Name:_____

ChBE 2130 Thermodynamics I
Fall 2015
Exam 3

Remember

- Write down relevant relationships needed to solve each problem
- Provide details, intermediate steps, and units
- Note any assumptions
- Show your work
- Where indicated, place your final answer on the **_____**
- **Submit your crib sheet with your exam.**

Problem	Possible Points	Score
1	20	
2	20	
3	20	
4	40	
Total		

1. Concept Questions **[20 pts: 5 points each,** no partial credit within sub-problem**]**

- For an ideal gas, simplify the equation, $V - T\left(\frac{\partial V}{\partial T}\right)_P$
  a. V
  b. R/P
  c. RT/P
  d. 0

- Using the differential form of enthalpy as a basis, simplify $\left(\frac{\partial H}{\partial S}\right)_P$
  a. P
  b. T
  c. U
  d. 0

- A gas is flowing in an insulated duct of constant cross sectional area at stable conditions. Compared to the inlet conditions, the outlet will have

  a. Lower pressure and higher velocity
  b. Higher pressure and higher velocity
  c. Lower pressure and lower velocity
  d. Higher pressure and lower velocity

- A saturated liquid at moderate temperature and pressure enter a throttle valve where the pressure is reduced by half. The existing stream will consist of which of the following
  a. Subcooled liquid
  b. Saturated liquid
  c. Mixed phase – gas and liquid
  d. Saturated gas

2. **[20 pts]** The behavior of a fluid is described by the following equation of state: $V = B + \left({}^{RT}/_{P}\right)$ where B is a constant. Develop a simplified expression for the residual enthalpy, H^R. Show intermediate steps for full credit.

3. **[20 pts]** In terms of experimentally measurable properties, $\left(\frac{\partial T}{\partial V}\right)_S$ equals which of the following? Show your calculations and substitutions for full credit. Hint: Start with the cyclic relationship for $\left(\frac{\partial T}{\partial V}\right)_S$.

   a. $-\left({}^{T}/_{C_V}\right)\left({}^{\beta}/_{\kappa}\right)$
   b. $-\left({}^{T}/_{C_V}\right)\left({}^{1}/_{\beta V}\right)$
   c. $\left({}^{C_P}/_{T}\right)\left({}^{1}/_{\beta V}\right)$
   d. $\left({}^{C_p}/_{T}\right)\left({}^{\beta}/_{\kappa}\right)$

4. **[40 pts]** Steam enters a turbine at 2000 kPa and 500°C. The exhaust is at 20 kPa.
    a. If the turbine operates isentropically, what is the outlet phase and/or quality and the enthalpy?

Phase/Quality_____

Outlet Enthalpy_____

    b. If work is produced at a rate of 2500 kW and the exhaust is saturated vapor, what is the outlet enthalpy, mass flow rate, and turbine efficiency? Note that a kW = kJ/s

Outlet Enthalpy_____

Mass Flow Rate (in kg/s)_____

Efficiency_____