is characteristic of such materials as aluminum and platinum. Paramagnetic materials have a relative permeability slightly in excess of unity.

So far we have considered those elements whose magnetic properties differ only very slightly from those of free space. As a matter of fact the vast majority of materials fall within this category. However, there is one class of materials-principally iron and its alloys with nickel, cobalt, and alumi- num-for which the relative permeability is very many times greater than that of free space. These materials are called *ferromagnetic* and are of great importance in electrical engineering. We may ask at this point why iron (and its alloys) is so very much more magnetic than other elements. Essentially, the answer is provided by the *domain* theory of magnetism. Like all metals, iron is crystalline in structure with the atoms arranged in a space lattice. However, domains are subcrystalline particles of varying sizes and shapes containing about 10 atoms in a volume of approximately cubic centimeters. *The distinguishing feature of the domain is that the magnetic moments of its constituent atoms are all aligned in the same direction* Thus in a ferromagnetic material, not only must there exist a magnetic moment due to a nonneutra- lized spin of an electron in an inner orbit, but also the resultant spin of all neighboring atoms in the domain must be parallel.

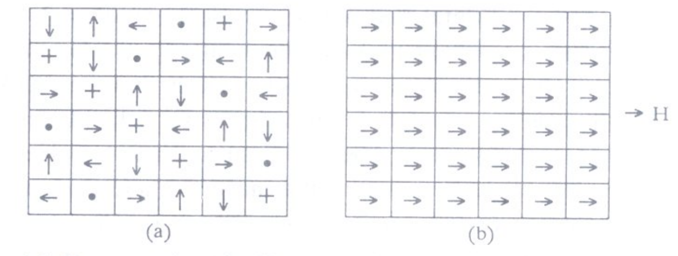

Figure d and (b)
Fully M

It would seem by the explanation so far that, if iron is composed of completely magnetized domains, then the iron should be in a state of complete magnetization throughout the body of material even without the application of a magnetizing force. Actually, this is not the case, because the domains act independently of each other, and for a specimen of unmagnetized iron these domains are aligned haphazardly in all directions so that the net magnetic moment is zero over the specimen. Figure 1-1 illustrates the situation diagrammatically in a simplified fashion. Because of the crystal

lattice structure of iron the ‘easy’ direction of domain alignment can take place in any one of six directions-left, right, up, down, out, or in-depending upon the direction of the applied magnetizing force. Figure l-l(a) shows the unmagnetized configuration. Figure l-l(b) depicts the result of applying a force from left to right of such magnitude as to effect alignment of all the domains. When this state is reached the iron is said to be *saturated-there* is no further increase in flux density over that of free space for further increases in magnetizing force.

Large increases in the temperature of a magnetized piece of iron bring about a decrease in its magnetizing capability. The temperature increase enforces the agitation existing between atoms until at a temperature of 750°C the agitation is so severe that it destroys the parallelism existing between the magnetic moments of the neighboring atoms of the domain and thereby causes it to lose its magnetic property. The temperature at which this occurs is called the *curie point*.

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

…….1. With his atomic theory, Bohr contributed to the understanding of the magnetic behavior of materials.

…….2. The atoms of a substance, if placed in a magnetic field, are subject to a torque.

…….3. Platinum is a diamagnetic material.

…….4. In ferromagnetic materials, the magnetic moments of large groups

…….5. In an unagnetized ferromagnetic material, the domains are aligned in different direction.

…….6. The magnetic properties of iron increase with an increase in temperature.

B. Choose a, b, c, or d which best completes each item.

1. Permeability of silver is less than unity ....
   a. because of its atoms setting up a field against the applied field
   b. because of its molecules rotating about the applied field
   c. due to the precessional spin of its positive charges
   d. due to the orbital motions of its negative charges