《材料导论》

复习重点题整理

CONTENT

Module 1 Introduction to Engineering Materials

1-1 Understand the following terms (a) engineering materials (b) engineering materials technology (c) materials (d) materials science (e) materials engineering (f) materials science and engineering (g) properties.

(a) **engineering materials**: a term often loosely used to define most materials that go into products and systems.

(b) **engineering materials technology**: covers fields of applied science related to materials, materials processing, and the many engineering specialties dealing with materials, such as research and development, design, manufacturing, construction, and maintenance.

(c) **materials**: the matter of the universe which have properties that make them useful in structures, machines, devices, products and systems.

(d)**materials science**: Focuses on discovering the nature of materials, which in turn leads to theories or descriptions that explain how structure relates to composition, properties, and behavior.

(e)**materials engineering**: deals with the synthesis and used of knowledge in properties, processing and behavior, prepare, modify, and apply materials to specific needs.

(f)**materials science and engineering**: a major field of study, which involves the generation and application of knowledge relating the composition, structure, and processing of materials to their properties and uses.

(g)**properties**: describes the behavior of materials when subjected to some external force or condition.

1-6 Understand the two terms, Life Cycle Analysis (LCA) and Life Cycle Inventory (LCI); what is the main purpose of LCA?

Life Cycle Analysis (LCA): products to determine their impact on the global environment.

Life Cycle Inventory (LCI): a listing of raw materials, bulk materials, gas emissions, product waste, recyclables, and so on.

Dealing with the materials and processes involved in products in terms of cost and environmental impacts.

1-12 What is the difference between design for assembly and design for disassembly.

Design for assembly emphasizes easy product assembly by robots and other automated equipment.

Design for disassembly is a concept that places recycling at the beginning or design stage of the materials cycle to ensure that waste going into municipal landfills will be minimized.

1-21 List the groups of family of materials

Metallics, polymerics, ceramics, composites and others.

1-22 Understand the terms of metals, alloys, and powdered metals

Metals: A type of solid mineral substance that is usually hard and shiny and that heat and electricity can travel through, for example tin, iron and lead.

Alloys: A metal that is formed by mixing two types of metal together, of by mixing metal with another substance.

Powdered metals 粉末金属:Alloying of metals involves malting the main ingredients together so that on cooling, the metal alloy is generally a nonporous solid.

1-23 List the subgroups（子组） of metallics.

Ferrous, Nonferrous and Powdered metal

1-32: PE: polyethylene PP: polypropylene PVC: polyvinyl chloride

1-33What type of chemical bonds existing in ceramics?

Ionic bonds and covalent bonding

1-41 Describe the aim of vulcanization.

Adding sulfur to NR

To increase hardness

To reduce susceptibility to oxidation and reaction with other chemicals

1-42 Vulcanization is important for traditional rubbers. Is it also required for elastoplastics?

No. Vulcanization is eliminated. Physical cross-linking instead of chemical cross-linking.

Module 2 Nature & Structure of Materials

2-19 What is the Chemical Bonding? What are the groups and subgroups of the chemical bonding? Give some examples for each group. Which bond is the strongest among the secondary bonds?

Chemical bonding: explained simply as the end product of the interaction（相互作用）of the electrical forces of attraction and repulsion（排斥）between oppositely charged or similarly charged particles（带电粒子） of matter.

Groups: Primary bonding（主价键） and secondary bonding

Subgroups: Primary bonding: covalent bonding, ionic bonding, metallic bonding; Secondary Bonding: hydrogen boning, Van der waals forces

主价键：Ionic bonding, covalent bonding, metallic bonding

次价键：Van de Waals Forces, Hydrogen Bonding

Hydrogen Bonding is the strongest among the secondary bonds

2-20 Understand the terms:

(a) **chemical bonding;**

(b) **covalent or shared electron-pair bonding：**The sharing of electrons between two or more atoms is known as covalent or shared electron-pair bonding.

(c**) triple covalent:** one in which two atoms share three of their electrons with each other.

(d) **ionic bonding：**some elements actually swap or transfer electrons to other elements

(e) **metallic bonding;：**Free or delocalized electrons can move in 3-d;A metallic bond is non-directional(bonds form in any direction)→atoms pack closely

(f) **polar molecule:：**in polar molecule the charges are polarized; that is, both the positive and negative chargers are localized within the molecule

(g) **nonpolar molecule：**each atom shares the bonding electrons equally, producing an electrical charge distribution that is symmetrical about a line joining the two nuclei

(j) **hydrogen bond**: The oxygen atom, having a slight negative charge, attracts a positive hydrogen atom belonging to an adjacent water molecule

2-21 What key word can be used to describe covalent bonding, ionic bonding, and metallic bonding?

