rigorously tested against known properties of the fluid. Only then may it be trusted to provide accurate results.

7.8 Problems

Problem 7.1: A pure fluid is described by the Antoine equation

$$\log_{10} P^{\mathrm{sat}} = 4.00266 - \frac{1171.53}{-48.784 + T}$$

The molecular weight is 78 g/mol.

with P in bar and T in kelvin. ~~The density of the liquid at room temperature is 0.656 g/cm^3~~. How much heat is required to evaporate 1 kg of that liquid at 25 °C?

Problem 7.2: Use the steam tables to obtain the fugacity coefficient and ideal Gibbs free energy of steam at 200 bar, 500 °C.

Problem 7.3: a) Calculate the chemical potential of solid acetylene at its triple point. The reference state is the saturated liquid at the triple point.
b) Calculate the change in the chemical potential of the vapor when the pressure is reduced from 1.3 atm to 0.1 atm at the constant temperature of −84 °C.
c) State and justify your assumptions.
Additional data at the triple point: $T_{\mathrm{triple}} = -84$ °C, $P_{\mathrm{triple}} = 1.3$ atm, $V^{\mathrm{solid}} = 34$ cm^3/mol, $V^{\mathrm{liq}} = 42.7$ cm^3/mol, $V^{\mathrm{vap}} = 12020$ cm^3/mol.

Problem 7.4: ~~Use the Pitzer equation and ϕ charts or tables to do the following:~~
a) Estimate the fugacity of CO_2 ice (dry ice) at its triple point (216.55 K, 5.17 bar).
b) Calculate the fugacity of CO_2 ice at 216.55 K, 70 bar.
Additional information: density of dry ice: 97.5189 lb/ft^3.

Problem 7.5: Use the Lee-Kesler tables to calculate the chemical potential of benzene at the following states:
a) critical point.
b) saturated liquid at 200 °C.
c) 200 °C, 45 bar.
Additional data: The reference state is the ideal gas at 562.1 K, 48.9 bar. The saturation pressure at 200 °C is 14.3 bar.

Problem 7.6: Calculate the chemical potential of benzene at the following states:
a) critical point.
b) saturated liquid benzene at 200 °C.
c) benzene at 200 °C, 45 bar.
Additional data: The reference state is the ideal gas at 562.1 K, 48.9 bar. The saturation pressure at 200 °C is 14.3 bar.

Kesler

Problem 7.7: Use the Pitzer correlation and the Lee-Weser ϕ tables to calculate the fugacity of ethane at the following states:
a) 1 bar, 40 °C.
b) 50 bar, −70 °C.

Problem 7.8: A fluid that is gas under ambient conditions is stored in a 2 m^3 tank. The amount of the gas in the tank is 150 mol. Estimate the fugacity of the gas. State your assumptions clearly.

Problem 7.9: Over a limited range of pressures, an unspecified gas obeys this equation of state,

$$\left(P - \frac{a}{V^2}\right) V = RT,$$

where a is constant.
a) Derive an expression for the fugacity coefficient.
b) At 30 °C, 1 bar, the compressibility factor of this gas is 0.88. Estimate its fugacity.
c) Calculate the residual Gibbs energy of the gas at 30 °C 1 bar.

Problem 7.10: The attached table from Perry's *Handbook* gives some properties of argon. Using data from this table estimate the following:
a) The fugacity at 300 K, 1 atm (state A).
b) The fugacity of the saturated liquid at 90 K (state B).
c) The ideal-gas Gibbs energy, G^{ig}, of the saturated liquid at 90 K.
d) The fugacity at 50 atm, 90 K (state C).
e) Draw a qualitative PV graph and show the states A, B, and C of the previous parts.

S_V (change subscript to V)

T (K)	P (atm)	ρ_L (mol/L)	ρ_V (mol/L)	H_L (J/mol)	H_V (J/mol)	S_L (J/mol K)	S_L (J/mol K)
90	1.321	34.47	0.1864	3099	9481	56.02	126.93

At atmospheric pressure and 300 K, the properties of argon are $\rho = 0.0406$ mol/L, $H = 13919$ J/mol, $S = 154.82$ J/mol K. (see Perry and Chilton, *Chemical Engineers' Handbook* 5th ed. (New York: McGraw-Hill, 1973), p. 3-159.)

Problem 7.11: Use the tabulated properties of Br in the table below to do the following:
a) Fugacity at 1 bar, 300 K.
b) Fugacity coefficient of saturated liquid bromine at 1 bar.
c) Fugacity and fugacity coefficient at 150 bar, 300 K.
Note: You may not use generalized correlations for this problem. Use only data given here and make any assumptions you deem appropriate or necessary.