

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. $\text{Zn}_{(s)} + 2 \text{MnO}_{2(s)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{Zn(OH)}_{2(s)} + \text{Mn}_2\text{O}_{3(s)}$
- 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. $\text{Ca(OH)}_2_{(aq)} + \text{CO}_{2(g)} \rightarrow \text{CaCO}_{3(s)} + \text{H}_2\text{O}_{(l)}$
- 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. $\text{SO}_2 + 2\text{H}_2\text{S} \rightarrow 2\text{H}_2\text{O} + 3\text{S}$

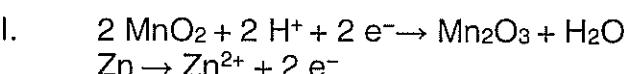
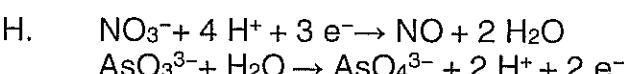
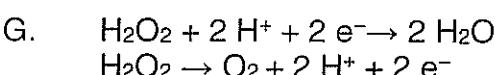
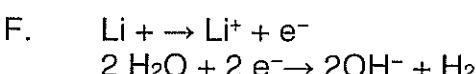
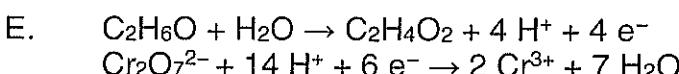
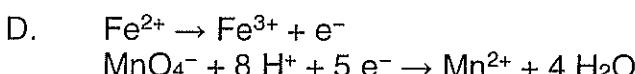
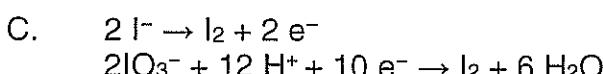
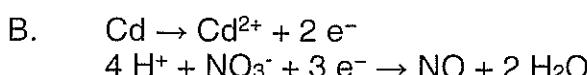
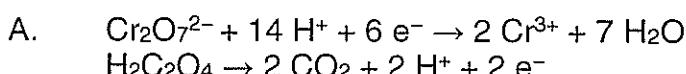
Q5. Identify the oxidising agent (oxidant) in the following reactions.

- 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. $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow 2\text{CuI} + \text{I}_2$

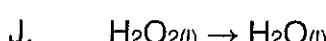
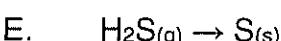
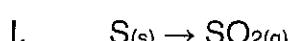
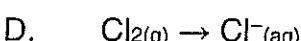
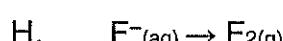
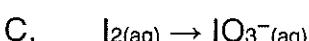
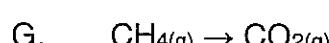
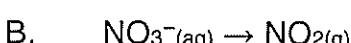
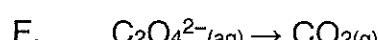
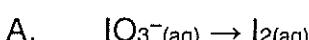
Q6. Write the full oxidation-reduction equation from the following two half-reactions:

$$\text{number of e}^- \text{ s lost} = \text{number of e}^- \text{ s gained}$$

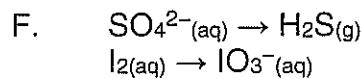
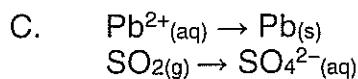
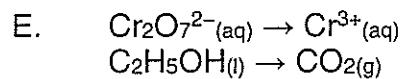
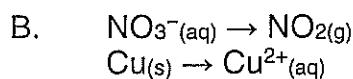
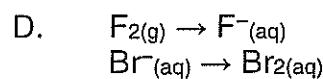
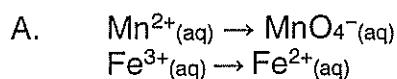
- Since charge is conserved, one or both $\frac{1}{2}$ equations may need to be multiplied by an integer so that number of e⁻s lost = number of e⁻s gained.
- Like terms such as H⁺ ions and H₂O molecules may need to be collected if they appear on both sides of the equation



