b) Full Redox Reactions

i) Procedure:

① Separate redox into its two half reactions
② Balance each half reaction as above
③ Make e- the same for both half reactions *(electrons gained = electrons lost)*
④ Add the two half reactions together *(cancel out species common to both sides)*

ii) Balance $Cu^{+2} + Al_{(s)} \rightarrow Cu_{(s)} + Al^{+3}$ (acidic)

1st Separate half reactions

$Cu^{+2} \rightarrow Cu_{(s)}$
$Al_{(s)} \rightarrow Al^{+3}$

2nd Balance half reactions

$Cu^{+2} + 2e^- \rightarrow Cu_{(s)}$
$Al_{(s)} \rightarrow Al^{+3} + 3e^-$

3rd Make e- the same

$3(Cu^{+2} + 2e^- \rightarrow Cu_{(s)})$ ..... $3Cu^{+2} + 6e^- \rightarrow 3Cu_{(s)}$
$2(Al_{(s)} \rightarrow Al^{+3} + 3e^-)$ ..... $2Al_{(s)} \rightarrow 2Al^{+3} + 6e^-$

4th Add half reactions together

$$3Cu^{+2} + 6e^- \rightarrow 3Cu_{(s)}$$
$$\underline{2Al_{(s)} \rightarrow 2Al^{+3} + 6e^-}$$
$$\mathbf{3Cu^{+2} + 2Al_{(s)} \rightarrow 3Cu_{(s)} + 2Al^{+3}}$$

iii) Balance $Cr_2O_7^{2-} + Fe^{+2} \rightarrow Cr^{+3} + Fe^{+3}$ (acidic)

1st Separate half reactions

$Cr_2O_7^{-2} \rightarrow Cr^{+3}$
$Fe^{+2} \rightarrow Fe^{+3}$

2nd Balance half reactions

$Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O$
$Fe^{+2} \rightarrow Fe^{+3}$

$6e^- + 14H^+ + Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O$
$Fe^{+2} \rightarrow Fe^{+3} + e^-$

3rd Make e- the same

$6e^- + 14H^+ + Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O$
$6(Fe^{+2} \rightarrow Fe^{+3} + e^-)$

4th Add two half reactions together

$$\begin{array}{r} 6e^- + 14H^+ + Cr_2O_7^{-2} \rightarrow 2Cr^{+3} + 7H_2O \\ \underline{6Fe^{+2} \rightarrow 6Fe^{+3} + 6e^-} \end{array}$$
$$\mathbf{14H^+ + Cr_2O_7^{-2} + 6Fe^{+2} \rightarrow 2Cr^{+3} + 7H_2O + 6Fe^{+3}}$$

iv) Balance $MnO_4^- + SO_2 \rightarrow Mn^{+2} + SO_4^{-2}$ (acidic)

1st Separate half reactions

$MnO_4^- \rightarrow Mn^{+2}$
$SO_2 \rightarrow SO_4^{-2}$

2nd Balance half reactions

$MnO_4^- \rightarrow Mn^{+2} + 4H_2O$
$SO_2 + 2H_2O \rightarrow SO_4^{-2}$

$8H^+ + MnO_4^- \rightarrow Mn^{+2} + 4H_2O$
$SO_2 + 2H_2O \rightarrow SO_4^{-2} + 4H^+$

$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{+2} + 4H_2O$
$SO_2 + 2H_2O \rightarrow SO_4^{-2} + 4H^+ + 2e^-$

3rd Make e- the same

$2(5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{+2} + 4H_2O) \ldots \quad 10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{+2} + 8H_2O$
$5(SO_2 + 2H_2O \rightarrow SO_4^{-2} + 4H^+ + 2e^-) \ldots \quad 5SO_2 + 10H_2O \rightarrow 5SO_4^{-2} + 20H^+ + 10e^-$

4th Add two half reactions together

$$\begin{array}{r} 10e^- + 16H^+ + 2MnO_4^- \rightarrow 2Mn^{+2} + 8H_2O \\ \underline{5SO_2 + 10H_2O \rightarrow 5SO_4^{-2} + 20H^+ + 10e^-} \end{array}$$
$$\mathbf{2MnO_4^- + 2H_2O + 5SO_2 \rightarrow 2Mn^{+2} + 5SO_4^{-2} + 4H^+}$$

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