# الجامعة التكنولوجية

# قسم الهندسة الكيمياوية

## المرحلة الثانية

# هندسة المواد I

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Syllabus Text Course Title

# Material Eng. (I)

| No. | Contents | Duration |
|---|---|---|
| 1 | **Classification of Materials**<br>Classification of materials, classification of materials based on structure and its application. | 4hr |
| 2 | **Mechanical Properties of Materials**<br>Stress-strain behavior, ductility, brittleness, toughness, modulus of resilience, poison's ratio, hardness, effect of temperature. | 6hr |
| 3 | **Atomic structure**<br>The structure of atom, atomic bonding, bonding energy and inter-atomic spacing | 6hr |
| 4 | **Atomic order in solids**<br>Types of atomic or ionic arrangements, crystal structure, lattice,unit cells, crystal systems, crystal direction and crystal planes , diffraction techniques for crystal structure analysis | 8hr |
| 5 | **Thermal and electrical properties of materials**<br>Heat capacity, thermal expansion, thermal conductivity, thermal stress, Glass transition temperature, Creep resistance, electrical conductivity, electron mobility, electrical resistivity of metals | 6hr |


1-Donaled R. Askeland, The science and engineering of materials, international student edition, 2006 .
2-William D. Callister, Jr. , Materials science and engineering, Fifth edition, 2000.
3-Lawrence H. Vanvlack , Elements of materials science and engineering, Fifth edition, 1987.

# Chapter One

# Classification of Materials

## 1.1 MATERIALS SCIENCE AND ENGINEERING

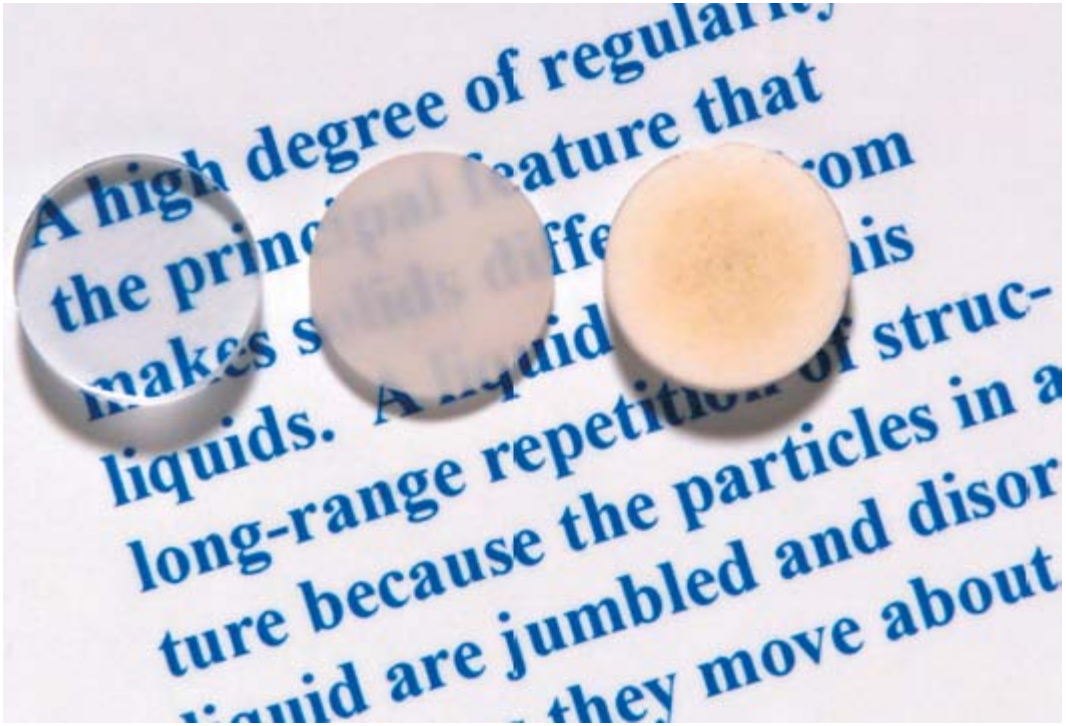
Sometimes it is useful to subdivide the discipline of materials science and engineering into *materials science and materials engineering subdisciplines. Strictly* speaking, "materials science" involves investigating the relationships that exist between the structures and properties of materials. In contrast, "materials engineering" is, on the basis of these structure–property correlations, designing or engineering the structure of a material to produce a predetermined set of properties. From a functional perspective, the role of a materials scientist is to develop or synthesize new materials, whereas a materials engineer is called upon to create new products or systems using existing materials, and/or to develop techniques for processing materials. Most graduates in materials programs are trained to be both materials scientists and materials engineers.

