

**2<sup>nd</sup> Law of Thermodynamics – Supplemental Worksheet**

1. Consider the 2<sup>nd</sup> law of thermodynamics explain what the signs of  $\Delta S_{\text{universe}}$ .

a)  $\Delta S_{\text{universe}} \geq 0$

b)  $\Delta S_{\text{universe}} \leq 0$

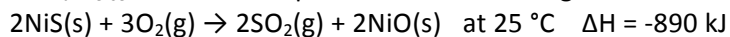
c)  $\Delta S_{\text{universe}} = 0$

2. If a system at -272 °C absorbs 545 J of heat, what is its change in entropy?

3. Consider the following reaction:  $\text{HNO}_3(\text{l}) + 1/2\text{H}_2(\text{g}) \leftrightarrow \text{H}_2\text{O}(\text{l}) + \text{NO}_2(\text{g})$  Calculate  $\Delta S^\circ_{\text{rxn}}$

	$\Delta H^\circ_f$ (kJ·mol <sup>-1</sup> )	$\Delta S^\circ_m$ (J·mol <sup>-1</sup> ·K <sup>-1</sup> )
HNO <sub>3</sub> (l)	-174.1	156
H <sub>2</sub> (g)	not provided	131
H <sub>2</sub> O(l)	-285.8	70
NO <sub>2</sub> (g)	33.2	240

4. Calculate  $\Delta S_{\text{universe}}$  after the completion of the following reaction:



Substance	$S(\text{J/Kmole})$
SO <sub>2</sub>	248
NiO	38
O <sub>2</sub>	205
NiS	53

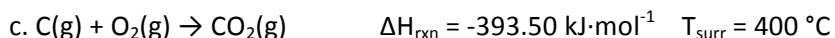
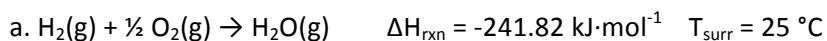
5. Determine the  $\Delta S_{\text{sys}}$  when:

$$\Delta S_{\text{universe}} = 1303 \text{ J/K}$$

$$\Delta H = -387.4 \text{ kJ}$$

$$T = 25 \text{ }^\circ\text{C}$$

6. Calculate  $\Delta S_{\text{surroundings}}$  for the reactions below based on the provided data.



7. A certain reaction (the system) is endothermic by  $45.68 \text{ kJ}\cdot\text{mol}^{-1}$  and its entropy increases by  $172.3 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$ . Calculate  $\Delta S_{\text{universe}}$ , if the surroundings are at a constant temperature of  $0 \text{ }^\circ\text{C}$ . Can the reaction occur at this temperature? If not, should we raise or lower the temperature to make it spontaneous.

8. Calculate the change in entropy that occurs when a 3.50 mol sample of water is heated from  $65^\circ$  to  $130^\circ$  at 1 atm. The molar heat capacities for  $\text{H}_2\text{O}(\text{l})$  is  $75.3 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$  and  $\text{H}_2\text{O}(\text{g})$  is  $36.4 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$ . The enthalpy of vaporization for water is  $40.7 \text{ kJ/mol}$  at  $100^\circ\text{C}$ .