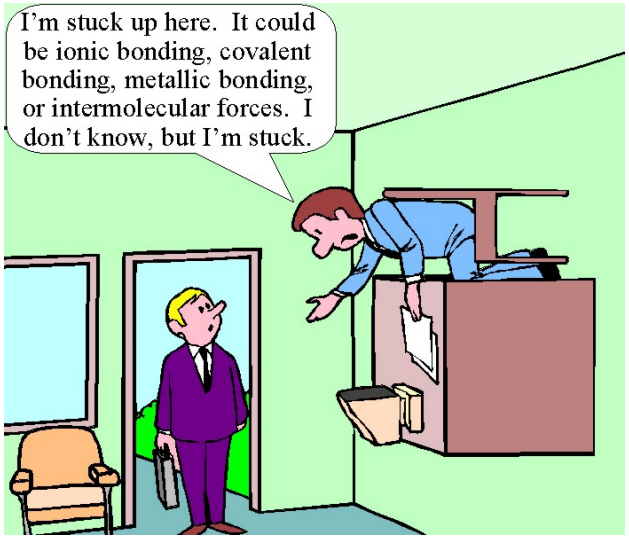
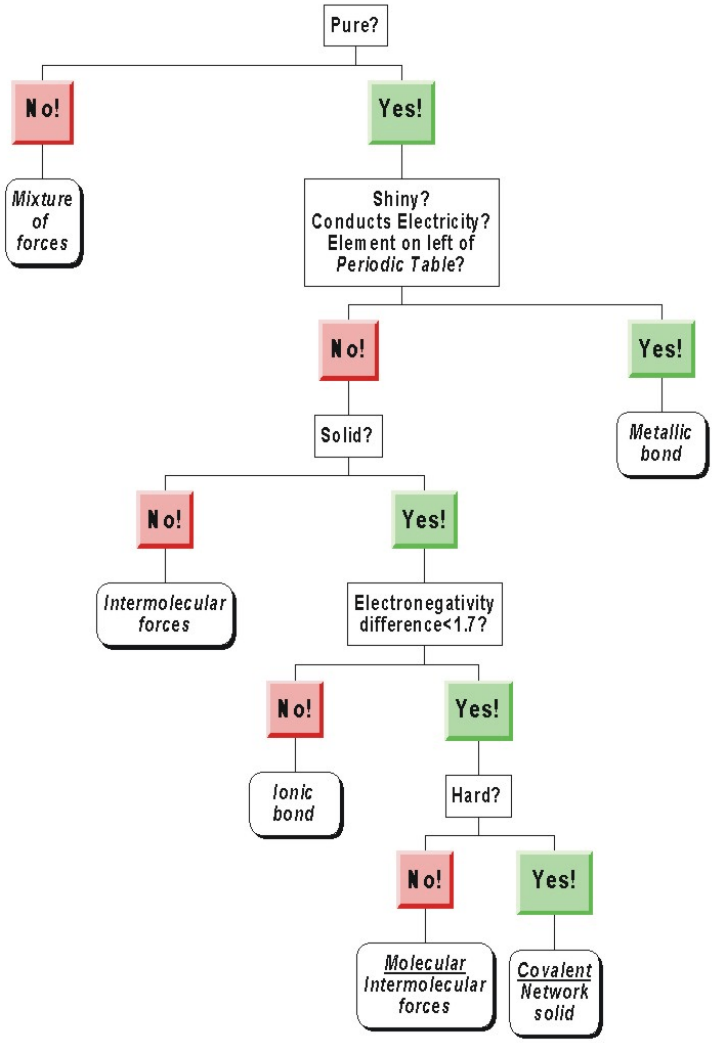
The Ties that Bind



Pure substances can be held together by ionic bonds, covalent bonds, metallic bonds, or intermolecular forces. Most materials are mixtures, and are held together by a mixture of these forces. Figuring out what holds things together takes some serious analysis. If the substance is pure and you know the formula, you can figure out the electronegativity difference. If it is 1.7 or greater, than it is ionic. All ionic substances are crystalline solids. Diamonds are also crystalline solids, but they are made of pure carbon. *What does that tell you about the electronegativity difference?* Electronegativity differences below 1.7 are covalent. Large crystals such as diamond or sand (SiO_2) that have a network of covalent bonds are called **macromolecules** or **network solids**. Smaller compounds containing covalent bonds are called **molecules**. The molecules of a substance may be attracted to each other to form solids or liquids by intermolecular forces. These are often called **molecular** compounds. Molecular solids are softer than covalent solids (network solids) and ionic solids, because intermolecular forces are weaker than chemical bonds. The flow chart to the right shows one way of classifying the types of forces that hold substances together.



Once you have determined that a material is held together by intermolecular forces, this can be further refined. If the substance is polar, it is held together by **dipole-dipole attractions**. If the polar substance contains hydrogen atoms attached to either oxygen, nitrogen, or fluorine atoms, it forms especially strong dipole-dipole attractions called a **hydrogen bonds**. Hydrogen bonds are responsible for the three dimensional shapes of many proteins because the large protein molecule folds in such a way that hydrogens in one part of the molecule are close to oxygens or nitrogens in another part of the molecule.

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Below are some familiar materials. Based on the reading and your knowledge of chemistry, state whether samples of these materials are held together by *ionic bonds*, *covalent bonds*, *metallic bonds*, *dipole-dipole attractions*, *hydrogen bonds*, or *other intermolecular forces*.

1. Water [$H_2O(\ell)$] . . . . . _____
2. Table sugar [$C_{12}H_{22}O_{11}(s)$] . . . _____
3. Table salt [$NaCl(s)$] . . . . . _____
4. Iron railing [$Fe(s)$] . . . . . _____
5. Liquid oxygen [$O_2(\ell)$] . . . . . _____
6. Diamond [$C(s)$] . . . . . _____
7. Salt substitute [$KI(s)$] . . . . . _____
8. Alcohol [$CH_3CH_2OH(\ell)$] . . . . . _____
9. Chlorine [$Cl_2(g)$] . . . . . _____
10. Gasoline [$C_8H_{18}(\ell)$] . . . . . _____
11. Gold [$Au(s)$] . . . . . _____
12. Rust [$Fe_2O_3(s)$] . . . . . _____
13. Tarnish [$Ag_2S(s)$] . . . . . _____
14. Tooth enamel [$Ca_3(PO_4)_2(s)$] . . _____
15. Copper wire [$Cu(s)$] . . . . . _____