Four important components are involved in the science and engineering of materials—namely structure and properties, processing and performance( Figure 1.1)


**Figure 1.1 The four components of the discipline of materials science and engineering and their interrelationship**.

An example of these processing-structure-properties-performance principles with Figure 1.2, a photograph showing three thin disk specimens placed over some printed matter. It is obvious that the optical properties (i.e., the light transmittance) of each of the three materials are different; the one on the left is transparent whereas the disks in the center and on the right are, respectively, translucent and opaque

**Figure 1.2**




.All of these specimens are of the same material, aluminum oxide, but the leftmost one is what we call a single crystal—that is, it is highly perfect—which gives rise to its transparency. The center one is composed of numerous and very small single crystals that are all connected; the boundaries between these small crystals scatter a portion of the light reflected from the printed page, which makes this material optically translucent.

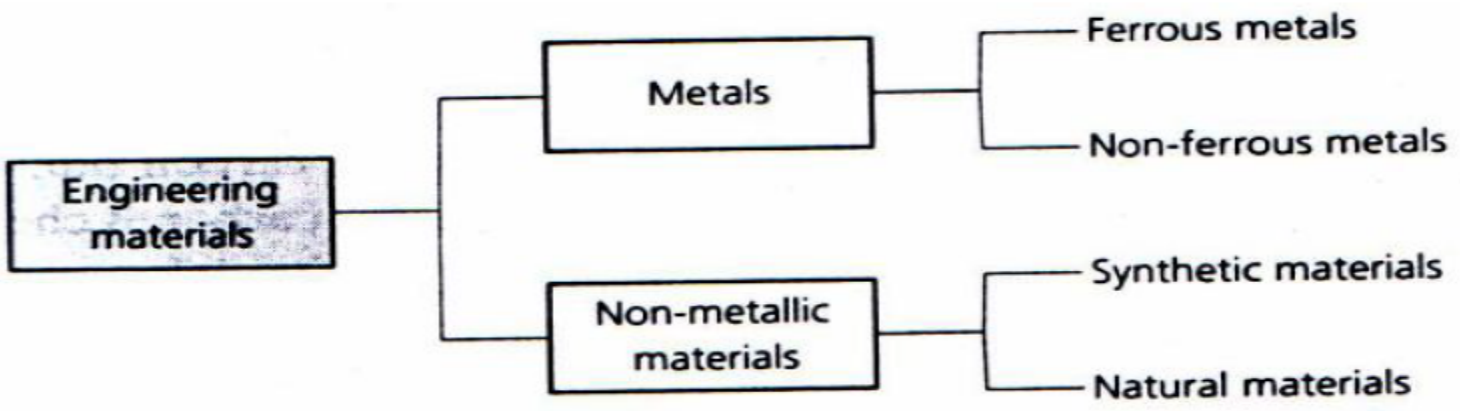
Finally, the specimen on the right is composed not only of many small, interconnected crystals, but also of a large number of very small pores or void spaces. These pores also effectively scatter the reflected light and render this material opaque. Thus, the structures of these three specimens are different in terms of crystal boundaries and pores, which affect the optical transmittance properties. Furthermore, each material was produced using a different processing technique. And, of course, the performance of each material will be different.

