

QUESTIONS on Oxidation Reduction Equations

Oxidation involves an increase in oxidation number (state)

Reduction involves a decrease in oxidation number (state)

Set 1:

Q1. Which of the following equations are oxidation–reduction reactions and which are not? Explain your decisions.

- A. $\text{Zn}_{(s)} + 2 \text{MnO}_{2(s)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{Zn}(\text{OH})_{2(s)} + \text{Mn}_2\text{O}_{3(s)}$
B. $\text{HCl}_{(aq)} + \text{NaOH}_{(aq)} \rightarrow \text{NaCl}_{(aq)} + \text{H}_2\text{O}_{(l)}$
C. $\text{CH}_{4(g)} + 2 \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + 2 \text{H}_2\text{O}_{(g)}$
D. $\text{Na}_{(s)} + \text{Fe}_2\text{O}_{3(s)} \rightarrow \text{Na}_2\text{O}_{(s)} + \text{Fe}_{(s)}$
E. $\text{Ag}^+_{(aq)} + \text{I}^-_{(aq)} \rightarrow \text{AgI}_{(s)}$
F. $\text{HNO}_{3(aq)} + \text{H}_3\text{AsO}_{3(aq)} \rightarrow \text{NO}_{(g)} + \text{H}_3\text{AsO}_{4(aq)} + \text{H}_2\text{O}_{(l)}$
G. $2\text{Cu}^{2+}_{(aq)} + 4 \text{I}^-_{(aq)} \rightarrow 2 \text{CuI}_{(s)} + \text{I}_{2(s)}$
H. $\text{CaCO}_{3(s)} + 2\text{H}^+_{(aq)} \rightarrow \text{Ca}^{2+}_{(aq)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$
I. $\text{SO}_{2(g)} + 2\text{H}_2\text{S}_{(g)} \rightarrow 2\text{H}_2\text{O}_{(l)} + 3\text{S}_{(s)}$
J. $\text{H}^+_{(aq)} + \text{OH}^-_{(aq)} \rightarrow \text{H}_2\text{O}_{(l)}$
K. $\text{Ca}(\text{OH})_{2(aq)} + \text{CO}_{2(g)} \rightarrow \text{CaCO}_{3(s)} + \text{H}_2\text{O}_{(l)}$
L. $3\text{SO}_{2(g)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} + 2\text{H}^+_{(aq)} \rightarrow 3\text{SO}_4^{2-}_{(aq)} + 2\text{Cr}^{3+}_{(aq)} + \text{H}_2\text{O}_{(l)}$
M. $\text{BaO}_{(s)} + \text{SO}_{2(g)} \rightarrow \text{BaSO}_3_{(s)}$
N. $\text{SO}_{2(g)} + 2\text{NO}_3^-_{(aq)} \rightarrow \text{SO}_4^{2-}_{(aq)} + 2\text{NO}_{2(g)}$
O. $2\text{NaHCO}_3_{(s)} \rightarrow \text{Na}_2\text{CO}_3_{(s)} + \text{CO}_{2(g)} + \text{H}_2\text{O}_{(l)}$
P. $2\text{Mg}_{(s)} + \text{SO}_{2(g)} \rightarrow 2\text{MgO}_{(s)} + \text{S}_{(s)}$
Q. $\text{MnO}_4^-_{(aq)} + 5\text{Fe}^{2+}_{(aq)} + 8\text{H}^+_{(aq)} \rightarrow \text{Mn}^{2+}_{(aq)} + 5\text{Fe}^{3+}_{(aq)} + 4\text{H}_2\text{O}_{(l)}$

Q2. Which of these half-reactions represent oxidation and which reduction? Explain your reasoning.

- A. $\text{Fe}_{(s)} \rightarrow \text{Fe}^{2+}_{(aq)} + 2 \text{e}^-$
B. $\text{Ni}^{4+}_{(aq)} + 2 \text{e}^- \rightarrow \text{Ni}^{2+}_{(aq)}$
C. $2 \text{H}_2\text{O}_{(l)} + 2 \text{e}^- \rightarrow \text{H}_{2(g)} + 2 \text{OH}^-_{(aq)}$
D. $\text{Cu}_{(s)} \rightarrow \text{Cu}^{2+}_{(aq)} + 2 \text{e}^-$
E. $\text{Pb}^{2+}_{(aq)} + 2\text{e}^- \rightarrow \text{Pb}_{(s)}$
F. $\text{Cl}_{2(g)} + 2 \text{e}^- \rightarrow 2 \text{Cl}^-_{(aq)}$
G. $\text{Cr}^{3+}_{(aq)} + 3\text{e}^- \rightarrow \text{Cr}_{(s)}$
H. $\text{Cr}_2\text{O}_7^{2-}_{(aq)} + 14 \text{H}^+_{(aq)} + 6 \text{e}^- \rightarrow 2 \text{Cr}^{3+}_{(aq)} + 7 \text{H}_2\text{O}_{(l)}$

