Chemistry in Grades Seven to Nine

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A teacher takes on the task of conveying to young people natural phenomena as well as insights into the relationships between natural events, and preferably in such a way that they receive a powerful developmental impulse. Chemistry is relevant in the seventh grade. But in chemistry lessons a negative effect can easily take place, either a cramping effect that leads to direct antipathy for the subject or the creation of rigid and abstract mental images. The first is more often found among girls and the latter among boys. This is not chemistry's fault, for this subject can answer some of the deepest riddles in nature and in the human being.

In addition we can practice active thinking. To do so, we cannot pack chemistry into a gray mass of formulas and experiments. If the teacher starts with methods that result in abstraction, it is hard to make chemistry come alive again. The children's first meeting with chemistry must help them understand that the subject has to do with them and with the world around them. Teachers should not believe they can introduce chemistry in the seventh grade according to scientific recipes. Chemistry must be embedded in a number of subjects, whether children are learning within the world of nature, culture, art or handicrafts. The subjects should support each other, and in that way children will be engaged from many sides and can respond from different aspects of their beings.

Seventh grade: Combustion

The following is an outline of a chemistry main lesson block with fourteen lessons. It is built upon the method of providing children with phenomena they can judge themselves. We begin with combustion. A large and spacious zinc vessel is filled will all kinds of burnable materials. Everyone contributes his own items. There are many surprises in pockets and backpacks of thirteen- to fourteen-year-olds. Soon the fire blazes and the lesson takes off. We feed it with paper, woodchips, birch bark, pine needles, dried grass, and so forth. The more things to burn the better. The whole first main lesson goes to the bonfire.

In the next lesson we have a conversation about it. Yesterday's experiences are a bit more distant, and we recall them together. Before us lies a pile of gray ash, the remains of warmth, light and smoke from yesterday. It provides valuable content for discussion if we do not lose ourselves in defining what has taken place. The more unanswered questions the better.

Then we try to research on our own. Experiments with burning candles under a glass are fascinating. Everyone knows that the flame will die after a while, but few have experienced it. The larger the glass the longer the flame can live. With this discovery we have taken a large step forward: flame needs nutrition, it needs air.

Here is a fine opportunity to include a historical comment on fire. We can draw on a lot of mythological materials from earlier years. We start with the first time fire came to the earth, then the moment when man learned how to control it and use it. Eventually man made fireplaces that enabled him to take it inside. Smoke was a nuisance so a hole in the roof became necessary. Later we built fire into ovens and fireplaces. We learned how to regulate the air with vents. We look at how fire has become more and more distant from man. Where do we find it today in our houses if we are not lucky enough to have a fireplace? Down in a forgotten corner of the basement, built into cement and steel we have an oil burner. Through the little window we can see a flame. The rooms are heated by radiators under the window. But an evening in front of the radiator is not the same as a fireplace.

We also speak of body warmth, blushing, fever and heat waves. This awakens their consciousness. Now the children want to move on.

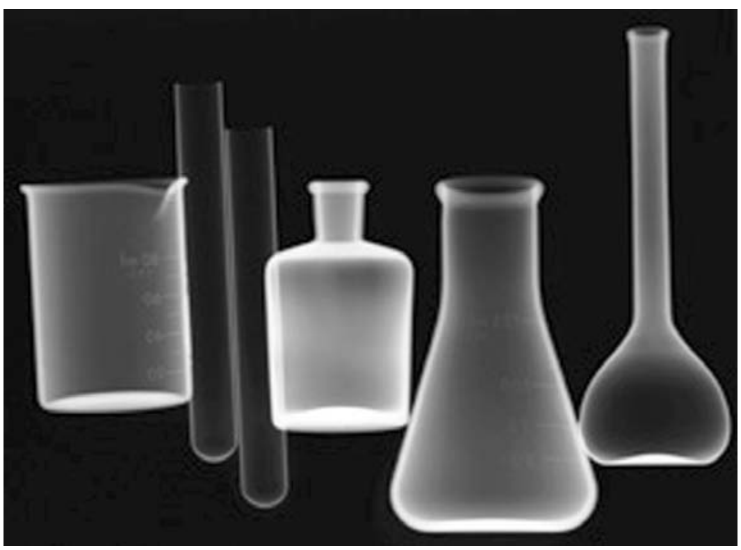
What happens if we reduce the air intake to a minimum? This is what we do in a charcoal-kiln and that is fun to describe. Children know the products from a kiln—charcoal, drawing charcoal and tar—but few know how they come about. Now they learn that charcoal comes from an incomplete burning in a charcoal-kiln and that tar is left at the bottom of the kiln. Yet something else disappeared through the little hole at the top of the charcoal-kiln. What can that be?

