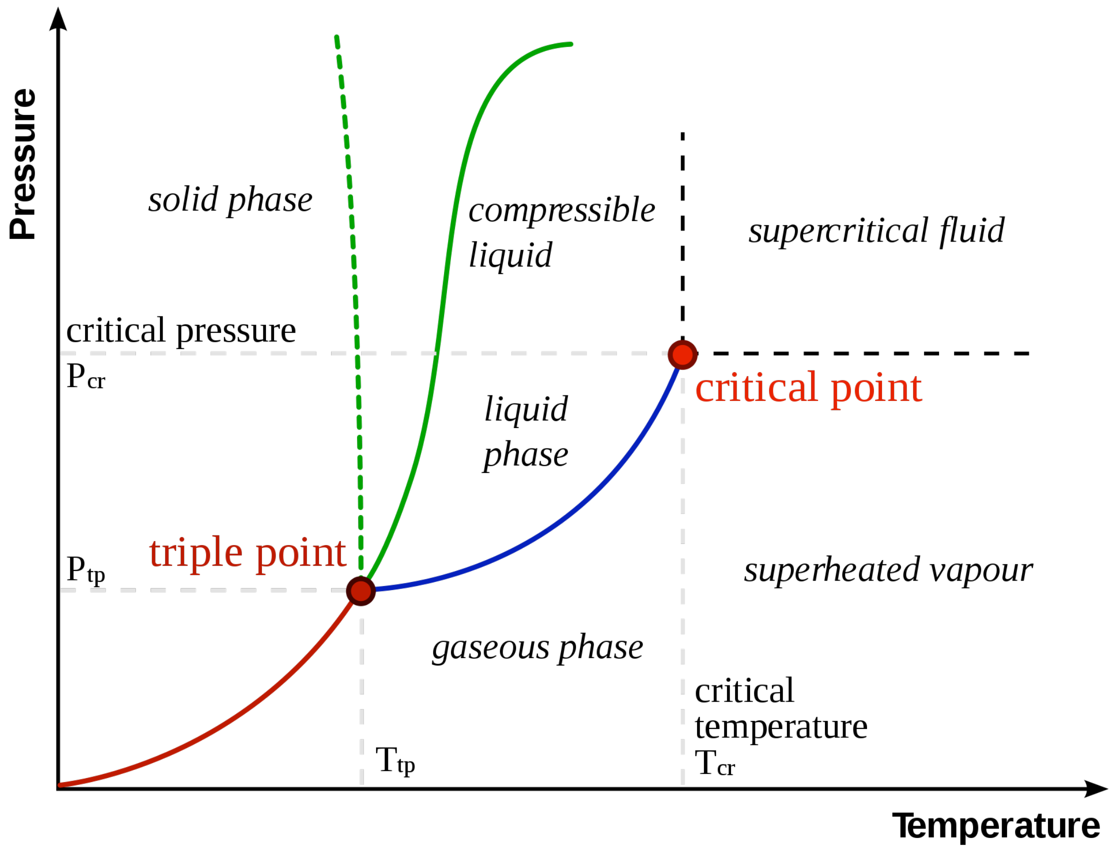
Source: http://en.wikipedia.org/wiki/Phase_diagram

Types of phase diagrams

2D phase diagrams

The simplest phase diagrams are pressure-temperature diagrams of a single simple substance, such as water. The axes correspond to the pressure and temperature. The phase diagram shows, in pressure-temperature space, the lines of equilibrium or phase boundaries between the three phases of solid, liquid, and gas.



A typical phase diagram. The dotted line gives the anomalous behavior of water. The green lines mark the freezing point and the blue line the boiling point, showing how they vary with pressure.

The curves on the phase diagram show the points where the free energy (and other derived properties) becomes non-analytic: their derivatives with respect to the coordinates (temperature and pressure in this example) change discontinuously (abruptly). For example, the heat capacity of a container filled with ice will change abruptly as the container is heated past the melting point. The open spaces, where the free energy is analytic, correspond to single phase regions. Single phase regions are separated by lines of non-analytical, where phase transitions occur, which are called **phase boundaries**.

In the diagram on the left, the phase boundary between liquid and gas does not continue indefinitely. Instead, it terminates at a point on the phase diagram called the critical point. This reflects the fact that, at extremely high temperatures and pressures, the liquid and gaseous phases become indistinguishable[2], in what is known as a supercritical fluid. In water, the critical point occurs at around T_c=647.096 K (1,164.773 °R), p_c=22.064 MPa (3,200.1 psi) and ρ_c=356 kg/m³.[3]