Ionic bonding：electron swapping

Covalent bonding: electron sharing

Metallic bonding: electron swarming（群集）

2-23 How is the hydrogen bond formed?

The covalent bonds between the hydrogen and oxygen atoms in a water molecule, being polar, result in an asymmetrical charge distribution. The oxygen atom, having a slight negative charge, attracts a positive hydrogen atom belonging to an adjacent water molecule and forms a hydrogen bond.

Exemplify the contributions of hydrogen bond to the properties and behavior of polymeric materials.

The hydrogen bond affects the properties and behavior of materials. In thermoplastics, the hydrogen bond joins long, chainlike molecules to each other. These relatively weak bonds can be easily loosened or broken by heating, permitting flow(流动) to take place.

2-26 Define the terms: unit cells（晶胞）, space lattices（空间点阵）, and intercepts.

Unite cell: used to describe the basic building block or basic geometric arrangement of atoms in a crystal.

Space lattices: repeat the unit cell in all three dimensions, you create a crystalline structure with a definite pattern. This larger pattern of atoms in a single crystal is known as a space lattices.

Intercepts: The sides of the box, labeled a, b, c, are the lattice parameters（晶格参数）in x, y, and z directions, respectively. These distances are also known as intercepts.

2-29 What are the three basic cubic crystal systems? What are their abbreviations（缩写）?

Simple cubic—sc

Body-centered cubic---bcc

Face-centered cubic---fcc

2-45 What are crystal impurities（杂质） and crystal defects（缺陷）?

Crystal impurities: there is some disorder in the atomic structure brought about by something other than impurity atoms.

Crystal defects: a disorder of the crystal structure, which is brought about by some mechanism such as thermal agitation(剧烈振动) of the crystal during its formation, the effects of gravity, or the result of high-energy radiation（辐射）.

2-46 Group, subgroup the crystal imperfections. List two crystal impurities and three crystal defects.

Group: Crystal impurities & crystal defects

Subgroup: Crystal impurities: a mixture; diffusion（扩散）; the doping（掺杂质）;

Crystal defects: point defects; line defects and area defects

2-47 What are substitutional solid solutions and interstitial solid solutions? What are the conditions on which the two solid solutions form?

Substitutional solid solutions: the solute atoms replace some of the solvent atoms in a crystal structure of the solvent.

Interstitial solid solutions: if impurity atoms take up sites in the lattice structure that are normally unfilled or unoccupied by the solvent atoms, they form an interstitial solid solution.

2-48 Define the terms: solution, solvent, solute, mixture, solid solution, alloy, plastic alloy, diffusion, and vacancy.

Solution: a homogeneous mixture of chemically distinct substances that forms a phase.

Solvent: the substance present in the greatest proportion.

Solute: the other substance or substances present.

Mixture: a material that has no fixed composition and contains more than one phase.

Solid solution: simply a solution in the solid state that consists of two kinds of atoms combined in one type of space lattice.

Alloy: a combination of a metal and one or more other elements forming either a mixture or a solid solution.

Plastic alloy: blends of polymers or copolymers with other polymers or elastomers.

Diffusion: the intermingling in solid materials of atoms (in metals),irons(in ceramics),or molecules (in polymers).

Vacancy: one lattice site that is not occupied.

2-62 Understand the terms: long-range-order materials, short-range-order materials, point defect, dislocation, and area defect.

Long-range-order materials: Materials with an orderly arrangement of atoms extending thought the entire material, forming a regular grid-like lattice or pattern.

Short-range-order materials: Materials with their order limited to an atom's nearest neighboring atoms.

Point defect: only affect the small volume of the crystal surrounding a single lattice site. Dislocation: a linear array of atoms along which there is some imperfection in the bonding of the atoms that causes distortion of the crystal structure.

Area defect: Interfacial or 2-dimensional defect existing in the form of grain boundaries.

Module 3 Properties and Characterization of Materials

3-1 Understand the following terms:

(a)Physical properties: Physical properties involve no change in the composition of the material. Density, strength, and hardness are examples of such properties. Physical properties are, in turn, arbitrarily subdivided into many categories.

