Both English and Chinese are acceptable for answering these questions.

1. (20 points) (a) Consider 1 mole of ideal gas undergoes a reversible isothermal expansion from $V = 1$ liter to 2 liters. The temperature is kept at 300 K. Please calculate the change of entropy of the gas system. [10 points] (b) Now consider the same 1 mole of ideal gas undergoes an irreversible free expansion process such that the volume is changed from $V = 1$ liters to 2 liters. What is the change of entropy of the gas? [10 points]

2. (20 points) The adiabatic thermoelastic effect describes the change in temperature with pressure for a brittle solid when it is loaded rapidly. This effect can be used to measure the stress that develop around defects in materials using cyclic loading and thermal imaging. (a) Show that the variation of temperature with respect to pressure at constant entropy (adiabatic condition) is $(\partial T/\partial P)_S = T\alpha V / c_P$. [10 points] (b) For 1 mole of alumina originally at $T = 298$ K, please estimate the change in temperature when it is loaded to 500 MPa, given that $\alpha = 2.2\times10^{-5}\,\mathrm{K}^{-1}$, $c_P = 80\,\mathrm{J/mole\cdot K}$, and molar volume $2.56\times10^{-5}\,\mathrm{m^3\cdot mole^{-1}}$. [10 points]

3. (20 points) CaO and MgO form a simple eutectic system with limited ranges of solid solubility. Assuming that the solutes in the two solid solutions obey Henry's law with $\gamma^0_{\mathrm{CaO}} = 12.88$ in MgO and $\gamma^0_{\mathrm{MgO}} = 6.23$ in CaO at the eutectic temperature, calculate the solubility of CaO in MgO and the solubility of MgO in Cao at such temperature.

4. (20 points) Consider the partial decomposition of gaseous P_4: $P_{4(g)} \rightleftharpoons 2P_{2(g)}$. Please calculate (a) the temperature at which $X_{P_4} = X_{P_2} = 0.5$ at a total pressure of 1 atm [10 points] and (b) the total pressure at which $X_{P_4} = X_{P_2} = 0.5$ at 2000 K [10 points], given that $\Delta G^\circ = 225{,}400 + 7.90T\ln T - 209.4T$ J for this reaction.

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5. (20 points) From electromagnetism it has been shown that the electromagnetic pressure exerted on the walls of a container of volume V is related to the internal energy U through $P = U/3V$. With the assumption that: (1) the entropy of the system $S(U,V)$ is a state function and (2) The energy density is related to temperature through $U/V = AT^{\lambda}$ (where A and λ are constants), please show that $\lambda = 4$. (Hint: Start from the 1st law of thermodynamics and express $dU = (\partial U/\partial T)_V dT + (\partial U/\partial V)_T dV$.)

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