SINGAPORE AMERICAN SCHOOL
HIGH SCHOOL SCIENCE STANDARDS
ADVANCED PLACEMENT CHEMISTRY

EARTH AND SPACE SCIENCES
Standard 1:
- **Understands atmospheric processes and the water cycle.**

Benchmarks
- None apply to standard 1.

EARTH AND SPACE SCIENCES
Standard 2:
- **Understands earth's composition and structure.**

Benchmarks
- None apply to Standard 2.

EARTH AND SPACE SCIENCE
Standard 3:
- **Understands the composition and structure of the universe and the earth's place in it.**

Benchmarks
- None apply to Standard 3

LIFE SCIENCES
Standard 4:
- **Understands the principles of heredity and related concepts.**

Benchmarks
- None apply to Standard 4.

LIFE SCIENCES
Standard 5:
- **Understands the structure and function of cells and organisms.**

Benchmarks
- None apply to Standard 5.

LIFE SCIENCES
Standard 6:
- **Understands relationships among organisms and their physical environment.**

Benchmarks
- None apply to standard 6

LIFE SCIENCES
Standard 7:
- **Understands biological evolution and the diversity of life.**

Benchmarks
- None apply to Standard 7.

PHYSICAL SCIENCES
Standard 8:
- **Understands the structure and the properties of matter.**

Benchmarks
Students will:

8.1 Know the structure of an atom;
- Negative electrons occupy most of the space in the atom;
- Neutrons and positive protons make up the nucleus of the atom;
- Protons and neutrons are almost two thousand times heavier than an electron;
- The electric force between the nucleus and electrons holds the atom together.

8.2 Understand how elements are arranged in the periodic table, and how this arrangement shows repeating patterns among elements with similar properties:
- Number of protons, neutrons, and electrons;
- Relation between atomic number and atomic mass.

8.3 Know how the electron configuration of atoms governs the chemical properties of an element as atoms interact with one another by transferring or sharing the outermost electrons;

8.4 Know that atoms may be bonded together into molecules or crystalline solids, and compounds are formed from chemical bonds

between two or more different kinds of atoms;

8.5 Know that the physical properties of a compound are determined by its molecular structure (eg: constituent atoms, distances and angles between them) and the interactions among these molecules;

8.6 Know that the number of electrons in an atom determines whether the atom is electrically neutral or an ion:
- Electrically neutral atoms contain equal numbers of protons and electrons;
- A positively charged atom has lost one or more electrons;
- A negatively charged atom has gained one or more electrons.

8.7 Know that most elements have two or more isotopes (i.e., atoms that differ in the number of neutrons in the nucleus); although the number of neutrons has little effect on how the atom interacts with others, it does affect the mass and stability of the nucleus;

8.8 Know how radioactive isotopes can be used to estimate the age of materials that contain them because radioactive isotopes undergo spontaneous nuclear reactions and emit particles and/or wavelike radiation; the decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate, which can be used to estimate the material's age;

8.9 Know that neutrons and protons are made up of even smaller constituents;

8.10 Understand that chemical reactions either release or consume energy:
- Some changes of atomic or molecular configuration require an input of energy;
- Others release energy.

8.11 Know that chemical reactions can take place at vastly different rates (eg: from the few femtoseconds required for an atom to move a fraction of a chemical bond distance to geologic times scales of billions of years) and reaction rates depend on a variety of factors that influence the frequency of collision of reactant molecules (eg: shape and surface area of the reacting species, temperature, pressure, the presence or absence of a catalyst);

8.12 Know that chemical reactions can be accelerated by catalysts:
- Metallic surfaces;
- Enzymes.

8.13 Understand the complete mole concept and ways in which it can be used:
- Actual mass vs. relative mass;
- Relationship between the mole and the volume of a mole of molecules;
- Relevance of molar volume and Avogadro's hypothesis.

8.14 Know that a large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms.

Performance Examples

Examples of activities in which students might demonstrate the above include:
- Build models of solids with spheres and toothpicks;
- Discuss trends in small groups;
- Take home essays which discuss trends and exceptions;
- Laboratory;
- Homework/Test/Quiz.

PHYSICAL SCIENCES
Standard 9:
- **Understands the sources and properties of energy.**

Benchmarks

Students will:

9.1 Understand the concept of entropy:
- Although the total energy of the universe remains constant, matter tends to become steadily less ordered as various energy transfers occur;
- The energy tends to spread out uniformly, thereby decreasing the amount of useful energy.

9.2 Know that all energy can be considered to be either:
- Kinetic energy (energy of motion);
- Potential energy (depends on relative position);
- Energy contained by a field (electromagnetic waves).

9.3 Understand the relationship between heat and temperature:
- Heat energy consists of the random motion and vibrations of atoms, molecules, and ions;

- The higher the temperature, the greater the atomic or molecular motion.

9.4 Know how the energy associated with individual atoms and molecules can be used to identify the substances they comprise;
- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts, and thus can absorb and emit light only at wavelengths corresponding to these amounts.

