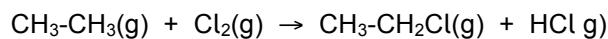


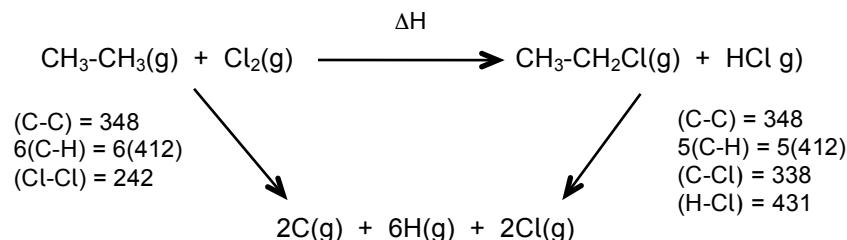


HESS'S LAW 3 – BOND ENTHALPIES

Example 1 Calculate the enthalpy change for the following reaction given the following bond enthalpies.



Bond enthalpies: C-C 348, C-H 412, Cl-Cl 242, C-Cl 338, H-Cl 431 kJ/mol

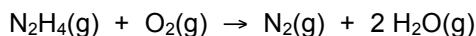


$$\Delta H + 348 + 5(412) + 338 + 431 = 348 + 6(412) + 242$$

$$\Delta H = 348 + 6(412) + 242 - 348 - 5(412) - 338 - 431$$

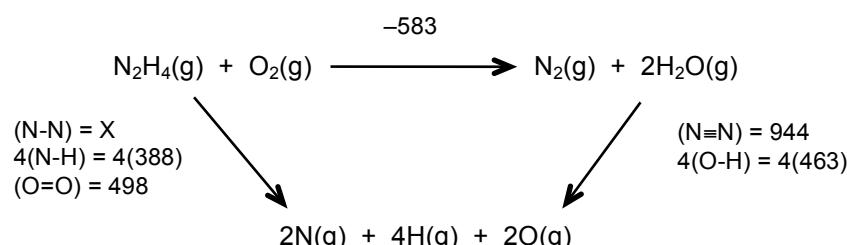
$$\Delta H = -115 \text{ kJ mol}^{-1}$$

Example 2 Hydrazine has the formula N_2H_4 and is used as a rocket fuel (e.g. for the Apollo moon rockets). It burns in the following reaction for which the enthalpy change is -583 kJ/mol.



Calculate the N-N bond enthalpy in hydrazine given the following bond enthalpies.

Bond enthalpies: N-H 388, O=O 498, N=N 944, O-H 463 kJ/mol

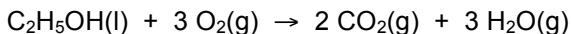


$$-583 + 944 + 4(463) = X + 4(388) + 498$$

$$X = -583 + 944 + 4(463) - 4(388) - 498$$

$$\Delta H = +163 \text{ kJ mol}^{-1}$$

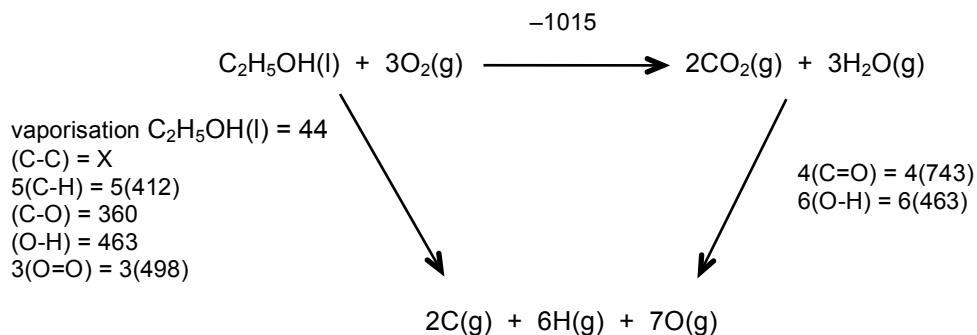
Example 3 Ethanol has the formula C₂H₅OH and is used as a fuel (e.g. for cars in Brazil). It burns in the following reaction for which the enthalpy change is -1015 kJ/mol.



