

CH1020 Exercises (Worksheet 18)
(Hess's law, standard enthalpy of reactions)

- State Hess's law. Why is it important to thermochemistry?
If a reaction can be described as a series of steps, ΔH for the reaction is the sum of the enthalpy changes for each step. As long as we can describe a route where ΔH for each step is known, ΔH for any process can be calculated.
- What is the connection between Hess's law and the fact that H is a state function?
Hess's law is a consequence of the fact that enthalpy is a state function. Since ΔH is independent of path, we can describe a process by any series of steps that add up to the overall process and ΔH for the process is the sum of the ΔH values for the steps.
- Consider the following hypothetical reactions:

$$\begin{array}{ll} \text{A} \rightarrow \text{B} & \Delta H = +30 \text{ kJ} \\ \text{B} \rightarrow \text{C} & \Delta H = +60 \text{ kJ} \end{array}$$
 Use Hess's law to calculate the enthalpy change for the reaction $\text{A} \rightarrow \text{C}$.

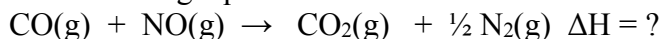
$$\Delta H_{\text{rxn}} = \Delta H_1 + \Delta H_2 = 30 \text{ kJ} + 60 \text{ kJ} = 90 \text{ kJ}$$

- Suppose you are given the following hypothetical reactions:

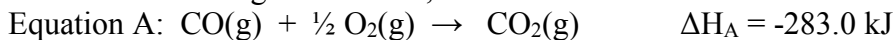


Use Hess's law to calculate the enthalpy change for the reaction $\text{Y} \rightarrow \text{Z}$
-55 kJ

- Two gaseous pollutants that form in auto exhaust are CO and NO. An environmental chemist is studying ways to convert them to less harmful gases through the following equation:

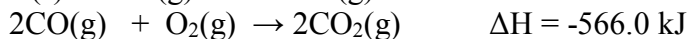


Given the following information, calculate the unknown ΔH :

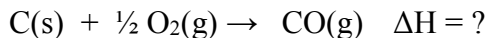


$$\text{-373.3 kJ}$$

- Given:



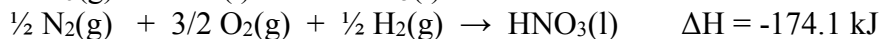
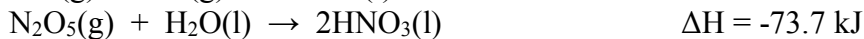
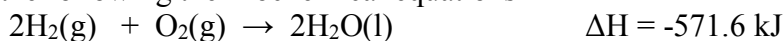
calculate ΔH for the reaction:



Solution:



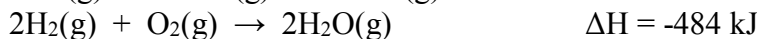
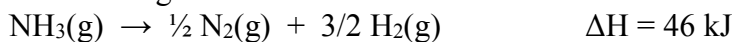
7. Given the following thermochemical equations



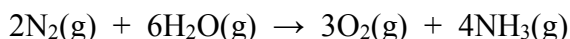
calculate ΔH for the formation of one mole of dinitrogen pentoxide from its elements.

$$+11.3 \text{ kJ}$$

8. Given the following data:



calculate ΔH for the reaction

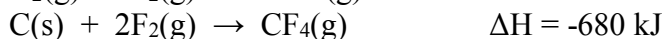


On the basis of the enthalpy change, is this a useful reaction for the synthesis of ammonia?

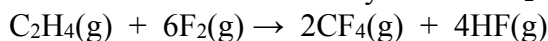
$$+1268 \text{ kJ}$$

No. Since the reaction is very endothermic (requires a lot of heat), it would not be a practical way of making ammonia due to the high energy costs required.

