Middle School DCI

Matter and Its Interaction

I **Structure and Properties of Matter**

a Structure and Properties of Matter PS1.A

i Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). MS-PS1-1

ii Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. MS-PS1-2

iii Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. MS-PS1-3

iv Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. MS-PS1-4

v In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. MS-PS1-5

II Chemical Reactions

a Chemical Reactions PS1.B

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iv The total number of each type of atom is conserved, and thus the mass does not change. MS-PS1-5

v Some chemical reactions release energy, others store energy MS-PS1-6

III Definitions of Energy

a Definitions of Energy PS3.A

i The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. MS-PS1-4

ii The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. MS-PS1-6

IV Developing Possible Solutions

a Developing Possible Solutions ETS1.B

i A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. MS-PS1-6

V Optimizing the Design Solution

a Optimizing the Design Solution ETS1.C

i Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. MS-PS1-6

ii The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. MS-PS1-6

Motion and Stability: Forces and Interactions

I Forces and Motion

a Forces and Motion PS2.A

i For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). MS-PS2-1

ii The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. MS-PS2-2

iii All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. MS-PS2-2

II Types of Interactions

b Types of Interactions PS2.B

i Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. MS-PS2-3

ii Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. MS-PS2-4

iii Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). MS-PS2-5

Energy

I Definitions of Energy

a Definitions of Energy PS3.A

i Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. MS-PS3-1

ii A system of objects may also contain stored (potential) energy, depending on their relative positions. MS-PS3-2

iii Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. MS-PS3-3

iv Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. MS-PS3-4

II Conservation of Energy and Energy Transfer

a Conservation of Energy and Energy Transfer PS3.B

i When the motion energy of an object changes, there is inevitably some other change in energy at the same time. MS-PS3-5

ii The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. MS-PS3-4

iii Energy is spontaneously transferred out of hotter regions or objects and into colder ones. MS-PS3-3

III Relationship Between Energy and Forces

a Relationship Between Energy and Forces PS3.C

i When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. MS-PS3-2

IV Defining and Delimiting an Engineering Problem

a Defining and Delimiting an Engineering Problem ETS1.A

i The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions MS-PS3-3

V Developing Possible Solutions

a Developing Possible Solutions ETS1.B

i A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. MS-PS3-3

Waves and Their Applications in Technologies for Information Transfer

I Wave Properties

a Wave Properties PS4.A

i. A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. MS-PS4-1

ii. A sound wave needs a medium through which it is transmitted. MS-PS4-2

II Electromagnetic Radiation

a Electromagnetic Radiation PS4.B

i. When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. MS-PS3-2

ii. The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. MS-PS4-2

iii. A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. MS-PS4-2

iv. However, because light can travel through space, it cannot be a matter wave, like sound or water waves. MS-PS4-2

III Information Technologies and Instrumentation

a Information Technologies and Instrumentation PS4.C

i. Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. MS-PS4-3