Marks 5

- Stearic acid, $C_{18}H_{36}O_2$, is a fatty acid common in animal fats and vegetable oils and is a valuable energy source for mammals. The net reaction for its metabolism in humans is:

$$C_{18}H_{36}O_2(s) + 26O_2(g) \rightarrow 18CO_2(g) + 18H_2O(l)$$

Calculate $\Delta H°$ for this reaction given the following heats of formation.

ΔH_f^o ($C_{18}H_{36}O_2$(s)) = –948 kJ mol^{-1}, ΔH_f^o (CO_2(g)) = –393 kJ mol^{-1} and ΔH_f^o (H_2O(l)) = –285 kJ mol^{-1}

Using $\Delta_{rxn}H^0 = \sum m\Delta_f H^0(\text{products}) - \sum n\Delta_f H^0(\text{reactants})$, the heat of the reaction as written is:

$$\begin{aligned}\Delta_{rxn}H^0 &= [18\Delta_f H^0(CO_2(g)) + 18\Delta_f H^0(H_2O(g))] \\ &\quad - [\Delta_f H^0(C_{18}H_{36}O_2(s)) + 26\Delta_f H^0(O_2(g))] \\ &= [(18\times -393) + (18\times -285)] - [(-948) + (26\times 0)] = -11256\,\text{kJ mol}^{-1}\end{aligned}$$

$\Delta_f H^0(O_2(g)) = 0$ for an element already in their standard states.

Answer: **-11256 kJ mol^{-1}**

If the combustion of stearic acid is carried out in air, water is produced as a vapour. Calculate the $\Delta H°$ for the combustion of stearic acid in air given that

$$H_2O(l) \rightarrow H_2O(g) \qquad \Delta H° = +44 \text{ kJ mol}^{-1}$$

Energy must be provided to vaporize the water so the enthalpy of combustion is reduced:

$\Delta_{comb}H^o$ = -11256 + (18 × 44) = -10464 kJ mol^{-1}

Answer: **-10464 kJ mol^{-1}**

Will ΔS be different for the two oxidation reactions? If so, how will it differ and why?

The entropy of H_2O(g) is greater than that of H_2O(l) so ΔS will be greater. In the oxidation reaction which produces H_2O(l), 26 mol of gas are converted into 18 mol of gas so that ΔS will be negative. In the oxidation reaction which produces H_2O(g), 26 mol of gas are converted into (18 + 18) = 36 mol of gas and ΔS will be positive.

ANSWER CONTINUES ON THE NEXT PAGE

Calculate the mass of carbon dioxide produced by the complete oxidation of 1.00 g of stearic acid.

The molar mass of stearic acid, $C_{18}H_{36}O_2$, is:

18 × 12.01 (C) + 36 × 1.008 (H) + 2 × 16.00 (O) = 284.468

1.0 g therefore contains:

$$\text{number of moles of stearic acid} = \frac{\text{mass}}{\text{molar mass}} = \frac{1.00}{284.468} = 0.00352\,\text{mol}$$

As 18 mol of CO_2 are produced for every mole of stearic acid:

number of moles of CO_2 = 18 × 0.00352 = 0.0633 mol

The molar mass of CO_2 is (12.01 (C) + 2 × 16.00 (O)) = 44.01. The mass of CO_2 is thus:

mass of CO_2 = number of moles × molar mass = 0.0633 × 44.01 = 2.78 g

Answer: **2.78 g**