Sulfur and Phosphorus

Here we take a little detour. We burn sulfur. *Sulfurum* or *solferos* is the scientific name that means "the sun carrier." Sulfur has a close connection to volcanic areas where it may be found in beautiful yellow crystals. It burns with mystical, sluggish and blue flame that is best observed in a darkened room. It melts when it burns, and when the burning mass is poured out onto a plate, the drops fall like blue fireballs through the air. Eventually the characteristic, caustic smell spreads around the room and a coughing concert takes place among the children. Up with the windows and doors, take five minutes in fresh air! Children remember such an experience with sulfur the rest of their lives! Then we experiment with smaller dosages of sulfur, with proper ventilation to avoid the bad smell. We capture the sulfur smoke in a tall measuring glass by letting the sulfur burn at the bottom of the glass. When the glass is filled with thick, white smoke, the spoon with sulfur is carefully removed. The collected sulfur smoke is “poured” out, a heavy gas compared with the air. We “pour” some of the gas in a glass containing water and mix it well. The gas disappears, dissolved into the water. If we taste the water, we notice an acidic taste that pricks our tongues. If we pour some blueberry juice into the water, the color changes quickly to red. The same happens with red beet juice and litmus. In this way we approach acids—sulfur’s acid.

This process may be repeated and done with more powerful effect using phosphorus. As with sulfur, phosphorus smoke can be collected. It is heavy and easy to “pour” out, dissolves easily in water and colors litmus red. A new acid is “discovered,” namely phosphoric acid.

With sulfur we had combustion with great warmth development and little light. With phosphorus we experience the opposite, an almost cold flame, but great light distribution. Yellow phosphorus will ignite in oxygen and must therefore be kept under water. With yellow phosphorus we must be extremely careful. It is very poisonous. Red phosphorus is neither poisonous nor self-ignitable and is more suitable for these experiments.



Carbonic acid

From these experiments a question arises, ”Can we make ‘charcoal acid’ if we burn wood?” The students are most often convinced that it is possible. We begin by agreeing that some preparation is required in order to succeed. The type of wood we will experiment with should first have no moisture or tar in it. This is often done on a large scale at a kiln, but can also be done on a smaller scale in the classroom lab. A piece of wood is put in a large test tube with a cork pierced by a glass rod. If we warm the test tube over the flame, we can watch the whole process of charcoal combustion. Soon tar collects inside the wall of the tube while a gas streams out of the glass rod. The gas is ignitable. Here we tell the children about the lack of gas during World War II and that instead of burning gas we burned “wood gas,” what we see streaming out of the rod.

Our piece of wood is now charcoal, but to make it catch fire is not easy. So we introduce oxygen. We need quite a bit. For this experiment we use oxygen from a steel bottle. Among other things we notice that the burning charcoal pieces light up so brightly that we must look away to avoid being blinded. Our thoughts move to diamonds (made of similar material) and their power of light. When we add oxygen to the sluggish, blue sulfur flame, we can hardly believe the vitality of the flame. We conclude that oxygen strengthens and intensifies combustion remarkably.

With the help of oxygen we burn the charcoaled piece of wood. In a special combustion-proof glass we set the little piece of wood together with other charcoal pieces so we can view the whole process much better. Oxygen is fed into the glass while it is warmed up carefully from the outside. As soon as the pieces of wood begin to glow, the flames are taken away and the stream of oxygen controls the combustion. The charcoal smoke is almost invisible. It is siphoned off into a glass filled with red cabbage juice. After a while it is colored red—it is a new acid, ”charcoal acid,” say the children. Or, if we choose, coal acid. We also observe that the charcoal gas puts out a burning light. These experiments are exciting because the gas is invisible. Now one of the children blows air through a straw down into the litmus-colored water. Shortly thereafter it is colored red, a surprising experience to many.

People breathe out acids, so there must be a combustion that goes on inside, if not an invisible flame. This topic will be revisited in the eighth grade. It is fine if some questions remain unanswered for now.

