

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

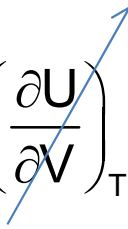
Sensible = No phase transitions, no chemical reactions, and no change in composition.

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

Total differential introduced
in L10, Slide 8, 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



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).

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

hyperbolic sine hyperbolic cosine

DIPPr Eq 107

The image shows a sequence of three software windows from Aspen+ illustrating how to find the DIPPr equation 107 for ideal gas heat capacity:

- Component List**: A window showing a list of components. "1 (62) Water" is selected. A blue arrow points to the "View/Edit" button at the bottom.
- View/Edit Component Data**: A window with a sidebar menu. A blue arrow points to "Heat Capacity Data" in the menu.
- Library Heat Capacity Data**: A window for "Water" (Component ID: 62). It displays three sections:
 - Ideal Gas Heat Capacity (J/kmol-K)**: "Equation No." is set to 107 (circled in red). Low T (K) is 100, High T (K) is 1500. Low value is 33359, High value is 47105.1.
 - Liquid Heat Capacity (J/kmol-K)**: "Equation No." is set to 100. Low T (K) is 273.15, High T (K) is 533.15. Low value is 76150.6, High value is 89393.9.
 - Solid Heat Capacity (J/kmol-K)**: "Equation No." is set to 100. Low T (K) is 3.15, High T (K) is 273.15. Low value is 180.148, High value is 38120.5.
 On the right, a table of coefficients (A through G) is shown for each section. A red circle highlights the coefficients for the Ideal Gas section: A=33359, B=26798, C=2609.3, D=8888, E=1167.6, F=, G=.

CC/DIPPr eq 107 found here

Ideal Gas Heat Capacity in Simulators

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

hyperbolic sine
hyperbolic cosine

The screenshot shows the Aspen+ software interface. The 'Results - Pure Components' window is open, displaying a table of heat capacity values for Methane, Ethane, and Propane. The table has columns for Component, Temperature units, Source, Property units, and seven elements. A red circle highlights the values for Element 1, 2, 3, 4, and 5 for Methane.

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

Aspen+/DIPPr eq 107 found here

Questions?

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.

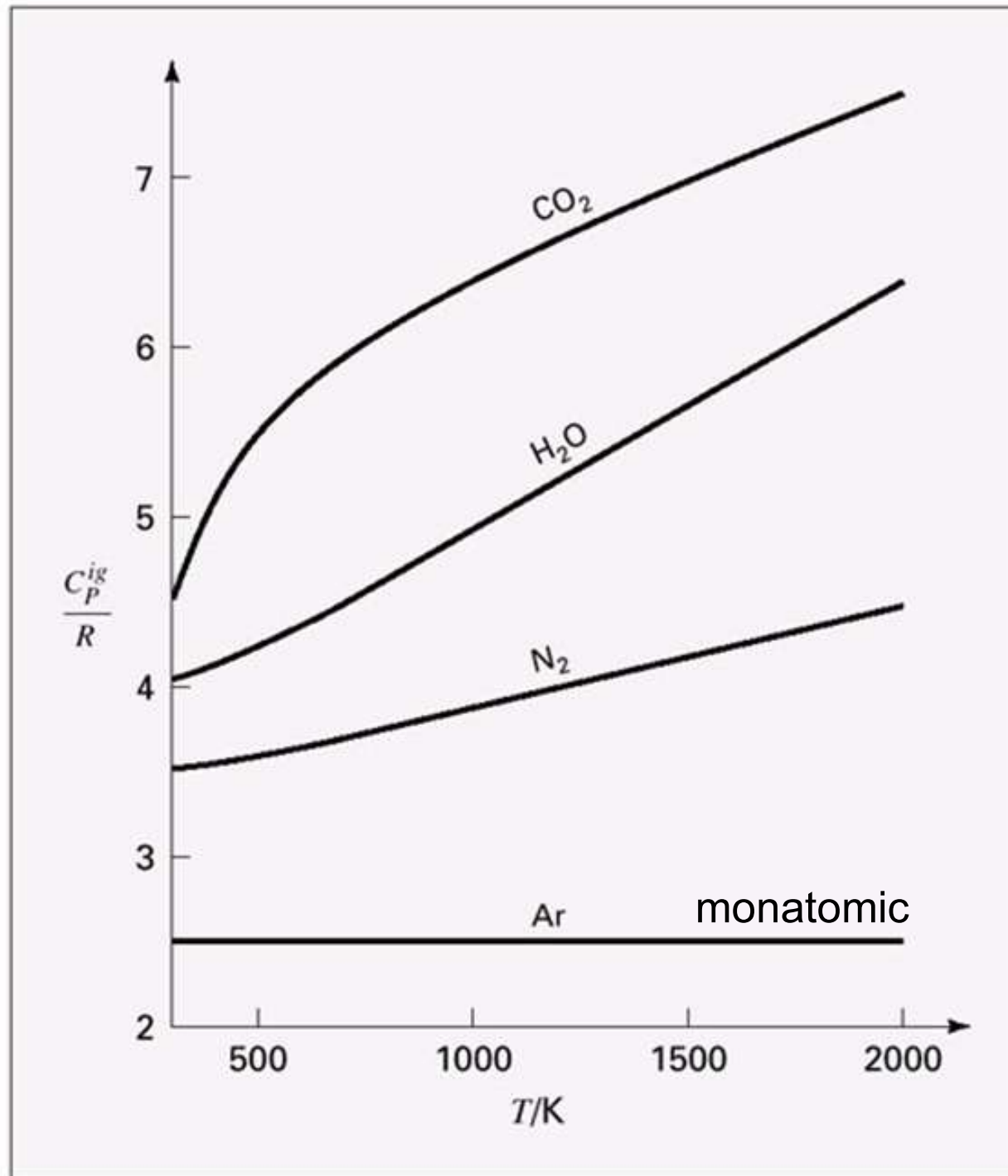


Figure 4.1. Ideal-gas heat capacities of argon, nitrogen, water, and carbon dioxide.