The Chemical Reaction; It's a Burgh Thing

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Contents of Unit

Overview

The thrust of this high school unit will be learning about chemical reactions in a historical context from an ethical perspective. It presents an integrated approach to the study of chemistry; an approach at once longitudinal in time, historical in content, and ethical in reflection. The unit begins in traditional sense; studying the chemical equation as a symbolic representation of the chemical reaction, balancing the equation, and classifying chemical reactions as to type. Special emphasis will be given to the combustion, oxidation-reduction, and decomposition reactions; to their resultant technologies; and to the roles these played in the history of Pittsburgh. The values that governed the use of these chemical reactions and technologies will be examined, as well as their effect on the lifestyle in Pittsburgh. The unit will attempt to create an empathy for those who willingly or unwillingly lived, and may still live, in the shadow of these reactions and technologies. High school students participating in the unit will engage in a "conceptual footprinting" exercise, designed to build an awareness of the resources and energy necessary for production of objects Pittsburgher's use in their daily lives.

The unit can be used in its entirety or as enrichment material. Any of the three major reactions studied could serve alone as a historical and an ethical extension of the regular chemistry unit on chemical reactions. Though designed for the chemistry classroom, this unit is relevant to earth science, environmental science and also general science. It crosses the curriculum into the social sciences and philosophy, emphasizing ethics, the values which govern decision making.

Rationale

Chemistry....The study of the structure and the properties of matter and the energy changes which matter undergoes is an integral part of the science curriculum at all Pittsburgh Public High Schools. Chemistry has played quite an influential role in the history of Pittsburgh, as chemical reactions shaped much of Pittsburgh's development. Anytime humans make use of their environment, anytime they observe its properties and attempt to use these properties to their advantage, then either deliberately or intuitively, they are using chemistry in their daily lives. Pittsburgh provides an excellent "historical reaction vessel" in which to study chemistry, because decisions concerning how and why to use the structure and properties of matter occurred daily in its development. Although humans in Pittsburgh may not have used the properties of matter and energy (their environment) any differently than the humans in either Europe or other places in North America, Pittsburgh is easier to study from a historical perspective than the former and of more local interest to our students than the latter.

Pittsburgh makes a good region to study because although by the late 1780's or 90's many European towns and cities were already well developed, Pittsburgh can be studied from its infancy as it had but, "36 log houses, one stone house, one frame house, and five small stores," according to the *Niles Weekly Register* for 1786. (Lorant 52). Pittsburgh's development, paralled by other growing regions across North America, can be studied as a "mircrocosm" typifying how humans interact with the environment at their disposal; how they decide what matter to alter and what energy to trap. It shows at what point humans begin to significantly alter their surroundings and at what price.

Section One of this unit begins like most units on chemical reactions. The symbols used in chemical equations and how chemical equations are balanced will be studied, because having a clear understanding of how chemical reactions affected the history of Pittsburgh means that the student can read and interpret the chemical equations which stand for these reactions. After basics are mastered, chemical reactions will be classified as to type. The following reaction types and their identifying characteristics will be studied, along with a brief preview of the significance of each reaction type to the history of Pittsburgh; the *synthesis reaction*, used to make the acid and basic anhydride refractory surfaces found in Acid or Basic Bessemer converters; the *decomposition reaction*, used to make coke from coal; the *single replacement reaction*, responsible for removing heavy metal impurities into the waste slag during iron and steel production; the *double replacement*reaction, responsible for the effectiveness of acidic or basic slags in the refining of steel ; *the combustion reaction*,especially the combustion of coal, responsible for warming homes and powering industry in the Pittsburgh area; and the *oxidation-reduction reaction* (called the redox reaction for short), responsible for the removal of iron from its ore. The combustion reaction, the redox reaction, and the decomposition reactions will be the focus of the unit. However, the other reaction types mentioned above also play a part in the intermediate processes of the industries being studied and are likewise included in the unit. Knowledge of various reaction types lays a basis for understanding the products of these reactions and for understanding the effects that these products had on the Pittsburgh environment and lifestyle.

At relevant points in this unit, students will be asked to reflect on philosophical material selected or paraphrased for use in high school. The philosophical material will include three dominant views of Nature; "Other," "Resource," and "Community"(Aiken, "The Values Issue"). Students will be asked to reflect on such concepts as "the real and the surrogate world," and "the land ethic," ideas drawn from The Green Reader: Essays Toward a Sustainable Society, when these apply to the effects of the chemical reactions or technologies being studied. Such material is included in the unit to make students begin to think about what "guides" human's decisions concerning the use of chemical reactions and their applied technologies. All technology is carried out in the framework of some outlook on Nature; this viewpoint must be expressed before it can be changed for the better. As students discuss the viewpoint of Nature that dominated the use of chemical reactions by most industries throughout Pittsburgh's history, it will become clear that by far the view of Nature that has prevailed to date has been the RESOURCE view; things only have worth if they further the human purpose or lifestyle! Any unit that studies the effects of chemical reactions and their use would be remiss if it didn't attempt to identify the underlying philosophy that guides that use.

Section two of the unit involves the study of three chemical reactions that have had major importance in the history of Pittsburgh. The first reaction to be studied in historical perspective is the combustion reaction; specifically the combustion of coal. Before focusing on the combustion of coal, the combustion reaction in general will be reviewed. Example combustion reactions using a variety of hydrocarbon fuels will be balanced; employing fractional coefficients if need be. The thermodynamic properties of combustion reactions will likewise be studied at this time. Bond energies, particularly the energy involved in the breaking and forming of single, double, and triple carbon bonds, will be calculated as a basis for understanding the mechanism by which energy is being released during the combustion of fossil fuels.(Masterton 97-99). Based on this knowledge of how the energy in carbon bonds is released during the oxidation or burning of a hydrocarbon fuel, the thermochemical equation will be introduced; as will the concept of stoichiometry; using the balanced equation to solve problems. Those who teach chemistry will notice that it is customary to teach thermodynamics and use of the thermochemical equation as a sequel to the chapter on stoichiometry, not as an introduction to it. However, since the classification of reactions by type, including the combustion reaction, is normally included with the study of this unit on chemical reactions(directly preceeding the chapter on stoichiometry), the combustion reaction in thermochemical form can just as well serve as a springboard for teaching the use of the chemical equation in solving problems, rather than being a final application of it. Simple problems using the combustion reaction in thermochemical form will be solved for the amount of heat in J or kJ, cal or kcal, released by a given amount of hydrocarbon fuel. The mole concept, studied just prior to this unit on chemical reactions, will be applied because students now know that the balancing coefficients on an equation stand for moles; therefore the balanced combustion reaction in thermochemical form provides practice working with mole ratios that include the heat absorbed or released during the reaction in J or kJ(Masterton 113-115).