We have now burned three separate substances of very different character and with very different results. The teacher can explain that in these combustions and with the help of oxygen, oxides were created, in particular sulfuric oxide, phosphoric oxide and carbonic oxide. When the oxides are dissolved in water, we obtain the acids of the materials. All of these acids color litmus paper red.

The wonders of lime

From the fiery and colorful “world of acids” we turn to something quite different: lime and its processes. It is important in the introduction to present a rich variety of materials: all kinds of shells, bird eggs, skeleton bones and various limestone rock formations. Children should see how lime sculptures form. The stalactite caves should be mentioned. How did they evolve? The cycle of nature, with all of the changing formations and transformations, decomposition and edification, again and again, is a wonderful thing to tell children.

But how can we set lime in process? A lot of warmth must be used. Lime-burning ovens obtain that warmth with the help of coal, but we do not have such an oven. We must use "explosive gas flames" to obtain a comparable effect so we can observe what happens when lime combusts. That is how we introduce hydrogen gas, that unbelievably light gas, which together with oxygen forms "explosive gas flame." The fact that the flame is very warm is demonstrated by placing a steel bar into it. The steel bar quickly becomes fiery white and turns into a sparkling inferno.

This effective flame can burn a piece of limestone, marble, for a while. On the outside we see no difference and we set aside for cooling. This piece and an unburned piece of marble are the prerequisite materials for the next experiment. Two children hold each their own piece while a third pours water over both pieces. Naturally water falls right off the unburned piece but the burned one sucks in the water. Soon it becomes warm, so warm that the child must put it down. Steam rises and soon the whole stone falls apart. It becomes a pile of white powder. There is great excitement and many comments from the children. Amazing!

When exposed to heat, lime emits carbonic acid that disappears with the gases. All that remains is burned lime. If we add water to burned lime, the lime is refreshed. Slake lime colors litmus blue. Now we have introduced the bases. Bases are as slippery as soap.

We knew that the carbonic acid that disappeared during the combustion was an acid. Our conclusion is that limestone contains both an acid and a base. Such connections are called salts. Now we can talk about the whole process of building walls, which had major cultural and historical significance. Burning lime has been known since ancient times. Slake lime was mixed with sand and used for masonry. When the process of hardening occurs the refreshed lime sucks in carbonic acid from the air and thereby returns to its original condition, limestone. To do so water must be emitted. Therefore new brick houses are wet and unhealthy. The hardening process can be improved by setting the bricks in ovens that release carbonic acid.

Finally we allow acids and bases to meet. We use strong salt acid and sodium lye. The combination is very strong but soon settles down. Then salt falls down, cooking salt. The acid that represents the light, fiery and airy has combined with the base that represents the heavy, earthly. Such forces are combined in salt!

Eighth grade: Sugar

The eighth grade chemistry block starts with sugar as our theme. Standing in front of an eighth grade class with a bag of sugar I wondered how to awaken excitement in them. The tough guys demanded gunpowder and dynamite, and they were served sugar! There are many ways in chemistry to inspire teens to discover new insight in their daily routines.

First I wanted to explore how sugar relates to water. We dissolved as much sugar as possible in a little cooking water and watched the continual expansion of volume. In the end the volume doubled many times. It is amazing to see how excited the teens become when they observe simple phenomena while learning something significant about the nature of sugar. We let the sugar water cool off. First it became syrupy, then fairly tough. We hung a thin thread down in the fluid, and after a few days we had the most beautiful sugar crystals. At this point the students needed time to think about how the process can be put into action for practical purposes. They understood that this is the way to sugar glaze, syrup, jelly, marmalade, and so forth.

As the next step, we let sugar meet fire. In a test tube we carefully warmed up the sugar and noticed that it melted into a clear fluid. With continued warming it became a golden brown, caramel-smelling fluid that awakened great excitement. But we continue warming and noticed that it became darker and darker brown, before finally ending as a black, smelly mass that emitted burning gases. We continued the experiment by bringing sugar in an iron crucible with top and warming it up strongly. A black mass poured out of the crucible. Suddenly it was all over. The crucible looked comical as it stood with its top to the side, and what was left of the sugar was a porous charcoal mass. We blew a little sugar into the gas flame and observed how a little corn flamed up like a little star.

With this experiment we covered sugar's relationship to water and to warmth, and we saw that sugar actually is a product where these polarities meet in a harmonious unity. Sugar can therefore, without transformation, be taken up in the blood of humans and animals where it contributes to body warmth. With plants it is different. Here a large part of the sugar transforms to solid substances that the plant uses to make its gestalt.