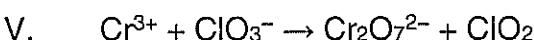
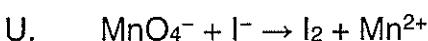
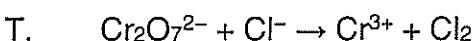
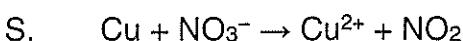
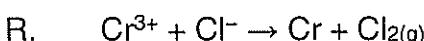
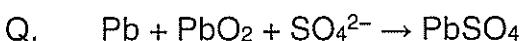
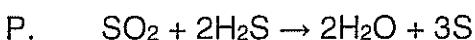
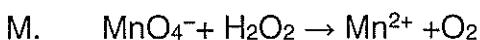
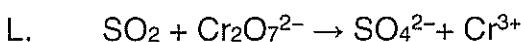
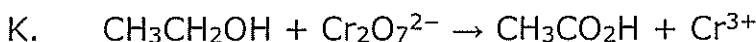
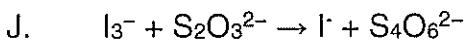
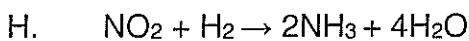
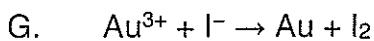
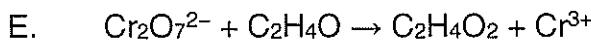
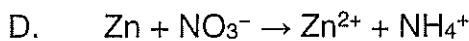
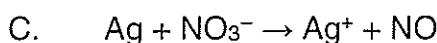
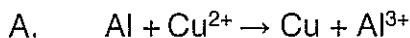
Q7. Balance each of the following ionic half-equations



Q8. Balance the following pairs of ionic equations and then write the overall net ionic equation.



Q9. Balance the following equations



- W. $\text{Mn}^{2+} + \text{BiO}_3^- \rightarrow \text{MnO}_4^- + \text{Bi}^{3+}$
- X. $\text{ClO}_3^- + \text{Cl}^- \rightarrow \text{Cl}_2 + \text{ClO}_2$
- Y. $\text{MnO}_4^- + \text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + \text{Mn}^{2+}$
- Z. $\text{PH}_3 + \text{I}_2 \rightarrow \text{H}_3\text{PO}_2^- + \text{I}^-$
- AA. $\text{NO}_2 \rightarrow \text{NO}_3^- + \text{NO}$
- AB. $\text{I}^- + \text{IO}_3^- \rightarrow \text{I}_2$

Q10. For each of the following reactions, write the two ionic half-equations involved in the process, the overall equation, the oxidizing agent (oxidant) and the reducing agent (reductant).

- A. Zinc reacting with hydrogen ions to produce zinc ions and hydrogen gas.
- B. The sulfide ion reacting with iodine to produce sulfur and iodide ions.
- C. Silver ions reacting with copper metal to produce silver metal and copper ions.
- D. The silver ion oxidizing zinc metal.
- E. Fluorine gas reacting with chloride ions to produce chlorine gas and fluoride ions.
- F. Iron metal reacting with bromine to produce iron(II) ions and bromide ions.
- G. Hydrogen ions reacting with magnesium metal.
- H. Iodide ions reacting with iron(III) ions to give iodine and iron(II) ions.

Answers:

- Q1.** A. Yes, Zn and Mn change oxidation state
 C. Yes, C and O change oxidation state
 E. No, no change in oxidation state
 G. Yes, Cu^{2+} and I^- change oxidation state
 I. Yes, S and S change oxidation state
 K. No, no change in oxidation state
 M. No, no change in oxidation state
 O. No, no change in oxidation state
 Q. Yes, Mn and Fe^{2+} change oxidation state
- B. No, no change in oxidation state
 D. Yes, Na and Fe change oxidation state
 F. Yes, N and As change oxidation state
 H. No, no change in oxidation state
 J. No, no change in oxidation state
 L. Yes, S and Cr change oxidation state
 N. Yes, S and N change oxidation state
 P. Yes, Mg and S change oxidation state
- Q2.** Oxidation: electrons on the right hand side Reduction: electrons on the left hand side
- A. Oxidation, increase in oxidation state
 C. Reduction, decrease in oxidation state
 E. Reduction, decrease in oxidation state
 G. Reduction, decrease in oxidation state
- B. Reduction, decrease in oxidation state
 D. Oxidation, increase in oxidation state
 F. 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. $\text{I}^- (\text{KI})$ F. $\text{S}(\text{H}_2\text{S})$
- Q5.** A. Pb^{2+} B. $\text{H}(\text{H}_2\text{O})$ C. Cr_2O_3 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. $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$
 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. $2\text{IO}_3^{-(aq)} + 12\text{H}^{+(aq)} + 10\text{e}^- \rightarrow \text{I}_2(\text{aq}) + 6\text{H}_2\text{O(l)}$
 B. $\text{NO}_3^{-(aq)} + 2\text{H}^{+(aq)} + \text{e}^- \rightarrow \text{NO}_2(\text{g}) + \text{H}_2\text{O(l)}$
 C. $\text{I}_2(\text{aq}) + 6\text{H}_2\text{O(l)} \rightarrow 2\text{IO}_3^{-(aq)} + 12\text{H}^{+(aq)} + 10\text{e}^-$
 D. $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^{-(aq)}$
 E. $\text{H}_2\text{S(g)} \rightarrow \text{S(s)} + 2\text{H}^{+(aq)} + 2\text{e}^-$
 F. $\text{C}_2\text{O}_4^{2-(aq)} \rightarrow 2\text{CO}_2(\text{g}) + 2\text{e}^-$
 G. $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O(l)} \rightarrow \text{CO}_2(\text{g}) + 8\text{H}^{+(aq)} + 8\text{e}^-$
 H. $2\text{F}^{-(aq)} \rightarrow \text{F}_2(\text{g}) + 2\text{e}^-$
 I. $\text{S(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{SO}_2(\text{g}) + 4\text{H}^{+(aq)} + 4\text{e}^-$
 J. $\text{H}_2\text{O}_2(\text{l}) + 2\text{H}^{+(aq)} + 2\text{e}^- \rightarrow 2\text{H}_2\text{O(l)}$
- Q8.** A. $\text{Mn}^{2+} + 4\text{H}_2\text{O} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$
 $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$] x5
 $\text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+}$
- B. $\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$] x2
 $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
 $2\text{NO}_3^- + 4\text{H}^+ + \text{Cu}^{2+} \rightarrow 2\text{NO}_2 + 2\text{H}_2\text{O} + \text{Cu}$
- C. $\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}$
 $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$
 $\text{Pb}^{2+} + \text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + \text{Pb}$
- D. $\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$
 $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$
 $\text{F}_2 + 2\text{Br}^- \rightarrow 2\text{F}^- + \text{Br}_2$
- E. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$] x2
 $\text{C}_2\text{H}_5\text{OH} + 3\text{H}_2\text{O} \rightarrow 2\text{CO}_2 + 12\text{H}^+ + 12\text{e}^-$
 $2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ + \text{C}_2\text{H}_5\text{OH} \rightarrow 4\text{Cr}^{3+} + 11\text{H}_2\text{O} + 2\text{CO}_2$ collect like terms (H_2O and H^+)
- F. $\text{SO}_4^{2-} + 10\text{H}^+ + 8\text{e}^- \rightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}$] x5
 $\text{I}_2 + 6\text{H}_2\text{O} \rightarrow 2\text{IO}_3^- + 12\text{H}^+ + 10\text{e}^-$] x4
 $5\text{SO}_4^{2-} + 4\text{I}_2 + 2\text{H}^+ + 4\text{H}_2\text{O} \rightarrow 5\text{H}_2\text{S} + 8\text{IO}_3^-$ collect like terms (H_2O and H^+)

