Macomb Intermediate School District
High School Science Power Standards Document

Chemistry

The Michigan High School Science Content Expectations establish what every student is expected to know and be able to do by the end of high school. They also outline the parameters for receiving high school credit as dictated by state law.

To aid teachers and administrators in meeting these expectations the Macomb ISD has undertaken the task of identifying those content expectations which can be considered power standards. The critical characteristics[1] for selecting a **power standard** are:

- ***Endurance* –** knowledge and skills of value beyond a single test date.
- ***Leverage* -** knowledge and skills that will be of value in multiple disciplines.
- ***Readiness* -** knowledge and skills necessary for the next level of learning.

The selection of **power standards** is not intended to relieve teachers of the responsibility for teaching all content expectations. Rather, it gives the school district a common focus and acts as a safety net of standards that all students must learn prior to leaving their current level.

The following document utilizes the unit design including the big ideas and real world contexts, as developed in the science companion documents for the Michigan High School Science Content Expectations.

[1] Dr. Douglas Reeves, Center for Performance Assessment

Unit 1: Atomic Theory

Big Ideas

Order in the universe is exhibited through the location and function of subatomic particles and the likeness of atoms of individual elements

A strong force is needed to hold the nucleus together in all atoms.

Radioactive dating is the direct function of the timed decay of radioactive atoms.

Conceptual Understandings

Radioactive isotopes are used in the health fields to monitor internal bodily functions or to kill cancerous tissue.

Historical items may be placed in proper chronology using radioactive decay A process called radioactive dating compares quantities of an isotope present in the item with the same isotopes present in a contemporary item.

Half life of drugs in the body can be used in forensic science. Examples of half-life: caffeine, 4.9 hours; aspirin, 0.25 hours; nicotine, 2.0 hours; Bromide ion, 168 hours.

The large amount of energy available from nuclear reactions (fission in nuclear reactors, or fusion in stars) comes from the mass defect in atoms. Mass defect is the difference between the sums of the mass of individual particles in an atom (neglecting the electrons) compared to the actual mass of the same atom from the periodic table. The actual mass is always larger than the experimental mass whenever the nucleus contains more than one particle. The difference in mass (mass defect) is converted into energy that holds the nucleus together and can be released in nuclear reactions.

The chemical reactivity or stability of real world materials is based on the electron stability in atoms. Unstable or highly reactive elements are the result largely of outer electrons being lost or gained by neutral atoms. The noble gases for example are very stable and don't gain or lose electrons to other atoms under normal conditions and are used in light bulbs, deep sea diving, and between window panes.

Static electricity is the result of the outer electrons being pulled from or pulled to neutral atoms creating ions (the process that drives photocopying).

Ions are discussed in advertising about acid balance in living organisms, swimming pools, shampoos, etc.

Charged particles in a solution will allow current electricity to be conducted across or through the solution. Blood and other body fluids are able to transmit messages through electrical conductivity.

Common terminology in today's world is to refer to the relative comparison of facts (i.e.: a measure of one object relative to the same measure in another object)

Problems that are encountered in our daily lives are analyzed through the creation of models like scientists did with the atomic theory.

Power Standards	Additional Standards
C4.8A: Identify the location, relative mass, and charge for electrons, protons, and neutrons.	C2.5a: Determine the age of materials using the ratio of stable and unstable isotopes of a particular type. C3.5a: Explain why matter is not conserved in nuclear reactions.

C4.8B: Describe the atom as mostly empty space with an extremely small, dense nucleus consisting of the protons and neutrons and an electron cloud surrounding the nucleus. C4.8C: Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus intact. C4.8D: Give the number of electrons and protons present if the fluoride ion has a -1 charge. C4.10A: List the number of protons, neutrons, and electrons for any given ion or isotope. C4.10B: Recognize that an element always contains the same number of protons. C4.10e: Write the symbol for an isotope, X^{Z}_{A} , where Z is the atomic number, A is the mass number, and X is the symbol for the element. C5.2C: Draw pictures to distinguish the relationships between atoms in physical and chemical changes.	C4.7b: Compare the density of pure water to that of a sugar solution.

Unit 2: Periodic Table

Big Ideas

The periodic table organizes the known elements into periods and families with similar properties.

The periodic table is organized to display trends in the characteristics of elements.

The type of chemical bonding determines some characteristic properties of materials.

Conceptual Understandings

Ionic bonds form very strong bonds. They form salts like table salt, NaCl. They are brittle, and while they dissolve easily in water they have high melting points, they are nonconductors as solids and don't readily corrode (react with gases in the air).

