ENGG 201 Winter 2013 – Volumetric Behaviour of Liquids Problem Set

Problem #1 – Winter 2012 Midterm 2

Use the data at the end of this exam (Table 7-1 and Table 7-2) to answer the following questions about liquid carbon tetrachloride (M=153.8 kg/kmol, T_c=556.4K, P_c=4493 kPa).

a) Calculate the volume occupied by 5 kg of carbon tetrachloride at 35°C and 1 atm using the data in Table 7-2. (/6)
b) Estimate the average isobaric coefficient of volume expansion for carbon tetrachloride between 35°C and 55°C at 1 atm. (/5)
c) Using Tait's law, calculate the volume occupied by 5 kg of carbon tetrachloride at 35°C and 200 atm. (/7) (use c and d from solution)
d) Use the Generalized Compressibility chart to estimate the molar volume of carbon tetrachloride at 35°C and 1347 kPa. (/4)

Answers: a) $3.2x10^{-3}m^3$; b) $1.2925x10^{-3}K^{-1}$; c) c=0.10384, d=856.6 atm, $3.125x10^{-3}m^3$; d) 0.095 m^3/kmol

Problem #2 – Winter 2011 Quiz 4

The critical pressure of hexane is 3020 kPa and the critical temperature is 234.5°C. Use this information and the generalized compressibility chart to estimate the volume of 2 kmol of liquid hexane at 1420 kPa and 183.75°C. (/2)

Answer: 0.4815 m^3

Problem #3 – Winter 2008 Quiz 4

Calculate the specific volume of carbon tetrachloride at 25°C and 400 atm using the information in Table 7-1. The specific volume of carbon tetrachloride at 25°C and 1atm is $6.312x10^{-4}$ m^3/kg.*(/3)*

Answer: c=0.1066, d=985.14 atm, $6.0827x10^{-4}m^3$/kg

Problem #4 – Winter 2005 Quiz 4

The isothermal compressibility of carbon tetrachloride (M=153.8 kg/kmol) at 35°C and 1 atm is $11.95x10^{-10}m^2$/N, and at 35°C and 1000 atm is 5.52 $x10^{-10}m^2$/N. Use the data to calculate the specific volume of liquid carbon tetrachloride at 700 atm and 35°C, given that the specific volume of liquid carbon tetrachloride at 1 atm and 35°C is $6.39x10^{-4}$ m^3/kg. (*3 Marks*).

Answer: c=0.1039, d=857.7 atm, $5.994x10^{-4}m^3$/kg

Volumetric Behaviour of Liquids

$$\beta_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T \qquad \alpha_P = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \qquad \gamma_V = \frac{1}{P}\left(\frac{\partial P}{\partial T}\right)_V$$

$$V_T = V_{T_o}\left(1 + A\theta + B\theta^2 + C\theta^3\right)$$

Tait's Equation

$$\beta_T = \frac{c}{P+d} \qquad \frac{V_o - V}{V_o} = c\ln\left[\frac{P+d}{d}\right]$$

Table 7-1 Isothermal Compressibilities of Selected Liquids

Liquid	Temperature °C	$\beta \times 10^{10}$, m²/N 1 atm	1000 atm
Benzene	25	9.67	5.07
	35	10.43	5.28
	45	11.32	5.50
	55	12.29	5.73
	65	13.39	5.98
Carbon-tetrachloride	25	10.67	5.30
	35	11.95	5.52
	45	12.54	5.75
	55	13.63	5.97
	65	14.87	6.22
n Hexane	0	13.04	5.92
	25	16.06	6.51
	40	18.31	6.89
	60	21.93	8.87
Mercury	20	0.40	0.39
Water	25	4.57	3.46
	35	4.48	3.42
	45	4.44	3.40
	55	4.44	3.42
	65	4.48	3.47

Table 7-2 Coefficients of Cubical Expansion of Liquids at 1 atm, $T_o = 0°C$

	$A \times 10^3$	$B \times 10^6$	$C \times 10^8$	$V_{T_o} \times 10^3$ m³/kg
Acetone	1.324	3.809	−0.87983	1.230
Benzene	1.17626	1.27755	0.80648	1.1109
Carbon-tetrachloride	1.18384	0.89881	1.35135	0.6126
Mercury	0.18169	0.00295	0.01146	0.07356
Water	−0.05325	7.6153	−4.3722	1.00013
n - Pentane	1.50697	3.435	0.975	1.549