# States of Matter Assignment

States of matter are the distinct forms that different phases of matter take on. Historically, the distinction is made based on qualitative differences in bulk properties. Solid is the state in which matter maintains a fixed volume and shape; the liquid is the state in which matter maintains a fixed volume but adapts to the shape of its container, and gas is the state in which matter expands to occupy whatever volume is available. This diagram shows the nomenclature for the different phase transitions. More recently, distinctions between states have been based on differences in molecular interrelationships.

Solid is the state in which intermolecular attractions keep the molecules in fixed spatial relationships. The liquid is the state in which intermolecular attractions keep molecules in proximity, but do not keep the molecules in fixed relationships. Gas is that state in which the molecules are comparatively separated, and intermolecular attractions have relatively little effect on their respective motions. Plasma is a highly ionized gas that occurs at high temperatures. The intermolecular forces created by ionic attractions and repulsions give these compositions distinct properties, for which reason plasma is described as the fourth state of matter. Forms of matter that are not composed of molecules and are organized by different forces can also be considered different states of matter. Fermionic condensate and the quark-gluon plasma are examples. Although solid, gas and liquid are the most common states of matter on Earth, much of the baryonic matter of the universe is in the form of hot Plasma, both as rarefied interstellar medium and as dense stars. States of matter may also be defined in terms of phase transitions. A phase transition indicates a change in structure and can be recognized by an abrupt change in properties.

By this definition, a distinct state of matter is any set of states distinguished from any other set of states by a phase transition. Water can be said to have several distinct solid states. [3] The appearance of superconductivity is associated with a phase transition, so there are superconductive states. Likewise, liquid crystal states and ferromagnetic states are demarcated by phase transitions and have distinctive properties. Because solids have thermal energy or heat capacity, their atoms vibrate about fixed mean positions within the ordered (or disordered) lattice. Shown here are the one-dimensional normal modes of vibration in a crystalline solid. The amplitude of the motion has been exaggerated and is much smaller than the lattice parameter. The entire spectrum of lattice vibrations in a crystalline or glassy network plays a key role in the kinetic theory of solids. The particles (ions, atoms or molecules) are packed closely together. The forces between particles are strong enough so that the particles cannot move freely but can only vibrate. As a result, a solid has a stable, definite shape, and a definite volume. Solids can only change their shape by force, as when broken or cut.

In crystalline solids, the particles (atoms, molecules, or ions) are arranged in an ordered three-dimensional structure. There are many different crystal structures, and the same substance can have more than one structure (or solid phase). For example, iron has a body-centred cubic structure at temperatures below 912C, and a face-centred cubic structure between 912 and 1394C. Ice has fifteen known crystal structures, or fifteen solid phases which exist at various temperatures and pressures. Solids can be transformed into liquids by melting, and liquids can be transformed into solids by freezing. Solids can also change directly into gases through the process of sublimation. Atoms have many nearest neighbours in contact, yet no long-range order is present. The volume is definite if the temperature and pressure are constant. When a solid is heated above its melting point, it becomes liquid, given that the pressure is higher than the triple point of the substance.

Intermolecular (or interatomic or interionic) forces are still important, but the molecules have enough energy to move relative to each other and the structure is mobile. This means that the shape of a liquid is not definite but is determined by its container. The volume is usually greater than that of the corresponding solid, the most well-known exception being water, H2O. The highest temperature at which a given liquid can exist is its critical temperature. In a gas, the molecules have enough kinetic energy so that the effect of intermolecular forces is small (or zero for an ideal gas), and the typical distance between neighbouring molecules is much greater than the molecular size. A gas has no definite shape or volume but occupies the entire container in which it is confined. A liquid may be converted to a gas by heating at constant pressure to the boiling point, or else by reducing the pressure at a constant temperature. At temperatures below its critical temperature, a gas is also called a vapour and can be liquefied by compression alone without cooling. A vapour can exist in equilibrium with a liquid (or solid), in which case the gas pressure equals the vapour pressure of the liquid (or solid).

A supercritical fluid (SCF) is a gas whose temperature and pressure are above the critical temperature and critical pressure respectively. It has the physical properties of a gas, but its high density confers solvent properties in some cases which lead to useful applications. For example, supercritical carbon dioxide is used to extract caffeine in the manufacture of decaffeinated coffee.

In crystalline solids, the atoms or molecules that compose the solid are packed closely together. In mineralogy and crystallography, a crystal structure is a unique arrangement of atoms in a crystal. A specific symmetry or crystal structure is composed of a Bravais lattice which is typically represented by a single unit cell. The unit cell is periodically repeated in three dimensions on a lattice. Non-crystalline or amorphous or glassy solids are often referred to as supercooled liquids but possess the mechanical properties of both a solid and a liquid, depending on the time scale under consideration.

In their molecular structure, their molecules do not exhibit the long-range order exhibited by crystalline substances. In addition, while a glassy solid does exhibit some viscous flow and plastic deformation, this only occurs on geologic timescales. Thus, it behaves mechanically as a solid for all practical intents and purposes and most experimental timescales. Common examples are silicate glasses, synthetic rubber and polystyrene and other polymers. Many amorphous solids soften into liquids when heated above their glass transition temperatures, at which the molecules become mobile.