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 = \( \frac{10}{16} = .625 \) moles

number of moles of ethane = \( \frac{20}{30} = .667 \) 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) 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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>.333</td>
<td>.333</td>
<td>16</td>
<td>5.33</td>
</tr>
<tr>
<td>Ethane</td>
<td>.333</td>
<td>.333</td>
<td>30</td>
<td>10.00</td>
</tr>
<tr>
<td>Propane</td>
<td>.333</td>
<td>.333</td>
<td>44</td>
<td>14.67</td>
</tr>
</tbody>
</table>

Total weight = 30.00

molecular wt. = \( \frac{30.00}{28.97} = 1.036 \) lb/lb-mole

\[ \gamma_g = \frac{30.00}{28.97} = 1.036 \]
2.4 Initially the container contains only air but at the end, the container has both air and CO₂

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

\[
\text{moles of CO}_2 = \frac{10}{44} = 0.227 \text{ moles}
\]

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

Using Eq. 2.4: \[
p = \frac{0.355(10.73)(505)}{50} = 38.47 \text{ psia}
\]

2.5 Cost of acetylene = \[
\frac{\$10.00}{20} = \$0.50 \text{ per lb or } \frac{\$10.00}{20/26} = \$13.00 \text{ per lb-mole}
\]

Cost of acetylene per SCF = \[
\frac{\$10.00}{379.4} = \$0.0264 \text{ per SCF}
\]

Cost of acetylene per MCF = \[
\$0.0264(1000) = \$26.40 \text{ per MCF}
\]

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

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.

Collapse pressure = \[
29.1 - \frac{0.75(29.9)}{16(14.7)} = 29.005 \text{ inches Hg}
\]

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

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

\[
V_f = \frac{p_f V_i}{p_t} = \frac{29.1(95,033)}{29,005} = 95,344 \text{ cu ft}
\]
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 \(20,000 \times (5.615) = 112,300\) cu ft/day

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

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

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

(c) The collapse time would have been less.

2.7 (a) basis of 100 lb of mixture
   let \(x = \text{lb of methane}\)

\[
\text{moles of mixture} = \text{moles of methane} + \text{moles of ethane} = \frac{\text{weight}}{\text{mol wt.}} = \frac{100}{0.65 \times (28.97)}
\]

\[
\frac{x}{16} + \frac{100 - x}{30} = \frac{100}{0.65 \times (28.97)} = 5.31
\]

\(x = 67.8\) 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 \(y = \text{methane mole fraction}\)
then, \(y \times (16) + (1 - y) \times (30) = 18.83\)

\(y = 0.798\) 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
the temperature is constant so the equation becomes \( p_1 V_1 + p_2 V_2 = p_f V_f \)

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

\( V_2 = 75 \text{ cu ft} \)

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

\[ V_s = \frac{p_s V_s T_s}{T_c p_s} = \frac{14.4(1)(520)}{15.025(540)} = 0.923 \text{ SCF} \]

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 \[ x = $6.50 \text{ per MCF} \]

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

\[ V_i = \frac{p_o V_o T_o}{T_p p_i} = \frac{14.7(45,000)(620)}{520(p_i)} \]

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 \( p = 300 \text{ psia} \), actual volumes = 2529 cc

\[ V_i = \frac{14.7(45,000)(620)}{520(300)} = 2629 \text{ cc} \]

\[ z = \frac{2529}{2629} = 0.962 \]
\[
B_g = \frac{0.02829 \times (0.962)(620)}{300} = 0.05624 \text{ cu ft/SCF}
\]

