MISCELLANEOUS I - Simple solution calculations using n=CV

1. Calculate the mass of $NaNO_3$ required to prepare a 400ml solution of 0.150mol/L $NaNO_3$ solution.

2. A solution is prepared by dissolving 45g of K_2SO_4 into 2.5L of distilled water. Calculate;
a) The concentration of K+ ions?
b) The concentration of sulfate ions?

3. How many moles of $AgNO_3$ are present in a 125ml sample of 0.215mol/L $AgNO_3$ solution?

4. What volume of water needs to be added to 12g of pure sodium fluoride to produce a solution with a concentration of 2.50mol/L?

5. What is the concentration of a solution prepared by dissolving 38g of Aluminium nitrate in 120ml of water?

6. What mass of solid oxalic acid crystals (formula $H_2C_2O_4.2H_2O$) needs to be used to make a 1.05L sample of 0.420mol/L $H_2C_2O_4$ solution?

7. What mass of $CuSO_4.5H_20$ crystals would remain in a beaker if a 200ml of 0.525mol/L $CuSO_4$ solution is left to evaporate to dryness?

8. Consider a sample of 55ml of 0.425mol/L Iron(III) nitrate solution. Calculate the following
a) The concentration of Fe^{3+} ions
b) The concentration of NO_3^{1-} ions
c) The moles of Fe^{3+} ions
d) The moles of Nitrate ions
e) The mass of Fe present in the sample

9. What is the concentration (in mol/L) of Chloride ions when 5.09g of Aluminium Chloride is dissolved in 250ml of water?

10. A 100ml sample of a solution of sulfuric acid is known to have a H^+ ion concentration of 0.2mol/L. What is the concentration of H_2SO_4?

1 $n(NaNO_3) = cV$
$= 0.15 \times .4$
$= 0.06$ mols

$n(NaNO_3) = \frac{m}{Mr}$ Mr $NaNO_3 = 85$

$0.06 = \frac{m}{85} = 5.1$ g

2 a) $n(K_2SO_4) = \frac{m}{Mr}$

Mr $K_2SO_4 = 174.2$ $= \frac{45}{174.2}$
$= 0.2583$ mols

$n(K_2SO_4) \times 2 = n(K^+)$
$= 0.5166$ mols.
$n(K^+) = cV$
$0.5166 = c \times 2.5$
$c = 0.2066$ mol L^{-1} or 0.21 mol L

b) $n(K_2SO_4) = n(SO_4^{2-})$
$= 0.2583$ mols.

$n(SO_4^{2-}) = cV$
$0.2583 = c \times 2.5$
$c = 0.1033$ mol L^{-1} or 0.1 mol L

3 $n(AgNO_3) = cV = 0.215 \times .125 = 0.026875$ mols,
or 2.69×10^{-2} mols.

4 $n(NaF) = \frac{m}{Mr}$

Mr NaF $= 42$ $= \frac{12}{42}$
0.2857 mols

$n(NaF) = cV$
$0.2857 = 2.5 \times V$
$V = 0.114$ L or 114 mL.

5 $n(Al(NO_3)_3 = \frac{m}{Mr}$

Mr $Al(NO_3)_3 = 213$ $= \frac{38}{218} = 0.1784$ mols

$n(Al(NO_3)_3 = cV$
$0.1784 = c \times 0.12$
$c = 1.49$ mol L^{-1}

6 $n(K_2C_2O_4.2H_2O) = cV$
0.441 mols $= 0.42 \times 1.05$
Mr $K_2C_2O_4.2H_2O = 126$

$n(K_2C_2O_4.2H_2O) = \frac{m}{Mr}$
$0.441 = \frac{m}{126}$
$= 55.6$ g.

