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Chapter Two: Computer Modeling Applications for Water and Wastewater Properties

2.7 Homework Problems in Water and Wastewater Properties

2.7.1 Discussion Problems

1)

Solution:

See Section 2.2 of Chapter 2 of the book.

2)

Solution:

See Sections 2.3, 2.4, 2.5 and 2.6 of Chapter 2 of the book.

3)

Solution:

See Section 2.3 of Chapter 2 of the book.

4)

Solution:

See Section 2.3 of Chapter 2 of the book.

5)

Solution:

See Section 2.4 of Chapter 2 of the book.

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6)

Solution:

See latest *Standard Methods for the Examination of Water and Wastewater*, American Water Works Association, APHA.

7)

Solution:

See latest *Standard Methods for the Examination of Water and Wastewater*, American Water Works Association, APHA.

8)

Solution:

Using equations 2.6, 2.7, 2.8, 2.9, and 2.10.

$$sa \quad 0.03 + 1.805ch \tag{2.6}$$

Where:

sa = Salinity, g/kg.

ch = Chlorinity, g/kg.

$$\rho \quad \frac{m}{V} \tag{2.7}$$

Where:

ρ = Density of the fluid, kg/m^3.

m = Mass, kg.

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V = Volume, m^3.

$$\upsilon \quad \frac{1}{\rho} \tag{2.8}$$

Where:

υ= Specific volume of the fluid, m^3/kg.

ρ= Density of the fluid, kg/m^3.

$$\gamma \quad \frac{mg}{V} \quad \rho g \tag{2.9}$$

Where:

γ = Specific weight, N/m^3.

m = Mass, kg.

g = Gravitational acceleration, m/s^2.

V = Volume, m^3.

ρ = Density of the fluid, kg/m^3.

$$s.g. \quad \frac{\rho}{\rho_{\text{water at } 4^o C}} \tag{2.10}$$

9)

Solution:

Search relevant journals of fluid mechanics, for example https://www.cambridge.org.

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10)

Table 2.1 Examples of Different Types of Fluids

Type	Example
Newtonian	Most fluids, Water, Gasoline, Oil, Air, Emulsions
Dilatants	Moving sand
Non-Newtonian	Flubber, Oobleck (suspension of starch in water)
Ideal liquid	Practically no ideal fluid exists. Real fluids are like kerosene, petrol, castor oil
Ideal solid	
Pseudoplastic	Clay, Cement, Milk, Colloidal solutions
Plastic	Sludge
Thixotropic	Raw sludge, Ketchup, Yoghurt, Paint
Rheopectic	Gypsum paste, Printer ink

11)

Solution:

Absolute viscosity coefficient is equal to kinematic viscosity coefficient, multiplied by density, i.e.:

$$\mu \quad \rho\nu \tag{2.12}$$

where:

μ = Dynamic (absolute) viscosity, $N*s*m^{-2}$.

ν = Kinematic viscosity, m^2*s^{-1} (usually defined as the ratio of dynamic viscosity to mass density).

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ρ = Density, kg*m^{-3}.

12)

Solution:

Surface tension is a property of a liquid that permits the attraction between molecules to form an imaginary film that is able to resist tensile forces at the interface between two immiscible liquids or at the interface between a liquid and a gas. As represented by equation 2.13.

$$h \quad \frac{4\sigma\cos\phi}{gD(\rho_l - \rho_g)} \tag{2.13}$$

Where:

h = Column height by which liquid rose along capillary tube, m.

σ = Surface tension, N/m.

ϕ = Angle of contact subtended by the heavier fluid and tube (= 0° for most organic liquids and water against glass {provided the glass is wet with a film of the liquid}, = 130° for mercury against glass).

ρ_l = Density of liquid, kg/m^3.

ρ_g = Density of gas (or light liquid), kg/m^3.

g = Local gravitational acceleration, m/s^2.

D = Inside diameter of capillary tube, m

13)

Solution:

- If any formulation changes at the molecular level (e.g. by the addition of another

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chemical or surfactant), or if anything contaminates the fluid, then its surface tension will change. Measuring surface tension level is a direct indicator of the quality of any chemical and any formulation.

- It is surface tension which keeps the billions of cells in the human body functional. Surface tension ensures the proper organization of the cellular bio-molecules, proteins, lipids, and nucleic acids, into membranes and various types of cellular organelles.
- Surface tension is a fundamental property of water, making it an ideal medium allowing for life to exist. As a general, easily comprehensible example, it is surface tension that makes water drops spherical.

14)

Solution:

Bulk modulus is a property that is used to evaluate the degree of compressibility. Equation 2.14 gives the bulk modulus.

$$E_b \quad -\frac{dP}{dV/V} \quad -\frac{dP}{\rho/d\rho} \tag{2.14}$$

where:

E_b = Bulk modulus, $N*m^{-2}$.

dP = Differential change in pressure, Pa.

dV = Differential change in volume, m^3.

V = Volume, m^3.

ρ = Density of fluid, kg/m^3.

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15)

Solution:

Table 2.2 Differences between Alpha, Beta and Gamma Radiation

	Alpha Particles	Beta Particles	Gamma Rays
Energy level	Most energetic	Much smaller than Alpha	Waves of electromagnetic energy
Travel distance	Few inches in air	Travel with high speed	Travel with speed of light
Stopping material	Sheet of paper	Thin sheet of aluminium or glass	Thick wall of concrete, lead , or steel.

Also See Section 6 of Chapter 2 of the book.

16)

Solution:

See Section 4 of Chapter 2 of the book.

17)

Solution:

See Section 4 of Chapter 2 of the book.

18)

Solution:

Bases and alkali substances are common, both in the natural environment and in our daily use.

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Some examples of everyday use alkali substances are toothpastes and baking soda. Ammonia is an exception to the common pattern for alkali substances, as it is a water-soluble base without a hydroxyl group. Copper oxide is a relatively common base that is not water soluble, and thus it is not an alkali.

Any basic substance has a pH above 7.0 (the pH of pure water). Acidic substances have a pH of below 7.0. Basic substances are being basic because they are capable of accepting hydrogen ions, and hydrogen ions are what give acids their caustic properties. In the case of many alkali substances, the hydrogen ions bond with hydroxyl ions to create water. The non-hydroxyl portions of the bases often form salts with the remnants of the acids. In the case of ammonia, the hydrogen ion is accepted to form ammonium.

19)

Solution:

Hardness is generally associated with divalent metallic cations of calcium, Ca^{++}, or magnesium, Mg^{++}, or strontium, Sr^{++}, or ferrous ion, Fe^{++}, or manganous ions, Mn^{++}.

