Reaction Prediction — 5

Write formulas for the reactants and predicted products for the chemical reactions that follow. Assume that in all cases a reaction occurs. The reaction must also be balanced, in the lowest whole number ratio, although descriptive symbols do not need to be included. Write all substances in their proper form—as ions if appropriate—and cancel any spectator ions. Assume that the reactions are in aqueous solutions unless otherwise stated. Answer the follow-up question also.

a) A piece of solid bismuth is heated strongly in oxygen.

\[ 4 \text{Bi} + 3\text{O}_2 \rightarrow 2\text{Bi}_2\text{O}_3 \]

Which has the higher ionization energy—bismuth or antimony? Explain.

Antimony - is smaller and will feel the pull from the nucleus more than Bismuth therefore more energy is required to remove e–

b) Equal volumes of 0.1 M sulfuric acid and 0.2 M potassium hydroxide are mixed.

\[ \text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O} \]

Would the pH of the resulting solution be acidic, neutral, or basic? Explain.

Neutral - all of the H₂SO₄ will be neutralized

c) Solid lithium hydride is added to water.

\[ \text{LiH} + \text{H}_2\text{O} \rightarrow \text{Li}^+ + \text{OH}^- + \text{H}_2 \]

If phenolphthalein is added to the resulting solution, what color will be observed? Explain.

Pink due to the production of OH⁻ ions

d) A concentrated solution of ammonia is added to a solution of zinc iodide.

\[ 4\text{NH}_3 + 2\text{Zn}^{2+} \rightarrow [2\text{n} (\text{NH}_3)_{\text{Zn}}]^{2+} \]

Name the product(s).

Tetraammine-zinc(II) ion

c) Excess chlorine gas is passed over hot iron filings.

\[ 3\text{Cl}_2 + 2\text{Fe} \rightarrow 2\text{FeCl}_3 \]

How many electrons are transferred, in total, in this reaction?

6 e⁻
Reaction Prediction — 6

Write formulas for the reactants and predicted products for the chemical reactions that follow. Assume that in all cases a reaction occurs. The reaction must also be balanced, in the lowest whole number ratio, although descriptive symbols do not need to be included. Write all substances in their proper form—as ions if appropriate—and cancel any spectator ions. Assume that the reactions are in aqueous solutions unless otherwise stated. Answer the follow-up question also.

a) Concentrated hydrochloric acid is added to solid manganese(II) sulfide.

\[ 2H^+ + MnS \rightarrow H_2S + Mn^{2+} \]

Which has the larger radius—the manganese atom or manganese(II) ion? Justify your choice.

Manganese atom has 25 e- whereas Mn^{2+} ion has 23 e-.

b) Water is added to a sample of solid magnesium nitride.

\[ 6H_2O + Mg_3N_2 \rightarrow 2NH_3 + 3Mg(OH)_2 \]

Which would have the greater lattice energy—magnesium nitride or magnesium oxide? Justify your choice.

The charge in Mg\(_3\)N\(_2\) is +2 and -3, this would create a greater attraction than the +2 and -2 in Mg(OH)\(_2\).

c) A solid sample of magnesium carbonate is heated strongly.

\[ MgCO_3 \rightarrow MgO + CO_2 \]

What evidence of a chemical reaction would you observe?

Formation of a gas

d) Ethene (ethylene) gas is bubbled through a solution of bromine.

\[ C_2H_4 + Br_2 \rightarrow C_2H_4Br_2 \]

What is the hybridization of carbon in ethene?

\[ \overset{\text{sp}}{\text{C}} \overset{2}{\text{H}} \]

\[ \overset{\text{sp}^2}{\text{C}} \overset{2}{\text{H}} \]

e) An excess of nitric acid solution is added to a solution of tetraamminecopper(II) sulfate.

\[ 4H^+ + Cu(NH_3)_4^{2+} \rightarrow 4NH_4^+ + Cu^{2+} \]

In tetraamminecopper(II) sulfate, what serves as the Lewis acid? Explain.

\[ Cu^{2+} \text{ ion} - \text{accepts pairs} \quad \overset{\text{receives e- pair}}{\text{from NH}_3} \]
Reaction Prediction — 7