Among the many covalently bonded compounds are: plastics ceramics/glasses, waxes, and common room temperature liquids and gases.

Plastic and glass are used as electrical insulators for power lines.

Glass can be made with special properties by adding different kinds of atoms to the glass. Adding cobalt makes glass blue; manganese makes glass purple, etc.

Corning Glass Company in 1912 found that by adding boron oxide to glass it became shock resistant to temperature changes (Pyrex).

Photochromic glasses (transition lenses in eyeglasses) are made by adding silver ions to the glass. The darkening is the result of the silver ions (Ag^+) converting to metallic silver (Ag) by picking up an electron. This color is lost again in the dark.

Glass that is very stable (doesn't react with other materials) is being developed to store nuclear waste material.

In physiology, the primary ions or electrolytes are sodium, (Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^-), phosphate (PO_4^{3-}), and hydrogen carbonate (HCO^{3-}).
Muscle contraction is dependent upon the presence of calcium ion (Ca^{2+}), sodium (Na^+), and potassium (K^+). Without sufficient levels of these key electrolytes, muscle weakness or severe muscle contractions may occur.

Today's sport drinks are packed with electrolytes (ions), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), and sodium (Na^+)

Power Standards	Additional Standards
C4.9A: Identify elements with similar chemical and physical properties using the periodic table. C4.9b: Identify metals, non-metals, and metalloids using the periodic table. C4.9c: Predict general trends in atomic radius, first ionization energy, and electronegativity of the elements using the periodic table.	C5.5d: Compare the relative melting point, electrical and thermal conductivity, and hardness for ionic, metallic, and covalent compounds. C4.10c: Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.

C5.5A: Predict if the bonding between two atoms of different elements will be primarily ionic or covalent. C5.5B: Predict the formula for binary compounds of main group elements. C5.5c: Draw Lewis structures for simple compounds.	C4.10d: Predict which isotope will have the greatest abundance given the possible isotopes for an element and the average atomic mass in the periodic table. C5.2g: Calculate the number of atoms present in a given mass of element.

Unit 3: Quantum Mechanics

Big Ideas

The emission spectrum of individual elements is always identical and can be used to identify the elements.

Electron transition within energy levels can account for a specific energy emission or absorption within atoms.

Conceptual Understandings

Fireworks produce specific colors because of the compounds used and the energy released when they burn.

Lighting, both commercial (neon lights) and highway or backyard lighting (mercury vapor or sodium) are a result of excited state electrons.

A rainbow is an example of a continuous spectrum being broken down into its different wavelengths as a result of rain droplets in the air.

Scientists can learn what stars are made of by observing the spectrum they emit.

The use of UV blockers in suntan lotions

Gas discharge tubes are used in UPC scanners

Photoelectric panels on solar houses, cars, and calculators

Aurora borealis (northern lights) or aurora australis (southern lights)

Power Standards	Additional Standards
C2.4a: Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions. C2.4d: Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy. C4.8e: Write the complete electron configuration of elements in the first four rows of the periodic table. C4.8f: Write kernel structures for main group elements. C4.8g: Predict oxidation states and bonding capacity for main group elements using their electron structure.	C2.4b: Contrast the mechanism of energy changes and the appearance of absorption and emission spectra. C2.4c: Explain why an atom can absorb only certain wavelengths of light. C4.8h: Describe the shape and orientation of s and p orbitals. C4.8i: Describe the fact that the electron location cannot be exactly determined at any given time.

Unit 4: Introduction to Bonding

Big Ideas

Chemical bonds form either by the attraction of a positive nucleus and negative electrons or the attraction between a positive ion and a negative ion.

Strength of chemical bonds can be measured by changes in energy that occur during chemical reactions.

Conceptual Understandings

In addition to NaCl, many minerals exist as ionic solids, such as pyrite (FeS_2), cinnabar (HgS), hematite (Fe_2O_3), fluorite (CaF_2), beryl ($Be_3Al_2Si_6O_{18}$), and barite ($BaSO_4$).

N_2 is an extremely stable and thus nonreactive substance. Fertilizers generally contain nitrogen in the form of ammonia or ammonium compounds because most plants cannot use the nitrogen out of the air (it exists as a stable N_2 molecule). The legumes and a few other plants are considered very important because they "fix" the atmospheric nitrogen into a usable form.

N_2 is used in the food industry. For example, many manufacturers use nitrogen to fill the space in the potato chip bags and to reduce or prevent oxidation from occurring before the bag is opened.

Water drops that form on plant blossoms from the early morning's dew is based on strong attractive forces between the highly polar water molecules. Water striders are able to stay on top of the water, rather than sink, because of the water tension or attractive forces of the molecules for one another.