9.5 Know that nuclear reactions convert a fraction of the mass of interacting particles into energy (fission involves the splitting of a large nucleus into smaller pieces; fusion is the joining of two nuclei at extremely high temperature and pressure) and release much greater amounts of energy than atomic interactions;

9.6 Know that waves (eg: sound, seismic, water, light) have energy and can transfer energy when they interact with matter;

9.7 Know the range of the electromagnetic spectrum (eg: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, gamma rays);
- Electromagnetic waves result when a charged object is accelerated or decelerated, and the energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

Performance Examples
Examples of activities in which students might demonstrate the above include:
- Electrocute pickles;
- Laboratory;
- Work in small groups to solve problems;
- Homework/Test/Quiz.

PHYSICAL SCIENCES
Standard 10:
- **Understands forces and motion.**

Benchmarks
Students will:

10.1 Know that materials that contain equal proportions of positive and negative charges are electrically neutral, but a very small excess or deficit of negative charges in a material produces noticeable electric forces.

Performance Examples
Examples of activities in which students might demonstrate the above include:
- Bend a stream of water with a charged ruler;
- Pick up pieces of paper with a charged ruler.

NATURE OF SCIENCE
Standard 11:
- **Understands the nature of scientific knowledge.**

Benchmarks
Students will:

11.1 Know ways in which science distinguishes itself from other ways of knowing and from other bodies of knowledge, through use of:
- Empirical standards;
- Logical arguments;
- Skepticism.

11.2 Know that scientific explanations must meet certain criteria to be considered valid:
- Must be consistent with experimental and observational evidence about nature;
- Make accurate predictions about systems being studied;
- Be logical;
- Respect the rules of evidence;
- Be open to criticism;
- Report methods and procedures;
- Make a commitment to making knowledge public.

11.3 Understand how scientific knowledge changes and accumulates over time:
- All scientific knowledge is subject to change as new evidence becomes available;
- Some scientific ideas are incomplete and opportunity exists in these areas for new advances;
- Theories are continually tested, revised, and occasionally discarded.

11.4 Know that from time to time, major shifts occur in the scientific view of how the world works, but usually the changes that take place in the body of scientific knowledge are small modifications of prior knowledge.

Performance Examples
Examples of activities in which students might demonstrate the above:
- Laboratory;
- Write error analysis essays.

NATURE OF SCIENCE
Standard 12:
- **Understands the nature of scientific inquiry.**

Benchmarks
Students will:

12.1 Understand the use of hypotheses in science:
- Selecting and narrowing the focus of data;
- Determining additional data to be gathered;
- Guiding the interpretation of data.

12.2 Design and conduct scientific investigations:
- Formulate testable hypotheses;
- Identify and clarify the method, controls, and variables;
- Organizes, display, and analyze data;
- Revise methods and explanations;
- Present results;
- Receive critical response from others.

12.3 Know that, when conditions of an investigation cannot be controlled, it may be necessary to discern patterns by observing a wide range of natural occurrences;

12.4 Use technology (eg: hand tools, measuring instruments, calculators, computers) and mathematics (eg: measurement, formulas, charts, graphs) to perform accurate scientific investigations and communications;

12.5 Know that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists;

12.6 Know; that scientists conduct investigations for a variety of reasons:
- To discover new aspects of the natural world;
- To explain recently observed phenomena;
- To test the conclusions of prior investigations;
- To test the predictions of current theories.

12.7 Know that investigations and public communication among scientists must meet certain criteria in order to result in new knowledge and methods:
- Arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge;
- The methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Performance Examples
Examples of activities in which students might demonstrate the above include:
- Laboratory;
- Small group discussion and problem solving ;
- Write essays;
- Homework/Test/Quiz.

NATURE OF SCIENCE
Standard 13:
- **Understands the scientific enterprise.**

Benchmarks
Students will:

13.1 Know that, throughout history, diverse cultures have developed scientific ideas and solved human problems through technology;

13.2 Understand that individuals and teams contribute to science and engineering at different levels of complexity:
- An individual may conduct basic field studies;
- Hundreds of people may work together on a major scientific question or technological problem.

13.3 Understand the ethical traditions associated with the scientific enterprise:
- Commitment to peer review;
- Truthful reporting about the methods and outcomes of investigations;
- Publication of the results of work;
- Scientists who violate these traditions are censored by their peers;

13.4 Know that science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen;

13.5 Understand that science involves different types of work in many different disciplines:
- Scientists in different disciplines ask different questions, use different methods of investigation and accept

different types of evidence to support their explanations;
- Many scientific investigations require the contributions of individuals from different disciplines;
- New disciplines of science, such as geophysics and biochemistry, often emerge at the interface of older disciplines.

13.6 Know that creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

Performance Examples

Examples of activities in which students might demonstrate the above include:

- Laboratory;
- Class discussion.