Chap 3 Properties of Fluids

- First examine phase diagrams - the experimental data that equations of state (EOS) endeavour to predict
- Review ideal gas law concept and relationships using
- Look at EOSs for real fluids (cubic equations in particular and generalised correlations.)

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Phase Diagrams

- Phase Diagrams present experimental data that equations of state are trying to predict.
- Phase diagrams are more accurate because they do not contain model inadequacies.
- Equations of state are meant to approximate information within a phase diagram
  - Many EOSs have been developed but none are able to predict all substances in all phases (yet)

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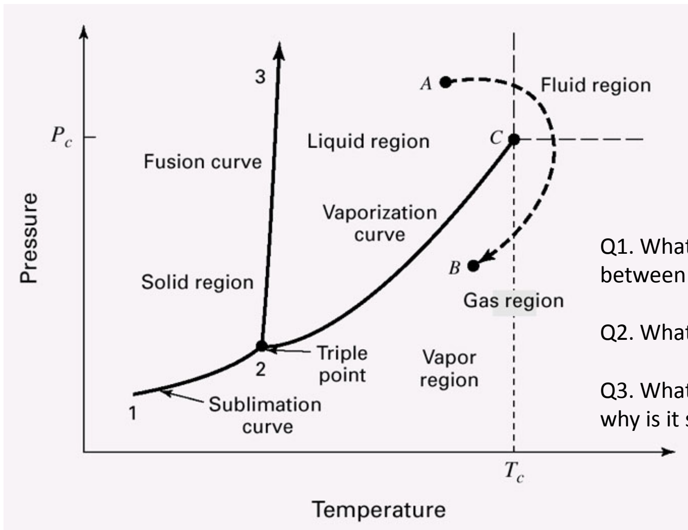
Example Phase Diagram

P-T diagram Generic



Q1. What is the difference between a gas and a vapour?

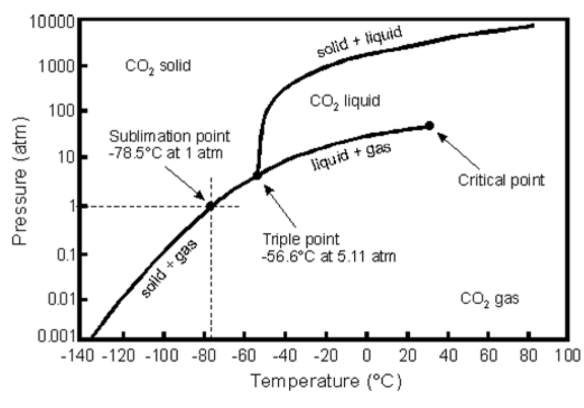
Q2. What is a supercritical gas?

Q3. What is the fluid region and why is it specified?

Fig 3.1 in text

Example Phase Diagram

P-T diagram for CO2



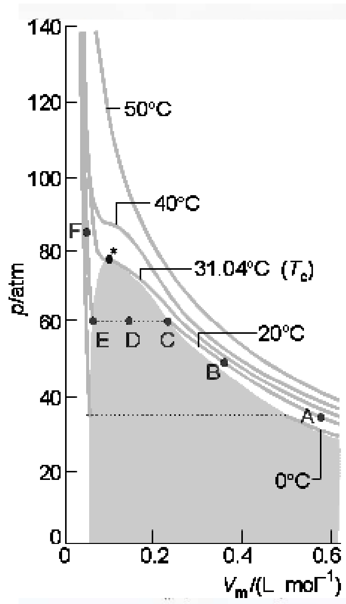
Pressure-Temperature phase diagram for CO_2.

Application of the Gibbs phase rule:

Q. For liquid CO2 in equilibrium with CO2 gas, how many degrees of freedom do we have?

Q. For CO2 gas, how many degrees of freedom do we have?

Example Phase Diagrams



PV phase diagram for CO2

Question: What happens if we compress CO2 isothermally at 20C?

Question: Why aren't there any abrupt volume changes for isotherms above Tc?

