

36 All combustion reactions are redox reactions. True or false?

True. All combustion reactions involve oxidation of a fuel by oxygen (which is then reduced).

42 What is the requirement for an element to undergo disproportionation reactions? Name five common elements that are likely to take part in such reactions.

To undergo disproportionation, an element must be capable of being both oxidized and reduced, so it must have multiple oxidation numbers allowable and be in an intermediate oxidation state. Some common elements that can do this are Cl, Br, I, S, C, and N.

52 Which of the following metals can react with water? (a) Au; (b) Li; (c) Hg; (d) Ca; (e) Pt

Any metal above hydrogen in the activity series (a stronger reducing agent) will displace it from water or from an acid. Since $2 \text{H}_2\text{O} + 2 \text{e}^- \rightarrow \text{H}_2 + 2 \text{OH}^-$ is the reduction, it is written in the forward direction on the reduction potential chart and must have the more positive E° .

Only (b) Li and (d) Ca are above hydrogen in the activity series (with more negative E°), so they are the only metals that are correctly positioned to be written in the reverse direction (as oxidations) in this problem and so will react with water.

53 On the basis of oxidation number considerations, one of the following oxides would not react with molecular oxygen NO, N₂O, SO₂, SO₃, P₄O₆:

Molecular oxygen is a powerful oxidizing agent, so the central atom needs to have an oxidation number lower than its maximum. In SO₃ alone, the oxidation number of the element bound to oxygen (S) is at its maximum value (+6); the sulfur cannot be oxidized further. The other elements bound to oxygen in this problem have less than their maximum oxidation number and can undergo further oxidation.

54 Predict the outcome of the reactions represented by the following equations by using the activity series and balance the equations.

(a) $\text{Cu}(s) + \text{HCl}(aq) \rightarrow$ no reaction, since Cu(s) is less reactive than the hydrogen (Cu is a worse reducing agent than H₂ or H⁺ is a worse oxidizing agent than Cu²⁺) from acids.

(b) $\text{I}_2(s) + \text{NaBr}(aq) \rightarrow$ no reaction, since I₂(s) is less reactive than Br₂(l) (I₂ is a worse oxidizing agent than Br₂ or Br⁻ is a worse reducing agent than I⁻).

(c) $\text{Mg}(s) + \text{CuSO}_4(aq) \rightarrow \text{MgSO}_4(aq) + \text{Cu}(s)$, since Mg(s) is more reactive than Cu(s) (Mg is a better reducing agent than Cu or Cu²⁺ is a better oxidizing agent than Mg²⁺).

Net ionic equation: $\text{Mg}(s) + \text{Cu}^{2+}(aq) \rightarrow \text{Mg}^{2+}(aq) + \text{Cu}(s)$

(d) $\text{Cl}_2(g) + 2\text{KBr}(aq) \rightarrow \text{Br}_2(l) + 2\text{KCl}(aq)$, since Cl₂(g) is more reactive than Br₂(l) (Cl₂ is a better oxidizing agent than Br₂ or Br⁻ is a better reducing agent than Cl⁻)

Net ionic equation: $\text{Cl}_2(g) + 2\text{Br}^-(aq) \rightarrow 2\text{Cl}^-(aq) + \text{Br}_2(l)$

56 Classify the following redox reactions:

(a) $\text{P}_4 + 10 \text{Cl}_2 \rightarrow 4 \text{PCl}_5$

Combination reaction

(b) $2 \text{NO} \rightarrow \text{N}_2 + \text{O}_2$

Decomposition reaction

(c) $\text{Cl}_2 + 2 \text{KI} \rightarrow 2 \text{KCl} + \text{I}_2$

Halogen displacement reaction

(d) $3 \text{HNO}_2 \rightarrow \text{HNO}_3 + \text{H}_2\text{O} + 2 \text{NO}$

Disproportionation reaction

122 Hydrochloric acid is not an oxidizing agent in the sense that sulfuric acid and nitric acid are. Explain why the chloride ion is not a strong oxidizing agent like SO_4^{2-} and NO_3^- .

In a redox reaction, the oxidizing agent gains one or more electrons. In doing so, the oxidation number of the element gaining the electrons must become more negative. In the case of chlorine in HCl, the -1 oxidation number is already the most negative state possible. The chloride ion *cannot* accept any more electrons; therefore, hydrochloric acid is *not* an oxidizing agent. The S in SO_4^{2-} and N in NO_3^- are both high (S is $+6$ and N is $+5$), so they can accept electrons and decrease (become less positive/more negative).