

Chapter 13

Materials of Technology

Concept Check 13.1

Why must a metal containing mineral be reduced to obtain the free metal?

Solution

Metals in ores and minerals are in an oxidized form where the free metal form is the neutral, elemental state.

Concept Check 13.2

A semi-conductor is a material where there is a separation between the filled band and an unfilled band called an energy gap. Would it take more or less energy to make a semi-conductor carry current?

Solution

It would take more energy because you would need to give the electrons enough energy to jump the gap into the unoccupied orbitals that make up the unfilled band.

Concept Check 13.3

For certain chemical reactions, quartz containers are used instead of glass. What would the meniscus of water look like in a quartz test tube? Come up with an explanation for your answer.

Solution

The meniscus of water would look the same as in glass, curved downward from the walls of the container. It attains this shape because of the hydrogen bonding interactions between the O atoms in the SiO_2 tetrahedra and the H atoms of the water molecules.

Conceptual Problem 13.29

Unless zinc is purified, cadmium is normally an impurity in the metal. Why might you expect this to be the case?

Solution

The refinement process for zinc produces metal that contains impurities such as lead, cadmium, and iron. Zinc and cadmium share many similar chemical and physical properties. They are both in group IIB on the periodic table.

Conceptual Problem 13.30

Electrolysis is used to obtain some metals from their compounds. List some metals obtained this way.

Solution

Metals obtained by electrolysis from their compounds include lithium, sodium, magnesium, and aluminum.

Conceptual Problem 13.31

Aluminum is the third most abundant element (first most abundant metal) in the earth's crust. Does this mean that aluminum ores are widespread and plentiful? Explain.

Solution

No, most aluminum is found in aluminum-containing clays and not in a mine. Also, much bauxite occurs in tropical and subtropical regions, where mining is not easy.

Conceptual Problem 13.32

The text says that the higher density of diamond compared with graphite suggests that the application of higher pressure would facilitate the transformation of graphite to diamond. Explain the reasoning behind this statement.

Solution

The higher density of diamond structure graphite indicates that the diamond structure of carbon contains more atoms per unit volume than the graphite structure. Therefore, increasing the pressure on graphite would increase the number of carbon atoms per unit volume (the carbon atoms are now packed closer together in a more dense structure). This increase in density (reduction of the distance between carbon atoms) then helps each carbon atom form four covalent bonds to neighboring carbon atoms, thereby forming a diamond.

Conceptual Problem 13.33

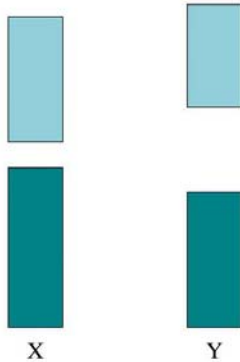
Diamond is an insulator, but when small amounts of boron are added it becomes a conductor. What is the explanation for this change in conduction? What are the electric current carriers?

Solution

Boron has one less electron than carbon, so it acts like a p-type semiconductor in that positive holes are created. Since positive holes are created, the electric current carriers are the positive holes.

Conceptual Problem 13.34

Elements X and Y have the following band structures:



One element is a semiconductor; the other is an insulator. Which is the semiconductor?

Solution

From the drawings, it appears that both elements X and Y have a filled lower band and a nearby unfilled band above it. The semiconductor will be the element with the smaller gap between the filled and unfilled band above it, namely element X, and the insulator will be the element with the larger gap between the filled and unfilled band above it, namely Y.

Conceptual Problem 13.35

Orthoclase feldspar has the chemical formula KAlSi_3O_8 . Think about what other cations could replace those in this chemical formula and write the resulting formula for two such minerals.

Solution

Examples are $\text{MgCaSi}_3\text{O}_8$ and $\text{KNaMgSi}_3\text{O}_8$.

Conceptual Problem 13.36

Cutting wheels have been made from alumina containing fine fibers of silicon carbide. How do the silicon carbide fibers help alumina in this application?

Solution

The fibers of silicon carbide function as a hard, durable and abrasive material.