

Enthalpy, Entropy, and Gibb's Free Energy

Name: _____

Date: _____ Per: _____

Part 1: Enthalpy

1. What is the sign of ΔH for an exothermic reaction?
2. What is the sign of ΔH for an endothermic reaction?
3. How is a thermochemical equation different from a balanced chemical equation?
4. Write the correct sign of ΔH for each of the following changes in physical state.

| Phase Change | Correct Sign for ΔH |
|---|-----------------------------|
| $C_2H_5OH (s) \rightarrow C_2H_5OH (l)$ | |
| $H_2O (g) \rightarrow H_2O (l)$ | |
| $CH_3OH (l) \rightarrow CH_3OH (g)$ | |
| $NH_3 (l) \rightarrow NH_3 (s)$ | |

5. Write the correct sign of ΔH for each of the following reactions then tell if the reaction is endothermic or exothermic.

| Reaction | Correct Sign for ΔH | Endothermic/Exothermic |
|---|-----------------------------|------------------------|
| $CaO (s) + H_2O (l) \rightarrow Ca(OH)_2 (s) + 65.2kJ$ | | |
| $2NaHCO_3 (s) + 129kJ \rightarrow Na_2CO_3 + CO_2 (g) + H_2O (g)$ | | |
| $C_2H_5OH (l) + 3O_2 (g) \rightarrow 2CO_2 (g) + 3H_2O (g) + 1235 kJ$ | | |
| $H_2O (l) + 44kJ \rightarrow H_2O (g)$ | | |

Part 2: Entropy

6. What does entropy of a substance measure?
7. What is the sign for ΔS when a physical or chemical change increases the disorder of the universe?
8. What is the sign for ΔS when a physical or chemical change decreases the disorder of the universe?
9. For each pair, circle the one with greater entropy.
 - a. $NH_3 (g)$ and $NH_3 (l)$
 - b. $NH_3 (g)$ and $NH_3 (aq)$
 - c. $CO_2 (s)$ and $CO_2 (g)$
 - d. $KBr (s)$ and $KBr (l)$

10. For each of the following physical or chemical changes, tell if it is a physical or chemical change, determine if entropy is increased or decreased, and give the sign for ΔS .

| Change | Physical or Chemical? | Disorder increased or decreased? | Sign of ΔS |
|---|-----------------------|----------------------------------|--------------------|
| The evaporation of water | | | |
| $\text{Mg (s)} + \text{O}_2 \text{ (g)} \rightarrow \text{MgO (s)}$ | | | |
| Dissolving copper (II) sulfate in water | | | |
| $2\text{NH}_3 \text{ (g)} \rightarrow \text{N}_2 \text{ (g)} + 3\text{H}_2 \text{ (g)}$ | | | |

Part 3: Gibb's Free Energy and Spontaneity

11. Calculate the ΔG for each of the following conditions. Then state if the reaction is spontaneous or nonspontaneous.

| ΔH | ΔS | T | ΔG | Spontaneous or Nonspontaneous? |
|------------|-------------|-------|------------|--------------------------------|
| 145kJ | 0.195 kJ/K | 293K | | |
| -232kJ | 0.138 kJ/K | 273K | | |
| -15.9kJ | -0.268 kJ/K | 373 K | | |

12. Determine whether the following reactions are spontaneous at 25°C.



13. Complete the following chart to summarize the relationship among entropy, enthalpy and reaction spontaneity.

| Enthalpy | Entropy | Spontaneity |
|------------------------|------------------------|---------------------------------------|
| ΔH is negative | ΔS is positive | |
| ΔH is positive | | Spontaneous only at high temperatures |
| ΔH is negative | | Spontaneous only at low temperatures |
| ΔH is positive | ΔS is negative | |