Salts dissolved in the oceans and most of the substances that comprise the earth's crust are held together by ionic bonds. Most seashells are made of the ionic compound calcium carbonate, but they are insoluble in sea water.

Power Standards	Additional Standards
C2.1a: Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy. C3.2b: Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms. C3.3c: Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond. C4.4a: Explain why at room temperature different compounds can exist in different phases. C4.4b: Identify if a molecule is polar or nonpolar given a structural formula for the compound. C5.8A: Draw structural formulas for up to ten carbon chains of simple hydrocarbons. C5.8B: Draw isomers for simple hydrocarbons. C5.8C: Recognize that proteins, starches, and other large biological molecules are polymers.	C2.1b: Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).

Unit 5: Nomenclature and Formula Stoichiometry

Big Ideas

Chemical compounds always have the same formula and the same composition.

The formal charge on ions determines the ratio of the ions in an ionic compound, just as the apparent charge on atoms determines the ratio of the atoms in a covalent compound.

Conceptual Understandings

Pharmacists make some special solutions and ointments using percent composition.

Examples of formulas in the work world are usually expressed in proportions of various compounds mixed together. An example is concrete which changes strength when the volume ratio of cement: sand : gravel is changed (1:2:4 is stronger than 1:3:6, a 1:1:2 mixture is used when concrete is used under water.) Another example is steel which changes properties when the formula of percent carbon is changed (carbon steel, 1% c; cast iron, 4% carbon; cementite, 6.7% carbon).

Minerals are everyday examples of empirical formulas (galena, PbS; magnetite, Fe3O4; pyrite, FeS2; quartz, SiO2; cinnabar, HgS).

Formula nomenclature is helpful when chemical formulas and/or chemical compounds are mentioned in news reports or in medical information.

Mole calculations are examples of packaging objects in larger units for ease of description or understanding. Terms are used to convey numbers in astronomy, the light year; or in the computer world, bytes, etc.

Power Standards	Additional Standards
C4.1a: Calculate the percent by weight of each element in a compound based on the compound formula. C4.1b: Calculate the empirical formula of a compound based on the percent by weight of each element in the compound. C4.1c: Use the empirical formula and molecular weight of a compound to determine the molecular formula. C4.2A: Name simple binary compounds using their formulae. C4.2B: Given the name, write the formula of simple binary compounds. C4.2c: Given a formula, name the compound. C4.2d: Given the name, write the formula of ionic and molecular compounds.	C4.2e: Given the formula for a simple hydrocarbon, draw and name the isomers.

C4.6a: Calculate the number of moles of any compound or element given the mass of the substance. C4.6b: Calculate the number of particles of any compound or element given the mass of the substance.	

Unit 6: Equations and Stoichiometry

Big Ideas

Balanced chemical equations always exhibit conservation of mass and conservation of heat.

The same number of all gaseous molecules will occupy the same volume under the same conditions.

Chemical reactions carried out in the same fashion will always produce the same products.

Breaking of chemical bonds consumes energy while formation of bonds releases energy.

Conceptual Understandings

Chemical reactions in everyday situations produce or absorb heat. Examples:
Hot and Cold Packs, Toilet bowl cleaners, Burning (paper, fuel, food), Photosynthesis, Respiration, etc.

The mass of materials produced or consumed in chemical reactions can be used to help understand natural phenomenon such as: global warming (CO2 produced or consumed), oxygen needs of organisms, etc.

The amount of reagents that are added to a chemical reaction will determine the amount of product produced. Examples are: smoky fires (not getting enough oxygen), Mentos and diet coke reaction too small (add more Mentos), fizzing too little in vinegar in baking soda (add more vinegar or baking soda).

Proper volumes of gases are required in certain situations such as air bag deployment, carbon dioxide produced by ingredients in rising bread, production of ammonia gas for industry, etc.

Power Standards	Additional Standards
C3.4A: Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory. C5.2A: Balance simple chemical equations applying the conservation of matter. C5.2B: Distinguish between chemical and physical changes in terms of the properties of the reactants and products. C5.2d: Calculate the mass of a particular compound formed from the masses of starting materials. C5.2e: Identify the limiting reagent when given the masses of more than one reactant. C5.2f: Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.	C3.4c: Write chemical equations including the heat term as a part of equation or using ΔH notation. C5.6b: Predict single replacement reactions.

Unit 7: States of Matter

Big Ideas

Particles in all matter are in constant motion until the temperature reaches absolute zero.

The order and organization in the universe is illustrated in the pressure, volume and temperature relationships which can be predicted by models, mathematical equations and graphs.

