Oppgaver for forståelse

1. A pressure cooker contains water and steam in equilibrium at a pressure greater than atmospheric pressure. How does this greater pressure increase cooking speed?

   Fasit:

   At higher pressure, the water and steam are in equilibrium at a higher temperature, the food will cook faster at higher temperature.

   Ved høyere trykk er vannet og dampen i likevekt ved høyere temperatur, maten vil koke raskere ved høyere temperatur.

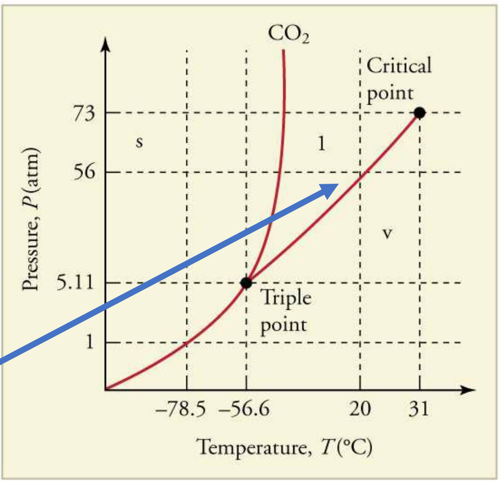
2. Norsk:
   Kan karbondioksid være flytende ved romtemperatur 20°C? I så fall, hvordan? Hvis ikke, hvorfor ikke?

   English:
   Can carbon dioxide be liquid at room temperature 20°C? If so, how? If not, why not?

   Fasit:

   On the phase diagram you can see that at 20°C, CO_2 is liquid at a pressure of 56 atm.

   På fasediagrammet kan du se at ved 20°C er CO_2 flytende ved et trykk på 56 atm.



Oppgaver for beregning

3. Norsk:
   Tørr luft er 78,1 % nitrogen. Hva er partialtrykket av nitrogen når atmosfærisk trykk er 1.01×10^5 N/m^2?

   English:
   Dry air is 78.1% nitrogen. What is the partial pressure of nitrogen when the atmospheric pressure is 1.01×10^5 N/m^2?

   Fasit:

   The total pressure is the sum of the pressure from each component of the air:

   ?ressure = pressure of nitrogen + pressure of other gasses:

   $P = P_N + P_{other}$

   $P_N = 0.781 \cdot 1.01 \times 10^5 \text{ N/m}^2 = 0.789 \times 10^5 \text{ N/m}^2$

4. Norsk:
Hva er den relative fuktigheten på en dag med temperaturen 25.0ºC når luften inneholder $18.0\ \mathrm{g/m^3}$ av vanndamp?

English:
What is the relative humidity on a day with temperature 25.0ºC when the air contains $18.0\ \mathrm{g/m^3}$ of water vapor?

Fasit:
Relative humidity = ratio of water vapor density / saturation water vapor density.
How saturated is the air with water.

$$\varphi = \frac{\rho_v}{\rho_s}$$

From table 13.5 in the book, at T = 25.0ºC , the saturation vapor density is : ρ_s = $23.0\ \mathrm{g/m^3}$

The relative humidity is:

$$\varphi = \frac{\rho_v}{\rho_s} = \frac{18.0\ \mathrm{g/m^3}}{23.0\ \mathrm{g/m^3}} = 0.782 = 78.2\ \%$$

5. Norsk:
Hvis den relative fuktigheten er 90,0 % på en fuktig sommermorgen når temperaturen er 20.0ºC, hva blir det senere på dagen når temperaturen er 30.0ºC, forutsatt at vanndamptettheten forblir konstant?

English:
If the relative humidity is 90.0% on a muggy summer morning when the temperature is 20.0ºC, what will it be later in the day when the temperature is 30.0ºC, assuming the water vapor density remains constant?

Fasit:

First calculate mass density of water vapor in the air:

From table 13.5 in the book, at T = 20.0ºC, the saturation vapor density is ρ_s = $17.2\ \mathrm{g/m^3}$

$$\rho_v = \varphi \times \rho_s = 0.90 \times 17.2\ g/m^3 = 15.5\ \mathrm{g/m^3}$$

At T = 30 ºC , ρ_s = $30.4\ \mathrm{g/m^3}$ and the relative humidity will then be

$$\varphi = \frac{\rho_v}{\rho_s} = \frac{15.5\ \mathrm{g/m^3}}{30.4\ \mathrm{g/m^3}} = 0.509 = 51\ \%$$

6. Norsk:
   Sent på en høstdag er den relative fuktigheten 45,0% og temperaturen er 20,0°C. Hva vil den relative fuktigheten være den kvelden når temperaturen har falt til 10,0°C, forutsatt konstant vanndamptetthet?