Advantages and disadvantages of hardness

- Hard water aids growth of teeth and bones.
- Hard water reduces degree of toxicity by poisoning with lead oxide (PbO) from pipelines made of lead.
- Soft waters are thought to be associated with cardiovascular diseases.
- Financial losses to hard water users via consumption of more soap.
- Development of residues, when using hard water, on hot water systems, boilers, domestic appliances, fittings, utensils, bath tubs, sinks, dishwashers and wash-hand basins.

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- Staining of clothes, and some household utensils, upon use of hard water.
- Hard water precipitates hardness-soap which may remain in pores of skins making it feeling rough and uncomfortable.
- Increase of a laxative effect on new hard water consumers primarily with existence of magnesium sulfates

20)

Solution:

See latest *Standard Methods for the Examination of Water and Wastewater*, American Water Works Association, APHA.

21)

Solution:

See Section 4 of Chapter 2 of the book.

22)

Solution:

The Biochemical Oxygen Demand (BOD) test measures the relative amount of oxygen that is needed to biologically stabilize organic matter present in a sample.

Equation 2.24 gives the value of BOD exerted at any time t and temperature T (See Figure 2.6).

$$BOD_t^T \quad L_o - L_t \quad L_o(1 - 10^{-k^{\copyright}_1 t}) \qquad (2.24)$$

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23)

Solution:

The advantages of the test include: estimation of the size of treatment units, evaluation of treatment efficiency, and estimation of the relative amount of oxygen required for oxidation of organic pollutants

24)

Table 2.3 Chemicals not in source (raw) water

Chemical	First chemical (Ans)	Second chemical (Ans)	Third chemical (Ans)
Example	Chlorine	Aluminum sulfate	Soda ash (Sodium carbonate) and Sodium hydroxide
How chemical entered water	Disinfection process	Coagulation/sedimentation treatment	Adjusting pH
Potential health impacts and effects	Carcinogenic trihalomethanes if formed	Aluminum linked with Alzheimer's disease, discoloration	Eye irritation or abdominal pain in high concentration
Suggested methods for getting rid of harmful chemical	Proper dosing, getting rid of residual chlorine	Use of optimum dose	Proper dosing

25)

Solution:

See extra references, for example World Water Works Association (http://www.worldwaterworks.com), or Global Water Partnership (GWP – http://www.gwp.org).

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26)

Solution:

See extra references, for example World Health Organization (http://www.who.int), or The World Bank (http://www.worldbank.org).

27)

Table 2.4 Group Matching

Group (I)	Rearranged group (II) (Ans)
Pollution	**Improper storage**
True solutions removal	**Gas transfer**
Pathogen removal	**Chlorination**
Colloidal suspensions removal	**Chemical coagulation**
Physical treatment	**Sedimentation**
Preliminary treatment	**Grit removal**
Leakage	**Water loss**
Sanitation barrier	**Hand washing**
House fly	***Muscadomestica***
Scistosomiasis	***Scistosoma***
Malaria	**Anopheles mosquitoes**
Eye disease	**Trachoma**
Water contact diseases	**Water-based**
Water washed diseases	**Quantity related**
Sanitation - related diseases	**Fecal related**
Water borne diseases	**Quality related**
Water insect vector	**Water site related**
Trypanosomiasis	**African sleeping sickness**
Methaemoglobinaemia	**Blue babies syndrome**
Fluoride	**Tooth decay**

28)

a) **T**
b) **T**
c) **T**
d) **T**
e) **T**
f) **T**

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g) **T**
h) **T**

29)

a) **disease causing**
b) **Health**
c) **poverty**
d) **Lead**
e) **lethal dose**
f) **Guidelines**
g) **corrosive**

2.7.2 Specific Mathematical Problems

1)

Solution

- Given: Angle of contact, Column height, Temperature, Inside diameter of capillary tube.
- Use equation of surface tension to calculate its value given the above.

$$\sigma \quad \frac{h * gD(\rho_l - \rho_g)}{4\cos\phi}$$

Where:

σ = Surface tension, N/m.

h = Column height by which liquid rose along capillary tube, m.

ϕ = Angle of contact subtended by the heavier fluid and tube (= 0° for most organic liquids and water against glass {provided the glass is wet with a film of the liquid = 130° for mercury against glass}.

ρ_l = Density of liquid, kg/m^3.

ρ_g = Density of gas (or light liquid), kg/m^3.

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g = Local gravitational acceleration, m/s^2.

D = Inside diameter of capillary tube, m

Program 2.1: Surface Tension

```
Imports System.Math
Public Class Form1
    Const g = 9.81          'acceleration due to gravity
    '************************************
    ' Density column of Table Appendix A1:
    ' Physical Properties of Water
    '************************************
    Dim density() As Double =
        {
        0, 0, 0, 0, 0,
        0.999965, 0.999941, 0.999902, 0.999849, 0.999781,
        0.9997, 0.999605, 0.999498, 0.999377, 0.999244,
        0.999099, 0.998943, 0.998774, 0.998595, 0.998405,
        0.998203, 0.997992, 0.99777, 0.997538, 0.997296,
        0.997044, 0.996783, 0.996512, 0.996232, 0.995944,
        0.995646, 0.99534, 0.995025, 0.994702, 0.994371,
        0.99403, 0.99368, 0.99333, 0.99296
        }
    Dim tempStr() As String =
```

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```
        {
        "5", "6", "7", "8", "9", "10", "11", "12", "13", "14", "15",
        "16", "17", "18", "19", "20", "21", "22", "23", "24", "25", "26",
        "27", "28", "29", "30", "31", "32", "33", "34", "35", "36", "37",
"38"
        }

    Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Me.Text = "Program 2.1"
        Label1.Text = "Temperature (C):"
        Label2.Text = "The diameter of the capillary tube (m):"
        Label3.Text = "The angle of contact in degrees:"
        Label4.Text = "The exent of the liquid rise in the tube (m):"
        Label5.Text = "Surface tension (N/m):"
        Label6.Text = "Decimal Places:"
        ComboBox1.Items.Clear()
        ComboBox1.Items.AddRange(tempStr)
        ComboBox1.SelectedIndex = 0
        NumericUpDown1.Maximum = 15
        NumericUpDown1.Minimum = 0
        NumericUpDown1.Value = 8
```

```
    End Sub

    Private Sub TextBox1_TextChanged(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles TextBox1.TextChanged
        calculateResults()
    End Sub