(b)Chemical properties: Chemical properties are associated with the transformation of one material into another.

(c)Mechanical properties: Mechanical properties are defined as a measure of a material's ability to carry or resist mechanical forces or stresses. Additionally, mechanical properties of a material affect how the material can be worked.

(d)Stress: Stress, defined as the resistance offered by a material to external forces or loads, is measured in terms of the force exerted per area [pounds per square inch(psi)].

(e)Strain: Strain, or unit deformation, is defined as the unit change in the size or shape of material as a result of force on the material.

(f)Deformation: Regardless of how small the force, a body will alter its shape when subjected to a force. In other words, the body will change its dimensions. The change in a physical dimension is called deformation(δ,Greek letter delta).

(g)Young's modulus: Young's modulus or elastic modulus (E) is defined as the ratio of engineering stress (σ) to engineering strain (ε) in the linear or elastic region of the stress-strain diagram.

(h)Elastic deformation: If the material reverts back to its normal size and shape upon removal of the load, it is elastic deformation.

(i)Plastic deformation: If the applied force of load is removed and the material is permanently deformed (changed in shape), the material is said to have undergone plastic deformation.

3-5 Describe the difference between elastic and plastic deformation and give an example of each.

Difference between the two: When it is unloaded the external forces, the material has change in shape or not.

Example: Elastic deformation: When the spring deformation in the elastic range, the spring can be restored to its original shape.

Plastic deformation: When the spring deformation beyond the elastic range, the spring can not be restored to its original shape.

3-6 Draw a stress-strain diagram that is obtained from a tensile test, a) Label at least four important properties that can be determined from the diagram; b) Indicate elastic region and plastic region; c) Indicate the area that represents the modulus of resilience; d) Indicate the area that represents the modulus of toughness.

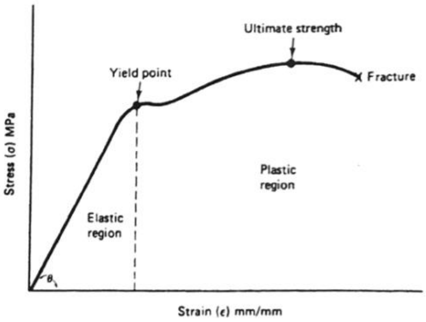


Figure 3-2 Engineering symbols for the sides of the triangle shown in the elastic region of the curve, θ (theta) is the slope angle, *E* is the modulus of elasticity or Young's modulus and is computed $E = \tan\theta$, and Δ is the symbol that means "a measurable change in" the stress–strain diagram.

3-7 Name the different names of elastic modulus and relate this property to the structure and stiffness of materials.

The different names of elastic modulus: The modulus of elasticity, elastic modulus, tensile modulus, Young's modulus, modulus of elasticity in tension, or coefficient of elasticity.

The stiffness of a material is defined as the ratio of the load to the deformation produced. The higher the value of Young's modulus, the stiffer the material. Reinforced metal composites possess greater stiffness than non-reinforced metals.

3-8 Which mechanical property refers to the lower stress at which plastic deformation occurs?

Yield strength

3-10 Which type of materials shows a little difference between yield strength and tensile strength, brittle materials or ductile materials?

Brittle materials

3-11 Which mechanical property is a measure of the energy per unit volume that the material can absorb without plastic deformation?

Resilience

3-12 Calculate ductility by using two methods. How to distinguish a ductile material form a brittle material with the aid of a stress-strain diagram or the value of ductility.

Percent elongation is a measure of ductility of a Material.

$$\%\ \text{elongation} = \frac{(l_F - l_O) \times 100\%}{l_O}$$

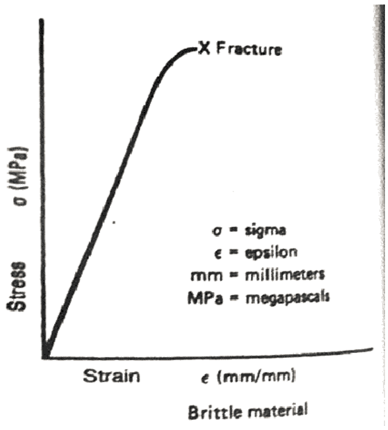
where $l_F =$ length at fracture $l_O =$ original length

