

CH365 Chemical Engineering Thermodynamics

Lesson 19

Heat Effects of Industrial Reactions

Open “Example_4-7_Cadet” mma file in CANVAS

Industrial Reactions

Review of Lesson 18

Slide 3

$$\Delta H^\circ = \Delta H_{298}^\circ + R \cdot \int_{T_0}^T \frac{\Delta C_p^\circ}{R} dT = \Delta H_{298}^\circ + R \cdot \text{IDCPH} \quad \text{Eq. 4.19}$$

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

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

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

$$\Delta H^\circ = \Delta H_{298}^\circ + R \cdot \int_{T_0}^T \frac{\Delta C_p^\circ}{R} dT = \Delta H_{298}^\circ + R \cdot \text{MDCPH} \cdot (T - T_0) \quad \text{Eq. 4.22}$$

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

$$\int_{T_0}^T \frac{\Delta C_p^\circ}{R} dT = \text{IDCPH}(T_0, T, \Delta A, \Delta B, \Delta C, \Delta D)$$

$$\frac{\langle \Delta C_p^\circ \rangle_H}{R} = \text{MDCPH}(T_0, T, \Delta A, \Delta B, \Delta C, \Delta D)$$

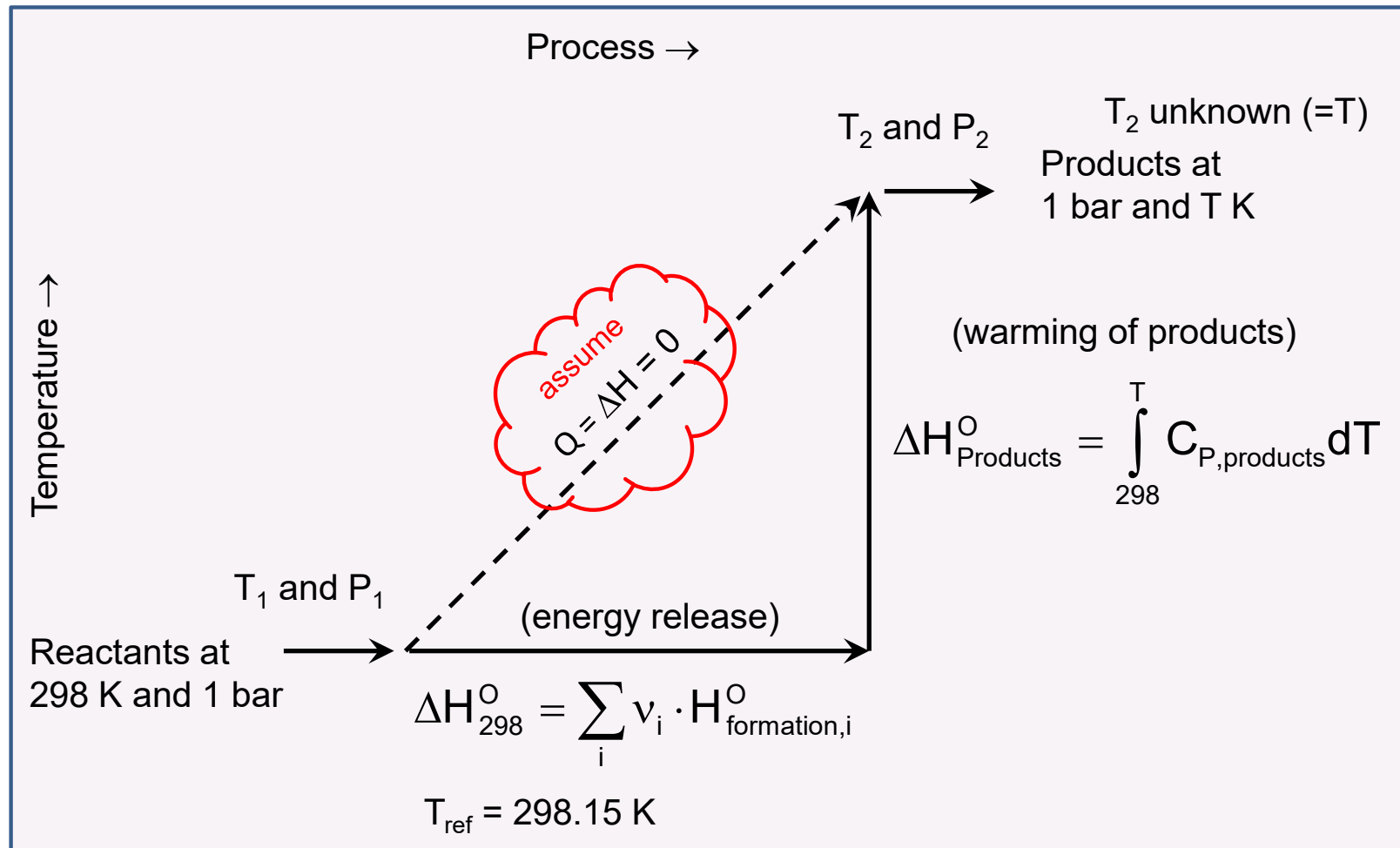
These are “parameters;” all but T_0 change

Functional nomenclature used in book

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.