The study of the combustion of coal and the nature of coal as a hydrocarbon fuel is now emphasized in the unit. Just as different types of hydrocarbon fuels contain different types of carbon bonds and release different amounts of energy when they burn, so the energy released by all coals is not the same, but varies with coal type. It is appropriate then, when studying the combustion of coal, to discuss the origin of coal as a fossil fuel and to note the processes which formed the characteristic grades of coal. Both factors determine the amount of heat energy derived from the combustion of certain coals, and the type of by-products and waste products that result from these combustion reactions. All coals, basically, are solid, carbon-rich, dark-colored materials found in stratified layers in many parts of the world. However, coals include a rather broad range of substances that vary greatly in their carbon content, depending on the degree to which the coal has undergone the process known as coalification. Lignites are low-rank coals with low coalification (concentrated carbon content) and high moisture and volatile material content; whereas anthracites are high-rank coals with high coalification and low moisture and volatile material content("Coal." 3: 408).

Two great eras of coal formation are known in geological history. The older era, which extends from the lower Carboniferous to the Permian Period, or from 345,000,000 years ago to 225,000,000 years ago, is usually called the Anthracolithicum era and gave rise to enormous deposits of some of the earliest and most carbon-rich coals. A second era of coal formation, which is qualitatively less important than the Carboniferous, commenced in the late Cretaceous, about 70,000,000 years ago and reached its peak during the Tertiary Period, from about 65,000,000 to 2,5000,00 years ago and gave rise to nearly all lignites and brown coals or low-carbon coals. It is important, however, to note that not all older coals are high rank coals. Beyond the lignite stage, time does not seem to account for the degree of coalification in coals. Some of the oldest coals are the low-rank brown coals found in the Moscow Basin and laid down during the Lower Carboniferous Period. These coals, however, stemming from the earliest Anthracolithicum era, were never very deeply buried (408).

The extent to which a coal has undergone coalification determines the rank of the coal and the degree to which it will be it useful in combustion reactions and as a fuel for steel and coke production.The factors that contribute to coalification are not entirely understood, and there is disagreement over the extent to which each of these factors plays a role in coalification. It is known, that coalification began during the Lower Carboniferous Period when widespread, uninterrupted swamps, covered by vast expanses of stagnant water that favored the transformation of vegetable debris (humus) into peat below their surface, subsided at different rates and formed extensive sunken areas called geosynclines. Eventually these sunken swamps became totally submerged and were covered with sedimentary deposits so that future coal seams were formed. These sunken peat bearing strata were worked on by the biochemcial action of bacteria in varying degrees (which some contend is the reason for the different amounts of coalification in various coals) and at first lay in a horizontal planes. Shortly after their formation, these deeply buried strata were exposed in many places to the process of folding and faulting (orogenesis.) As these seams increased in coalification or carbon content, the tectonic forces that afterward acted on the earth's crust were not capable of refolding the stiffened Carboniferous strata and great, long faults developed in the coal seams. Most coal experts feel that neither tectonic forces nor bacteria acting on the coal seams had an appreciable effect on coalification.("Fuels." 19: 603).

Though coalification continued in many of these seams, only a general relationship seemed to be at play in the peat-lignite-bituminous-anthracite coalification series. To attribute overburden (the weight of the rock overlying the coal seam) alone as the cause of coalification, does not give a complete explanation; but overburden does, however, have an effect on the density and the porosity of the coal under it; especially the moisture content. "Pressure above the seam" is not likely because there is a lack of correlation between coal rank and the intensity of tectonic movement; a type of pressure on the seam exerted by the earth. The majority of investigators seem to feel that it is the temperature in the coal seam that is the most influential factor when accounting for coalification. Normally, the earlier these seams were buried, the deeper they were in the earth, where the temperature gradient increases at a rate of 1 C per 30 m (1 F per 55 ft.). Higher rank, high carbon anthracite and high rank bituminous coals that are near the surface now, most likely were pushed there by later movements in the earth's crust, and were probably at one time buried at great depths where the temperature is much higher than on the surface. (603).

The classification of coal by rank, which was formulated by the French chemist Henri-Victor Regnault in 1837, is based primarily on the amount of volatile matter in the coal. Volatile matter is easily vaporized material, and the rank is based on the amount of weight lost when the coal is heated at 950 C (1750 F.) The lower the amount of volatile material in the coal, the higher its carbon content and the higher its rank. Coals with less than 8% volatile matter are called anthracites. Coals with 8% to 14% volatile matter are called semi-anthracite coals or lean coals. Coals that contain 14%-20% volatile matter are called low-volatile bituminous coals in the US, and coals that contain 20%-30% volatile matter are called medium-volatile bituminous or real coking coal. Coals with volatile matter above 30% are lower coals that are classified according to caloric content as well as volatile content. They are, in decreasing order of rank; high-volatile bituminous, sub-bituminous, and lignitic coals. At any rate, the higher the rank of coal, the lower the amount of volatile material that will escape upon combustion, the greater the amount of pure carbon left behind as a concentrated carbon fuel, and the greater will be the energy released as it burns (599-600).

A few other factors are also associated with coal rank. Many coals have a high reflectance, that is, reflect light from their surface, and the degree of this reflectance increases with coal rank. Different coals also exhibit different electrical properties, and coals increase in their semiconducting properties with increase in coal rank. Hardness and magnetic properties also increase with coal rank (601).

Just as important to the history of Pittsburgh as how the coal seams were formed, and how coals are ranked, is the close location of massive coal seams to the Pittsburgh area. Great coal deposits in North America and Europe were laid down during the Anthracolithicum era; some accumulating formations 3 miles deep! One example of an extensive geosyncline that was formed during the Carboniferous Period in the area known now as the eastern part of the United States is none other than the famous Pittsburgh Seam; a coal seam centered over the Pittsburgh area which can be mined over an area of 21,000 sq. km, or 8,000 sq. miles!! Its position in the Pittsburgh area made advantageous the location here of iron, steel and many other industries that depended on this readily available hydrocarbon fuel for an energetically favorable and cheap combustion reaction, and gave rise to the large coal extraction industry, coal mining, that fed the need for coal in industrial Pittsburgh (602).

In keeping with the theme of the unit, the study of chemical reactions in historical perspective (a "Burgh thing" is a "tradition"...which itself implies something of historical dimensions) it is necessary to examine the "effects" of the combustion reaction on the Pittsburgh environment and lifestyle. The effect of this reaction on Pittsburgh's history is, of course, of great renown! Though there was little smoke from industry in the Pittsburgh area before 1793, when the first blast furnace for turning out "pig iron" was built in what is now Shadyside,(Lorant 70) the pioneers and native Americans and European soldiers and settlers had been digging readily available coal from the ground near their dwellings since the mid-1700's; burning it for domestic warmth. Coal was plentiful in the Pittsburgh hills and made an excellent fuel...and a real mess; generating clouds of smoke, particulates, and noxious gases right from the very beginning of Pittsburgh's history. By 1817, Pittsburgh had acquired the reputation as the "smoky city." The combustion reaction was (and still is) a real "Burgh thing," as long as there has been a Burgh! *Darby's Emigrant Guide for 1818* complained, "The constant volume of smoke preserves the atmosphere in a continued cloud of coal dust."(Lorant 79) Continuing on throughout Pittsburgh's history, the combustion of coal not only heated homes, but powered the steamboats and later the railroad trains, provided heat energy for a variety of industries, produced concentrated coke used in the steel industry, produced coke by-products such as coal tar and town gas (used temporarily for lighting the streets of Pittsburgh), and rained particulate black dust down upon every white sheet hung out to dry and every white shirt put on that morning from the mid-1800's to the mid 1900's!

