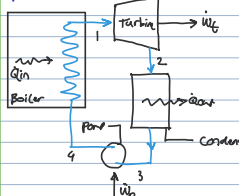


Ran kinu cycle



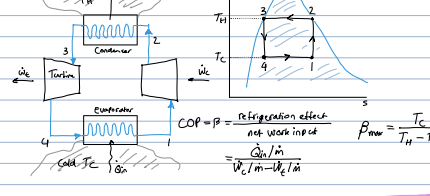
1 Turbine
 $W_t = \dot{Q}_{in} - \dot{m}(h_1 - h_2)$
2 Pump (Internally reversible)
 $W_p = \dot{Q}_{out} - \dot{m}(h_3 - h_4)$
 $\dot{W}_m = -\int T ds + h_3 - h_4$
 $\int_3^4 T ds = \int_3^4 \frac{dh}{\gamma} = h_4 - h_3$
 $P_4 = P_3$
 $P_2 = P_1$
 $x = \frac{h_2 - h_1}{h_3 - h_4}$

Losses in Turbine & Pump

Turbine
 $\eta_{t1} = \frac{W_t}{W_{t1}} = \frac{h_1 - h_2}{h_1 - h_{2s}}$
 $\eta_{t2} = \frac{h_1 - h_2}{h_1 - h_{2s}}$
 $\eta_{t3} = \frac{h_3 - h_4}{h_3 - h_{4s}}$
 $\eta_{t4} = \frac{h_3 - h_4}{h_3 - h_{4s}}$

Pump
 $\eta_{p1} = \frac{W_{p1}}{W_p} = \frac{h_3 - h_4}{h_3 - h_{4s}}$
 $\eta_{p2} = \frac{h_3 - h_4}{h_3 - h_{4s}}$
 $\eta_{p3} = \frac{h_3 - h_4}{h_3 - h_{4s}}$
 $\eta_{p4} = \frac{h_3 - h_4}{h_3 - h_{4s}}$

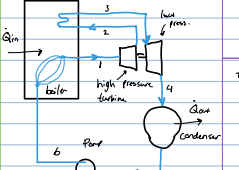
Carnot Refrigeration Cycle



COP
 $COP = \beta = \frac{\text{ref. effect}}{\text{net work input}} = \frac{Q_{in}/\dot{m}}{W_{in}/\dot{m}}$
 $COP = \beta = \frac{T_c}{T_h - T_c}$

Process Quantities
 - isotherm
 - isobar
 - adiabat

Reheat

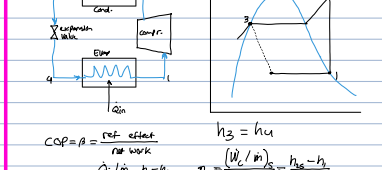


Open feed water heater

Superheated fluid

Thermal efficiency
 $\eta = \frac{CP(T_2 - T_1) - CP(T_3 - T_1)}{CP(T_2 - T_1)}$
 $\eta = 1 - \frac{T_3 - T_1}{T_2 - T_1}$
 $\eta = 1 - \left(\frac{P_3}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

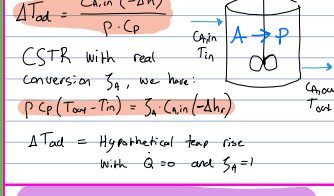
Vapor Compression Refr. Syst.



Process Quantities
 - isotherm
 - isobar
 - adiabat

Thermal efficiency
 $\eta = \frac{CP(T_2 - T_1) - CP(T_3 - T_1)}{CP(T_2 - T_1)}$
 $\eta = 1 - \frac{T_3 - T_1}{T_2 - T_1}$
 $\eta = 1 - \left(\frac{P_3}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