Q3. How many electrons are in the following $\frac{1}{2}$ equations

- A. $\text{Al} \rightarrow \text{Al}^{3+} + ? \text{e}^-$
B. $\text{MnO}_4^- + 8 \text{H}^+ + ? \text{e}^- \rightarrow \text{Mn}^{2+}_{(aq)} + 4 \text{H}_2\text{O}_{(l)}$
C. $\text{H}_2\text{O}_2 \rightarrow 2 \text{H}^+ + \text{O}_2 + ? \text{e}^-$
D. $\text{H}_2\text{O}_2 + ? \text{e}^- \rightarrow 2 \text{OH}^-$
E. $\text{S}_8 + ? \text{e}^- \rightarrow 8 \text{S}^{2-}$
F. $\text{NO}_3^- + 2 \text{H}^+ + ? \text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$

Q4. Identify the reducing agent (reductant) in the following reactions.

- A. $2 \text{Cr}^{3+} + \text{H}_2\text{O} + 6 \text{ClO}_3^- \rightarrow \text{Cr}_2\text{O}_7^{2-} + 6 \text{ClO}_2 + 2 \text{H}^+$
B. $\text{Cr}_2\text{O}_7^{2-} + \text{HCHO} \rightarrow \text{HCOOH} + \text{Cr}^{3+}$
C. $7 \text{CN}^- + 2 \text{OH}^- + 2 \text{Cu}(\text{NH}_3)_4^{2+} \rightarrow 2 \text{Cu}(\text{CN})_3^{2-} + 8 \text{NH}_3 + \text{CNO}^- + \text{H}_2\text{O}$
D. $2 \text{Li} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH} + \text{H}_2$
E. $\text{Cl}_2 + 2 \text{KI} \rightarrow 2 \text{KCl} + \text{I}_2$
F. $\text{SO}_2 + 2\text{H}_2\text{S} \rightarrow 2\text{H}_2\text{O} + 3\text{S}$

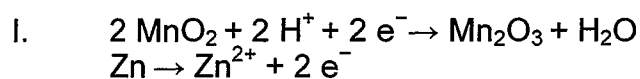
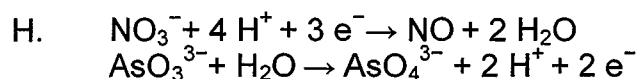
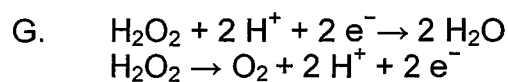
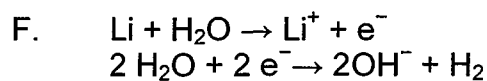
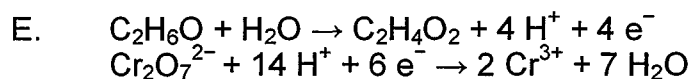
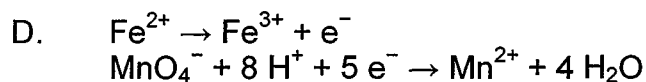
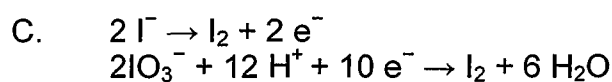
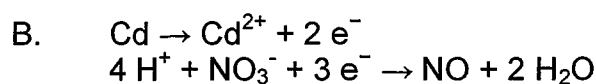
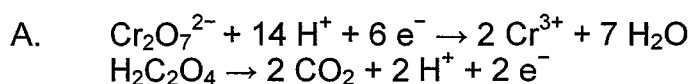
Q5. Identify the oxidising agent (oxidant) in the following reactions.

