Question 5 :

A sample of chromium containing alloy weighing 3.45 g was dissolved in acid and all chromium was oxidised to CrO_4^{2-}. 3.15g of Na_2SO_3 was required to reduce the CrO_4^{2-} to CrO_2^- in a basic solution while SO_3^{2-} ion being oxidised to SO_4^{2-}. Calculate mass % of chromium in sample. [Molar mass of Cr=52]

Answer : (option 1) 25.13%

The given reaction can be separated into two reactions:

Oxidation: : $SO_3^{2-} \rightarrow SO4^{2}$

Reduction: $CrO_4^{2-} \rightarrow CrO^{2}$

Then, we will balance each reaction by adding hydroxide ions (since it occurs in a basic medium), water molecules, and electrons.

Oxidation: $SO_3^{2-} + 2OH^- \rightarrow SO4^{2-} + H2O + 2e-$

Reduction: $CrO_4^{2-} + 2H_2O + 3e- \rightarrow CrO^{2-} + 4OH-$

Finally, we can obtain the balanced redox reaction by multiplying each reaction by a factor to eliminate the electrons. We will multiply the oxidation reaction by 3 and the reduction reaction by 2.

Oxidation: $3SO_3^{2-} + 6OH^- \rightarrow 3SO4^{2} + 3H2O + 6e-$

Reduction: $2\ CrO_4^{2-} + 4H_2O + 6e- \rightarrow 2CrO^{2-} + 8OH-$

Overall : $2\ CrO_4^{2-} + 3SO_3^{2-} + H2O \rightarrow 2CrO^{2-} + 3SO4^{2} + 2OH-$

moles of Na_2SO_3 (molar mass=126.043 g/mol) that was required to reduce CrO_4^{2-}

=3.18g / 126.043g/mol

= 0.02523mol

the moles of CrO_4^{2-} that reacted

$$=0.02523\text{mol } Na_2SO_3 \times (\ 2\text{mol } CrO_4^{2-} / 3\text{mol} SO_3^{2-}\ )$$

$$= 0.01682\text{mol}$$

Now, we will use the mole ratio of chromium to CrO_4^2 and the molar mass of chromium (51.9961 g/mol) to calculate the mass of Cr in the alloy sample.

$$\text{Mass Cr} = 0.01682\text{mol} \times (1\text{mol Cr}/ 1\text{mol } CrO_4^{2-} \times 51.9961\text{g/mol}$$

$$\text{Mass Cr} = 0.8746\text{g}$$

percentage by mass of chromium in the alloy:

$$\%Cr = (0.8746\text{g}/3.450\text{g}) \times 100\%$$

% Cr = 25.35%