PHYSICAL CHEMISTRY

**DPP**

DAILY PRACTICE PROBLEMS

# DPP No. 10

**Total Marks : 52**

**Max. Time : 62 min.**

**Topic : Mole Concept**

| Type of Questions | | M.M., Min. |
|---|---|---|
| Subjective Questions ('–1' negative marking) Q.1 to 3 , 7 to 11, 13 | (4 marks, 5 min.) | [32, 40] |
| Short Subjective Questions ('–1' negative marking) Q.12 | (3 marks, 3 min.) | [3, 3] |
| Comprehension ('–1' negative marking) Q.4 to 6 | (3 marks, 3 min.) | [9, 9] |
| Match the Following (no negative marking) (2 × 4) Q.14 | (8 marks, 10 min.) | [8, 10] |

**1.** An alloy has Fe,Co and Mo equal to 60%,29.5% and 10.5% by mass respectively. How many cobalt atoms are there in a cylinder made from same alloy, having radius 2.1 cm and a length of 10 cm ? The density of alloy is $\frac{100}{21}$ g/mL. Atomic weight of cobalt = 59 u.

**2.** What weight of CO is required to form $Re_2(CO)_{10}$ from 2.42 g of $Re_2O_7$ according to the given unbalanced reaction ? $Re_2O_7 + CO \longrightarrow Re_2(CO)_{10} + CO_2$
(Atomic mass of Re = 186 u)

**3.** Haemoglobin contains 0.25% iron by weight. The molecular weight of Haemoglobin is 89600 u. Calculate the weight of $K_4[Fe(CN)_6]$ that can be produced, if all the iron atoms from 4.48 kg haemoglobin are converted into $K_4[Fe(CN)_6]$ through a series of reactions.

**Comprehension # (Q. 4 to Q. 6).**

Nitric acid is the most important oxyacid formed by nitrogen. It is one of the major industrial chemicals and is widely used. Nitric acid is manufactured by the catalytic oxidation of ammonia, that is known as Ostwald process, which can be represented by the sequence of reactions shown below :

$$4NH_3(g) + 5O_2(g) \xrightarrow[\text{Catalyst}]{\text{Pt/Rh}} 4NO(g) + 6H_2O(g) \quad ...(1)$$

$$2NO(g) + O_2(g) \xrightarrow{1120\text{ K}} 2NO_2(g) \quad ...(2)$$

$$3NO_2(g) + H_2O(\ell) \longrightarrow 2HNO_3(aq) + NO(g) \quad ...(3)$$

The aqueous nitric acid obtained by this method can be concentrated by distillation to ≈ 68.5% by weight. Further concentration to 98% acid can be achieved by dehydration with concentrated sulfuric acid.

**4.** 85 kg of $NH_3$ (g) was heated with 320 kg oxygen in the first step and $HNO_3$ is prepare according to the above reactions. If the final solution has volume 500 L, then molarity of $HNO_3$ solution is :
(A) 2M (B) 8M (C) 3.33 M (D) 6.66 M

**5.** If 180 L of water completely reacts with $NO_2$ produced to form nitric acid according to the above reactions, then the volume of air required at STP containing 20% of $NH_3$ by volume is : $(\rho_{H_2O} = 1\text{ g/mL})$
(A) $1.56 \times 10^6$ L (B) $6.72 \times 10^4$ L (C) $3.36 \times 10^6$ L (D) None of these

6. If 170 kg of $NH_3$ is heated in excess of oxygen, then the volume of $H_2O$ ($\ell$) produced in 1[st] reaction at STP is : ($\rho_{H_2O} = 1 g/mL$)

(A) $336 \times 10^3$ L (B) 270 L (C) $224 \times 10^3$ L (D) 170 L

7. How many grams of Sodium dichromate ($Na_2Cr_2O_7$) should be added to a 50 mL volumetric flask to prepare 0.025 M $Na_2Cr_2O_7$ solution, when the flask is filled upto the mark with water ?

8. What volume of 0.25 M $HNO_3$ (nitric acid) solution reacts with 50 mL of 0.15 M $Na_2CO_3$ (sodium carbonate) solution in the following reaction :

$$2HNO_3(aq) + Na_2CO_3(aq) \longrightarrow 2NaNO_3(aq) + H_2O(\ell) + CO_2(g)$$

9. How would you prepare exactly 3 litre of 1 M NaOH solution by mixing proportions of stock solutions of 2.5 M NaOH and 0.4 M NaOH, if no water is to be used. Find the ratio of the volume ($v_1/v_2$).

