Balancing redox reactions and O.C.s

1 Half equation method

STEPS

- Half equ. = O.A., R.A. 各至的 rα，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 } HALF EQU.
  2. 欠H加H^+ } HALF EQU.
  3. 加电子平衡电荷 } HALF EQU.
  4. 左右两边的 LCM 加在一起 } FULL EQU.

EXAMPLES

1. $MnO_4^- + I^-$

$$5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$$
(×2: 10, 16, 2 → 2, 8; LCM = 10)
$$2I^- \rightarrow I_2 + 2e^-$$
(×5: 10 → 5, 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)

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

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

(pale green, 但颜色太浅 → 被MnO_4^-盖过了)

→ 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

1. conc. nitric acid + Fe

(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^-)

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

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

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

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

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

$$12H^+ + 2IO_3^- + 2I^- \rightarrow I_2 + I_2 + 6H_2O$$
(×10 for $2I^-$, ×5 for I_2; 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.

$$S + 2H_2SO_4 \rightarrow SO_2 + 2SO_2 + 2H_2O$$
(S: 0 → +4, Δ = 4; S: +6 → +4, Δ = 2)

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

→ Sulphur dissolves
Choking smell

4a. $100cm^3$ 0.1M Sn^{2+} reacts w/ $40cm^3$ 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.

$$16H^+ + 5Sn^{2+} + 2MnO_4^- \rightarrow 5Sn^{?+} + 2Mn^{2+} + 8H_2O$$
(Sn: +2×5 → +20; Mn: +7, +7 → +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 $80cm^3$ 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. $200cm^3$ 0.05M SO_2 reacts w/ $20cm^3$ 0.2M MnO_4^- completely.
(0.01 mol : 0.004 mol = 5 : 2)
If SO_2 oxidizes to become SO_x^{2-}, MnO_4^- reduces to become Mn^{2+}, write balanced equ.

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

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