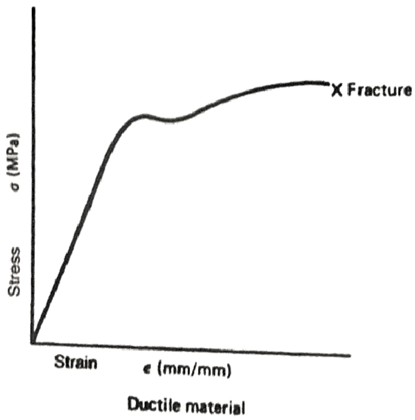
Percent reduction in area is also a measure of ductility.

$$\%\ \textbf{RA}\ \text{in area reduction} = \frac{(A_O - A_F) \times 100\%}{A_O}$$

where $A_O =$ original cross-sectional area $A_F =$ cross-sectional area at fracture

The difference between yield strength and tensile strength. The difference in the amount of plastic deformation shown by each curve prior to fracture.





Brittle material Ductile material

(Very little difference, little plastic deformation) (Wide difference, large plastic deformation)

3-13 Is the specimen that has 5% or less elongation considered as a brittle materials or ductile materials?

Brittle material

3-14 Which mechanical property represents the energy per unit volume of a material required to produce fracture under static conditions?

Toughness

3-15 Which properties of metals does the temperature affect the most?

Impact resistance

3-17 In impact testing of metals, the brittle failures can be found above or below the critical temperature?

Below the critical temperature

3-24 Understand the terms fatigue limit, fatigue ratio, endurance ratio, fatigue strength.

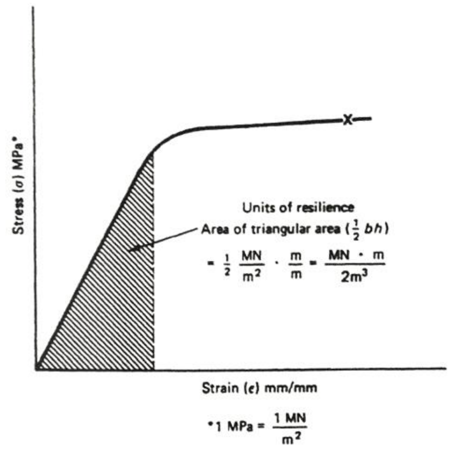
Fatigue limit is the maximum stress below which a material can presumably endure an infinite number of stress cycles, fatigue ratio has the same meaning with endurance ratio which means comparing the fatigue limit to the tensile strength, fatigue strength is the maximum stress that can be sustained for a specified number of cycles without fracture

3-26 A material plastically deforms or flows very slowly under load as a function of time. What is this phenomenon called?

Creep

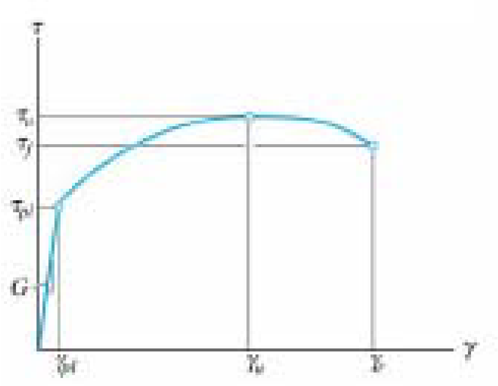
3-34 Understand the terms modulus of rupture, modulus of rigidity, modulus of resilience, and modulus of elasticity.

1)Modulus of resilience(R) 回弹模量



The area under which the straight-line portion (elastic region) of the stress-strain curve. A measure of the energy per unit volume that the material can absorb without plastic deformation.

2)Modulus of rigidity (G) 刚性模量



Shear modulus of elasticity (G)

The ratio of the shearing stress to the shearing strain in elastic region

$$G = \frac{\tau}{\gamma}$$

3)Modulus of rigidity

A measure of the ability of material to withstand a twisting load. It is roughly equivalent to the ultimate shear strength.

3-35 List four important hardness tests.

1) Rockwell test

Direct-reading instrument, A variety of indentors:1/8 and 1/16 inch ball; diamond cone. A variety of loads: Scales (硬度标): HRB, HRC, etc. Difference in penetration depth gives hardness number

2) Brinell test

A measure of the size of the penetration made by a 10-mm steel or tungsten carbide sphere with different loads.

