

## Chapter 1 Learning Objective Checklist

Be sure to review the margin notes and boxed comments for major concepts. Also read the chapter summary.

After studying this chapter you should be able to:

- Apply the following terms:
  - sink/reservoir
  - absolute temperature
  - open/closed system
  - intensive/extensive property
  - phase rule
  - saturation temperature/pressure
  - bubble/dew conditions
  - superheated
  - subcooled
  - compressed liquid
  - critical point, critical T, critical P
  - quality
- Explain the relationship of incompressible behavior and the shape of the P-V isotherms for liquids.
- Apply single and double interpolation using steam tables given: (1) P,T; (2) P,H.
- Locate the correct steam tables for interpolation, including interpolation between saturation tables and superheated tables if necessary.
- Computationally relate quality to overall molar or specific properties.
- Sketch the following pathways in a PV diagram in the vicinity of the phase envelope: isotherm, isobar, isochore.

## Chapter 2 Learning Objective Checklist

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- Show with equations how  $PV\dot{m}$  relates to flow work.
- Explain in words why enthalpy is a convenient property to define and tabulate.
- Explain the importance of assuming reversibility in making engineering calculations of work.
- Calculate work and heat flow for an ideal gas along the following pathways: isotherm, isochore, adiabat.
- Simplify the general energy balance for problems similar to the homework problems, textbook examples, and practice problems.
- Rapidly estimate the enthalpy of compressed liquid using saturated liquid properties and Eqn 2.32.

- ❑ Properly use heat capacity polynomials to calculate changes in U, H for ideal gases and condensed phases.
- ❑ Properly use latent heats to include phase transitions into  $\Delta U$  and  $\Delta H$  calculations.
- ❑ Calculate ig or liq properties relative to an ideal gas or liquid reference state, using the ig gas law for the vapor phase properties.
- ❑ Rapidly simplify the energy balance to arrive at the balances for the process equipment in section 2.12.
- ❑ Properly apply the strategy of 2.13 to problems similar to the homework problems and practice problems. (not including unsteady-state open systems).
- ❑ Use the energy balance for solving closed system problems, and open, steady-state problems.

#### Advanced Level

- ❑ Write, simplify, rearrange, solve (including integration) unsteady-state open system problems.

### Chapter 3 Learning Objective Checklist

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- ❑ Apply Eqn 3.4 and 3.2 for determining configurational entropy for particles in boxes at constant energy.
- ❑ Apply Stirling's approximation to the above calculations when N is large.
- ❑ Explain in words why entropy increases when different species mix.
- ❑ Relate in words entropy generation to the reversibility/feasibility of a process.
- ❑ Calculate entropy changes using polynomial heat capacities or constant heat capacities along the following pathways for an ideal gas or a liquid: isotherm, isobar, adiabat, phase transition.
- ❑ Apply Eqn. 3.23 for state changes of ideal gases.
- ❑ Recognize temperature derivatives of entropy at constant V or P as related to heat capacities.
- ❑ Simplify the entropy balance for a heat engine and combine with the energy balance to follow the steps of the derivation of thermal efficiency. (Also for heat pump).
- ❑ Apply turbine and compressor efficiency without confusing them with each other or with thermal efficiency.
- ❑ Simplify the S-balance for a steady-state reversible adiabatic turbine, compressor, pump.
- ❑ Explain in words why a standard heat exchanger cannot be reversible.
- ❑ Explain in words why a throttle valve cannot be reversible.
- ❑ Sketch a T-S schematic including the phase envelope and isobars.
- ❑ Be able to read a T-S diagram.
- ❑ Sketch a P-H schematic including the phase envelope, isentropes and isotherms, and lines of constant quality.
- ❑ Be able to read a P-H diagram.

- Apply single and double interpolation using steam tables given: (1) P,S.
- Locate the correct steam tables for interpolation, including interpolation between saturation tables and superheated tables if necessary.
- Given  $T_{in}$ ,  $P_{in}$  calculate reversible and actual outlet states (when given efficiency) for the following cases:
 

| <u>Reversible Outlet</u> | <u>Actual Outlet</u> |
|--------------------------|----------------------|
| superheated              | superheated          |
| wet steam                | superheated          |
| wet steam                | wet steam            |
- Avoid using quality,  $q$ , for calculating superheated states.
- Use actual turbine outlet states to determine the efficiency of a turbine.
- For multistage turbines and compressors, properly calculate intermediate entropy, enthalpy when given stage efficiencies.
- Be able to use a P-H charts for finding: (1) reversible outlets for adiabatic turbines and compressors; (2) outlets from throttle valves in the one and two-phase regions.
- Be able to correct reversible outlets for efficiency and plot the actual outlet states on P-H charts.
- Combine the energy and entropy balances for solving closed system problems, and open, steady-state problems.

#### Advanced Level

- Write, simplify, rearrange, solve (including integration) unsteady-state open system problems, combining the entropy and energy balances.

### Chapter 4 Learning Objective Checklist

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Recognize that Chapter 4 simply combines the principles from Chapters 1-3 into process cycles. There is a little more terminology introduced to describe the cycles or equipment configurations.

- Explain why a Carnot cycle is not practical for large-scale industrial application.
- Sketch a process flow diagram and T-S diagram for the Rankine cycle.
- Recognize that the outlet from a power plant boiler is always superheated.
- Recognize first order assumptions used in process design for process streams including: (1) boiler/evaporator outlets are assumed to be saturated except for power plant boilers or unless otherwise specified; (2) condenser outlets are considered to be saturated liquids; (3) flash drum/economizer outlets are considered to be saturated liquid and saturated vapor.
- Write energy balances around multiple pieces of equipment using correct notation including mass flowrates.
- Simplify energy balances by recognizing when streams have the same properties (e.g. splitter) or flowrates (heat exchanger inlet/outlet).

- ❑ Be able to apply the correct strategy for working through a power cycle with multiple feedwater preheaters.
- ❑ For ordinary vapor compression cycles, be able to locate condenser P/T given one or the other and plot the process outlet.
- ❑ For ordinary vapor compression cycles, be able to locate evaporator P/T given one or the other and plot the process outlet.
- ❑ Plot the behavior of a throttle valve on a P,H diagram.
- ❑ Properly identify the number of operating pressures in a complex flow system such as Fig 4.5, 4.7, 4.8, 4.11, 4.12, 4.13, 4.14, 4.15.
- ❑ Properly write the energy balance around process equipment for problems that you haven't seen before by recognizing the process equipment inside the system boundary.
- ❑ Successfully approach complex processes by simplifying the E-balance and using the principles from chapters 1-3 to solve for unknowns.