The opinions of Pittsburghers concerning this smoky state are included in the unit as part of the "effects" of the combustion reaction on the history of the region. Anecdotal accounts from the early 1800's typifying these opinions and attitudes toward smoke laden Pittsburgh will be included. It is important to realize that not all citizens at that time disliked the smoky atmosphere. Some austere Presbyterian Scotch-Irish citizens actually saw it as a sign of thriving industry and as a confirmation of the strong work ethic so characteristic of Pittsburgh's inhabitants. Yet not everyone in Pittsburgh was in complete agreement with this point of view. As early as 1804, a contingent of Pittsburgh citizens complained that the smoke arising from the burning of bituminous coal by blacksmiths had become a public nuisance!("The History of Smoke Nuisance and of Smoke Abatement in Pittsburgh." 352). The controversy continued, often portrayed as a tension between the more gentile class of Pittsburghers and those who embraced the growth of industry. James Parton, in his 1868 *Atlantic Monthly* article, "Pittsburg," states, "No dandies could live in Pittsburg because yellow kid gloves would not stay clean." (17-19) Yet Parton also goes on to say in this same article that no matter how much Pittsburghers claim that smoke is the salvation of their economy and a matter of Pittsburgh lifestyle, nevertheless, many Pittsburghers had begun moving out to surroundings villages in order to experience life outside the smoky city!(Parton 20,22). This two-sided attitude toward the results of the combustion reaction, smoke, carried on throughout the next two centuries, and is in itself a historical characteristic of the history of this reaction in Pittsburgh. In the early 1900's, when the Pittsburgh Survey decried the particulate matter in the air, mostly the result of the steel industry, others were beginning to claim that the particulate matter was of no extreme danger and was not at all the origin of disease, but was rather a sign of a booming industry (Holman 104-122).

Yet it was not industry alone that was the source of the "smoky" problem! When too many citizens were burning the low-rank coal in their homes, the air was more polluted from domestic heating than from industry! Laws were then enacted to require Pittsburgh inhabitants to burn only higher-rank coals.(Tarr 563) Thus the "environmental effect" of using the combustion of coal in Pittsburgh had as much to do with the grade of coal which was being burned for domestic warmth as it did with uncontrolled industry. In balanced historical perspective, the unit will expose students to the many-faceted "combustion reaction effects" controversy because this controversy is part of the history of the combustion reaction in Pittsburgh.

The study of the use of the combustion of coal in Pittsburgh history will conclude with reflection upon which view of Nature seemed to govern the use of this reaction. Certainly the view that Nature is "Other," that it is an object of reverence or a spiritual entity, was hardly evident in the behavior of the majority of Pittsburghers. Except for the Princeton-educated lawyer, Hugh Henry Brackenridge, who came to Pittsburgh in 1781 and fell so in love with the area that he talked about the "sprites" who played on the rivers stating, "There is not a more delightful spot under the heaven to spend any of the summer months than this place,"(Lorant 52) most other Pittsburghers had no trouble digging the coal out of the hills and burning it incessantly! Nature, it appears, to the most people in Pittsburgh, was a "Resource," a place filled with materials to meet human needs; coal being one such material. Nature also provided the "sink" that was to absorb the constant volume of smoke generated by industry in Pittsburgh. Nor was the Community view of Nature dominant, as Pittsburgh was infamous for passing all its waste products, from smoke to pollutants dumped into the river....down stream.

The second reaction to be studied in this unit that had a great an impact on the history of Pittsburg is the oxidation-reduction reaction; the type of reaction responsible for the reduction of iron from its ore. Long before 1200 BC, the date of the beginning of the iron age, humans noticed when iron-containing rocks were in the presence of a very hot part of a fire and in contact with some type of carbon fuel (particularly charcoal, a concentrated carbon product resulting from the partial destruction of cellulose or wood), that a molten metal, iron, would come out of the rock.("Industries, Extraction and Processing." 21: 361) This process, carried on for centuries, was the basis of the blast furnace method of removing iron from its ore (hot, air-rich flame with charcoal present.) The history of iron production in Pittsburgh began when Alsace-born George Anshutz established the first blast furnace at Shadyside in 1793; however, it was not profitable because the iron ore had to be transported over the mountains to Pittsburgh. Though the next foundry in Pittsburgh was not established until 1805, the surrounding countryside area was studded with about 11 such furnaces that were turning out nails, shovels, frying pans by 1800. (Lorant 55,70.) And from this time onwards, the iron industry in Pittsburgh grew steadily; Zadok Cramer's *Almanac for 1803* valued Pittsburgh's total iron output at $56,548; eight years later in 1810, the U.S. Census reported Pittsburgh's total iron output at $94,890; and by 1839 making iron was the principle industry in Pittsburgh. In 1839, an engraving of a Pittsburgh ironworks appeared in *The Young Tradesman-The Iron Maker,* and the city produced $4,946,400 worth of iron that year.(Lorant 70,72,74,96.) It is no wonder then, with the advent of economical technologies for producing steel, the Bessemer converter in the 1860's and the open hearth furnace in the 1870's, that Carnegie and Frick choose Pittsburgh as the site for their steel industries.

Understanding how iron is obtained from its oxide form, its ore, is contingent on a grasp of the oxidation-reduction process. It is the carbon in the mix that gives up its electrons to the oxygen that is bound to the iron in the ore. The iron consequently receives its electrons back from the oxygen to which it was originally bound and it is reduced to pig iron (crude form of iron with fairly high level of impurities.) Unit participants can now apply what has been learned about the oxidation state of the atom and the hallmarks of a redox reaction to the steel making process.

In order to understand the technology of the iron and steel industry and their effect on the Pittsburgh environment, iron and steel making reactions are studied. Steel production begins with the reduction of crude iron from its ore in the blast furnace. The way a blast furnace functions will now be taken up in the unit. The different regions in the furnace and the chemical reactions characteristic of each region in the furnace are examined, with an emphasis on how certain reactions enable iron to be removed from its ore and how other reactions concurrently remove the waste products from the furnace. Actually, the blast furnace exhibits a very efficient use of materials. The waste products of the fire that heats it are simultaneously used as reactants in the processes of iron reduction and slag formation. The blast furnace, about 40 meters in height, is filled to the top with the "charge," a mixture of iron ore, coke and limestone. The limestone, which is principally calcium carbonate, CaCO3, undergoes thermal decomposition in the middle of the furnace at about 1000 C and then, because it is basic, combines with the acidic anhydrides (nonmetal oxides such as silicon oxide and phosphorus oxide) and amphoteric oxides (oxides which can function as either an acid or a base) removing these impurities into the slag. This slag is molten at temperatures in the blast furnace, and floats on the denser molten iron from which it is then removed. In addition, the decomposition of calcium carbonate gives rise to carbon dioxide, that is broken down into carbon monoxide near the bottom of the furnace at temperatures around 1300 C. This CO, carbon monoxide is what "reduces" the iron in the ore to pure iron metal, resulting in pure iron and carbon dioxide again. Even the "coke" fuel that is burning to produce the heat is mixed right into the charge and produces carbon monoxide that will go on to reduce more iron ore to pure iron. Such is the efficiency of the blast furnace and associated chemical reactions (Petrucci 676-678). While reactions in the blast furnace are being studied, sets of thermochemical equations and associated stoichiometry problems derived from these blast furnace reactions will be solved. Students will solve problems like, " Coke (pure carbon) is burned in a blast furnace to produce enough CO to reduce Fe from the ore Fe2O3. How many kilograms of coke must be burned to form enough CO to react with 1.00 metric ton of this ore?" (Masterton 82-83).