    Private Sub TextBox2_TextChanged(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles TextBox2.TextChanged
        calculateResults()
    End Sub

    Private Sub TextBox3_TextChanged(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles TextBox3.TextChanged
        calculateResults()
    End Sub

    Private Sub NumericUpDown1_ValueChanged(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles NumericUpDown1.ValueChanged
        calculateResults()
    End Sub

    Sub calculateResults()
        Dim s, h, rho, D, phi As Double
```

```
        Dim T As Integer = ComboBox1.SelectedIndex
        If T = -1 Then
            MsgBox("Please select temperature from the list.", vbOKOnly Or
vbCritical)
            Exit Sub
        End If
        T += 5
        rho = density(T) * 1000
        D = Val(TextBox1.Text)
        phi = Val(TextBox2.Text)
        h = Val(TextBox3.Text)
        phi = phi * PI / 180    'in radians
        s = h * g * D * rho / (4 * Cos(phi))
        TextBox4.Text = FormatNumber(s, NumericUpDown1.Value)
    End Sub

    Private Sub ComboBox1_SelectedIndexChanged(sender As Object, e As
EventArgs) Handles ComboBox1.SelectedIndexChanged
        calculateResults()
    End Sub
End Class
```

2)

Solution

1. Relate the Centigrade temperature to the Fahrenheit temperature using equation:

   $^{o}C = [5/9](^{o}F - 32)$

2. For temperatures to be equal: assume temperature = x and substitute in step 1 above:

   $x = [5/9](x-32)$

   This yields $x = -40^{o}$.

Program 2.2: Equal Temperatures

```
Public Class Form1
    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        Dim msg As String
        Me.Text = "Program 2.2"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Dim x As Double
        Const fact = 5 / 9
        x = (-fact * 32) / (1 - fact)
        msg = "Equation:" + vbCrLf + "C = [5/9](F - 32)" + vbCrLf + vbCrLf
        msg += "For temperatures to be equal:" + vbCrLf
        msg += "assume temperature = x," + vbCrLf
        msg += "and substitute in step 1 above, giving:" + vbCrLf + vbCrLf
```

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```
        msg += "x = [5/9](x-32)" + vbCrLf
        msg += "Which yields: x = " + FormatNumber(x, 1)
        Label1.Text = msg
    End Sub
End Class
```

3)

Solution

1. Given: volume and specific gravity.

2. Find weight, W in N = Volume (V) * specific gravity (ρ)*gravitational acceleration (g in m/s^2).

Program 2.3: Weight of Liquid

```
Public Class Form1
    'gravitational acceleration
    Const g = 9.81
    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        Me.Text = "Program 2.3"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Label1.Text = "Volume:"
```

```
        Label2.Text = "Specific Gravity:"
        Label3.Text = "Weight:"
        Button1.Text = "&Calculate"
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim V, sg, W As Double
        V = Val(TextBox1.Text)
        sg = Val(TextBox2.Text)
        W = V * sg * g
        TextBox3.Text = FormatNumber(W, 2)
    End Sub
End Class
```

4)

Solution

1. Given: viscosity (dynamic and kinematic).
2. Absolute viscosity (Pa*s (Pascal*second)) = viscosity (centipoise) *0.1 Ns/m^2.
3. Kinematic viscosity ν (m^2/s) = absolute viscosity (μ)/ρ.

Program 2.4: Viscosity

```
Public Class Form1
```

```
    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        Dim msg As String
        msg = "Equations:" + vbCrLf + vbCrLf
        msg += "1. Absolute viscosity (Pa*s)  = Viscosity (centipoise)*0.1
Ns/m2"
        msg += vbCrLf
        msg += "2. Kinematic viscosity (m2/s) = Absolute Viscosity/Density"
        Label1.Text = msg
        Label2.Text = "Viscosity (centipoise):"
        Label3.Text = "Density (kg/m3):"
        Label4.Text = "Absolute Viscosity (Pa*s):"
        Label5.Text = "Kinematic Viscosity (m2/s):"
        Button1.Text = "&Calculate"
        Me.Text = "Program 2.4"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
    End Sub


    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim Vis, AbsVis, KinVis, Density As Double
        Vis = Val(TextBox1.Text)
        Density = Val(TextBox2.Text)
```

```
        AbsVis = Vis * 0.1

        KinVis = AbsVis / Density

        TextBox3.Text = AbsVis

        TextBox4.Text = KinVis

    End Sub

End Class
```

5)

Solution

1) Given: Materials found in the periodic table.
2) Determine molecular weight of compound as:
   a. MWbarium acetate ($Ba(C_2H_3O_2)_2$) = 137 +2*(12*2+1*3+16*2) = 255
   b. MWnitrous oxide (N_2O) = 14*2 +16 = 44
   c. MWammonium aluminum sulfate $(NH_4)_2Al_2(SO_4)_4$=2*(14+1*4)+27*2+4*(32+16*4) = 474
   d. MWstrontium sulfate ($SrSO_4$) = 87 + 32 + 16*4 = 183
   e. MWcopper sulfate, (Blue Vitriol) ($CuSO_4*5H_2O$) = 63.5+32+16*4+5*(1*2+16) = 249.5
3) Determine the equivalent weight as: EW = MW/a (valency)
   a. EWbarium acetate ($Ba(C_2H_3O_2)_2$) = (137+2*(12*2+1*3+16*2)/2 = 127.5
   b. EWnitrous oxide (N_2O) =(14*2+16)/2 = 22
   c. EWammonium aluminum sulfate $(NH_4)_2Al_2(SO_4)_4$=2*(14+1*4)+27*2+4*(32+16*4)/2 = 237

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d. EWstrontium sulfate ($SrSO_4$) = 44 +32+16*4/2 = 70

e. EWcopper sulfate, (Blue Vitriol) ($CuSO_4*5H_2O$) = 63.5+32+16*4+5*(1*2+16)/2 = 124.75

Program 2.5: Molecular Weights

```
Public Class Form1
    Dim PerTab(118) As Double
    Dim Element(118) As String
    Const TotalElements = 118

    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        'Molecular weights from the periodic table
        PerTab(0) = 1.008 : PerTab(1) = 4.002602 : PerTab(2) = 6.94
        PerTab(3) = 9.012182 : PerTab(4) = 10.81 : PerTab(5) = 12.011
        PerTab(6) = 14.007 : PerTab(7) = 15.999 : PerTab(8) = 18.998
        PerTab(9) = 20.1797 : PerTab(10) = 22.989 : PerTab(11) = 24.305
        PerTab(12) = 26.981 : PerTab(13) = 28.085 : PerTab(14) = 30.973
        PerTab(15) = 32.06 : PerTab(16) = 35.45 : PerTab(17) = 39.948
        PerTab(18) = 39.0983 : PerTab(19) = 40.078 : PerTab(20) = 44.955
        PerTab(21) = 47.867 : PerTab(22) = 50.9415 : PerTab(23) = 51.9961
        PerTab(24) = 54.938 : PerTab(25) = 55.845 : PerTab(26) = 58.933
        PerTab(27) = 58.6934 : PerTab(28) = 63.546 : PerTab(29) = 65.38
```

