CH365 Chemical Engineering Thermodynamics

Lesson 19
Heat Effects of Industrial Reactions

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CANVAS Modules, Lesson 19

Industrial Reactions

Review of Lesson 18

Today we will use these in the homework.

$$\Delta H^o = \Delta H^o_{298} + R \cdot \int_{T0}^{T} \frac{\Delta C_P^o}{R} dT = \Delta H^o_{298} + R \cdot IDCPH$$ Eq. 4.19

$$IDCPH = \int_{T_0}^{T} \frac{\Delta C_p^o}{R} dT = (\Delta A) \cdot (T - T_0) + \frac{\Delta B}{2} \cdot (T^2 - T_0^2) + \frac{\Delta C}{3} \cdot (T^3 - T_0^3) + \Delta D \cdot \left(\frac{T - T_0}{T \cdot T_0} \right)$$ Eq. 4.20

$$\Delta A = \sum_i \nu_i \cdot A_i, \quad \Delta B = \sum_i \nu_i \cdot B_i, \quad \text{etc.}$$

This only works when T is the same for reactants and products. (see L18 Slide 5) Not explained in book!

$$\Delta H^o = \Delta H^o_{298} + R \cdot \int_{T0}^{T} \frac{\Delta C_P^o}{R} dT = \Delta H^o_{298} + R \cdot MDCPH \cdot (T - T_0)$$ Eq. 4.22

$$MDCPH = \frac{\langle \Delta C_p^o \rangle_H}{R} = \Delta A + \frac{\Delta B}{2} \cdot (T + T_0) + \frac{\Delta C}{3} \cdot (T^2 + T_0^2 + T \cdot T_0) + \frac{\Delta D}{T \cdot T_0}$$ Eq. 4.21

$$\int_{T_0}^{T} \frac{\Delta C_p^o}{R} dT = IDCPH(T_0, T, DA, DB, DC, DD)$$

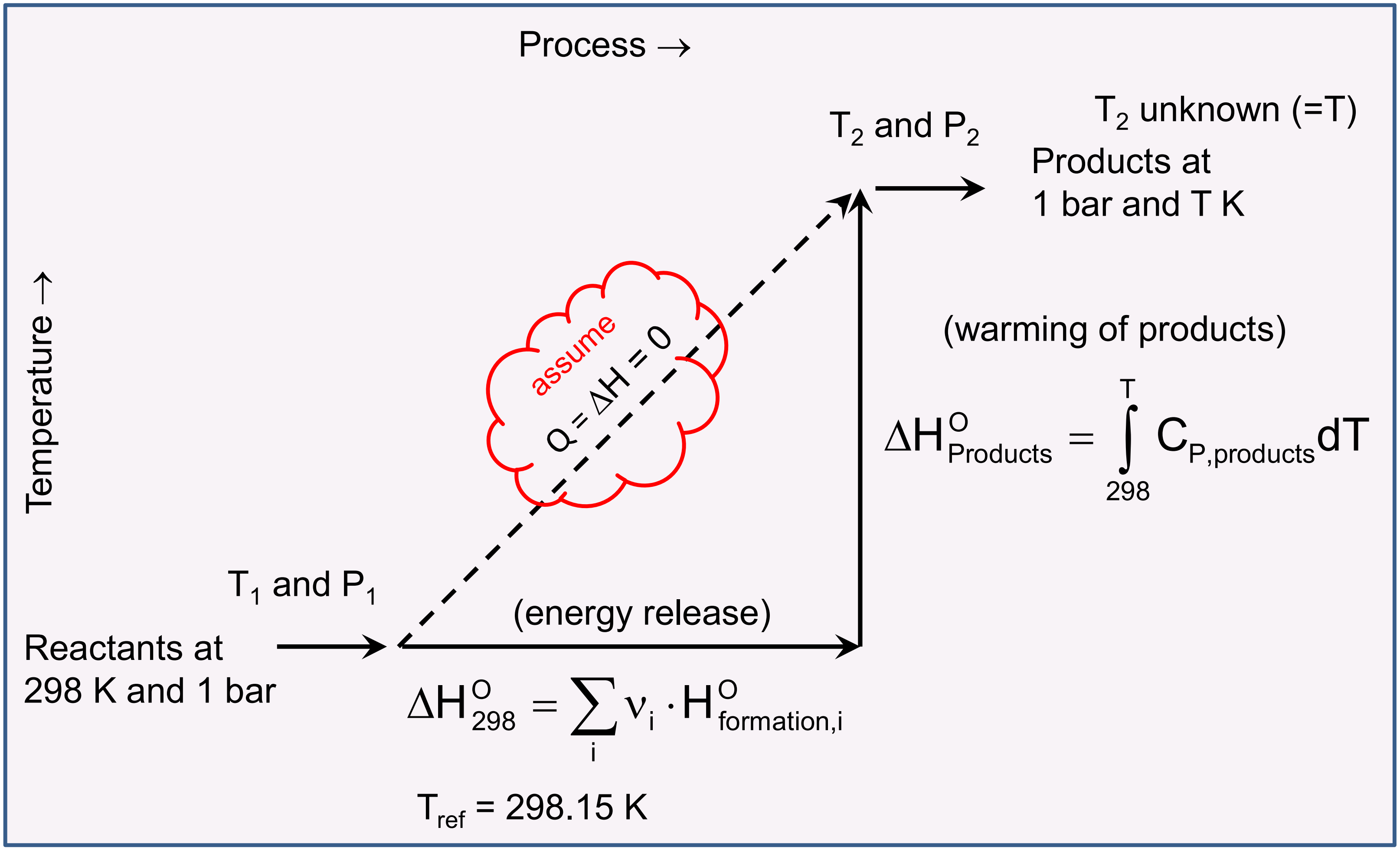
$$\frac{\langle \Delta C_p^o \rangle_H}{R} = MDCPH(T_0, \underbrace{T, DA, DB, DC, DD)}_{\text{These are "parameters;" all but } T_0 \text{ change}}$$

