Heating of a fuel in an engine

Consider the fact that after combustion the octane fuel has been converted into CO_2 and H_2O in the vapor phase. Assuming an average value of c_p = 33 J/mol-K for vapor produced by combustion, what is the final temperature if 12 microliters of octane are combusted? ? (ρ_{oct} = 0.7 gm/cm^3)

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Solution: For the reaction in which all products are in the vapor phase we can write:

$$C_8H_{18}(\ell) + \frac{25}{2}\, O_2\,(g) \rightarrow 8\, CO_2(g) + 9\, H_2O\ (g)$$

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The difference in the number of moles is:

$$\Delta n = 9 + 8 - 12.5 = 4.5$$

Thus, for each mole of octane combusted there will be 4.5 moles of gas to be heated. The number of moles of octane is obtained from:

$$n = \frac{\rho V}{M_m} = \frac{(0.7\ gm/cm^3)(1.2\ x\ 10^{-5}\ L)(1000\frac{cm^3}{L})}{114\ gm/mol}$$
$$= 7.37\ x\ 10^{-5}\ mol$$

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Therefore, the total number of moles to be heated is:

$$n_{vapor} = 3.31\ x\ 10^{-4}\ mol$$

The total heat is obtained from the molar heat of combustion of octane, which is -5430 kJ/mol.

$$q = n\Delta H^o = (7.37\ x\ 10^{-5}\ mol)(-5430\ kJ/mol) = 400\ J$$

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Finally, the temperature difference is given by

$$\Delta T = \frac{q}{n_{vapor} c_p} = \frac{400\ J}{(3.31\ x\ 10^{-4}\ mol)(225.7\ J/molK)}$$

$$\Delta T = 5350\ K \ \ and\ T_f = 5650\ K$$

For the very small explosion that takes place there is a very high local temperature. However, this temperature is rapidly lowered by transfer to the surrounding metal.