CHEMISTRY POWER STANDARDS

BAISD Standards	**4** – Power Standard; **3** - Almost a Power Standard; **2 –** Important, but not primary; **1 –** important as an example supporting a Power Standard; __ - Ranked Prerequisite (should be addressed in lower grades)	
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STANDARD CI: INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS

C1.1 Scientific Inquiry

4	**C1.1A**	Generate new questions that can be investigated in the laboratory or field.
4	**C1.1B**	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.
4	**C1.1C**	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).
4	**C1.1D**	Identify patterns in data and relate them to theoretical models.
4	**C1.1E**	Describe a reason for a given conclusion using evidence from an investigation.
4	**C1.1f**	Describe a reason for a given conclusion using evidence from an investigation.
4	**C1.1g**	Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.
3	**C1.1h**	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.
2	**C1.1i**	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.

C1.2 Scientific Reflection and Social Implications

4	**C1.2A**	Critique whether or not specific questions can be answered through scientific investigations.
4	**C1.2B**	Identify and critique arguments about personal or societal issues based on scientific evidence.
2	**C1.2C**	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.
2	**C1.2D**	Evaluate scientific explanations in a peer review process or discussion format.
2	**C1.2E**	Evaluate the future career and occupational prospects of science fields.
2	**C1.2f**	Critique solutions to problems, given criteria and scientific constraints.
2	**C1.2g**	Identify scientific tradeoffs in design decisions and choose among alternative solutions.
3	**C1.2h**	Describe the distinctions between scientific theories, laws, hypotheses, and observations.
2	**C1.2i**	Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.
2	**C1.2j**	Apply science principles or scientific data to anticipate effects of technological design decisions.

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4	C1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.

STANDARD C2: FORMS OF ENERGY

P2.pl Potential Energy (prerequisite)

2	P2.p1A	Describe energy changes associated with changes of state in terms of the arrangement and order of the atoms (molecules) in each state. *(prerequisite)*
2	P2.p1B	Use the positions and arrangements of atoms and molecules in solid, liquid, and gas state to explain the need for an input of energy for melting and boiling and a release of energy in condensation and freezing. *(prerequisite)*

C2.Ix Chemical Potential Energy

2	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
2	C2.1b	Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).
2	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.

C2.2 Molecules in Motion

4	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.
4	C2.2B	Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.

C2.2x Molecular Entropy

4	C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.
2	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.
3	C2.2e	Compare the entropy of solids, liquids, and gases.
2	C2.2f	Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.

C2.3x Breaking Chemical Bonds

2	C2.3a	Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.
2	C2.3b	Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.

C2.4x Electron Movement

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2	**C2.4a**	Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.
2	**C2.4b**	Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.
2	**C2.4c**	Explain why an atom can absorb only certain wavelengths of light.
2	**C2.4d**	Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy.

C2.5x Nuclear Stability

2	**C2.5a**	Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.
1	**C2.r5b**	Illustrate how elements can change in nuclear reactions using balanced equations. *(recommended)*
1	**C2.r5c**	Describe the potential energy changes as two protons approach each other. *(recommended)*
1	**C2.r5d**	Describe how and where all the elements on earth were formed. *(recommended)*

STANDARD C3: ENERGY TRANSFER AND CONSERVATION

P3.pl Conversation of Energy (prerequisite)

2	**P3.p1A**	Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature. *(prerequisite)*

C3.lx Hess's Law

2	**C3.1a**	Calculate the Δ*H* for a given reaction using Hess's Law.
2	**C3.1b**	Draw enthalpy diagrams for exothermic and endothermic reactions.
3	**C3.1c**	Calculate the Δ*H* for a chemical reaction using simple coffee cup calorimetry.
3	**C3.1d**	Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.

P3.p2 Energy Transfer (prerequisite)

2	**P3.p2A**	Trace (or diagram) energy transfers involving various types of energy including nuclear, chemical, electrical, sound, and light. *(prerequisite*

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C3.2x Enthalpy

2	**C3.2a**	Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.
2	**C3.2b**	Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms

C3.3 Heating Impacts

3	**C3.3A**	Describe how heat is conducted in a solid.
3	**C3.3B**	Describe melting on a molecular level.

