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**Work independently. Do not look at others' exams.
Do not allow your exam responses to be shared.**

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.

Reversible

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**).

irreversible

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.

Larger

(**ΔH , ΔS , ΔG , ΔE**) implies constant temperature.

G

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

Pressure

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. E for the system is (**greater than zero / equal to zero / less than zero**).

Zero

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

Zero

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

Less than zero

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According to the 2nd 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 (**adiabatically, irreversibly, reversibly, without work done**).

Irreversibly

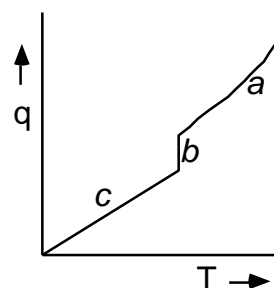
For the balloon above, the heat gained by the surroundings is equal to the negative of the (**internal energy change, enthalpy change, entropy change, Gibbs free energy change**) of the system.

Enthalpy change

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

Greater than

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.



For region (c) of the process, you can discern that the heat capacity (C_p) is (**zero / non-zero**).

zero

For region (a) of the process, you can discern that the heat capacity (C_p) is (**zero / non-zero**).

non-zero

Region (b) of the process most likely represents (**a phase change / an irreversible process / a glitch in the instrument, it can't happen**).

A phase change

2. (40 points) Answer the questions in the space provided. Show your work clearly and completely, but show only the relevant work. Use the back for scratch.

a) Calculate the enthalpy change when two moles of ice are heated from -20°C to $+10^\circ\text{C}$ at 1 atm. Show your work and break the enthalpy down into individual steps.

$$H = q_{\text{heating ice}} + q_{\text{melting ice}} + q_{\text{heating water}}$$

$$H = n\bar{C}_p^{\text{ice}}(273\text{K} - T_i) + n H_{\text{melting}} + n\bar{C}_p^{\text{water}(l)}(T_f - 273\text{K})$$

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

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

$$H = 1523 \text{ kJ} + 12.0 \text{ kJ} + 1508 \text{ kJ} = 3043 \text{ kJ}$$

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- b) Calculate the entropy change when two moles of H_2O (g) are cooled irreversibly at constant P from 120°C to 100°C . Consider this an ideal gas.

$$S = n\bar{C}_P \ln \frac{T_2}{T_1}$$

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

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