

## Problems of Enthalpy and internal energy

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1) Consider the following reaction at 25 °C:



Find out: **a)** The change of enthalpy at 25 °C. **b)** The heat released when 200 g of methanol react at constant pressure.

2) In a chemical reactor a mixture of gases reacts. The system releases 1705 kJ of heat into its surroundings. A work of 3780 kJ is done by the system on the surroundings. **a)** Calculate the change of enthalpy for this process. **b)** Calculate the change of internal energy for this process.

3) Consider the reaction at 25 °C:

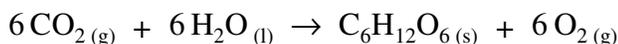


Find out: **a)** The change of internal energy at 25 °C. **b)** The heat released when 215 g of carbon monoxide react at constant pressure.

4) In a reaction chamber hydrogen reacts with oxygen. The system releases 358 kJ of heat while doing 737 kJ of work on the surroundings. Determine the change of internal energy for this process.

5) At a temperature of 25 °C and a pressure of 1 atm, the enthalpy of formation of butane ( $\text{C}_4\text{H}_{10(g)}$ ) is  $-125.7 \text{ kJ/mol}$ , the enthalpy of combustion of carbon is  $-393.51 \text{ kJ/mol}$  and the enthalpy of formation of liquid water is  $-285.83 \text{ kJ/mol}$ . Calculate the enthalpy of combustion of  $\text{C}_4\text{H}_{10(g)}$  (butane).

6) Given the reaction:



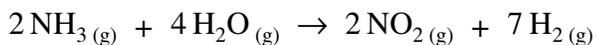
Determine: **a)** The change of enthalpy at 25 °C. **b)** The heat released/absorbed when 45 g of carbon dioxide react at constant pressure.

*Enthalpies of formation* (in kJ/mol at 25 °C, 1 atm):

$$\Delta H_f^\circ(\text{CO}_{2(g)}) = -393.51, \quad \Delta H_f^\circ(\text{H}_2\text{O}_{(l)}) = -285.83, \quad \Delta H_f^\circ(\text{C}_6\text{H}_{12}\text{O}_{6(s)}) = -1273.3$$

7) At 25 °C and 1 atm, the combustion reaction of 1 mol of cyclooctane ( $\text{C}_8\text{H}_{16(l)}$ ) releases 5267.02 kJ. At this temperature and pressure the enthalpies of formation of carbon dioxide and liquid water are  $-393.51 \text{ kJ/mol}$  and  $-285.83 \text{ kJ/mol}$  respectively. Find out the enthalpy of formation of  $\text{C}_8\text{H}_{16(l)}$  (cyclooctane).

8) Consider the following reaction:



Determine: **a)** The change of enthalpy at 25 °C. **b)** The heat released/absorbed when 125 g of ammonia react at constant pressure.

*Enthalpies of formation* (in kJ/mol at 25 °C, 1 atm):

$$\Delta H_f^\circ(\text{NH}_3(g)) = -46.11, \quad \Delta H_f^\circ(\text{H}_2\text{O}(g)) = -241.82, \quad \Delta H_f^\circ(\text{NO}_2(g)) = 33.18$$

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9) The combustion reaction of 1 gram of methane ( $\text{CH}_4(\text{g})$ ) at  $25^\circ\text{C}$  and 1 atm releases 55.65 kJ. **a)** Calculate its enthalpy of combustion. **b)** If at this temperature and pressure the enthalpies of formation of carbon dioxide and liquid water are  $-393.51\text{ kJ/mol}$  and  $-285.83\text{ kJ/mol}$  respectively, determine the enthalpy of formation of methane.

Atomic masses (g/mol): C = 12, H = 1.

10) Consider the following reaction:



Calculate: **a)** The change of enthalpy at  $25^\circ\text{C}$ . **b)** The heat released/absorbed when 125 g of ethane react at constant pressure.

Enthalpies of formation (in kJ/mol at  $25^\circ\text{C}$ , 1 atm):

$$\Delta H_f^\circ(\text{C}_2\text{H}_6(\text{g})) = -83.85, \quad \Delta H_f^\circ(\text{C}_4\text{H}_{10}(\text{g})) = -125.65$$

### Answers:

- 1)        **a)**  $-726.51\text{ kJ}$ ;    **b)**  $4540.7\text{ kJ}$ .
- 2)        **a)**  $-1705\text{ kJ}$ ;    **b)**  $-5485\text{ kJ}$ .
- 3)        **a)**  $-281.74\text{ kJ}$ ,    **b)**  $2172.9\text{ kJ}$ .
- 4)         $-1095\text{ kJ}$ .
- 5)         $-2877.49\text{ kJ/mol}$ .
- 6)        **a)**  $2802.74\text{ kJ}$ ;    **b)**  $477.7\text{ kJ}$ .
- 7)         $-167.7\text{ kJ/mol}$ .
- 8)        **a)**  $1125.86\text{ kJ}$ ;    **b)**  $4139.2\text{ kJ}$ .
- 9)        **a)**  $-890.4\text{ kJ/mol}$     **b)**  $-74.77\text{ kJ/mol}$ .
- 10)       **a)**  $42.05\text{ kJ}$ ;    **b)**  $87.6\text{ kJ}$ .