ANSWER KEY.

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4.9 Oxidation-Reduction (Redox) Reactions

AP Chemistry | ANSWER KEY

Show oxidation numbers and half-reactions. Check atoms and charge in every final equation.

1. Assign an oxidation number to every element.

(a) SO_2 (b) Fe_2O_3 (c) NH_4^+ (d) Na_2SO_4 (e) $Cr_2O_7^{2-}$

(a) S = +4, O = −2 (b) Fe = +3, O = −2 (c) N = −3, H = +1
(d) Na = +1, S = +6, O = −2 (e) Cr = +6, O = −2
Example setups: (d) 2(+1) + S + 4(−2) = 0; (e) 2Cr + 7(−2) = −2.

2. Zinc reacts with hydrochloric acid.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

(a) Assign oxidation numbers to every element on both sides.
(b) Which element is oxidized? Which is reduced? Which does not change?
(c) How many electrons are transferred in the reaction as written?

(a) Left: Zn = 0, H = +1, Cl = −1. Right: Zn = +2, Cl = −1, H = 0.
(b) Zn is oxidized (0 → +2, up). H is reduced (+1 → 0, down). Cl does not change (−1).
(c) 2 electrons. One Zn loses 2 e^-; two H each gain 1 e^-.

3. Label each half-reaction as oxidation or reduction.

(a) $Fe^{3+} + e^- \rightarrow Fe^{2+}$ (b) $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$ (c) $Br_2 + 2e^- \rightarrow 2Br^-$

(a) Reduction (e^- are reactants; +3 → +2)
(b) Oxidation (e^- are products; +2 → +4)
(c) Reduction (e^- are reactants; 0 → −1)

4. Write the oxidation and reduction half-reactions, then the balanced equation.

$Al(s) + Ag^+(aq) \rightarrow Al^{3+}(aq) + Ag(s)$

Oxidation: $Al \rightarrow Al^{3+} + 3e^-$
Reduction: $Ag^+ + e^- \rightarrow Ag$, multiplied by 3: $3Ag^+ + 3e^- \rightarrow 3Ag$
$Al(s) + 3Ag^+(aq) \rightarrow Al^{3+}(aq) + 3Ag(s)$
Charge check: 3(+1) = +3 on the left; +3 on the right.

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5. Use half-reactions to balance this equation. Show how you matched the electrons.

$Mg(s) + Fe^{3+}(aq) \rightarrow Mg^{2+}(aq) + Fe(s)$

Oxidation: $Mg \rightarrow Mg^{2+} + 2e^-$ × 3 → $3Mg \rightarrow 3Mg^{2+} + 6e^-$

Reduction: $Fe^{3+} + 3e^- \rightarrow Fe$ × 2 → $2Fe^{3+} + 6e^- \rightarrow 2Fe$

$3Mg(s) + 2Fe^{3+}(aq) \rightarrow 3Mg^{2+}(aq) + 2Fe(s)$

The lowest common multiple of 2 and 3 is 6. Charge check: 2(+3) = +6; 3(+2) = +6.

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6. Balance this half-reaction in acidic solution. Then state whether it is an oxidation or a reduction.

$Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq)$

Balance Cr: $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

Balance O with water: $Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

Balance H with H^+: $14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

Balance charge (left +12, right +6): $6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

Reduction. Each Cr goes from +6 to +3, and electrons are reactants (2 Cr × 3 = 6 e^-).

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7. Balance this reaction in acidic solution.

$MnO_4^-(aq) + SO_3^{2-}(aq) \rightarrow Mn^{2+}(aq) + SO_4^{2-}(aq)$

Reduction: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (Mn: +7 → +2)

Oxidation: $SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^-$ (S: +4 → +6)

Match electrons (10): $2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$ and $5SO_3^{2-} + 5H_2O \rightarrow 5SO_4^{2-} + 10H^+ + 10e^-$

Add, then cancel $10e^-$, $10H^+$, and $5H_2O$:

$2MnO_4^-(aq) + 6H^+(aq) + 5SO_3^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 3H_2O(l) + 5SO_4^{2-}(aq)$

Check: O 23 = 23, H 6 = 6. Charge −2 + 6 − 10 = −6 on the left; +4 − 10 = −6 on the right.

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