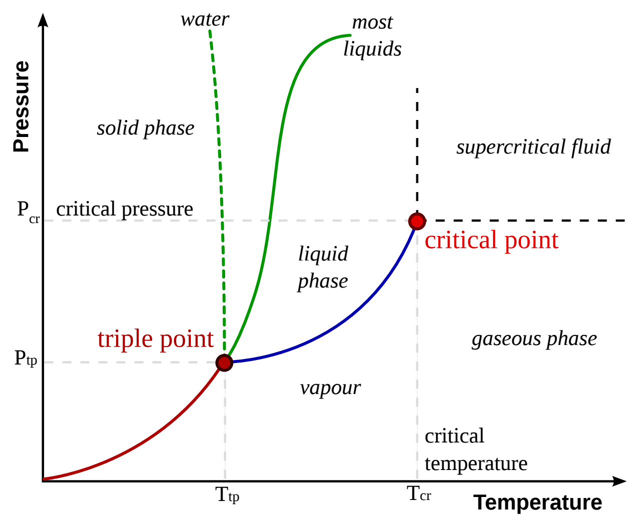
Phase Diagrams

Skills to Develop

- Identify and describe the parts of a phase diagram

You know that phase changes usually depend on temperature, which determines the kinetic energy of atoms and molecules. We mentioned before that they also depend on pressure. In the section on phase changes we said that the boiling point is the place where vapor pressure is the same at the external pressure, so clearly boiling point depends on pressure! Melting temperature also depends on pressure (usually the density of solid and liquid are different, so it makes sense) but not nearly as much as boiling point, since the volume changes are smaller. We use **phase diagrams** to show how the transition temperatures depend on temperature and pressure both.



A generic phase diagram. The triple point and critical point are labeled. The solid green line represents the melting point of most liquids, and the dotted green line represents the unusual behavior of water. Figure adapted from Matthieumarechal via Wikimedia Commons.

Look at the diagram. Notice that the gas phase is on the bottom, where the pressure is low. Solid is on the left, where the temperature is low. Liquid is in between. The red line shows the sublimation point: along this line, a low pressure, solid turns directly into gas without going through liquid. The point where liquid become stable is called the triple point, where all three phases (solid, liquid and gas) are all in equilibrium. The blue line is the boiling point. Notice that the boiling temperature changes a lot with a change in pressure. The solid green line shows the melting point of most liquids. Notice that the melting point doesn't depend on pressure nearly as much as the boiling point (which makes sense, because the change in volume from solid to liquid is small). Most liquids are less dense than the solid phase, so higher pressure increase the melting point. The dotted green line shows the melting point for water. Water is denser as a liquid, so higher pressures decrease the melting temperature.

The second red point in the diagram is the **critical point**. The dotted black lines show the area where a **supercritical fluid** exists. This is the high-temperature, high-pressure part of the diagram. Because the temperature is high, the molecules have lots of kinetic energy, so a liquid form isn't really stable because the intermolecular forces aren't strong enough to hold such energetic molecules together. However, the pressure is so high that the molecules can't really get away from each other either, so they bump into each other a lot, and feel some attractions, and don't really act like a normal gas (certainly not an ideal gas!). Past the critical point, there's no distinct liquid or gas, just a supercritical fluid with some special properties.

Supercritical fluids can make good solvents. For instance, supercritical CO_2 is commonly used because it is a safe, inert, inexpensive non-polar solvent. Most non-polar solvents are not very safe (toxic and flammable), and disposing of them is expensive; supercritical CO_2 avoids these problems.

Outside Link

- Khan Academy: Phase Diagrams (13 min)

Contributors and Attributions

- Emily V Eames (City College of San Francisco)