Varmafræði - Dæmablað 2

Q1

Is it possible to have water in liquid phase at 140°C?

- Já vatn getur verið liquid við 140° ef þrýstingur er nógu hár.
- það getur verið liquid þangað til hitastig nær 374°C (critical point).

---

*Q2

We have 3,5 atm = 354,637 kPa

and 11,3 atm = 1144,973 kPa

According to table A5 we get

h_{fg} at 355 kPa ≈ 2147,7 kJ/kg

h_{fg} at 1150 kPa ≈ 1999,6 kJ/kg

And thus it takes more energy at 3,5 atm

*Q4

$T = 50^\circ C$, $d = 4\,cm$, $L = 30\,m$, $\dot{m} = 100\ kg/h$

According to table A4 we have:

$$h_{fg} \text{ at } 50^\circ C = 2382{,}0\ kJ/kg$$

So the rate of heat transfer is

$$\dot{Q} = \dot{m} \cdot h_{fg} = 100\,\frac{kg}{h} \cdot \frac{1\,h}{3600\,s} \cdot 2382{,}0\,\frac{kJ}{kg}$$

$$= 66{,}17\ kJ/s$$

$$= \underline{\underline{66{,}17\ kW}}$$

*Q7) $V = 2,5 m^3$, steam at $T = 235°C$

$\frac{1}{3}$ liquid phase, $\frac{2}{3}$ vapour

a) According to table A4 we have

$$P_{steam}(T = 235°C) = 3062,6 \ kPa$$

b) $V_{vapor} = 2,5 m^3 \cdot \frac{2}{3} = 1,67 m^3$

$V_{liq} = 2,5 m^3 \cdot \frac{1}{3} = 0,83 m^3$

$v_{vapor @ 235°C} = 0,0653 \frac{m^3}{kg}$

$v_{liquid @ 235°C} = 0,00125 \frac{m^3}{kg}$

$m_{vap} = \frac{1,67 m^3}{0,0653 m^3/kg} = 25,6 \ kg$

$m_{liq} = \frac{0,83 m^3}{0,001219 m^3/kg} = 680,9 kg$

$X = \frac{m_{vap}}{m_{total}} = 0,036$

$\boxed{Q8}$

$m = 6\ kg, \quad P = 536\ kPa, \quad T = 295\ K$

$R_{helium} = 2,0769\ kJ/(kg \cdot K)$

Sol

$$PV = mRT \Rightarrow V = \frac{mRT}{P}$$

$$\Rightarrow V_{container} = \frac{6\ \cancel{kg} \cdot 2.0769 \frac{\cancel{k}J}{\cancel{kg \cdot K}} \cdot 295\ \cancel{K}}{536\ \cancel{k}Pa}$$

$$= 6,86 \frac{J}{Pa} = \underline{\underline{6,86\ m^3}}$$

*Q9 $P_0 = 550\ kPa$, $T_0 = 30°C$, $T_1 = 256°C$

First look at ethane:

$$R_{Ethane} = 0,276\ kJ/kg \cdot K$$

$$T_{cr} = 305,3\ K$$

$$P_{cr} = 4,88\ MPa$$

According to compressability chart

$$T_{R0} = \frac{T_0}{T_{cr}} = \frac{303}{305,3} = 0,993$$

$$P_{R0} = \frac{P_0}{P_{cr}} = \frac{550\ kPa}{4,88\ MPa} = 0,113$$

So from chart:

$$Z_0 \approx 0,97$$

Now:

$$Pv = ZRT \Rightarrow v_{act} = \frac{ZRT}{P}$$

$$= 0,1475\ m^3/kg$$

At final state we have

$$T_{R1} = \frac{T_1}{T_{cr}} = \frac{529\ K}{305,3\ K} = 1,73$$

Now we find

$$v_{R1} = \frac{v_{actual}}{R \cdot \frac{T_{cr}}{P_{cr}}} = 8,54\ m^3/kg$$

→

And from chart we get

$$Z_1 \cong 1$$

Now we have

$$P_1 = \frac{Z_1 R T_1}{v_{actual}} = \frac{1 \cdot 0{,}2760 \frac{kJ}{kg \cdot K} \cdot 529\ K}{0{,}1475\ m^3/kg}$$

$$= \underline{\underline{989{,}86\ kPa}}$$