

CH365 Chemical Engineering Thermodynamics

Lesson 16 Sensible Heat Effects

Ethylene Glycol Process

Slide 2

- Sensible heat effects are associated with temperature change
- Latent heat (phase changes) – no temperature change
- Heat of Reaction
- Heat of Mixing

“Sensible” Heat Effects

Sensible = No phase transitions, no chemical reactions, and no change in composition.

$$U = U(T, V)$$

Total differential introduced
in L10, Slide 9, page 138

$$dU = \left(\frac{\partial U}{\partial T} \right)_V dT + \left(\frac{\partial U}{\partial V} \right)_T dV$$

0 for constant volume process,
ideal gases, or incompressible fluids

L11, Slide 3

$$dU = C_V dT$$

Eq. 4.1

$$Q = \Delta U = \int_{T_1}^{T_2} C_V dT$$

$Q = \Delta U$ for mechanically reversible, constant
volume process (why? $\Delta U = Q + W$)

Mean Heat Capacity

Integral evaluated forms – “user-defined functions” – simplifies working with mixtures

These forms are used in later derivations in the textbook.

Ideal Gas Heat Capacity in Simulators

Improved function – used in professional simulators such as CC and Aspen+

F. A. Aly and L. L. Lee, "Self-Consistent Equations for calculating the Ideal Gas Heat Capacity, Enthalpy, and Entropy," *Fluid Phase Equilibria*, 1981, Vol. 6, Issues 3-4, pp. 169-179.

a, b, c, d & e are constants published and maintained by DIPPr (link on course web site).

$$C_p = C_p(T) = a + b \cdot \left(\frac{c/T}{\text{Sinh}[c/T]} \right)^2 + d \cdot \left(\frac{e/T}{\text{Cosh}[e/T]} \right)^2 \quad \text{DIPPr Eq 107}$$

hyperbolic sine
hyperbolic cosine

The sequence of screenshots illustrates the steps to access the heat capacity data for water in a simulator:

- Component List:** A window showing a list of components. '1 (62) Water' is selected. A blue arrow points to the 'View/Edit' button.
- View/Edit Component Data:** A window showing various data categories for the selected component. 'Heat Capacity Data' is selected. A blue arrow points to this category.
- Library Heat Capacity Data:** A window showing the heat capacity data for water. The 'Equation No.' is set to 107. The coefficients A through G are listed. A red circle highlights the 'Equation No.' field, and another red circle highlights the coefficient list. A blue arrow points to the 'Help' button.

CC/DIPPr eq 107 found here

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The screenshot shows the Aspen+ software interface. The 'Results - Pure Components' window is open, displaying the 'T-Dependent' tab. The 'Parameters' dropdown is set to 'CPIGDP-1'. The table below shows the results for Methane, Ethane, and Propane. The 'Element 1' row is circled in red, indicating the value 33298 J/KMOL-K for Methane.

Component	METHANE	ETHANE	PROPANE
Temperature units	K	K	K
Source	PURE37	PURE37	PURE37
Property units	J/KMOL-K	J/KMOL-K	J/KMOL-K
Element 1	33298	44256	59474
Element 2	79933	84737	126610
Element 3	2086.9	872.24	844.31
Element 4	41602	67130	86165
Element 5	991.96	2430.4	2482.7
Element 6	50	298.15	298.15
Element 7	1500	1500	1500

Aspen+/DIPPr eq 107 found here

Homework

Problem 4.5

How much heat is required when 10,000 kg of CaCO_3 is heated at atmospheric pressure from 50 deg C to 880 deg C?

Solve by three methods: (a) direct integration of C_p polynomial, (b) ICPH, and (c) MCPH

Express all answers in MJ.

Submission in Mathematica required.

All problems and cover sheet bundled into single pdf.

Problem 4.9

A process stream is heated as a gas from 25 deg C to 250 deg C at constant P. A quick estimate of the energy requirement is obtained from Eq. 4.3, with C_p taken as constant and equal to its value of 25 deg C. Is the estimate of Q likely to be low or high? Why?

Submission in Mathematica required.

