Chapter 22

Metallurgy and Chemistry of the Main Group Metals

Concept Check 22.1

As discussed in the text, Zr is used as cladding for nuclear fuel rods in power plants. Why don't you want to use a fuel rod cladding material that absorbs neutrons?

Solution

The neutrons are what cause fission and a sustainable nuclear reaction. Therefore, an element that blocks the neutrons prevents a nuclear reaction.

Concept Check 22.2

Considering the fact that N_2 makes up about 80% of the atmosphere, why don't animals use the abundant N_2 instead of O_2 for biological reactions?

Solution

Given the high energy demands of animals to move and maintain body temperature, breaking the very strong triple bond of N_2 requires too much energy when compared to the lower energy double bond of O_2.

Concept Check 22.3

Why do we need such low temperatures to liquefy gasses such as nitrogen, oxygen, and He?

Solution

The only intermolecular forces in these materials are very weak van der Waals forces.

Conceptual Problem 22.59

When producing Coke, why is the coal heated in the absence of air? Write the chemical reaction for what would happen when it is heated in air.

Solution

If air is present, the oxygen in the air would react with the coal (undergo oxidation) by the following equation: $C(s) + O_2(g) \rightarrow CO_2(g)$.

Conceptual Problem 22.60

Even though hydrogen isn't a metal, why is it in group IA of most periodic tables?

Solution

It has one valence electron like the other elements in group IA.

Conceptual Problem 22.61

What happens to the metallic character of the main-group elements as you move left to right across any row of the periodic table? What happens to the metallic character of the main-group elements as you move down a column (group)?

Solution

The metallic character decreases from left to right and increases going down a column.

Conceptual Problem 22.62

Lithium hydroxide, like sodium hydroxide, becomes contaminated when exposed to air. What is the source of this contamination? What reactions take place?

Solution

Lithium hydroxide is contaminated by reaction with carbon dioxide absorbed from the air:

$2LiOH(s) + CO_2(g) \rightarrow Li_2CO_3(s) + H_2O(l)$

$Li_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2LiHCO_3(s)$.

Conceptual Problem 22.63

Aluminum hydroxide is an amphoteric substance. What does this mean? Write equations to illustrate.

Solution

This means that aluminum hydroxide reacts with both acids and bases. For example,

$Al(OH)_3(s) + 3HCl(aq) \rightarrow 3H_2O(l) + AlCl_3(aq)$ and

$Al(OH)_3(s) + NaOH(aq) \rightarrow Na^+(aq) + Al(OH)_4^-(aq)$.

Conceptual Problem 22.64

Tin metal would not make a very good structural metal in cold climates. Why?

Solution

Below 13°C the stable white metallic allotrope undergoes a transition to the brittle powder allotrope called gray tin.

Conceptual Problem 22.65

Oxygen, like other second-period elements, is somewhat different from the other elements in its group. List some of these differences.

Solution

Oxygen is a very electronegative element, and its bonding involves only the *s* and *p* orbitals, in contrast to bonding using the *d* orbitals in sulfur, etc. Molecular oxygen is a reactive gas but forms mainly compounds in which its oxidation state is -2, compared to compounds of sulfur, etc., which exhibit positive oxidation states as well as the -2 state.

Conceptual Problem 22.66

Given the reaction $Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(aq)$ readily occurs, would you expect the reaction $I_2(s) + 2KCl(aq) \rightarrow 2KI(aq) + Cl_2(aq)$ to occur?

Solution

Applying your chemical knowledge and consulting the table of standard reduction potentials (Appendix I), you would not expect I_2 to be a better oxidizing agent than Cl_2.

Conceptual Problem 22.67

Hydrogen chloride can be prepared by heating NaCl with concentrated sulfuric acid. Why is substituting NaBr for NaCl in this reaction not a satisfactory way to prepare HBr?

Solution

Consulting the table of standard reduction potentials (Appendix I), you find that HBr cannot be prepared by adding sulfuric acid to NaBr because the hot concentrated acid will oxidize the bromide ion to bromine.

Conceptual Problem 22.68

Do you expect an aqueous solution of sodium hypochlorite to be acidic, neutral, or basic? What about an aqueous solution of sodium perchlorate?

Solution

An aqueous solution of sodium hypochlorite should be basic because HClO is a weak acid. A solution of sodium perchlorate should be neutral because $HClO_4$ is a strong acid and NaOH is a strong base.