3) Barcol test

A surface hardness value obtained by measuring the penetration resistance of a given material to a sharp point under a spring load. Hardness: 0-100 scale

4) Mohs test

Classes hardness of all materials between 1and 10. Mohs scale is based on the ability of a hard material to scratch a softer material.

3-36 What is the difference between Brinell hardness and Vickers hardness tests?

1) Rockwell test: Indentation is small, suitable for finished products and flakes, attributed

to non-destructive testing of a class, measuring harder materials.

2) Vickers Hardness Test**:** Applied loads between 1 and 1000, much smaller than for Rockwell and Brinell.

3-37 What data should be included in reporting Rockwell hardness readings?

The scale letter so that the person wishing to use the information knows the type of indentors as well as the size of load used in the test.

3-38 Which type of hardness test compares a materials' hardness to some 10 known minerals arranged in order of hardness.

Mohs hardness

3-71 What thermal effect does a metal exhibit when it is heated deliberately? What are the corresponding properties for describing the effect?

The included stresses created by the difference in expansion will cause the metallic strip to bend.

3-72 List the thermal expansion of the following materials in a decreasing order, i.e.: polymer, metal, covalent and ionic bonded materials.

Polymer>Metal>Covalent and ionic bonded materials

3-73 Compare polymers with metals in terms of expansion coefficient and thermal conductivities.

Expansion coefficient: polymers>metals; Thermal conductivities: metals>>polymers

Module 4 Metallic Materials

Supplementary teaching materials (page 41-42)：

4-1 What are the general characteristics of metallic metal?

Relatively strong; Luster; Ductile 有延展性的;Malleable 可锻造的; Good thermal and electrical conductors

4-27 What is P/M？

Powder metallurgy.

4-48 What is nonferrous metals?

Metals contain little or no iron.

Self-assessment (text pp219-222)：

4-1 Adding elements to replace base metal atoms in a solid solution is called _d_.

a. Interstitial b. Elutriation c. Addition d. Substitutional

4-2 The ability of a metal to exist in more than one space lattice is called _c_.

a. Isotopic b. Amorphous c. Allotropic d. Equilibrium

4-23 The carbon content in a 1020 steel is b.0.2%.

4-25 Metal with no iron is c. Nonferrous.

4-30 Another name for nodular cast iron is c. Ductile.

4-36 In addition to corrosion resistance, chromium also gives d. Strength to steel.

4-43 Martensitic stainless steels have at least c.12% of Cr.

4-51 Titanium, at certain temperatures, can be deformed as much as d.2000%.

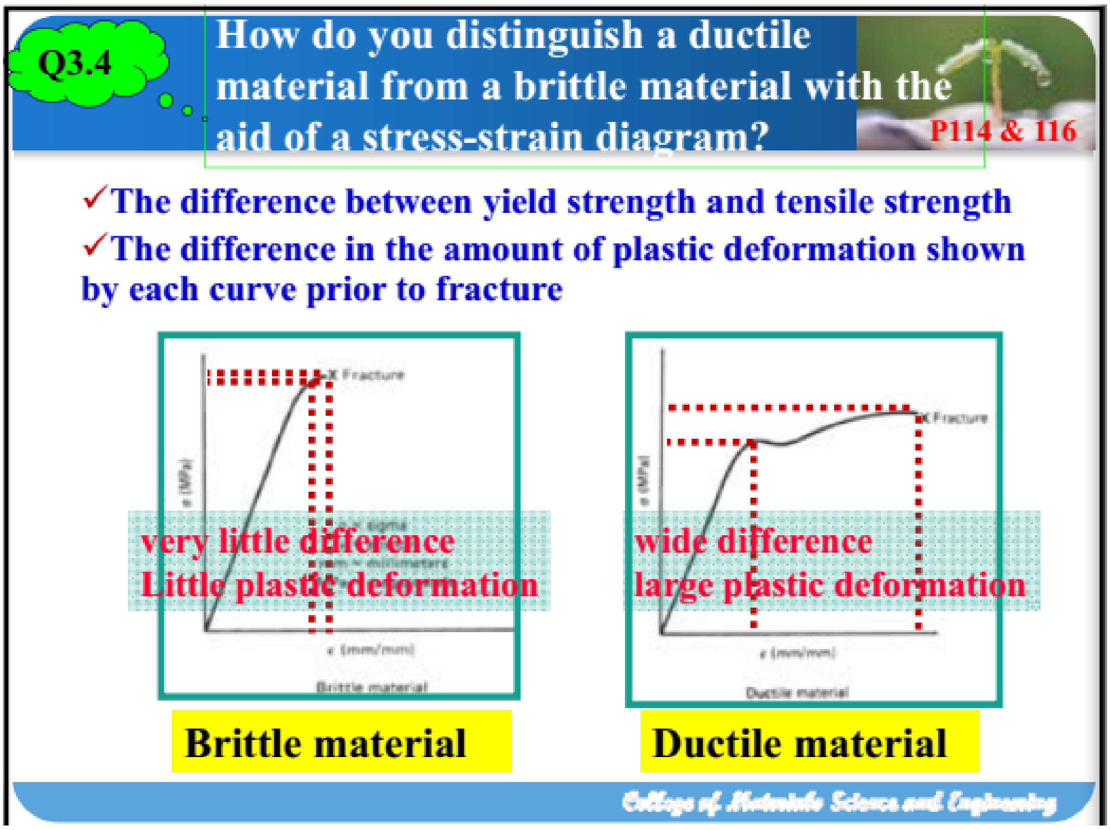
4-60 Which metal listed below is capable of being super plastically deformed 2000%?