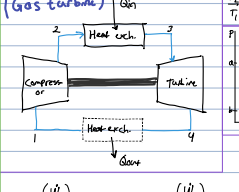
Adiabatic Temperature Rise CSTR



Balance:
 $\Delta T_{ad} = \frac{C_{in}(-\Delta h)}{P \cdot Cp}$
 CSTR with real conversion X_A , we have:
 $P \cdot Cp(T_{out} - T_{in}) = S_A(-\Delta h)$
 $\Delta T_{ad} = \text{Hypothetical temp rise with } Q=0 \text{ and } S_A=1$

Exergic rate balance open system
 $0 = \sum_j (1 - \frac{T_0}{T_j}) \dot{Q}_j - \dot{W} + \sum \dot{m}_i e_i - \sum \dot{m}_e e_e - \dot{E}_d$
 $e_f = h - h_0 - T_0(s - s_0) + \frac{V^2}{2} + \frac{gz}{g_0}$
 $e_g = (h - h_0) - T_0(s - s_0) + \frac{V^2}{2} + \frac{gz}{g_0}$

Brayton Cycle



Adiabatic compression/expansion ideal gas
 $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$
 $K = \frac{C_p}{C_v} = \frac{\gamma}{\gamma-1}$

Thermal efficiency
 $\eta = \frac{CP(T_3 - T_1) - CP(T_4 - T_2)}{CP(T_3 - T_2)}$
 $\eta = 1 - \frac{T_4 - T_1}{T_3 - T_2}$
 $\eta = 1 - \left(\frac{P_4}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

Combustion

Combustion Definition: Combustion or burning is a high-temperature exothermic (releases heat) redox chemical reaction between a fuel (reductant) and an oxidant, usually atmospheric oxygen, that produces oxidized, often gaseous products.

AF Ratio: mass of air / mass of fuel or mass of air / mass of fuel

Theoretical air: 100% theoretical air means the amount of air sufficient for complete combustion

Reaction consist of atoms of C, H, O and N, example:
 $C_8H_{18} + a(O_2 + 3.76 N_2) \rightarrow b CO_2 + c H_2O + d N_2$
 $a = 12.5 \quad b = 8 \quad c = 9 \quad d = 47$
 Mols of air = $(12.5 + 12.5 \cdot 3.76) = 57.8$
 AF = $\frac{\text{Mols of air}}{\text{Mols of fuel}} = 1$

Exergic (second law) efficiency

Balance:
 $(1 - \frac{T_0}{T_1}) \dot{Q}_s = (1 - \frac{T_0}{T_u}) \dot{Q}_u + \dot{E}_d$

First law efficiency:
 $\eta = \frac{\dot{Q}_u}{\dot{Q}_s}$

Second law efficiency:
 $\epsilon = \frac{(1 - \frac{T_0}{T_u}) \dot{Q}_u}{(1 - \frac{T_0}{T_1}) \dot{Q}_s}$
 $\epsilon = \eta \frac{(1 - T_0/T_u)}{(1 - T_0/T_1)}$

Reactors

Batch reactor
 $A \rightarrow P \quad r_A = -k_1 C_A$
 $\frac{dC_A}{dt} = -k_1 C_A \Rightarrow C_A(t) = C_{A0} e^{-k_1 t}$
 max yield: $t = \frac{1}{k_1} \ln\left(\frac{C_{A0}}{C_A}\right)$
 $\frac{d\eta}{dt} = 0$

CSTR
 Residence time: $\tau = \frac{V_0}{\dot{V}}$
 max operating $d\tau \rightarrow 0$

Plug flow
 $\frac{dC_A}{dt} = r_A \frac{L}{v}$

Fluidized bed reactor

Fluidized bed reactor
 $U_{MF} = \frac{d_p^2 (\rho_s - \rho_f) g}{150 \mu} \rightarrow Re_p < 5$
 $U_{MF} = \frac{d_p^2 (\rho_s - \rho_f) g}{1.75 \mu} \rightarrow Re_p > 500$
 - if $5 < Re_p < 500$ both terms!