Functional nomenclature used in book, page 155

(no equation numbers)

Example 4.7

What is the maximum temperature that can be reached by the combustion of methane with 20% excess air? Methane and air enter the burner at 25 °C.



Process →
Temperature →
T_2 and P_2
T_2 unknown (=T)
Products at
1 bar and T K
assume
$Q = \Delta H = 0$
(warming of products)
$\Delta H^O_{Products} = \int_{298}^{T} C_{P,products} dT$
T_1 and P_1
Reactants at
298 K and 1 bar
(energy release)
$\Delta H^O_{298} = \sum_i \nu_i \cdot H^O_{formation,i}$
T_{ref} = 298.15 K

Example 4.7

What is the maximum temperature that can be reached by the combustion of methane with 20% excess air? Methane and air enter the burner at 25 deg C.

Solution:

Part (1) Calculate heat of reaction at 298:

Questions?

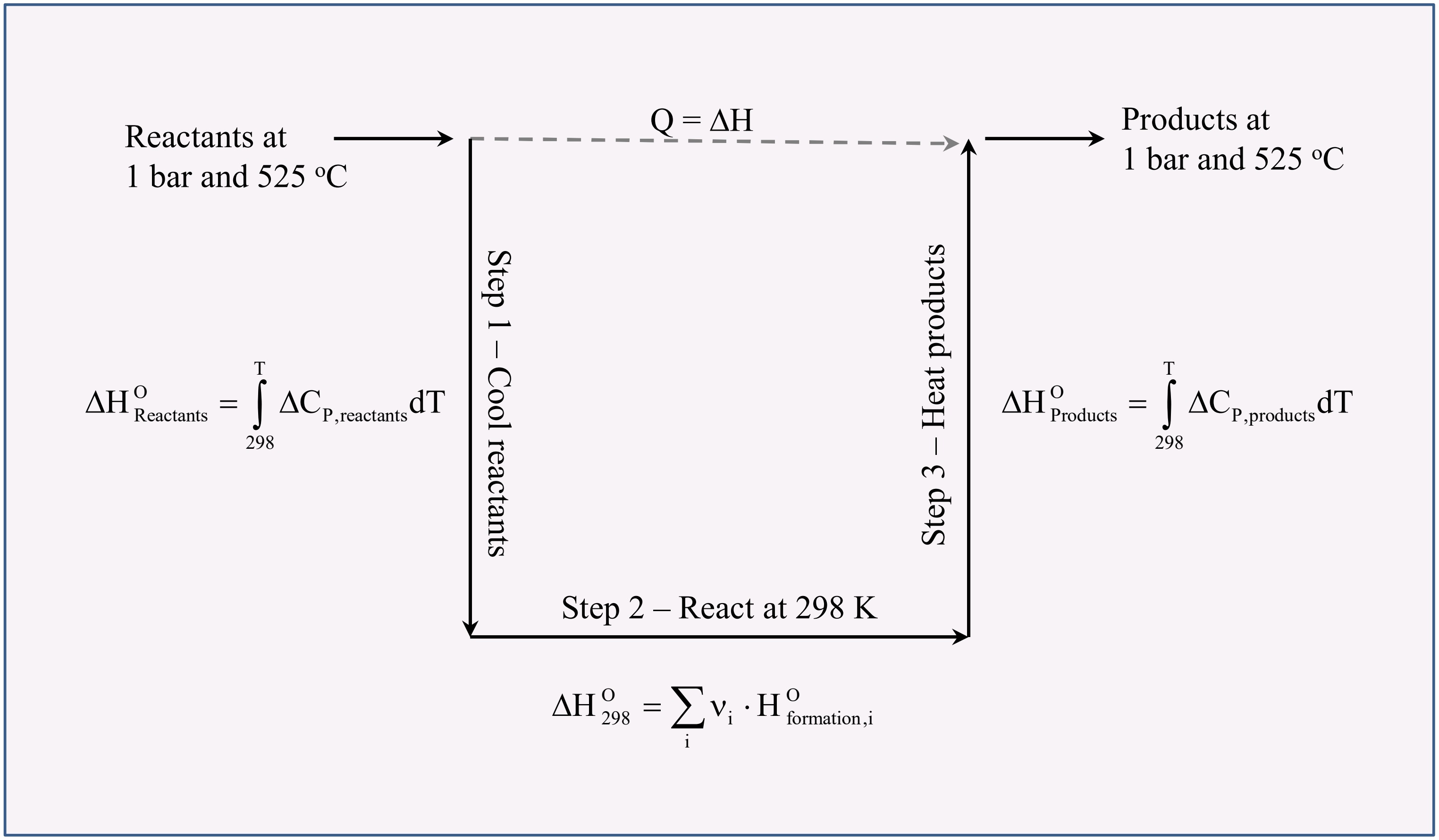
Homework

Problem 4.45

A process for the production of 1,3-butadiene results from the catalytic dehydrogenation at atmospheric pressure of 1-butene according to the reaction:

$$C_4H_8\ (g) \rightarrow C_4H_6\ (g) + H_2\ (g)$$

To suppress side reactions, the 1-butene feed is diluted with steam in the ratio of 10 moles of steam per mole of 1-butene. The reaction is carried out *isothermally* at 525 °C, and at this temperature 33% of the 1-butene is converted to 1,3-butadiene. How much heat is transferred to the reactor per mole of entering 1-butene?



Thermal process for problem 4.45

Problem 4.55

A natural-gas fuel contains 85mol-% methane, 10 mol-% ethane, and 5 mol-% nitrogen.

(a) What is the standard heat of combustion (kJ/mol) of the fuel at 25 °C with H_2O(g) as a product?

(b) The fuel is supplied to a furnace with 50% excess air, both entering at 25 °C. The products leave at 600 °C. If combustion is complete and if no side reactions occur, how much heat (kJ per mole of fuel) is transferred in the furnace?