Then it was natural to speak about the creation of sugar in plants. We refreshed our seventh grade concepts of oxygen and carbonic gas and discussed how these two gases play their roles in the world of plants. A more complete description of the carbon assimilation process in plants can wait for the ninth grade. At this time it is more fruitful to work on the relationship between air, light and water. Light, air and warmth represent more the cosmic side that is above the earth while water represents the "earthly."

From the history of sugar

Honey, that represents the plant's flower-region, was known in ancient times and was considered a very important source of nutrition. During Alexander the Great's conquests from Persia to India, sugar cane was "discovered." Already a cultivated plant in India, it did not take long before sugar cane was known and grown all over Europe. But sugar cane, which represents the plant's stem and leaf region, was considered a luxury rather than a nutritional substance during the Middle Ages. Columbus brought sugar cane to the Americas, where many plantations grew forth. This is an appropriate time to include discussions of all of the human suffering that is related to the production of sugar.

Beetroot sugar, that represents the sub-earthly part of plant life, had its breakthrough during the Napoleonic wars. When Napoleon tried to weaken England by blockade by stopping all supplies to and from the European continent, the beetroot sugar industry became a necessity. Our discussions proceed to distinguishing between the various types of sugar and the sugar-carrying plants.

During our study of glucose, we can look at Fehling's experiment, that can indicate small amounts of glucose in urine. Glucose's ability to reduce makes it possible for copper-oxide to be released from Fehling's liquids. A more blinding example of glucose's ability to reduce can be demonstrated by creating a silver mirror. Pure silver is reduced from a silver nitrate solution. Helped by glucose the reduced silver sticks to the glass walls and makes excellent silver plating.

Starch

Our starting point for learning about starch is potato flour and other types of flour. Flour can remind us of loafsugar, but we can quickly discover the difference by rubbing them between our fingers. Potato flour, which contains most starch, is much "drier." We spread some in a glass with water. First it swims on the surface and later sinks to the bottom. But it does not dissolve. We also examine how flour reacts to fire. Rather than melt like sugar it quickly becomes charred. It flames up longer but not as brightly as sugar.

We speak about starch in plants. Sugar always retains a streaming movement through the plants. A characteristic feature of sugar is that it is found in a thinned, streaming condition in nature. The abundance of sugar that plants produce is transformed to starch. Characteristically, starch appears in numberless small grains distributed throughout the plant and remains still. The starch grains are stocked continually by the streaming sugar as a reserve. With weak light or at night the starch grains are again transformed and dissolved into sugar. The plant also stores starch in areas that stagnate, for example in tubes and seeds that contain large quantities of starch. Trees collect starch in their trunks during the summer, and when they awaken to new life in the spring, the starch transforms to sugar that is taken into the sap streams.

Under a microscope we discover that every starch grain is formed uniquely for every plant. A professional chemist can identify the different types. The potato, which is a child of the West, has starch grains that remind us of mussel shells with eccentric middle points. The rice plant, that represents the East, has a multi-leafed starch grain centered on a middle point. Wheat is a more European product and its starch grains are formed concentrically around a middle point. These observations lead to meaningful discussions with fourteen- to fifteen-year-olds.

If we spread a little potato flour in cold water and carefully pour boiling water in it, we see that the gray-white starch grains disappear. The boiling water becomes more and more hard and streaming; the steam bubbles must fight their way to the surface. Soon we discover that we have a pudding-like mass. Every single starch grain has swelled and lost it structure when it is in boiling water. The boundary between water and starch is washed out. We call this a colloidal state.

We demonstrated sugar with Fehling's liquid. The presence of starch can be detected in similar fashion with potassium iodide, as a dark brown-violet liquid. With the slightest presence of starch, the liquid takes on a strong, deep blue color. Now we can experiment with all kinds of vegetables and foods. A piece of bread or potato gives a strong reaction to starch while a piece of carrot shows the characteristic blue color more spread out on the piece. The class becomes convinced that starch is an important part of our nutrition. And all of the starch-rich foods are transformed into sugar in our digestion, a process that already begins in our mouth when the foods meet our saliva. This theme can be followed up in a block on the human body.