Calculate the C-C bond enthalpy in ethanol given the following bond enthalpies and enthalpy of vaporisation of ethanol.

Bond enthalpies: C-H 412, O-H 463, C-O 360, C=O 743, O=O 498 kJ/mol

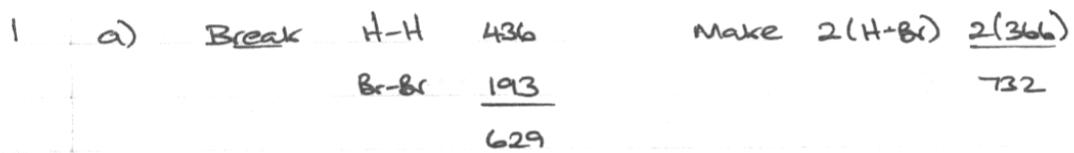
Enthalpy of vaporisation of ethanol, C₂H₅OH(l) = 44 kJ/mol



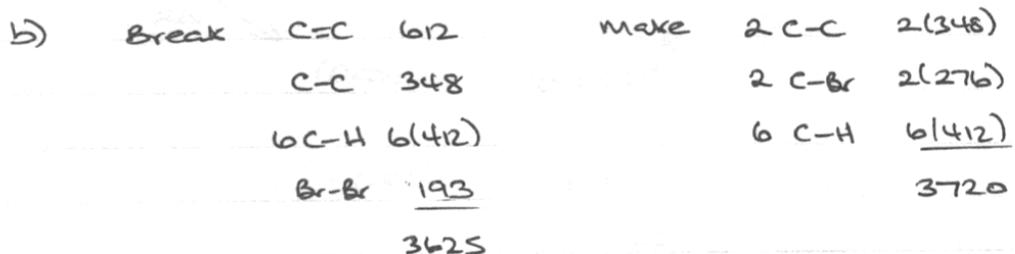
$$-1015 + 4(743) + 6(463) = 44 + X + 5(412) + 360 + 463 + 3(498)$$

$$X = -1015 + 4(743) + 6(463) - 5(412) - 360 - 463 - 3(498) - 44$$

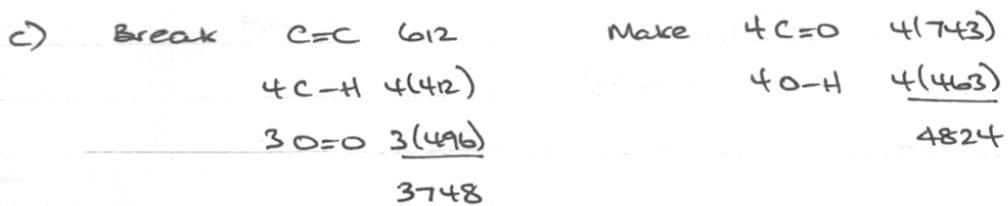
$$\Delta H = +314 \text{ kJ mol}^{-1}$$



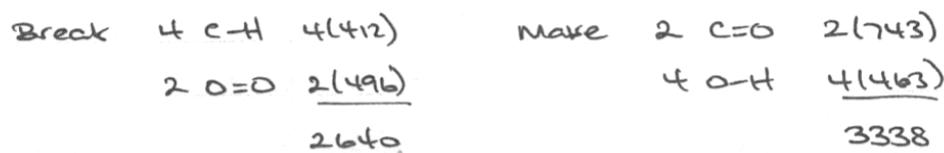
$$\Delta H = 629 - 732 = -103 \text{ kJ/mol}$$



