**Dougherty Valley HS AP Chemistry**

**WORKSHEET #3**

**Thermodynamics – Entropy and Gibbs II**

**Name: Date: Period: Seat #:**

Show all work

[1] Which of the following processes are spontaneous?

|  |  |  |
| --- | --- | --- |
| a. Spreading the fragrance of perfume through a room | YES | NO |
| b. Separating a mixture of N2 and O2 into pure containers of each | YES | NO |
| c. Bursting of a normally inflated balloon | YES | NO |
| d. The reaction of sodium metal with chlorine gas to form NaCl | YES | NO |
| e. The dissolution of NaCl(s) in water form NaCl(aq) | YES | NO |

[2] Consider what happens when the explosive TNT is detonated.

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| a. Is the detonation a spontaneous process? | YES | NO |
| b. What is the sign of q for the process? | | |

[3] The normal boiling point of methanol is 64.7 °C and its molar enthalpy of vaporization is ΔHvap = 71.8 kJ/mol.

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| a. When methanol boils at its normal boiling point, will its entropy increase or decrease? |
| b. Calculate the value of ΔS when 1.00 mol of methanol is vaporized at 64.7°C. |

[4] What do you expect the sign of ΔS to be for the following situations?

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| a. In a reaction, 2 moles of gaseous reactants → 3 moles gaseous products. |
| b. In a chemical reaction, two gases combine to form a solid. |

[5] In which of the following situations does entropy of the system increases?

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| --- | --- | --- |
| a. Melting of ice cubes | YES | NO |
| b. Dissolving sugar in a cup of hot coffee | YES | NO |
| c. Formation of methane and oxygen gas from CO2 and H2O | YES | NO |
| d. A solid sublimes | YES | NO |
| e. Volume of a gas increases | YES | NO |

[6] For each of the following pairs, circle the one with the higher entropy per mole at room temp. Explain why.

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| --- | --- |
| a. Ar(*l*) or Ar(g) | b. He(g) at 3atm or He(g) at 1.5atm |

[7] Predict the sign of the entropy change of the system for each reaction. Explain why.

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| --- | --- | --- |
| a. 2SO2(g) + O2(g) → 2SO3(g) | NEGATIVE | POSITIVE |
| b. Ba(OH)2(s) → BaO(s) + H2O(g) | NEGATIVE | POSITIVE |
| c. CO(g) + 2H2(g) → CH3OH(*l*) | NEGATIVE | POSITIVE |

[8] Using S° values from Appendix Four, calculate ΔS° values for each reaction.

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| a. N2H4(g) + H2(g) → 2NH3(g) | N2H4(g) | 238.5 |
| H2(g) | 130.7 |
| NH3(g) | 192.8 |
|  |  |  |
| b. 2Al(s) + 3Cl2(g) → 2AlCl3(s) | AlCl3(s) | 109.3 |
| Cl2(g) | 223.1 |
| Al(s) | 28.3 |
|  |  |

[9] For a certain chemical reaction, ΔH° = -35.4 kJ and ΔS° = -85.5 J/K.

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| a. Is the reaction endothermic or exothermic? |  |
| b. Does the reaction lead to an increase or decrease in the disorder of the system? |  |
| c. Calculate ΔG° for the reaction at 298 K. |  |
| d. Is the reaction spontaneous at 298K under standard conditions? |  |

[10] a. Using data in Appendix Four, calculate ΔH°, ΔS°, and ΔG° at 298K for the reaction below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| H2(g) + F2(g) → 2HF(g) |  | | | ΔH° = | |
| ΔS° = | |
| ΔG° = | |
|  | **ΔS° (J/mol⋅K)** | **ΔH° (kJ/mol)** | | **ΔG° (kJ/mol)** |
| H2(g) | 130.7 | 0 | | ---- |
| F2(g) | 202.8 | 0 | | ---- |
| HF(g) | 173.8 | -273.3 | | -275.4 |
| b. Show that ΔG° = ΔH° − TΔS° | | | | | |

[11] a. Using data from Appendix four, calculate the change in Gibbs free energy for the following reaction.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2NOCl(g) → 2NO(g) + Cl2(g) |  | | | | ΔG° = | | |
|  | **ΔS° (J/mol⋅K)** | **ΔH° (kJ/mol)** | | | **ΔG° (kJ/mol)** | |
| NOCl(g) | 261.7 | 51.7 | | | 66.4 | |
| NO(g) | 210.8 | 91.3 | | | 87.6 | |
| Cl2(g) | 2231 | 0 | | | 0 | |
| b. Is the reaction spontaneous under standard conditions? Explain. | | | | YES | | | NO |

[12] A particular reaction is spontaneous at 450 K. The enthalpy change for the reaction is +34.5 kJ. What can you conclude about the sign and magnitude of ΔS for the reaction?

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