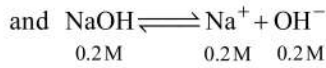
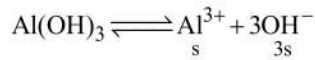


# Solutions

1. What is the molar solubility of  $\text{Al}(\text{OH})_3$  in 0.2 M NaOH solution? Given that, solubility product of  $\text{Al}(\text{OH})_3 = 2.4 \times 10^{-2}$
2. At room temperature, a dilute solution of urea is prepared by dissolving 0.60 g of urea in 360 g of water. If the vapour pressure of pure water at this temperature is 35 mmHg, what will be the lowering of vapour pressure? (molar mass of urea = 60 g mol<sup>-1</sup>)
3. Molal depression constant for a solvent is 4.0 K kg mol<sup>-1</sup>. Calculate the depression in the freezing point (in K) of the solvent for 0.03 mol kg<sup>-1</sup> solution  $\text{K}_2\text{SO}_4$ . (Assume complete dissociation of the electrolyte)
4. The osmotic pressure of a dilute solution of an ionic compound XY in water is four times that of a solution of 0.01 M  $\text{BaCl}_2$  in water. Assuming complete dissociation of the given ionic compounds in water, find the concentration of XY (in mol L<sup>-1</sup>) in solution.
5. Calculate the amount of sodium chloride (in g) which must be added to 1000 mL of water so that its freezing point is depressed by 0.744K. For water,  $K_f = 1.86$  K/m. Assume density of water to be 1 g mL<sup>-1</sup>.
6. What weight of the non-volatile solute (in g), urea ( $\text{NH}_2 - \text{CO} - \text{NH}_2$ ) needs to be dissolved in 100g of water, in order to decrease the vapour pressure of water by 25%?
7. A bottle of commercial sulphuric acid (density 1.787 g/mL) is labelled as 86 percent by weight. What volume of the acid has to be used to make 1 litre of 0.2 M  $\text{H}_2\text{SO}_4$ ?
8. 0.5 gm of fuming  $\text{H}_2\text{SO}_4$  (Oleum) is diluted with water. This solution is completely neutralized by 26.7 ml of 0.4 N NaOH. Find the percentage of free  $\text{SO}_3$  in the sample of oleum.
9. The vapour pressure of pure benzene at a certain temperature is 640mm Hg. A non-volatile solid weighing 2.175g is added to 39.0g of benzene. The vapour pressure of the solution is 600mm Hg. What is the molecular weight (in g) of the solid substance ?
10. 0.400 g of an acid HA (mol. mass = 80) was dissolved in 100 g of water. The solution showed a depression of freezing point of 0.12 K. What will be the dissociation constant (in multiple of  $10^{-3}$ ) of the acid at about 0°C? Given  $K_f$  (water) = 1.86 K Kg mol<sup>-1</sup> (Assume molarity of solution  $\approx$  molality)
11. An element X (Atomic mass = 25) exists as  $\text{X}_4$  is benzene. 51g of saturated solution of X in benzene was added to 50.0 g of pure benzene. The resulting solution showed a depression of freezing point of 0.55 K. Find the solubility of X per 100 g of benzene. ( $K_f$  for benzene = 5.5 K kg mol<sup>-1</sup>)
12. At 10°C, the osmotic pressure of urea solution is 500 mm. The solution is diluted and the temperature is raised to 25°C, when the osmotic pressure is found to be 105.3 mm, determine extent of dilution.
13. A mixture of two immiscible liquids nitrobenzene and water boiling at 99°C has a partial vapour pressure of water 733 mm and that of nitrobenzene 27 mm. Find the ratio of the weights of nitrobenzene to the water in distillate.
14. A solution containing 28 g phosphorus in 315 g  $\text{CS}_2$  (b. pt. 46.3°C) boils at 47.98°C.  $K'_b$  for  $\text{CS}_2$  is 2.34 K mol<sup>-1</sup> kg. What are the no. of phosphorus atom present in its molecular formula?
15. Calculate the molality of 1 litre solution of 93%  $\text{H}_2\text{SO}_4$  (weight/volume). The density of the solution is 1.84 g/mL.

# SOLUTIONS

1. (3) Let the solubility of  $\text{Al(OH)}_3$  in 0.2M NaOH solution be  $s$ .  
Then,



$$[\text{Al}^{3+}] = s \text{ and } [\text{OH}^-] = 3s + 0.2 \approx 0.2$$

$$K_{sp} = 2.4 \times 10^{-2} = [\text{Al}^{3+}] [\text{OH}^-]^3$$

$$2.4 \times 10^{-2} = s(0.2)^3$$

$$s = \frac{2.4 \times 10^{-2}}{8 \times 10^{-3}} = 3 \text{ mol/L}$$

2. (0.017) Relative lowering of vapour pressure, is given

$$\text{by, } \frac{p^\circ - p}{p^\circ} = x_A = \frac{n_A}{n_A + n_B} \approx \frac{n_A}{n_B}$$