The starch-pudding we made by adding boiling water to potato flour has been set aside for further experimentation. The pudding is now very hard and stiff and has a strong reaction to potassium iodide. If we now add some hydrochloric acid to the pudding, an acid that is strong enough to dissolve metals, we witness a genuine transformation. The colloidal state is broken down and all that remains is a thin, streaming liquid. We let that solution cook a long while. During the cooking we take out two samples at intervals. We add potassium iodide to one sample and the Fehling's liquid to the other. What we observe is how starch gradually transforms to sugar: the longer the solution is cooked, the less reaction to potassium iodide and the more reaction to Fehling's liquid.

This process is also used on an industrial scale. After removing the acid the sugar is cleaned and steamed and sold in stores as glucose, dextrose, sugar cane, and so forth. Before we leave the starch theme, we create a starch by finely grating the potato. The grated potato mass is mixed in a beaker with water and set aside for a while. At the bottom of the glass lies a fine snow-white powder—potato starch. This is how simple it is to create potato flour industrially. We also spoke about making homemade alcohol.

Cellulose

Cellulose is also made from the plant's living sugar stream. Cellulose cultivates no grain as starch does, but chemically both are closely related. Everything that gives plants form is cellulose, from the finest nerve network in the flower and leaves to the fibrous stalk and down to the root system. The purest cellulose in nature is found in the plant's fruit hair, for example in the cotton plant or the bog grass. Flax also has a long tradition of application and is worth mentioning. The luster of a bundle of flax thread provides opportunity for many associations.

Cellulose has great resistance to chemical and mechanical stress. Therefore when all materials are removed by chemical or mechanical processes, leaving a pure cellulose, cell substance, this is a good base material for the paper and clothing industries. We took the time to describe a spruce tree's path from the forest to the piece of paper in front of us.

Cellulose is a substance that is eaten in large quantities without being nutritious. The grazing animals are able to digest cellulose. We notice how a plant's sugar stream is such a mighty transformer. But when a plant transforms sugar to cellulose it no longer can turn it back into sugar, as is the case with starch. A permanent, stiff substance is created.

A bit about perfume

Against the " hardening process" the sugar stream moves in a continuously finer and finer substance to the flower region and transforms the flower in color, pollen and scent. We should not resist touching upon the manufacture of perfume, as part of our study

The home of perfume is France, in particular La Province known as "The Garden of France," a sun-filled garden with excellent climate and protected fields where Catherine of Medici built a garden for making perfume. In this countryside the air has been filled with flower scents since ancient times. Endless fields of roses, violets, carnations, hyacinths, narcissi and mimosas—all of these leaves shall be made into perfume. The scents have since been reproduced in perfume manufacturer's laboratories to be made into clouds of scents that are sprayed all over the world.

Every month has its color. In the spring the violets spread out their beautiful violet blanket, followed by the Easter lilies' golden bells, and on and on! Early in the morning while the flowers are still wet from the mist the leaves are picked by hand upon the fields. They are placed in large baskets before taken to the factories where their valuable essence oils are extracted. It can happen in three different ways: distillation, transferring the essences to fat substances or washing out the essences through petroleumeters. Huge quantities of flowers are needed: 1000 kg orange flowers to extract 1 kg of essence, and 5000 kg of rose leaves to make 1 kg rose essence. The right distribution and mixture of the valuable essence is the great art and secret of perfume.

Albumen

Our next theme is albumen. This substance is specially related to living forces. It is natural to look first at chicken eggs and describe how the albumen that is inside the shell creates a new animal with all of its organs within three weeks. This albumen creates many processes that we know as feathers, neb and claws. If the teacher is able to describe such processes the following experiments will more easily guide the children into the secrets of this substance. What is special about this substance?

It is very fluid but not like water, a state between moving and hardness that gives it flexibility but keeps it from flowing away. Heating it up does not make it more pliable, but it becomes fatter, it becomes stiff, therefore it can carry so much life.

Fats and Oils

Fats and oils are the next step. Once again we begin with the world of plants. Fats and oils are created in the seeds, where lie the germs for new life. The oil from sunflowers, cotton and olives are well known to everyone. But how the oil is extracted by cold pressing, warm pressing or extraction and then used as food oils, animal food, and so forth, these are interesting topics for most students. Also in the animal kingdom among the warm-blooded sea animals, fats and oils are created on the periphery of their skins. The outer layers of fat support the inner warmth processes and protect them from the outside cold.

