

## Fundamental questions about matter

and basic observations and propositions of the Atomic Theory of Matter

### 1. What are things made of and how can we explain their properties?

- a) Objects are constituted of matter, which exists as many different material kinds. Objects have properties that can be measured and depend on the amount of matter and on the material kinds they are made of.
  - i. All matter is made of a limited number of different kinds of atoms, which are commonly bonded together in molecules and networks. Each atom takes up space, has mass, and is in constant motion.
  - ii. The mass and weight of an object is explained by the masses and weights of its atoms. The different motions and interactions of atoms in solids, liquids, and gases help explain their different properties.
  - iii. The properties of materials are determined by the nature, arrangement, and motion of the molecules that they are made of.

### 2. What changes and what stays the same when things are transformed?

- a) Matter can be transformed, but not created or destroyed, through physical and chemical processes.
  - i) Mass and weight are conserved across a broad range of transformations.
  - ii) Materials kinds stay the same across some transformations and change across others.
  - iii) Mass and weight are conserved in physical and chemical changes because atoms are neither created nor destroyed.
  - iv) In chemical changes new substances are formed as atoms are rearranged into new molecules. The atoms themselves remain intact.
  - v) In physical changes, molecules change arrangement and/or motion but remain intact, so the chemical substance remains the same.

### 3. How do we know?

- a) We can learn about the world through measurement, modeling, and argument.
  - i. Good measurements provide more reliable and useful information about object properties than common sense impressions.
  - ii. Modeling is concerned with capturing key relations among ideas rather than surface appearances.
  - iii. Arguments use reasoning to connect ideas and data.
  - iv. Atoms are too small to see directly with commonly available tools.
  - v. The properties of and changes in atoms and molecules have to be distinguished from the macroscopic properties and phenomena for which they account.
  - vi. We learn about properties of atoms and molecules indirectly, using hypothetico-deductive reasoning.

From the Appendix of Taking Science to School—Sample learning progression for Matter—available from <http://nap.edu>