7 $n(CuSO_4 . 5H_2O) = CV$

$= 0.525 \times 0.2$

$= 0.105$ mols

$n = \frac{m}{Mr}$

$0.105 = \frac{m}{249.55}$

$= 26.2g$

Mr $CuSO_4 . 5H_2O$

$249.55 = 159.55 + 90$

8 a) $Fe(NO_3)_3 \xrightarrow{H_2O} Fe^{3+}_{(aq)} + 3NO_3^-{}_{(aq)}$

0.425 mol L^{-1} = Fe^{3+}

b) $n(Fe(NO_3)_3) \times 3 = n(NO_{3(aq)})$

0.425 mol $L^{-1} \times 3 = 1.275$ mol L^{-1}

c) $n(Fe(NO_3)_3) = CV$

$= 0.425 \times 0.055$

$n(Fe(NO_3)_3) = n(Fe)$

$= 0.02337$ mols

d) $0.02337 \times 3 = 0.070$ mols.

e) $n(Fe) = \frac{m}{Mr}$ $0.02337 = \frac{m}{55.85} = 1.305g$

9 $n(AlCl_3) = \frac{5}{133.35} = 0.0375$ mols

Mr $AlCl_3 = 133.35$

$n = CV$

$0.0375 = C \times 0.25$

$C = 0.15$ mol L^{-1}

10 $n(H^+) = CV$

$= 0.2 \times 0.1$

$= 0.02$ mols

$n(H^+) \times \frac{1}{2} = n(H_2SO_4)$

$= 0.01$ mols

$n = CV$

$0.01 = C \times 1$

$= 0.01$ mol L^{-1}

Problems

1. Determine the pH of a solution that has a hydronium concentration of $2.6x10^{-4}M$.
2. Determine the hydronium concentration of a solution that has a pH of 1.7.
3. If a solution has a hydronium concentration of $3.6x10^{-8}M$ would this solution be basic or acidic?
4. What is the pH of a solution that has 12.2 grams of hydrochloric acid in 500 ml of water?
5. Why do acids cause burns?

Answers

1. Remembering the equation: $pH = -log[H_3O]$

Plug in what is given: pH=–log[2.6×10–4M]

When entered into a calculator: pH = 3.6

2. Remembering the equation: $[H_3O] = 10^{-pH}$

Plug in what is given: $[H_3O] = 10^{-1.7}$

When entered into a calculator: $1.995x10^{-2}M$

3. Determine pH the same way we did in question one: $pH = -log[3.6x10^{-8}]$

pH = 7.4 Because this pH is above 7 it is considered to be basic.

4. First write out the balanced equation of the reaction:

HCl(aq)+H2O(l)⇌H3O+(aq)+Cl−(aq)

Notice that the amount of HCl is equal to the amount of H3O+ produced due to the fact that all of the stoichiometric coefficents are one.

So if we can figure out concentration of HCl we can figure out concentration of hydronium.

Notice that the amount of HCl given to us is provided in grams. This needs to be changed to moles in order to find concentration:

12.2gHCl×1molHCl36.457g=0.335molHCl

Concentration is defined as moles per liter so we convert the 500mL of water to liters and get .5 liters.

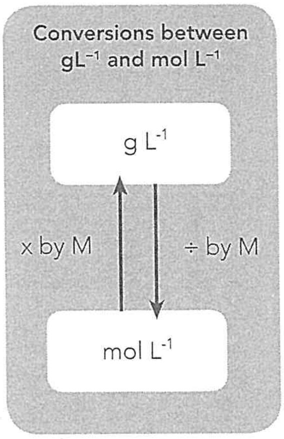
0.335molHCl0.5L=0.67M

Using this concentration we can obtain pH: pH = -log[.67M] pH=0.17

5. Acids cause burns because they dehydrate the cells they are exposed to. This is caused by the dissociation that occurs in acids where H^+ions are formed. These H^+ ions bond with water in the cell and thus dehydrate them to cause cell damage and burns.

Worked Example 9.1

A solution of sodium carbonate is made up by dissolving 4.65 g of this substance to make up 250.0 mL of solution. Calculate the concentration of this solution in:
(a) moles per litre; (b) grams per litre.



(a) Firstly determine moles of solute.

$$n = \frac{m}{M} = \frac{4.65}{105.99} = 0.0439 \text{ mol}$$

Hence find concentration of Na_2CO_3 solution.

$$c = \frac{n}{V} = \frac{0.0439}{0.250} = 0.175 \text{ mol L}^{-1}$$

(b) To find concentration in g L^{-1}.

$$c = \frac{\text{mass of solute}}{\text{volume of solution}} = \frac{4.65 \text{ g}}{0.250 \text{ L}} = 18.6 \text{ g L}^{-1}$$

Worked Example 9.2

(a) The concentration of ethanoic (acetic) acid (CH_3COOH) in a sample of vinegar is 38.5 g L^{-1}. What is the concentration in mol L^{-1}?