9. From the following enthalpies of reaction:

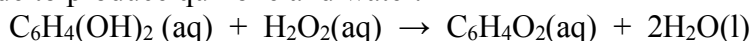


calculate ΔH for the reaction of ethylene with F_2 :

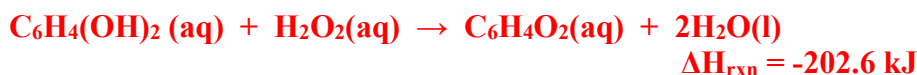
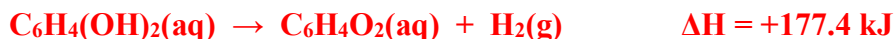
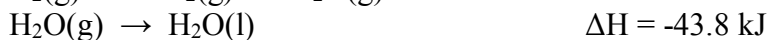
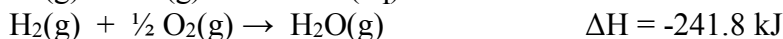


$$-2486.3 \text{ kJ}$$

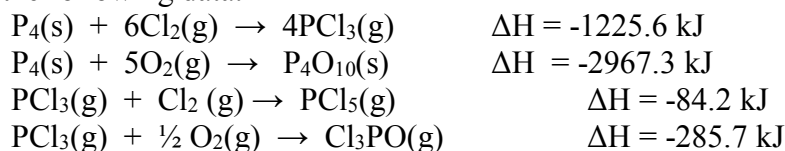
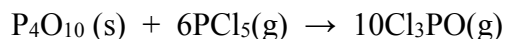
10. The bombardier beetle uses an explosive discharge as a defensive measure. The chemical reaction involved is the oxidation of hydroquinone by hydrogen peroxide to produce quinone and water:



Calculate ΔH for this reaction from the following data:



11. Given the following data:

Calculate ΔH for the reaction**-610.1 kJ**

12. Why are tables of standard enthalpies of formation so useful?

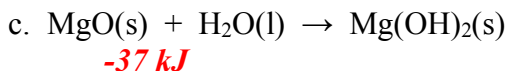
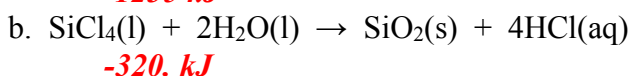
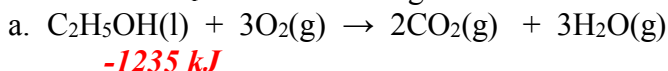
Tables of ΔH°_f are useful because, according to Hess's law, the standard enthalpy of any reaction can be calculated from the standard enthalpies of formation for the reactants and products :

$$\Delta H^\circ_{\text{reaction}} = \Sigma \Delta H^\circ_f (\text{products}) - \Sigma \Delta H^\circ_f (\text{reactants})$$

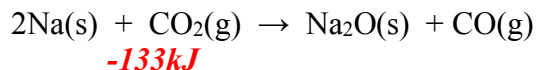
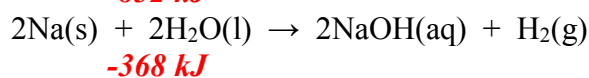
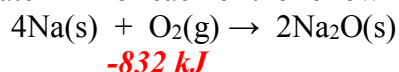
13. What is the value of the standard enthalpy of formation of an element in its most stable form?

The standard enthalpy of formation for any element in its standard state is zero. Elements in their standard states are the reference point for the enthalpy of formation scale.

14. Calculate
- ΔH°_f
- for the following reactions:



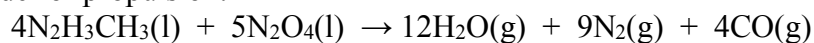
15. Calculate
- ΔH°
- for each of the following reactions:



Explain why a water or carbon dioxide fire extinguisher might not be effective in putting out a sodium fire.

In both cases, Na metal reacts with the 'extinguishing agent'. Both reactions are exothermic and each reaction produces a flammable gas, H₂ and CO, respectively.

16. The space shuttle orbiter utilizes the oxidation of methyl hydrazine by dinitrogen tetroxide for propulsion:

Calculate ΔH° for the reaction.

-3460 kJ

17. The standard enthalpy of combustion of ethane gas, $\text{C}_2\text{H}_4(\text{g})$, is -1411.1 kJ/mol at 298 K. Given the following enthalpies of formation, calculate the enthalpy of formation for $\text{C}_2\text{H}_4(\text{g})$:

 $\text{CO}_2(\text{g})$ -393.5 kJ/mol $\text{H}_2\text{O}(\text{l})$ -285.8 kJ/mol **52.5 kJ/mol**