

NAME: _____

ChBE 2130 Thermodynamics I
Fall 2015
Exam 1

Remember

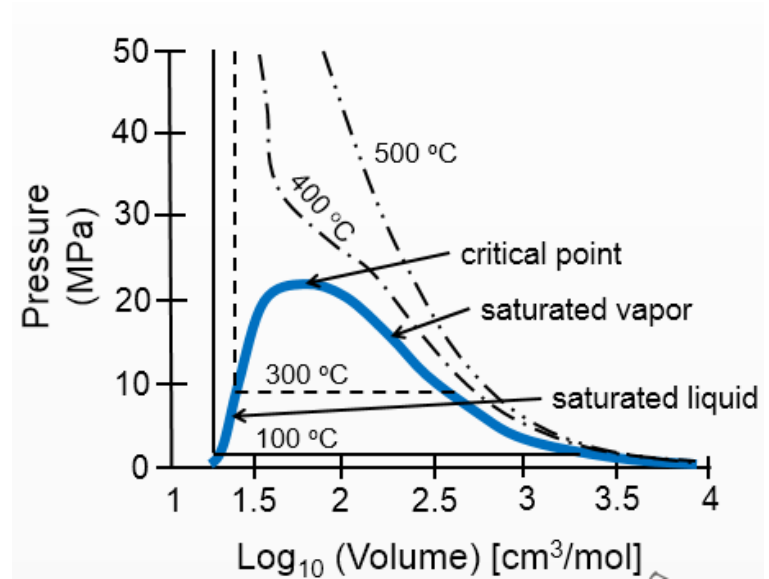
- Write down relevant relationships needed to solve each problem
- Provide details, intermediate steps, and units
- Note any assumptions
- Show your work
- Where indicated, place your final answer on the _____
- **Submit your crib sheet with your exam.**

| Problem | Possible Points | Score |
|------------|-----------------|-------|
| 1 | 20 | |
| 2 | 28 | |
| 3 | 28 | |
| 4 | 24 | |
| Crib Sheet | Yes No (-5) | |
| Total | 100 | |

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

- From diagram, what is the condition of water at 370 K and 15 MPa?
 - Vapor
 - Liquid
 - Mixed Phase
 - Supercritical

- From diagram, what is the approx. temperature in a 500 cm³ vessel containing 5 mole of water at 9 MPa?
 - 100° C
 - 200° C
 - 300° C
 - 400° C



- Water is in vapor-liquid (mixed) equilibrium in a fixed pressure container. Heat is added until the temperature increases by 5°C. How does the phase change?
 - Some vapor is condensed
 - All vapor is condensed
 - Some liquid evaporates
 - All liquid evaporates
- A gas undergoes reversible expansion from 40 bar and 500 K to 5 bar and 500 K by one of two pathways. Which process creates more work?
 - A constant pressure process to the final volume and then constant volume process to 5 bar.
 - A constant volume process to 5 bar and then constant pressure to the final volume.
 - Same work for both

2. **[28 pts]** Consider an isothermal, mechanically reversible compression of a fluid from V_1 to V_2 . Develop the equation for heat (in terms of V_1 and V_2) using the van der Waals equation of state:

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

Assume that the coefficients, a and b , are constant and the internal energy is only a function of temperature.

Show intermediate steps for complete credit.

3. An ideal gas undergoes the following cyclic process in a closed system:

- Initially at 30°C and 100 kPa (state 1)
- Adiabatically compressed to 500 kPa (state 2)
- Cooled at constant pressure to 30°C (state 3)
- Expanded isothermally to the original state

The process steps are mechanically reversible. $C_p = (7/2) R$ and $C_v = (5/2) R$

a. **[12 pts]** Complete the following table:

| State | T (K) | P (kPa) |
|-------|-------|---------|
| 1 | | |
| 2 | | |
| 3 | | |

b. **[16 pts]** Determine W for each step and the total W for one process cycle

| Step | W (J/mol) |
|-------|-----------|
| 12 | |
| 23 | |
| 31 | |
| Total | |

4. Five mol/s of water enter a boiler at 1 atm and 25°C and exit at 130°C and 1 atm. At 1 atm, the heat of fusion at 0°C is 6.02 kJ/mol and the heat of vaporization at 100°C is 40.6 kJ/mol.

a. **[2 pts]** What is the phase of the inlet stream?

b. **[2 pts]** What is the phase of the outlet stream?

c. **[20 pts]** How much heat is required in kJ/s to be added to the boiler?