- A. $\text{Ni} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{Ni}(\text{NO}_3)_2(\text{aq}) + \text{Pb}(\text{s})$
- B. $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$
- C. $\text{Cr}_2\text{O}_3 + \text{Al} \rightarrow \text{Cr} + \text{Al}_2\text{O}_3$
- D. $\text{FeO} + \text{H}_2 \rightarrow \text{Fe} + \text{H}_2\text{O}$
- E. $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$
- F. $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow 2\text{CuI} + \text{I}_2$

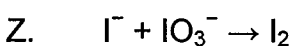
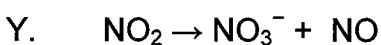
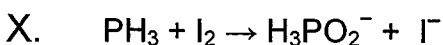
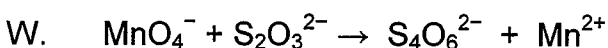
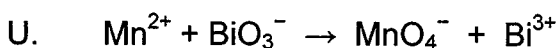
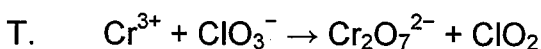
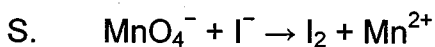
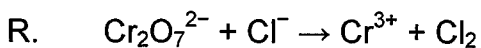
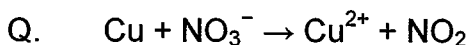
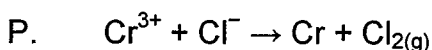
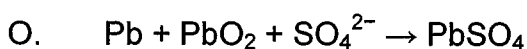
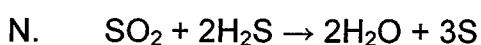
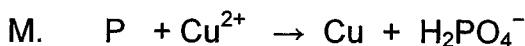
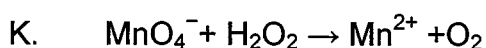
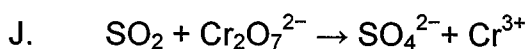
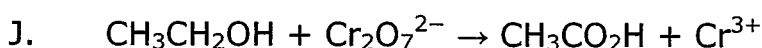
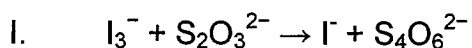
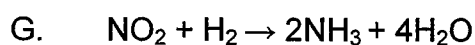
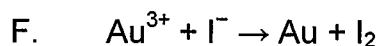
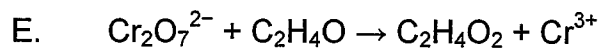
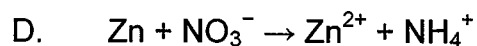
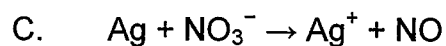
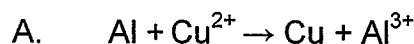
Q6. Write the full oxidation-reduction equation from the following two half-reactions:

number of e^- s lost = number of e^- s gained

- Since charge is conserved, one or both $\frac{1}{2}$ equations may need to be multiplied by an integer so that number of e^- s lost = number of e^- s gained.
- Like terms such as H^+ ions and H_2O molecules may need to be collected if they appear on both sides of the equation



Q7. Balance the following equations



Answers:

- Q1. A. Yes, Zn and Mn change oxidation state
 B. No, no change in oxidation state
 C. Yes, C and O change oxidation state
 D. Yes, Na and Fe change oxidation state
 E. No, no change in oxidation state
 F. Yes, N and As change oxidation state
 G. Yes, Cu^{2+} and I^- change oxidation state
 H. No, no change in oxidation state
 I. Yes, S and S change oxidation state
 J. No, no change in oxidation state
 K. No, no change in oxidation state
 L. Yes, S and Cr change oxidation state
 M. No, no change in oxidation state
 O. No, no change in oxidation state
 P. Yes, Mg and S change oxidation state
 Q. Yes, Mn and Fe^{2+} change oxidation state

Q2. Oxidation: electrons on the right hand side Reduction: electrons on the left hand side

- A. Oxidation, increase in oxidation state
 B. Reduction, decrease in oxidation state
 C. Reduction, decrease in oxidation state
 D. Oxidation, increase in oxidation state
 E. Reduction, decrease in oxidation state
 F. Reduction, decrease in oxidation state
 G. Reduction, decrease in oxidation state
 H. Reduction, decrease in oxidation state

Q3. A. $3e^-$ B. $5e^-$ C. $2e^-$ D. $2e^-$ E. $16e^-$ F. $1e^-$

Q4. A. Cr^{3+} B. HCHO C. CN^- D. Li E. I^- (KI) F. $\text{S}(\text{H}_2\text{S})$

Q5. A. Pb^{2+} B. $\text{H}(\text{H}_2\text{O})$ C. $\text{Cr}_2\text{O}_7^{2-}$ D. FeO E. MnO_4^- F. Cu^{2+}