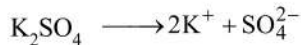
$$\text{Given, } p^\circ = 35 \text{ mm Hg, } n_{\text{urea}} = \frac{0.60}{60},$$

$$n_{\text{water}} = \frac{360}{18}$$

$$\frac{p^\circ - p}{35} = \frac{0.6 \times 18}{60 \times 360} = \frac{1}{2000}$$

$$\Delta p = p^\circ - p = 0.017$$

3. (0.36) Dissociation of Potassium Sulphate ( $\text{K}_2\text{SO}_4$ ),



$$i \text{ (Van't Hoff factor)} = 3$$

$$\text{We know that, } \Delta T_f = iK_f m$$

where,  $K_f$  is molal depression constant and  $m$  is molality.

$$\therefore \Delta T_f = 3 \times 4 \times 0.03 = 0.36 \text{ K}$$

4. (0.06) We know,  $\pi = iCRT$ ;  $\pi_{xy} = 4\pi_{\text{BaCl}_2}$

$$\therefore 2[\text{XY}] = 4 \times (0.01) \times 3$$

$$[\text{XY}] = 0.06$$

$$= 6 \times 10^{-2} \text{ mol/L} = 0.06 \text{ mol/L}$$

5. (11.7) Mass of NaCl,  $w_2 = ?$ , Volume of water = 1000 mL,

$$\Delta T_f = 0.744 \text{ K, Density of water} = 1 \text{ g mL}^{-1}$$

$$\text{So, mass of water } w_1 = 1000 \text{ mL} \times 1 \text{ g mL}^{-1} = 1000 \text{ g} = 1 \text{ kg}$$

$$\Delta T_f = iK_f m = iK_f \times \frac{(w_2/58.5)}{w_1} = \frac{iK_f w_2}{58.5 \times w_1}$$

$$w_2 = \frac{\Delta T_f \times 58.5 \times 1}{i \times K_f} = \frac{0.744 \times 58.5}{2 \times 1.86} = 11.7 \text{ g}$$

$$(\because i \text{ for NaCl} = 2)$$

So, Mass of NaCl required = 11.7g.

$$6. \quad (111) \quad \frac{P^\circ - P}{P^\circ} = \frac{\frac{w}{m}}{\frac{w}{m} + \frac{W}{M}}$$

Let the initial (normal) pressure ( $P^\circ$ ) =  $P$

$$\therefore \text{Pressure of solution} = \frac{75}{100} \times P = \frac{3}{4} P$$

$$m = 60, M = 18, W = 100 \text{ g}$$

$$\therefore \frac{P - \frac{3}{4}P}{P} = \frac{\frac{w/60}{\frac{w}{60} + \frac{100}{18}}}{\frac{w}{60} + \frac{100}{18}}$$

$$\frac{1}{4} = \frac{w/60}{(w/60) + 5.55} \text{ or } \frac{4w}{60} = \frac{w}{60} + 5.55$$

$$\text{or } w = 111 \text{ g}$$

7. (12.65) Molarity

$$= \frac{\text{Mass of solute / M. wt. of solute}}{\text{Mass of solution/density of solution}} \times 1000$$

$$M = \frac{86/98}{100/1.787} \times 1000$$

$$= \frac{0.8775}{55.5} \times 1000 = 15.81 \text{ M}$$

Now,

$$M_1 V_1 = M_2 V_2$$

$$\therefore 15.81 \times V_1 = 0.2 \times 1000$$

$$\text{or } V_1 = \frac{0.2 \times 1000}{15.81} = 12.65 \text{ mL}$$

$\therefore$  Amount of acid to be used to make 1 L of 0.2 M  $\text{H}_2\text{SO}_4 = 12.65$ .

8. (3.84)  $N_1 = 1, V_1 = ?, N_2 = 26.7, V_2 = 0.4$

$$N_1 V_1 = N_2 V_2$$

$$1 \times V_1 = 26.7 \times 0.4$$

$$V_1 = \frac{26.7 \times 0.4}{1} = 10.68$$

49g ( $\because$  eq wt of  $\text{H}_2\text{SO}_4 = 49$ ) of  $\text{H}_2\text{SO}_4$  will be neutralised by 1N 1000 mL of NaOH.

$\therefore$  0.5g of  $\text{H}_2\text{SO}_4$  will be neutralised by

$$= \frac{1000}{49} \times 0.5 = 10.20 \text{ mL 1N NaOH}$$

$$\text{Volume of 1 N NaOH used by dissolved } \text{SO}_3 = 10.68 - 10.20 = 0.48 \text{ mL}$$



$$\therefore \text{Eq wt of } \text{SO}_3 = \frac{\text{Mol wt}}{2} = \frac{80}{2} = 40$$

Wt of  $\text{SO}_3$  in 0.48 ml of 1 M solution

$$= \frac{40}{1000} \times 0.48 = 0.0192 \text{ g}$$

$$\% \text{ of } \text{SO}_3 = \frac{0.0192}{0.5} \times 100 = 3.84\%$$

9. (65.25) According to Raoult's law

$$\frac{P^\circ - P}{P^\circ} = \frac{w/m}{w/m + W/M}$$

Here,  $P^\circ = 640$  mm Hg,  $P = 600$  mm Hg,  $w = 2.175$  g,  $W = 39.0$  g,

