**External questions**

Q1: Calculate the number of mole of ammonia, NH3, required to produce 2.5 mol of Cu(NH3)4SO4 according to the equation :

**CuSO4 + 4NH3 Cu(NH3)~~4~~SO4**

Solve :

 **No. of mol of NH3 = No. of mol of Cu(NH3)~~4~~SO4 × 4**

 **= 2.5 × 4 = 10 mol of NH3**

Q2: Calculate the number of mole of Ca(HCO3)2 required to prepare 1.5 mol of CO2 according to the equation :

**Ca(HCO3)2 + 2HCl CaCl2 + 2CO2 + 2H2O**

Solve :

 **No. of mol of Ca(HCO3)2 = No. of mol of CO2× 0.5**

 **= 1.5 × 0.5 = 0.75 mol of Ca(HCO3)2**

Q3: Calculate the mass of BaCO3 produced when excess CO2 is bubbled through a solution containing 0.205 mol of Ba(OH)2 .

**Ba(OH)2 + CO2 BaCO3 + H2O**

Solve :

 **No. of mol of BaCO3 = No. of mol of Ba(OH)2 = 0.205 mol**

$Mol=\frac{wt}{M.wt}$ **wt. of BaCO3 = mol × M.wt**

 **Wt. of BaCO3 = 0.205 × 197.4= 40.5 gm**

Q4: Caustic soda, NaOH, can be prepared commercially by the reaction of Na2CO3 with slaked lime, Ca(OH)2 . How many gram of NaOH can be obtained by treating 1.000 kg of Na2CO3 with Ca(OH)2 ?

**Na2CO3 + Ca(OH)2 2NaOH + CaCO3**

Solve :

$mol=\frac{wt}{M.wt}$ **mol of Na2CO3 = 1000 gm / 106 gm . mol-1**

 **mol of Na2CO3= 9.433 mol of Na2CO3**

 **No. of mol of NaOH = 2 × No. of mol of Na2CO3 = 2× 9.433=18.87 mol**

 **wt of NaOH= mol × M.wt = 18.87 × 40 = 755 gm NaOH**

Q5: What mass of KI is needed to produce 69.6 gm of K2SO4 by the reaction :

**8KI + 5H2SO4 4K2SO4 + 4I2 + H2S + 4H2O**

Solve :

**No. of mol of K2SO4= wt / M.wt 69.6 gm / 174 gm . mol-1= 0.4 mol**

**No. of mol of KI = 2× 0.4= 0.8 mol**

**wt of KI= mol × M.wt = 0.8 × 166 = 133gm K**

Q6: What volume of 1.71 M NaCl solution contains 0.2 mol of NaCl ?

Solve :

**Molarity = mol / volume volume=mol / molarity**

**V = 0.2 / 1.71 = 0.117 L = 117 ml**

Q7: What volume of 0.3 M NaOH ( M.wt= 40 g mol-1) can be prepared with 84 gm NaOH ?

Solve :

$$M=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{V (mL)}$$

$$3.0= \frac{84 (g)}{40 (\frac{g}{mol})} × \frac{1000}{V (mL)}=700 ml$$

Q8: How many of water must be added to 200 ml of 0.65 M HCl to dilute the solution to 0.2 M ?

Solve :

**M1 V1 = M2 V2 200 × 0.65 = V2 × 0.2**

**V2 = 650 ml approximately 650 – 200 = 450 ml must be added**

Q9: How much 1.00 M HCl should be mixed with what volume of 0.25 M HCl in order to prepare 1.00 L of 0.500 M HCl ?

Solve :

**Let x= volume of 0.25 M HCl ; then 1.00- x = volume of 1.00 M HCl**

**No. of mol of S1 + No. of S2 = No. of S3**

**(1.00 – x) 1.00 + x (0.25) = 1.00(0.500)**

**Thus x= 0.667 L = 667 ml of 0.25 M HCl and 1.00 – x=**

**1.00 – 0.667=0.333 L = 333 ml**

Q10: What is the molar concentration of a solution containing 16 gm CH3OH in 200 ml solution ?

