States of Matter
Part I. The Three Common States: Solid, Liquid and Gas

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Abstract

There are three basic states of matter that can be identified: solid, liquid, and gas. Solids, being compact with very restricted movement, have definite shapes and volumes; liquids, with less compact makeup have definite volumes, take the shape of the containers; and gases, composed of loose particles, have volumes and shapes that depend on the container. This paper is in two parts. A short description of the common states (solid, liquid and gas) is described in Part I. This is followed by a general observation of three additional states (plasma, Bose-Einstein Condensate, and Fermionic Condensate) in Part II.

Keywords: *Ionic solids, liquid crystals, London forces, metallic solids, molecular solids, network solids, quasicrystals.*

Introduction

This paper is in two parts. The common or usual states of matter: solid, liquid and gas or vapor[1], are mentioned in Part I; and the three additional states: plasma, Bose-Einstein condensate (BEC), and Fermionic condensate are described in Part II.

Solid formation occurs when the attraction between individual particles (atoms or molecules) is greater than the particle energy (mainly kinetic energy or heat) causing them to move apart. The particles are locked in positions near each other, so that solids have defined shapes and volumes. The particles of solids are still in motion, but they remain fixed in place and only vibrations take place.

Liquids are formed when the particle energy is increased and the rigid solid structure breaks down. Liquid particles can slide past one another and collide with other particles, but they remain close to each other. Thus liquids can 'flow' to take the container shape but they cannot be readily compressed. Therefore liquids have defined volumes but undefined shapes.

Gases are formed when energy exceeds attraction between molecules. Particles move quickly and freely in all directions spreading out everywhere within the container. Gases can be compressed easily and they have undefined shapes.

It is well known that heating will cause substances to change state - state conversion, in accordance with their enthalpies of fusion ΔH_f or vaporization ΔH_v, or latent heats of fusion and vaporization. For example, ice will be converted to water (fusion) and thence to vapor (vaporization). What happens if a gas is super-heated to very high temperatures? What happens if it is cooled to near absolute zero temperatures? Such curiosity led to the discoveries of plasma in 1879; Bose-Einstein condensate (BEC) in 1995; and to the first observation of the Fermionic condensate in 2003.

Plasmas are hot ionized gases. High energy of plasmas causes stripping of electrons from individual atoms forming a gas of charged ions. The center of stars such as the sun is the most common place that plasmas can be found. The Sun is a 1.5 million kilometer ball of plasma, heated by nuclear fusion. But plasma exists in many ordinary things also, such as neon lights and fluorescence lights.

Bose-Einstein Condensates (BEC) are super cooled materials that exist at temperatures close to absolute zero. In this state all atoms jump into a single quantum-mechanical state, forming a giant super atom.

[1] The gas state of a substance that is a liquid or solid at normal temperatures and pressures (101.3 kPa).