(b) A salt solution (NaCl) has a concentration of 0.150 mol L^{-1}. What is the concentration in g L^{-1}?

(a) c (CH_3COOH) in vinegar = 38.5 g L^{-1}

or $= \frac{38.5}{60.05} = 0.641 \text{ mol L}^{-1}$

(b) c (NaCl) in saline solution = 0.150 mol L^{-1}

or = (0.150) (58.44) = 8.77 g L^{-1}

Worked Example 9.3

The typical analysis for different spring waters varies with their source. One particular brand indicates total dissolved solids of only 80 ppm. What mass of solids would be contained in a 1.50 L bottle of this water? (Assume 1 L of spring water weighs 1 kg.)

c (solids) = 80 ppm = 80 mg per kg
∴ mass of solids = (80 mg) (1.5) = 120 mg = 0.12 g

Worked Example 9.4

A particular brand of beer contains 2.5% (w/w) alcohol (ethanol, CH_3CH_2OH). Determine:
(a) the ethanol concentration in mol L^{-1}
(b) the mass of ethanol in a 200.0 mL glass of this beer.

Assume density of the beer is 1.00 g mL^{-1}.

(a) 2.5% = 2.5 g / 100 g beer

= 25 g / 1000 mL beer (density = 1.00 g mL^{-1})

$= \frac{25}{46.07}$ ($M_{ethanol}$ = 46.07 g mol^{-1}) = 0.543 mol L^{-1}

(b) mass of ethanol = 2.5 g / 100 g ∴ = 5.0 g in 200 mL

Question 9.17

A solution of NaOH has a concentration of 1.75 mol L^{-1}.

(a) How many moles of NaOH would 5.0 L of this solution contain?

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(b) What mass of NaOH would be needed to make up 250 mL of this solution?

____

Question 9.18

A 2.50 kg sample of sea water was evaporated to dryness and 86.5 g of solids remained. Further analysis showed that 73.4 g of the solids were sodium chloride (NaCl). The density of the sea water was also determined to be 1.03 g mL^{-1}.

(a) Calculate the concentration of the solids in:

(i) % by mass ______________________________

(ii) ppm ______________________________

(b) Calculate the concentration of NaCl in sea water in:

(i) ppm ______________________________

(ii) moles per litre ______________________________

Hint: You may need to use density = mass/volume to find the volume of the 2.50 kg sample of sea water.

Question 9.19

Determine the concentration in g L^{-1} and mol L^{-1} of the solute in each of the following solutions.

(a) 20.0 g of potassium nitrate (KNO_3) in 250 mL of solution.

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(b) 87.7 g of alcohol (ethanol – CH_3CH_2OH) in a 750 mL bottle of wine.

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(c) 75.6 g of ethanoic acid (CH_3COOH) in a 2.0 L container of vinegar.

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(d) 44.5 g of sucrose ($C_{12}H_{22}O_{11}$) in a 375 mL can of soft drink.

____

9.15

(a)

(i) An increase in temperature increases solubility of solids.

(ii) An increase in temperature decreases solubility of gases.

(b) Yes, solubility of sugar at 50°C = 257 g/100g. ∴ 514 g would dissolve in 200 mL of water (we only put in 500 g).

(c)

(i) Crystals will appear when solution is saturated.

100 g/250 mL H_2O = 40 g/100 g H_2O

∴ occurs at ≈ 27°C.

(ii) saturated solution.

(iii) supersaturated solution.

9.16

(a) (i) Freezing point is lowered.

(ii) Boiling point is raised.

(b) Directly related to concentration of solute particles (mol L^{-1}), e.g. 200 g of MgF_2 has more effect than 200 g of NaCl because of the greater mol L^{-1} concentration and hence more ions in solution.

(c) Salt lowers the F.P. of water and hence the ice melts.

(d) Ethylene glycol lowers the F.P. of water and hence prevents the water in radiators from freezing in cold climates. In warm climates it allows water to reach a higher temperature before it boils.

