Unfortunately, in most basic chemistry courses this inappropriate approach to problem solving is reinforced by presenting only a factor-label (unit conversion) method for solving problems. Whereas the factor-label method is useful for solving certain types of problems, it is typically presented in a manner that causes many students a great deal of difficulty in subsequent courses for the following reasons: (1) there is no discussion of what types of problems this method is suitable for, or for what problems the method is not applicable, (2) no distinction is made between unit conversions (i.e., expressing the same physical quantity using different units) and the relationship between two physically different properties (e.g., for a single pure substance the substance, the density. But density is not a conversion factor that converts volume into mass).

In a typical basic survey type course, where a large number of topics are treated in a very superficial manner, students commonly acquire many fundamentally incorrect ideas, particularly with regard to those topics that are conceptually more difficult. Consequently, a student who goes on to study more chemistry does so carrying an added burden of misconceptions. For example, many basic survey type courses do a horrendous job of "explaining" electronic structure and bonding. Inappropriate analogies that foster the notion that energy levels are specific distances from the nucleus quite are quite frequently used. Thermodynamic concepts are also commonly given a sound mistreatment. For example, virtually all students leave a basic survey type course with the mistaken idea that, when an exothermic reaction occurs, all of the energy is liberated in the form of heat irrespective of the reaction conditions. Another topic that seems to be admirably suited to the use of overdrawn analogies and neglect of what is taking place at molecular level is rates of chemical reactions. Students often learn that "activation energy is the energy needed to get it over a bump and them roll down a hill," or that "catalysts change the rate of chemical reactions but are not part of the reaction, they just reduce the activation energy."

In a typical basic survey type course there usually isn't time to adequately explain many important concepts. As a consequence, students are often presented with an approach that amounts to "this is the way it is, accept it". Unfortunately, one of the things that students in a preparatory course need most is encouragement to think about why something is the way it is. For example, discussions of the important topic of valence electrons are typically limited to statements such as "the electrons that are in the highest energy level are called valence electrons. These electrons are the ones that are involved in chemical activity". There is no explanation of why valence electrons are the electrons involved in chemical activity.

In preparation for further study of chemistry, a student must appreciate that the models chemists use are based on experimental facts. But this is usually ignored in a basic survey type course. For example, it is quite common for students in this type of course to be taught that "multiple bonds are used in molecules so that we can draw Lewis structures that satisfy the octet rule". No mention is make of the experimental facts that are the real basis for why chemists classify bonds as single, double, or triple bonds.

Another all too common liability of a typical basic survey type course as preparation for further study of chemistry is reinforcement of a student's feeling of inadequacy and anxiety about studying chemistry. One approach basically amounts to "you aren't sufficiently capable of understanding an explanation so we won't give you one". For example, the discussion of mass and weight, right at the beginning of many basic chemistry texts, boils down to something such as "mass and weight are fundamentally different quantities, but for the purpose of this course we will use them interchangeably". Feelings of inadequacy are also reinforced significantly by presentations in which a very superficial.

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