SPECIFY

CONSTANT PHYS. PROP., ρ, etc.

CONSTANT $V\,(m^3)$, 1ST ORDER RXN, $r_A = -kC_A^1$

RXN $A \rightarrow B$ (EQUIL ALMOST ALL B)

& SPECIFY

NEGLIGIBLE "SHAFT WORK" DUE TO MIXER

MOL BAL ON REACTANT A

ACCUMULATION = IN − OUT + GENERATION

$$\frac{dN_A}{dt} = V\frac{dC_A}{dt} = F_{A_0}\left(\frac{mol}{m^3}\right) - F_A + r_A V(m^3)$$

@ CONST V

(0) = INLET

$F_A\left(\frac{mol}{s}\right) = v\left(\frac{m^3}{s}\right) C_A\left(\frac{mol}{m^3}\right)$ → MOLAR FLOW RATE OF A

$\tau(s) \equiv \frac{V(m^3)}{v(m^3/s)}$ SPACE TIME

$X_A \equiv \frac{F_{A_0} - F_A}{F_{A_0}}$ CONVERSION

FOR CONSTANT v ONLY

$$X_A = \frac{C_{A_0} - C_A}{C_{A_0}}$$

FOR NOW, SYS @ STEADY STATE (SS)

$$V\frac{dC_A}{dt} = 0 = F_{A_0}X_A + r_A V = C_{A_0}X_A - k\,C_{A_0}(1 - X_A)\tau = 0$$

$$\rightarrow X_A = \frac{k\tau}{1 + k\tau}$$

$$(-r_A V) = F_{A_0}X = F_{A_0}\left(\frac{k\tau}{1 + k\tau}\right)$$

E - BAL

T of reactant fluid

Heat xfer in across jacket wall

$$\rho C_{pm} V \frac{dT}{dt} = Q + \rho C_{pm} v (T_o - T) + (-\Delta H)(-r_A) V$$

Density

Ave. mass-based heat capacity C_p ∴ C_{pm}

Inlet fluid T

Enthalpy (heat) of rxn

$$Q = UA(T_j - T) \quad \left[\frac{kJ}{m^2 \cdot s \cdot K}\right]$$

$$\frac{kJ}{mol} \cdot \frac{mol}{m^3 \cdot s} \cdot m^3 = kJ/s = kW$$

For now, system is @ SS, specify $\rho C_{pm} V \frac{dT}{dt} = 0$

Rearrange,

$$-(UAT_j + \rho C_{pm} v T_o) + (UA + \rho C_{pm} v) T = (-\Delta H)(-r_A) V = (-\Delta H) F_{Ao} \frac{k\tau}{1+k\tau}$$

Intercept @ T = 0 K; Slope

$Q_{REMOVAL} = Q_{GENERATION}$ (kW)

REM = GEN

R = G

$$Q_{REM}(T) = Q_{GEN}(T)$$ ← only T varies above → Goal, find value of T given operating conditions, T_j, C_{Ao}, etc.

$\Delta H > 0$ for ENDO

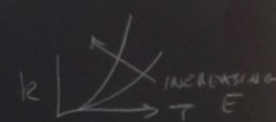
$\Delta H < 0$ for EXO

∴ $(-\Delta H) > 0$ for EXO

$(-r_A) > 0$ for reactant

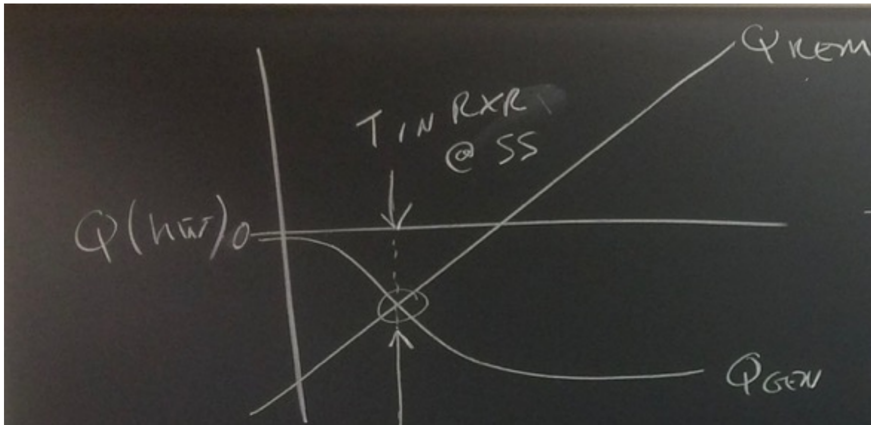
∴ $(-\Delta H)(-r_A) > 0$ for exothermic rxn of reactant

Choices: endothermic & exothermic



where $k = A e^{-E/RT}$

$$= k_{T_{ref}} e^{-\left(\frac{E}{R}\right)\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)}$$

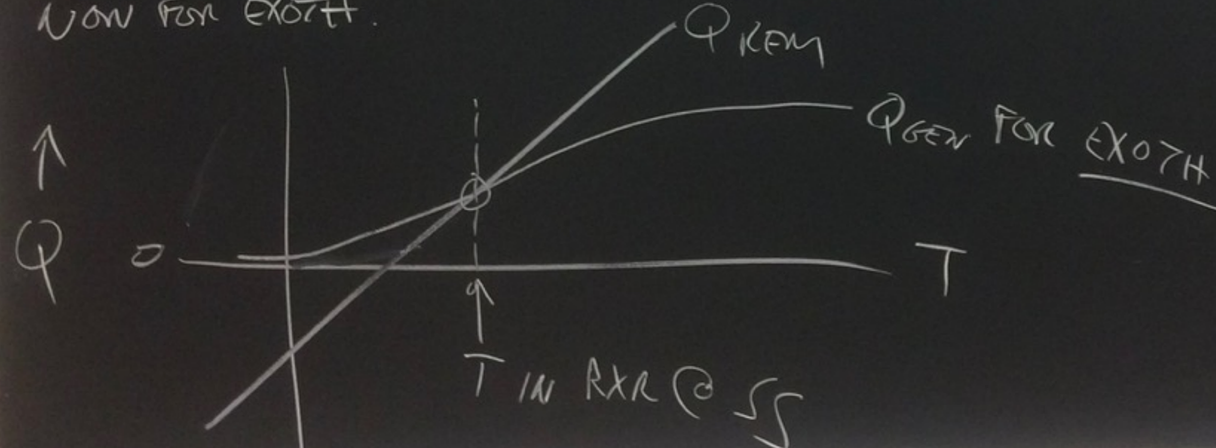


$Q_{GEN} < 0$

$\Delta H > 0$

KNOWING T, CALC k, CALC X, CALC C_A IN RXR

NOW FOR EXOTH.



$$\frac{k\tau}{1+k\tau} = f(\tau)$$

@ LOW T, SMALL k

WHERE $k\tau \ll 1$

$f(\tau) \propto e^{-E/RT}$

@ HIGH T, LARGE k

WHERE $k\tau \gg 1$.

$$f \simeq \frac{k\tau}{k\tau} = 1$$

SO $\frac{k\tau}{1+k\tau}$