- Q9. A. $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$] x 2
 $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$] x 3
 $2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}$ check that the charges are balanced
- B. $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{NO}_2^- + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2\text{e}^-$] 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. $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$] x 3
 $\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$
 $3\text{Ag} + \text{NO}_3^- + 4\text{H}^+ \rightarrow 3\text{Ag}^+ + \text{NO} + 2\text{H}_2\text{O}$ check that the charges are balanced
- D. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$] x 4
 $\text{NO}_3^- + 10\text{H}^+ + 8\text{e}^- \rightarrow \text{NH}_4^+ + 3\text{H}_2\text{O}$
 $4\text{Zn} + \text{NO}_3^- + 10\text{H}^+ \rightarrow 4\text{Zn}^{2+} + \text{NH}_4^+ + 3\text{H}_2\text{O}$ check that the charges are balanced
- E. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{C}_2\text{H}_4\text{O} + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_4\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$] 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. $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^-$] 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^+)
- G. $2\text{l}^- \rightarrow \text{l}_2 + 2\text{e}^-$] x 3
 $\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$] x 2
 $2\text{Au}^{3+} + 6\text{l}^- \rightarrow 2\text{Au} + 3\text{l}_2$ check that the charges are balanced
- H. $2\text{NO}_2 + 14\text{H}^+ + 14\text{e}^- \rightarrow 2\text{NH}_3 + 4\text{H}_2\text{O}$
 $\text{H}_2\text{O} + \text{H}_2 \rightarrow \text{H}_2\text{O} + 2\text{H}^+ + 2\text{e}^-$] x 7
 $2\text{NO}_2 + 7\text{H}_2 \rightarrow 2\text{NH}_3 + 11\text{H}_2\text{O}$ collect like terms (H_2O and H^+)
- I. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{NO}_2^- + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + 2\text{e}^-$] 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^+)
- J. $\text{l}_3^- + 2\text{e}^- \rightarrow 3\text{l}^-$
 $2\text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{e}^-$
 $\text{l}_3^- + 2\text{S}_2\text{O}_3^{2-} \rightarrow 3\text{l}^- + \text{S}_4\text{O}_6^{2-}$ check that the charges are balanced
- K. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$] x 2
 $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CO}_2\text{H} + 4\text{H}^+ + 4\text{e}^-$] x 3
 $2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ + 3\text{CH}_3\text{CH}_2\text{OH} \rightarrow 4\text{Cr}^{3+} + 3\text{CH}_3\text{CO}_2\text{H} + 11\text{H}_2\text{O}$
- L. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
 $\text{SO}_2 + 2\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$] x 3
 $3\text{SO}_2 + \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ \rightarrow 2\text{Cr}^{3+} + \text{H}_2\text{O} + 3\text{SO}_4^{2-}$ collect like terms (H_2O and H^+)
- M. $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2
 $\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$] 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
- N. $2\text{l}^- \rightarrow \text{l}_2 + 2\text{e}^-$
 $\text{OCl}^- + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O}$
 $\text{OCl}^- + 2\text{H}^+ + 2\text{l}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O} + \text{l}_2$ check that the charges are balanced
- O. $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$] 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
- P. $\text{SO}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{S} + 2\text{H}_2\text{O}$
 $\text{H}_2\text{S} \rightarrow \text{S} + 2\text{H}^+ + 2\text{e}^-$] 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
- Q. $\text{Pb} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 + 2\text{e}^{+}$
 $\text{PbO}_2 + \text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$
 $\text{Pb} + \text{PbO}_2 + 2\text{SO}_4^{2-} + 4\text{H}^+ \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O}$ collect the PbSO_4
- R. $\text{Cr}^{3+} + 3\text{e}^- \rightarrow \text{Cr}$] 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
- S. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
 $\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{NO}_2 + \text{H}_2\text{O}$] 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