## 1.2 Classification of Materials

**Figure 1.3 Familiar** objects that are made of polymer,ceramic ,metals and metal alloys

## Engineering materials:

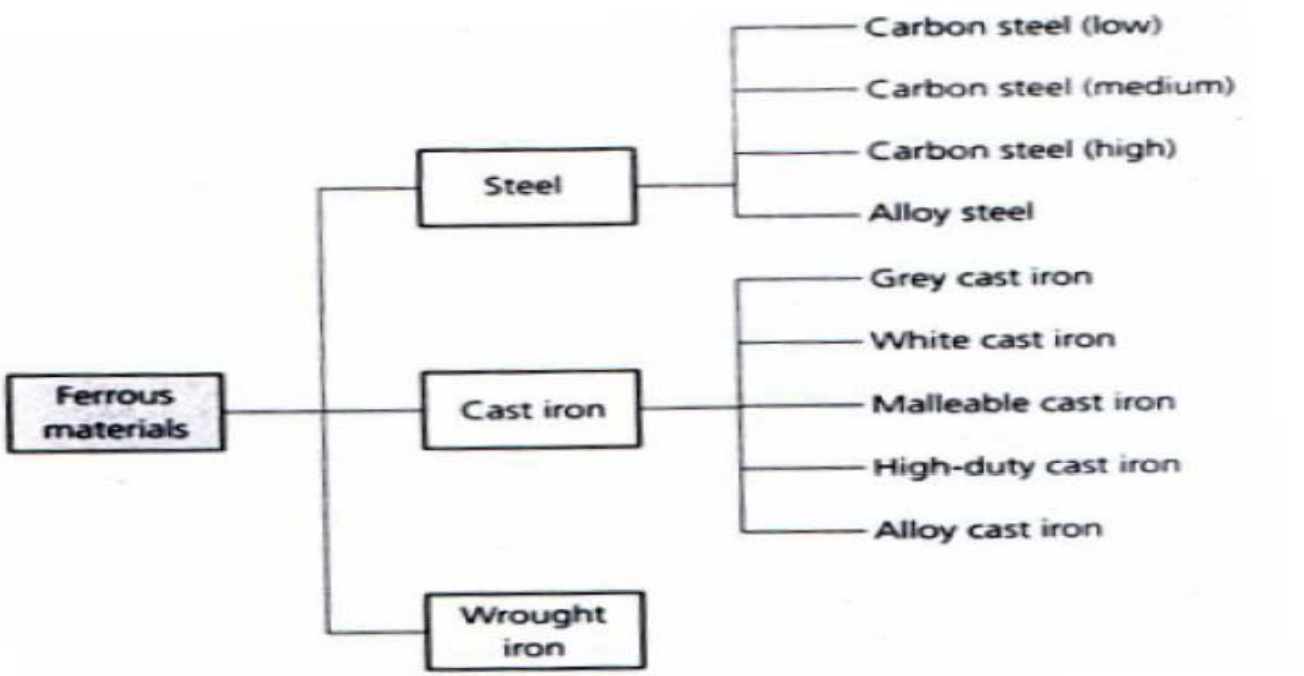
Almost every substance known to man has found its way into the engineering workshop at some time or other. The most convenient way to study the properties and uses of engineering materials is to classify them into 'families' as shown in figure below:




# 1. Metals

## 1.1 Ferrous metals

- These are metals and alloys containing a high proportion of the element iron.
- They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.
- As an example of ferrous metals such as : bridge building, the structure of large buildings, railway lines, locomotives and rolling stock and the bodies and highly stressed engine parts of road vehicles.




## 1.2 Non – ferrous metals

- These materials refer to the remaining metals known to mankind.
- The pure metals are rarely used as structural materials as they lack mechanical strength.
- They are used where their special properties such as corrosion resistance, electrical conductivity and thermal conductivity are required. Copper and aluminum are used as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials.
- They are mainly used with other metals to improve their strength.