Packed bed reactor
 pressure drop across a bed of particles:
 $\Delta P = \frac{150 \mu L (1 - \epsilon)^2}{d_p^2 \epsilon^3} v_0 + \frac{1.75 \rho_f L (1 - \epsilon)^2}{d_p \epsilon^3} v_0^2$
 $\Delta P = \frac{150 \mu L (1 - \epsilon)^2}{d_p^2 \epsilon^3} v_0 + \frac{1.75 \rho_f L (1 - \epsilon)^2}{d_p \epsilon^3} v_0^2$
 $\Delta P = \frac{150 \mu L (1 - \epsilon)^2}{d_p^2 \epsilon^3} v_0 + \frac{1.75 \rho_f L (1 - \epsilon)^2}{d_p \epsilon^3} v_0^2$

Stable properties VS Process Quantity

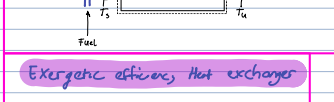
Stable properties: only dependent on the state of the system.
 For example: T, v, ρ

Process Quantity: Depends on the way a process is executed.
 For example: Q, W, \dot{Q}, \dot{W}

Extensive stable properties VS non extensive stable properties
 - extensive: making the system 'n' larger, makes the property 'n' larger.
 For example: V, S, H, C_p, C_v

Equation of state
 Relation between pressure, temperature, density, composition

Distillation

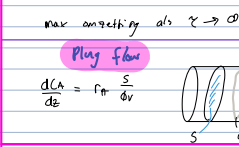


Distillation
 "flash"
 molar balance:
 $F = B + D$
 $x_F F = x_B B + x_D D$
 - top feed heated under pressure
 - vapor condensed in flash drum
 - D.C. mixture for small droplets not to escape

Exergic efficiency Heat exchanger
 balance:
 $0 = \dot{m}_h c_p (T_1 - T_2) + \dot{m}_c c_p (T_3 - T_4) - \dot{m}_h c_p (T_2 - T_1) - \dot{m}_c c_p (T_4 - T_3) - \dot{E}_d$

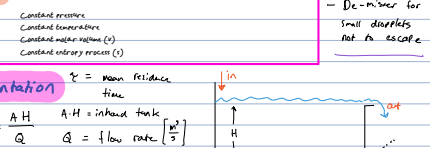
Efficiency
 $\epsilon = \frac{\dot{m}_c (e_{T_3} - e_{T_4})}{\dot{m}_h (e_{T_1} - e_{T_2})}$

Activation energy



Activation energy
 $A + B \rightleftharpoons C + D$
 Forward rate: $k_1 [A][B]$
 Backward rate: $k_2 [C][D]$
 $k = \frac{k_1}{k_2} = \frac{k_{10}}{k_{20}} \exp\left(\frac{-(E_1 - E_2)}{RT}\right) = K_0 \exp\left(\frac{-\Delta h^\ddagger}{RT}\right)$
 $k_1 = k_{10} e^{\frac{-E_1}{RT}}$
 $k_2 = k_{20} e^{\frac{-E_2}{RT}}$
 frequency factors (often ignored)

Sedimentation



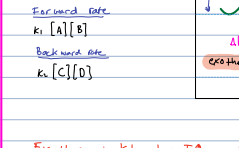
Sedimentation
 $\tau = \frac{H}{v}$
 $\tau_{sed} = \frac{H}{v_0}$
 $A = \frac{Q}{v_0}$
 $A = \text{min Horizontal area}$

Distributie van een component in niet-neighbor

Distributie van een component in niet-neighbor
 Vloeistof A & B met neighbor.
 4 mol A, 3 mol B, 4 mol X \rightarrow Na evenwicht: $X_A^* = 0.2$

3 Bereken k
 $K = \frac{X_A^*}{X_B^*} = \frac{N_A^*}{N_B^*} = 4$
 $X_A^* = 0.2 = \frac{N_A^*}{N_A^* + N_B^*} \Rightarrow 0.2(4 + 0.2 N_B^*) = N_A^*$
 $N_A^* = 1$
 $N_B^* = 3$
 $K = \frac{0.2}{0.8} = 0.25$

