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 between temperature and kinetic energy.
- ❑ Compare the kinetic energy of liquids and gases at the same temperature.
- ❑ Explain the relationship between molecular 'stickiness' and the pair potential.
- ❑ Explain internal energy.
- ❑ 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 2.39 and as shown in Example 2.6.
- 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 ΔU and ΔH 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 2.13.
- Properly apply the strategy of Section 2.14 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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- Understand the steps of the Carnot engine and Carnot heat pump.
- Utilize thermal efficiency and COP.
- Understand the sections of a distillation column and concept of constant molar overflow. Show proficiency at material and energy balances for a distillation column using constant molar overflow.
- write the mole balances using ξ for a given feed properly using the stoichiometric numbers for single and multiple reactions.
- write the mole fractions using ξ for single and multiple reactions.
- find ΔH^o_{298} for a given reaction.
- set up the energy balance for a given feed and conversion, testing for closure or solving for Q, using either the Heat of Reaction method or the Heat of Formation method.
- Properly use pathways for different reference states.

Chapter 4 Learning Objective Checklist

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

- ❑ Apply Eqn 4.2 and 4.4 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.
- ❑ Calculate entropy of mixing.
- ❑ 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.
- ❑ Relate the entropy for phase change to the enthalpy for phase change.
- ❑ Apply Eqn. 4.28 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 Tin, Pin calculate reversible and actual outlet states (when given efficiency) for the following cases:

Reversible Outlet	Actual Outlet
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 5 Learning Objective Checklist

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

Recognize that Chapter 5 simply combines the principles from Chapters 1-4 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 5.5 - 5.7, 5.10 - 5.13, Brayton cycle.
- ❑ 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 1-4 to solve for unknowns.