10. A sample of $H_2SO_4$ (density 1.4 g $mL^{-1}$) solution is labelled as 84% by weight. What is molarity of acid solution? What volume of this acid solution has to be used to make 1 litre of 0.2 M $H_2SO_4$ solution ?

11. 10 mL of sulphuric acid solution (sp. gr. = 1.84) contains 98% by weight of pure acid. Calculate the volume of 2.5 M NaOH solution required to just neutralize the above acid solution.

12. When 10 g NaOH is added with 90 g of $H_2O$, a solution having density 1.2 g/mL is obtained. Then, calculate the following for this solution :

(i) % w/w (ii) % w/v (iii) mole fraction of NaOH (iv) molarity (M) (v) molality (m)

13. Out of 5.85% w/v aq. NaCl solution and 5.55% w/v aq. $CaCl_2$ solution, which solution has more number of $Cl^-$ ions per mL of solution ?

14. **Match the following :**

| **Column-I** | **Column-II** |
|---|---|
| (A) 1 M glucose solution | (p) 1 mole solute per litre solution |
| (B) 3 M urea solution | (q) 180 g solute per litre solution |
| (C) 3 M $CH_3COOH$ solution | (r) % w/v = 18% (solution) |
| (D) 1 M $H_2SO_4$ solution | (s) % w/v = 9.8% (solution) |

# Answer Key

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1. $3.3 N_A$. 2. 2.38 g 3. 73.6 g 4. (D) 5. (C)

6. (B) 7. 0.3375 g. 8. 60 mL 9. 2 : 5

10. 12 M, 16.66 mL 11. 147.2 mL

12. (i) % w/w = 10% (ii) % w/v = 12% (iii) mole fraction of NaOH = 1/21
(iv) molarity (M) = (3M) (v) molality (m) = (2.78 m)

13. Both have equal no. of $Cl^-$ ions per ml. 14. (A - p, q, r) ; (B - q, r) ; (C - q, r) ; (D - p, s)

# Hints & Solutions

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**1.** Volume of cylinder = $\pi r^2 h$

$$= \frac{22}{7} \times (2.1)^2 \times 10$$

$$= 138.6 \text{ cm}^3$$

Mass of cylinder = V × d = $138.6 \times \frac{100}{21} = 660$ g

Mass of cobalt = $\frac{29.5}{100} \times 600 = 194.7$ g.

Moles of cobalt = $\frac{194.7}{59} = 3.3$

∴ Number of atoms of cobalt = 3.3 $N_A$

**2.** Balance equation is $Re_2O_7 + 17CO \longrightarrow Re_2(CO)_{10} + 7CO_2$

**3.** 100 g haemoglobin has = 0.25 g Fe

89600 g --------- " -------- " -------- = $\frac{0.25 \times 89600}{100}$ = 224 g Fe

∴ 1 mol of Haemoglobin has = $\frac{224}{56}$ mol Fe atoms = 4 mol Fe.

Now mole of haemoglobin given = $\frac{4480\text{g}}{89600\text{g/mol}}$ = 0.05 mol

mol. wt of $K_4[Fe(CN)_6]$ = 368 g/mol

Applying POAC for Fe atoms – mole of Haemoglobin × 4 = mole of $K_4[Fe(CN)_6]$ × 1

$$0.05 \times 4 = \frac{\text{weight of } K_4[Fe(CN)_6]}{368\text{g/mol}} \times 1$$

weight of $K_4[Fe(CN)_6]$ = 0.05 × 4 × 368 g = 73.6 g

**4.** $4NH_3(g) + 5O_2(g) \longrightarrow 4NO + 6H_2O$

mole (मोल) $5 \times 10^3$ $10^4$ mole (मोल) $5 \times 10^3$

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

$5 \times 10^3$ $5 \times 10^3$

$3NO_2 + H_2O(\ell) \longrightarrow 2HNO_3(g) + NO(g)$

$5 \times 10^3$ $\frac{2}{3} \times 5 \times 10^3$

molarity (मोलरता) = $\frac{2}{3} \times \frac{5 \times 10^3}{500}$ = 6.66 M.

5. Moles of water reacted = $\frac{180 \times 10^3}{18}$ = $10^4$

$\therefore$ moles of $NO_2$ required = $30 \times 10^3$ = mole of $NH_3$ required

$\therefore$ volume of air at STP = $\frac{30 \times 10^3 \times 22.4}{0.2}$ = $3.36 \times 10^6$ L.