   English:
   Late on an autumn day, the relative humidity is 45.0% and the temperature is 20.0°C. What will the relative humidity be that evening when the temperature has fallen to 10.0°C? Assume the water content does not change, constant water vapor density.

   Fasit:

   First calculate mass density of water vapor in the air:

   From table 13.5 in the book, at T = 20.0°C, the saturation vapor density is $\rho_s = 17.2\ \mathrm{g/m^3}$

   $$\rho_v = \varphi \times \rho_s = 0.45 \times 17.2\ \mathrm{g}/m^3 = 7.74\ \mathrm{g/m^3}$$

   At T = 10 °C , $\rho_s = 9.4\ \mathrm{g/m^3}$ and the relative humidity will then be

   $$\varphi = \frac{\rho_v}{\rho_s} = \frac{7.74\ \mathrm{g/m^3}}{9.4\ \mathrm{g/m^3}} = 0.823 = 82\ \%$$

7. Norsk:
   Hvis du vil lage mat i vann ved 120°C, trenger du en trykk-koker som tåler det nødvendige trykket.
   (a) Hvilket trykk er nødvendig for at kokepunktet for vann skal være så høyt?
   (b) Hvis lokket på trykkokeren er en skive 25,0 cm i diameter, hvilken kraft må den kunne tåle ved dette trykket? Typiske trykk-kokere er designet for 110 °C.

   English:
   If you want to cook in water at 120°C, you need a pressure cooker that can withstand the necessary pressure.
   (a) What pressure is required for the boiling point of water to be this high?
   (b) If the lid of the pressure cooker is a disk 25.0 cm in diameter, what force must it be able to withstand at this pressure? Typical pressure cookers are designed for 110 °C.

   Fasit:

   a) We can read the pressure from Table 13.5 in the book.
   At T = 100 °C water will boil at pressure $P_{100} = 1.01 \times 10^5\ \mathrm{N/m^2}$
   At T = 120 °C water will boil at pressure $P_{120} = 1.99 \times 10^5\ \mathrm{N/m^2}$

   b) The lid must hold in a pressure of $P_{120} = 1.99 \times 10^5\ \mathrm{N/m^2}$

   The force on the lid: $P = \frac{Force}{Area} = \frac{F}{A}$ and F = P · A

   The area of the lid is: $A = \pi r^2 = \pi\,(12.5\ \mathrm{cm})^2 = 490\ \mathrm{cm^2} = 0.049\ \mathrm{m^2}$
   We need the area in m^2 if we are using pressure units of Pa = N / m^2

   $F = P \cdot A = 1.99 \times 10^5\ \mathrm{N/m^2} \cdot 0.049\ \mathrm{m^2} = 9.75 \times 10^3\ \mathrm{N}$

8. Norsk:
   På en bestemt dag er temperaturen 25,0°C og den relative fuktigheten er 90,0%. Hvor mange gram vann må kondensere ut av hver kubikkmeter luft hvis temperaturen faller til 15,0°C? En slik temperaturfall kan dermed produsere tung dugg eller tåke.
   Fasit: c = 387 J/(kg°C)

   English;
   On a certain day, the temperature is 25.0°C and the relative humidity is 90.0%. How many grams of water will condense out of each cubic meter of air if the temperature drops to 15.0°C? Such a drop in temperature can thus produce heavy dew or fog.
   Answer: c = 387 J/(kg°C)

   Fasit:

   First calculate how much water is in the air:
   From table 13.5 in the book, at T = 25.0°C, the saturation vapor density is ρ_s = 23.0 g/m^3

   $$\rho_v = \varphi \times \rho_s = \quad 0.90 \times 23.0 \ \mathrm{g}/m^3 \quad = 20.7 \ \mathrm{g/m^3}$$

   When the air cools to T = 15.0°C the saturation vapor density is ρ_s = 12.8 g/m^3

   The vapor density in the air is higher than 12.8 g/m^3

   The excess will condense out until $\rho_v = \rho_s$ and the relative humidity will be 100 %

   How much condense out:
   $\rho_{condense} = \rho_v - \rho_s$ = 20.7 g/m^3 - 12.8 g/m^3 = 7.9 g/m^3