Science
Knowledge and Skills for Environmental Technology Education

High School – Science Knowledge and Skills

This document is not a comprehensive course description. Rather, these knowledge and skills concepts have been systematically identified as those that need to be emphasized for students interested in an environmental technology career. In addition, ATEEC recommends that the principles of the National Science Education Standards be reflected in the complete high school science curriculum.

Basic Knowledge and Skills: For students interested in entering an environmental technology program, the following basic skills should be addressed throughout their four-year science experience.

Unifying Knowledge and Skills

- Given chemical formulas or symbols, name the compounds or elements (and vice versa)
- Describe various types of chemical bonds (e.g. ionic and covalent)
- Measure the mass and volume of solids and liquids, and calculate density and specific gravity.
- Distinguish between elements and compounds.
- From a macroscopic and microscopic level, define and differentiate the states of matter: solid, liquid, and gas.
- Verify and replicate experimentation.
- Interpret and evaluate laboratory analysis results.

Safety and Lab Procedures

- Read and follow laboratory and field procedures.
- Demonstrate safe practices and the use of safety equipment.
- Demonstrate proper techniques for mixing various chemicals.
- Perform typical lab procedures such as heating, cooling, filtration, glassware set-up, distillation, weighing, measuring, and preparation and standardization of reagents.
- Determine what personal protective equipment is required for safety.
- Recognize the potential hazards involved in performing an analysis or field operation and take appropriate precautions, including the use of safety equipment and personal protective equipment.
- Appropriately label samples and reagents.
- Demonstrate handling techniques for the hazardous chemical classes (e.g. flammables, corrosives, toxics, and reactives) and describe actions to be taken in case of accidents.

Accuracy and Data Collection

- Identify, calibrate, maintain, and use lab and field equipment (glassware, balances, meters, electrodes, etc.)
- Maintain accurate lab/log books.

Instrumentation

- Perform laboratory and field tests to determine the level of contaminants in a water sample.
- Calibrate and use analytical meters and instruments.

Critical Thinking

- Draw conclusions from a set of facts (i.e. data)
- Correlate results and plan action needed.
- Make comparative judgement from data.
- Diagnose problems from a set of data and observations, and identify solutions.
- Interpret data generated for records, files, and reports.
- Analyze data for accuracy.
- Make sense of ambiguous information/instructions.
- Identify, assimilate, and integrate (and evaluate) information from diverse sources.
- Make decisions based on large and small amounts of information.
- Recognize one's limitations.
- Recognize and correct discrepancies.
- Recognize/assess/anticipate emergencies.
- Analyze data retrieved from instrument output.
- Generate new ideas by being able to:
    - use imagination freely
    - combine ideas or information in new ways
    - make connections between seemingly unrelated ideas
    - reshape goals in ways that reveal new possibilities
- Demonstrate effective decision-making skills to:
    - specify goals and restraints
    - generate alternatives
    - consider risks
    - evaluate and choose the best alternatives
- Demonstrate problem solving skills to:
    - recognize that a problem exists
    - identify possible reasons for the problem
    - devise and implement a plan of action to resolve the problem
    - evaluate and monitor the progress of an action plan
    - revise plan as indicated by findings
- Discover a rule or principle underlying the relationship between two or more objects and apply it in solving a problem by being able to:
    - use logic to draw conclusions from available information
    - extract rules or principles from a set of objects or written text
    - apply rules and principles to a new situation
    - determine which conclusions are correct when given a set of facts and a set of conclusions

Life and Environmental Science Strand:

- Define pH and use a pH meter or common indicators to determine the pH of soil, liquid, and dissolved gaseous materials.
- Classify common microorganisms (e.g., viruses, bacteria, protozoans, algae, and fungi)
- Identify common pathogenic organisms.
- Identify common microorganisms found in water.
- Identify resource management practices.
- Collect, count, and identify flora and fauna commonly found in aquatic and terrestrial ecosystems.
- Explain basic biochemical processes (e.g. microbial fermentation) and metabolic pathways.
- Use sterile technique during handling and sampling procedures.
- Discuss the concept of indicator organism/species.
- Explain the impact of pollutants on ecosystems.
- Identify the structures and discuss the functions of major organ systems.
- Differentiate between aerobic and anaerobic.
- Differentiate between inorganic and organic compounds.

