Solutions Manual for

Applied Petroleum Reservoir Engineering

Third Edition

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CHAPTER 2

2.1 using Equation 2.4: pV = nRT

(a) $V = \frac{1(10.73)(60+460)}{14.7} = 379.6\ \text{SCF}$

(b) $V = \frac{1(10.73)(32+460)}{14.7} = 359.1\ \text{SCF}$

(c) $V = \frac{1(10.73)(80+460)}{14.7+10/16} = 378.1\ \text{SCF}$

(d) $V = \frac{1(10.73)(60+460)}{15.025} = 371.4\ \text{SCF}$

2.2 (a) number of moles of methane = 10/16 = .625 moles

number of moles of ethane = 20/30 = .667 moles

total number of moles = .625 + .667 = 1.292 moles

(b) from Equation 2.4

$$p = \frac{1.292(10.73)(550)}{500} = 15.25\ \text{psia}$$

(c) $\text{molecular wt. of mixture} = \frac{\text{wt. of mixture}}{\text{moles of mixture}} = \frac{10+20}{1.292} = 23.22\ \text{lb/lb-mole}$

(d) using Equation 2.6

$$\gamma_g = \frac{23.22}{28.97} = 0.802$$

2.3 using a basis of one mole of gas mixture

Component	Vol. Fraction	Moles	Mol. Wt.	Weight. lb.
Methane	.333	.333	16	5.33
Ethane	.333	.333	30	10.00
Propane	.333	.333	44	14.67
			Total weight	30.00

$\text{molecular wt.} = 30/1 = 30\ \text{lb/lb-mole}$ $\qquad \gamma_g = \frac{30.00}{28.97} = 1.036$

2.4 initially the container contains only air but at the end, the container has both air and CO_2

$$\text{moles of air} = \frac{14.7(50)}{10.73(535)} = 0.128 \text{ moles}$$

$$\text{moles of } CO_2 = 10/44 = 0.227 \text{ moles}$$

total moles in the tank at the final state $= 0.128 + 0.227 = 0.355$ moles

using Eq. 2.4: $p = \dfrac{0.355(10.73)(505)}{50} = 38.47 \text{ psia}$

2.5 cost of acetylene $= \dfrac{\$10.00}{20} = \$0.50$ per lb or $\dfrac{\$10.00}{20/26} = \$13.00$ per lb-mole

$$\text{cost of acetylene per SCF} = \frac{\$10.00}{379.4} = \$0.0264 \text{ per SCF}$$

$$\text{cost of acetylene per MCF} = \$0.0264(1000) = \$26.40 \text{ per MCF}$$

$$\text{amount of acetylene used per day} = \frac{(1+14.7)(200)(520)}{14.7(545)} = 203.8 \text{ SCF/day}$$

$$\text{cost of acetylene per day} = 203.8(\$0.0264) = \$5.38 \text{ per day}$$

2.6 The tank will collapse when the inside pressure reaches the outside pressure minus the pressure that the tank is designed to withstand. This will be used caused by oil being pumped from the tank.

$$\text{collapse pressure} = 29.1 - \frac{0.75(29.9)}{16(14.7)} = 29.005 \text{ inches Hg}$$

the initial volume of the air space, $V_i = \dfrac{3.1416(110^2)}{4}[35-25] = 95{,}033$ cu ft

the volume of the air space in the tank at the collapse pressure will be:

$$V_f = \frac{p_i V_i}{p_f} = \frac{29.1(95{,}033)}{29.005} = 95{,}344 \text{ cu ft}$$

the volume of oil removed at the time of collapse will be the difference or 311 cu ft

the pump removes oil at a rate of $20{,}000(5.615) = 112{,}300$ cu ft/day

(a) the time of collapse will be $\frac{311}{112{,}300}(24)(60) = 3.99$ minutes

(b) total force on roof at time of collapse will be $F = pA$

$$F = (29.1 - 29.005)\left(\frac{14.7}{29.9}\right)\left[\frac{3.1416(110^2)}{4}\right](144) = 63{,}920 \text{ lb}_f$$

(c) The collapse time would have been less.

