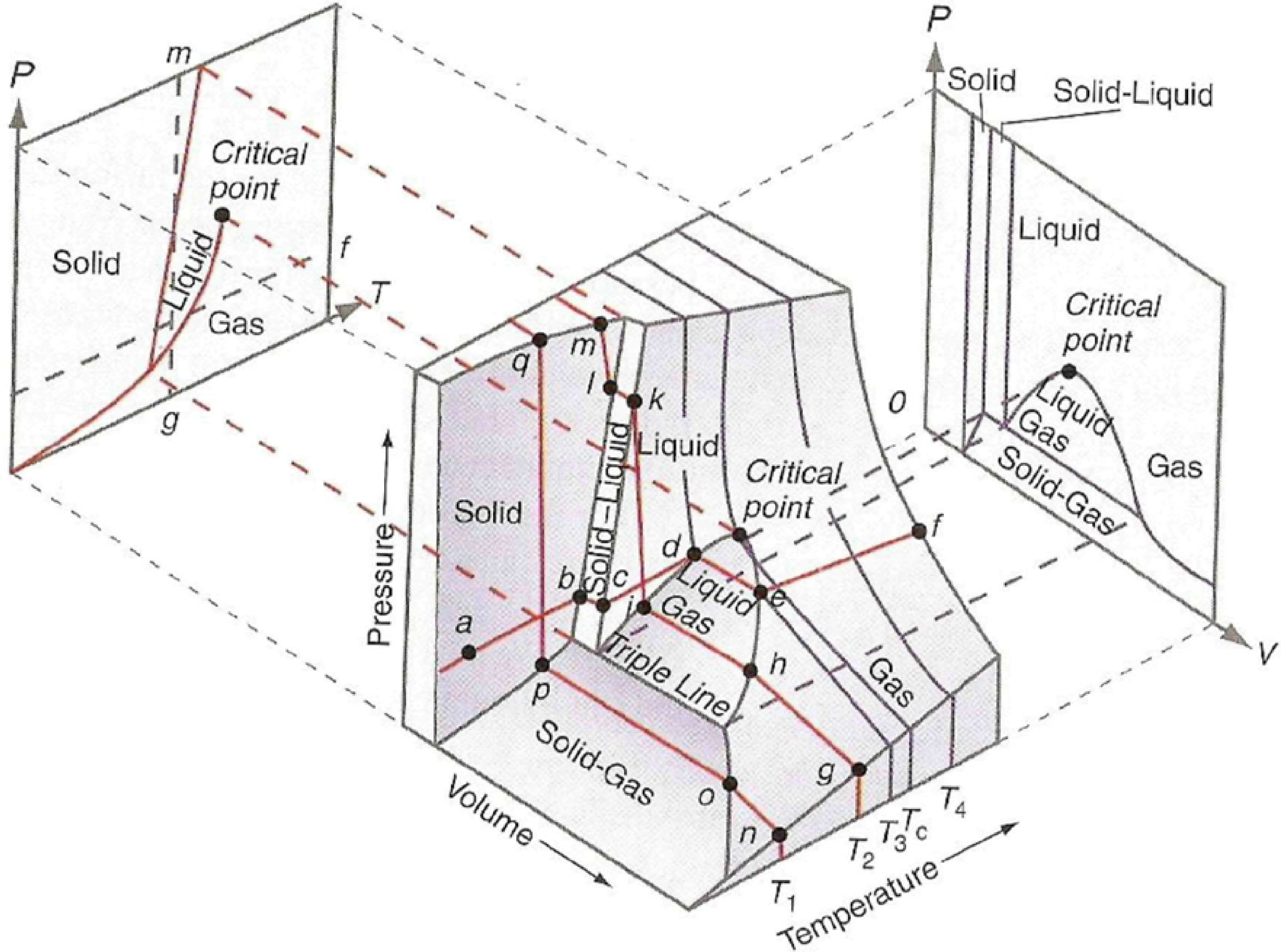
REAL GAS

Rita Prasetyowati
FMIPA UNY


P
m
Critical
point
Solid
Liquid
Gas
f
T
g
P
Solid
Solid-Liquid
Liquid
Critical
point
Liquid
Gas
Gas
Solid-Gas
V
q
m
l
k
Liquid
Solid–Liquid
Solid
Critical
point
d
b
c
e
f
a
i
Liquid
Gas
Pressure
Triple Line
h
p
Gas
Solid-Gas
g
o
n
Volume
T_1
T_2
T_3
T_c
T_4
Temperature

The part of the process where liquid and vapor can exist in equilibrium, the vapor is called *saturated vapor* and the liquid is *saturated liquid*.