Conceptual Understandings

Hot liquids can make the handle of a metal spoon hot through conduction.

Air pressure in automobile tires increase while driving due to friction within the tire and friction between the road and the tire. Recommended tire pressure is based on cold pressure (before driving).

Weather balloons are never filled to capacity because they continue to inflate as they rise due to changes in the air pressure.

Cooking pans get hot because of conduction of heat.

Perfume and smoke spread out in a room or area because of the motion of the particles. Through diffusion from an area of high concentration to areas of less concentration smoke or perfume spreads throughout a room.

Pressure relief values are used on hot water boilers and in pressure cookers as safety devices. Regulators are used in SCUBA diving to match water pressure with the air pressure going into the lungs.

Aerosol can works because of the pressure (propellant) in the can.

Power Standards	Additional Standards
C2.2A: Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases. C2.2B: Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance. C3.3A: Describe how heat is conducted in a solid. C3.3B: Describe melting on a molecular level. C4.3A: Recognize that substances that are solid at room temperature have stronger attractive forces than liquids at room temperature, which have stronger attractive forces than gases at room temperature. C4.3B: Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.	C2.2f: Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature. C2.2c: Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model. C4.5a: Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases. C4.5b: Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases. C4.5c: Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.

Unit 8: Advanced Bonding Concepts

Big Ideas

Many physical properties of substances can be determined by knowing the type of bond structure that exists within the substance.

Forces that exist between atoms can be classified into specific categories.

Conceptual Understandings

Wiring in homes is mostly done with Cu. However, depending on cost factors, sometimes Al has been used. In computers, gold is used in some connections because of its better conductivity.

The properties of water, which we depend on greatly, are the result of its special bonding.

Carbon dioxide, dry ice, is used to keep food products cold during shipment.

Diamond, a covalent network, is used in manufacturing processes (cutting and drilling) because of its hardness and in jewelry because of its lasting ability and beauty.

Carbon is covalently bonded when used to form polymers. These polymers may be used in various types of plastics, such as garbage bags, milk cartons, shrink wrap, automobile parts and toys.

Ionic bonded compounds are used in fertilizers, K2CO3, NH4NO3, and Ca(H2PO4)2 because of their ability to dissolve in water.

Some ionic compounds, as anhydrous compounds, are used as drying agents and are packaged with electronic equipment and many other substances, to remove moisture after manufacturing and before consumer use.

Water drops that form on plant blossoms from the early morning's dew is based on strong attractive forces between the highly polar water molecules.

Water striders are able to stay on top of the water, rather than sink, because of the water tension or attractive forces of the molecules for one another.

Power Standards	Additional Standards
C4.3e: Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table. C4.3f: Identify the elements necessary for hydrogen bonding (N, O, F). C4.3g: Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding). C4.3h: Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.	C4.3c: Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances. C4.3d: Compare the strength of the forces of attraction between molecules of different elements. (For example, at room temperature, chlorine is a gas and iodine is a solid.) C5.4c: Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane). C5.4e: Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).

C4.3i: Explain why ionic solids have higher melting points than covalent solids. (For example, NaF has a melting point of 995°C while water has a melting point of 0° C.) C5.4d: Explain why freezing is an exothermic change of state.	

Unit 9: Thermochemistry and Solutions

Big Ideas

Heat released or absorbed in chemical reactions is proportional to the amounts of reactants consumed.

When a reversible process occurs, the same amount of energy is involved no matter which way the reaction proceeds. The difference will be if the energy is released or absorbed.

Conceptual Understandings

The decreasing solubility of gases with increasing temperatures is also responsible for the formation of boiler scale. (At higher temperatures, the amount of CO_2 (g) decreases which in turn causes the following reaction to occur: HCO_3^{1-}(aq) « H2O (l) + CO_2(g) + CO_3^{2-}(aq) If Ca^{2+} ions are present, calcium carbonate, which has low solubility in water will form, which is boiler scale.)

Thermal pollution in rivers and lakes causes a decrease in the amounts of dissolved oxygen.

Putting salt on the icy roads in winter to melt the ice, lowers the freezing point of water.

The differences in cooking pans are due to differences in specific heat capacities. An iron pan will not heat up as quickly as an aluminum or copper pan.

In order to maintain body temperature, part of the cooling process is done by convection. Heat is lost by virtue of heating air that is in contact with the body. The heated air rises and is replaced by cooler air and the process continues.