C3.3x Bond Energy

3	**C3.3c**	Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.

C3.4 Endothermic and Exothermic Reactions

2	**C3.4A**	Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.
2	**C3.4B**	Explain why chemical reactions will either release or absorb energy.

C3.4x Enthalpy and Entropy

3	**C3.4c**	Write chemical equations including the heat term as a part of equation or using ΔH notation.
3	**C3.4d**	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.
2	**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.)
2	**C3.4f**	Explain why some endothermic reactions are spontaneous at room temperature.
2	**C3.4g**	Explain why gases are less soluble in warm water than cold water.

C3.5x Mass Defect

2	**C3.5a**	Explain why matter is not conserved in nuclear reactions.

STANDARD C4: PROPERTIES OF MATTER

P4.pl Kinetic Molecular Theory (prerequisite)

4	**P4.p1A**	For a substance that can exist in all three phases, describe the relative motion of the particles in each of the phases. *(prerequisite)*
4	**P4.p1B**	For a substance that can exist in all three phases, make a drawing that shows the arrangement and relative spacing of the particles in each of the phases. *(prerequisite)*

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4	**P4.p1C**	For a simple compound, present a drawing that shows the number of particles in the system does not change as a result of a phase change. *(prerequisite)*

P4.p2 Elements, Compounds, and Mixtures (prerequisite)

4	**P4.p2A**	Distinguish between an element, compound, or mixture based on drawings or formulae. *(prerequisite)*
4	**P4.p2B**	Identify a pure substance (element or compound) based on unique chemical and physical properties. *(prerequisite)*
4	**P4.p2C**	Separate mixtures based on the differences in physical properties of the individual components. *(prerequisite)*
4	**P4.p2D**	Recognize that the properties of a compound differ from those of its individual elements. *(prerequisite)*

C4.1x Molecular and Empirical Formulae

4	**C4.1a**	Calculate the percent by weight of each element in a compound based on the compound formula.
4	**C4.1b**	Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.
4	**C4.1c**	Use the empirical formula and molecular weight of a compound to determine the molecular formula.

C4.2 Nomenclature

3	**C4.2A**	Name simple binary compounds using their formulae.
3	**C4.2B**	Given the name, write the formula of simple binary compounds.

C4.2x Nomenclature

4	**C4.2c**	Given a formula, name the compound.
4	**C4.2d**	Given the name, write the formula of ionic and molecular compounds.
2	**C4.2e**	Given the formula for a simple hydrocarbon, draw and name the isomers.

C4.3 Properties of Substances

4	**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.
4	**C4.3B**	Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.

C4.3x Solids

2	**C4.3c**	Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.
2	**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.)

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2	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.
2	C4.3f	Identify the elements necessary for hydrogen bonding (N, O, F).
2	C4.3g	Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding).
2	C4.3h	Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.
2	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.)

C4.4x Molecular Polarity

2	C4.4a	Explain why at room temperature different compounds can exist in different phases.
3	C4.4b	Identify if a molecule is polar or nonpolar given a structural formula for the compound.

C4.5x Ideal Gas Law

4	C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.
4	C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.
4	C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.

C4.6x Moles

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

C4.7x Solutions

2	C4.7a	Investigate the difference in the boiling point or freezing point of pure water and a salt solution.
2	C4.7b	Compare the density of pure water to that of a sugar solution.

C4.8 Atomic Structure

4	C4.8A	Identify the location, relative mass, and charge for electrons, protons, and neutrons.

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4	**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.
4	**C4.8C**	Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus Intact.
4	**C4.8D**	Give the number of electrons and protons present if the fluoride ion has a -1 charge.

C4.8x Electron Configuration

4	**C4.8e**	Write the complete electron configuration of elements in the first four rows of the periodic table.
3	**C4.8f**	Write kernel structures for main group elements.
4	**C4.8g**	Predict oxidation states and bonding capacity for main group elements using their electron structure.
2	**C4.8h**	Describe the shape and orientation of *s* and *p* orbitals.
2	**C4.8i**	Describe the fact that the electron location cannot be exactly determined at any given time.

C4.9 Periodic Table

4	**C4.9A**	Identify elements with similar chemical and physical properties using the periodic table.