Once an understanding of how the blast produces pig iron has been gained, the processes used to convert pig iron into steel will be studied. Steel is an alloy of iron containing carbon as an essential constituent, with carbon content usually ranging from 0.03 percent to 1.5 percent. The three commercial classes of steel are; the "carbon steels", used in applications where steel must be shaped, such as in automobile bodies; "the low-alloy steels" which total 1-5% of other common alloying elements such as nickel, chromium, etc., used in applications where special properties are not desired, such as the production of machine parts, airplance gear, etc.; and "high-alloy steels", containing over 5% of at least one other alloying element, used for their special properties, such as resistance to corrosion in the stainless steels of tableware. Any alloy containing less than 50% iron is customarily not classified as a steel. Objects associated with different types of steel will be discussed in light of their chemical compositions.("Industries, Extraction and Processing." 21:365)

Steelmaking processes can be classified according to the furnace type used. Furnaces are classified broadly in terms of their shape and the way in which heat is provided. The open-hearth furnace has a broad, shallow hearth to contain the pool of metal and slag. Heat is supplied by a large luminous flame above the surface of the slag. Electric- arc furnaces also have a shallow hearth, but heat is supplied from arcs struck between graphite electrodes and the metal bath. The converter furnace is a pear-shaped vessel into which an oxidizing gas is injected. Heat to support the reduction process is supplied by the chemical reactions between this gas and the materials in the charge. At this point in the unit, the open hearth furnace, the Basic and Acid Bessemer converters, the electric arc furnace, and the basic oxygen furnace will be compared as to the thermodynamics and chemical reactions involved in their specific methods of steel production (369).

Of interest also when studying the various converters will be the flame that shoots out the top of a Bessemer converter furnace, above the "charge," during steel production, This is indicative of what reactions are taking place in the converter, with a light blue flame being the removal of contaminant metals from the charge and the bright red flame indicating that the actual reduction of the iron has begun. This red flame results when the coke is being oxidized , thus reducing the iron to pure metal and releasing massive amounts of carbon monoxide gas, CO, that burns in the surrounding air. When most of the carbon is burned out of the steel, the flame drops. Steelmakers operating the furnace learn to judge the carbon content of the steel and the temperature in the furnace just by the color and height of this flame (371).

The steelmaking process can also be classified as to the type of slag necessary to refine the steel and the type of refractory material used to line the furnace. Decisions as to slag and refractory type are an excellent application of acid/base chemical reactions and will be emphasized in the steelmaking portion of the unit. Basic slags, containing lime, CaO, and magnesia, MgO, are used when iron charges contain high levels of sulfur and phosphorus to be removed. Sulfur and phosphorus oxides are acidic, and can therefore be neutralized by these basic oxides in the slag and removed. This basic slag, however, will also attack and dissolve the refractory lining (brick lining) of the furnace if it is lined with an acid refractory surface, such as a silica surface (silicon oxides are acidic.) Therefore, the refractory lining of the converter used in the above case would have to be a basic refractory material such as pure magnesia, MgO, calcinated dolomite CaO-MgO, or lime. The type of steelmaking process used here is termed a "basic" process; so named for the type of slag used. This is also, however, the nature of the lining of the furnace used. It is prudent to use a refractory surface that has low solubility in the slag, ie., has the same acidic or basic character as the slag. The reverse, of course, is also true when an charge to be refined is basic in character, that is, contains a low level of phosphorus and nitrogen oxides (acid oxides) and a higher level of basic oxides. Then an acidic slag high in silica (silicon oxide) and low in lime is used. This is called an acidic steel making process, and the refractory lining of the furnace is then a silica refractory or acid refractory, chosen because it is the same as the acid content of the slag and will not be dissolved by it (396).

The "effects" of the iron and steel industries on the Pittsburgh environment, are both famous and infamous! One has only to take a walk over to Duck Hollow, where Nine Mile Run meets the Mon River, to view the heaps of slag looming along the edges of Beechwood Blvd. Surely any unit that emphasizes the effects of chemical reactions on the Pittaburgh area would be remiss without a study of the "heavy metal," arsenic containing slag heaps strategically placed in reasonable proximity to the huge blast furnaces that belched this waste night and day for years. In addition , the dangerous conditions to which workers were daily subjected as well as the environmental pollutants that resulted from the steel making process are part of the environmental legacy of the steel industry.

The "effect" of the steel industry of the on the lives of the people in Pittsburgh will also be considered. It caused the Pittsburghers (often immigrants) who worked in and lived beside the mills to "trade off" between a job and a safe, pleasant lifestyle for themselves and their families. Several readings from Thomas Bell's, Out of This Furnace, and a reworking of his short story, "Zinc Works Craneman to Wed," will set the tone for a feeling of what it would be like to live with these trade-offs on a daily basis. This is aptly expressed by Roy Lubove in this book, Twentieth-Century Pittsburgh: Government,Business, and Environmental Change, Vol.1 when, referring to the time of the 1908Pittsburgh Survey he states, "All the' progressiveness and invention' had gone into Pittsburgh the industrial center, and not Pittsburgh the community. One had only to compare the efficiency of the blast furnace in performing its function with the efficiency of the many houses in performing theirs."(p.10) The unit makes no attempt to cover up these trade-offs and glorify these chemical reaction technologies; but rather attempts to identify the "trade-offs" in hopes that chemical reactions will be used more wisely in the future by those studying the unit. When is economics valued over human lives and why?

Study of the oxidation-reduction reaction will conclude with reflection on the view of Nature that dominated the decisions made in relation to the iron and steel industries in Pittsburgh. Again, as with the combustion reaction, it will be evident that the "Other," view of Nature was hardly given any serious consideration by these industries. Massive amounts of iron ore and all the other materials that went into steel production were extracted at a hectic pace. The "Resource" view of Nature again dominated most decisions. The rivers and air were again used as "sink" resources; poisonous materials, both solid slag and gaseous vapors, were often dumped directly into the Pittsburgh environment, with industrial profit being the motivating factor. Certainly, as stated in Lubove's observation above, the idea of Nature as any sort of "Community" never prevailed at this time. More energy went into improving and making industry technologically profitable than into building any sort of community; environmental or otherwise.

The last major reaction type studied in the unit is the decomposition reaction. This reaction is responsible for carbonization; the reaction that converts coal to the concentrated carbon fuel, coke. Coke, or "processed coal," was known as an excellent fuel for blast furnaces from the 16th century onwards, when it became necessary to find a source of carbon to supplement the wood charcoal that was originally used in iron making. By 1709, coke was regularly used by Abraham Darby in his iron producing blast furnaces at Coalbrookdale, Shropshire, England, and he used it in production of the first iron bridge ever constructed; the Coalbrooksdale Bridge over the River Severn ("Industries, Extraction and Processing." 21: 457). Coke proved to be the best fuel for the blast furnaces of the steel industry in Pittsburgh, and coke plants sprung up in the Pittsburgh area as accessories to the steel industry.