- Describe how microorganisms impact/affect nutrient cycles.
- Discuss the importance of biological diversity, including evolution, adaptation, and extinction.
- Discuss energy flow in ecosystems.
- Describe the effect of phosphorus and nitrogen on the ecology of surface water.
- Discuss microbial decomposition and the use of microbes in degrading pollutants.
- Define basic routes of entry and the toxicological effects of chemicals on the body, including acids, bases, solvents, carcinogens, etc.

Physical Sciences Strand

- Identify signs and symptoms associated with exposure to chemicals in the hazard classes.
- Define solute and solvent.
- Define toxicity, flammability, corrosivity, volatility, and reactivity and recognize these hazardous characteristics of commonly encountered chemical elements and compounds.
- Define physical properties such as turbidity, conductivity, vapor pressure, vapor density, solubility, boiling point, melting point, specific gravity, and particle shape/size.
- Define acids, bases, and salts in terms of their properties, reactivities, and corrosivities.
- Define the half life of radioactive isotopes.
- Define work in terms of force, distance, and energy.
- Define and identify relationships in electrical terms such as volts, amps, and resistance.
- Identify electrical properties by using appropriate meters and grounding methods.
- For each group in the periodic table, describe the chemistry of compounds containing elements from the group (especially the carbon, oxygen, nitrogen, and halogen groups).
- Use chemical handbooks to determine the chemical and physical properties of elements and substances.
- Define oxidation and reduction and describe oxidation/reduction reactions.
- Describe solubility and the properties of solutions.
- Determine molarity, normality, and molality of solutions given the appropriate data.
- Demonstrate knowledge of the transmutation of elements that takes place in alpha and beta decay.
- Describe the effects of alpha, beta, and gamma radiation on body tissues.
- Demonstrate knowledge of simple machines such as pulleys, gears, levers, etc.
- Calculate mechanical advantage and efficiency.
- Use a voltmeter to measure voltage.
- Use wiring principles and diagrams to construct simple circuits.
- Describe the effects of momentum in mechanical and fluid systems.
- Distinguish between the characteristics of metals and nonmetals.
- Apply the relationship between potential energy, kinetic energy, and heat energy in the conservation of energy law.
- Distinguish between AC and DC electricity.
- Determine the pressure in a fluid as a function of depth in the fluid.
- Given two of the following, wavelength, frequency, and velocity of light, calculate the third.
- Recognize and use the quantities that describe sound waves (i.e., intensity, distance, frequency, time).
- Apply gas laws to volume, temperature, and pressure problems.
- Compare and contrast functional groups of organic compounds.
- Perform the following analyses according to standard procedural methods: volumetric, gravimetric, titrametric, colorimetric, calorimetric, distillation, spectrometric, chromatographic, electrochemical, atomic absorption, and pH.
- Explain the relationship between energy and electricity.
- Explain the principles of electricity to include AC, DC, 220,440, single phase, three phase, transformers, capacitors, resistance, resistors, etc.
- Explain and apply basic hydraulic theory.
- Explain the basics of how valves and pumps work in terms of efficiency, energy usage, and units.
- Predict or calculate solubility of liquids and solids with the use of reference materials.

- Describe what force, pressure, voltage, and temperature difference have in common, and predict what happens to an object when unbalanced forces act on it.
- Evaluate chemical compatibilities and incompatibilities.
- Differentiate the properties of aqueous and nonaqueous solvents and cleaners.
- Differentiate among alpha, beta, and gamma radiation and describe their relative penetration through various materials.

Eartha nd Space Science Strand

- Explain the classifications of surface water.
- Measure meteorological factors: temperature, barometric pressure, humidity, and wind velocity.
- Locate positions on the ground that correspond with points on a map.
- Read and interpret geologic and topographic maps.
- Classify soil components (i.e., gravel, sand, silt, clay) and determine soil texture.
- Evaluate groundwater features such as aquifer, saturated and unsaturated zones, cone-of depression, capillary zone, porosity, and permeability when analyzing hydrology.
- Identify soil horizons and recognize depositional environments and facies changes using cross sectional techniques.