Solve :

$$M=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{V (mL)} = \frac{16 (g)}{32 (\frac{g}{mol})} × \frac{1000}{200 (mL)}=2.5 M$$

**Normality**

Q11: What is the difference between the definition of an equivalent in an acid- base reaction and an equivalent in an oxidation – reduction reaction?

Solve :

An equivalent in an acid – base reaction is that amount of a substance which reacts with or liberates 1 mol of hydrogen ions ; an equivalent in a redox reaction is that amount of substance which reacts with or liberates 1 mol of electrons .

Q12: What volume of a 0.232 N solution contains **(a)** 3.17 meq of solute **(b)** 6.5 eq of solute ?

Solve:

**(a )** $N=\frac{No.of milliequivalent}{Solution Volumn (ml)}$

$$Solution Volumn (ml)=\frac{No.of milliequivalent}{N}=\frac{3.17}{0.232}=13.7 ml$$

$$\left(b\right) Solution Volumn (L)=\frac{No.of equivalent}{N}=\frac{6.5}{0.232}=28.0 L$$

Q13: How many **(a)** equivalent and **(b)** milliequivalent of solute are present in 60 ml of 4.0 N solution ?

Solve:

**(a)** **No. of equivalent = No. of liters × normality = 0.060 × 4.0 = 0.24 eq .**

**(b)** **0.24 eq × 1000 = 240 meq .**

Q14: How many equivalent of solute are contained in **(a)** 1 L of 2 N solution , **(b)** 1L of 0.5 N solution , **(c)** 0.5 L of 0.2 N solution ?

**(a)** No. of eq = 2 eq , **(b)** No. of eq = 0.5 eq , **(c)** No. of eq = 0.1 eq

Q15: What is normality of 0.3 M H3PO3 when it undergoes the following reaction ? **H3PO3  + 2OH- HPO3-2 + 2H2O**

Solve:  **Normality = a × molarity = 2 × 0.3 = 0.6 N .**

Q16: How many cm3 of concentrated sulfuric acid , of density 1.84

g/ cm3 and containing 98.0 % H2SO4 by weight , should be taken to make **(a)** 1 L of 1 N solution **(b)** 1 L of 3 N solution **(c)** 200 cm3 of 0.5 N solution ?

**(a)** 27.2 cm3 ,**(b)** 81.7 cm3 , **(c)** 2.72 cm3.

**Mole fraction and Molality**

Q17: Calculate the mole fraction(x) of water in a mixture consisting of 9.0 gm water , 120 gm acetic acid , and 115 gm ethyl alcohol ?

Solve:

The molecular weight of water , acetic acid , and ethyl alcohol are 18 , 60 and 46 gm/mol , respectively .

**Molwater =wt / M.wt 9.0 / 18 = 0.5 mol**

**Molacetic acid =wt / M.wt 120 / 60 = 2.0 mol**

**Molethyl alcohol =wt / M.wt 115 / 46 = 2.5 mol**

**Sum of mole = 0.5 + 2.0 + 2.5 = 5.0 mole**

$$Mole fraction for waterX =\frac{no.mole water \left(n\_{1}\right)}{sum of mole}$$

$$Mole fraction for waterX =\frac{0.5 mole}{5.0 mole} =0.10$$

Q18: What is the mole fraction of H2 in a gaseous mixture containing 1.0 gm H2 , 8.0 gm O2 , and 16 gm CH4 ?

Solve:

**Mol H2 =wt / M.wt 1.0 / 2.0 = 0.5 mol**

**Mol O2 =wt / M.wt 8.0 / 32.0 = 0.25mol**

**Mol CH4 =wt / M.wt 16 / 16 = 1.0 mol**

**Sum of mole = 0.5 + 0.25 + 1.0 = 1.75 mole**

$$Mole fraction for H\_{2}(X) =\frac{no.mole H2 \left(n\_{1}\right)}{sum of mole}$$

$$Mole fraction for H\_{2}(X) =\frac{0.5 mole}{1.75 mole} =0.29$$

Q19: A solution contains 116 gm acetone ( CH3COCH3 ) , 138 gm ethyl alcohol ( C2H5OH ) , and 126 gm water . Determine the mole fraction of each ?

