Science
Grade-Level Expectations: Chemistry
(Recommended for Grades 11–12)

Science as Inquiry

The Abilities Necessary to Do Scientific Inquiry

1. Write a testable question or hypothesis when given a topic (SI-H-A1)
2. Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
3. Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
4. Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5. Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6. Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7. Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8. Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9. Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10. Given a description of an experiment, identify appropriate safety measures (SI-H-A7)

Understanding Scientific Inquiry

11. Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
12. Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)
13. Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2)
14. Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)
15. Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
16. Use the following rules of evidence to examine experimental results:
    (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability?
    (b) Has the technique or theory been subjected to peer review and publication?
    (c) What is the known or potential rate of error of the technique or theory when applied?
    (d) Were standards and controls applied and maintained?
    (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)

Physical Science

Measurement and Symbolic Representation

1. Convert metric system units involving length, mass, volume, and time using dimensional analysis (i.e., factor-label method) (PS-H-A1)
2. Differentiate between accuracy and precision and evaluate percent error (PS-H-A1)
3. Determine the significant figures based on precision of measurement for stated quantities (PS-H-A1)

4. Use scientific notation to express large and small numbers (PS-H-A1)
5. Write and name formulas for ionic and covalent compounds (PS-H-A2)
6. Write and name the chemical formula for the products that form from the reaction of selected reactants (PS-H-A2)
7. Write a balanced symbolic equation from a word equation (PS-H-A2)

Atomic Structure

8. Analyze the development of the modern atomic theory from a historical perspective (PS-H-B1)
9. Draw accurate valence electron configurations and Lewis dot structures for selected molecules, ionic and covalent compounds, and chemical equations (PS-H-B1)
10. Differentiate among *alpha, beta*, and *gamma* emissions (PS-H-B2)
11. Calculate the amount of radioactive substance remaining after a given number of half-lives has passed (PS-H-B2)
12. Describe the uses of radioactive isotopes and radiation in such areas as plant and animal research, health care, and food preservation (PS-H-B2)
13. Identify the number of bonds an atom can form given the number of valence electrons (PS-H-B3)

The Structure and Properties of Matter

14. Identify unknowns as elements, compounds, or mixtures based on physical properties (e.g., density, melting point, boiling point, solubility) (PS-H-C1)
15. Predict the physical and chemical properties of an element based only on its location in the periodic table (PS-H-C2)
16. Predict the stable ion(s) an element is likely to form when it reacts with other specified elements (PS-H-C2)
17. Use the periodic table to compare electronegativities and ionization energies of elements to explain periodic properties, such as atomic size (PS-H-C2)
18. Given the concentration of a solution, calculate the predicted change in its boiling and freezing points (PS-H-C3)
19. Predict the conductivity of a solution (PS-H-C3)
20. Express concentration in terms of molarity, molality, and normality (PS-H-C3)
21. Design and conduct a laboratory investigation in which physical properties are used to separate the substances in a mixture (PS-H-C4)
22. Predict the kind of bond that will form between two elements based on electronic structure and electronegativity of the elements (e.g., ionic, polar, nonpolar) (PS-H-C5)
23. Model chemical bond formation by using Lewis dot diagrams for ionic, polar, and nonpolar compounds (PS-H-C5)
24. Describe the influence of intermolecular forces on the physical and chemical properties of covalent compounds (PS-H-C5)
25. Name selected structural formulas of organic compounds (PS-H-C6)
26. Differentiate common biological molecules, such as carbohydrates, lipids, proteins, and nucleic acids by using structural formulas (PS-H-C6)
27. Investigate and model hybridization in carbon compounds (PS-H-C6)
28. Name, classify, and diagram *alkanes*, *alkenes*, and *alkynes* (PS-H-C6)
29. Predict the properties of a gas based on gas laws (e.g., temperature, pressure, volume) (PS-H-C7)
30. Solve problems involving heat flow and temperature changes by using known values of specific heat and latent heat of phase change (PS-H-C7)

Science
Grade-Level Expectations: Chemistry
(Recommended for Grades 11–12)

Chemical Reactions

31. Describe chemical changes and reactions using diagrams and descriptions of the reactants, products, and energy changes (PS-H-D1)
32. Determine the concentration of an unknown acid or base by using data from a titration with a standard solution and an indicator (PS-H-D2)
33. Calculate pH of acids, bases, and salt solutions based on the concentration of hydronium and hydroxide ions (PS-H-D2)
34. Describe chemical changes by developing word equations, balanced formula equations, and net ionic equations (PS-H-D3)
35. Predict products (with phase notations) of simple reactions, including acid/base, oxidation/reduction, and formation of precipitates (PS-H-D3)
36. Identify the substances gaining and losing electrons in simple oxidation-reduction reactions (PS-H-D3)
37. Predict the direction of a shift in equilibrium in a system as a result of stress by using LeChatalier's principle (PS-H-D4)
38. Relate the law of conservation of matter to the rearrangement of atoms in a balanced chemical equation (PS-H-D5)
39. Conduct an investigation in which the masses of the reactants and products from a chemical reaction are calculated (PS-H-D5)
40. Compute percent composition, empirical formulas, and molecular formulas of selected compounds in chemical reactions (PS-H-D5)
41. Apply knowledge of stoichiometry to solve mass/mass, mass/volume, volume/volume, and mole/mole problems (PS-H-D5)
42. Differentiate between activation energy in endothermic reactions and exothermic reactions (PS-H-D6)
43. Graph and compute the energy changes that occur when a substance, such as water, goes from a solid to a liquid state, and then to a gaseous state (PS-H-D6)
44. Measure and graph energy changes during chemical reactions observed in the laboratory (PS-H-D6)
45. Give examples of common chemical reactions, including those found in biological systems (PS-H-D7)

Forces and Motion

46. Identify and compare intermolecular forces and their effects on physical and chemical properties (PS-H-E1)

Interactions of Energy and Matter

47. Assess environmental issues related to the storage, containment, and disposal of wastes associated with energy production and use (PS-H-G4)