<table>
<thead>
<tr>
<th>Pressure</th>
<th>actual volume</th>
<th>ideal volume</th>
<th>(z)</th>
<th>(B_g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>2529</td>
<td>2629</td>
<td>0.962</td>
<td>0.05624</td>
</tr>
<tr>
<td>750</td>
<td>964</td>
<td>1052</td>
<td>0.917</td>
<td>0.02144</td>
</tr>
<tr>
<td>1500</td>
<td>453</td>
<td>526</td>
<td>0.862</td>
<td>0.01007</td>
</tr>
<tr>
<td>2500</td>
<td>265</td>
<td>315</td>
<td>0.840</td>
<td>0.00589</td>
</tr>
<tr>
<td>4000</td>
<td>180</td>
<td>197</td>
<td>0.913</td>
<td>0.00400</td>
</tr>
<tr>
<td>5000</td>
<td>156.5</td>
<td>158</td>
<td>0.992</td>
<td>0.00348</td>
</tr>
<tr>
<td>6000</td>
<td>142.2</td>
<td>131</td>
<td>1.082</td>
<td>0.00316</td>
</tr>
</tbody>
</table>

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

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

(b)

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

\[
\gamma_g = \frac{\sum yM_w}{28.97} = \frac{18.84}{28.97} = 0.65 \quad p_{pc} = \sum yP_c = 671.52 \quad T_{pc} = \sum yT_c = 376.59
\]

<table>
<thead>
<tr>
<th>$p$</th>
<th>$P_{pr}$</th>
<th>$T_{pr}$</th>
<th>$Z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>0.45</td>
<td>1.65</td>
<td>0.97</td>
</tr>
<tr>
<td>750</td>
<td>1.12</td>
<td>1.65</td>
<td>0.925</td>
</tr>
<tr>
<td>1000</td>
<td>1.49</td>
<td>1.65</td>
<td>0.87</td>
</tr>
<tr>
<td>1500</td>
<td>2.24</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>2000</td>
<td>2.99</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>2500</td>
<td>3.73</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>3000</td>
<td>4.48</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>4000</td>
<td>5.97</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>5000</td>
<td>7.46</td>
<td>1.65</td>
<td>0.84</td>
</tr>
<tr>
<td>6000</td>
<td>8.96</td>
<td>1.65</td>
<td>0.84</td>
</tr>
</tbody>
</table>
(c) To keep the error less than 2%, the deviation factor would have to be between 1 and 0.98. Reading from the graph, the pressure would have to be less than 180 psia.

(d) A reservoir will contain more SCF of a real gas than of an ideal gas when the deviation factor is less than unity but less than an ideal gas when the deviation factor is greater than unity.

2.12 Writing a mole balance, initial moles – moles produced = final moles or \( n_i - n_p = n_f \)

\[
n_i = \frac{p_i V_i}{z_i R T_i} = \frac{2500(0.33)}{0.75(10.73)(590)} = 0.1738 \text{ moles}
\]

\[
n_p = \frac{43.6 \text{ SCF}}{379.4 \text{ SCF/mole}} = 0.1149 \text{ moles}
\]

\[
n_f = 0.1738 - 0.1149 = 0.0589 \text{ moles}
\]

\[
z_f = \frac{1000(0.33)}{0.0589(10.73)(590)} = 0.885
\]
2.13 \( n_i = \frac{p_iV_i}{z_iR^iT_i} \quad n_f = 0.5n_i = \frac{p_fV_f}{z_fR^iT_f} \)

Assume: \( V_f = V_i \) and \( T_i = T_f \)

\[
0.5\frac{p_iV_i}{z_iR^iT_i} = \frac{p_fV_f}{z_fR^iT_f} \quad \text{or} \quad p_f = z_f\left(0.5\frac{p_i}{z_i}\right)
\]

From Eq. 2.9 and 2.10: \( p_{pc} = 666 \text{ psia} \) and \( T_{pc} = 372\degree \text{R} \)

\[
T_{pc} = \frac{620}{372} = 1.68 \quad p_{pc} = \frac{6000}{666} = 9.01 \quad \text{from Figure 2.2:} \ z_i = 1.09
\]

\[
p_f = z_f\left(0.5\frac{p_i}{z_i}\right) = 0.5\left(\frac{6000}{1.09}\right)z_f = 2752z_f
\]