- Q6. A. $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{CO}_2$
 B. $3\text{Cd} + 8\text{H}^+ + 2\text{NO}_3^- \rightarrow 3\text{Cd}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$
 C. $6\text{H}^+ + 5\text{I}^- + \text{IO}_3^- \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$
 D. $\text{MnO}_4^- + 8\text{H}^+ + \text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$
 E. $2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ + 3\text{C}_2\text{H}_6\text{O} \rightarrow 4\text{Cr}^{3+} + 3\text{C}_2\text{H}_4\text{O}_2 + 11\text{H}_2\text{O}$
 F. $2\text{Li} + 2\text{H}_2\text{O} \rightarrow 2\text{LiOH} + \text{H}_2$
 G. $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
 H. $2\text{NO}_3^- + 2\text{H}^+ + 3\text{AsO}_3^{3-} \rightarrow 2\text{NO} + \text{H}_2\text{O} + 3\text{AsO}_4^{3-}$
 I. $\text{Zn} + 2\text{MnO}_2 + 2\text{H}^+ \rightarrow \text{Mn}_2\text{O}_3 + \text{H}_2\text{O} + \text{Zn}^{2+}$

Q7. A. $\text{Al} \rightarrow \text{Al}^{3+} + 3e^-$] x 2
 $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$] x 3
 $2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}$ check that the charges are balanced

B. $\text{MnO}_4^- + 8\text{H}^+ + 5e^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{NO}_2^- + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2e^-$] x 5
 $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{NO}_2^- \rightarrow 2\text{Mn}^{2+} + 5\text{NO}_3^- + 3\text{H}_2\text{O}$ collect like terms (H_2O and H^+)

C. $\text{Ag} \rightarrow \text{Ag}^+ + e^-$] x 3
 $\text{NO}_3^- + 4\text{H}^+ + 3e^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$
 $3\text{Ag} + \text{NO}_3^- + 4\text{H}^+ \rightarrow 3\text{Ag}^+ + \text{NO} + 2\text{H}_2\text{O}$ check that the charges are balanced

D. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-$] x 2
 $\text{NO}_3^- + 6\text{H}^+ + 4e^- \rightarrow \text{NH}_4^+ + 3\text{H}_2\text{O}$
 $2\text{Zn} + \text{NO}_3^- + 6\text{H}^+ \rightarrow 2\text{Zn}^{2+} + \text{NH}_4^+ + 3\text{H}_2\text{O}$ check that the charges are balanced

E. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{C}_2\text{H}_4\text{O} + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_4\text{O}_2 + 2\text{H}^+ + 2e^-$] x 3
 $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{C}_2\text{H}_4\text{O} \rightarrow 2\text{Cr}^{3+} + 3\text{C}_2\text{H}_4\text{O}_2 + 4\text{H}_2\text{O}$ collect like terms (H_2O and H^+)

F. $2\text{I}^- \rightarrow \text{I}_2 + 2e^-$] x 3
 $\text{Au}^{3+} + 3e^- \rightarrow \text{Au}$] x 2
 $2\text{Au}^{3+} + 6\text{I}^- \rightarrow 2\text{Au} + 3\text{I}_2$ check that the charges are balanced

G. $\text{MnO}_4^- + 8\text{H}^+ + 5e^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{CO}_2 + 2\text{H}^+ + 2e^-$] x 5
 $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 10\text{CO}_2$ collect like terms (H_2O and H^+)

H. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{NO}_2^- + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2e^-$] x 3
 $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{NO}_2^- \rightarrow 2\text{Cr}^{3+} + 4\text{H}_2\text{O} + 3\text{NO}_3^-$ collect like terms (H_2O and H^+)

I. $\text{I}_3^- + 2e^- \rightarrow 3\text{I}^-$
 $2\text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2e^-$
 $\text{I}_3^- + 2\text{S}_2\text{O}_3^{2-} \rightarrow 3\text{I}^- + \text{S}_4\text{O}_6^{2-}$ check that the charges are balanced

J. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6e^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$] x 2
 $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CO}_2\text{H} + 4\text{H}^+ + 4e^-$] x 3
 $2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ + 3\text{CH}_3\text{CH}_2\text{OH} \rightarrow 4\text{Cr}^{3+} + 3\text{CH}_3\text{CO}_2\text{H} + 11\text{H}_2\text{O}$

K. $\text{MnO}_4^- + 8\text{H}^+ + 5e^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}^+ + 2e^-$] x 5
 $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{O}_2 \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2$ collect the H^+ ions

