Thermodynamics
Mini Project

solution:- We know that

$$C_p - C_v = R = 8.3144598 \text{ J/mol k}$$

part (a):- Also, $C_p = a + bT + cT^2 + dT^3$

From the given table,

For O_2: $C_p = 25.48 + 1.520 \times 10^{-2} T - 0.7155 \times 10^{-5} T^2 + 1.312 \times 10^{-9} T^3$

For H_2: $C_p = 29.11 - 0.1916 \times 10^{-2} T + 0.4003 \times 10^{-5} T^2 - 0.8704 \times 10^{-9} T^3$

For H_2O: $C_p = 32.24 + 0.1923 \times 10^{-2} T + 1.055 \times 10^{-5} T^2 - 3.595 \times 10^{-9} T^3$

At temperature, $T = 273$ k

1) Oxygen (O_2):

a) $C_p = 25.48 + 1.520 \times 10^{-2} (273) - 0.7155 \times 10^{-5} (273)^2 + 1.312 \times 10^{-9} (273)^3$

$= 25.48 + 414.96 \times 10^{-2} - 53325.4995 \times 10^{-5} + 26694499.104 \times 10^{-9}$

$= 29.12\,30395041$ J/mol.k

$$\boxed{C_p = 0.02912\,30395041 \text{ kJ/mol.k}}$$

b) $C_v = C_p - R$

$= 0.02912\,30395041 - 0.0083144598$

$$\boxed{C_v = 0.0208085797 \text{ kJ/mol k}}$$

2) Hydrogen (H_2):

a) $C_p = 29.11 - 0.1916 \times 10^{-2} (273) + 0.4003 \times 10^{-5} (273)^2 - 0.8704 \times 10^{-9} (273)^3$

$= 29.11 - 52.3068 \times 10^{-2} + 29833.9587 \times 10^{-5} - 17709521.3568 \times 10^{-9}$

$= 28.867562066$ J/mol k

$$\boxed{C_p = 0.028867562066 \text{ kJ/mol k}}$$

b) $C_v = C_p - R$

$= 0.028867562066 - 0.008314459 8$

$C_v = 0.020553102 27 \text{ kJ/mol k}$

3) Water (H_2O):

a) $C_p = 32.24 + 0.1923 \times 10^{-2}(273) + 1.055 \times 10^{-5}(273)^2 - 3.595 \times 10^{-9}(273)^3$

$= 32.24 + 52.4979 \times 10^{-2} + 78628.095 \times 10^{-5} - 73145369.115 \times 10^{-9}$

$= 33.478123130 88 \text{ J/mol k}$

$C_p = 0.033478123130 88 \text{ kJ/mol k}$

b) $C_v = C_p - R$

$= 0.033478123130 88 - 0.008314459 8$

$C_v = 0.025163663 33 \text{ kJ/mol k}$

At Temperature, $T = 1000 \text{ k}$

1) oxygen (O_2):

a) $C_p = 25.48 + 1.520 \times 10^{-2}(1000) - 0.7155 \times 10^{-5}(1000)^2 + 1.312 \times 10^{-9}(1000)^3$

$= 25.48 + 15.2 - 7.155 + 1.312$

$= 34.837 \text{ J/mol k}$

$C_p = 0.034837 \text{ kJ/mol k}$

b) $C_v = C_p - R$

$= 0.034837 - 0.008314459 8$

$C_v = 0.026522540 2 \text{ kJ/mol k}$

2) Hydrogen (H_2):

a) $c_p = 29.11 - 0.1916\times10^{-2}(1000) + 0.4003\times10^{-5}(1000)^2 - 0.8704\times10^{-9}(1000)^3$

$= 29.11 - 1.916 + 4.003 - 0.8704$

$= 30.3266$ J/mol k

$c_p = 0.0303266$ KJ/mol k

b) $c_v = c_p - R$

$= 0.0303266 - 0.008314459 8$

$c_v = 0.0220121402$ KJ/mol k

3) Water (H_2O):

a) $c_p = 32.24 + 0.1923\times10^{-2}(1000) + 1.055\times10^{-5}(1000)^2 - 3.595\times10^{-9}(1000)^3$

$= 32.24 + 1.923 + 10.55 - 3.595$

$= 41.118$ J/mol k

$c_p = 0.041118$ KJ/mol k

b) $c_v = c_p - R$

$= 0.041118 - 0.008314459 8$

$c_v = 0.0328035402$ KJ/mol k

Here, calculation of c_p and c_v for oxygen, hydrogen and water is done at two specific temperature i.e., 273 K and 1000 K. similarly, it can also be done for any other value of the temperature.

part (b): We know that,

molecular weight of $H_2 = 2.01568$ g/mol

molecular weight of $O_2 = 31.998$ g/mol

molecular weight of $H_2O = 18.01468$ g/mol

Now,

mass fraction of hydrogen = $\frac{2 \times \text{Mwt of } H_2}{\text{Mwt of } H_2O} \times 100$

$= \frac{2 \times 2.01568}{18.01468} \times 100$

$\Rightarrow$ $\boxed{\%\, H_2 = 22.378193784 18\ \%}$

mass fraction of oxygen = $\frac{2 \times \text{Mwt of } O_2}{\text{Mwt of } H_2O} \times 100$

$= \frac{2 \times 31.998}{18.01468} \times 100$

$\boxed{\%\, O_2 = 355.24361243164\ \%}$

$\%\, H_2 + \%\, O_2 = 22.378193784 18 + 355.24361243164$

$= 377.62180621582\ \% \neq 100\%$

Therefore, water cannot be considered as a mixture of hydrogen and oxygen.