

## 1.8 Condensation of real gases

By discussing the condensation of real gases, here as an example  $\text{CO}_2$ , we will learn much about the standard vocabulary of thermodynamics and various phenomena. The prefix *iso* (Greek: equal) is found in many phrases like isobars, isotropic, etc.. So isotherms represent data measured at constant temperature. In Fig. 1.4 several isotherms for  $\text{CO}_2$  in a  $pV$ -diagram are shown. Comparing just the shape of the isotherms a critical temperature  $T_c$  is found:

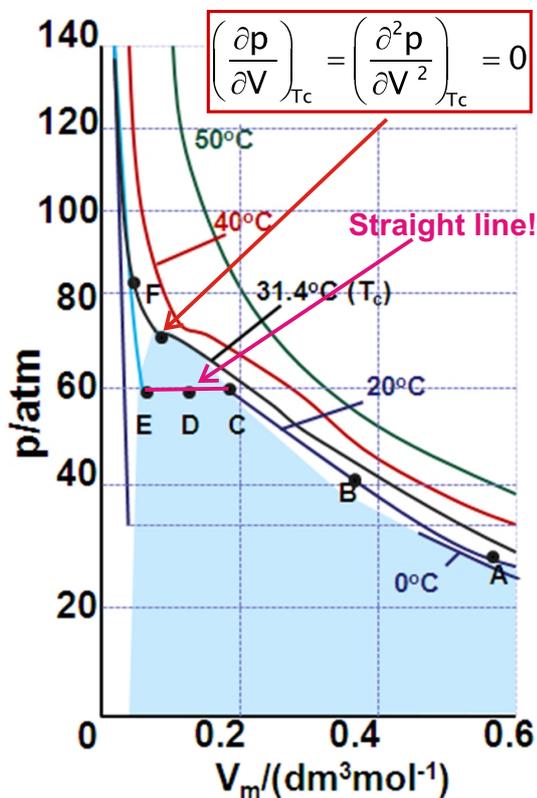


Figure 1.4:  $pV$ -diagram of  $\text{CO}_2$ : Several isotherms

- At the critical point the first and second derivative are zero. To determine the value of the critical point we need a third condition which is the thermal equation of state under consideration. In the next section we will use the Van-der-Waals approach to solve this problem.
- Supercritical isotherms ( $T > T_c$ ) show no buckles / edges. No phase separation exists but one single phase of a supercritical fluid (SCF). Under compression a SFC with high density is formed.
- Subcritical isotherms ( $T < T_c$ ) show buckles / edges. Generally such edges indicate phase separation implying many properties we will discuss later in detail. Here phase separation means that a liquid and a vapor phase exist simultaneously in separated regions of the system. Under compression  $V_m$  decreases by condensation, i.e.  $\text{CO}_2(\text{g})$  (g: gas) is transformed into  $\text{CO}_2(\text{l})$  (l: liquid).

In detail the characteristic points in Fig. 1.4 indicate:

- At C condensation to  $\text{CO}_2(\text{l})$  starts
- Along CDE: constant  $p$  but increase of  $\text{CO}_2(\text{l})$  amount
- Strong slope EF due to compression of pure  $\text{CO}_2(\text{l})$
- Critical point  $p_c, V_c, T_c$ : critical constants. The practical meaning of the critical constants will be discussed later.

The properties of gases and fluids discussed here have a large impact for physical/technical processes. E.g. to liquify gases typically high pressure is used. So one could ask the question: Is it possible to produce liquid oxygen by compression at room temperature? The answer is: NO! The temperature must be below the critical temperature, otherwise a supercritical isotherm is present.