Important Example. “Adiabatic Flame Temperature”



Similar to
“nonadiabatic”
exchanger



“Q” = energy release from reaction

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.

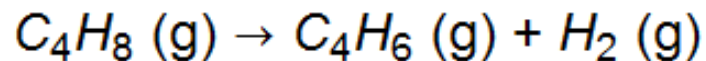
Solution:

Part (1) Calculate heat of reaction at 298:

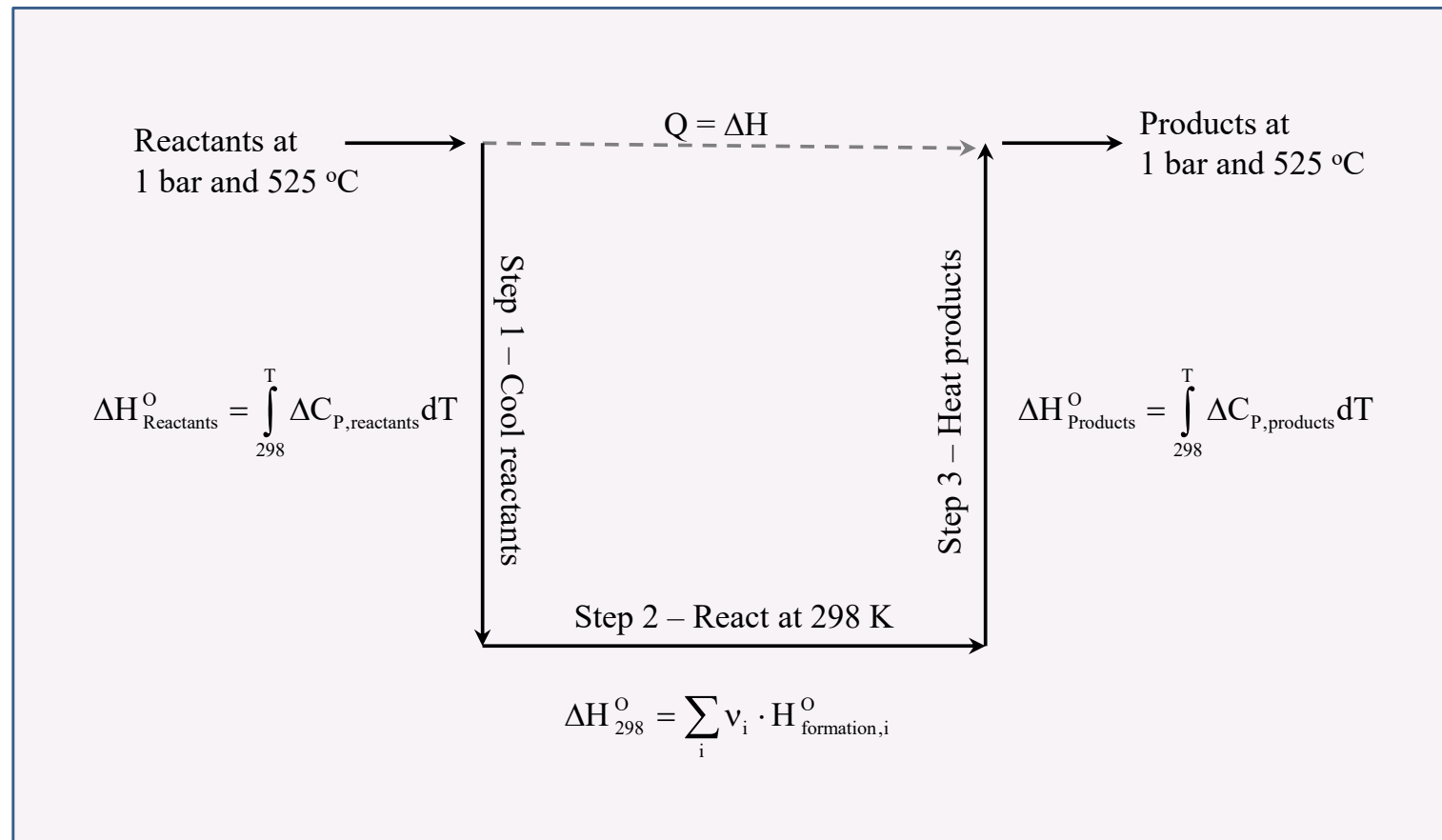
Homework

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:



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 deg 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 deg C with $H_2O(g)$ is a product?

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

