Entropy and Introductory Spontaneity

Student Worksheet | g10_u02_w08

I can: use entropy, enthalpy, and temperature as separate ideas when making a limited thermodynamic prediction.
Classroom model: at stated constant temperature and pressure, use $\Delta G = \Delta H - T\Delta S$. A negative ΔG indicates a thermodynamically favorable (spontaneous) direction *under those stated conditions*; it does not tell how fast a change occurs. Match units: use ΔH in kJ/mol and ΔS in $\mathrm{kJ\,mol^{-1}\,K^{-1}}$. All prompts are paper/data-card analyses; no materials or chemical handling are requested.

1. Distinguish heat, temperature, and entropy in one accurate sentence each.

2. Why is "disorder" only an imperfect shortcut for entropy? Give a more useful qualitative description involving arrangements or energy dispersal.

3. A gas expands into a larger available volume at the same temperature. Predict the sign of ΔS_{system} and explain using possible molecular arrangements.

4. Ice melts to liquid water at its melting temperature. Predict the sign of ΔS_{system}. Why does that sign alone not decide whether melting is favorable at every temperature?

5. Two different inert gases, initially separated at the same temperature and pressure, are allowed to mix in a larger shared volume. Predict the sign of ΔS_{system} and state one model assumption.

6. Explain the difference between ΔS_{system} and the entropy change of the surroundings. Why should a system boundary be named?

7. For each sign pair, identify the likely temperature dependence of a favorable direction: (a) $\Delta H < 0$, $\Delta S > 0$; (b) $\Delta H > 0$, $\Delta S < 0$; (c) $\Delta H < 0$, $\Delta S < 0$; (d) $\Delta H > 0$, $\Delta S > 0$.

8. Write the classroom Gibbs-energy relation. What temperature scale and unit conversion are required before substitution?

9. A data card gives $\Delta H = -40.0$ kJ/mol and $\Delta S = -100\ \mathrm{J\,mol^{-1}\,K^{-1}}$ at 298 K. Convert ΔS to matching units.

10. Use item 9's card to calculate ΔG at 298 K. State the limited thermodynamic conclusion.

11. For item 9's signs, find the crossover temperature at which this simplified model gives $\Delta G = 0$. State whether lower or higher temperatures favor the indicated direction.

12. A second card gives $\Delta H = +20.0$ kJ/mol and $\Delta S = +100\ \mathrm{J\,mol^{-1}\,K^{-1}}$. Calculate ΔG at 298 K and give the conclusion under the model.

13. Find the crossover temperature for item 12. Which side of that temperature favors the indicated direction?

14. A third card gives $\Delta H = -20.0$ kJ/mol and $\Delta S = -50.0\ \mathrm{J\,mol^{-1}\,K^{-1}}$ at 298 K. Calculate ΔG and interpret it cautiously.

15. A fourth card gives $\Delta H = +20.0$ kJ/mol and $\Delta S = -50.0\ \mathrm{J\,mol^{-1}\,K^{-1}}$ at 298 K. Calculate ΔG and interpret it cautiously.

16. A student says, "Exothermic means spontaneous." Use one sign pair from item 7 and one calculation card to correct the claim.

17. A student says, "If $\Delta G < 0$, the reaction will be fast and go to completion." Correct both parts of this claim.

18. At equilibrium under the stated conditions, what is the value of ΔG for the net change? Does equilibrium mean molecules stop changing?

19. A process is not favorable for the chosen system alone but occurs when coupled to another process. Explain why the chosen boundary and the full combined process matter.

20. A headline reads, "Higher temperature always makes reactions spontaneous." Rewrite it accurately, mentioning ΔH, ΔS, and the stated-condition limit of this model.