Answer 5 items for full 100 points. The 6th correct answer will be considered a 20 point bonus.

1. For a real gas that obeys a virial equation given by: \( \left( \frac{P_v}{RT} \right) = 1 + Bv + Cv^2 + Dv^3 \), then
   a. \( \left( \frac{\partial P}{\partial T} \right)_v = \frac{p}{T} \)
   b. \( \left( \frac{\partial P}{\partial T} \right)_v = \frac{T}{P} \)
   c. \( \left( \frac{\partial P}{\partial T} \right)_v = \frac{R}{v} \)
   d. \( \left( \frac{\partial P}{\partial T} \right)_v = R(1 + Bv + Cv^2 + Dv^3) \)
   e. None of the above

2. Which of the following is an equality?
   a. \( \left( \frac{\partial P}{\partial T} \right)_p \left( \frac{\partial P}{\partial v} \right)_T \left( \frac{\partial T}{\partial P} \right)_v = -1 \)
   b. \( \left( \frac{\partial P}{\partial v} \right)_T \left( \frac{\partial T}{\partial P} \right)_v = \left( \frac{\partial T}{\partial P} \right)_p \)
   c. \( \left( \frac{\partial P}{\partial v} \right)_T = - \left( \frac{\partial T}{\partial P} \right)_v \left( \frac{\partial T}{\partial v} \right)_p \)
   d. \( 1 + \left( \frac{\partial P}{\partial v} \right)_T \left( \frac{\partial v}{\partial T} \right)_S \left( \frac{\partial T}{\partial P} \right)_v = 0 \)
   e. None of the above

3. For a real gas, the partial derivative \( \left( \frac{\partial h}{\partial v} \right)_s \) is given by
   a. \( \left( \frac{\partial h}{\partial v} \right)_s = \frac{\beta c_p}{k c_v} v \)
   b. \( \left( \frac{\partial h}{\partial v} \right)_s = -v \frac{c_p}{c_v} \left( \frac{\partial P}{\partial T} \right)_v \left( \frac{\partial T}{\partial P} \right)_p \)
   c. \( \left( \frac{\partial h}{\partial v} \right)_s = -T \frac{c_p}{c_v} \left( \frac{\partial P}{\partial T} \right)_v \left( \frac{\partial T}{\partial P} \right)_p \)
   d. \( \left( \frac{\partial h}{\partial v} \right)_s = \frac{\beta c_p}{k c_v} T \)
   e. None of the above
4. Let $a$ and $g$ be the Helmholtz and Gibbs energy, respectively, then
   a. $\left( \frac{\partial(g-a)}{\partial P} \right)_v = T$
   b. $\left( \frac{\partial(g-a)}{\partial P} \right)_v = P$
   c. $\left( \frac{\partial(g-a)}{\partial P} \right)_v = v$
   d. $\left( \frac{\partial(g-a)}{\partial P} \right)_v = 0$
   e. None of the above

5. Let $\omega = \left( \frac{\partial v}{\partial P} \right)_T / \left( \frac{\partial v}{\partial T} \right)_p$ be ratio of isothermal compressibility to the thermal expansion coefficient. Then, for a gas obeying the Van der Waals’ equation

   $$P = \frac{RT}{\nu - b} - \frac{a}{\nu^2}$$

   a. $\omega = \left( \frac{\partial T}{\partial P} \right)_v$
   b. $\omega = \frac{b - \nu}{R}$
   c. $\omega = a \frac{R}{\nu^2}$
   d. $\omega = -1$
   e. None of the above

6. Consider a steam power plant undergoing an ideal Rankine cycle and producing a net power of $5 \text{ MW}$, then the rate of heat removal in the condenser, $Q_c$, corresponding to a Rankine cycle efficiency of $10\%$ is closest to

   a. $Q_c = 15 \text{ MW}$
   b. $Q_c = 25 \text{ MW}$
   c. $Q_c = 35 \text{ MW}$
   d. $Q_c = 45 \text{ MW}$
   e. $Q_c = 55 \text{ MW}$