CHEMISTRY CALCULATIONS WS 3

Moles & Solutions

1 If 10.00 g of NaOH is dissolved in water and the volume is made up to 200.0 cm^3, calculate the concentration in $moldm^{-3}$ and gdm^{-3}.

gdm^{-3}:
We know 10g are present in 200cm^3
so xg will be in 1000cm^3 (1dm^3)
The conc. is 50 gdm^{-3}

Mr of NaOH = 23 + 16 + 1 = 40.
50g of NaOH = $\frac{50}{40}$ = 1.2 mol.

1.2 mol dm^{-3}

2 Calculate the number of moles of HCl present in 50.0cm^3 of 2.00 $moldm^{-3}$ hydrochloric acid.

2 mol in 1 dm^3
x in 50 cm^3
x = 0.1 mol

OR

$n = CV$
$= \frac{50}{1000} \times 2$
$n = 0.1$ moles

3 Calculate the number of moles of chloride ions present in 50.0cm^3 of a 0.0500 $moldm^{-3}$ solution of iron(III) chloride ($FeCl_3$) and the total concentration of all the ions present.

n of $FeCl_3$ = $\frac{0.05}{1000} \times 50 = 2.5 \times 10^{-3}$ mol.
n of Cl^- = $3 \times 2.5 \times 10^{-3} = 7.5 \times 10^{-3}$ mol

n of ions = $2.5 \times 10^{-3} \times 4 = 0.01$ mol
0.01 mol in 50cm^{-3}
Thats 0.2 mol dm^{-3}.

4 Sulfuric acid is titrated against 25.00cm^3 of 0.2000 $moldm^{-3}$ sodium hydroxide solution; 23.20 cm^3 of sulfuric acid is required for neutralisation. Calculate the concentration of the sulfuric acid.

These are the moles of NaOH present & NaOH : H_2SO_4 = 2 : 1

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

25cm^3 of 0.2 mol dm^{-3} is = $\frac{0.2}{1000} \times 25 = 5 \times 10^{-3}$ mol
mol of H_2SO_4 used = $\frac{5 \times 10^{-3}}{2} = 2.5 \times 10^{-3}$ mol
conc of H_2SO_4 = $\frac{n}{V} = \frac{2.5 \times 10^{-3}}{23.2/1000} = 0.107$ mol dm^{-3}

5 For neutralisation, 25.00 cm^3 of phosphoric(V) acid (H_3PO_4) requires 28.70 cm^3 of NaOH of concentration 0.1500mol dm^{-3}.What is the concentration of the phosphoric(V) acid?

$$H_3PO_4(aq) + 3NaOH(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

n in 28.7cm^3 of 0.15 mol dm^{-3} of NaOH = $\frac{0.15}{1000} \times 28.7 = 4.3 \times 10^{-3}$ mol.
n of H_3PO_4 = $\frac{4.3 \times 10^{-3}}{3} = 1.43 \times 10^{-3}$ mol are in 25cm^3

C = $\frac{1.43 \times 10^{-3}}{25/1000}$
= 0.057 mol dm^{-3}

6 Acidified potassium manganate(VII) oxidises hydrogen peroxide to produce oxygen:

$$2KMnO_4(aq) + 3H_2SO_4(aq) + 5H_2O_2(aq) \rightarrow 2MnSO_4(aq) + 8H_2O(l) + K_2SO_4(aq) + 5O_2(g)$$

If 45.00 cm^3 of 0.020 mol dm^{-3} $KMnO_4$ is reacted with excess H_2O_2 and H_2SO_4, calculate the volume of O_2 produced (at RTP).

$0.02\ mol\,dm^{-3} = \frac{n\ mol}{(45/1000)\ dm^3}$

$n = 0.9 \times 10^{-3}$ mol

mol of $KMnO_4$ ↑

$KMnO_4 : O_2$

$2 : 5$

$0.9 \times 10^{-3} : 2.25 \times 10^{-3}$ mol of O_2 produced.

$V = n \times 24\ dm^3 = 54 \times 10^{-3}\ dm^3$ or $54\ cm^3$

7 Work out the numbers of moles present in the following solutions:

a. 20.0cm^3 of 0.220 moldm^{-3} NaOH(aq)

0.22 mol in 1000 cm^3

so 4.4×10^{-3} mol in 20 cm^3

4.4×10^{-3} mol Ans.

OR...