To understand what fats are, it is important to look at its consistency. Fat has its own form and does not crystallize in the transition from liquid to solid. Even when fat stiffens it retains flexibility with a smooth, butter-like consistency. Here warmth is at work as in no other substance; every heating or cooling raises or lowers the degree of flexibility and movement. Nowhere else in nature is warmth expressed in this way. The same is true for oils. For our study we choose experiments with practical uses in daily life: grilling with fat, oil in water, fat and oil meeting fire, and so forth.

Very characteristic for oil and fat is their relation with water—the substance where most life processes and chemical reactions take place. Fat and oil separate sharply from water by floating lightly on the surface. Even after you shake oil and water together vigorously, still the oil will separate from the water and climb to the surface and form a new cohesive layer. To the contrary fat and oil can dissolve in liquids such as gas and ethers, liquids that ignite readily, but do not mix with water. We also discussed how to make butter, margarine, candles and soap.

Ninth grade

Now the children are in the middle of puberty. They are not only physically mature but they are slowly becoming mature in their lives on earth. If you choose to help young people find a healthy development you must awaken interest and engagement in the world. Teens have enormous interest and take much enjoyment when they deepen their understanding of everyday things. The role of a teacher is not to give them certain opinions but to be as objective as possible when he shows them where the problems lie. A teacher can support the students with the opportunity to figure it out themselves. Alcohol and the arms industry in relation to Alfred Nobel are good themes to address at this stage. A natural starting point for this block is:

Photosynthesis

When we study carbonic acid assimilation, we introduce transformational processes that provide a basis for plant life, animals and human beings. It is called photosynthesis. Jan Ingenhouse, the man who discovered photosynthesis, described it accurately in his treatise of 1779. His title was: “Experiments upon Vegetables discovering their great Power of purifying the common Air in the Sun-shine, and injuring it in the Shade and at Night.” He said:

> I registered that the plants do not clean the air, as [Joseph] Priestley claimed; first after six to ten days, but that they complete this valuable process within a couple of hours. The origin does not take place in the plant’s growth, as Priestley stated, but in the influences from the sunrays. I found that plants have a remarkable ability to transform the air taken up by the atmosphere into truly oxygen- rich air. This cleaned air flows continuously from plants and enables the atmosphere to support life. The lighter the day, the more the plants receive sunlight and the faster the process continues. Plants that stand in deep shadows do not meet the prerequisites for cleansing the air; they give off destructive air that disturbs the atmosphere. Not all parts of the plants can clean the air, merely leaves and the green stems. Bad-smelling, poisonous plants have the same ability to clean the air as healing plants. The strongest, oxygen-rich air streams from the underside of leaves. All plants pollute the air at night.

This theme provides an excellent educational moment, a concrete starting point for looking at a mysterious process that the children can penetrate. We are at the core of pollution and ecology. We realize that pollution cannot be stopped easily or quickly but must be addressed through a new way of thinking.

We try to demonstrate how photosynthesis and breathing take place and how the gases relate to each other. If you breath into a glass with a limewater solution, we can prove carbonic acid in our exhaling as the limewater becomes paler. We revisit our experience of carbonic acid from the seventh grade.

We demonstrate the plant's ability to develop oxygen in sunlight by using water plants. The oxygen that is developed underwater is collected in a funnel with a rubber hose and a clamp. The collected oxygen is proven with a glowing woodchip. We also revisit our experience of oxygen from the seventh grade.

It is useful to draw a plant that stands between heaven and earth, surrounded by air. From the root water is taken in with a certain amount of salts that stream through the stalks and into the leaves. In the heavenly part of the plant carbonic acid is taken in by sun forces. There are also starches and sugar in the leaves. Now is a good time to present a simple formula. Photosynthesis can be formulated as: Carbonic acid plus water gives sugar and oxygen.

A glowing woodchip is held over the vessel with limewater. It fades. Therefore: carbon and oxygen become carbonic acid. But in the plants the opposite takes place: carbonic acid minus oxygen gives carbon. Yet we find nothing black in a plant, no hardened carbon, but rather starch grains and dissolved sugar that are flexible, moving, life-giving substances. Sugar is created by carbon and water; we call it carbon hydrate. It is living and moving carbon. Carbon plus water gives carbon hydrate. In other words, air is the plant's coalmine.

We should also take a look at sugar combustion within the human being. It is the opposite of photosynthesis. We take in sugar and oxygen and breath out carbonic acid and water. Sugar plus water gives carbonic acid and water. Sugar and starch were already characterized in the eighth grade, and now we can approach these substances more scientifically. From this starting point we can visit many new areas of chemistry.