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```
PerTab(30) = 69.723 : PerTab(31) = 72.63 : PerTab(32) = 74.9216
PerTab(33) = 78.96 : PerTab(34) = 79.904 : PerTab(35) = 83.798
PerTab(36) = 85.4678 : PerTab(37) = 87.62 : PerTab(38) = 88.90585
PerTab(39) = 91.224 : PerTab(40) = 92.90638 : PerTab(41) = 95.96
PerTab(42) = 98 : PerTab(43) = 101.07 : PerTab(44) = 102.9
PerTab(45) = 106.42 : PerTab(46) = 107.8682 : PerTab(47) = 112.411
PerTab(48) = 114.818 : PerTab(49) = 118.71 : PerTab(50) = 121.76
PerTab(51) = 127.6 : PerTab(52) = 126.9 : PerTab(53) = 131.293
PerTab(54) = 132.9 : PerTab(55) = 137.327 : PerTab(56) = 138.9
PerTab(57) = 140.116 : PerTab(58) = 140.9 : PerTab(59) = 144.242
PerTab(60) = 145 : PerTab(61) = 150.36 : PerTab(62) = 151.964
PerTab(63) = 157.25 : PerTab(64) = 158.92 : PerTab(65) = 162.5
PerTab(66) = 164.93 : PerTab(67) = 167.259 : PerTab(68) = 168.93
PerTab(69) = 173.054 : PerTab(70) = 174.9668 : PerTab(71) = 178.49
PerTab(72) = 180.94 : PerTab(73) = 183.84 : PerTab(74) = 186.207
PerTab(75) = 190.23 : PerTab(76) = 192.217 : PerTab(77) = 195.084
PerTab(78) = 196.96 : PerTab(79) = 200.59 : PerTab(80) = 204.38
PerTab(81) = 207.2 : PerTab(82) = 208.98 : PerTab(83) = 209
PerTab(84) = 210 : PerTab(85) = 222 : PerTab(86) = 223
PerTab(87) = 226 : PerTab(88) = 227 : PerTab(89) = 232.03
PerTab(90) = 231.03 : PerTab(91) = 238.02 : PerTab(92) = 237
PerTab(93) = 244 : PerTab(94) = 243 : PerTab(95) = 247
PerTab(96) = 247 : PerTab(97) = 251 : PerTab(98) = 252
PerTab(99) = 257 : PerTab(100) = 258 : PerTab(101) = 259
```

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```
PerTab(102) = 262 : PerTab(103) = 267 : PerTab(104) = 268
PerTab(105) = 271 : PerTab(106) = 272 : PerTab(107) = 270
PerTab(108) = 276 : PerTab(109) = 281 : PerTab(110) = 280
PerTab(111) = 285 : PerTab(112) = 284 : PerTab(113) = 289
PerTab(114) = 288 : PerTab(115) = 293 : PerTab(116) = 294
PerTab(117) = 294

'element names
Element(0) = "H" : Element(1) = "He" : Element(2) = "Li"
Element(3) = "Be" : Element(4) = "B" : Element(5) = "C"
Element(6) = "N" : Element(7) = "O" : Element(8) = "F"
Element(9) = "Ne" : Element(10) = "Na" : Element(11) = "Mg"
Element(12) = "Al" : Element(13) = "Si" : Element(14) = "P"
Element(15) = "S" : Element(16) = "Cl" : Element(17) = "Ar"
Element(18) = "K" : Element(19) = "Ca" : Element(20) = "Sc"
Element(21) = "Ti" : Element(22) = "V" : Element(23) = "Cr"
Element(24) = "Mn" : Element(25) = "Fe" : Element(26) = "Co"
Element(27) = "Ni" : Element(28) = "Cu" : Element(29) = "Zn"
Element(30) = "Ga" : Element(31) = "Ge" : Element(32) = "As"
Element(33) = "Se" : Element(34) = "Br" : Element(35) = "Kr"
Element(36) = "Rb" : Element(37) = "Sr" : Element(38) = "Y"
Element(39) = "Zr" : Element(40) = "Nb" : Element(41) = "Mo"
Element(42) = "Tc" : Element(43) = "Ru" : Element(44) = "Rh"
Element(45) = "Pd" : Element(46) = "Ag" : Element(47) = "Cd"
```

