Please answer the following questions showing all equation derivations and calculations as necessary. Your answers can be in English or Turkish.

1) a) $dU = C_v dT$ is valid if the system is an ideal gas. Why?

b)Does this equation hold for a general/real gas? If so, under what conditions? (Hint: Use the equation of state relating U and T)

2) a)Draw a simple graph to illustrate how the entropy of a system changes with respect to temperature at constant pressure during a phase change from solid to liquid at the melting temperature T_m as the system temperature is increased from T_1 to T_2 where $T_1<T_m<T_2$. Explain the graph relating entropy with enthalpy and specific heat.

b)Fill in the blanks with one of the following words: remains constant, increases, decreases
Characteristics of Entropy are as follows:

1. It _____ when the heat is supplied irrespective of the fact whether temperature changes or not.
2. Whether temperature changes or not the entropy _____ when heat is rejected.
3. In all the adiabatic processes, the entropy _____.

3) Consider a recrsytallization process at constant pressure, where a pure metal is transforming naturally from an α solid phase to a β solid phase with a different crystal structure as the temperature is decreased from T_1 to T_2, where $T_1 > T_2$.

a)Draw a simple graph of this transformtion showing how the Gibbs free energy of the system changes with temperature. Indicate the driving force for this phase transformation on the graph at T

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b)Indicate what the slope of the G-T graph indicates and how it compares for the two crystal phases.

c)Would the driving force for this transformation be negative or positive? How would the entropy of the system change? (Explain using thermodynamic equations)

Take home question:

Two identical closed systems have fundamental relation $S_i = C[N_iV_iU_i]^{1/3}$. Is this compatible with axioms 2 and 3 we studied in class? Is the entropy properly extensive? What is the fundamental relation for the composite system in terms of N_i, V_i, U_i, i=1,2, with all constraints still in place?

Given that the two systems are identical, what is the fundamental relation of the closed composite system in terms of $N = N_1 + N_2$, $V = V_1 + V_2$, $U = U_1 + U_2$ once the systems are combined and any internal restraint is relaxed?

Is that entropy greater than, or equal to, the entropy before the two identical systems were combined? Which should it be based on common sense? This is the Gibbs paradox!

Comment on how it might be resolved if the systems truly are identical.