c. Titanium

4-65 Another name for sintered metals is c.P/M.

补充题

Least three methods to distinguish a ductile material from a brittle material with the aid of a stress-strain diagram.



Module 5 Polymeric Materials

5-1.Define the term polymer. List the major groups of polymers.

A polymer is a chainlike molecule made up of smaller molecular units.

Major group of polymers: Organic polymers: Natural polymers, Synthetic polymers

Applications: Plastics , Elastomers, Fibers ,Protective coatings, Adhesives.

5-5.Define the term monomer. List the prerequisites of monomers for polymerization.

Monomer: a simple compound whose molecules can join together to form polymers .

prerequisites of monomers for polymerization.:1. Unsaturated2. Bifunctional

5-6.Define the term isomer. What are the three categories of stereoisomers.

Variations in the molecular structure of the same composition.

stereoisomer : isotactic, syndiotactic, atactic

5-8.Define the term polymerization. Describe the two main polymerization processes and list the typical products of each.

Polymerization: A chemical reaction in which the molecules of a monomer are linked together to form large molecules.

the two main polymerization processes: Addition polymerization 加成聚合:PE, PP, PVA, PVC, ABS, PTFE. Condensation polymerization 缩聚反应:phenolic (PF)酚醛树脂,polyester (PET) 聚酯,nylon (PA),polycarbonate (PC)

5-10.Name the polymerization approaches to improving the properties of polymers. Exemplify the typical products of at least one such polymerization.

Copolymerization: SBR, Terpolymerization: EPM, Multicomponent polymerization.

5-11.Define the degree of polymerization(DP).How is the average molecular weight calculated for a polymer? How does the value relate to the polymer chain length and the degree of viscosity of chain polymers.

The number of repeating mers (重复单元) in the material.

DP ×mer's weight

chain length ↑,M↑,viscosity ↑

5-12.What is the difference in crystallinity between polymers and metals? Name the term used to describe the crystallinity polymers.

Metals: Fully crystalline. Uniform nature of the unit cells (晶胞) of their space lattice (晶格)

Polymers: Semi crystalline in varying degrees. Sufficient regular structure allows some degree of crystallization.

Degree of crystallinity (结晶度）

5-15.What bonds form between chains in thermoplastic polymers and thermosetting polymers.

Thermoplastic polymers: Heating causes the bonds lose their hold.

Thermosetting polymers: Cross-linking (交联) is resulted from covalent bonds (共价键) between chains.

5-17.Whe are additives compounded with plastic? What are the functions of colorants, plasticizers, flame retardants, fillers, foaming agents, lubricants, preservatives, and viscosity depressants, stabilizers, and carbon black.

They are compounded with the resin to enhance their properties.

Colorants: to add color to plastics or serve dual roles, such as stabilization.
Plasticizers :increase the flexibility (柔顺性)Mechanism: reduce the attraction between polymer chains.
Flame retardants: to reduce flammability of plastics.
Filler: Increase bulk, tensile strength, hardness, abrasion resistance 抗磨性 , rigidity. Improve electrical, thermal properties, appearance, and chemical resistance. Increase or decrease specific gravity. Decrease cost.
foaming agents 发泡剂: produce cellular plastics.
lubricants 滑润剂:decrease friction and resin melt during processing.
preservatives 防腐剂: retain physical &chemical properties, prevent growth of bacteria 细菌 and algae 藻类.
viscosity depressant 粘度抑制剂:reduce viscosity during processing.
Stabilizer: to prevent the degradation of polymers.
Carbon black （碳黑）: block out ultraviolet light, strengthen plastics.

