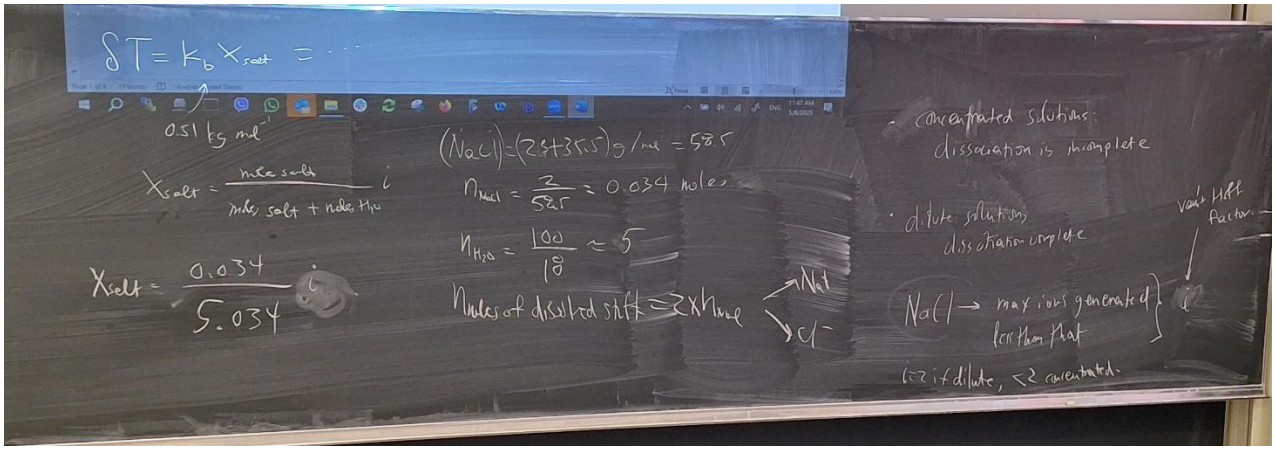
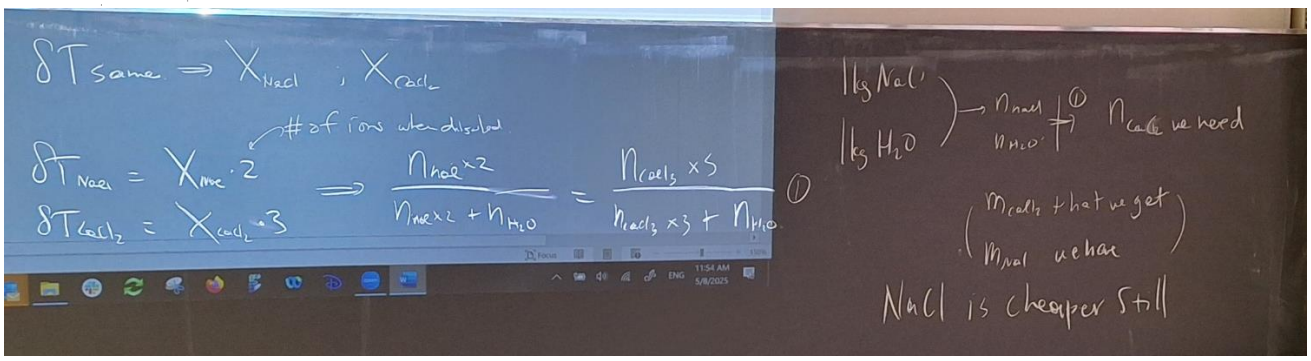
ENV-413: Thermodynamics of the Earth systems

Exercise session for Lecture 9

1. Colligative properties depend on the total number of particles dissolved in a solvent: sometimes this means keeping alert…. Estimate the freezing point of 100g of water containing 2 g of NaCl. (remember, K_b for water is 0.51 kg mol^{-1})



2. Common salt (NaCl) is spread on roads to prevent icing in the wintertime. The cost of salt is \$1/kg. A rich new source of $CaCl_2$ was discovered and mined at \$1.4/kg. Which salt is more cost-effective?



1. From the following data, roughly sketch the p-T phase diagram for carbon dioxide: a) critical point at 31°C and 73 atm; b) triple point at -57°C and 5.3 atm; c) solid is denser than liquid at the triple point. Identify all regions and lines drawn. Mark on the diagram points which are examples of the following (use the letters A, B, C)