T.	$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$] 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
U.	$2\text{l}^- \rightarrow \text{l}_2 + 2\text{e}^-$] x 5 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2 $2\text{MnO}_4^- + 16\text{H}^+ + 10\text{l}^- \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{l}_2$	check that the charges are balanced
V.	$2\text{Cr}^{3+} + 7\text{H}_2\text{O} \rightarrow \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^-$ $\text{ClO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$] 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^+)
W.	$\text{BiO}_3^- + 6\text{H}^+ + 2\text{e}^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O}$ $\text{Mn}^{2+} + 4\text{H}_2\text{O} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$ $\text{Mn}^{2+} + \text{H}_2\text{O} + \text{BiO}_3^- \rightarrow \text{MnO}_4^- + 2\text{H}^+ + \text{Bi}^{3+}$	check that the charges are balanced
X.	$\text{ClO}_3^- + 2\text{H}^+ + \text{e}^- \rightarrow \text{ClO}_2 + \text{H}_2\text{O}$] 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
Y.	$2\text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{e}^-$] x 5 $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$] x 2 $2\text{MnO}_4^- + 16\text{H}^+ + 10\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{S}_4\text{O}_6^{2-}$	
Z.	$\text{PH}_3 + 2\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_2^- + 4\text{H}^+ + 3\text{e}^-$] x 2 $\text{l}_2 + 2\text{e}^- \rightarrow \text{l}^-$] x 3 $2\text{PH}_3 + 4\text{H}_2\text{O} + 3\text{l}_2 \rightarrow 2\text{H}_3\text{PO}_2^- + 8\text{H}^+ + 6\text{l}^-$	check that the charges are balanced
AA.	$\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{e}^-$] 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^+)
AB.	$2\text{l}^- \rightarrow \text{l}_2 + 2\text{e}^-$] x 5 $2\text{IO}_3^- + 12\text{H}^+ + 10\text{l}^- \rightarrow \text{l}_2 + 6\text{H}_2\text{O}$ $2\text{IO}_3^- + 12\text{H}^+ + 10\text{l}^- \rightarrow 5\text{l}_2 + \text{l}_2 + 6\text{H}_2\text{O}$ $2\text{IO}_3^- + 12\text{H}^+ + 10\text{l}^- \rightarrow 6\text{l}_2 + 6\text{H}_2\text{O}$] $\text{IO}_3^- + 6\text{H}^+ + 5\text{l}^- \rightarrow 3\text{l}_2 + 3\text{H}_2\text{O}$	collect the l_2 molecules $\div 2$ to get the smallest coefficients check that the charges are balanced
Q10.	A. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ oxidation ½ equation $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ reduction ½ equation $\text{Zn} + 2\text{H}^+ \rightarrow \text{Zn}^{2+} + \text{H}_2$ overall equation	Zn: reducing agent (reductant) H^+ : oxidizing agent (oxidant)
	B. $\text{S}^{2-} \rightarrow \text{S} + 2\text{e}^-$ oxidation ½ equation $\text{l}_2 + 2\text{e}^- \rightarrow 2\text{l}^-$ reduction ½ equation $\text{S}^{2-} + \text{l}_2 \rightarrow \text{S} + 2\text{l}^-$ overall equation	S^{2-} : reducing agent (reductant) l_2 : oxidizing agent (oxidant)
	C. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ oxidation ½ equation $2\text{Ag}^+ + 2\text{e}^- \rightarrow 2\text{Ag}$ reduction ½ equation $\text{Cu} + 2\text{Ag}^+ \rightarrow \text{Cu}^{2+} + 2\text{Ag}$ overall equation	Cu: reducing agent (reductant) Ag^+ : oxidizing agent (oxidant)
	D. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ oxidation ½ equation $2\text{Ag}^+ + 2\text{e}^- \rightarrow 2\text{Ag}$ reduction ½ equation $\text{Zn} + 2\text{Ag}^+ \rightarrow \text{Zn}^{2+} + 2\text{Ag}$ overall equation	Zn: reducing agent (reductant) Ag^+ : oxidizing agent (oxidant)
	E. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ oxidation ½ equation $\text{F}_2 + 2\text{e}^- \rightarrow 2\text{F}^-$ reduction ½ equation $2\text{Cl}^- + \text{F}_2 \rightarrow \text{Cl}_2 + 2\text{F}^-$ overall equation	Cl^- : reducing agent (reductant) F_2 : oxidizing agent (oxidant)
	F. $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ oxidation ½ equation $\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-$ reduction ½ equation $\text{Fe} + \text{Br}_2 \rightarrow \text{Fe}^{2+} + 2\text{Br}^-$ overall equation	Fe: reducing agent (reductant) Br_2 : oxidizing agent (oxidant)
	G. $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ oxidation ½ equation $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ reduction ½ equation $\text{Mg} + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2$ overall equation	Mg: reducing agent (reductant) H^+ : oxidizing agent (oxidant)
	H. $2\text{l}^- \rightarrow \text{l}_2 + 2\text{e}^-$ oxidation ½ equation $\text{Fe}^{3+} + 1\text{e}^- \rightarrow \text{Fe}^{2+}$ reduction ½ equation $2\text{Fe}^{3+} + 2\text{l}^- \rightarrow 2\text{Fe}^{2+} + \text{l}_2$ overall equation	l^- : reducing agent (reductant) Fe^{3+} : oxidising agent (oxidant)

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