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```
Element(48) = "In" : Element(49) = "Sn" : Element(50) = "Sb"
Element(51) = "Te" : Element(52) = "I" : Element(53) = "Xe"
Element(54) = "Cs" : Element(55) = "Ba" : Element(56) = "La"
Element(57) = "Ce" : Element(58) = "Pr" : Element(59) = "Nd"
Element(60) = "Pm" : Element(61) = "Sm" : Element(62) = "Eu"
Element(63) = "Gd" : Element(64) = "Tb" : Element(65) = "Dy"
Element(66) = "Ho" : Element(67) = "Er" : Element(68) = "Tm"
Element(69) = "Tb" : Element(70) = "Lu" : Element(71) = "Hf"
Element(72) = "Ta" : Element(73) = "W" : Element(74) = "Re"
Element(75) = "Os" : Element(76) = "Ir" : Element(77) = "Pt"
Element(78) = "Au" : Element(79) = "Hg" : Element(80) = "Tl"
Element(81) = "Pb" : Element(82) = "Bi" : Element(83) = "Po"
Element(84) = "At" : Element(85) = "Rn" : Element(86) = "Fr"
Element(87) = "Ra" : Element(88) = "Ac" : Element(89) = "Th"
Element(90) = "Pa" : Element(91) = "U" : Element(92) = "Np"
Element(93) = "Pu" : Element(94) = "Am" : Element(95) = "Cm"
Element(96) = "Bk" : Element(97) = "Cf" : Element(98) = "Es"
Element(99) = "Fm" : Element(100) = "Md" : Element(101) = "No"
Element(102) = "Lr" : Element(103) = "Rf" : Element(104) = "Db"
Element(105) = "Sg" : Element(106) = "Bh" : Element(107) = "Hs"
Element(108) = "Mt" : Element(109) = "Ds" : Element(110) = "Rg"
Element(111) = "Cn" : Element(112) = "Nh" : Element(113) = "Fl"
Element(114) = "Mc" : Element(115) = "Lv" : Element(116) = "Ts"
Element(117) = "Og"
```

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```
        Me.Text = "Program 2.5"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Label1.Text = "Enter formula:"
        Label2.Text = "Molecular Weight:"
        Label3.Text = "Equivalent Weight:"
        Button1.Text = "&calculate weights"
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim compoundStr As String = TextBox1.Text
        Dim i As Integer = 0
        Dim len As Integer = compoundStr.Length
        Dim MolWt As Double = 0.0
        Dim tmp As Double = 0.0
        Dim Valency As Double
        While i < len
            'skip any leading white space
            While Char.IsWhiteSpace(compoundStr.Chars(i))
                i += 1
            End While
            'check for braced expressions
```

```
            If compoundStr.Chars(i) = "(" Then
                'error occured during parsing
                If getSegment(compoundStr, i, len, tmp) = 0 Then
                    Exit Sub
                End If
                MolWt += tmp
                Continue While
            End If
            'error occured during parsing
            If getElem(compoundStr, i, len, tmp) = 0 Then
                Exit Sub
            End If
            MolWt += tmp
        End While
        TextBox3.Text = FormatNumber(MolWt, 2)
        Valency = Val(TextBox2.Text)
        If Valency = 0.0 Then
            Valency = 1.0
        End If
        TextBox4.Text = FormatNumber(MolWt / Valency, 2)
    End Sub

    Public Function getSegment(ByRef compoundStr As String, ByRef i As
Integer, len As Integer, ByRef Result As Double) As Integer
```

```
        If compoundStr.Chars(i) <> "(" Then
            Return 0
        End If
        'skip '('
        i += 1
        Dim MolWt As Double = 0.0
        Dim tmp As Double = 0.0
        Dim fact As Integer = 0
        While i < len
            'skip any leading white space
            While Char.IsWhiteSpace(compoundStr.Chars(i))
                i += 1
            End While
            'end of braced expression
            If compoundStr.Chars(i) = ")" Then
                Exit While
            End If
            tmp = 0
            'check for braced expressions
            If compoundStr.Chars(i) = "(" Then
                'error occured during parsing
                If getSegment(compoundStr, i, len, tmp) = 0 Then
                    Return 0
                End If
```

```
            Else
                'error occured during parsing
                If getElem(compoundStr, i, len, tmp) = 0 Then
                    Return 0
                End If
            End If
            MolWt += tmp
        End While
        'check for a missing ')'
        If compoundStr.Chars(i) <> ")" Then
            MsgBox("Error: Missing ')' in formula.", vbCritical Or vbOKOnly)
            Return 0
        End If
        i += 1
        fact = 0
        While i < len AndAlso Char.IsDigit(compoundStr.Chars(i))
            fact = (fact * 10) + Integer.Parse(compoundStr.Chars(i))
            i += 1
        End While
        If fact <> 0 Then
            MolWt *= fact
        End If
        Result = MolWt
        Return 1
```

```
    End Function


    Public Function getElem(ByRef compoundStr As String, ByRef i As Integer,
len As Integer, ByRef Result As Double) As Integer
        Dim MolWt As Double = 0.0
        Dim arrIndex As Integer
        Dim fact As Integer = 0
        If Char.IsUpper(compoundStr.Chars(i)) Then
            Dim name As String
            If i < len - 1 AndAlso Char.IsLower(compoundStr.Chars(i + 1))
Then
                name = compoundStr.Chars(i) + compoundStr.Chars(i + 1)
                i += 2
            Else
                name = compoundStr.Chars(i)
                i += 1
            End If
            arrIndex = getIndex(name)
            If arrIndex = -1 Then
                MsgBox("Error: Invalid element name: " + name, vbCritical Or
vbOKOnly)
                Return 0
            End If
            MolWt = PerTab(arrIndex)
```

```
            While i < len AndAlso Char.IsDigit(compoundStr.Chars(i))
                fact = (fact * 10) + Integer.Parse(compoundStr.Chars(i))
                i += 1
            End While
            If fact <> 0 Then
                MolWt *= fact
            End If
            Result = MolWt
            Return 1
        End If
        Return 0
    End Function

    Public Function getIndex(name As String) As Integer
        Dim i As Integer
        For i = 0 To TotalElements - 1
            If Element(i).Equals(name) Then
                Return i
            End If
        Next
        Return -1
    End Function
End Class
```

6)

Solution

1) Given: wt. H_2SO_4 = 2.5 g, V = 4 L.
2) Find the equivalent weight of the compound H_2SO_4 as:EW = MW/av = [2*1 + 32 + 4*16]/2 = 98/2 = 49.
3) Use the equation of normality as:N = (wt/EW)/V
4) Substitute the values given in step 1 into step 3 above to find the normality of the acid:N = (2.5g/49)/4 L, which yields N = 0.013N
5) Find the molecular weight of the compound H_2SO_4 as:MW = Summation of atomic weights of acid = [2*1 + 32 + 4*16] = .98
6) Use the equation of molarity as:M = (wt/MW)/V
7) Substitute the values given in step 1 into step 3 above to find the molarity of the acid:
8) M = (2.5g)/98)/4 L, which yields M = 0.0063M

Program 2.6: Normality and Molarity

To save space, this program listing is truncated. The parts that are similar to Program 2.5 are marked as such.

```
Public Class Form1
    Dim PerTab(118) As Double
    Dim Element(118) As String
    Const TotalElements = 118
```

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```
    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        '*******************************************************'
        ' The code that loads the arrays with values from the periodic table
        ' has been truncated. It can be found from Program 2.5 listing.
        '*******************************************************'
       ……
        Me.Text = "Program 2.6"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Label1.Text = "Enter formula:"
        Label2.Text = "Valency:"
        Label3.Text = "Weight (g):"
        Label4.Text = "Volume (L):"
        Label5.Text = "Normality (N):"
        Label6.Text = "Molarity (M):"
        Button1.Text = "&Calculate"
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim compoundStr As String = TextBox1.Text
        Dim i As Integer = 0
```