Steam turbine + condensator



Steam turbine + condensator
 $P_1 = 90 \text{ bar}$
 $h_1 = 2911.1$
 $P_2 = 2911.1$
 $\dot{Q}_{out} = h_3 - h_{c1}$
 $\dot{Q}_{out} = 2162.8 \text{ kJ/kg}$
 $h_3 = \frac{\dot{Q}}{\dot{m}} + h_{in}$
 $= 2162.8 + 193.88 = 2356.68$
 $x_2 = \frac{h_2 - h_f}{h_g - h_f} = \frac{2356.68 - 191.98}{2577.0 - 193.88} = 0.90$

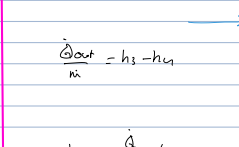
Formule alleen aan de verhouding

Formule alleen aan de verhouding
 $\frac{T_1, P_1}{T_2, P_2} \rightarrow (T_1, P_1) \rightarrow (T_2, P_2)$
 adiabatisch en reversibel dus: $\Delta S_1 + \Delta S_2 = 0$
 $\Delta S_1 = \int_1^2 \frac{C_p}{T} dT = \int_1^2 \dots dT = 0 \text{ met } N=0$
 $\Delta S_1 = - \int_1^2 \frac{L}{T} + \frac{Q}{T^2} dT$
 $= - \left[L \ln\left(\frac{P_2}{P_1}\right) + \frac{Q}{T^2} (P_2 - P_1) \right]$

1 mol A toevoegd. Bereken X_A^* na evenwicht

1 mol A toevoegd. Bereken X_A^* na evenwicht
 $A \rightleftharpoons B: 5 \text{ mol A} \& \ N_A^* = X$
 $B \rightleftharpoons C: 3 \text{ mol B} \& \ N_B^* = 4 - X$
 $X_A^* = \frac{X}{5+X} \quad X_B^* = \frac{4-X}{7-X}$
 $K = 0.15 = \frac{X_A^*}{X_B^*}$
 $0.15 = \frac{X(7-X)}{(5+X)(4-X)}$
 $X = 1.1973$
 $N_A^* = 1.1973 \quad X_A^* = \frac{1.1973}{5+1.1973} = 0.199$

3



3
 $P_1 = 90 \text{ bar}$
 $h_1 = 2911.1$
 $P_2 = 2911.1$
 $\dot{Q}_{out} = h_3 - h_{c1}$
 $\dot{Q}_{out} = 2162.8 \text{ kJ/kg}$
 $h_3 = \frac{\dot{Q}}{\dot{m}} + h_{in}$
 $= 2162.8 + 193.88 = 2356.68$
 $x_2 = \frac{h_2 - h_f}{h_g - h_f} = \frac{2356.68 - 191.98}{2577.0 - 193.88} = 0.90$

8

8
 Hoort de waarde v op om dit gas om de druk af?
 \Rightarrow als dit is: $\left(\frac{dP}{P}\right)_T \neq 0$
 $-T \left(\frac{dP}{P}\right)_T = 3 \frac{dP}{P} \neq 0 \rightarrow$ ja hoort om de druk af

5

5
 $\eta = \frac{(h_1 - h_2) - (h_{u1} - h_{u2})}{h_1 - h_{u1}} \quad P_A = \frac{J}{m^3} \frac{m^3}{kg} = \frac{J}{kg}$
 $h_1 = 1742.1$
 $h_2 = 1336.68$
 $h_3 = 173.88$
 $\dot{W}_p = \dot{m} (h_3 - h_2) = 1.000 \text{ mol} \cdot (173.88 - 1336.68) = -1162.8 \text{ kJ/kg}$
 $= 9.067 \text{ kJ/kg} = h_3 - h_2$
 $h_{u1} = 182.17$
 $\eta = 0.17$