6. Moles of $NH_3$ = $\frac{170}{17}$ = $10 \times 10^3$

$\therefore$ moles of $H_2O$ formed = $\frac{6}{4} \times 10 \times 10^3$

$\therefore$ mass of $H_2O$ formed = $\frac{6}{4} \times 10 \times 10^3 \times 18$

$\therefore$ volume of $H_2O$ formed = 15 × 18 L = 270 L.

7. Molarity (मोलरता)= 0.025 = $\frac{\text{Mole}}{50} \times 1000$

Mole(मोल) = $\frac{50 \times 0.025}{1000}$

wt. of $Na_2Cr_2O_7$(का भार) = $\frac{50 \times 0.025}{1000} \times 270$ = 0.3375 gm.

8. $2HNO_3(aq) + Na_2CO_3(aq) \longrightarrow 2NaNO_3(aq) + H_2O(\ell) + CO_2(g)$

$\frac{\text{Millmole of } HNO_3}{2} = \frac{\text{Millmole of } Na_2CO_3}{1}$

$0.25 \times V_{ml} = 2 \times 50 \times 0.15$

$V_{ml} = \frac{2 \times 50 \times 0.15}{0.25}$ = 60 mL.

9. $N_1V_1 + N_2V_2 = N_TV_T$

$2.5\,V_1 + 0.4\,V_2 = 3 \times 1$

$2.5\,V_1 + 0.4\,(3 - V_1) = 3$

$2.5\,V_1 + 1.2 - 0.4\,V_1 = 3$

$2.1\,V_1 = 1.8$

$$V_1 = \frac{1.8}{2.1} = \frac{6}{7}$$

$$V_2 = 3 - \frac{6}{7} = \frac{15}{7}$$

$$\frac{V_1}{V_2} = \frac{6}{7} \times \frac{7}{15} = 2:5$$

10. $$M = \frac{86 \times 1.787}{98} \times 10 = 15.68\text{ M}$$

$M_1V_1 = M_2V_2$

$15.68 \times V_1 = 0.2 \times 1000$

$V_1 = 12.75$ ml.

11. For neutralisation

m moles of $H_2SO_4$ = 2 × m moles of NaOH

$$\frac{98}{98} \times 1.84 \times 10 \times 10 = 2 \times 2.5 \times V$$

V = 147.2 ml

12. (i) $$\% (w/w) = \frac{10}{90+10} \times 100 = 10\%$$

(ii) $$\% (w/v) = \frac{10}{\frac{(90+10)}{1.2}} \times 100 = 12\%$$

(iii) $$\text{Mole fraction of NaOH} = \frac{\frac{10}{40}}{\frac{10}{40} + \frac{90}{18}} = \frac{1}{21}$$

(iv) $$\text{Molarity} = \frac{\frac{10}{40}}{\frac{(90+10)}{1.2}} \times 1000 = 3\text{ M}$$

(v) $$\text{Molality} = \frac{\frac{10}{40}}{90} \times 1000 = 2.78\text{ M.}$$

13. 5.85% (w/v) → 5.85 g NaCl / 100 ml NaCl

$$\text{So, Mole/ ml} = \frac{5.85}{58.5} = 0.1/100\text{ ml}$$

$$Cl^- / ml = \frac{0.1 \times 1}{100}$$

5.55 % (w/v) $\rightarrow$ 5.55 g $CaCl_2$ / 100 ml $CaCl_2$

$$\text{So, Mole/ ml} = \frac{5.55}{111} = 0.05 \text{ ml}$$

$$Cl^- / ml = \frac{0.05 \times 2}{100} = \frac{0.1}{100}$$

**14.** (A) 1 M glucose solution $\equiv$ 1mole of solute/L

$\equiv$ 180 g solute/L

$\equiv$ (180 g/1000)× 100 = 18% (w/v)

(B) 3 M urea solution ($NH_2CoNH_2$) $\equiv$ 3 mole of solute/L

$\equiv$ (60 × 3)g of solute/L

$\equiv$ (180 g/1000)× 100 = 18% (w/v)

(C) 3 M $CH_3COOH$ solution $\equiv$ 3 mole of solute/L

$\equiv$ (3 × 60)g of solute/L

$\equiv$ (180 g/1000)× 100 = 18% (w/v)

(D) 1 M $H_2SO_4$ solution $\equiv$ 1 mole of solute/L

$\equiv$ 98g of solute/L

$$\equiv \frac{98}{1000} \times 100 = 9.8 \text{ \% (w/v)}$$