The carbonization reactions that result in the destructive decomposition of coal have been the source of many chemicals in addition to coke. Carbonization, a type of pyrolysis, is a process whereby coal is slowly heated in the absence of air in order to partially or fully decompose it. While coal is undergoing this destructive decomposition, many impurities and commercially desired products are removed from it and the carbon content is simultaneously heightened. A carbon rich fuel, coke, results. The process was used as early as 1800 in England, and later in many other countries, to produce "town gas," a gas used to light the city streets; with coke being the by-product(457). A study of the products that come out of coal when coke is produced show the horrible effect that this industrial process has had on the environment in Pittsburgh. No matter how advantageous coke is to the steel industry, or how helpful town gas was for lighting the city streets, an environmental price was to be paid for the destructive decomposition of coal. The chemistry text, Dangerous Properties of Industrial Materials, by Sax and Lewis, will serve as a springboard reference regarding the characteristics of the chemicals that result from this decomposition. Listed under the title, "Coal Conversion Materials, SRC-II," these include "heavy distillate," "coal fly ash," "coal tar," "coal tar creosote," "coal tar dye," and "coal tar pitch." The text provides much information about the health effects of each of these chemicals. It provides an HR rating that indicates the relative hazard for toxicity; a NIOSH number, or the National Institute for Occupational Safety and Health's Registry of Toxic Effects of Chemical Substances accession number; a CODEN that represents a cited reference for toxicity data; a Reviews and Status section that lists such information as the IARC carcinogenic evaluations, the NTP carcinogenic tests status, EPA extremely Hazardous Substance List, the EPA Community Right-To-Know List, EPA Genetic Toxicology Program and the EPA TSCA status lines; finally OSHA PEL and NIOSH REL safe workplace levels are also given. Examination of data for the "Coal Conversion" products listed above shows that they are in most cases extremely toxic, carcinogenic or mutagenic. For instance, the THR for Coal Tar reads, "An experimental carcinogen by skin contact and an experimental tumorigen by ingestion. A human skin irritant. Human mutagenic data." (935-937).

Once the data about coke plant chemicals has been accessed, it will become obvious that the decomposition reactions giving rise to a good fuel for the steel industry also produced chemicals that were extremely toxic to the coke plant workers and to Pittsburgh's population in general. Beehive coke ovens were common in the Pittsburgh area by the early 1800's, and the excellent "coking coal" in the Pittsburgh area was a prime factor in the location here of the iron and steel industry. By the 1870's, Allegheny County's coke production exceeded that of all states except Pennsylvania, Ohio, and West Virginia! At these times, little attempt was made to trap the poisonous chemicals that came out of the coal during coke production.(Lorant 162-163.) It takes little imagination to determine the amount of deadly chemicals that were vented into the Pittsburgh atmosphere when the steel industry and its associated coke-making plants were booming! A Pittsburgher's lifestyle was one of constant exposure to fairly carcinogenic materials.

Modern coke ovens can be as large as 21 ft. high, 50 ft. long, and 1.5 ft wide, each holding up to 36 tons of coal to be "coked." These ovens are arranged in" batteries" up to 100 ovens each, and coke plants often contain more than one battery of ovens. They are highly mechanized and supposedly minimize atmospheric pollution, thus improving the lifestyle of those who must work in these plants and of the people who live beside them.("Industries, Extraction and Processing,." 21: 459) To give the feeling that the coke industry now must abide by stricter laws than at the century's turn and to make students aware of these regulations in order that they be knowledgeable about what currently affects their daily lives, current EPA regulations on carcinogenic industries such as the coke industry will be accessed from the EPA website (*http://www.access.gpo.gov/nara/cfr/cfr-table-search.html).* Learning from the history of these reactions helps citizens take an active part in ensuring a better environment in decades to come.

As with the other two major reactions studied, this part of the unit is reserved for reflection on the values that governed the decision of the coke plant owners and the steel industry to employ chemical reactions that were harmful to Pittsburgh's environment and population. When these values are discussed in light of the three ways of looking at Nature; the idea of Nature as a Resource again plays the dominant role. Nature, at the beginning of the industrial age in Pittsburgh when coke ovens spewed carcinogens into the environment, was never considered to be a"Web," an intricate connection in which waste from one human process could possibly be damaging to other human beings or animals! Nature was again considered the "sink" for all the wastes produced by human activities; a portion of the "Sole Value Assumption" that the environment is only useful if it provides a service to humans.(Aiken, "The Values Issues "). The toxic chemicals involved in coke production, as with the steel production wastes, would be taken away and "neutralized" by the atmosphere and the environment.

Another ethic implicit in the Resource view of Nature is a glorification of human ingenuity and inventiveness. Things in Nature only have value if they forward the lifestyle or the activities of humans. From the Enlightment onwards, and particularly during the early industrial age (late 1800's to early 1900's), there has been an entrancement with industrial processes and with human scientific invention, which often considers only the needs of the processes or the inventions, rather than their effects on the environment or the surrounding population. The coke industry and steel industry in Pittsburgh are classic examples of this way of viewing Nature. This ethic rises to a peak with the beginning of industrialization, when entrepreneurship was glorified. Nature was not at all viewed as "Other," a place that humans should revere or a place where humans do not belong. On the contrary, the more humans could use Nature for their inventions, or the more they could conform Nature to what they wanted, the more they were rewarded by the values of the day! Key thoughts from David Ehrenfeld's book, The Arrogance of Humanism, and reflection on the *Pittsburgh Press Sunday Magazine* article entitled, "Pittsburgh's Link to a Deadly Cure," will end this section of the unit; illustrating that the Resource view of Nature has dominated the use of all the chemical reactions studied.

The unit will culminate with a regular chemistry exam on chemical reactions; with a conceptual "footprinting exercise" that attempts to heighten an awareness of the "environmental connectedness" internally embodied in the objects around us; and with a project, either in essay or graphic form, that reflects on the use of one of these three chemical reactions in Pittsburgh to date, and projects how this reaction can be sustainably used to insure a better lifestyle for generations of Pittsburgher's to come. Hopefully, someday, the "Burgh thing" will encompass the view of Nature that is a "Community thing." (philosophically speaking)

Objectives

Upon completion of this unit, students should be able to define the chemical reaction and its relation to the chemical equation; balance various chemical equations and classify chemical reactions according to type. As an overall objective, they should be able to identify example reactions from the technologies studied for each type of reaction learned, and they likewise should be able to describe the role of these reactions in the technology with which they associate it. Students should be able to explain the major processes involved in each of these technologies and their major products and by-products The overall objectives associate directly with #1 of the Pittsburgh Public School Content Standards for Science and Technology, "All students explain how scientific principles of chemical, physical, and biological phenomena have developed and relate them to real-world situations."(that is, relate the reactions to specific real-world technologies) The objectives also relate to Standard #2, "All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological, and earth sciences."