5-20.Compare the toughness and impact resistance of thermoplastics to that of thermosets.

Thermoplastics > thermosets

5-21.What is the property unique to polymers? What properties incorporate in the property? Explain how the property relates to the behavior of plastics. How is the property determined?

Viscoelasticity 黏弹性 Viscosity 黏度 and Elasticity 弹性
A sudden impact on the plastic will not result in immediate strain or immediate and full recovery when the stress is removed.
stress relaxation 应力松弛 Creep 蠕变

5-23What is the maximum continuous-service-temperature for the most commonly used plastics?

< 150^{o} C (low or no stress), slight increase in stress reduce T.

5-24.Define the terms: glass-transition temperature or glass point, and glass transition. How is the strength of a material related to Tg value?

Glass-transition 玻璃化转变:A reversible change that occurs when a resin polymer is heated to a certain temperature(Tg), resulting in a sudden change or transition from a rigid polymer to a flexible rubbery material or a viscous liquid.
Glass-transition temperature (Tg）玻璃化转变温度: The point at which polymers act as glass or become viscous liquid.
Below Tg: hard and brittle, like glass.
Near Tg: major loss in strength
Above Tg: flexible, viscous

5-25.How are most plastics compared to metals in thermal conductivity, thermal expansion, and density.

Thermal conductivity 导热性:Low in most plastics, insulating properties.
thermal expansion 热膨胀: Plastics > metals, 10 times.
Density 密度: Plastics < other engineering and general-purpose materials 通用材料.

5-26.Exemplify the wide range of flammability for plastics. Compare the flammability of thermoplastics to that of thermosets.

Nonburning, without fire-retardant additives: phenolics, polyimides, fluorocarbons.
Highly flammable: cellulosics 纤维素塑料
Thermoplastics > thermosets

5-28.What are the typical phenomena of plastic’s deterioration.

5-31.Explain why plastics of low moisture absorption are required when high dimensional accuracy must be maintained.

Moisture absorption causes swelling in plastics, which creates problems in holding dimensional accuracy.

5-32.How does the crystallinity affect the optical properties of plastics? Give examples to explain the effect.

crystallinity 结晶性↑,Opacity 阻光度↑
amorphous structure produces transparency 透明度
LDPE: transparent; HDPE: opaque

5-33.What polymers provide substrate for CD-ROMs? What properties of plastics? Give examples to explain the effect.

Polycarbonates(PC) possess excellent optical as well as hardness and toughness. PC provides the substrate for CD-ROMs, which can store up to 660MB of information as compared to less than 2 megabytes on floppy disks.

5-35.What are the typical processes applied to thermoplastic(TP)plastics and thermosetting(TS)plastics, respectively.

Typical processes applied to TS: Casting 铸塑 Spraying 喷射成型 Compression molding 模压成型 Transfer molding 传递模塑成型 Reaction injection molding (RIM) 反应注射成型
Typical processes applied to TP: Casting 铸塑 Extrusion 挤出成型 Blow molding 吹塑成型 Thermoforming 热成型 Calendering 压延成型 Rotational molding 旋转模塑成型 Resin transfer molding (RTM)树脂转移模塑法 Drawing 拉制法 Rolling 滚塑成型 Foaming 发泡模塑成型 Spinning 纺丝

5-37.What does the process RTM refer to?