This becomes a trial and error solution since \( z_f \) is a function of \( p_f \)

Guess a \( p_f \), calculate \( z_f \), and then calculate \( p_f \) to see if the assumed \( p_f \) is correct

\( p_f = 2400 \text{ psia} \)

\[
n_i = \frac{p_iV_i}{z_iR^iT_i} = \frac{6000(1 \text{ MM})}{1.09(10.73)(620)} = 0.827 \text{ MM moles}
\]

At 500 psia, using Fig. 2.2, \( z_{500} = 0.952 \)

\[
n_i = \frac{p_fV_f}{z_fR^iT_f} = \frac{500(1 \text{ MM})}{0.952(10.73)(620)} = 0.0789 \text{ MM moles}
\]

Moles produced = \( (0.827 - 0.0789) \text{ MM} = 0.748 \text{ MM moles} \)

\[
(0.748 \text{ MM moles})(379.4 \text{ SCF/mole}) = 283.8 \text{ MM SCF of gas produced}
\]

2.14

<table>
<thead>
<tr>
<th>( p )</th>
<th>( z )</th>
<th>( \frac{dz}{dp} ) (slope)</th>
<th>( c_g )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.86</td>
<td>-0.001</td>
<td>2200 ( (10^6) )</td>
</tr>
<tr>
<td>2200</td>
<td></td>
<td>0</td>
<td>455 ( (10^6) )</td>
</tr>
<tr>
<td>4000</td>
<td>0.89</td>
<td>0.000085</td>
<td>154 ( (10^6) )</td>
</tr>
</tbody>
</table>
2.15 from Eq. 2.9 and 2.10: \( p_{pc} = 664 \) psia and \( T_{pc} = 389^\circ R \)

\[
\begin{align*}
   p_{pr} &= \frac{5000}{664} = 7.53 \\
   T_{pr} &= \frac{663}{389} = 1.70
\end{align*}
\]

from Figure 2.5: \( c_r T_{pr} = 0.3 \)

\[
c_r = \frac{0.3}{1.74} = 0.17 \quad \text{therefore} \quad c_g = \frac{c_r}{p_{pc}} = \frac{0.17}{665} = 260 \left(10^{-6}\right) \text{psi}^{-1}
\]

2.16 \( c_r = \frac{1}{p_{pr}} - \frac{1}{z} \left( \frac{dz}{dp_{pr}} \right) = \frac{1}{4.0} - \frac{1}{0.653} \left( \frac{0.705 - 0.608}{5.0 - 3.0} \right) = 0.176
\)

from Fig. 2.4: \( c_r T_{pr} = 0.21 \quad c_r = \frac{0.21}{1.3} = 0.16
\]

2.17 from Figure 2.6: \( \mu_1 = 0.01185 \) cp

adding corrections for \( N_2, CO_2, H_2S \)

\[
\mu_1 = 0.01185 + 0.0002 + 0.00025 + 0.0002 = 0.0125 \text{ cp}
\]

from Eq. 2.9 and 2.10: \( T_{pc} = 455^\circ R \) and \( p_{pc} = 656 \) psia

\[
\begin{align*}
   p_{pr} &= \frac{7000}{656} = 10.61 \\
   T_{pr} &= \frac{680}{455} = 1.50
\end{align*}
\]

from Figure 2.7 \( \mu / \mu_1 = 3.2 \quad \mu = 3.2 \left(0.0125\right) = 0.040 \) cp
2.18 (a) composition of oil and gas, pressure, and temperature

(b) The oil is undersaturated originally. The horizontal portion of the curve indicates that there is no more free gas present (above 2500 psia) to go into solution. Therefore, above 2500 psia, the oil is undersaturated.

(d) The reservoir had no original gas cap since the oil was undersaturated.