Power Standards	Additional Standards
C2.1c: Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid. C5.4A: Compare the energy required to raise the temperature of one gram of aluminum and one gram of water the same number of degrees. C5.4B: Measure, plot, and interpret the graph of the temperature versus time of an ice-water mixture, under slow heating, through melting and boiling.	C2.2d: Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion. C3.1c: Calculate the ΔH for a chemical reaction using simple coffee cup calorimeter. C3.1d: Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation. C3.4g: Explain why gases are less soluble in warm water than cold water. C4.7a: Investigate the difference in the boiling point or freezing point of pure water and a salt solution. C5.5e: Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.

Unit 10: Acid/Base

Big Ideas

The environment is impacted by chemical reactions on earth.

Acids, bases and pH are systems developed by man to help describe natural systems.

Conceptual Understandings

Household cleaners are acidic or basic. Examples: soaps, shampoos, window cleaners, toilet bowl cleaners, vinegar and drain cleaners, etc.

Foods and medicines are acidic or basic. Examples are: soda pop, antacids, vinegar, salad dressing etc.

Food processing requires adherence to strict pH ranges: canning, meat tenderizer, etc.

Indicators are used to test pH of soil and swimming pools.

Red cabbage juice and grape juice are common substances that can be used as a pH indicator.

Some plants may change flower color due to the pH of the soil. Some hydrangeas bloom blue in acid soil and pink in alkaline soil.

Acid rain can have economic and aesthetic effects on lakes and structures (limestone, marble and metals)

Nitrous oxides are produced from nitrogen in the air reacting at high temperatures with the oxygen in the air. Examples: internal combustion engines and lightning

Power Standards	Additional Standards
C5.7A: Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II. C5.7B: Predict products of an acid-based neutralization. C5.7C: Describe tests that can be used to distinguish an acid from a base. C5.7D: Classify various solutions as acidic or basic, given their pH. C5.7E: Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.	C5.7f: Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations. C5.7g: Calculate the pH from the hydronium ion or hydroxide ion concentration. C5.7h: Explain why sulfur oxides and nitrogen oxides contribute to acid rain

Unit 11: Redox/Equilibrium

Big Ideas

Many redox (oxidation-reduction) reactions are a source of energy.

Redox reactions significantly impact humans in both positive and negative ways.

In a closed system, many reactions will reach equilibrium. Changes to the equilibrium can be predicted by using Le Châtelier's Principle.

Conceptual Understandings

Unprotected iron on automobiles or other steel structures will rust.

Batteries are electrochemical cells.

Hydrogen fuel cells produce water and energy using hydrogen and oxygen.

Outdoor grilling uses combustion, a redox reaction.

Commercially available hot and cold packs.

Electroplating of jewelry and other metals is a redox process.

Sacrificial anodes (made of magnesium or zinc generally) are used on ships, in water heaters, and on the Alaskan pipeline to prevent corrosion of the primary metal.

Power Standards	Additional Standards
While this unit has value, it did not contain content expectations that met the power standard criteria set by the committee.	C5.3a: Describe equilibrium shifts in a chemical system caused by changing conditions (Le Châtelier's Principle). C5.3b: Predict shifts in a chemical system caused by changing conditions (Le Châtelier's Principle). C5.3c: Predict the extent reactants are converted to products using the value of the equilibrium constant. C5.6a: Balance half-reactions and describe them as oxidations or reductions. C5.6c: Explain oxidation occurring when two different metals are in contact. C5.6d: Calculate the voltage for spontaneous redox reactions from the standard reduction potentials. C5.6e: Identify the reactions occurring at the anode and cathode in an electrochemical cell.

Unit 12: Thermodynamics

Big Ideas

Chemical compounds and chemical reactions strive toward states of highest disorder as does every thing in the universe.

Bond formation releases energy to the system.

Conceptual Understandings

Ice packs and hot packs chemically react and free energy is put to work.

Fuels involve a tremendous output of energy.

Food—digestion is the slow release of chemical energy.

Plants—photosynthesis is the accumulation of energy from a chemical reaction.

The major difference between the formation of diamond versus graphite is due to the large change of entropy.

Power Standards	Additional Standards
While this unit has value, it did not contain content expectations that met the power standard criteria set by the committee.	C2.2e: Compare the entropy of solids, liquids, & gases. C2.3a: Explain how the rate of a given chemical reaction is dependent on the temp and activation energy. C2.3b: Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature. C3.1a: Calculate the ΔH for a given reaction using Hess's Law. C3.1b: Draw enthalpy diagrams for exothermic and endothermic reactions. C3.2a: Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making. C3.4d: Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions. C3.4e: Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.) C3.4f: Explain why some endothermic reactions are spontaneous at room temperature C3.4B: Explain why chemical reactions will either release or absorb energy.