Balancing redox reactions and O.C.s

1 Half equation method

STEPS

- Half equ. = O.A., R.A. 各至的 rx，有电子
- Full equ. = 两个 half equ. 结合在一起，没电子
- 四部曲
  1. 欠O加水
  2. 欠H加 H^+
  3. 加电子平衡电荷
  4. 左右两边的 LCM 加在一起

(Steps 1–3: HALF EQU.; step 4: FULL EQU.)

EXAMPLES

1. $MnO_4^- + I^-$

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O \quad (\times 2)$$
$$2I^- \rightarrow I_2 + 2e^- \quad (\times 5)$$
(LCM = 10)

→ $16H^+ + 2MnO_4^- + 10I^- \rightarrow 2Mn^{2+} + 8H_2O + 5I_2$

→ Sol^n changes from purple to brown

2. (acidified) $MnO_4^-{}_{(aq)}$ + $FeSO_4{}_{(aq)}$

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$
$$Fe^{2+} \rightarrow Fe^{3+} + e^- \quad (\times 5)$$
(LCM = 5)

[pale green, 但颜色太浅 → 被 MnO_4^- 盖过了]

→ $8H^+ + MnO_4^- + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+} + 5e^-$

→ Sol^n changes from purple to pale yellowish brown

Common mistakes

1. $MnO_4^- \rightarrow Mn^{2+}$
2. 写了 SO_4^{2-} 作 R.A.（可是不在表上 ⇒ 很弱，Fe^{2+} 更强）
3. 写错 half equ.
   $KMnO_4 \rightarrow Mn^{2+}$
   $FeSO_4 \rightarrow Fe^{3+}$
   → 这是 (aq)，要拆 spectator ion
   如果是 (s) / (l)，则靠四部曲平衡
   → eg. $Zn + CuO \rightarrow ZnO + Cu$
   - $Cu^{2+} \rightarrow Cu$ ✗
   - $2e^- + 2H^+ + CuO \rightarrow Cu + H_2O$ ✓

2 Change in O.N. method

STEPS

- 四部曲
  1. 写 O.N.（for 氧化素变了的 atoms）
  2. 写每个 element O.N. 变了多少
  3. R.A., O.A. 式各至乘至 $\Delta_{O.N.}$ 的 LCM
  4. 欠O加水，欠H加 H^+（不用平衡电荷）

EXAMPLES

[与 conc. $HNO_{3(aq)}$ react 变 Fe^{2+} unless specified → 反应产生水 ⇒ 把 $HNO_{3(aq)}$ 稀释，不够使 Fe^{2+} 再 react 变 Fe^{3+} → $H_2SO_{4(l)}$ 可以！∵ H_2SO_4 is stronger O.A. than NO_3^-]

1. conc. nitric acid + Fe

$$4H^+ + 2NO_3^- + Fe \rightarrow 2NO_2 + Fe^{2+} + H_2O$$
[O.N.: N +5 → +4, Δ = 1 × 2; Fe 0 → +2, Δ = 2]

→ $4H^+ + 2NO_3^- + Fe \rightarrow 2NO_2 + Fe^{2+} + H_2O$
[charge = 4(+1) + 2(−1) + 0 = +2; charge = 0 + (+2) + 0 = +2]

→ brown fumes evolve
Sol^n changes from colourless to green

2. $Cr_2O_7^{2-} + SO_3^{2-}$

$$8H^+ + Cr_2O_7^{2-} + 3SO_3^{2-} \rightarrow 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$$
[O.N.: Cr +6,+6 → +3,+3, Δ = 6; S +4 → +6, Δ = 2; 有两个Cr，要分开写 O.N.]

→ $8H^+ + Cr_2O_7^{2-} + 3SO_3^{2-} \rightarrow 2Cr^{3+} + 3SO_4^{2-} + 4H_2O$

→ Sol^n changes from orange to green

3a. Potassium iodiate (KIO_3) is mixed w/ potassium iodide to give I_2.

$$12H^+ + 2IO_3^- + 10I^- \rightarrow I_2 + 5I_2 + 6H_2O$$
[O.N.: I +5,+5 → 0,0, Δ = 10; I −1,−1 → 0,0, Δ = 2]

→ $12H^+ + 2IO_3^- + 10I^- \rightarrow 6I_2 + 6H_2O$
↳ $6H^+ + IO_3^- + 5I^- \rightarrow 3I_{2(aq)} + 3H_2O$

→ Sol^n changes from colourless to brown

3b. Sulphur is added to conc. $H_2SO_{4(l)}$ to give SO_2.

$$S + 2H_2SO_4 \rightarrow SO_2 + 2SO_2 + 2H_2O$$
[O.N.: S 0 → +4, Δ = 4; S +6 → +4, Δ = 2]

→ $S + 2H_2SO_4 \rightarrow 3SO_2 + 2H_2O$

→ Sulphur dissolves
choking smell

4a. 100cm³ 0.1M Sn^{2+} reacts w/ 40cm³ 0.1M MnO_4^- completely. [0.01 mol : 0.004 mol = 5 : 2]
If MnO_4^- is reduced to Mn^{2+}, write balanced equ. + O.C.

$$16H^+ + 5Sn^{2+} + 2MnO_4^- \rightarrow 5Sn^{x+} + 2Mn^{2+} + 8H_2O$$
[O.N.: +2×5; +7,+7; +20; +2,+2; +10 ← −10; 5(x) = +20 → x = +4]

→ $16H^+ + 5Sn^{2+} + 2MnO_4^- \rightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$

→ Sol^n changes from purple to colourless.

If only 80cm³ 0.1M Sn^{2+} is added, state & explain 1 O.C.

→ purple colour intensity ↓ / purple colour becomes paler.

→ Sn^{2+} mol : MnO_4^- mol = 0.008 : 0.004
= 2 : 1 < 5 : 2

∴ MnO_4^- is in excess, remaining MnO_4^- provides purple colour.
∴ Since $[MnO_4^-{}_{(aq)}]$ decreases, colour intensity decreases.

4b. 200cm³ 0.05M SO_2 reacts w/ 20cm³ 0.2M MnO_4^- completely. [0.1 mol : 0.04 mol = 5 : 2]
If SO_2 oxidizes to become SO_x^{2-}, MnO_4^- reduces to become Mn^{2+},
write balanced equ.

$$2H_2O + 5SO_2 + 2MnO_4^- \rightarrow 5SO_x^{2-} + 2Mn^{2+} + 4H^+$$
[O.N.: +4×5; +7×2; +30; +2×2; +10 ← −10; (一个S = 30÷5 = 6) 6 + (−2)x = −2 → x = 4]

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