A. unsaturated vapor

B. a parcel containing liquid and solid in equilibrium

C. a parcel of saturated vapor and liquid in metastable equilibrium at T < -57°C

2. Which phases of water are possible on Earth?

a) vapor b) liquid c)solid

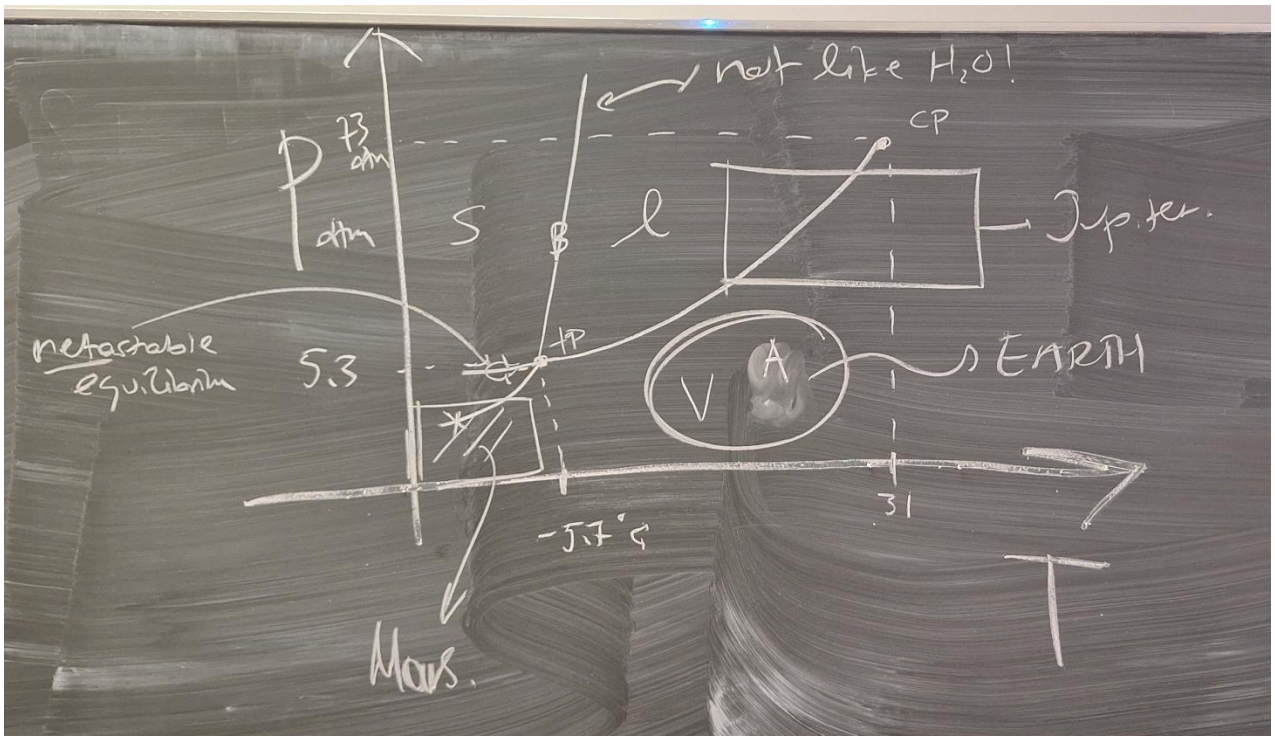
Which phases of CO_2 are possible on Earth?

a) vapor b) liquid c)solid

Which phases of CO_2 are possible on Mars (where p ~ 1mbar)?

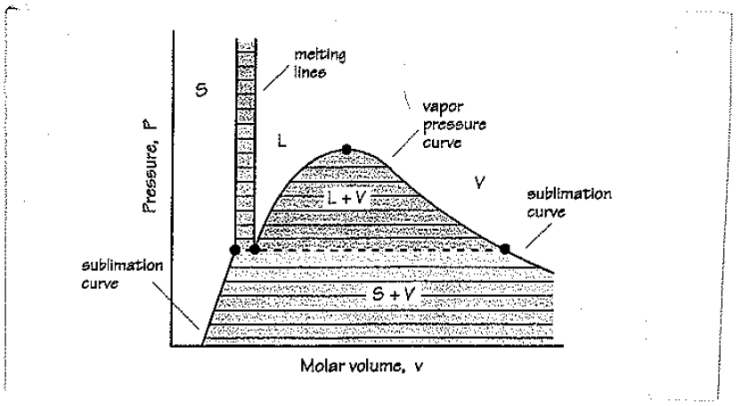
a) vapor b) liquid c)solid

Solutions for 1,2



3. A phase diagram is given below in the p-v plane. Label the following on the diagram:
a) Number of thermodynamic degrees of freedom associated with each region and line
b) label the triple line and the critical point

Mark on the diagram examples of each of the following
A. unsaturated vapor
B. liquid and vapor in equilibrium
C. path of isothermal compression, starting from point X until system is completely liquid



4. Consider a two-component system consistent of H_2O and NaCl. Write the Gibbs phase rule for this two-component system.

5. To conveniently represent the phase diagram on a graph, we can eliminate one degree of freedom if we examine the system only at constant pressure. For the two-component system at constant pressure, what is the maximum number of thermodynamic degrees of freedom for this system?