The energy of an atom can change only in discrete jumps, with no possible values in between. The change in energy occurs when light is absorbed or emitted, so the light must also have particular energy values, and therefore particular frequencies. Therefore, the light emitted or absorbed by separate atoms or molecules (as in a gas) can be used to identify what the substance is. 4E/H5*

4E/H4*

4G/H2c

The number of protons in the nucleus of an atom determines the atom's identity and what its electron configuration can be. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms with similar electron configuartions have similar chemical reactivity. Atoms form bonds to other atoms by transferring or sharing electrons. 4D/H2*

4D/H3*

Atoms and Molecules
Electricity and Magnetism

4D/H10**

4E/H4*

Some atoms and molecules are highly effective in encouraging the interaction of others. 4D/H9b

4G/H2a*

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others. 4D/H8

At the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus are involved in all chemical reactions. 4G/H2b

Atoms are made of a positively charged nucleus surrounded by negatively charged electrons. The nucleus is a tiny fraction of the volume of an atom, but makes up almost all of its mass. The nucleus is composed of protons and neutrons which have roughly the same mass, but differ in that protons are positively charged while neutrons have no electric charge. 4D/H1*

4D/H7

The rate of reactions among atoms and molecules depends partially on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. 4D/H9a*

5B/H3*

6-8

8B/M6**

5E/M5**

5E/M1d*

5E/M1b*

All atoms and molecules are in constant motion. For any single state of matter, the average speed of the atoms or molecules increases as the temperature of a substance increases and decreases as the temperature of a substance decreases. For any single state of matter, changes in temperature typically change the average distance between atoms or molecules. Most substances or mixtures of substances expand when heated and contract when cooled. 4D/M3*

5E/M1a

When substances interact to form new substances, the atoms that make up the molecules of the original substances are rearranged into new molecules. 4D/M13**

4D/M7b*

Flow of Matter and Energy in Living Systems

Atoms and Molecules
Conservation of Matter
States of Matter

Atoms may link together in well-defined molecules, or may be packed together in crystal patterns. Different arrangements of atoms into groups compose all substances and determine the characteristic properties of substances. 4D/M1cd*

4D/M6b*

4D/M7a*

Materials Science

All matter is made up of atoms, which are extremely small. All atoms have mass and take up space. There are over a hundred different kinds of atoms. 4D/M1a*

Conservation of Matter

Equal volumes of different materials usually have different masses. 4D/M2*

A pure substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the substance and can be used to identify it. 4D/M10** (NSES)

Many substances react chemically in predictable ways with other substances to form new substances with different characteristic properties. 4D/M11** (NSES)

Many substances dissolve in water, which may greatly facilitate reactions between them. The temperature and acidity of a solution influence reaction rates.4D/M4*

Atoms and Molecules

3-5

8B/E2*

When a new material is made by combining two or more materials, it has properties that are different from the original materials. 4D/E4*

8B/M1*

Materials Science

8B/E1*

12C/E2*

All materials have certain physical properties, such as strength, hardness, flexibility, durability, resistance to water and fire, and ease of conducting heat. 4D/E6**

Heating and cooling can cause changes in the properties of materials, but not all materials respond the same way to heating and cooling them. 4D/E1*

4B/E3*

K-2

8B/P1*

Conservation of Matter
States of Matter

Objects can be described in terms of their properties. Some properties, such as hardness and flexibility, depend upon what material the object is made of, and some properties, such as size and shape, do not. 4D/P1*

Design Constraints
Atoms and Molecules
Materials Science

All objects take up space and have weight. 4D/P3**

properties [of substances]

reactions

invisibly small pieces