2.7 (a) basis of 100 lb of mixture

let x = lb of methane

$$\text{moles of mixture} = \text{moles of methane} + \text{moles of ethane} = \frac{\text{weight}}{\text{mol.wt.}} = \frac{100}{.65(28.97)}$$

$$\frac{x}{16} + \frac{100 - x}{30} = \frac{100}{.65(28.97)} = 5.31$$

$x = 67.8$ lb which suggests that mixture is 67.8% by weight methane

change the basis to one mole of mixture to calculate the mole or volume fraction

let y = methane mole fraction

then, $y(16) + (1 - y)(30) = 18.83$

$y = 0.798$ which suggests that the mixture is 79.8% by volume methane, recognize that mole fraction = volume fraction for the mixture

(b) The per cent by volume is greater than the per cent by weight for methane because the methane molecule is lighter than the ethane molecule.

2.8 writing a mole balance on the tanks, we get

moles in tank 1 + moles in tank 2 = total moles at the final conditions

$$\frac{p_1 V_1}{R' T_1} + \frac{p_2 V_2}{R' T_2} = \frac{p_f V_f}{R' T_f}$$

the temperature is constant so the equation becomes $p_1 V_1 + p_2 V_2 = p_f V_f$

or $50(50) + 25(V_2) = 35(50 + V_2)$

$V_2 = 75$ cu ft

2.9 basis: 1 cu ft

$\frac{p_s V_s}{R' T_s} = \frac{p_c V_c}{R' T_c}$ where the subscripts s and c stand for standard conditions and contact conditions

$$V_s = \frac{p_c V_c T_s}{T_c p_s} = \frac{14.4(1)(520)}{15.025(540)} = 0.923 \text{ SCF}$$

At the new conditions, the price could be stated in two ways:

1. \$6.00 per 0.923 MCF
2. \$x per MCF

$\frac{6.00}{x} = \frac{0.923}{1}$ or $x = \$6.50$ per MCF

2.10 (a) and (b) the ideal volumes are calculated from the following equation:

$V_i = \frac{p_o V_o T_i}{T_o p_i} = \frac{14.7(45{,}000)(620)}{520(p_i)}$ where the subscripts, i and o, refer to ideal and original conditions

the z factors will be calculated from $z = \frac{\text{actual volume}}{\text{ideal volume}}$

the B_g for part (b) can be calculated from $B_g = 0.02829 \frac{zT}{p}$

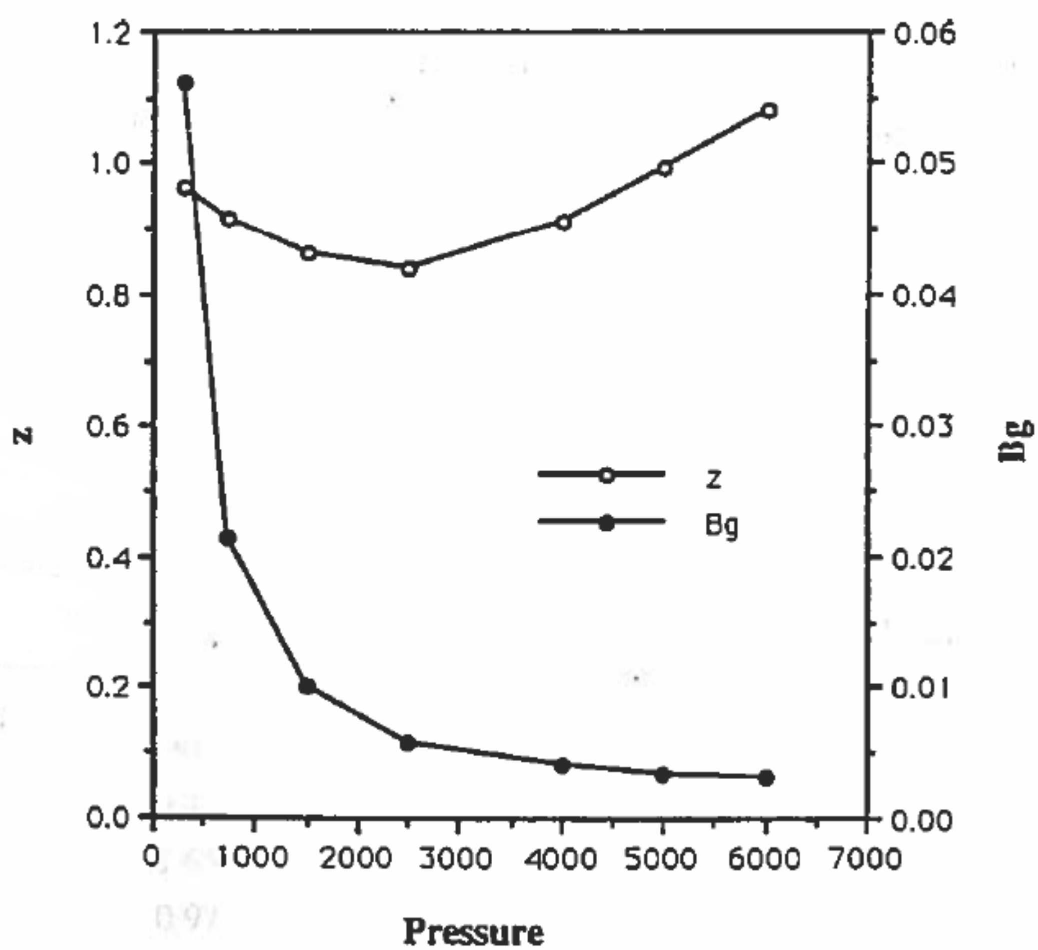
sample calculation, at p = 300 psia, actual volumes = 2529 cc