Solve:

**Mol acetone =wt / M.wt 116 / 58.0 = 2.0 mol**

**Mol C2H5OH =wt / M.wt 138 / 46.0 = 3.0mol**

**Mol water =wt / M.wt 126 / 18 = 7.0 mol**

**Sum of mole = 2.0 + 3.0 + 7.0 = 12.0 mole**

$$Mole fraction for (X) =\frac{no.mole solute}{sum of mole}$$

$$Mole fraction for acetone(X) =\frac{2.0 mole}{12.0 mole} =0.167$$

$$Mole fraction for C2H5OH(X) =\frac{3.0 mole}{12.0 mole} =0.250 $$

$$Mole fraction for water(X) =\frac{7.0 mole}{12.0 mole} =0.583$$

Q20: Determine the mole fraction of both substances in a solution containing 36.0 gm water and 46.0 gm glycerin , C3H5(OH)3 ?

Solve:

**The molecular weight of C3H5(OH)3 is 92.0 ; of water , 18.0**

**Mol glycerin =wt / M.wt 46.0 / 92.0 = 0.5 mol**

**Mol water =wt / M.wt 36.0 / 18.0 = 2.0 mol**

**Sum of mole = 0.5+ 2.0 = 2.5 mole**

$$Mole fraction for glycerin(X) =\frac{0.5 mole}{2.5 mole} =0.20 $$

$$Mole fraction for water(X) =\frac{2.0 mole}{2.5 mole} =0.80$$

**Check *:* Sum of mole fractions = 0.20 + 0.80 = 1.0**

Q21: The density of a 2.0 M solution of acetic acid (M.wt = 60 ) in water is 1.02 kg/L . Calculate the mole fraction of acetic acid ?

Solve:

Per liter of solution :

$$M=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{V (mL)}$$

$$0.2= \frac{wt (g)}{60 (\frac{g}{mol})} × \frac{1000}{1000 (mL)}=120 gm acetic$$

**Weight = volume × density = 1.000L × 1.02 kg/ L = 1.02kg = 1020 gm of solution .**

**Weight og water = 1020 – 120 = 900 gm water .**

**Mol water =wt / M.wt 900 / 18.0 = 50.0 mol**

**Sum of mole = 50.0+ 2.0 = 52.0 mole**

$$Mole fraction for acetic acid (X) =\frac{2.0 mole}{52.0 mole} =0.038 $$

Q22: Asolution contains 10.0 gm acetic acid , CH3COOH , in 125 gm water . What is the concentration of solution expressed as **(a)** mole fractions of CH3COOH and water **(b)** molality ?

Solve:

**(a) Mol CH3COOH =wt / M.wt 10.0 / 60.0 = 0.167 mol**

**Mol water =wt / M.wt 125 / 18.0 = 6.94 mol**

**Sum of mole = 0.167+ 6.94 = 7.107 mole**

$$Mole fraction for CH\_{3}COOH(X) =\frac{0.167 mole}{7.107 mole} =0.0235 $$

$$Mole fraction for water(X) =\frac{6.94 mole}{7.107 mole} =0.965$$

**(b) molality = 0.167 mol** $CH\_{3}COOH$ **/ 0.125 kg water = 1.34 m**

Q23: Calculate the molalities and mole fractions of acetic acid in two solutions prepared by dissolving 120 gm acetic acid **(a)** in 100 gm water **(b)** in 100 gm ethanol ?

Solve:

1. in water$m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$

$$m= \frac{120 (g)}{60 (\frac{g}{mol})} × \frac{1000}{100 gm}=2.00 m acetic acid$$

$$Mole fraction for CH3COOH(X) =\frac{2.00 mole}{2.00+5.55 mole} =0.265 $$

**(b)** in ethanol

$$m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$$

$$m= \frac{120 (g)}{60 (\frac{g}{mol})} × \frac{1000}{100 gm}=2.00 acetic acid$$

$$Mole fraction for CH\_{3}COOH(X) =\frac{2.00 mole}{2.00+2.17 mole} =0.480 $$

Q24: What is the molality of a solution which contains 20.0 gm cane suger , C12H22O11 , dissolved in 125 gm water ?