$M = 78$ ,  $m =$  Molecular weight of solute

Substituting the various values in the above

$$\text{equation, } \frac{640 - 600}{640} = \frac{2.175/m}{2.175/m + 39/78}$$

$m = 65.25$  g

10. (5.92) Molality (m) of solution =  $\frac{0.4 \times 1000}{80 \times 100} = 0.05$

$$\Delta T_f(\text{normal}) = K_f \times m = 1.86 \times 0.05 = 0.093 \text{ K}$$

Van't Hoff factor,

$$i = \frac{\Delta T_f(\text{observed})}{\Delta T_f(\text{normal})} = \frac{0.12}{0.093} = 1.290$$



$$\alpha = \frac{i - 1}{n - 1} = \frac{1.290 - 1}{2 - 1} = 0.29$$

$$K_a = \frac{C\alpha^2}{1 - \alpha} = \frac{0.05 \times (0.29)^2}{1 - 0.29} = 5.92 \times 10^{-3}$$

11. (2) Let  $x$  g be the mass of element in 51.0 g of saturated solution.

Mass of benzene in 51.0 g of saturated solution =  $51.0 - x$  g

Total mass of benzene containing  $x$  g of solute =  $50 + 51 - x = (101 - x)$  g

$$\Delta T_f = \frac{1000 K_f W_B}{M_B W_A} = \frac{1000 \times 5.5 \times x}{4 \times 25 \times (101 - x)}$$

= 0.55 (given)

$$\Rightarrow x = 1.0 \text{ g}$$

Hence, solubility

$$= \frac{W_B \times 100}{W_A} = \frac{1}{(51 - 1)} \times 100 = 2.0 \text{ g}$$

12. (5) For initial solution,

$$\therefore \pi = \frac{500}{760} \text{ atm, } T = 283 \text{ K}$$

$$\frac{500}{760} \times V_1 = n \times R \times 283 \dots(i)$$

After dilution, let volume becomes  $V_2$  and temperature is raised to  $25^\circ\text{C}$ , i.e., 298 K.

$$\pi = \frac{105.3}{760} \text{ atm}$$

$$\frac{105.3}{760} \times V_2 = n \times R \times 298 \dots(ii)$$

$$\therefore \text{By Eqs. (i) and (ii), we get } \frac{V_1}{V_2} = \frac{283}{298} \times \frac{105.3}{500}$$

$$\frac{V_1}{V_2} = \frac{1}{5}$$

$$\therefore V_2 = 5V_1$$

i.e., Solution was diluted to 5 times.

13. (4)  $P' = P_M \cdot X_A$

where  $X'_A$  is mole fraction in gaseous phase

$$\therefore 27 = 760 \times \frac{\frac{w_2}{18}}{\frac{w_1}{18} + \frac{w_2}{123}} \text{ (for nitrobenzene)}$$

$$\text{and } 733 = 760 \times \frac{\frac{w_1}{18}}{\frac{w_1}{18} + \frac{w_2}{123}} \text{ (for water)}$$

$$\therefore \frac{w_1}{w_2} = 4$$

14. (4)  $\Delta T = \frac{1000 \times K_b' \times w}{m \times W}$

$$1.68 = \frac{1000 \times 2.34 \times 28}{m \times 315}$$

$$\therefore m_{\text{exp}} = 123.80$$

$$\frac{m_N}{m_{\text{exp}}} = 1 - \alpha + \frac{\alpha}{n}$$

$$\therefore \alpha = 1 \quad \therefore \frac{m_N}{m_{\text{exp}}} = \frac{1}{n} \text{ (} m_N \text{ of P} = 31)$$

$$\therefore \frac{31}{123.80} = \frac{1}{n}$$

$$\therefore n \approx 4$$

15. (10.43) Mass of  $\text{H}_2\text{SO}_4$  in 100ml of 93%  $\text{H}_2\text{SO}_4$  solution  
= 93g

$\therefore$  Mass of  $\text{H}_2\text{SO}_4$  in 1000 ml of the  $\text{H}_2\text{SO}_4$  solution  
= 930g

Mass of 1000 ml  $\text{H}_2\text{SO}_4$  solution  
=  $1000 \times 1.84 = 1840\text{g}$

Mass of water in 1000 ml of solution  
=  $1840 - 930 = 910\text{ g}$

$$\text{Moles of } \text{H}_2\text{SO}_4 = \frac{\text{Wt. of } \text{H}_2\text{SO}_4}{\text{Mol Wt. of } \text{H}_2\text{SO}_4} = \frac{930}{98}$$

$\therefore$  Moles of  $\text{H}_2\text{SO}_4$  in 1 kg of water

$$= \frac{930}{98} \times \frac{1000}{910} = 10.43 \text{ mol kg}^{-1}$$

$\therefore$  Molality of 1 litre solution = 10.43