```
        Dim len As Integer = compoundStr.Length
        Dim MolWt As Double = 0.0
        Dim tmp As Double = 0.0
        Dim Valency As Double
        Dim Wt, Vol As Double
        Dim N, M As Double
        While i < len
            'skip any leading white space
            While Char.IsWhiteSpace(compoundStr.Chars(i))
                i += 1
            End While
            'check for braced expressions
            If compoundStr.Chars(i) = "(" Then
                'error occured during parsing
                If getSegment(compoundStr, i, len, tmp) = 0 Then
                    Exit Sub
                End If
                MolWt += tmp
                Continue While
            End If
            'error occured during parsing
            If getElem(compoundStr, i, len, tmp) = 0 Then
                Exit Sub
            End If
```

```
            MolWt += tmp
        End While
        Valency = Val(TextBox2.Text)
        If Valency = 0.0 Then
            Valency = 1.0
        End If
        Wt = Val(TextBox3.Text)
        Vol = Val(TextBox4.Text)
        N = (Wt / (MolWt / Valency)) / Vol
        M = (Wt / MolWt) / Vol
        TextBox5.Text = FormatNumber(N, 4)
        TextBox6.Text = FormatNumber(M, 4)
    End Sub

        '*******************************************************'
        ' The code for getSegment(…), getElem(…) and getIndex(…) functions
        ' has been truncated. It can be found from Program 2.5 listing.
        '*******************************************************'
       ……
End Class
```

7)

Solution:

1) Given: fructose. $CH_2OH(CHOH)_3COCH_2OH$, and compound zincdimethyl-

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dithiocarbamate $Zn[S_2CN(CH_3)_2]_2$.

2) Determine the molecular weight of fructose $CH_2OH(CHOH)_3COCH_2OH$ as: MWfructose = 12*6+1*12 = 84
3) Compute the percentage of elements in fructose as:
4) % C in fructose = 6*12/84 = 85.7 %.
5) Determine the molecular weight of zincdimethyl-dithiocarbamate $Zn[S_2CN(CH_3)_2]_2$. as: MWcompund = 65+2*(32*2+12+14+2*(12+1*3)) = 305
6) Compute the percentage of zinc in zincdimethyl-dithiocarbamate as:
7) % Zn in compound = (1*65/305)*100 = 21.3%.

Program 2.7: Elemental Percentages

To save space, this program listing is truncated. The parts that are similar to Program 2.5 are marked as such.

```
Public Class Form1
    Dim PerTab(118) As Double
    Dim Element(118) As String
    Dim reqElementIndex As Integer
    Dim reqElementCount As Integer
    Const TotalElements = 118

    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
```

```
        '*******************************************************'
        ' The code that loads the arrays with values from the periodic table
        ' has been truncated. It can be found from Program 2.5 listing.
        '*******************************************************'
       ……
        Me.Text = "Program 2.7"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Label1.Text = "Enter formula:"
        Label2.Text = "Element Symbol to count its percentage:"
        Label3.Text = "Molecular Weight:"
        Label4.Text = "Percentage of requested element:"
        Button1.Text = "&calculate weights"
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim compoundStr As String = TextBox1.Text
        Dim i As Integer = 0
        Dim len As Integer = compoundStr.Length
        Dim MolWt As Double = 0.0
        Dim tmp As Double = 0.0
        Dim Valency As Double
        Dim tmp2 As Integer = 0
```

```
        Dim perc As Double
        Dim reqElementName As String
        reqElementName = TextBox2.Text
        reqElementCount = 0
        reqElementIndex = getIndex(reqElementName)
        If reqElementIndex = -1 Then
            MsgBox("Invalid element symbol: " + reqElementName)
            Exit Sub
        End If


        While i < len
            'skip any leading white space
            While Char.IsWhiteSpace(compoundStr.Chars(i))
                i += 1
            End While
            'check for braced expressions
            If compoundStr.Chars(i) = "(" Then
                'error occured during parsing
                If getSegment(compoundStr, i, len, tmp, tmp2) = 0 Then
                    Exit Sub
                End If
                MolWt += tmp
                reqElementCount += tmp2
                Continue While
```

```
            End If
            'error occured during parsing
            If getElem(compoundStr, i, len, tmp, tmp2) = 0 Then
                Exit Sub
            End If
            MolWt += tmp
            reqElementCount += tmp2
        End While
        TextBox3.Text = FormatNumber(MolWt, 2)
        perc = reqElementCount * PerTab(reqElementIndex) / MolWt
        TextBox4.Text = FormatNumber(perc * 100, 2) + "%"
    End Sub

    Public Function getSegment(ByRef compoundStr As String, ByRef i As
Integer, len As Integer, ByRef Result As Double, ByRef Result2 As Integer) As
Integer
        If compoundStr.Chars(i) <> "(" Then
            Return 0
        End If
        'skip '('
        i += 1
        Dim MolWt As Double = 0.0
        Dim tmp As Double = 0.0
        Dim fact As Integer = 0
```

```
        Dim count As Integer = 0
        Dim tmp2 As Integer = 0
        While i < len
            'skip any leading white space
            While Char.IsWhiteSpace(compoundStr.Chars(i))
                i += 1
            End While
            'end of braced expression
            If compoundStr.Chars(i) = ")" Then
                Exit While
            End If
            tmp = 0
            tmp2 = 0
            'check for braced expressions
            If compoundStr.Chars(i) = "(" Then
                'error occured during parsing
                If getSegment(compoundStr, i, len, tmp, tmp2) = 0 Then
                    Return 0
                End If
            Else
                'error occured during parsing
                If getElem(compoundStr, i, len, tmp, tmp2) = 0 Then
                    Return 0
                End If
```

```
            End If
            MolWt += tmp
            count += tmp2
        End While
        'check for a missing ')'
        If compoundStr.Chars(i) <> ")" Then
            MsgBox("Error: Missing ')' in formula.", vbCritical Or vbOKOnly)
            Return 0
        End If
        i += 1
        fact = 0
        While i < len AndAlso Char.IsDigit(compoundStr.Chars(i))
            fact = (fact * 10) + Integer.Parse(compoundStr.Chars(i))
            i += 1
        End While
        If fact <> 0 Then
            MolWt *= fact
            count *= fact
        End If
        Result = MolWt
        Result2 = count
        Return 1
    End Function
```

