1. (60 points) Choose 15 of the 17 short answer questions below. Write "SKIP" clearly next to the two which you wish to skip. For those that you answer, circle ALL correct answers

A (reversible / irreversible) process is one that proceeds by a succession of equilibrium states.

Rev

For a process that can be carried out by either a reversible or an irreversible path, the change in \( (H, P, T, V, q, E, w) \) must be the same for both paths.

P,T,V,E,H

The path which produces the lesser work is (reversible / irreversible).

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The heat needed to change the phase of a substance is typically (larger / smaller) than the heat needed to increase its temperature by 12 K.

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(\( \Delta H, \Delta S, \Delta G, \Delta E \)) implies constant temperature.

\( \Delta G \)

\( \Delta H \) equals the heat transferred to the system under constant (temperature, pressure, volume).

P

For the mixing of one gas into another (by opening a valve between containers), the entropy of the system will (increase / decrease / remain unchanged).

increase

For the mixing of octane (a nonpolar solvent) and water, the entropy of the system will (decrease / increase / remain unchanged).

decrease

An ideal gas expands adiabatically into a vacuum. \( \Delta E \) for the system is (greater than zero / equal to zero / less than zero).

Z

An ideal gas expands isothermally against an external pressure of 1 atm. \( \Delta E \) for the system is (greater than zero / equal to zero / less than zero).

Z

An ideal gas expands adiabatically against an external pressure of 1 atm. \( \Delta E \) for the system is (greater than zero / equal to zero / less than zero).

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According to the 2\textsuperscript{nd} law of thermodynamics, a spontaneous process, such as a balloon filled with a hot gas cooling to the surroundings at constant pressure, will always occur \textbf{(adiabatically, irreversibly, reversibly, without work done)}.

For the balloon above, the heat gained by the surroundings is equal to the negative of the \textbf{(internal energy change, enthalpy change, entropy change, Gibbs free energy change)} of the system.

\textbf{Enthalpy change}

To return the system (balloon, above) to its initial state requires from the surroundings an expenditure of entropy whose magnitude is \textbf{(greater than, equal to, less than)} that which is gained during the spontaneous process.

You carry out some process (on a non-gaseous sample) in a constant pressure calorimeter and measure the heat added as a function of temperature. The plot you get is shown at right.

\[ \Delta H = q_{\text{heating \ ice}} + q_{\text{melting \ ice}} + q_{\text{heating \ water}} \]

\[ \Delta H = nC_{p}^{\text{ice}}(273K - T_{i}) + n\Delta H_{\text{melting}} + nC_{p}^{\text{water \ (l)}}(T_{f} - 273K) \]

\[ \Delta H = 2\text{mol}(38.07 \text{ kJ mol}^{-1} \text{ K}^{-1})(273K - 253K) \]

\[ + 2\text{mol}(6.007 \text{ kJ mol}^{-1}) + 2\text{mol}(75.4 \text{ kJ mol}^{-1} \text{ K}^{-1})(283K - 273K) \]

\[ \Delta H = 1523 \text{ kJ} + 12.0 \text{ kJ} + 1508 \text{ kJ} = 3043 \text{ kJ} \]
b) Calculate the entropy change when two moles of H₂O (g) are cooled irreversibly at constant P from 120°C to 100°C. Consider this an ideal gas.

\[ \Delta S = nC_P \ln \frac{T_2}{T_1} \]

\[ \Delta S = (2 \text{ mol})(18.016 \text{ g mol}^{-1})(1.874 \text{ J K}^{-1} \text{ g}^{-1})\ln \frac{393K}{373K} = 3.53 \text{ J K}^{-1} \]