Critical temperature T_c is used to denote a point which the spesific volumes of *saturated liquid and vapor* become equal.

Above the *critical temperature*, no separation into two phases of different densities occures in an isothermal compression from a large volume.
(The liquid phase does not separate out. Separation into a gas and solid phase may occure at sufficiently high pressures).

The common value of the spesific volumes of saturated liquid and vapor at the *critical temperature* is called the *critical spesific volume,* v_c, and corresponding pressure the *critical pressure,* P_c.

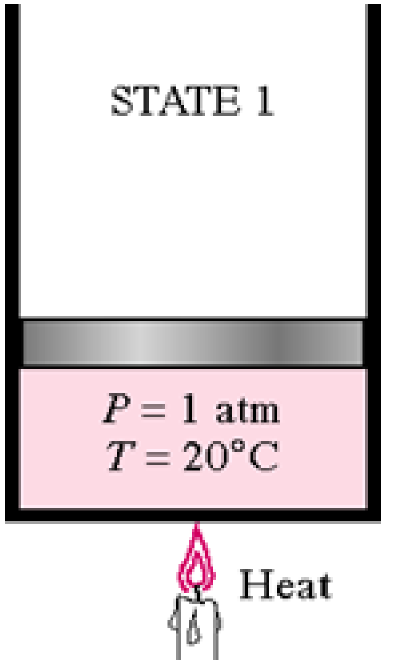
The point on the *P-v-T* surface whose coordinates at T_c, P_c and v_c is the critical point.

The term "*critical point*" is sometimes used to denote specifically the vapor-liquid critical point of a material. The vapor-liquid critical point denotes the conditions above which distinct liquid and gas phases do not exist.

Let's consider the results of heating liquid water from 20°C, 1 atm while keeping the pressure constant. We will follow the constant pressure process shown in process 1- 5. First place liquid water in a piston-cylinder device where a fixed weight is placed on the piston to keep the pressure of the water constant at all times. As liquid water is heated while the pressure is held constant, the following events occur.

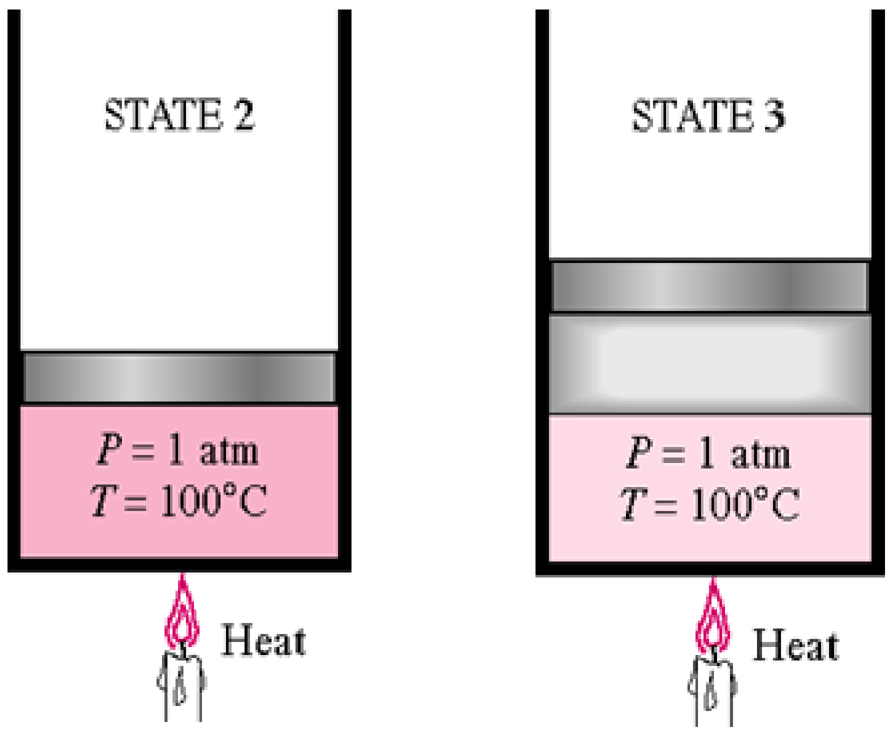
Process 1:

The temperature and specific volume will increase from the compressed liquid, or subcooled liquid, state 1, to the saturated liquid state 2. In the compressed liquid region, the properties of the liquid are approximately equal to the properties of the saturated liquid state at the temperature.



Process 2-3:

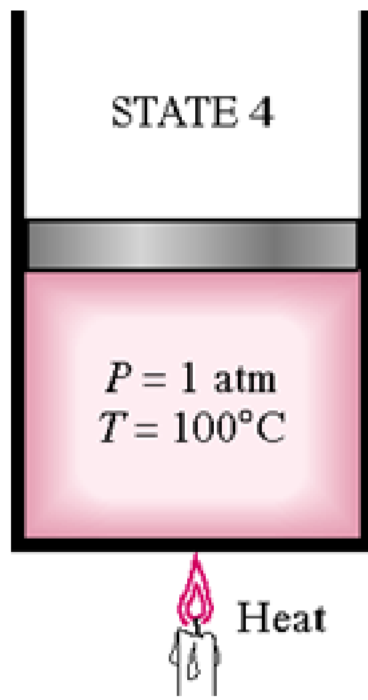
At state 2 the liquid has reached the temperature at which it begins to boil, called the saturation temperature, and is said to exist as a saturated liquid. Properties at the saturated liquid state are noted by the subscript f and $v_2 = v_f$. During the phase change both the temperature and pressure remain constant (according to the International Temperature Scale of 1990, ITS-90, water boils at 99.975°C ≅ 100°C when the pressure is 1 atm or 101.325 kPa). At state 3 the liquid and vapor phase are in equilibrium and any point on the line between states 2 and 3 has the same temperature and pressure.



Process 3-4:

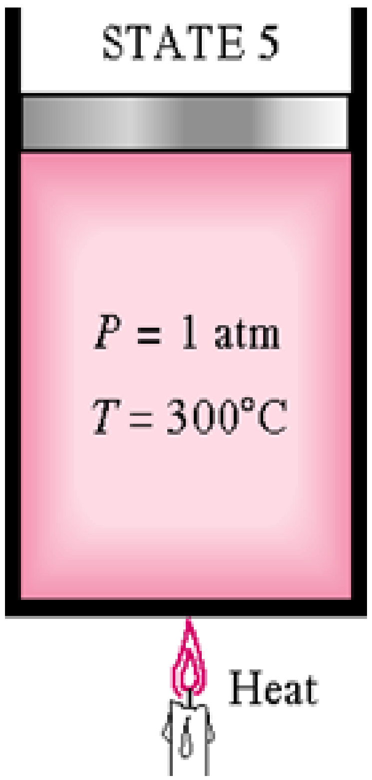
At state 4 a saturated vapor exists and vaporization is complete. The subscript *g* will always denote a saturated vapor state. Note $v_4 = v_g$.

Thermodynamic properties at the saturated liquid state and saturated vapor state are given in Table A-4 as the saturated temperature table and Table A-5 as the saturated pressure table. These tables contain the same information. In Table A-4 the saturation temperature is the independent property, and in Table A-5 the saturation pressure is the independent property. The saturation pressure is the pressure at which phase change will occur for a given temperature. In the saturation region the temperature and pressure are dependent properties; if one is known, then the other is automatically known.



Process 4-5:

If the constant pressure heating is continued, the temperature will begin to increase above the saturation temperature, 100 °C in this example, and the volume also increases. State 5 is called a superheated state because T_5 is greater than the saturation temperature for the pressure and the vapor is not about to condense. Thermodynamic properties for water in the superheated region are found in the superheated steam tables, Table A-6.