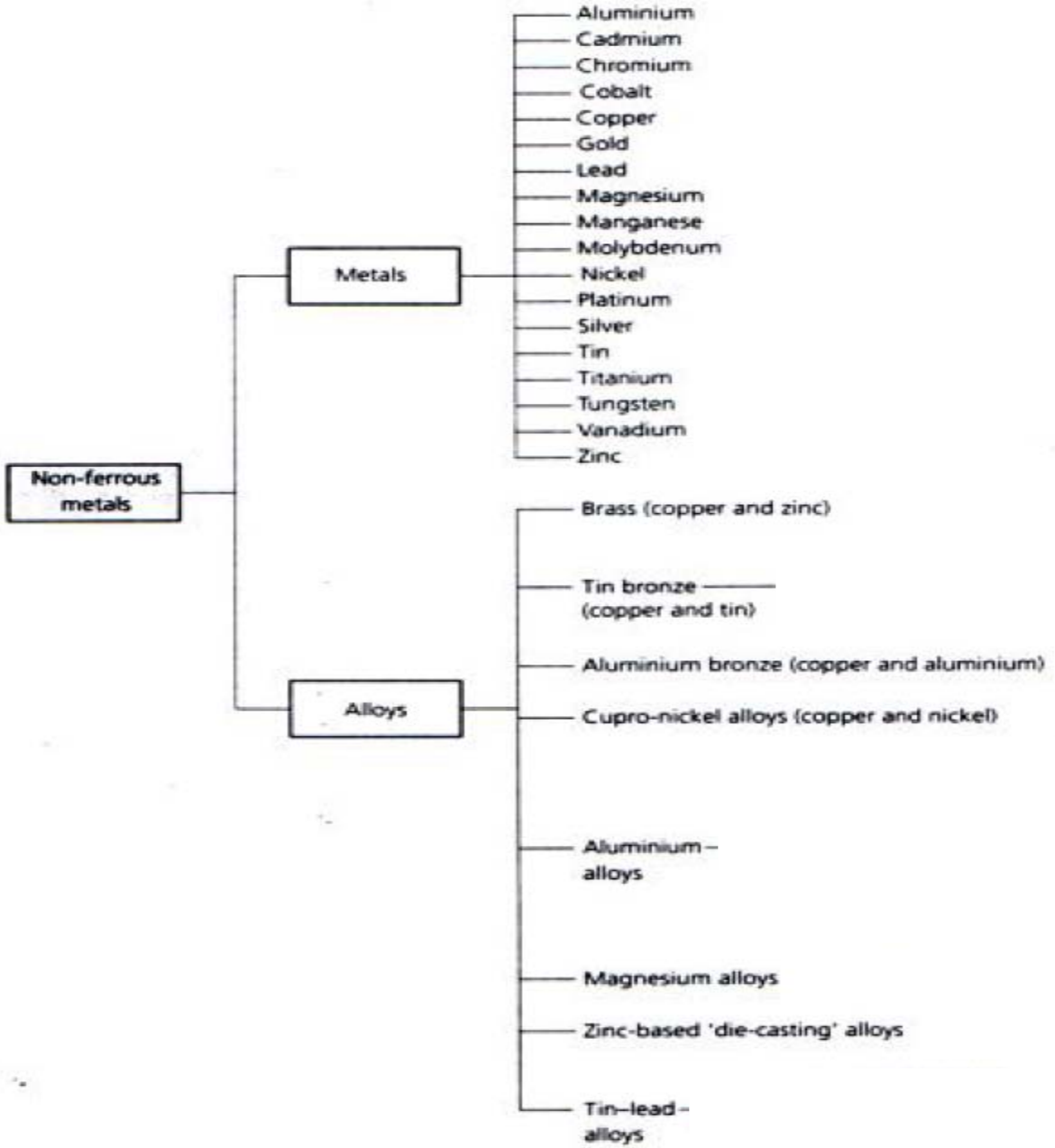



**Figure 1.4 Classification of non-ferrous metals and alloys.