8.3 Basic Energy Computations

Computing Enthalpy and Internal Energy Changes for Common Situations

Internal energy (U) and enthalpy ($H = U + PV$) are thermodynamic state variables. We can use this property to compute changes in internal energy or enthalpy due to changes in pressure, temperature, phase, composition, and mixing/solution. The following table presents basic formulas for these calculations.

Change in	$\Delta \hat{H} = \Delta \hat{U} + P\Delta \hat{V}$	$\Delta \hat{U}$	**Comments**
Pressure	~ 0 (gas) ~$\hat{V}\Delta P$ (solid or liquid)	~ 0	Generally neglected except for large pressure changes.
Temperature	$\int_{T_1}^{T_2} C_p(T)dT$ $\approx \bar{C}_p(T_2 - T_1)$	$\int_{T_1}^{T_2} C_v(T)dT$ $\approx \bar{C}_v(T_2 - T_1)$	Expressions available for $C_p(T)$ $C_p \approx C_v$ (gases) $+ R$ $C_p \approx C_v$ (liquids and solids)
Phase	$\Delta \hat{H}_{vap}$ (liquid to vapor) $\Delta \hat{H}_m$ (solid to liquid)	$\Delta \hat{U}_{vap} \approx \Delta \hat{H}_{vap} - RT_b$ $\Delta \hat{U}_m \approx \Delta \hat{H}_m$	
Composition due to Reaction	$\Delta \hat{H}_r^\circ = \sum_i \nu_i \Delta \hat{H}_{f,i}^\circ$ $\Delta \hat{H}_r^\circ = -\sum_i \nu_i \Delta \hat{H}_{c,i}^\circ$	$\Delta \hat{U}_r \approx \Delta \hat{H}_r - RT\Delta n_r$ $\Delta \hat{U}_r \approx \Delta \hat{H}_r$ (solid or liquid)	Δn_r is the cange in moles due to reaction Standard conditions are 25°C and 1 atm. Be sure all data uses same standard conditions.
Composition due to Mixing/Sol'n	$\Delta \hat{H}_{soln}$ $\Delta \hat{H}_{mix}$	$\Delta \hat{U}_{soln} \approx \Delta \hat{H}_{soln}$ $\Delta \hat{U}_{mix} \approx \Delta \hat{H}_{mix}$	Important for non-ideal mixtures. Typical units are per mole of solute, not solution.

Examples

Pumping a Fluid

For a particular fire-fighting situation, it is determined that 1,250 gpm is required. The fire hydrant will supply sufficient water at a pressure of 35 psig. A pressure of 180 psig is needed to reach the top of the 212 foot bulding. What size engine (in Hp) is required to power the fire pump?

In [1]:

```
Vdot = 1250/264.172/60          # flow in m**3/s
dP = (180 - 35)*101325/14.696    # pressure change in pascals (N/m**2)

P = Vdot*dP                     # power in N-m/sec = watts
print("fire pump requirement [watts] =", P)
print("fire pump requirement [hp] =", P/746)
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```
fire pump requirement [watts] = 78841.96681903958
fire pump requirement [hp] = 105.68628259924876
```

Exercises

Vaporization of Phenol

Solid phenol at 25°C and 1 atm is converted to phenol vapor at 300°C and 3 atm. How much heat will be required?

In [ ]:

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