As a specific objective, students should be able to identify and describe the characteristics of the combustion reaction. They should be able to predict the heat energy released by these reactions using the bond energies in hydrocarbon fuel; they should be able to solve thermochemical stoichiometry problems using combustion reactions; they should be able to explain the nature of coal as an excellent fuel, including the factors involved in coalification and the characteristics associated with coal rank; they should be able to describe the effect coal combustion has had on the environment in Pittsburgh and give examples from both sides of the continuing smoke controversy. These specific objectives not only associate with Standards #1 and #2, but also with Standard #7, "All students evaluate advantages, disadvantages, and ethical implications associated with the impact of science and technology on current and future life." and #8, "All students evaluate the impact on current and future life of the development and use of varied energy forms..." (The combustion of coal being a very important form of energy in Pittsburgh's past, present, and possibly future)

Another specific set of objectives are in like manner drawn from the study of the redox reaction and the study of the iron and steel industry technology. Students should be to define the terms oxidation and reduction, and they should be able to balance redox reactions; they should be able to describe the way iron was discovered and explain the function of carbon and heat in the reduction of iron from iron ore. Students should be able to describe how a blast furnace functions; specifically, they should be able to identify the main ingredients in the "charge" and the function of each. Students should be able to construct a model or draw a cross section of the blast furnace, identifying each region of the furnace, its temperature and the chemical reactions that go on in that region. This last objective connects with Standard #5, "All students construct and evaluate scientific and technological systems using models to explain or predict results." Students also should be able to describe the major furnace types for making steel. They should be able to apply acid/base chemistry to describe what type of iron is best refined by an acidic process and what type is best refined by a basic process.

A final set of specific objectives come from studying the decomposition of coal to produce coke. Students should be able to describe the carbonization process and give the products and by-products that result from coke formation. They should be able to use a reference manual, such as a Dangerous Properties of Industrial Materials, to obtain codes and associated reference numbers, learning how to follow-up on the "Right-to Know" information found in these. This objective matches Standard #3, "All students use and master materials, tools (a reference manual is a handy tool), and processes of major technologies which are applied in economic and civic life." In like manner, students should be able to access the EPA website in order to obtain information on the regulations that apply to the coke industry today. Standard #9 applies to this objective, "All students demonstrate basic computer literacy, including word processing, software applications, and the ability to access the global information infrastructure, using current technology." Students should be able also to demonstrate via a lab of their own design, how surface area affects the combustion of coal versus the combustion of coke, and why coke is favored over coal as a fuel and why it burns at such a high temperature in relation to coal. This fulfills Standard #6, "All students develop and apply skills of observation, data collection, analysis, pattern recognition, prediction and scientific reasoning in designing and conducting experiments and solving technological problems."

The unit is also designed to foster higher level thinking skills. Higher level thinking objectives include the following; The students should be able to describe effects of the reactions and technologies on the lifestyle of the people of Pittsburgh. They should be able to weigh the "benefits" derived from these reactions with the "liabilities" associated with them. Students should be able to discuss the "values" which governed the use of these reactions and the dominant view of Nature from which these values were drawn. Student should likewise develop an empathy for those who had to live in conditions imposed by the use of certain reactions over which they had no control.

For reactions still in use today, the student should be able to use higher level thinking skills to present an argument for or against the continued use of these reactions. They should be able to explain how the concept of sustainability applies to the use of these reactions; identifying any by-products or wastes generated by these reactions and listing any precautions or clean-up procedures necessary to insure a safe clean environment for future generations of Pittsburghers. They should be able to visualize a conceptual "resource and energy footprint" for objects in their daily lives and they should be able to suggest ways in which this footprint can be modified so as to sustain resources and energy for future generations.

Strategies

Information regarding the definition of, balancing of, and classifying of chemical reactions will be obtained via traditional classroom activities; inductive discussions bridging the gap, in keeping with good pedagogy, between what students have already mastered and what they will be required to know. Thus, the study of chemical reactions begins with a review of the structure of the atom, the Law of Conservation of Matter, and the modern version of Dalton's Atomic Theory. Reflection on what has been learned from these concepts enables students to conclude, as did Dalton that "Chemical reactions occur when atoms are separated, joined, or rearranged." This rearrangement of atoms is what is known as a chemical reaction, and drawing on the Law of Conservation of Matter, students begin to see that the atoms that participate in a chemical reaction cannot just disappear, but must reappear in the products of that reaction. Also, it is at this point that the term "chemical equation" is first introduced. All will agree that except for the heat and light at times generated by a chemical reaction, the rearrangement of atoms themselves during the reaction cannot be observed, therefore a symbolic means of recording the reaction is needed; the chemical equation. Observation of this symbolic form of the chemical reaction leads quickly to the conclusion that all chemical reactions must be "balanced," that is, all atoms must be accounted for on both sides of the equation. Following up on that conclusion, much practice is given to the students in chemical equation balancing; a practical application of the formerly learned conservation of matter concept; specifically leading to the idea of the "conservation of atoms." Students will practice balancing equations in small groups (so those who have mastered the skill of balancing can assist those who still are experiencing difficulty.) Eventually students will work on packets of equations to be balanced individually.

As an overaching theme for the study of chemical reactions in historical perspective, students will be introduced to the three dominant ways of viewing Nature. Before the first groups are assigned and the study of the combustion reaction begins, these three views of Nature and the hallmarks of each will be discussed. Following this philosophical introduction, students will be divided into small groups which they will keep for the study of each major reaction type. Each student will receive the outline presented at the end of this unit, "formatted" so that terms may be defined; processes outlined; notes on any topics for discussion recorded; ideas from brainstorming sessions listed The outlines will be due from each student at the conclusion of the unit, though the student may have completed it together with three different groups over the unit's duration. After each reaction and technology is studied, groups will reflect on which of the three views of Nature applied to the time period and chemical reactions and technologies just studied. Students will be required to cite specific examples of the philosophy of Nature which they feel is dominant in the part of Pittsburgh's history to which they are referring; or to the technologies to which they are referring.

Groups provide a good strategy for teaching the material in this unit because the reactions studied and their resultant technologies provide much information to assimilate and discuss. Work to be done and material to be studied can best be handled by a group dividing up the workload and pulling together the results of at the conclusion of the study of each major reaction and technology. The groups also function as good "nucleating centers" for reflection on the pros and cons of the uses of reactions and technologies studied, as well as reflection on any effects these may have on the environment and the lifestyles of the inhabitants of Pittsburgh at that time. The group arrangement is ideal for any lab exercises in this unit and for construction of the models and diagrams designed to help students understand in a visual and tactile way the function of the blast furnace. Groups can work together to lay out a large "concept footprint," with group members suggesting different connections and aspects that are part of the footprint. This is cooperative learning at its best! Lastly, groups provide a good atmosphere for "brainstorming" about solutions to environmental problems and for generating ideas that will lead to a sustainable use of resources.