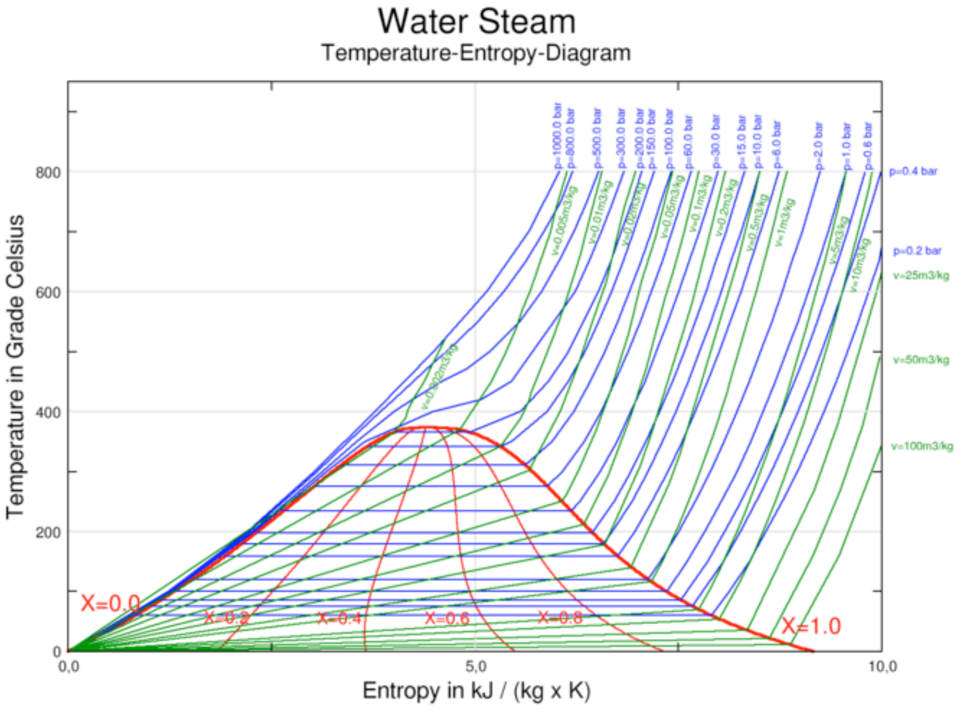
The existence of the liquid-gas critical point reveals a slight ambiguity in labelling the single phase regions. When going from the liquid to the gaseous phase, one usually crosses the phase boundary, but it is possible to choose a path that never crosses the boundary by going to the right of the critical point. Thus, the liquid and gaseous phases can blend continuously into each other. The solid-liquid phase boundary can only end in a critical point if the solid and liquid phases have the same symmetry group[*citation needed*].

The solid-liquid phase boundary in the phase diagram of most substances has a positive slope; the greater the pressure on a given substance, the closer together the molecules of the substance are brought to each other, which increases the effect of the substance's intermolecular forces. Thus, the substance requires a higher temperature for its molecules to have enough energy to break out the fixed pattern of the solid phase and enter the liquid phase. A similar concept applies to liquid-gas phase changes.[4] Water, because of its particular properties, is one of the several exceptions to the rule.

Other thermodynamic properties

In addition to just temperature or pressure, other thermodynamic properties may be graphed in phase diagrams. Examples of such thermodynamic properties include specific volume, specific enthalpy, or specific entropy. For example, single-component graphs of Temperature vs. specific entropy (T vs. s) for water/steam or for a refrigerant are commonly used to illustrate thermodynamic cycles such as a Carnot cycle, Rankine cycle, or vapor-compression refrigeration cycle.

In a two-dimensional graph, two of the thermodynamic quantities may be shown on the horizontal and vertical axes. Additional thermodynamic quantities may each be illustrated in increments as a series of lines - curved, straight, or a combination of curved and straight. Each of these **iso-**lines represents the thermodynamic quantity at a certain constant value.



Temperature vs. specific entropy phase diagram for water/steam. In the area under the red dome, liquid water and steam coexist in equilibrium. The critical point is at the top of the dome. Liquid water is to the left of the dome. Steam is to the right of the dome. The blue lines/curves are **isobars** showing constant pressure. The green lines/curves are **isochors** showing constant specific volume. The red curves show constant quality.

3D phase diagrams

It is possible to envision three-dimensional (3D) graphs showing three thermodynamic quantities.[5][6][7] For example for a single component, a 3D Cartesian coordinate type graph can show temperature (T) on one axis, pressure (P) on a second axis, and specific volume (v) on a third. Such a 3D graph is sometimes called a P-v-T diagram. The equilibrium conditions would be shown as a 3D curved surface with areas for solid, liquid, and vapor phases and areas where solid and liquid, solid and vapor, or liquid and vapor coexist in equilibrium. A line on the surface called a **triple line** is where solid, liquid and vapor can all coexist in equilibrium. The critical point remains a point on the surface even on a 3D phase diagram. An orthographic projection of the 3D P-v-T graph showing pressure and temperature as the vertical and horizontal axes effectively collapses the 3D plot into a 2D pressure-temperature diagram. When this happens, the solid-vapor, solid-liquid, and liquid-vapor surfaces collapse into three corresponding curved lines meeting at the triple point, which is the collapsed orthographic projection of the triple line.