$n = CV$

$= \frac{(0.22)(20)}{1000}$

$= 4.4 \times 10^{-3}$ mol.

b. 27.8 cm^3 of 0.0840 moldm^{-3} HCl(aq)

0.084 mol ⟶ 1000 cm^3

2.33×10^{-3} mol ⟶ 27.8 cm

2.33×10^{-3} mol

OR...

$n = CV$

$= \frac{0.084}{1000} \times 27.8$

$= 2.33 \times 10^{-3}$ mol

c. 540 cm^3 of 0.0200 moldm^{-3} $KMnO_4$(aq)

$n = CV$

$= \frac{0.02}{1000} \times 540 = 10.8 \times 10^{-3}$ mol

8 If 29.70cm^3 of sulfuric acid of concentration 0.2000 moldm^{-3} is required for neutralisation of 25.00cm^3 of potassium hydroxide solution, calculate the concentration of the potassium hydroxide solution.

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

$n\ H_2SO_4 = \frac{29.7 \times 0.2}{1000} = 5.94 \times 10^{-3}$ mol.

$n\ KOH = 11.88 \times 10^{-3}$ mol

×2

This is present in 25cm^3, in 1dm^3

$Conc = \frac{11.88 \times 10^{-3} \times 1000}{25}$

$= 0.475$ moldm^{-3}

9 Calcium carbonate is reacted with 50.0cm^3 of 0.500 moldm^{-3} hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

a. What mass of calcium carbonate is required for an exact reaction?

n of $HCl = \frac{(0.5\ mol.dm^{-3})(50\ cm^3)}{1000\ cm^3.dm^{-3}} = 0.025$ mol

n of $CaCO_3 = \frac{0.025}{2} = 0.0125$ mol

Mass of $CaCO_3 = (0.0125)(40.1 + 12 + 48)$

$= 1.25$ g used.

b. What volume of CO_2, measured at RTP, will be produced?

η of CO_2 = η of $CaCO_3$
= 0.0125 mol

$V = 24\ \frac{dm^3}{mol} \times 0.0125\ mol = 0.3\ dm^3$

The $24\ dm^3$ in the formula is a ratio of moles of gas to volume Hence the units dm^3/mol.

10 What volume (in cm^3) of 0.0100 mol dm^{-3} barium chloride must be reacted with excess sodium sulfate to produce 0.100g of barium sulfate?

$$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$$

$BaSO_4 = 137 + 32.1 + 16\times4 = 233.1$

$\eta\ BaSO_4 = \frac{0.1\ g}{233.1} = 4.29\times10^{-4}\ mol$

$\eta\ BaCl_2 = 4.29\times10^{-4}\ mol$

$V = \frac{\eta}{C} = \frac{4.29\times10^{-4}}{0.01} = 4.29\times10^{-2}\ dm^3$

$= 42.9\ cm^3$

11 If 0.100g of magnesium is reacted with 25.00cm^3 of 0.200 mol dm^{-3} hydrochloric acid, calculate the volume of hydrogen gas produced at RTP.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

η of $Mg = \frac{0.1}{24.3} = 4.11\times10^{-3}$ mol.

η of $HCl = \frac{0.2}{1000} \times 25 = 5\times10^{-3}$ mol

HCl is the limiting factor, as with 5×10^{-3} mol of HCl 2.5×10^{-3} mol of Mg will react to form 2.5×10^{-3} of H_2

Vol. of $H_2 = 2.5\times10^{-3} \times 24000$
$= 60\ cm^3$.

12 When 2.56 g hydrated magnesium sulfate ($MgSO_4.xH_2O$) is heated, 1.25 g of anhydrous magnesium sulfate ($MgSO_4$) is formed. Determine the value of ***x*** in the formula.

$MgSO_4.xH_2O \longrightarrow MgSO_4 + xH_2O$

2.56g 1.25g

Mr of $MgSO_4 = 120.4$

Mr of $MgSO_4.xH_2O = 120.4 + 18x$

η of $MgSO_4 = \frac{1.25}{120.4} = 10.38\times10^{-3}$

$\eta\ MgSO_4 = \eta$ of $MgSO_4.xH_2O = 10.38\times10^{-3}$

$10.38\times10^{-3} = \frac{2.56}{120.4+18x}$

$120.4 + 18x = 246.62$

$x = 7.012$

$x = 7$

a. If 10.00g of hydrated copper sulfate ($CuSO_4.5H_2O$) is dissolved in water and made up to a volume of 250.0 cm^3, what is the concentration of the solution?