**

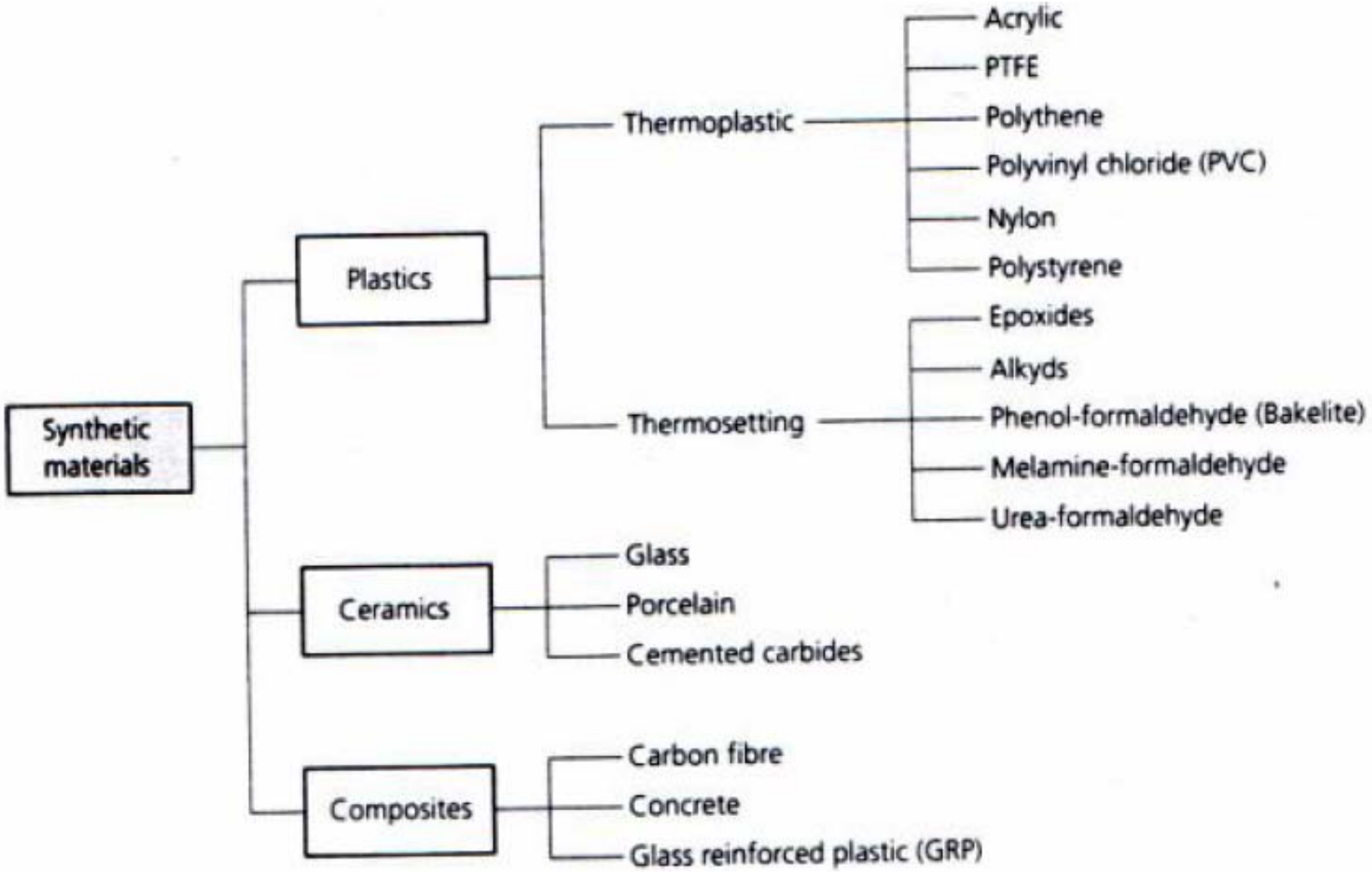
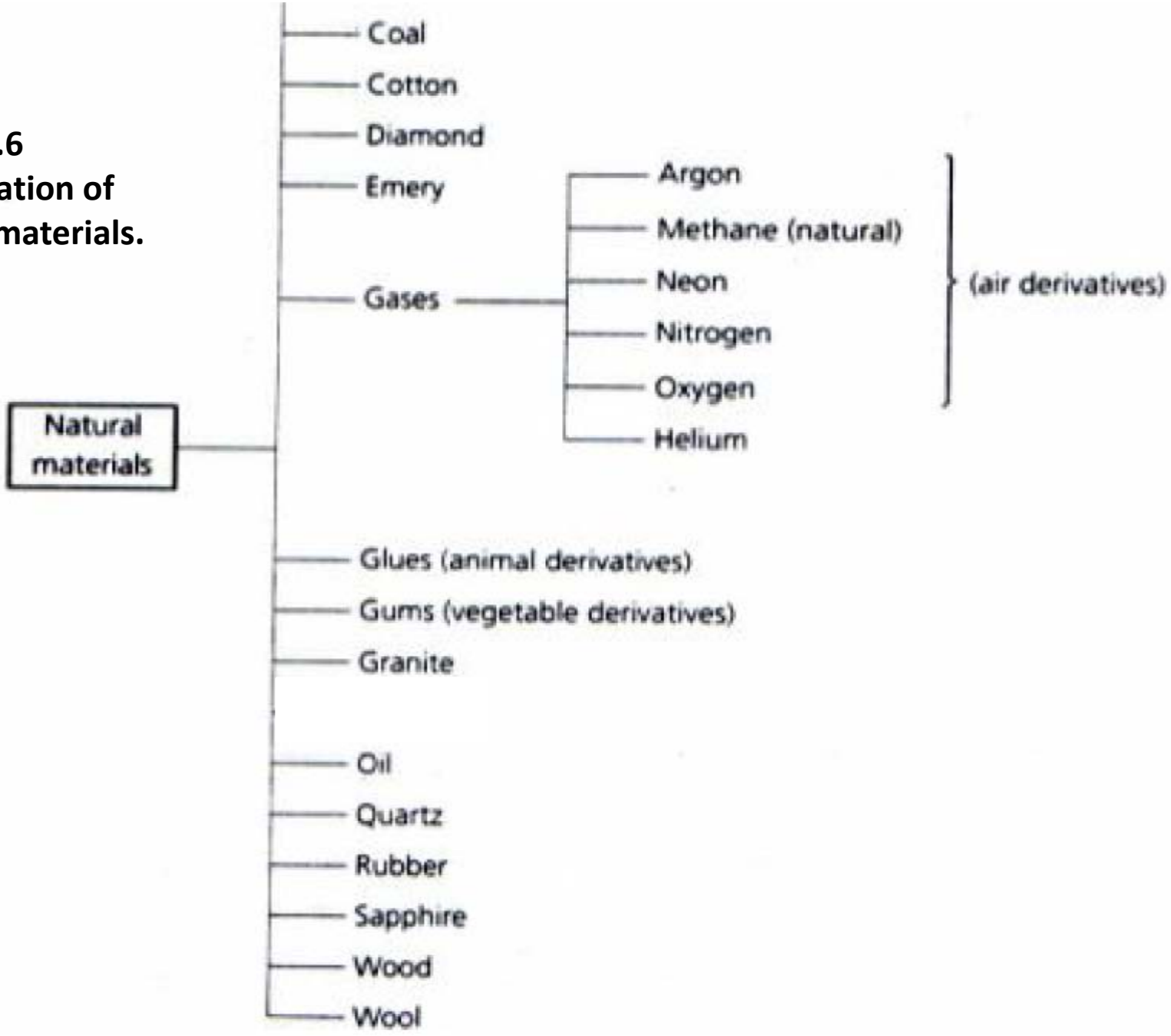