Solve: The molecular weight of C12H22O11 is 342 .

$$m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$$

$$m= \frac{20.0 (g)}{342 (\frac{g}{mol})} × \frac{1000}{125 gm}=0.468 m$$

Q25: The molality of a solution of ethanol , C2H5OH , in water is 1.54 m. How many gm of ethanol is dissolved in 2.50 kg water ?

Solve:

**Molality= mole / wt(kg) mole = 2.50 × 1.54 = 3.85 mol**

**and mass of ethanol = mole × M.wt 3.85 × 46.1 = 177 gm**

Q26: Calculate the molality of a solution containing **(a)** 0.65 mol glucose , C6H12O6 , in 250 gm water **(b)** 45 gm glucose in 1.00 kg water **(c)** 18 gm glucose in 200 gm water ?

Solve:

**(a) Molality= mole / wt(kg) molality = 0.65/ 0.250 = 2.6 m**

**(b)**

$$m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$$

$$m= \frac{45 (g)}{180 (\frac{g}{mol})} × \frac{1000}{1000 gm}=0.25 m$$

**(c)** $m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$

$$m= \frac{18 (g)}{180 (\frac{g}{mol})} × \frac{1000}{200 gm}=0.50 m$$

Q27: How many gram CaCl2 should be added to 300 ml water to make up a 2.46 m solution ?

Solve:

Assuming that water has a density of 1.00 gm/ ml .

**Weight = density × volume wt = 300 × 1.00 = 300 gm**

$$m=\frac{wt (g)}{M.wt (\frac{g}{mol})} × \frac{1000}{wt(gm)}$$

$$2.46= \frac{wt (g)}{111 (\frac{g}{mol})} × \frac{1000}{300 gm}=81.9 gm$$

**Acids and bases**

Q28: Distinguish between acid strength and acid concentration?

Solve: The concentration of acid in a solution is determined by how many mol of acid is dissolved per L of solution; its strength is determined by how completely it ionizes. Both of these factors affect the hydronium ion concentration.

Q29: Explain why a solution containing a strong base and its salts does not act as a buffer solution?

Solve: Addition of OH- does not shift an equilibrium toward un-ionized base, as it would with a weak base and it’s conjugate.

 Q30: Explain the difference between a strong electrolyte and a weak electrolyte. Is an “insoluble” salt a weak or a strong electrolyte?

Solve: A strong electrolyte is completely ionized in solution, while a weak electrolyte is only partially ionized in solution.

Q31: What is the Brønsted acid–base theory? What is the Lewis acid–base theory?

Solve: The bronsted acid- base theory assumes that an acid is a proton donor, and a base is a proton accepter. In the Lewis theory, an acid is an electron accepter, while a base is an electron donor.

Q32: Calculate the pH of a solution which has a hydronium ion concentration

 of 6 × 10-8 M ?

**Solve:**

**PH = -log[H+] PH = - log 6 – log 10-8 = -0.78 + 8= 7.22**

Q33: Calculate the hydronium ion concentration of a solution which

 has a pH of 11.73 ?

Solve:

**[ H+] = 10-PH [H+] = 10-11.73 = 100.27× 10-12**

**From the logarithm table , 100.27 = 1.9 [H+] = 1.9×10-12**

Q34: Calculate the hydrogen ion concentration and the hydroxide ion concentration in pure water at 25 0C ?

**Solve:**

**2H2O H3O+ + OH-**

**Kw = [H+] [OH-] = 1.0 ×10-14**

**Let x = [H+] = [OH-] , hence x2 = 1.0 × 10-14 and x = 1.0 ×10-7M =[H+]= [OH-]**

Q35: Calculate the hydronium ion concentration of a 0.100 M NaOH solution ?

**Solve: NaOH Na+ + OH-**

 **0.100M 0.100M**

**Kw = [H+] [OH-] = 1.0 ×10-14**

**In this solution , 1.0 × 10-14 = [H+] (0.100) , thus [H+] = 1.0 × 10-13 M.**

Q36: Calculate the PH values , assuming complete ionization , of **(a)** 4.9× 10-4  M monoprotic acid **(b)** 0.0016 M monoprotic base ?