Classroom Activities

Session One

The initial session of this unit will involve introducing students to the chemical equation as a symbolic representation of the chemical reaction. Activities in this first session are designed to familiarize students with the more common symbols used in equations and to make the students aware that only "balanced" equations accurately represent the chemical reaction. Begin the session by dropping several pieces of mossy zinc into a large test tube partially filled with 4M HCl. Immediately place an deflated balloon over the mouth of the test tube. (Prior to running this reaction, let several students feel the pieces of mossy zinc and the bottom of the test tube to insure students realize that the starting materials are at room temperature.) As the reaction proceeds, discuss with the class what they see happening in the test tube and list their observations as to evidence that a chemical reaction is in progress. Use this visual demonstration to "construct" the equation that represents this reaction in symbol form. Let students name the "reactants" which they just saw you put together, Zn and HCl. Write these to the left of the board. Next add the large horizontal arrow and explain that it represents "yields." Let the students brainstorm as to the products of the reaction, one of which, they can see from the balloon, is a gas. When hydrogen is decided on, write its symbol to the right of the arrow and emphasize this is the "product" side of the equation. The only two remaining atoms in the reaction are the chlorine and the zinc, which students can put together as "zinc chloride." This is also written on the product side and should be written in correct "electrically neutral" form as students have already studied chemical formulae writing. From this exercise, the students can see that the chemical equation is indeed a symbolic representation of an actual chemical reaction.

Visual inspection of this equation, however, will reveal that when hydrogen gas is written as a diatomic molecule and the correct formula for zinc chloride is written, the number of hydrogen atoms and chlorine atoms on the product is double that on the reactant. Drawing on a discussion of the Law of Conservation of Mass and what the students know about moles, the conclusion will soon be drawn that it takes two hydrogen chloride molecules on the reactant side to provide the atoms necessary to form the products on the product side. Thus the need to "balance" equations is a direct consequence of the Law of Conservation of Mass and atoms are conserved!

After these exercises, students first practice balancing equations in groups, with equations on the list given becoming progressively harder. Students end the session balancing equations from the book and from assorted worksheets on their own.

Session Two

In this session, students obtain a copy of the unit outline as given in the back of this unit. However, the student version will be much larger and more spread out, with room to write examples, define terms, etc. The five different reaction types on this outline are listed on the board. The student version of this outline does not contain the example reactions from industry. These will be added as the student studies each applicable technology. The identifying characteristics of each reaction type will be discussed, with a short demo of each type of reaction given (Simple examples of each reaction type can be found in the reference chemistry texts at the end of this unit.) Students will practice balancing equations and classifying them as to type through a series of worksheet exercises or from equations provided for that purpose in their chemistry text.

Session Three

Students are arranged in a large circle to facilitate discussion of the three views of Nature; "Other," "Resource," and "Community." Examples of all three views will be discussed, and each students that wants will given their own "personal" view of Nature which they hold at the beginning of this unit. No one view will be emphasized or discouraged at this time. Hopefully, all three views will be reflected by individual students in the class. (There just might be people who feel a supernatural communion with Nature; and ones who feel that it is perfectly ok to make Nature sink for everything from sewage to nuclear waste.) The student outline will have room to define these terms right on the paper and there will be room to write examples and other student's opinions down; as well as their own.

Session Four

Divide the class into six groups (preferably of four or less each.) Explain to the class they will be studying three reactions that have played important roles in the history of this region, Pittsburgh. To introduce the combustion reaction, its characteristic and thermodynamics, explain that the combustion reaction is the result of the combining of a fuel with oxygen (normally this fuel is a hydrocarbon.) Students are given a few moments to think with their groups about what the products of combustion reactions could be(as a hint, remind them that they themselves are little slow combustion reactions...the doughnut they ate for breakfast is being combined with the oxygen they breath in... the food is oxidized and the energy trapped as ATP to empower their muscles and they breath out....what???) Most students know that they breath out carbon dioxide, but many do not realize that they also breath out water (the other product.) Let the students fill in their outlines with some examples of the combustion of propane, butane, etc. and the resulting products, CO2 and H2O. Practice balancing these combustion reactions with them.

Give the students a list of "bond energies" for various single, double, and triple carbon-carbon bonds; also C-H bond energies, etc. Broken bonds require energy put in and formed bonds require energy to be released. Practice calculating change in energies across these reactions with bond energies.

Introduce the thermochemical equation; the chemical reaction with heat expressed in the equation. Practice with the students setting up "ratios" from the balanced equation; ratios that include the amount of heat released per mole of substances reacting. Use the combustion thermochemical equation to solve problems with these ratios; ie, to do stoichiometry. This will introduce the concept of stoichiometry prior to the next chapter, when it is normally introduced. Students practice solving these problems as a group at first. Thermochemical problems solved by the group should be recorded in each student's outline for later reference. Example thermochemical stoichiometry problems will be assigned on an individual basis for homework following this session.

Session Five

An introductory lecture on the history of coal in Pittsburgh begins this unit, with emphasis on the role coal has played as an excellent source of heat energy for both domestic and industrial use from the mid 1790's onwards. Notes are taken on the student outlines. Now the real group work ensues and students will stay with their same groups until they work on the combustion reaction is complete. Groups will divide up the topics that must be researched in this part of the unit; as indicted by their outlines; Coal Formation, including The Geological Periods of formation, the coalification processes and factors which affect this, and the Pittsburgh coal seam location and size. Groups may work in the classroom, in the library or at home, but they will have several days to obtain this information which will be shared first within the group and then presented by a representative group member to the class. Of course, outlines will be completed during all this research.

Session Six and Seven

Combustion of Coal Research Session (computers, especially net research, will be encouraged if available) will be carried out in session six and sharing of combustion reaction research with the entire class will be the focus of the first part of session seven. Following this, groups will be reading anecdotal accounts of the smoke controversy between different groups of Pittsburghers...one from the early 1800's, one from the mid-1800's, one from the early 1900's and one from the mid 1900's. These are discussed in the Rationale section of the unit and can be obtained from the references in the back of the unit under "works cited." Students discuss this controversy with their groups and practice writing down perspectives taken by both sides in the controversy.

Session Eight

To conclude the study of the combustion reaction, students groups discuss which view of Nature was dominant in the use of the combustion reaction throughout Pittsburgh's history. They list "examples" that illustrate whichever value they feel was dominant and why. These should be recorded in the student outline and a conclusion about the dominant view reached.

Session Nine

New groups are assigned. An introductory lecture on the oxidation-reduction reaction and the reduction of iron from its ore is presented. Student groups research the function of the blast furnace and each group will obtain the information as required on their outline. Groups will make either a 3-D model or the blast furnace or make a large color-coded cross section of the furnace on poster board; listing the temperature zones and the reactions that occur in each zone. This requires coordination of tasks and working as a team to make a coherent diagram or model.

Session Ten

An introductory lecture on steel, its composition and characteristics will begin this session.

The students view a video on the steel making process; which shows the various types of steel making furnaces and the processes that go on in each. The acidic and basic steel processes will be introduced in the film. Students will also be introduced to acid/base chemistry and a special form of the double replacement reaction; the neutralization reaction. This will help them in their group research on the various ways of making steel. Students work as a group to research the information about steel production as listed on their outlines, and also the effects of this industry on the Pittsburgh environment. Research will be done in the same manner as that on the combustion reaction, only with a different group.

Session Eleven

Groups conclude their research on steel production and report to the class.

Student groups now read together anecdotal accounts of life near the steel mills from Out of This Furnace They are asked to reflect on how these stories make them feel and they are encouraged to imagine what it would be like to carry your friend home from a mill accident; only to watch him die! Students today are surrounded by vicarious violence so they may not react as strongly as one would suspect. The group members will then take turns doing a dramatic reading from Thomas Bell's short story, "Zinc Works Craneman to Wed." One group will present this reading to the entire class, but a discussion will ensue as to all the sensory data that can be determined from this short story. How is the "atmosphere" created in this story? What does this story tell you about how people lived when the mills were active? How did people cope with daily pollution around them and danger in their jobs? Which line from the story affects you the most?

