Next Generation Science Standards **Physical Science DCI Arrangements**

High School

Matter and its Interactions HS-PS1

A Structure and Properties of Matter HS-PS1-A

1. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) HS-PS1-A-1
2. The periodic table orders elernent5 horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) HS-PS1-A-2
3. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6) HS-PS1-A-3
4. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) HS-PS1-A-4

B Chemical Reactions HS-PS1-B

1. Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) HS-PS1-B-1
2. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers Of all types of molecules present. (HS-PS1-6) HS-PS1-B-2
3. The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) HS-PS1-B-3

C Nuclear Processes HS-PS1-C

1. Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) HS-PS1-C-1
2. Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary to HS-ESS1-5),(secondary to HS-ESS1-6) HS-PS1-C-2

Forces and Interactions HS-PS2

A Forces and Motion HS-PS2-A

1. Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) HS-PS2-A-1
2. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) HS-PS2-A-2
3. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) HS-PS2-A-3

B Types of Interactions HS-PS2-B

1. Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) HS-PS2-B-1
2. Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) HS-PS2-B-2
3. Attraction and repulsion between electric charges at the atomic scale explain the Structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3) HS-PS2-B-3

Energy HS-PS3

A Definitions of Energy HS-PS3-A

1. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2) HS-PS3-A-1
2. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2),(HS-PS3-3) HS-PS3-A-2
3. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) HS-PS3-A-3

B Conservation of Energy and Energy Transfer HS-PS3-B

1. Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) HS-PS3-B-1
2. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) HS-PS3-B-2
3. Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) HS-PS3-B-3
4. HS-PS3-B-4 The availability of energy limits what can occur in any system. (HS-PS3-1) HS-PS3-B-4
5. Uncontrolled systems always evolve toward more stable states - that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) HS-PS3-B-5

C Relationship Between Energy and Forces HS-PS3-C

1. When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) HS-PS3-C-1

D Energy in Chemical Processes HS-PS3-D

1. Although energy cannot be destroyed, it can be converted to less useful forms - for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) HS-PS3-D-1
2. Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) HS-PS3-D-2
3. The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary to HS-LS2-5) HS-PS3-D-3

Waves and Their Applications in Technologies for Information Transfer HS-PS4

A Wave Properties HS-PS4-A

1. The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) HS-PS4-A-1
2. Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5) HS-PS4-A-2
3. [From the 3-5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) HS-PS4-A-3

B Electromagnetic Radiation HS-PS4-B

1. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) HS-PS4-B-1
2. When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) HS-PS4-B-2
3. Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) HS-PS4-B-3

C Information Technologies and Instrumentation HS-PS4-C

1. Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5) HS-PS4-C-1