Write formulas for the reactants and predicted products for the chemical reactions that follow. Assume that in all cases a reaction occurs. The reaction must also be balanced, in the lowest whole number ratio, although descriptive symbols do not need to be included. Write all substances in their proper form—as ions if appropriate—and cancel any spectator ions. Assume that the reactions are in aqueous solutions unless otherwise stated. Answer the follow-up question also.

a) Dilute hydrochloric acid is added to a solution of potassium sulfite.

\[ 2H^+ + SO_3^{2-} \rightarrow H_2O + SO_2 \]

How many electrons would need to be shown in a Lewis structure for the sulfite ion?

\[ 6 + 18 + 2 = 26 \text{e}^- \]

b) A piece of nickel metal is immersed in a solution of copper(II) sulfate.

\[ \text{Ni} + \text{Cu}^{2+} \rightarrow \text{Ni}^{2+} + \text{Cu} \]

What color change would you observe in this reaction?

- Blue copper solution would fade and reddish brown solid copper would appear. Nickel solution is light green.

c) Solid ammonium nitrate is heated to temperatures above 300 °C.

\[ 2\text{NH}_4\text{NO}_3 \rightarrow 2\text{N}_2 + 4\text{H}_2\text{O} + \text{O}_2 \]

Predict the algebraic sign of \( \Delta S^\circ \) for the reaction and explain your reasoning.

\( \Delta S^\circ \) would be positive as entropy would be increasing due to the production of 8 moles of gas from 2 moles of a solid.

d) Liquid bromine is shaken with a sodium iodide solution.

\[ \text{Br}_2 + 2\text{I}^- \rightarrow 2\text{Br}^- + \text{I}_2 \]

Would you predict the boiling point of bromine to be higher or lower than the boiling point of iodine? Justify your choice.

\( \text{I}_2 \) is large so more affected by London dispersion forces. Harder to break attractions so \( \text{I}_2 \) boiling point is higher.

e) A solution of sodium bromide is added to an acidified solution of potassium bromate.

\[ \text{Br}^- + \text{BrO}_3^- + 6\text{H}^+ \rightarrow \text{Br}_2 + 3\text{H}_2\text{O} \]

What is the oxidation number of bromine in potassium bromate?

\[ +5 \]
**Reaction Prediction — 8**

Write formulas for the reactants and predicted products for the chemical reactions that follow. Assume that in all cases a reaction occurs. The reaction must also be balanced, in the lowest whole number ratio, although descriptive symbols do not need to be included. Write all substances in their proper form—as ions if appropriate—and cancel any spectator ions. Assume that the reactions are in aqueous solutions unless otherwise stated. Answer the follow-up question also.

a) Solutions of cobalt(II) nitrate and sodium hydroxide are mixed.

\[
\text{Co}^{2+} + 20H^- \rightarrow \text{Co(OH)}_2
\]

Rank cobalt, chromium, and copper atoms in terms of increasing ionization energy and explain your reasoning.

\[ \text{Cr, Co, Cu} \]

IE ↑ from left to right across a period. Atoms are smaller and feel the pull from the nucleus more strongly.

b) Ethene gas is burned in air.

\[
\text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O}
\]

List the number of sigma and pi bonds present in an ethene molecule.

\[
\text{H}^+ \text{C} = \text{C}^- \text{H} \quad \underline{5} \quad \text{sigma}
\]

\[
\text{H}^+ \text{H} \quad \underline{1} \quad \text{pi}
\]

c) Carbon dioxide gas is passed over hot, solid sodium oxide.

\[
\text{CO}_2 + \text{Na}_2\text{O} \rightarrow \text{Na}_2\text{CO}_3
\]

Is this a redox reaction? Explain why/why not.

No, no change in oxidation numbers from reactants to products.

d) Equal volumes of equimolar solutions of phosphoric acid and potassium hydroxide are mixed.

\[
\text{H}_3\text{PO}_4 + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{H}_2\text{PO}_4^- 
\]

Would you predict the pH of the resulting solution to be acidic, basic, or neutral? Explain.

Acidic due to the presence of the weak acid \( \text{H}_2\text{PO}_4^- \)

e) Aluminum metal is added to a solution of copper(II) chloride.

\[
2\text{Al} + 3\text{Cu}^{2+} \rightarrow 2\text{Al}^{3+} + 3\text{Cu}
\]

What is being oxidized in this reaction? Justify your choice.

\( \text{Al} \) is being oxidized. It is losing \( \text{e}^- \).