

Physical Science Benchmarks & Indicators: Grade 9

Source: Ohio Science Academic Content Standards

Describe that matter is made of minute particles called atoms and atoms are comprised of even smaller components. Explain the structure and properties of atoms.

1. Recognize that all atoms of the same element contain the same number of protons, and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes.
2. Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral.
3. Show that when elements are listed in order according to the number of protons (called the atomic number), the repeating patterns of physical and chemical properties identify families of elements. Recognize that the periodic table was formed as a result of the repeating pattern of electron configurations.
4. Describe how ions are formed when an atom or a group of atoms acquire an unbalanced charge by gaining or losing one or more electrons.

Explain how atoms react with each other to form other substances and how molecules react with each other or other atoms to form even different substances.

5. Explain that the electric force between the nucleus and the electrons hold an atom together. Relate that on a larger scale, electric forces hold solid and liquid materials together (e.g., salt crystals, water).
6. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).
7. Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic or neutral.

Describe the identifiable physical properties of substances (e.g., color, hardness, conductivity, density, concentration, ductility). Explain how changes in these properties can occur without changing the chemical nature of the substance.

8. Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).
9. Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored).

10. Explain how an object's kinetic energy depends on its mass and its speed ($KE=1/2 mv^2$).
11. Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight (mg where m is the object's mass and g is the acceleration due to gravity) and height (h) above a reference surface ($PE=mgh$).

Explain how energy may change form or be redistributed, but the total quantity of energy is conserved.

12. Describe radioactive substances as unstable nuclei that undergo random spontaneous nuclear decay emitting particles and/or high energy wavelike radiation.

13. Summarize how nuclear reactions convert a small amount of matter into a large amount of energy (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high energies).
14. Trace the transformations of energy within a system (e.g., chemical to electrical to mechanical) and recognize that energy is conserved. Show that these transformations involve the release of some thermal energy.
15. Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels).
16. Explain how thermal energy exists in the random motion and vibrations of atoms and molecules. Recognize that the higher the temperature, the greater the average atomic or molecular motion, and during changes of state the temperature remains constant.
17. Demonstrate that thermal energy can be transferred by conduction, convection or radiation (e.g., through materials by the collision of particles, moving air masses or across empty space by forms of electromagnetic radiation).

Demonstrate that waves (e.g., sound, seismic, water, light) have energy and waves can transfer energy when they interact with matter.

18. Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays).
19. Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.
20. Describe how waves can superimpose on one another when propagated in the same medium. Analyze conditions in which waves can bend around corners, reflect off surfaces, are absorbed by materials they enter and change direction and speed when entering a different material.

Explain the movement of objects by applying Newton's three laws of motion.

21. Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.
22. Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.
23. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object ($F_{\text{net}}=ma$. Note that weight is the gravitational force on a mass).
24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
25. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).

Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of physical sciences.

26. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., atomic theory, quantum theory, Newtonian mechanics).
27. Describe advances and issues in physical science that have important, long-lasting effects on science and society (e.g., atomic theory, quantum theory, Newtonian mechanics, nuclear energy, nanotechnology, plastics and ceramics and communication technology).