C4.9x Electron Energy Levels

4	**C4.9b**	Identify metals, non-metals, and metalloids using the periodic table.
4	**C4.9c**	Predict general trends in atomic radius, first ionization energy, and electonegativity of the elements using the periodic table.

C4.10 Neutral Atoms, Ions, and Isotopes

4	**C4.10A**	List the number of protons, neutrons, and electrons for any given ion or isotope.
4	**C4.10B**	Recognize that an element always contains the same number of protons.

C4.10x Average Atomic Mass

2	**C4.10c**	Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.
2	**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
2	**C4.10e**	Write the symbol for an isotope, *XZA*, where *Z* is the atomic number, *A* is the mass number, and *X* is the symbol for the element.

STANDARD C5: CHANGES IN MATTER

P5.pl Conservation of Matter (prerequisite)

2	**P5.p1A**	Draw a picture of the particles of an element or compound as a solid, liquid, and gas. *(prerequisite)*

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C5.rlx Rates of Reaction (recommended)

2	**C5.r1a**	Predict how the rate of a chemical reaction will be influenced by changes in concentration, temperature, and pressure. *(recommended)*
2	**C5.r1b**	Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. *(recommended)*

C5.2 Chemical Changes

4	**C5.2A**	Balance simple chemical equations applying the conservation of matter.
4	**C5.2B**	Distinguish between chemical and physical changes in terms of the properties of the reactants and products.
2	**C5.2C**	Draw pictures to distinguish the relationships between atoms in physical and chemical changes.

C5.2x Balancing Equations

4	**C5.2d**	Calculate the mass of a particular compound formed from the masses of starting materials.
4	**C5.2e**	Identify the limiting reagent when given the masses of more than one reactant.
3	**C5.2f**	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.
2	**C5.2g**	Calculate the number of atoms present in a given mass of element.

C5.3x Equilibrium

2	**C5.3a**	Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).
2	**C5.3b**	Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).
2	**C5.3c**	Predict the extent reactants are converted to products using the value of the equilibrium constant.

C5.4 Phase Change/Diagrams

4	**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.
4	**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.

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C5.4x Changes of State

2	**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).
2	**C5.4d**	Explain why freezing is an exothermic change of state.
2	**C5.4e**	Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).

C5.5 Chemical Bonds — Trends

4	**C5.5A**	Predict if the bonding between two atoms of different elements will be primarily ionic or covalent.
4	**C5.4B**	Predict the formula for binary compounds of main group elements.

C5.5x Chemical Bonds

4	**C5.5c**	Draw Lewis structures for simple compounds.
2	**C5.5d**	Compare the relative melting point, electrical and thermal conductivity, and hardness for ionic, metallic, and covalent compounds.
2	**C5.5e**	Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.

C5.6x Reduction/Oxidation Reations

2	**C5.6a**	Balance half-reactions and describe them as oxidations or reductions.
4	**C5.6b**	Predict single replacement reactions.
2	**C5.6c**	Explain oxidation occurring when two different metals are in contact.
2	**C5.6d**	Calculate the voltage for spontaneous redox reactions from the standard reduction potentials.
2	**C5.6e**	Identify the reactions occurring at the anode and cathode in an electrochemical cell.

C5.7 Acids and Bases

4	**C5.7A**	Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.
4	**C5.7B**	Predict products of an acid-base neutralization.
4	**C5.7C**	Describe tests that can be used to distinguish an acid from a base.
4	**C5.7D**	Classify various solutions as acidic or basic, given their pH.
3	**C5.7E**	Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.

C5.7x Bronsted-Lowry

4	**C5.7f**	Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.
4	**C5.7g**	Calculate the pH from the hydronium ion or hydroxide ion concentration.

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2	**C5.7h**	Explain why sulfur oxides and nitrogen oxides contribute to acid rain.
1	**C5.r7i**	Identify the Brønsted-Lowry conjugate acid-base pairs in an equation. *(recommended)*

C5.8 Carbon Chemistry

2	**C5.8A**	Draw structural formulas for up to ten carbon chains of simple hydrocarbons.
2	**C5.8B**	Draw isomers for simple hydrocarbons.
2	**C5.8C**	Recognize that proteins, starches, and other large biological molecules are polymers.