```
    Public Function getElem(ByRef compoundStr As String, ByRef i As Integer,
len As Integer, ByRef Result As Double, ByRef Result2 As Integer) As Integer
        Dim MolWt As Double = 0.0
        Dim arrIndex As Integer
        Dim fact As Integer = 0
        Dim count As Integer = 0
        If Char.IsUpper(compoundStr.Chars(i)) Then
            Dim name As String
            If i < len - 1 AndAlso Char.IsLower(compoundStr.Chars(i + 1))
Then
                name = compoundStr.Chars(i) + compoundStr.Chars(i + 1)
                i += 2
            Else
                name = compoundStr.Chars(i)
                i += 1
            End If
            arrIndex = getIndex(name)
            If arrIndex = -1 Then
                MsgBox("Error: Invalid element name: " + name, vbCritical Or
vbOKOnly)
                Return 0
            End If
            MolWt = PerTab(arrIndex)
            If arrIndex = reqElementIndex Then
```

```
                count = 1
            End If
            While i < len AndAlso Char.IsDigit(compoundStr.Chars(i))
                fact = (fact * 10) + Integer.Parse(compoundStr.Chars(i))
                i += 1
            End While
            If fact <> 0 Then
                MolWt *= fact
                count *= fact
            End If
            Result = MolWt
            Result2 = count
            Return 1
        End If
        Return 0
    End Function

        '*******************************************************'
        ' The code for getIndex(…) function
        ' has been truncated. It can be found from Program 2.5 listing.
        '*******************************************************'
       ……
End Class
```

8)

Solution:

1) Given: $[H^+]$ or $[OH^-]$ ion concentration.
2) Find the hydromium ion concentration using equation:

   pH = - log{H+} = log 1/[H+]

3) Substitute the values given in step 1 into equation to determine the pH of the solution:
4) Otherwise use equation

   pOH = 14 – pH to compute pH value.

5) Use scale 1 to 14 to differentiate between the acidity of different solutions (1 to 7 acidic and 7 to 14 alkaline).

Program 2.8: pH Calculation

```
Public Class Form1
    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        Me.Text = "Program 2.8"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        RadioButton1.Text = "[H+]:"
        RadioButton2.Text = "[OH-]:"
        RadioButton1.Checked = True
        RadioButton2.Checked = False
        TextBox2.Enabled = False
```

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```
        Label1.Text = "pH:"
        Button1.Text = "&Calculate pH"
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        Dim conc As Double
        Dim pH As Double
        Dim msg As String
        If RadioButton1.Checked Then
            conc = Val(TextBox1.Text)
            pH = -Math.Log10(conc)
        Else
            conc = Val(TextBox1.Text)
            Dim pOH As Double
            pOH = -Math.Log10(conc)
            pH = 14.0 - pOH
        End If
        msg = FormatNumber(pH, 1)
        If pH >= 1.0 And pH < 7.0 Then
            msg += " (Acidic)"
        ElseIf pH >= 7.0 And pH <= 14 Then
            msg += " (Alkaline)"
        Else msg += " (Out of range)"
```

```
        End If
        TextBox3.Text = msg
    End Sub

    Private Sub RadioButton1_CheckedChanged(sender As Object, e As EventArgs)
Handles RadioButton1.CheckedChanged
        If RadioButton1.Checked Then
            TextBox1.Enabled = True
            TextBox2.Enabled = False
        End If
    End Sub

    Private Sub RadioButton2_CheckedChanged(sender As Object, e As EventArgs)
Handles RadioButton2.CheckedChanged
        If RadioButton2.Checked Then
            TextBox2.Enabled = True
            TextBox1.Enabled = False
        End If
    End Sub
End Class
```

9)

Solution:

1) Given: concentration of cations involving calcium, magnesium, sodium, strontium and

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iron, and anions containing: chloride, sulfate, nitrate, carbonate and bicarbonate, the total hardness and percent experimental error.

2) Find concentration of different substances in terms of milliequivalent/L by dividing given concentrations in mg/L, by the equivalent weight of each substance.
3) Convert the concentrations expressed as milliequivalent/L calculated in 2 above to mg/L as $CaCO_3$. This is to be done by multiplying the concentrations of equivalent/L by the equivalent weight of $CaCO_3$. EW of $CaCO_3$ = (40+12+16*3)/2 = 50. Tabulate your results.
4) Use value of experimental error to identify missing concentration of anion or cation as deemed necessary.
5) Use value of total hardness = Ca++ + Mg++ + Sr++ = mg/L $CaCO_3$ in your computations where appropriate.

Program 2.9: Ion Concentration

```
Public Class Form1
    Dim ions() As String =
        {
        "Ca++", "Mg++", "Sr++", "Fe++",
        "HCO3-", "SO4-", "Cl-", "NO3-", "SiO3-"
        }
    Dim EW() As Double =
        {
```

```
        20, 12.15, 44, 28,
        61, 48, 35.5, 62, 76
        }
    Const totalIons = 9

    Private Sub Form1_Load(sender As Object, e As EventArgs) Handles
MyBase.Load
        Me.Text = "Program 2.9"
        Me.FormBorderStyle = FormBorderStyle.FixedSingle
        Me.MaximizeBox = False
        Label1.Text = "Fill in the cation and anion concentration in the
table," + vbCrLf
        Label1.Text += "enter a value for percent experimental error," + vbCr
        Label1.Text += "then click Calculate." + vbCr
        Label1.Text += "The first empty ion will be considered the"
        Label1.Text += " value to be calculated"
        Label2.Text = "Percent experimental error:"
        Button1.Text = "&Calculate"
        DataGridView1.Rows.Clear()
        DataGridView1.Columns.Clear()
        DataGridView1.Columns.Add("ion", "Ions")
        DataGridView1.Columns.Add("concMgL", "Conc. mg/L")
        DataGridView1.Rows.Add(totalIons)
        Dim i As Integer
```

```
        For i = 0 To totalIons - 1
            DataGridView1.Rows(i).Cells("ion").Value = ions(i)
        Next
        DataGridView1.AllowUserToAddRows = False
        DataGridView1.AllowUserToDeleteRows = False
        DataGridView1.AllowUserToOrderColumns = False
    End Sub

    Private Sub Button1_Click(sender As Object, e As EventArgs) Handles
Button1.Click
        If DataGridView1.ColumnCount <> 5 Then
            DataGridView1.Columns.Add("EW", "EW mg/meq")
            DataGridView1.Columns.Add("concMeqL", "Conc. meq/L")
            DataGridView1.Columns.Add("concCaCO3", "Conc. mg/L CaCO3")
        End If
        Dim i As Integer
        Dim missingValIndex As Integer = -1
        Dim mgL, meqL, CaCO3 As Double
        Dim totMeqL As Double = 0.0
        Dim totCations As Double = 0
        Dim totAnions As Double = 0
        For i = 0 To totalIons - 1
            DataGridView1.Rows(i).Cells("EW").Value = EW(i).ToString
            mgL = Val(DataGridView1.Rows(i).Cells("concMgL").Value)
```

