Question 1. *A vessel is filled completely with liquid water and sealed at* $15.0^\circ C$ *and a pressure of 1.00 bar. What is the pressure if the temperature of the system is raised to* $75.5^\circ C$*? Under these conditions,* $\alpha_{water} = 2.04 \times 10^{-4}$ *1/K,* $\alpha_{vessel} = 1.42 \times 10^{-4}$ *1/K, and* $\kappa_T = 4.59 \times 10^{-5}$ *1/bar.*

Question 2. *Let* $f(x, y) = xy \sin 5x + x^2\sqrt{y} \ln y + 3e^{-2x^2} \cos y$*. Determine*

(a) $\frac{\partial f}{\partial x}$ *(c)* $\frac{\partial^2 f}{\partial x^2}$ *(e)* $\frac{\partial^2 f}{\partial y \partial x}$

(b) $\frac{\partial f}{\partial y}$ *(d)* $\frac{\partial^2 f}{\partial y^2}$ *(f)* $\frac{\partial^2 f}{\partial x \partial y}$

Obtain an expression for the exact differential df*.*

Question 3. *A mass of 25.0 g of* $H_2O_{(s)}$ *at 273 K is dropped into 130 g of* $H_2O_{(\ell)}$ *at 298 K in an insulated container at 1 bar of pressure. Calculate the temperature of the system once equilibrium has been reached. Assume that* $C_{P,m}$ *for* H_2O *is constant at its values for 298 K throughout the temperature range of interest.*

Question 4. *A 62.5-g piece of gold at 650 K is dropped into 165 g of* $H_2O_{(\ell)}$ *in an insulated container at 1 bar pressure. Calculate the temperature of the system once equilibrium has been reached. Assume that* $C_{P,m}$ *for Au and* H_2O *are constant at their values for 298 K throughout the temperature range of interest.*

Question 5. *Calculate* W*,* q*,* ΔH *and* ΔU *for the process in which 2.50 mol of water undergoes the transition*

$$\mathrm{H_2O_{(\ell, 373\ K)}} \rightarrow \mathrm{H_2O_{(g, 610\ K)}}$$

at 1 bar of pressure. The volume of the liquid water at 373 K is 1.89×10^{-5} m^3/mol *and the volume of steam is 373 K and 610 K is 3.03 and* 5.06×10^{-2} m^3/mol*, respectively. For steam,* $C_{P,m}$ *can be considered constant over temperature interval of interest at 33.58 J/mol K.*

Question 6. *The molar heat capacity* $C_{P,m}$ *of* $SO_{2(g)}$ *is described by the following equation over the range* $300\ K < T < 1700\ K$*:*

$$\frac{C_{P,m}}{R} = 3.093 + 6.967 \times 10^{-3}\frac{T}{K} - 45.81 \times 10^{-7}\frac{T^2}{K^2} + 1.035 \times 10^{-9}\frac{T^3}{K^3}$$

In this equation, T *is the absolute temperature in Kelvin. The ratios* T^n/K^n *ensure that* $C_{P,m}$ *has the correct dimension. Assuming ideal gas behavior, calculate* q*,* W*,* ΔU *and* ΔH *if 2.25 mol of* $SO_{2(g)}$ *are heated from* $10.0^\circ C$ *to* $1250^\circ C$ *at a constant pressure of 1 bar. Explain the sign of* W*.*

Question 7. *For a gas that obeys the equation of state*

$$V_m = \frac{RT}{P} + B(T)$$

derive the result

$$\frac{\partial H}{\partial P} = B(T) - T\frac{dB}{dT}$$