**Figure1.5 classification of synthetic materials**.

**Figure 1.6**
**Classification of natural materials.**



## 1.3 Properties of Some Types of Materials

a-Metals and Alloys

Metals are inorganic materials th

at are normally combination of metallic elements

-They usually have a crystalline structure and are good thermal and electrical conductors.

-Many metals have high strength and high elastic module.

--They also have sufficient ductility, which is important for many engineering applications.

-They are least resistant to corrosion.

-An alloy is a mixture of two or more elements in solid solution in which the major component is a metal .Combining different ratios of metals as alloys modify the properties of pure metals to produce desirable characteristics. The aim of making alloys is generally to make them less brittle , harder,and resistant to corrosion. Examples of alloys are steel (iron and carbon) ,brass (copper and zinc), and bronze (copper and tin).

b-Ceramics and glasses

They are inorganic materials consisting of both metallic and non-metallic elements bonded together chemically.

-They can be crystalline (ceramics),non-crystalline (glasses) or mixture of both (glass-ceramics).

-They are good electrical and thermal insulators.

-They have high hardness ,high moduli , and high temperature strength.

-They are resistant to high temperature and corrosive environments.

-They are very brittle.

c-Polymers

They are organic materials which consist of long molecular chain and they are chemically based on carbon and hydrogen.

-Most polymers are non-crystalline ,but some consist of mixtures of both crystalline and non-crystalline regions.

-They are generally have low density and are not stable at high temperatures.

-They generally have a good strength to weight ratio.

-Most of them are corrosion resistant, but cannot be used at high temperatures.

-They provide a good electrical and thermal insulation.

-Polymers may be either ductile(thermoplastic) or brittle(thermosetting).

d-Semiconductors

They have electrical properties intermediate between metallic conductors and ceramic insulators.

-Silicon is the most commercially important semiconductors.

-Semiconductors may be elemental materials such as silicon and germanium,or alloys such as silicon germanium.

-The semiconductor devices are combined with simpler components,such as semiconductor capacitors and resistors,to produce a variety of electronic devices.

e-Composite materials

Materials where two or more of the above materials are brought together.They are designed to combine the best properties of each of its components.

-usually they consist of a matrix and a reinforcement.

-Fiber,a combination of glass and a polymer,is an example.Concrete is other familiar composites.

## 1-4 Classification of materials based on structure

a-Crystalline materials

-single crystals

-polycrystalline

b-Amorphous materials

## 1-5 Classification of materials based on the function

a-Mechanical material b-Electronic material c-Magnetic material d-Optical material e-Medical material .