4

4
 $\dot{E}_d = -\dot{W}_e + (e_{f1} - e_{f2})$
 $\dot{W}_e = h_1 - h_2 = 405.1 \text{ kJ/kg}$
 $e_{f1} - e_{f2} = h_1 - h_2 - T_0(s_1 - s_2)$
 $s_1 = 5.6172$
 $s_2 = X_2(s_g - s_f) + s_f = 7.465$
 $\dot{E}_d = -405.1 + (2911.1 - 2356.68) - 300(5.6172 - 7.465) = -536.37 \text{ kJ/kg}$

5

5
 $\eta = \frac{(h_1 - h_2) - (h_{u1} - h_{u2})}{h_1 - h_{u1}} \quad P_A = \frac{J}{m^3} \frac{m^3}{kg} = \frac{J}{kg}$
 $h_1 = 1742.1$
 $h_2 = 1336.68$
 $h_3 = 173.88$
 $\dot{W}_p = \dot{m} (h_3 - h_2) = 1.000 \text{ mol} \cdot (173.88 - 1336.68) = -1162.8 \text{ kJ/kg}$
 $= 9.067 \text{ kJ/kg} = h_3 - h_2$
 $h_{u1} = 182.17$
 $\eta = 0.17$

6

6
 Leid formule af voor evenwichtstoestand van (T, P) naar (T_0, P_0)
 $\Rightarrow \Delta T = 0$
 $S_2 - S_1 = \int_1^2 \frac{C_p}{T} dT = \int_1^2 \dots dT = 0 \text{ met } T_1 = T_2$
 $\left(\frac{\partial v}{\partial P}\right)_T = \frac{R}{P} + \frac{a}{RT^2}$
 $\Delta S_1 = - \int_1^2 \frac{L}{T} + \frac{Q}{T^2} dT$
 $= - \left[L \ln\left(\frac{P_2}{P_1}\right) + \frac{Q}{T^2} (P_2 - P_1) \right]$

Stoomturbine

3) Temp out
 $T_2 = T_1$???
 $w_{out} = 420 \text{ kJ/kg}$
 $h_1 = 5174.32$
 $P_1 = 20 \text{ bar}$
 $h_2 = 2328 \text{ kJ/kg}$
 $P_2 = 0.1 \text{ bar}$
 $S_2 = 5174.12$
 $w_{in} = 420 \text{ kJ/kg}$
 $h_2 = h_1 - w_{in} = 2328 \text{ kJ/kg}$
 $h_2 = h_1 - h_f = 2328 - 191.83 = 2136.17$
 $x_2 = \frac{h_2 - h_f}{h_g - h_f} = \frac{2136.17 - 191.83}{2586.7 - 191.83} = 0.877$

Calculate isentropic efficiency

$\eta_t = \frac{h_1 - h_2}{h_1 - h_{2s}}$
 als isochoor: $S_1 = S_{2s} = 5174.32$
 $x_{2s} = \frac{S_{2s} - S_f}{S_g - S_f} = \frac{5174.12 - 0.693}{8170.1 - 0.693} = 0.627$
 $x_{2s} = \frac{h_{2s} - h_f}{h_g - h_f} = 0.627$
 $h_{2s} = 0.627 \cdot (2586.7 - 191.83) + 191.83$
 $h_{2s} = 1812.34 \text{ kJ/kg}$
 $\eta_t = \frac{h_1 - h_2}{h_1 - h_{2s}} = \frac{2846.32 - 2328}{2846.32 - 1812.34} = 0.904$

Verdampen vloeistoffen

in vloeistof A bevinden zich B & C
 Tijdens verdampen is op het moment
 stopt v B met de vloeistof verdamping
 \Rightarrow hoeveel C is er nog?