(e) As water evaporates the remaining solution becomes more concentrated (salt does not evaporate) and hence boiling point is raised.

(f) A solute decreases the vapour pressure of a liquid, e.g. adding salt to boiling water reduces the vapour pressure of the water and hence boiling stops. At a higher temperature the vapour pressure of the water again reaches atmospheric pressure and boiling occurs.

9.17

(a) $n = cV = (1.75)(5.0) = 8.75$ mol

(b) for 250 mL of NaOH solution

$n = cV = (1.75)(0.25) = 0.4375$ mol

$m(NaOH) = nM = (0.4375)(40.0)$

$= 17.5$ g

9.18

(a)

(i) % solids (by mass)

$$= \frac{86.5}{2500} \times 100 = 3.46\%$$

(ii) $$ppm = \frac{86500 \text{ mg}}{2.50 \text{ kg}} = 34600 \text{ ppm}$$

(b)

(i) $$ppm\ (NaCl) = \frac{73400 \text{ mg}}{2.50 \text{ kg}} = 29360 \text{ ppm}$$

(ii) $$n\ (NaCl) = \frac{m}{M} = \frac{73.4}{58.44} = 1.26 \text{ mol}$$

$$\text{Volume } H_2O = \frac{m}{\rho} = \frac{2.50}{1.03} = 2.427 \text{ L}$$

$$\therefore c\ (NaCl) = \frac{n}{V} = \frac{1.25}{2.427} = 0.515 \text{ mol L}^{-1}$$

9.19

(a) $M(KNO_3) = 101.1$ g mol^{-1}

$$c = \frac{20 \text{ g}}{0.250 \text{ L}} = 80.0 \text{ g L}^{-1}$$

or $c = (80.0) \div (101.1) = 0.791$ mol L^{-1}

$$\text{or } c = \frac{n}{V} = \frac{20.0/101.1}{0.250} = 0.791 \text{ mol L}^{-1}$$

(b) $$c = \frac{87.7 \text{ g}}{0.750 \text{ L}} = 117 \text{ g L}^{-1}$$

or $c = (117) \div (46.068) = 2.54$ mol L^{-1}

$$\text{or } c = \frac{n}{V} = \frac{87.7/46.068}{0.750} = 2.54 \text{ mol L}^{-1}$$

(c) $$c = \frac{75.6 \text{ g}}{2.0 \text{ L}} = 37.8 \text{ g L}^{-1}$$

or $c = (37.8) \div (60.05) = 0.629$ mol L^{-1}

$$\text{or } c = \frac{n}{V} = \frac{75.6/60.05}{2.0} = 0.629 \text{ mol L}^{-1}$$

(d) $$c = \frac{44.5 \text{ g}}{0.375 \text{ L}} = 119 \text{ g L}^{-1}$$

or $c = (119) \div (342.3) = 0.348$ mol L^{-1}

$$\text{or } c = \frac{n}{V} = \frac{44.5/342.3}{0.375} = 0.348 \text{ mol L}^{-1}$$

9.20

(i) soluble – $Zn(NO_3)_2$, $AlCl_3$, $(NH_4)_3PO_4$ $MgSO_4$, $BaCl_2$, Na_2CO_3 , $NaNO_3$, NaCl

(ii) slightly soluble - $PbCl_2$, $Ca(OH)_2$, $CaSO_4$, Ag_2SO_4 , $PbBr_2$

(iii) insoluble - AgI , $BaSO_4$, AgCl , $PbSO_4$, $Mg(OH)_2$, AgBr

9.21

(a) No precipitate.

(b) $Zn(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow Zn(OH_2)_{(s)} + 2NaNO_{3(aq)}$

$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)}$

(c) $CaCl_{2(aq)} + 2AgNO_{3(aq)} \rightarrow 2AgCl_{(s)} + Ca(NO_3)_{2\,(aq)}$

$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$

(d) $BaCl_{2(aq)} + (NH_4)_2SO_{4\,(aq)} \rightarrow BaSO_{4\,(s)} + 2NH_4Cl_{\,(aq)}$

$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\,(s)}$

(e) $Pb(NO_3)_{2(aq)} + 2NaI_{(aq)} \rightarrow PbI_{2(s)} + 2NaNO_{3(aq)}$

$Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$