Mr of $CuSO_4 \cdot 5H_2O = 159.6 + 90 = 249.6$

$n\ CuSO_4 = n\ CuSO_4.5H_2O = \frac{10}{249.6} = 0.04006$ mol

0.04006 is in 250 cm^3
0.1602 will be in 1000 cm^3

$C = 0.160$ mol dm^{-3}

b. What mass of anhydrous copper sulfate would be required to make 250.0cm^3 of solution with the same concentration as in **a**?

Mr $CuSO_4$ = 159.6
n required = 0.04006 mol
That quantity in grams is = $159.6 \times 0.04006 = 6.39$g

✳ **13** A 3.92 g sample of hydrated sodium carbonate ($Na_2CO_3.\boldsymbol{x}H_2O$) was dissolved in water and made up to a total volume of 250.0 cm^3. Of this solution, 25.00 cm^3 was titrated against 0.100 mol dm^{-3} hydrochloric acid, and 27.40 cm^3 of the acid was required for neutralisation. Calculate the value of ***x*** in $Na_2CO_3.\boldsymbol{x}H_2O$.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Mr of $Na_2CO_3 . xH_2O = 106 + 18x$
Mr of HCl = 36.5

n of $HCl = \frac{0.1 \times 27.4}{1000} = 2.74 \times 10^{-3}$ mol

n of $Na_2CO_3 = 1.37 \times 10^{-3}$ mol

mass of Na_2CO_3 = 0.145 g was present in the 25cm^3 sol of Na_2CO_3

1.45g were in the 250 cm^3

Na_2CO_3	:	xH_2O	(divided by Mr to get moles.)
1.45 g	:	2.47g	
0.01368 mol	:	0.137 mol	
1	:	10	

$x = 10$.

14 Limestone is impure calcium carbonate ($CaCO_3$): 2.00 g of limestone is put into a beaker and 60.00 cm^3 of 3.000 moldm^{-3} hydrochloric acid is added.They are left to react and then the impurities are filtered off and the solution is made up to a total volume of 100.0 cm^3. Of this solution, 25.00 cm^3 requires 35.50 cm^3 of 1.000 moldm^{-3} sodium hydroxide for neutralisation. Work out the percentage $CaCO_3$ in the limestone (assume that none of the impurities reacts with hydrochloric acid).

$CaCO_3 + 2HCl \rightarrow H_2O + CO_2 + CaCl_2$

If the sample was 100% $CaCO_3$, then 2g would be 0.02 mol which would react with 0.04 mol of HCl. 100cm^3 of sol contains the Left over HCl.

n of $HCl = C \cdot V = \frac{3 \times 60}{1000} = 0.18$ mol

n of $NaOH = \frac{1 \times 35.5}{1000} = 0.0355$ mol. → $NaOH + HCl \rightarrow NaCl + H_2O$.

n of HCl in 25cm^3 = 0.0355 mol.

n HCl in 100cm^3 = $0.0355 \times 4 = 0.142$ mol — Left over HCl after it reacted with $CaCO_3$.

Amount of HCl that actually reacted = 0.182 − 0.142 = 0.038 mol.

mol of $CaCO_3$ = $\frac{0.038}{2}$ = 0.019 mol

mass $CaCO_3$ = 0.019 × 100.1 = 1.9019 g

% by mass of $CaCO_3$ = $\frac{1.9019}{2} \times 100$

= 95.1% Ans

15 A 25.0cm^3 sample of a solution of copper(II) nitrate is added to 10.0cm^3 of 1moldm^{-3} potassium iodide.The iodine produced is titrated against 0.0200 moldm^{-3} sodium thiosulfate solution using starch indicator near the end point. 22.50 cm^3 of the sodium thiosulfate solution was required for the titration. Calculate the concentration of the copper(II) nitrate solution.

$4KI + 2Cu(NO_3)_2 \longrightarrow 2CuI + I_2 + 2K_2NO_3$

η of KI = $\frac{1 \times 10}{1000}$ = 0.01 mol

$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$

η of $Na_2S_2O_3$ = $\frac{0.02 \times 22.5}{1000}$ = 450×10^{-6} mol

η of I_2 = 2.25×10^{-4} mol (× 1/2)

η $Cu(NO_3)_2$ = 450×10^{-6} mol (× 2)

Conc. = $\frac{450 \times 10^{-6}}{25/1000}$ = 0.018 moldm^{-3}