# CH365 Chemical Engineering Thermodynamics

Lesson 16
Sensible Heat Effects

## Ethylene Glycol Process

- 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 7, page 138  $dU = \left(\frac{\partial U}{\partial T}\right)_{V} dT + \left(\frac{\partial U}{\partial V}\right)_{T} dV$ 

L11, Slide 8

$$dU = C_V dT$$

$$dU = C_{V}dT$$

$$Eq. 4.1$$

$$Q = \Delta U = \int_{T_{1}}^{T_{2}} C_{V}dT$$

0 for constant volume process,

ideal gases, or incompressible fluids

Q=ΔU 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.

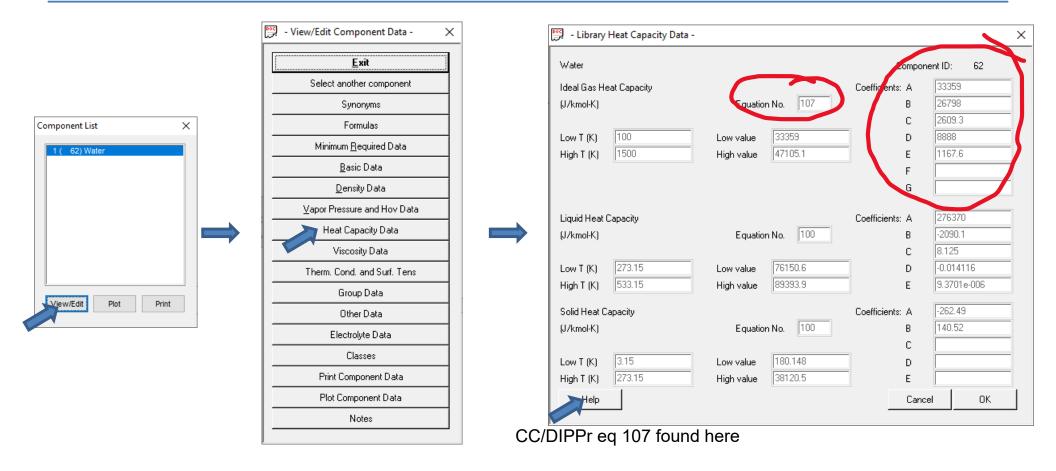
# Ideal Gas Heat Capacity in Simulators

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).

$$C_{p} = C_{p}(T) = a + b \cdot \left(\frac{c/T}{Sinh[c/T]}\right)^{2} + d \cdot \left(\frac{e/T}{Cosh[e/T]}\right)^{2}$$
hyperbolic sine
hyperbolic cosine



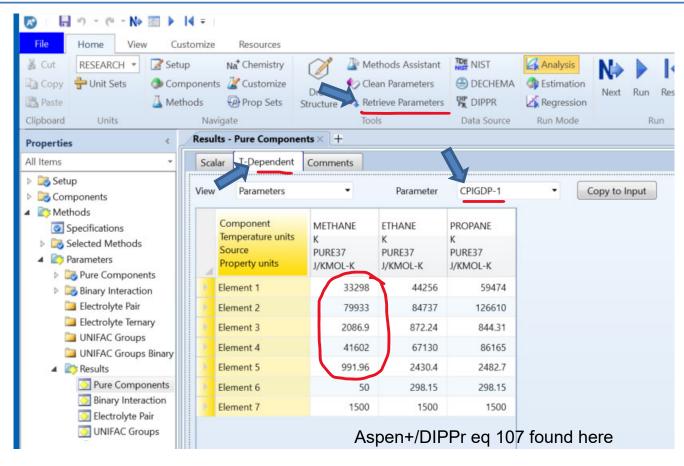
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## Homework

#### Problem 4.5

How much heat is required when 10,000 kg of CaCO<sub>3</sub> is heated at atmospheric pressure from 50 deg C to 880 deg C?

Solve by three methods: (a) direct integration of C<sub>P</sub> polynomial, (b) ICPH, and (c) MCPH

Express all answers in MJ.

Submission in Mathematica Required

### 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.