

Name: _____

Date: _____

- [4 pt] 1. Define the term Gibbs free-energy, give the symbol, and standard units. Also include the sign conventions for Gibbs free-energy.

- [8 pt] 2. Complete the following table:

Statement	Sign of ΔH	Sign of ΔS	Sign of ΔG
Spontaneous at all Temp:			
Nonspontaneous at all Temp:			
Spontaneous at Low Temp:			
Spontaneous at High Temp:			

- [6 pt] 3. Answer the following questions about spontaneous and nonspontaneous processes:

(a) Is it possible for a reaction to be endothermic (absorb heat), yet spontaneous? Explain.

(b) Is it possible for a reaction to be exothermic (release heat), yet nonspontaneous? Explain.

(c) Is it possible for a reaction to never be spontaneous? Explain.

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[6 pt] 4. Tell whether reactions with the following values of ΔH and ΔS are (S)pontaneous, or (N)onspontaneous. Explain.

(a) $\Delta H = -128 \text{ kJ}$, $\Delta S = 35 \text{ J/K}$, at 500 K 4(a) _____

(b) $\Delta H = +67 \text{ kJ}$, $\Delta S = -140 \text{ J/K}$, at 250 K 4(b) _____

(c) $\Delta H = +75 \text{ kJ}$, $\Delta S = 95 \text{ J/K}$, at 800 K 4(c) _____

[8 pt] 5. Vinyl chloride ($\text{H}_2\text{C}=\text{CHCl}$), is the starting material used in the industrial preparation of polyvinylchlorides. It is prepared by a two step process that begins with the following reaction: $\text{Cl}_2(\text{g}) + \text{H}_2\text{C}=\text{CHCl}(\text{g}) \longrightarrow \text{ClCH}_2\text{CH}_2\text{Cl}(\text{l})$ where $\Delta H = -217.5 \text{ kJ/mol}$ and $\Delta S = -233.9 \text{ J/K}\cdot\text{mol}$.

5(a) Is the reaction favored enthalpically? Explain. 5(a) _____

5(b) Is the reaction favored entropically? Explain. 5(b) _____

5(c) What is ΔG for the reaction (at STP) in kJ/mol ? Show work. 5(c) _____

5(d) What is the equilibrium temperature at which the reaction switches between spontaneous and nonspontaneous? Show work. 5(d) _____

5(e) Is the reaction spontaneous at 500K? Explain. 5(e) _____

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- [3 pt] 6. The boiling point of a substance is defined as the temperature at which the liquid and vapor can coexist in equilibrium. Use the heat of vaporization ($\Delta H_{vap} = 30.91 \text{ kJ/mol}$) and the entropy of vaporization ($\Delta S_{vap} = 93.2 \text{ J/K}\cdot\text{mol}$) to calculate the boiling point in $^{\circ}\text{C}$ of liquid bromine.

- [9 pt] 7. Calculate ΔH° , ΔS° , and ΔG° for the following reactions at STP and predict whether the reaction is spontaneous or nonspontaneous. Show work on a separate sheet of paper if required.

Reaction	ΔH	ΔS	ΔG	Spont/Non
(a) $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{SO}_3(\text{g})$				
(b) $\text{N}_2(\text{g}) + 2\text{H}_2(\text{g}) \longrightarrow \text{N}_2\text{H}_4(\text{l})$				
(c) $\text{CH}_3\text{OH}(\text{l}) + \text{O}_2(\text{g}) \longrightarrow \text{HCO}_2\text{H}(\text{l}) + \text{H}_2\text{O}(\text{l})$				

- [6 pt] 8. For each of the reactions in the first problem, are they (A) Always spontaneous (B) Never Spontaneous (C) Spontaneous below a certain temperature (include temperature), or (D) Spontaneous above a certain temperature (include temperature). Explain.