Sessions Twelve

Groups discuss again which view of Nature prevailed in the use of the redox reaction and in the iron and steel industries in Pittsburgh. This is a summarizing activity, but an important one. Again students record their thought and examples on each view in light of the discussion.

Session Thirteen

New groups are assigned. Students by this time know what is required of them in the research on the facets of the coke industry; they are to divide up the work and find the information on coke production as listed in their outline. This time let them even work together to find out the history behind the coke industry in Pittsburgh.

Session Fourteen

Half of the groups are given the reference text Dangerous Properties of Industrial Materials by Sax and Lewis. They are to look up the coded data on the various Coal Conversion Materials (produced when coal is converted to coke) and find this information in other documents to which they are referred. The other half of the groups will access the EPA website, looking for regulations on the coke industry,*http://www.access.gpo.gov/nara/cfr/cfr-table-search.html,* 40CFRSection63.300 to 313. The results of this research is at first reported and recorded within the group and then shared with the class.

Session Fifteen

This session will begin with groups again, for the last time, discussing which view of Nature is dominant in the coke industry. They will list examples to support their ideas. It will become apparent that most of time, the view of Nature as a Resource had dominated the use of chemical reactions throughout Pittsburgh's history. This awareness will lay the basis for the second part of this session.

The second part of this session will bring in reflection on several passages from David Ehrenfeld's book The Arrogance of Humanism. How does this explain the fact that the only real view of Nature that has been used in Pittsburgh's history is the Resource view? What laid the basis for this view in history? The teacher will then have "story time" with the class and read to them an article from the Pittsburgh Press entitled, "Pittsburgh's Link to A Deadly Cure." This article is about two turn of the century self-proclaimed entrepreneuers who started a radium refining plant in the Pittsburgh area. They were fascinated with the substance, and because of this fascination, they died of cancer and many of the workers in their plant did also. They contaminated a whole site near Canonsburg, PA, which today still remains the site of elevated cancer values and is still toxic. Students discuss in their groups how this story is an application of the Resource view of Nature and is an illustration of what Ehrenfled calls "The arrogance of humanism."

Session Sixteen

Groups work together to make a "conceptual matter and energy footprint." Given an object in someway connected to Pittsburgh...a pickle pin, a Heinz ketchup bottle, a can of Budweiser (empty of course!!), the groups brainstorm and connect all the matter and energy sources that went into the production of the object. Energy sources and resource sources are drawn relative to their size (a mine or a power plant a really large compared to a piece of steel.) If you start with the pickle pin...you can begin by "relating" the clasp to a steel fabricating machine that itself is made of parts made of other metals, all of which originally were transported from a steel processing plant by a truck that has tires that come from a tire making plant that requires the raw material rubber that is brought from forest reserves by another train or truck; the tire plant also uses energy to run so it is connected to an electrical generating plant which uses coal from a mine that covers a huge area to get the coal necessary to run the plant...and all these resources and energy go in to getting the pickle pin to you, and that is only part of the picture because the matter and energy path through the steel mill that made the steel in the pin (and that requires large expanses of iron ore to support it... huge mines) has not even been traced yet. These conceptual footprints get pretty big, so each group should be supplied with lots of paper and tape to keep connecting more and more energy and resources to the poor little pickle pin! Groups can color their footprints and decorate them anyway they see fit. Now if you say that this is not accurate because it only took a little bit of the energy or a little bit of resources to make just one pickle pin, that may be true empirically and theoretically...but it is not true in reality. No one will dig one little piece of iron ore out of the ground and fashion it into one pickle pin!! If these things were not produced en mass then they would not be profitable and they would not be made at all...so there you have it....things will be made en mass to make a profit; so one pickle pin only exists because a million can be made and that takes the energy and resources all implicit in one little piece of Pittsburgh, PA!

Sessions Seventeen and Eighteen

A chemistry exam on chemical reactions is given. Students will turn in their completed outlines indicating all the things they have studied and researched during the duration of the unit. Each student individually gets time to write an essay about or make a graphic representation of the use of one of the chemical reactions(or their associated technologies) in the history of Pittsburgh. The theme of the project is like the title of this unit; "The Chemical Reaction; Its a Burgh Thing" except the essay or poster or model should be two-sided; showing how the reaction was used in Pittsburgh's past, and how it can be used sustainably in the future.

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Appendix A- Unit Outline

The Chemical Reaction; It's a Burgh Thing

I. Basic Concepts

A. The Chemical Equation...symbolic representation of the chemical reaction

B. Balancing Chemical Equations

1. Conservation of Mass, Atoms

2. Coefficients as Moles

C. Reaction Types and Examples from the Unit

1. Synthesis... formation of Acid Anhydride formation of Basic Anhydride use; Acidic and Basic Bessemer converter refractories

2. Decomposition...Pyrolysis, coke production

3. Single Replacement... removal of heavy metals into slag

4. Double Replacement...basic and acidic neutralization reactions in slag formation; refining of steel

5. Combustion...of coal, as hydrocarbon fuel powering local industry

6. Oxidation-Reduction...removal of iron from ore

D. Views of Nature...philosophy guiding chemical reaction use

1. Other...Nature as a place to revere or to avoid

2. Resource...Nature as a material source and/or a sink

3. Community...Nature as an interactive net

II Chemical Reactions in the History of Pittsburgh

A. The Combustion Reaction

1. Characteristics

2. Thermodynamics

a. Bond Energies in Hydrocarbons

b. The Thermochemical Equation and Heat Calculations

3.The Combustion of Coal

a. Coal in Pittsburgh's History

b. Coal Formation

1. The Geological Periods

2. Coalification Processes

3. Factors Affecting Coalification

c. Location of Coal; the Pittsburgh Seam

4. Environmental Effects

5. Effects on Pittsburgh Lifestyle; The Controversy

6. View of Nature Dominant

B. The Oxidation-Reduction Reaction

1. Characteristics

2. History

3.The Blast Furnace

a. Construction

b. Temperature Regions and Associated Reactions

c. Charge Composition and the Reduction of Iron from Ore

d. Slag Composition and Removal

4. Steelmaking

a. furnace types

b. acidic and basic processes

1. acid/base chemistry

2. slag requirements

3. refractory lining requirements

c. the furnace flame and associated chemistry

4. Environmental Effects

5. Effects on Lifestyle; <u>Out of This Furnace</u>

6. View of Nature Dominant

C. The Decomposition Reaction

1. Characteristics

2. Pyrolysis; Coke Production

3. History of Coke Making in Pittsburgh

4. By-Products and Pollutants from Coke Production

5. Effects on Lifestyle

6. Environmental Effects

7. EPA Regulations on the Coke Industry

8. View of Nature Dominant

D. Conceptual Footprinting of Materials and Energy Related to a Pittsburgh Object

E. Project; essay or graphic

"The Chemical Reaction as a Burgh Thing....Pittsburgh's Past and Future"