(e) solubility = \( \frac{567 - 143}{2500 - 200} \) = 0.184 SCF/STB/psi

(f) project \( R_{so} \) curve from 2500 psia to 3600 psia by extending the straight line
\[ R_{so} = 769 \text{ SCF/STB} \]

Since there are 1000 SCF of gas for every STB and only 769 are required for saturation, the reservoir oil would be saturated. There would also be a gas cap.

2.19 (a) see plot in last problem
(b) There is no more gas to go into solution to increase the volume as the pressure is increased, therefore the volume is reduced with increased pressure. The break in the curve occurs when the last gas goes into solution.
(c) Since there is no additional gas to go into solution to increase the volume as the pressure is increased, the increased pressure reduces the volume instead of increasing the volume as it does below the saturation pressure. The negative slope (above saturation pressure) is smaller than the positive slope (below saturation pressure) because the liquid is only slightly compressible.
(d) initial STB in place, \[ N = \frac{\text{reservoir bbl in place}}{B_{oi}} = \frac{250 \times 10^6}{1.310} = 190.8 \times 10^6 \text{ STB} \]
(e) initial volume of dissolved gas = \[ NR_{sol} = 190.8 \times 10^6 \times 567 = 108.2 \times 10^9 \text{ SCF} \]
(f) \[ B_o = \frac{V_l}{V_o} = 1 + \beta (T - 60) = 1 + 0.0006 (160 - 60) = 1.06 \text{ bbl/STB} \]

2.20 \[ Y_g = 0.00091 (165) - 0.0125 (30) = -0.225 \]

\[ R_{so} = 0.80 \left[ \frac{2500}{18(10)^{0.325}} \right]^{1.204} = 567 \text{ SCF/STB} \]
\[ \gamma_o = \frac{141.5}{131.5 + 30} = 0.876 \]
\[ F = 567 \left( \frac{0.8}{0.876} \right)^5 + 1.25 (165) = 748 \]
\[ B_o = 0.972 + 0.000147 (748^{1.175}) = 1.322 \text{ bbl/STB} \]
2.21 amount of gas in solution = 0.25(85)(500) = 10,625 SCF
free gas above liquid = 20,000 – 10,625 = 9375 SCF
volume occupied by undissolved gas = \( \frac{znRT}{p} = \frac{0.90(9375/379.4)(10.73)(580)}{500} = 277 \text{ cu ft} \)
volume of oil and solution gas = 1000 – 277 = 723 cu ft or 128.8 bbl

\[
B_o = \frac{128.8}{85} = 1.515 \text{ bbl}/\text{STB}
\]

2.22 \( \frac{B_o}{B_{ob}} = e^{c_o(p_o-p)} = e^{20(10^4)(3200-4400)} = 0.976 \)

2.23 (a) from Eq. 2.36: \( \log\left[\log(\mu_{od} + 1)\right] = 1.8653 - .025086(35) - .5644\log(130) \)

\[
\mu_{od} = 3.2 \text{ cp}
\]

from Eq. 2.37: \( \mu_o = A\mu_{od}^B \)

\[
A = 10.715 (750+100)^{-315} = .332 \quad B = 5.44(750+150)^{-338} = .546 \\
\mu_o = .332(3.2)^{.546} = 0.63 \text{ cp}
\]

(b) \( \mu_{ob} = 0.63 \text{ cp} \)

from Eq. 2.38

\[
\mu_o = \mu_{ob} + 1.3449(10^{-1})(p - p_b)10^A \\
A = -1.0146 + 1.3322[\log(\mu_{ob})] - .4876[\log(\mu_{ob})]^2 - 1.15036[\log(\mu_{ob})]^3
\]

\[
A = -1.293 \\
\mu_o = 0.73 \text{ cp}
\]

