

Energy and Chemical Change

- Calculate the amount of heat released in the complete combustion of 8.17 g of Al to form $\text{Al}_2\text{O}_3(\text{s})$ at 25°C and 1 atm. ΔH_f° for $\text{Al}_2\text{O}_3(\text{s}) = -1680 \text{ kJ/mol}$.

$$4\text{Al}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Al}_2\text{O}_3(\text{s})$$
- From the following data at 25°C ,

$$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \quad \Delta H = -185 \text{ kJ}$$

$$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) \quad \Delta H = -483.7 \text{ kJ}$$
 calculate ΔH at 25°C for the reaction below.

$$4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$
- Determine ΔS for the reaction

$$\text{SO}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_4(\text{l}),$$
 given the following entropies.

Compound	Entropy (J/mol·K)
$\text{SO}_3(\text{g})$	256.8
$\text{H}_2\text{O}(\text{l})$	70.0
$\text{H}_2\text{SO}_4(\text{l})$	156.9
- Calculate the molar entropy of vaporization for liquid hydrogen iodide at its boiling point, -34.55°C .

$$\text{HI}(\text{l}) \rightleftharpoons \text{HI}(\text{g}) \quad \Delta H_{\text{vap}} = 19.76 \text{ kJ/mol}$$
- Ozone (O_3) in the atmosphere may react with nitric oxide (NO).

$$\text{O}_3(\text{g}) + \text{NO}(\text{g}) \rightarrow \text{NO}_2(\text{g}) + \text{O}_2(\text{g})$$
 From the following data, calculate the ΔG° in kJ for the reaction at 25°C and determine whether the reaction is spontaneous.

$$\Delta H^\circ = -199 \text{ kJ}$$

$$\Delta S^\circ = -4.1 \text{ J/K}$$
- For the reaction $\text{H}_2(\text{g}) + \text{S}(\text{s}) \rightarrow \text{H}_2\text{S}(\text{g})$, $\Delta H = -20.2 \text{ kJ}$ and $\Delta S = 43.1 \text{ J/K}$. When will the reaction be spontaneous?
- The following reaction is nonspontaneous at 25°C .

$$\text{Cu}_2\text{O}(\text{s}) \rightarrow 2\text{Cu}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g})$$

$$\Delta H_f^\circ = 168.6 \text{ kJ}$$
 If $\Delta S = 75.8 \text{ J/K}$, what is the lowest temperature at which the reaction will be spontaneous?
- Calculate ΔH° at 25°C for the reaction below.

$$2\text{ZnS}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{ZnO}(\text{s}) + 2\text{SO}_2(\text{g})$$

-206.0	0	-350.5	-296.8
$\Delta H_f^\circ(\text{kJ/mol})$			
- How much heat is evolved in the formation of 35.0 g of $\text{Fe}_2\text{O}_3(\text{s})$ at 25°C and 1.00 atm pressure by the following reaction?

$$4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s})$$

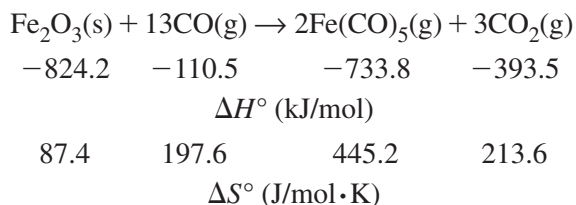
ΔH_f° (kJ/mol)	0	0	-824.2
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- Calculate the standard heat of vaporization, ΔH_{vap} , for tin(IV) chloride, SnCl_4 .

$$\Delta H_f^\circ = -511.3 \text{ kJ/mol}$$
 for $\text{SnCl}_4(\text{l})$ and -471.5 kJ/mol for $\text{SnCl}_4(\text{g})$.
- Given the following data at 298 K, calculate ΔS for the given reaction.

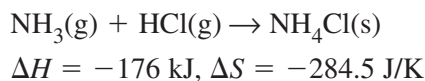
$$2\text{Ag}_2\text{O}(\text{s}) \rightarrow 4\text{Ag}(\text{s}) + \text{O}_2(\text{g})$$

ΔS (J/mol·K)	121.3	42.6	205.2
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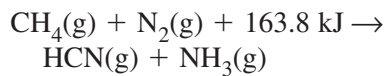
12. Calculate the ΔG° at 298 K for the following reaction.



13. Estimate the temperature at which $\Delta G = 0$ for the following reaction.

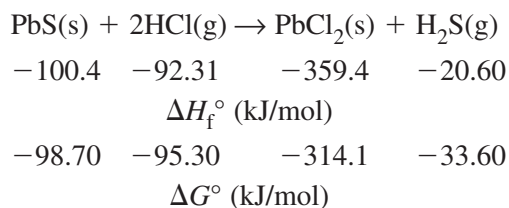


14. Consider the reaction below at 25°C for which $\Delta S = 16.1 \text{ J/K}$.



At what temperature will this reaction be spontaneous?

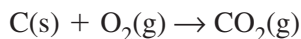
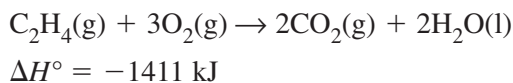
15. Estimate the temperature above which the following reaction is not spontaneous.



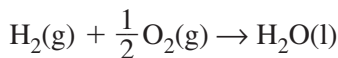
16. Copper metal has a specific heat of $0.385 \text{ J/g}\cdot^\circ\text{C}$ and a melting point of 1083°C . Calculate the amount of heat required to raise the temperature of 22.8 g of copper from 20.0°C to 875°C .

17. How many degrees of temperature rise will occur when a 25.0-g block of aluminum absorbs 10.0 kJ of heat? The specific heat of aluminum is $0.897 \text{ J/g}\cdot^\circ\text{C}$.

18. Find the standard enthalpy of formation for ethylene, $\text{C}_2\text{H}_4(\text{g})$, given the following data.

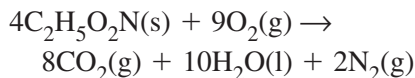


$\Delta H^\circ = -393.5 \text{ kJ}$



$\Delta H^\circ = -285.8 \text{ kJ}$

19. Glycine is important for biological energy. The combustion of glycine is given by the following equation.



$\Delta H = -3857 \text{ kJ}$

Given that $\Delta H_f^\circ \text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}$ and $\Delta H_f^\circ \text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}$, calculate the enthalpy of formation per mole of glycine.

20. At body temperature, 2404 J is required to evaporate 1 g of water. After vigorous exercise, a person feels chilly because the body is giving up heat to evaporate the perspiration. A typical person perspires 25 mL of water after 20 minutes of exercise. How much body heat is used to evaporate this water?