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```
            If mgL = 0 Then
                If missingValIndex <> -1 Then
                    MsgBox("Error: More than one missing value!.", vbCritical
Or vbOKOnly)
                    Exit Sub
                End If
                missingValIndex = i
            Else
                meqL = mgL / EW(i)
                DataGridView1.Rows(i).Cells("concMeqL").Value =
FormatNumber(meqL, 2)
                CaCO3 = meqL * 50
                DataGridView1.Rows(i).Cells("concCaCO3").Value =
FormatNumber(CaCO3, 2)
                totMeqL += meqL
                If i < 4 Then
                    totCations += meqL
                Else
                    totAnions += meqL
                End If
            End If
        Next
        If missingValIndex = -1 Then
            Exit Sub
```

```
        End If
        '***********************
        'calculate value of x
        '***********************
        Dim x, y As Double
        Dim err As Double = Val(TextBox1.Text)
        If err > 1 Then
            err /= 100
        End If
        If missingValIndex < 4 Then
            'missing is cation
            Dim a As Double = (err * totCations) - totCations + totAnions
            Dim b As Double = 1 - err
            x = a / b
        Else
            'missing is anion
            x = totCations - totAnions - (err * totCations)
        End If
        y = x * EW(missingValIndex)
        DataGridView1.Rows(missingValIndex).Cells("concMgL").Value =
FormatNumber(y, 2)
        DataGridView1.Rows(missingValIndex).Cells("concMeqL").Value =
FormatNumber(x, 2)
        CaCO3 = x * 50
```

```
        DataGridView1.Rows(missingValIndex).Cells("concCaCO3").Value =
FormatNumber(CaCO3, 2)
    End Sub
End Class
```

10)

Solution:

- Given: concentration of ions and experimental error of 3% .
- Determine concentration of given species in units of milliequivalent/L by dividing given concentration (mg/L), by the equivalent weight of each substance, i.e. $C_{meq} = C_{mg/L}/EW$.
- Convert concentrations (milliequivalent/L) to units of mg/L as $CaCO_3$. This is achieved by multiplying concentrations of milliequivalent/L by equivalent weight (EW) of $CaCO_3$.

  Equivalent weight of calcium carbonate = molecular weight of calcium carbonate (MW)/valency (Z), i.e.,

  EW of $CaCO_3$ = MW/Z = (40+12+16*3)/2 = 50.

  Tabulate results as in the table shown below:

Constituent	**EW**	**Concentration**		
	mg/meq	**C, mg/L**	**c = C/EW, meq/L**	**c*50, (mg/L $CaCO_3$)**
Cations				
Ca^{++}	20	35	1.75	87.5

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Mg^{++}	12.15	40	3.29	165
Sr^{++}	44	9	0.2	10
Fe^{++}	28	23	0.82	41
		Sum	**6.06**	
Anions				
HCO_3^-	61	122	2	100
SO_4^{--}	48	34	0.71	35
Cl^-	35.5	**y**	**y/35.5**	
NO_3^-	62	22	0.35	18
SiO_3^-	76	14	0.18	9
		Sum	**3.24+y/35.5**	

- For a percent error of 3% = Sum of cations – sum of anions/sum of cations

  Error = 0.03 = (6.06 – (3.24 + x))/6.06

  This yields, x = 2.638meq/l

  Thus chloride concentration y = 2.638*35.5 = 52.85 mg Cl^-/l.

  This gives 2.638*50 = 131.9 mg/L as $CaCO_3$.

  (Check error = (6.06 – 3.24 -2.638))/6.06 = 3% O.K.)

11)

Solution:

1) Given: either CH_3CH_2 = 0.1M, glycerol $CH_2OH.CHOH.CH_2OH$ = 5g and uric acid $C_5H_4O_3N_4$ = 20 mg/L.

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2) Determine the number of oxygen moles that react with ether as shown by the reaction equation:

   $4CH_3CH_2 + 13O_2 = 10H_2O + 8CO_2$

   Find the molecular weight of ether = (12*2+1*5) = 29.

   The equation reveals that 4*29 of ether reacts with 13*32 of Oxygen.

   Therefore, 0.1M ether reacts with x of O_2.

   Thus, the amount of Oxygen needed to oxidize ether is, x = 0.1*(13*32*1000)/116 = 358.62 mg/L.

3) The aerobic oxidation of glycerol may be represented by the following reaction equation:

   $2CH_2OH.CHOH.CH_2OH + 7O_2 = 8H_2O + 6CO_2$

   Determine the molecular weight of glycerol

   MW glycerol = 3*12+ 8*1+ 3*16 = 84.

   The equation reveals that 2*84 moles glycerol reacts with 7*32 moles of O_2

   Therefore, 5 g of glycerol reacts with y moles O_2,

   Thus, the amount of Oxygen needed to oxidize the glycerol may be computed as: y = 7*32*1000/168 = 1333.3 mg/L.

4) The aerobic oxidation of uric acid may be represented by the following reaction equation:

   $2C_5H_4O_3N_4 + 21O_2 = 4H_2O + 8NO_3 + 10CO_2$

   Find the molecular weight of uric acid = 12*5+4*1+3*16+ 4*14 = 168.

   The equation reveals that 2*168 moles Hexane reacts with 21*32 moles of O_2

   Therefore, 20 mg of uric acid reacts with z moles O_2,

   Thus, the amount of Oxygen needed to oxidize the uric acid may be computed as: z = (21*32)/336 = 2 mg/L.

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5) Determine the total BOD as:

Total BOD = amount of oxygen needed to oxidize either + amount of oxygen needed to oxidize glycerol + amount of Oxygen needed to oxidize uric acid = x + y + z = 358.62 + 1333.3 + 2 = 1693.92 mg/L.

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Chapter Three: Computer Modeling Applications for Water Resources, Usage, Groundwater and Water Storage and Distribution

3.9 Homework Problems in Water Resources, Water Storage and Distribution

3.9.1 Discussion Problems

1)

Solution:

See Section 3.2 of Chapter 3 of the book.

2)

Solution:

See Section 3.2 of Chapter 3 of the book.

3)

Solution:

Transmissibility: rate at which water of prevailing kinematic viscosity is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Equation 3.14 may be used for determination of transmissibility of an aquifer.

$$TR \quad kh \tag{3.14}$$

Where:

TR = Transmissibility of aquifer, $m^3/d*m$.

k = Permeability coefficient, m/d.

h = Saturated thickness of aquifer, m.

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