Alcohol

To demonstrate the fermentation process from sugar, we begin by making a "composition" that is then set aside. In the meantime we make experiments to see how the mixture emits carbonic acid during fermentation and a special smell appears. How do you separate the alcohol? With heat and an ingenious apparatus, we can separate out different substances from a mixture by converting each liquid into steam (gas form) and then cool and condense it to liquid again. This is distillation. I explain how we can make alcohol starting with starch from potatoes or grain. The starch must first be changed to sugar, as we learned in the eighth grade.

Wine grapes provide an alternate starting point for making alcohol. First the grapes should be described in detail. We are told that if you cut a grape vine at the root, a waterspout can be sent thirty yards in the air from the pressure the plant creates at the root. When you tell how much warmth the plant demands, that the farther south it grows the sweeter it becomes, you understand the polarity that is united in these grapes; namely fire and water. If you let grape juice ferment, carbonic acid will be emitted and the sweet taste gives way to a strong, burning taste. Sugar becomes alcohol and carbonic acid.

Here is short description of how alcohol works in the human body. Sugar is taken directly into the bloodstream; only the liver can regulate the percent of sugar. Alcohol skips past the liver so that the alcohol spreads throughout the entire body. The basic sugar in the body that allows for harmonious body control and willpower is replaced with alcohol and a false feeling of body control without our abilities being improved. Instead of a peaceful warming effect, a condition for exaggeration takes place. One becomes weak in personality and self.

In the classroom we can experiment with alcohol. Its motion and ignitability plus the unlimited dissolvability in water are characteristic.

Sometimes pupils prepare arguments for and against the use of alcohol. As they are immune to moralizing, it is often more effective to approach the issues of alcohol abuse from the insights they have gained in chemistry. What does the abuse mean for the individuals, families and society as a whole? Can the problems be solved with stricter laws or higher costs for alcohol consumption?

Our experiments can take their understanding of alcohol to another level. A fermenting mixture of alcohol with potassium oxide produces ether. The ether has both increased movement and ignitability, but the dissolvability is reduced. We know how the ether works on people from ether narcosis. While the self is weakened under the influence of alcohol, it is shut down completely by ether narcosis.

It is important to record the alcohol tables in order to characterize the various types. Other tables such as plant acids, fat acids and their salts can be written down and learned by heart.

The chemical industry: Alfred Nobel

Our study of fats and oils is a continuation of the eighth grade study. In the ninth grade we approach industrial production and uses of margarine and soap.

We can obtain fat acids and glycerin when we separate fats. Glycerin leads us into the study of explosives. Alfred Nobel's discoveries and adventurous biography are valuable resources. We describe his greatness, all-sidedness and noble character and also his deeply problematic endeavors. He was split between mind and heart. The work he did with glycerin paved the way for new weapons while his heart protested against the use of weapons. From him we learn about the concept that remains in our modern times: prevent war by developing weapons! The revolutionary character of dynamite as used in great tunnels casts a dark shadow over the Nobel Peace Prize when you realize that the prize money comes from the weapon industries.

By treating fatty acids and their salts we learn about stearine acids and their salts that produce light. Stearine candles have a long history and their development is worth describing. We burn our candles and enjoy the atmosphere but few realize how much work went into the easy-burning, drip-free object. Notice how the wick bends away from the flame's area. Therefore it burns out and disappears on its own. This was designed a hundred years ago by weaving together three threads but allowing one thread to be shorter than the others. The teacher can refer to Michael Faraday's book, Lectures on the Chemical History of a Candle, a series of lectures given at Christmastime in 1860 to a group of young boys and girls. Faraday teaches us how to observe.

When we learned about fat and oil we also discussed crude oil. How the oil is brought out of the sea is a theme that excites ninth graders. It is processed at huge refineries, where distillation technology has reached it high mark, a technical triumph. In the tall, distillation towers crude oil's various components are conducted to different zones according to their boiling points. We are familiar with these products from everyday life: gas, petroleum, heating oil, lubrications, Vaseline (petroleum jelly) and asphalt. We are dependent on all of these products, and now is an appropriate time to talk about responsible use.

We have seen a few moments from chemistry lessons in the seventh, eighth and ninth grades. We can conclude that lessons are most successful when they relate to the themes and challenges with which the students are familiar. Because chemistry is a large part of everyone's daily life, our main lessons can quickly