- dampspanning A is heel klein $P_A \approx 0$
- verdamping door aanwezigheid B = 2 ke
- activiteitscoëfficiënt v C in vloeistof 4 x zo groot als die van B

$P_i = y_i P = P_{sat,i} \cdot x_i \cdot \gamma_i$

- $P_A \approx 0$
- $P_{sat,B} = 2 \cdot P_{sat,C}$
- $\gamma_C = 4 \gamma_B$

moment 5: 50% v alk B uit vloeistof A verdamp

als er een verdampingsflaks platform, geldt:

$\frac{dn_i}{dt} = -k \cdot (A_{sat}) \cdot P_i$
 → dampspanning
 → oppervlakte
 → constante

strome van het aantal mol van 'i' met de tijd

$x_i = \frac{n_i}{\sum n_i}$
 opgem is dat A & B by concentraties hebben naar onder
 En zijn niet veranderd ster
 ic het in de constante k

$= -k \cdot P_{sat,i} \cdot \gamma_i \cdot x_i$
 $= -k \cdot P_{sat,i} \cdot \gamma_i \cdot \frac{n_i}{\sum n_i}$

$\frac{dn_i}{dt} = -k \cdot P_{sat,i} \cdot \gamma_i \cdot n_i$

Differentiaal vgl oplossen door scheiden van variabelen

$n_i(t) = n_i(0) \cdot \exp(-k \cdot t \cdot P_{sat,i} \cdot \gamma_i) = e^{-k \cdot t \cdot P_{sat,i} \cdot \gamma_i}$

op een moment is er nog 70% v B
 $n_B(t) = 70$

$70 = \exp(-k \cdot t \cdot P_{sat,B} \cdot \gamma_B)$
 $\ln(70) = -k \cdot t \cdot P_{sat,B} \cdot \gamma_B \Rightarrow k \cdot t = \frac{\ln(70)}{P_{sat,B} \cdot \gamma_B}$
 dit invullen in vgl voor C

$\frac{n_C(t)}{n_C(0)} = e^{-(k \cdot t \cdot P_{sat,C} \cdot \gamma_C)}$
 $= \exp\left(\frac{-\ln(70)}{P_{sat,B} \cdot \gamma_B} \cdot P_{sat,C} \cdot \gamma_C\right)$
 $= \exp\left(\frac{-\ln(70) \cdot 4}{2}\right) = 1/4$

$P_A \approx 0$
 $P_{sat,B} = 2 \cdot P_{sat,C}$
 $\gamma_C = 4 \gamma_B$

Tasland vloeistof Gas

$P = c / (V \cdot T)$
 $c = \text{constante}$
 $V = \text{molecul volume}$
 $T = \text{temperatuur}$
 $b = 5 \cdot 10^{-6} \text{ m}^3/\text{mol}$
 $C = 40 \frac{\text{m}^3}{\text{mol} \cdot \text{K}}$
 \Rightarrow molen mod: $C = BT$
 \Rightarrow in de literat van by de druk gaat het elk van zijn fractie
 \Rightarrow last van dat Cp niet afhangt van druk
 $\left(\frac{\partial G}{\partial T}\right)_P = 0 \Rightarrow$ anal $G = \ln \frac{P}{P^*}$
 $\int \left(\frac{\partial G}{\partial T}\right)_P = \int \left[V - T \left(\frac{\partial V}{\partial T}\right)_P\right] dT$
 $v = \frac{RT}{P} + b$
 $\frac{\partial v}{\partial T} = \frac{R}{P}$
 $v - T \left(\frac{\partial v}{\partial T}\right)_P = \frac{RT}{P} + b - T \cdot \frac{R}{P} = b$
 integrat $\int b dT = b \cdot T = 50 \text{ J/mol}$

EVENWICHTS reactie ideaal gas

3) bereken K
 $A + B \leftrightarrow C + D$
 even wicst: 1 mol A, 1 mol B, 2 mol C, 1 mol D
 $P_i = P \cdot y_i$
 $y_i = \frac{n_i}{\sum n_i}$
 $P_i = \frac{n_i RT}{V}$
 $K = \frac{P_C \cdot P_D}{P_A \cdot P_B} = \frac{n_C \cdot n_D}{n_A \cdot n_B} \left(\frac{RT}{V}\right)^{\Delta n}$
 $= \frac{2}{1} = 2$

