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Δu, Δh, C_p, C_v for solids and gases.

$$C_p = C_v = C$$

specific heat for various solids/liquids are in table A.3, & A.4

$$\Delta u = \int_1^2 C\,dT$$

for a smaller temperture interval, C value at an average value can be used and treated as a constant. thus...

$$\Delta u \cong C_{AVG}(T_2 - T_1)$$

$$C_{AVG} = \frac{C_2(\text{calc at } T_2) + C_1(\text{calc at } T_1)}{2}$$

recall that

$$h = u + pv$$

$$dh = du + p\,dv + v\,dp.$$

zero for incompressable substances.

$$dh \cong du + v\,dp.$$

integrating the process

$$\Delta h = \Delta u + v\,\Delta p$$

note that:

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{\frac{R}{C_v}} = \left(\frac{V_1}{V_2}\right)^{K-1} = \left(\frac{\forall_1}{\forall_2}\right)$$

for ideal gases in an adiabatic system

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\left(\frac{K-1}{K}\right)}$$

in all these relations T must be in degrees Kelvin.

Ex.

Given: Nitrogen gas is heated from 327°C to 727°C

Required: determine the enthalpy change of the nitrogen, $\Delta h = ?$, using:

A. $(C_{P0})_{N_2}$; using table A.6

B. $(C_{P0})_{N_2}$ at room temp.

C. Δh using table A.8

Analysis:

A. $C_{P0} = C_1 + C_2\Theta + C_3\Theta^2 + C_4\Theta^3$

$\Theta = T/1000$ $\quad C_1 = 1.11 \quad C_2 = -4.08 \quad C_3 = 0.96 \quad C_4 = -0.42$

$\therefore C_{P0} =$

$$\int_1^2 C_{P0}\, dT = \Delta h$$

$$= 449.9 \frac{kJ}{kg}$$

B.

from table a.5 we find that

$C_{po} = 1.042$

and we have our relationship

$$\Delta h = \int_{600}^{1000} C_{po}\, dT$$

$$= 1.042[1000 - 600]$$

$$= 416.8 \ \frac{kJ}{kg.}$$

c. from table A.8,

$T(600\ K)$; $h = 627.24$

$T(1000\ K)$; $h = 1075.91$

the difference between the 2 is

$$448.67 \ \frac{kJ}{kg.}$$

EX

Given: A insulated tank contains Liquid water H_2O of volume 40 L (of H_2O) at 25°C and atmospheric pressure. An unknown mass of aluminum at 60°C is dropped into the tank. The final equilibrium temp. of a system is 30°C

Required: find the mass

$m_{AL} = ?$

Analysis: Consider the water an aluminum as a closed system. Applying first laws of energy.

$$ {}_1Q_2 - {}_1W_2 = \Delta U + \Delta PE + \Delta KE $$

no mention, ∴ = 0

nothing in or out of the system.

$$ 0 = \Delta u = \Delta U_{H2O} + \Delta U_{AL}. $$

$$ \Delta u = C(T_2 - T_1) \; ; \; \Delta U = m \Delta u $$
$$ \Delta U = mC(T_2 - T_1) $$

$$ 0 = [mC(T_2 - T_1)]_{H2O} + [mC(T_2 - T_1)]_{AL} $$

<u>Evaluation of properties.</u>

from table A.3

$$ C_{H2O} = 4.18 \; \frac{KJ}{kg \cdot K} $$

$$ C_{AL} = 0.90 \; \frac{KJ}{kg \cdot K} $$

$$ m_{H2O} = \rho \cdot \forall = 40 \, kg. $$

substituting we will find $m_{AL} \cong 31.0 \, kg$.

EX.

GIVEN: Air is compressed in an insulated cylinder from $\forall_1 = 6 ft^3$ to $\forall_2 = 1.2 ft^3$

$T_1 = 50°F \quad P_1 = 30 \, psi$

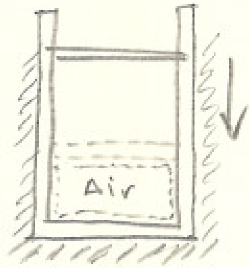
Required: determine the work done on the air

$${}_1W_2 = ?$$ Assume C_{vo} = Constant.

Data: $R_{air} = 53.3 \ \frac{lbf\,ft}{lbm \cdot R}$ $\quad K_{air} = 1.4$

$$C_{vo} = 0.171 \left(\frac{btu}{lbm \cdot R}\right)$$

Analysis:



we look at the first law of thermodynamics

$$\cancel{{}_1Q_2}^{\,0} - {}_1W_2 = \Delta u + \cancel{\Delta KE}^{\,0} + \cancel{\Delta PE}^{\,0}$$

and we know that

$$\Delta u = u_2 - u_1 = \int_{T_1}^{T_2} C_{vo}\, dT$$

since C_{vo} is given, we assume that it is constant.

$$\Delta u = C_{vo}\,\Delta T$$

$$-{}_1W_2 = mC_{vo}(T_2 - T_1)$$

since we have an ideal gas we can use the formula.

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{K-1}$$

and to find the mass of the air

$$m_{air} = \frac{P_1 \forall_1}{R T_1}$$

then substitute and we find that

$${}_1W_2 = -75.1 \text{ Btu.}$$