**Solve:**

**(a) [H+] = 4.9× 10-4  PH = -log [H+] = -log(4.9×10-4) =**

**-log 4.9 + 4 = 3.31**

**(b) Kw = [H+] [OH-] = 1.0 ×10-14 [H+] = 10-14 / [OH-]**

**[H+] = 10-14 / 1.6×10-3**

**PH = -log 10-14 / 1.6×10-3 = -(- 14- log 1.6 + 3) = 14 + 0.20 – 3 = 11.20**

Q37: Calculate the PH of 1.0 × 10-3 M solutions of each the following: **(a)** HCl **(b)** NaOH **(c)** Ba(OH)2 **(d)** NaCl ?

**(a)** PH = 3.00 **(b)** PH = 11.00 **(c)** PH = 11.30 **(d)** PH = 7

Q38: Calculate the pH and pOH of the following strong acid solutions: **(a)** 0.020 *M* HClO4, **(b)** 1.3 × 10−4 *M* HNO3, **(c)** 1.2 *M* HCl?

Solve:

**(a) PH = - log [ H+ ] = - log 2× 10-2 = 2 – 0.3 = 1.7**

 **POH = 14 – 1.7 = 12.3**

**(b) PH = - log [ H+ ] = - log 1.3× 10-4 = 4 – 0.11 = 3.89**

 **POH = 14 – 3.89 = 10.11**

**(c) PH = - log [ H+ ] = - log 1.2 = - 0.08**

 **POH = 14 – (-0.08) = 14.08**

Q39: Calculate the pH and pOH of the following strong base solutions: **(a)** 0.050 *M* NaOH, **(b)** 2.4 *M* NaOH,**(c)** 3.7 × 10−3 *M* KOH.?

Solve:

**(a) POH = - log [ OH- ] = -log 5× 10-2 = 2- 0.7 = 1.3**

 **PH = 14 – 1.3 = 12.7**

**(b) POH = - log [ OH- ] = -log 2.4 = - 0.38**

 **PH = 14 – (-0.38) = 14.38**

**(c) POH = - log [ OH- ] = -log 3.7×10-3 = 3 – 0.57 = 2.43**

 **PH = 14 – 2.43 = 11.57**

Q40: Calculate the hydrogen ion concentration of the solutions with the following pH values: **(a)** 3.47, **(b)** 0.20, **(c)** 8.60 ?

**Solve: (a) [ H+ ] = 10-PH = 10-3.47 = 10-4 × 100.53 = 3.4 × 10-4 M .**

**(b) [ H+ ] = 10-PH = 10-0.02 = 10-1 × 100.80 = 6.3× 10-1 M .**

**(c) [ H+ ] = 10-PH = 10-8.6 = 10-9 × 100.40 = 2.5 × 10-9 M .**

Q41: Calculate the pH and pOH of a solution obtained by mixing equal volumes of 0.10 *M* H2SO4 and 0.30 *M* NaOH ?

**Solve:**

**Assume the volume = 1 ml**

**Excess of NaOH = mmole of NaOH – mmole of H2SO4**

 **= 0.3× 1 ml – 0.1× 1 ml× 2 = 0.1 mmole of NaOH**

**M = mmole / V(ml) = 0.1 / 2 ml = 0.5 M .**

**POH = -log [ OH- ] = -log 5× 10-2 = 2 – 0.7 = 1.3**

**PH = 14 – 1.3 = 12.70**

42: Calculate the pH of a solution obtained by mixing equal volumes of a strong acid solution of pH 3.00 and a strong base solution of pH 12.00 ?

Solve:

**Assume the volume = 1 ml**

 **[ H+ ] = 10-PH**

**[ H+ ] of acid solution = 1.0 ×10-3 M .**

**[ H+ ] of base solution = 1.0× 10-12 M .**

**[ H+ ] [ OH- ] = 1.0× 10-14**

**1.0× 10-12 [ OH- ] = 1.0 × 10-14 ; [ OH- ] = 1.0×10-14 / 1.0× 10-12 = 1.0×10-2 M .**

**Excess of base = mmole of NaOH – mmole of acid**

 **= 1.0×10-2 \* 1 ml – 1.0×10-3 \* 1 ml = 9 / 2 × 10-3 = 4.5×10-3 M .**

**POH = -log [ OH- ] = -log 4.5 × 10-3 = 3 – 0.65 = 2.35**

**PH = 14 – 2.35 = 11.65**