1) Mol A toegevoegd bereken y_A na evenwicht

$n_A = 2 - x$
 $n_B = 1 - x$
 $n_C = 2 + x$
 $n_D = 1 + x$
 $n = 6$
 $\frac{2+x}{6} = \frac{1+x}{6} = 2$
 $(2+x)(1-x) = 2(2-x)(1-x)$
 $2+x-x^2 = 2(2-x-x^2)$
 $x^2 - 3x + 2 = 0$
 $x = \frac{3 \pm \sqrt{9-4}}{2} = \frac{3 \pm 2.24}{2}$
 $x = 2.62$
 $n_A = 2 - 0.62 = 1.38$
 $y_A = \frac{1.38}{6} = 0.23$

Productie proces met een Compressor

3) bereken opbrengst van B
 opbrengst B = mol A per second / mol A per second
 $\eta_B = \frac{0.6 \cdot 100}{100} = 0.6$

4, 5)

	1	2	3	4	5	6	7
A	100	$y = 156.25$	$0.6y = 62.5$	0	0.6y	$0.6y \cdot f = 0.6y \cdot 1$	$0.6y \cdot (1-f)$
B	0	0	$0.6y \cdot 2 = 187.5$	0	0	0	0
I	1	$x = 10$	0	0	x	$x \cdot f = 1$	$x \cdot (1-f)$
Tot	101	$y + 10$	0.6y	0			

$1 = x \cdot f$
 $f = 0.1$
 $x = 10$
 $y = 10 + 0.1y$
 $y = 10.105 = 10.1$

6) $\eta_B = \frac{93.25}{100} = 0.9325$

Batch Reactor

1) Bereken omzetting van 2^o orde reactie $2A \rightarrow B$

$\frac{dC_A}{dt} = -k C_A^2$
 $\int_{C_{A0}}^{C_A} \frac{1}{C_A^2} dC_A = -k \int_0^t dt$
 $-\frac{1}{C_A} + \frac{1}{C_{A0}} = -kt$
 $\frac{1}{C_A} = kt + \frac{1}{C_{A0}}$
 $\frac{C_{A0}}{C_A} = (C_{A0} kt + 1)$
 $\frac{1}{C_{A0} kt + 1} = \frac{C_A}{C_{A0}}$
 $S_A = 1 - \frac{C_A}{C_{A0}} = 1 - \frac{1}{C_{A0} kt + 1} = \frac{C_{A0} kt}{1 + C_{A0} kt}$

8) hoeveel mol van na 600s gegeneerd?
 $\Delta n = -50 \text{ kg mol B}$

$Q = (\text{tot aantal mol omgezet}) \cdot (\Delta n \text{ per mol A})$
 $= -\sum n_i \cdot C_{A0} \cdot V \cdot (-\Delta n / 2)$

Vloeistof mengsel 50 mol% water & 50 mol% ethanol kookt by 1.1 bar \Rightarrow grafiek

\Rightarrow Raoult gebruiken:

$w = \text{water}$ $e = \text{ethanol}$

$P = 1.1 \text{ bar}$

$P_i = y_i P = P_{sat,i} \cdot x_i \cdot \gamma_i = 1$ (ideal 4.)

$P = 1.1 = P_{sat,w} \cdot x_w + P_{sat,e} \cdot x_e$ ($x_w + x_e = 1$)
 $= P_{sat,w} \cdot x_w + P_{sat,e} \cdot (1 - x_w)$

\Rightarrow 50-50 mengsel, dus $x_w = 1/2 = x_e$

$\Rightarrow 1.1 = P_{sat,w} \cdot 1/2 + P_{sat,e} \cdot 1/2$

$P_{sat,w} + P_{sat,e} = 2.2 \text{ bar}$

in de grafiek nu zoeken naar een verticale lijn, opgeteld zit het.