$$\Delta H = 3625 - 3720 = -95 \text{ kJ/mol}$$

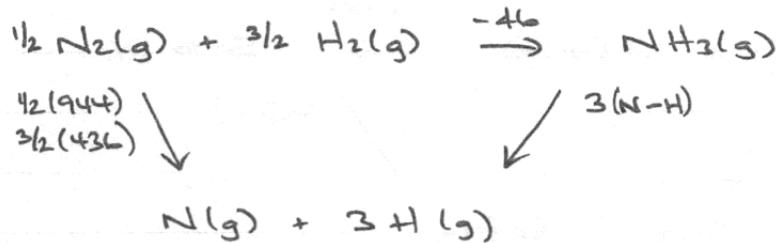


$$\Delta H = 3748 - 4824 = \underline{-1076 \text{ kJ/mol}}$$



$$\Delta H = 2640 - 3338 = \underline{-698 \text{ kJ/mol}}$$

2

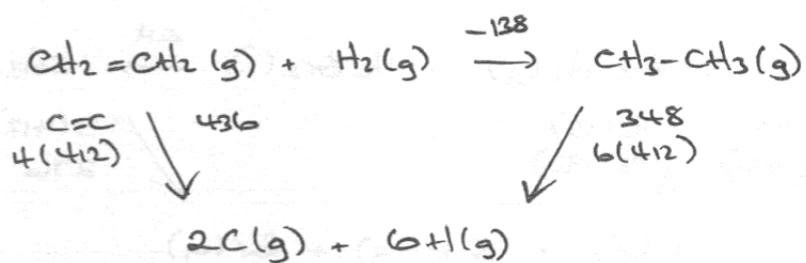


$$-46 + 3(\text{N}-\text{H}) = \frac{1}{2}(944) + \frac{3}{2}(436)$$

$$3(\text{N}-\text{H}) = 1172$$

$$\text{N}-\text{H} = \underline{391 \text{ kJ/mol}}$$

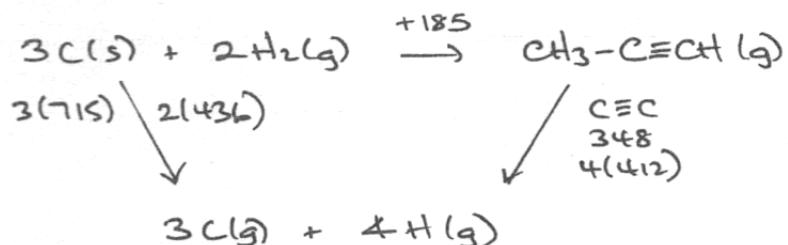
3



$$(\text{C}=\text{C}) + 4(412) + 436 = -138 + 348 + 6(412)$$

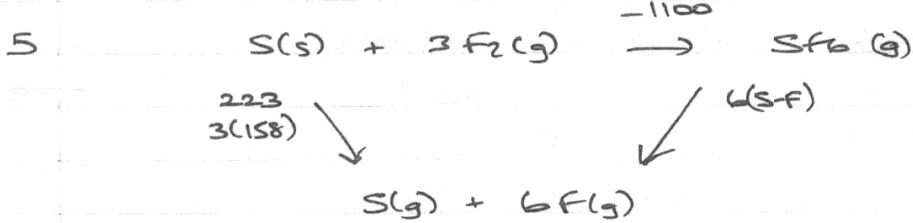
$$\text{C}=\text{C} = \underline{598 \text{ kJ/mol}}$$

4



$$(\text{C}\equiv\text{C}) + 348 + 4(412) + 185 = 3(715) + 2(436)$$

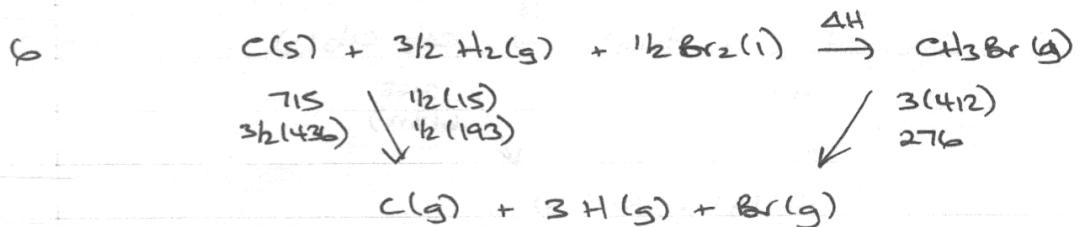
$$\text{C}\equiv\text{C} = \underline{836 \text{ kJ/mol}}$$



$$6(S-F) - 1100 = 223 + 3(158)$$

$$6(S-F) = 1797$$

$$S-F = \underline{300 \text{ kJ/mol}}$$



$$\Delta H + 3(412) + 276 = 715 + 3h(436) + \frac{1}{2}(1s) + \frac{1}{2}(1s)$$

$$\Delta H = \underline{-39 \text{ kJ/mol}}$$