$$V_i = \frac{14.7(45{,}000)(620)}{520(300)} = 2629 \text{ cc} \qquad z = \frac{2529}{2629} = 0.962$$

$$B_g = 0.02829 \frac{(.962)(620)}{300} = 0.05624 \text{ cu ft/SCF}$$

Pressure	actual volume	ideal volume	z	B_g
300	2529	2629	0.962	0.05624
750	964	1052	0.917	0.02144
1500	453	526	0.862	0.01007
2500	265	315	0.840	0.00589
4000	180	197	0.913	0.00400
5000	156.5	158	0.992	0.00348
6000	142.2	131	1.082	0.00316

(c)



2.11 (a) from Eq. 2.9 and 2.10: $p_{pc} = 670$ psia and $T_{pc} = 366$ °R

p	p_{pr}	T_{pr}	z (from Figure 2.2)
300	0.45	1.69	0.97
750	1.12	1.69	0.93
1000	1.49	1.69	0.91
1500	2.24	1.69	0.88
2000	2.99	1.69	0.86
2500	3.73	1.69	0.86
3000	4.48	1.69	0.865
4000	5.97	1.69	0.915
5000	7.46	1.69	0.99
6000	8.96	1.69	1.07

(b)

Component	y	M_w	yM_w	p_c	yp_c	T_c	yT_c
Methane	0.875	16.04	14.04	673.1	588.96	343.2	300.30
Ethane	0.083	30.07	2.50	708.3	58.79	549.9	45.64
Propane	0.021	44.09	0.93	617.4	12.97	666.0	13.99
Isobutane	0.006	58.12	0.35	529.1	3.17	734.6	4.41
Butane	0.008	58.12	0.46	550.1	4.40	765.7	6.13
Isopentane	0.003	72.15	0.22	483.5	1.45	829.6	2.49
Pentane	0.002	72.15	0.14	489.8	0.98	846.0	1.69
Hexane	0.001	86.17	0.09	440.1	0.44	914.0	0.91
Heptane	0.001	114.20	0.11	362.2	0.36	1025.0	1.03

$$\gamma_g = \frac{\sum yM_w}{28.97} = \frac{18.84}{28.97} = 0.65 \qquad p_{pc} = \sum yp_c = 671.52 \qquad T_{pc} = \sum yT_c = 376.59$$

p,	300	750	1500	2500	4000	5000	6000
p_{pr},	0.45	1.12	2.23	3.72	5.96	7.45	8.94
T_{pr},	1.65	1.65	1.65	1.65	1.65	1.65	1.65
Z,	0.97	0.925	0.87	0.84	0.905	0.98	1.065