All problems and cover sheet bundled into single pdf.

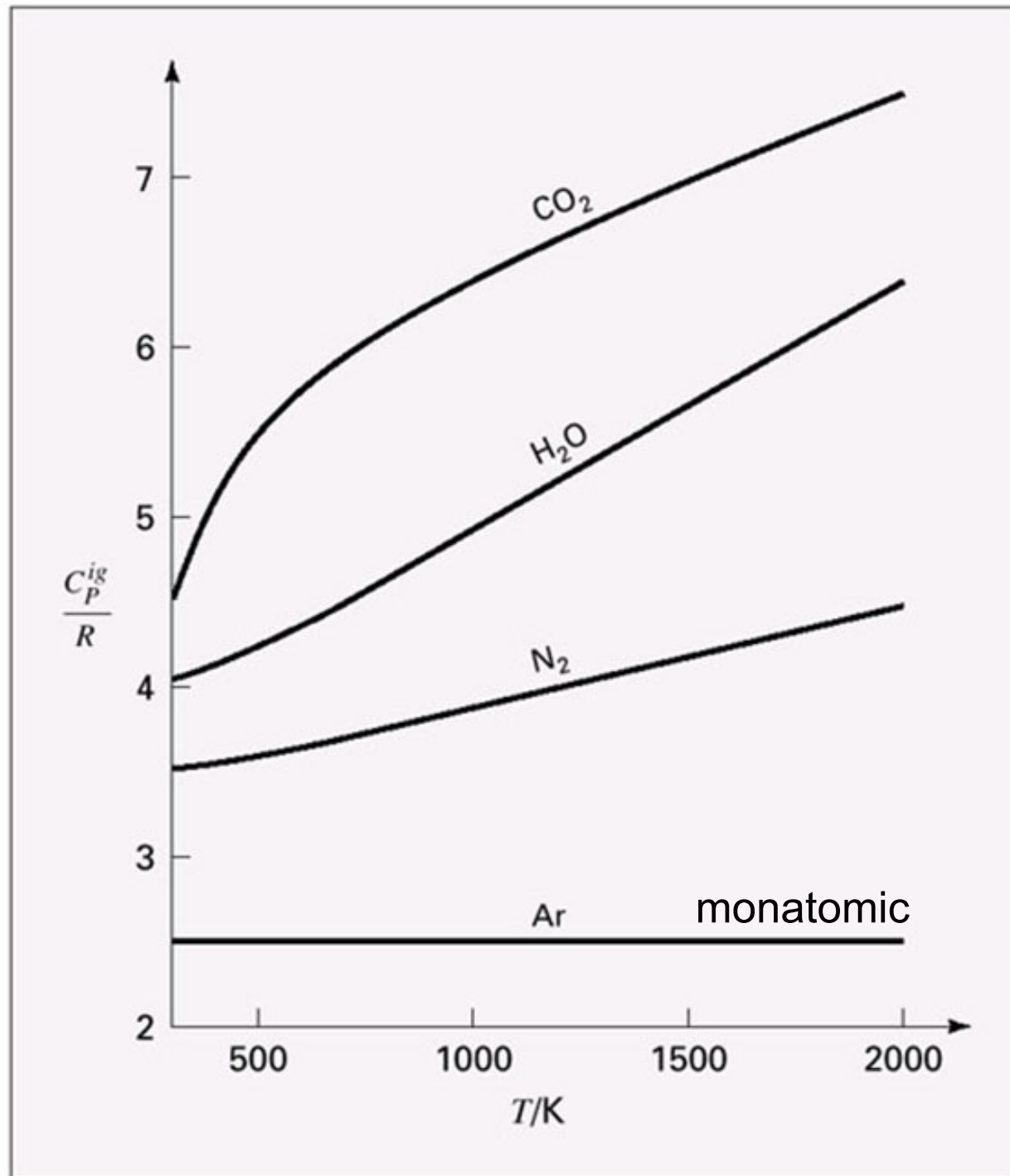


Figure 4.1. Ideal-gas heat capacities of argon, nitrogen, water, and carbon dioxide.