Two-Year College – Science Knowledge and Skills

Introduction to Inorganic Chemistry

- Perform unit conversions using dimensional analysis (including English/metric, C/F, kg/lbs, gpd/MGD, etc).
- Recognize and interpret units of concentration.
- Define solvent and solute.
- Describe solubility and the properties of solutions.
- Predict or calculate solubility of liquids and solids with the use of reference materials.
- Differentiate the properties of aqueous and nonaqueous solvents and cleaners.
- Determine normality, molarity and molality of solutions, given the appropriate data.
- Given chemical formulas or symbols, name the compounds or elements (and vice versa).
- Distinguish between elements and compounds.
- Demonstrate safe practices and the use of safety equipment.
- Read and follow laboratory and field procedures.
- Appropriately label samples and reagents.
- Maintain accurate lab/log book.
- Interpret and evaluate laboratory analysis results.
- Determine accuracy and precision.
- Demonstrate proper techniques for mixing various chemicals.
- From a macroscopic and microscopic level, define and differentiate the states of matter: solid, liquid, and gas.
- Describe various types of chemical bonds (e.g., ionic and covalent).
- Evaluate chemical compatibilities and incompatibilities.
- Define physical properties such as turbidity, conductivity, vapor pressure, vapor density, solubility, boiling point, melting point, specific gravity, and particle shape/size.
- Define acids, bases, and salts in term of their properties, reactivities, and corrosivities.
- Define pH and use a pH meter or common indicators to determine the pH of soil, liquid, and dissolved gaseous materials.
- Differentiate between inorganic and organic compounds.
- For each group in the periodic table, describe the chemistry of compounds containing elements from the group.
- Use chemical handbooks to determine the chemical and physical properties of elements and substances.
- Define oxidation and reduction, and describe oxidation/reduction reactions.

- Apply gas laws to volume, termperature, and pressure problems.
- Identify, calibrate, maintain, and use lab equipment (glassware, balances, meters, electrodes, etc).
- Perform typical laboratory procedures such as heating, cooling, filtration, glassware set-up, distillation, weighing, measuring, and preparation and standardization of reagents.
- Perform the following chemical analyses such as volumetric, gravimetric, titrametric, colorimetric, calorimetric, distillation, spectrometric, chromatographic, electrochemical, atomic absorption, and pH.

Introduction to Organic Chemistry

- Given chemical formula or symbols, name the compounds.
- Use chemical handbooks to determine the chemical and physical properties of organic compounds.
- Compare and contrast functional group classes of organic compounds.
- Differentiate the properties of aqueous and nonaqueous solvents and cleaners.
- Interpret and evaluate laboratory analysis results.

Biology

- Read and follow laboratory and field procedures.
- Identify, calibrate, maintain, and use lab and field equipment (glassware, balances, meters, electrodes, etc.).
- Explain basic biochemical processes (e.g. microbial fermentation) and metabolic pathways.
- Identify the structures and discuss the functions of major organ systems in plants and animals.
- Differentiate between aerobic and anaerobic.
- Interpret and evaluate laboratory analysis results.
- Discuss energy flow in ecosystems.
- Discuss the importance of biological diversity.

Suggested Science Electives:

Physics

- Apply the relationship between potential energy, kinetic energy, and heat energy in the conservation of energy law.
- Define the half-life of radioactive isotopes.
- Differentiate among alpha, beta, and gamma radiation and describe their relative penetration through various materials.
- Demonstrate knowledge of the transmutation of elements that takes place in alpha and beta decay.
- Determine the pressure in a fluid as a function of depth in the fluid.
- Explain the relationship between energy and electricity.

Geology

- Locate positions on the ground that correspond with points on a map.
- Classify soil components (i.e., gravel, sand, silt, clay) and determine soil texture.
- Read and interpret geologic and topographic maps.
- Identify soil horizons and recognize dispositional environments and facies changes using cross-sectional techniques.
- Analyze groundwater features such as aquifer, saturated and unsaturated zones, cone-of-depression, capillary zone, porosity, and permeability.

Microbiology

- Explain basic biochemical processes (e.g. microbial fermentation) and metabolic pathways.
- Use sterile technique during handling and sampling procedures.
- Utilize a microscope, incubator, colony counter, and other basic microbiology analytical equipment.
- Classify common microorganisms (e.g. viruses, bacteria, protozoans, algae, and fungi).
- Identify common pathogenic organisms.
- Identify common microorganisms found in water.
- Describe how microorganisms impact/affect nutrient cycles.
- Discuss microbial decomposition and the use of microbes in degrading pollutants.

Ecology / Environmental Science

- Identify and describe aquatic and terrestrial ecosystems.
- Discuss the concept of indicator organism/species.
- Collect, count, and identify flora and fauna commonly found in aquatic and terrestrial ecosystems.
- Explain the impact of specific pollutants on ecosystems.
- Describe resource management practices.

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