Question:

1. Calculate the standard enthalpy change for the reaction:

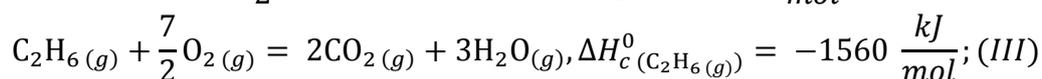$$C_2H_{4\,(g)} + H_{2\,(g)} = C_2H_{6\,(g)}$$
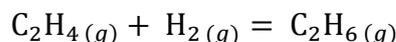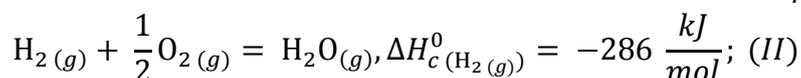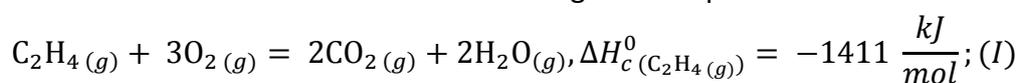
given that the enthalpy of combustion, for the reactants and products are:

$$\Delta H^0_{c\,(C_2H_4\,(g))} = -1411\,\frac{kJ}{mol};\ \Delta H^0_{c\,(C_2H_6\,(g))} = -1560\,\frac{kJ}{mol};\ \Delta H^0_{c\,(H_2\,(g))} = -286\,\frac{kJ}{mol}$$

Solution:

1. Write down the reactions of contribution of reagents and products:

$$C_2H_{4\,(g)} + 3O_{2\,(g)} = 2CO_{2\,(g)} + 2H_2O_{(g)}, \Delta H^0_{c\,(C_2H_4\,(g))} = -1411\,\frac{kJ}{mol};\ (I)$$

$$H_{2\,(g)} + \frac{1}{2}O_{2\,(g)} = H_2O_{(g)}, \Delta H^0_{c\,(H_2\,(g))} = -286\,\frac{kJ}{mol};\ (II)$$

$$C_2H_{6\,(g)} + \frac{7}{2}O_{2\,(g)} = 2CO_{2\,(g)} + 3H_2O_{(g)}, \Delta H^0_{c\,(C_2H_6\,(g))} = -1560\,\frac{kJ}{mol};\ (III)$$

2. If we take the equation (III) with opposite sign and then add all three equations (I), (II) and (III), we will obtain the following:

$$C_2H_{4\,(g)} + 3O_{2\,(g)} + H_{2\,(g)} + \frac{1}{2}O_{2\,(g)} + 2CO_{2\,(g)} + 3H_2O_{(g)}$$

$$= 2CO_{2\,(g)} + 2H_2O_{(g)} + H_2O_{(g)} + C_2H_{6\,(g)} + \frac{7}{2}O_{2\,(g)}$$

3. The result is:

$$C_2H_{4\,(g)} + H_{2\,(g)} = C_2H_{6\,(g)}$$
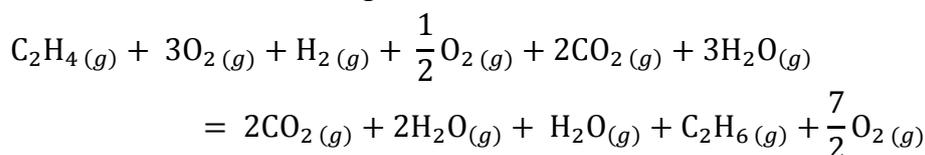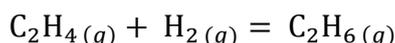
4. The standard enthalpy change for this reaction is equal to:

$$\Delta H^0 = \Sigma\Delta H^0_{c\,(reagents)} - \Sigma\Delta H^0_{c\,(products)}$$

$$= -1411\,\frac{kJ}{mol} + \left(-286\,\frac{kJ}{mol}\right) - \left(-1560\,\frac{kJ}{mol}\right) = -137\,\frac{kJ}{mol}$$
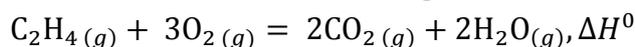
Answer: the standard enthalpy change for the reaction is $-137\,\frac{kJ}{mol}$.

2. Calculate the enthalpy change of combustion for ethene gas ($C_2H_{4\,(g)}$) given the following enthalpy changes of formation:

$$\Delta H^0_{f\,(C_2H_4\,(g))} = +52\,\frac{kJ}{mol};\ \Delta H^0_{f\,(CO_2\,(g))} = -394\,\frac{kJ}{mol};\ \Delta H^0_{f\,(H_2O_{(g)})} = -286\,\frac{kJ}{mol}$$

Solution:

1. Write down the reaction of contribution of ethane gas:

$$C_2H_{4\,(g)} + 3O_{2\,(g)} = 2CO_{2\,(g)} + 2H_2O_{(g)}, \Delta H^0$$

2. The standard enthalpy change for this reaction is equal to:

$$\Delta H^0 = \Sigma \Delta H^0_{f\,(products)} - \Sigma \Delta H^0_{f\,(reagents)}$$

$$= 2 \cdot \Delta H^0_{f\,(CO_{2\,(g)})} + 2 \cdot \Delta H^0_{f\,(H_2O_{(g)})} - \left(\Delta H^0_{f\,(C_2H_{4\,(g)})} + 3 \cdot \Delta H^0_{f\,(O_{2\,(g)})} \right)$$

3. The enthalpy changes of formation of oxygen gas as an elementary substance equals zero:

$$\Delta H^0 = 2 \cdot \Delta H^0_{f\,(CO_{2\,(g)})} + 2 \cdot \Delta H^0_{f\,(H_2O_{(g)})} - \left(\Delta H^0_{f\,(C_2H_{4\,(g)})} \right)$$

$$= 2 \cdot \left(-394 \ \frac{kJ}{mol} \right) + 2 \cdot \left(-286 \ \frac{kJ}{mol} \right) - 52 \ \frac{kJ}{mol} = -1412 \ \frac{kJ}{mol}$$

Answer: the standard enthalpy change for the reaction is $-1412 \ \frac{kJ}{mol}$.

3. Calculate the standard entropy change for the reaction:

$$N_{2\,(g)} + 3H_{2\,(g)} = 2NH_{3\,(g)}$$
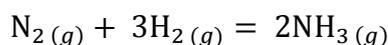
given the standard entropies

$$S^0_{(N_{2\,(g)})} = 191.6 \ \frac{J}{K \cdot mol}; \ S^0_{(H_{2\,(g)})} = 130.6 \ \frac{J}{K \cdot mol}; \ S^0_{(NH_{3\,(g)})} = 193.3 \ \frac{J}{K \cdot mol}$$

Solution:

The standard entropy change for this reaction is equal to:

$$\Delta S^0 = \Sigma \Delta S^0_{(products)} - \Sigma \Delta S^0_{(reagents)} = 2 \cdot S^0_{(NH_{3\,(g)})} - \left(S^0_{(N_{2\,(g)})} + 3 \cdot S^0_{(H_{2\,(g)})} \right)$$

$$= 2 \cdot 193.3 \ \frac{J}{K \cdot mol} - \left(191.6 \ \frac{J}{K \cdot mol} + 3 \cdot 130.6 \ \frac{J}{K \cdot mol} \right)$$

$$= -196.8 \ \frac{J}{K \cdot mol}$$

Answer: the standard entropy change for this reaction is $-196.8 \ \frac{J}{K \cdot mol}$.