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1. (a) Prove that it is impossible for two lines representing reversible, adiabatic processes on a PV diagram to intersect. (b)Consider any two states (labelled 1 and 2), prove that if state 1 is accessible from state 2 by an irreversible adiabatic process, then state 2 is inaccessible from state 1 by same process? (c) Prove that the rate at which shaft work is obtained or required for a reversible change of state in a closed system is equal to the negative of the product of temperature and the rate of change of the entropy for the system at constant internal energy and volume. (15% total)

2. Draw a schematic phase diagram for a eutectic binary system A-B. Select two temperatures, one just above and the other just below the eutectic temperature, draw the free energy curves for these two temperatures as a function of X_B. (15 %)

3. The following data given by Dr. Xbox for the thermodynamic properties of graphite and diamond. Assuming that the entropy and densities are approximately independent of temperature and pressure, please determine the range of conditions for which diamond can be produced from graphite. (The operation proposed would be to hold the graphite at high temperatures and pressures until diamonds formed, following by rapid cooling and depressurizing procedure so that the diamonds can not revert to graphite.) (10%)

Property	**Graphite**	**Diamond**
$\underline{G}$ (T = 298 K)	0 J mol^{-1}	2900 J mol^{-1}
$\underline{S}$ (T = 298 K)	5.740 J mol^{-1} K^{-1}	2.377 J mol^{-1} K^{-1}
Density	2220 kg m^{-3}	3510 kg m^{-3}

4. A particular protein, T, also know as medical reagent, binds with human plasma albumin in the reaction T + A $\overset{k}{\longleftrightarrow}$ TA. The following measured or apparent data at 30 ℃ are available for this binding reaction, $\Delta_{bind}G$ = -35.5 kJ mol^{-1}. $\Delta_{bind}H$ = -13.8 kJ mol^{-1} and $\Delta_{bind}Cp$~0, where these apparent changes are for the following equilibrium constant: $\Delta_{bind}G = RTlnK$ where $k = \dfrac{M_{TA}}{M_T \bullet M_A}$, where M is the concentration in molality. (a) What is the entropy change for this reaction at 30℃? (b) Starting with the concentration of T protein and albumin of 0.0001M, what is the fraction of unbound (not reacted) albumn over the temperature range of 0 to 45℃? (20 %)

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5. As we know that methane gas hydrates are formed from liquid water by the following equation: $CH_4(g)+5.75H_2O(l)\rightarrow CH_4\cdot 5.75H_2O(s)$; (a) Please calculate the Gibbs energy of formation of the hydrate at 278 K and 283 K using the information that the methane partial pressure in the equilibrium with the hydrate at 278 K is 4.2 MPa and at 283 K is 6.8 MPa. (b) A common way to present hydrates from forming is by addition of an inhibitor to the system, usually methanol or salt. If 10 wt % methanol is added to water, what will be the equilibrium partial pressure for the methane for hydrate formation at 278 K and 283 K? (Assume no methanol is present in the vapour) (20%)

Component-I~Component-II	Temperature Range (℃)	α	β
Methanol-water	25	0.58	0.46
	64.6~100	0.83	0.51

6. Define and describe the following terms: (a) Thermodynamics laws; (b) Maxwell relations for thermodynamics; (c) Gibbs phase rule; (d) Mollier diagram (20% total)