(c) \( \mu_{od} = 3.2 \text{ cp} \)
\[
A = 10.715(300 + 100)^{-0.515} = 0.490 \quad B = 5.44(300 + 150)^{-0.338} = 0.690
\]
\[
\mu_o = 0.49(3.2)^{0.69} = 1.09 \text{ cp}
\]

2.24 at 2000 psia:

\[
R_{so} = \frac{44,500}{500}(5.615) = 500 \text{ SCF/STB}
\]
\[
B_o = \frac{650}{500} = 1.300 \text{ bbl/STB}
\]
\[
B_t = 1.300 \text{ bbl/STB}
\]

at 1500 psia:

\[
R_{so} = 500 \text{ SCF/STB}
\]
\[
B_o = \frac{669}{500} = 1.338 \text{ bbl/STB}
\]
\[
B_t = 1.338 \text{ bbl/STB}
\]

at 1000 psia:

\[
R_{so} = \frac{44,500 - \left( \frac{150(1000)}{0.02829(.91)(655)} \right)}{500}(5.615) = 400 \text{ SCF/STB}
\]
\[
B_o = \frac{650}{500} = 1.300 \text{ bbl/STB}
\]
\[
B_t = \frac{650 + 150}{500} = 1.600 \text{ bbl/STB}
\]

at 500 psia:

\[
R_{so} = \frac{44,500 - \left( \frac{700(500)}{0.02829(.95)(655)} \right)}{500}(5.615) = 276 \text{ SCF/STB}
\]
\[ B_o = \frac{615}{500} = 1.23 \text{ bbl/STB} \]
\[ B_t = \frac{650 + 700}{500} = 2.63 \text{ bbl/STB} \]

2.25 (a) from Eq. 2.42

\[ c_w = \frac{1}{7.033(4000) + 541.5(20) - 537(150) + 403.3} = 2.76 \times 10^{-6} \text{ psi}^{-1} \]

(b) from Eq. 2.39:

\[ \Delta V_{wt} = -1.0001 \times 10^{-2} + 1.3339 \times 10^{-4}(150) + 5.50654 \times 10^{-7}(150)^2 = 0.02240 \]
\[ \Delta V_{wp} = -1.95301 \times 10^{-9}(4000)150 - 1.72834 \times 10^{-13}(4000^2)150 \]
\[ \quad - 3.58922 \times 10^{-7}4000 - 2.25341 \times 10^{-10}4000^2 = -0.006628 \]
\[ B_w = (1 + 0.0224)(1 - 0.006628) = 1.016 \text{ bbl/STB} \]

2.26 (a) from Eq. 2.44: with \( S = 0 \)

\[ \mu_w = AT^B = 109.574 (70)^{-1.12166} = 0.93 \text{ cp} \]

(b) \( \mu_w = 109.574 (200)^{-1.12166} = 0.29 \text{ cp} \)

2.27 (a) from Eq. 2.39:

\[ \Delta V_{wt} = -1.0001 \times 10^{-2} + 1.33391 \times 10^{-4}(180) + 5.50654 \times 10^{-7}(180)^2 = 0.03185 \]
\[ \Delta V_{wp} = -1.95301 \times 10^{-9}(p)180 - 1.72834 \times 10^{-13}(p^2)180 - 3.58922 \times 10^{-7}p - 2.25341 \times 10^{-10}p^2 \]

at \( p = 6000 \text{ psia} \) \( \Delta V_{wp} = -0.01350 \)

at \( p = 1000 \text{ psia} \) \( \Delta V_{wp} = -0.000967 \)

\[ B_{w6000} = (1 + 0.03185)(1 - 0.01350) = 1.0179 \text{ bbl/STB} \]
\[ B_{w1000} = (1 + 0.03185)(1 - 0.000967) = 1.0309 \text{ bbl/STB} \]
volume change = \frac{500}{1.0179} - \frac{500}{1.0309} = 6.2 \text{ cc}

(b) salinity has been found to have an insignificant effect on $B_w$, therefore the answer for part (b) is the same as that for part (a)