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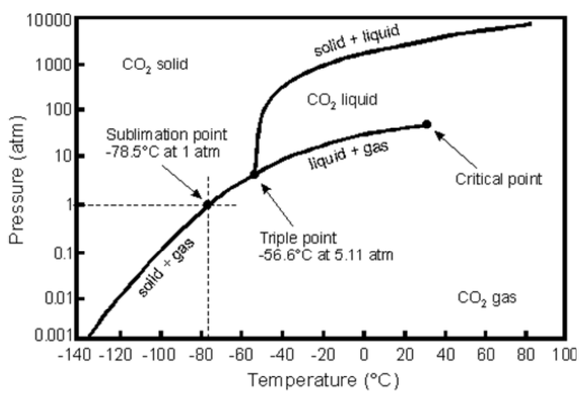
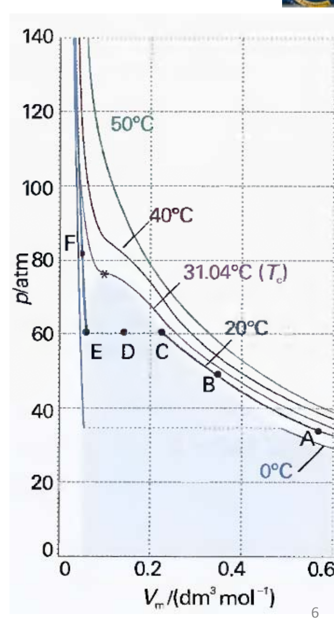
Comparison of PT and PV for CO2



Pressure-Temperature phase diagram for CO_2.



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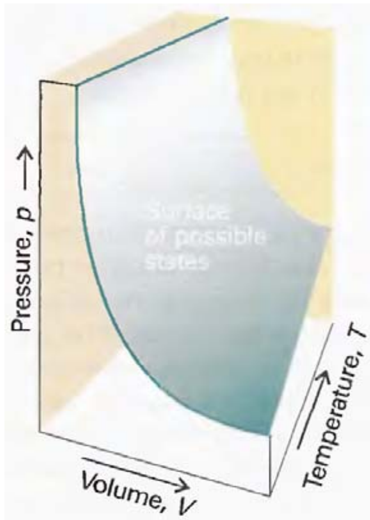
PVT Diagram For Ideal Gas



- Example: Make your own PV diagram using ideal gas law

Differences between real and ideal gases

- Molecules in real gases interact with one another (except in the limit as P->0)
- Long range and short range intermolecular forces change the compressibility of the gas
  - Long range attractive forces between molecules tend to attract molecules: Gas is more compressible compared to ideal case
  - Short range repulsive forces tend to push two molecules away: Gas is less compressible (tends to expand) compared to ideal case
  - At medium pressures, attractive forces tend to dominate (due to distances between molecules), at high pressures repulsive forces tend to dominate

Differences between real and ideal gases

- The compressibility of a real gas is defined by:

$$Z = \frac{V_{m\ \text{(actual)}}}{V_{m\ \text{(ideal)}}}$$

  - To do yourself: Derive the following EOS for a real gas

$$PV = ZRT$$

- Other differences:

Real gas

$$U = U(P,T)$$

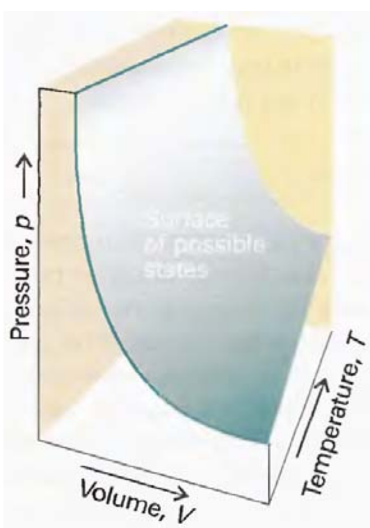
Ideal gas

$$\lim_{P \to 0} U = U(T)$$

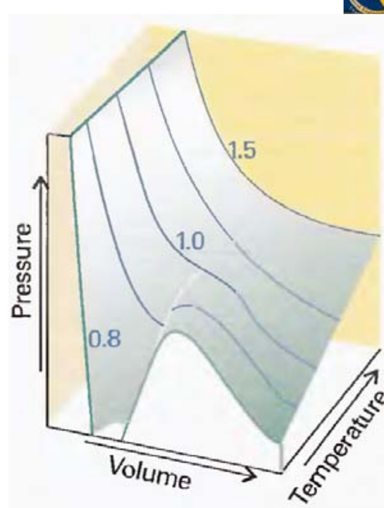
As a consequence:

$$C_P = C_V + R$$

Ideal vs Real gas comparison



$$PV = RT$$



$$PV = ZRT$$

(Actually from van der Waals equation)