Given: $kJ := 1000J$ $kmol := 1000mol$

Air at 300 K and 200 kPa is heated at constant pressure to 600 K.

Required:

Determine the change in internal energy of air per unit mass, using

(a) data from the air table
(b) the functional form of the specific heat
(c) the average specific heat value

Solution:

The given temperatures and pressure are defined below.

$$T_1 := 300K \qquad P_0 := 200kPa \qquad T_2 := 600K$$

Going to Table A-17 @ $T_1 = 300K$ and $T_2 = 600K$ shows

$$u_1 := 214.07 \frac{kJ}{kg} \qquad u_2 := 434.78 \frac{kJ}{kg}$$

The change of specific internal energy is then

$$\boxed{\Delta u_a := u_2 - u_1 = 220.71 \frac{kJ}{kg}} \quad \text{(a)}$$

Going to Table A-2(c) @ air shows

$$a := 28.11 \qquad b := 0.1967 \cdot 10^{-2} \qquad c := 0.4802 \cdot 10^{-5} \qquad d := -1.966 \cdot 10^{-9}$$

Thus the molar specific heat at constant pressure of air is given by

$$\bar{c}_p(T) := \left[a + b \cdot \frac{T}{K} + c \cdot \left(\frac{T}{K}\right)^2 + d \cdot \left(\frac{T}{K}\right)^3\right] \cdot \frac{kJ}{kmol \cdot K}$$

The molar specific heat at constant volume for an ideal gas is then given by

$$\bar{c}_v(T) := \bar{c}_p(T) - R_u \qquad \text{where} \qquad R_u := 8.314 \frac{kJ}{kmol \cdot K}$$

The molar change of internal energy of air is then given by

$$\Delta \bar{u} := \int_{T_1}^{T_2} \bar{c}_v(T)\, dT = 6447 \frac{kJ}{kmol}$$

Going to Table A-1 @ air shows

$$M_{air} := 28.97 \frac{kg}{kmol}$$

The change of specific internal energy is then

$$\boxed{\Delta u_b := \frac{\Delta \bar{u}}{M_{air}} = 222.546 \frac{kJ}{kg}} \quad \text{(b)}$$

Solution (cont.):

The average temperature between the two states is

$$\overline{T} := \frac{T_1 + T_2}{2} = 450\,K$$

Going to Table A-2(b) @ $\overline{T} = 450K$ shows

$$c_v := 0.733\,\frac{kJ}{kg}$$

The change of specific internal energy is then

$$\boxed{\Delta u_c := c_v \cdot \left(T_2 - T_1\right) = 219.9\,K\,\frac{kJ}{kg}} \quad \text{(c)}$$