- L. $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$
 $\text{OCl}^- + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$
 $\text{OCl}^- + 2\text{H}^+ + 2\text{I}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O} + \text{I}_2$ check that the charges are balanced
- M. $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$] x 5
 $\text{P} + 4\text{H}_2\text{O} \rightarrow \text{H}_2\text{PO}_4^- + 6\text{H}^+ + 5\text{e}^-$] x 2
 $2\text{P} + 8\text{H}_2\text{O} + 5\text{Cu}^{2+} \rightarrow 2\text{H}_2\text{PO}_4^- + 12\text{H}^+ + 5\text{Cu}$ check that the charges are balanced
- N. $\text{SO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{S} + 2\text{H}_2\text{O}$
 $\text{H}_2\text{S} \rightarrow \text{S} + 2\text{H}^+ + 2\text{e}^-$] x 2
 $\text{SO}_2 + 2\text{H}_2\text{S} \rightarrow 2\text{H}_2\text{O} + 3\text{S}$ collect the H^+ ions and the S atoms
- O. $\text{Pb} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 + 2\text{e}^-$
 $\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$
 $\text{Pb} + \text{PbO}_2 + 2\text{SO}_4^{2-} + 4\text{H}^+ \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O}$ collect the PbSO_4
- P. $\text{Cr}^{3+} + 3\text{e}^- \rightarrow \text{Cr}$] x 2
 $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$] x 3
 $2\text{Cr}^{3+} + 6\text{Cl}^- \rightarrow 2\text{Cr} + 3\text{Cl}_2$ check that the charges are balanced
- Q. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
 $\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$] x 2
 $\text{Cu} + 2\text{NO}_3^- + 4\text{H}^+ \rightarrow \text{Cu}^{2+} + 2\text{NO}_2 + 2\text{H}_2\text{O}$ check that the charges are balanced
- R. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$] x 3
 $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Cl}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{Cl}_2$ check that the charges are balanced
- S. $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$] x 5
 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $2\text{MnO}_4^- + 16\text{H}^+ + 10\text{I}^- \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{I}_2$ check that the charges are balanced
- T. $2\text{Cr}^{3+} + 7\text{H}_2\text{O} \rightarrow \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^-$
 $\text{ClO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$] x 6
 $2\text{Cr}^{3+} + \text{H}_2\text{O} + 6\text{ClO}_3^- \rightarrow \text{Cr}_2\text{O}_7^{2-} + 6\text{ClO}_2 + 2\text{H}^+$ collect like terms (H_2O and H^+)
- U. $\text{BiO}_3^- + 6\text{H}^+ + 5\text{e}^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O}$
 $\text{Mn}^{2+} + 4\text{H}_2\text{O} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$
 $\text{Mn}^{2+} + \text{H}_2\text{O} + \text{BiO}_3^- \rightarrow \text{MnO}_4^- + 2\text{H}^+ + \text{Bi}^{3+}$ check that the charges are balanced
- V. $\text{ClO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$] x 2
 $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$
 $2\text{ClO}_3^- + 4\text{H}^+ + 2\text{Cl}^- \rightarrow 2\text{ClO}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$ check that the charges are balanced
- W. $2\text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{e}^-$] x 5
 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $2\text{MnO}_4^- + 16\text{H}^+ + 10\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{S}_4\text{O}_6^{2-}$
- X. $\text{PH}_3 + 2\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_2^- + 4\text{H}^+ + 3\text{e}^-$] x 2
 $\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$] x 3
 $2\text{PH}_3 + 4\text{H}_2\text{O} + 3\text{I}_2 \rightarrow 2\text{H}_3\text{PO}_2^- + 8\text{H}^+ + 6\text{I}^-$ check that the charges are balanced
- Y. $\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{e}^-$] x 2
 $\text{NO}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{NO} + \text{H}_2\text{O}$
 $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{NO}_3^- + \text{NO} + 2\text{H}^+$ collect like terms (H_2O and H^+)
- Z. $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$] x 5
 $2\text{IO}_3^- + 12\text{H}^+ + 10\text{e}^- \rightarrow \text{I}_2 + 6\text{H}_2\text{O}$
 $2\text{IO}_3^- + 12\text{H}^+ + 10\text{I}^- \rightarrow 5\text{I}_2 + \text{I}_2 + 6\text{H}_2\text{O}$
 $2\text{IO}_3^- + 12\text{H}^+ + 10\text{I}^- \rightarrow 6\text{I}_2 + 6\text{H}_2\text{O}$]
 $\text{IO}_3^- + 6\text{H}^+ + 5\text{I}^- \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$ collect the I_2 molecules
 $\div 2$ to get the smallest coefficients
check that the charges are balanced