This constant pressure heating process is illustrated in the following figu

99.975 ≅

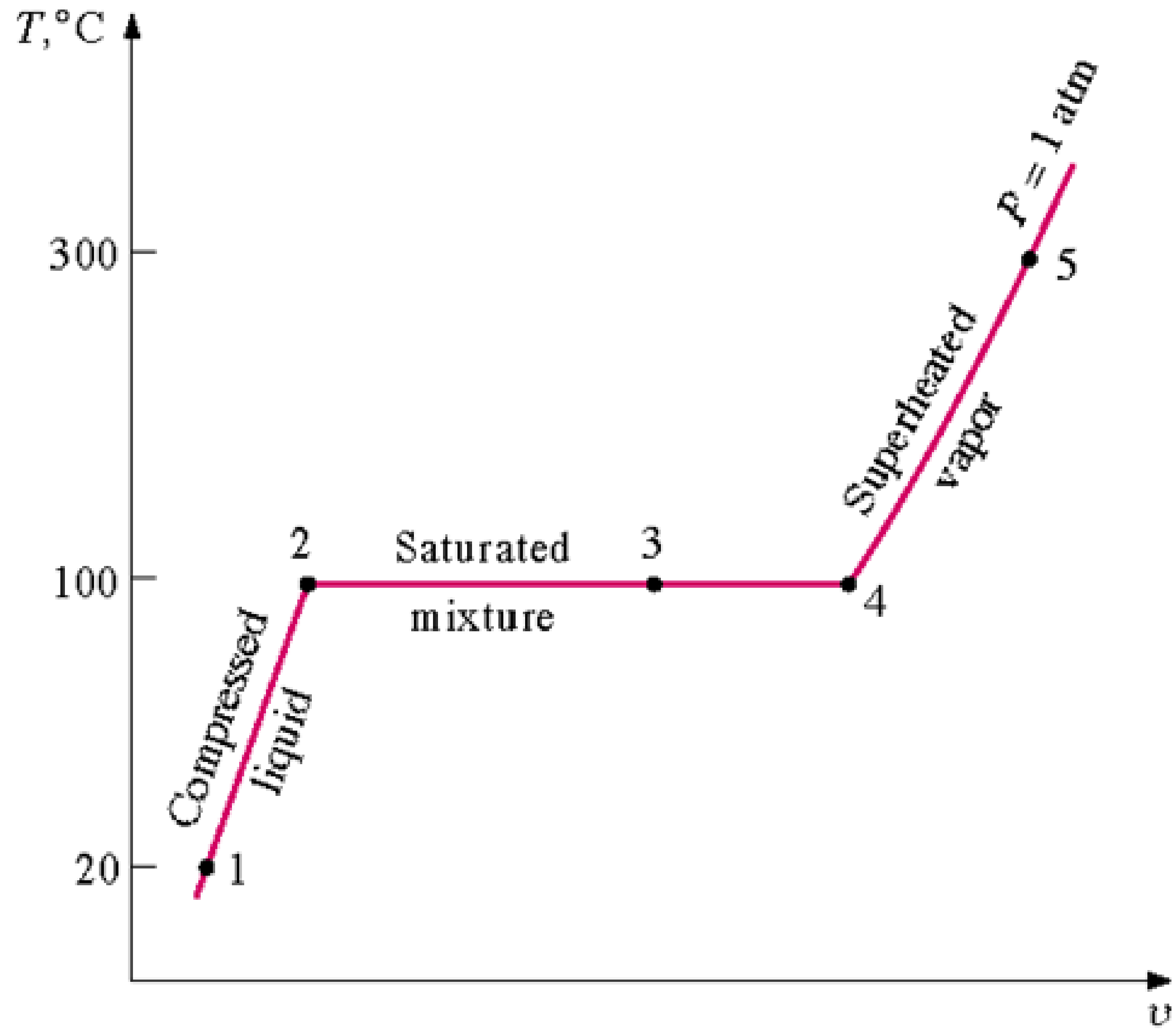


Figure 1