

Note: items marked with \* you should be able to perform on a closed book exam.

## Chapter 6 Learning Objective Checklist

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

Sections 6.1-6.2

After studying this chapter you should be able to:

- reproduce the Legendre transformation of  $dU$  into  $dH$ ,  $dA$ ,  $dG$  given  $dU$  and the definition of  $H$ ,  $A$ ,  $G$ .\*
- recognize when a function is written in terms of its 'natural' variables.\*
- describe what is meant by a 'measurable property'.\*
- apply Equations 6.11 – 6.17 to arbitrary functions.
- Write equation 6.14 where  $F = \{U, H, A, G, S\}$  and  $x, y = \{T, P, V, S\}$ . (Note:  $S$  would only appear as  $F$  or  $x$  or  $y$ ).
- derive Maxwell relations starting with Eqn 6.4-6.7, or extend the principle to other exact functions.
- use Maxwell relations to interchange derivatives.
- manipulate partial derivatives using two to three steps of manipulations to put in terms of measurable properties.
- substitute  $C_p$  and  $C_v$  for the appropriate temperature derivatives of entropy.
- prove using equations that  $U$  and  $H$  are functions of only  $T$  for an ideal gas.

### Advanced Level

- manipulate partial derivatives using five to six steps of manipulations to put in terms of measurable properties.
- use the Jacobian method to express a partial derivative with specified independent variables.

## Chapter 7 Learning Objective Checklist

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

Sections 7.1-7.9, 7.11

After studying this chapter you should be able to:

- Calculate reduced properties.\*
- Convert  $P^{sat}$  data to/from  $P_r^{sat}$ ,  $T_r^{sat}$  coordinates.\*
- explain why the use of  $Z$  is a convenient method for summarizing PVT properties.\*

- explain the role of the acentric factor in improving the representation of PVT properties.\*
- use the generalized compressibility factor charts to calculate molar volume at a given T, P by looking up  $T_c$ ,  $P_c$ ,  $\omega$ .
- use the generalized second virial coefficient correlation to calculate molar volume at a given T, P by looking up  $T_c$ ,  $P_c$ ,  $\omega$ .
- calculate cubic equation of state parameters at a given T, P by looking up  $T_c$ ,  $P_c$ ,  $\omega$ .
- rearrange a cubic equation into a dimensionless cubic equation in Z by introducing dimensionless forms of  $a$  and  $b$ , e.g.  $A = aP/(RT)^2$  and  $B = bP/RT$ .\*
- find the fourth property from the set {Z,P,V,T} given three.\*
- determine which cubic root is most stable given program output.\*
- evaluate partial derivatives (like those from chapter 6) using an equation of state to represent PVT properties. (remember Peng-Robinson  $a = f(T)$ ).

#### Advanced Level

- sketch the radial distribution function for various densities of spheres.\*
- calculate the second virial coefficient for a square well fluid given the pair potential parameters.
- sketch the radial distribution function at low density given an expression for the pair potential.
- derive an equation of state for a square well fluid with a given radial distribution function.
- Identify the repulsive and attractive contributions to an equation of state and critically evaluate their accuracy relative to molecular simulations and experimental data.

#### Chapter 8 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 (note: for closed book problems you are not expected to have memorized the departure integrals!):

#### Sections 8.1-8.10

- explain why use of departure functions is preferred over calculating the effect of P, T changes directly for real fluids.\*
- explain using a sketch the difference between  $(M - M^{ig})$  and  $(M - M^{ig})_{TV}$ .\*
- choose between using the integrals in section 8.5 or 8.6 for a given equation of state.\*
- evaluate the integrals of section 8.5 or 8.6 for simple equations of state.\*
- combine departure functions with ideal gas calculations to determine numerical values of changes in state properties.\*

- define and use a reference state to calculate values for U, H, S using departure functions.
- use the results of the solution of a cubic equation of state (Z, A, B values) to calculate the departure functions given the integrated form.
- solve process thermodynamics problems using a tool like PREOS.m or PREOS.xls rather than a chart or table. This skill requires integration of several concepts covered by other topical objectives including selection of the correct root, reading of the output screen as used in homework problems.\*

### Chapter 9 Learning Objective Checklist

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

Sections 9.1-9.13

After studying this chapter you should be able to:

- explain why the Clapeyron equation is more broadly applicable than the Clausius-Clapeyron equation.
- use the Clapeyron and Clausius-Clapeyron to calculate thermodynamic properties from limited data.
- explain the origin of the shortcut vapor pressure equation and its limitations.\*
- use the Antoine equation to calculate saturation temperature or saturation pressure.\*
- describe in words the relationship between the Gibbs departure and the fugacity.\*
- given the pressure, give the value of fugacity for an ideal gas, including units.\*
- calculate the fugacity if given the fugacity coefficient and the pressure.\*
- calculate the fugacity of a pure vapor or liquid using the virial correlation.
- calculate the fugacity coefficient of a vapor or liquid given an expression for a cubic equation of state and the parameter values Z, A, B, and decide which root among multiple roots is most stable.
- estimate the fugacity of a liquid or solid if given the vapor pressure.\*
- interpret equation of state results at saturation and apply the lever rule to properties like enthalpy, internal energy, entropy for a two-phase mixture.\*
- solve throttling, compressor, and turbine expander problems using a cubic equation of state for thermodynamic properties rather than a chart or table.\*