Resin transfer molding 树脂转移模塑法

5-40 Why are the properties of natural rubber required to improve? How are the properties changed through vulcanization? How is vulcanization accelerated?（为什么要硫化，如何改变性能，如何加快硫化？）

Natural rubber are that it is too soft and has too many reactive sites, which cause rapid oxidation and dry rot（氧化和干腐）. It is also somewhat plastic and will irrecoverable(无法回收）from high stress（大应力）. The sulfur vulcanizes（硫化）the rubber, or changes it into a thermosetting polymer, by linking together the molecular(分子）chains at their double bonds. Accelerators and activators added to the compound will result in vulcanization within minutes. 促进剂和化合物添加到激活将导致在几分钟之内硫化。

5-42 Is natural rubber a thermoplastic polymer, and vulcanized rubber a thermosetting polymer？(天然橡胶是热塑性聚合物，硫化橡胶是热固性聚合物？)

Yes。natural rubber is a thermoplastic polymer, and vulcanized rubber is a thermosetting polymer。

Vulcanization of rubber uses sulfur to transfer it from thermoplastic polymer into a thermosetting polymer

5-46 Is there a physical or a chemical cross-linking in the rubber network of thermoplastic rubbers（在热塑性橡胶的橡胶网络中是否存在物理交联或化学交联？）

There is a physical cross-linking in the rubber network of thermoplastics rubbers.

5-47 What properties place thermoplastic rubbers in contention as a substitute for thermosetting rubbers(作为热固性橡胶的替代物，热塑性橡胶的特性是什么性质)

Thermoplastic elastomers have a wide variety of possible configurations. The most fundamental one is the need to have at least two polymer phases dispersed into each other. At normal service temperatures, one phase is fluid and the other phase is solid, with the two phases present interaction.(热塑性弹性体具有多种可能的结构，最根本的一条是需要有至少两个互相分散的聚合物相,在正常使用温度下，一相为流体,另一相为固体,并且两相之间存在相互作用。)

5-50 What have polymer chains composed of silicon and oxygen backbone? How can the physical state of the SO_2 polymer be changed?(有什么聚合物链由硅和氧骨架组成？SO_2 聚合物的物理状态如何改变？)

polysiloxane

5-52.Q:What are the advantages of adhesive bonding over other joining methods? Name three applications. 粘合剂粘合与其他连接方法相比有哪些优点？提出三种应用。

A:Light weight, load spreading, join sealing. 重量轻，载荷分散，接合密封。

5-53. Q:Define the terms adhesives and adherends.定义术语粘合剂和粘合物。

A:An adhesive is a substance capable of holding materials together by surface attachment. The materials held together are adherends or substrate. 粘合剂是能够通过表面附着将材料保持在一起的物质。粘合在一起的材料是被粘物或基底。

5-54.Q: What nature must the adhesive have to achieve wetting of an adherend? 粘合剂必须具有什么性质才能实现被粘物的润湿?

A1: The adhesive must not have cohesive forces(attraction of moleculesinside the adhesive)that provide a very strong surface tension(forces contracting the liquid into a droplet).The surface tension must be less than the adhesive forces between the adherend and the adhesive. 粘合剂必须不具有提供强烈表面张力（将液体压缩成液滴的力）的内聚力（引入粘合剂内的分子的吸引力）。其表面张力必须小于粘合剂和粘合剂之间的粘合力。

A2: The adhesive can achieve wetting on an adherend when the adhesive must have surface energy lower than dose the adherend have or the adhesive must have zero or very small contact angle. 当粘合剂必须具有低于被粘物所具有的表面能或者粘合剂必须具有零或非常小的接触角时，粘合剂可以实现对被粘物的润湿。

5-55.Q: What is a measure of how a liquid will spread on a soild? How is it related to wetting? 什么是液体在固体上扩散程度的度量？它与润湿有什么关系？

A:The wetting or contact angle is a measure of how a liquid will spread on a soild. If the contact angle is not greater than 90。,it is considered wetting. If the contact angle is greater than 90。,it is considered nonwetting. 润湿角或接触角是衡量液体如何在固体上扩散的度量。如果接触角不大于 90°，则认为是润湿的。 如果接触角大于 90°，则认为不润湿。

5-57.Q: Exemplify how adhesives are classified according to bonding characteristics. List two examples in each group. 举例说明如何根据粘合特性对粘合剂进行分类。列出每个组中的两个例子。

A:Structural adhesives: phenol-resorcinol-formaldehyde polymers, casein adhesives. Nonstructural adhesives: urea-formaldehyde, starch, dextrin. 结构型粘合剂：苯酚 - 间苯二酚 - 甲醛聚合物，酪蛋白粘合剂。非结构型粘合剂：尿素甲醛，淀粉，糊精。

Self-assessment (pp284-285)

5-15 a property unique to polymer that gives them the ability to return to their original size and shape once a load is removed ,much like a shock absorber handles bumps,is

一种聚合物特有的性质，使得它们能够在卸下负荷后恢复到其原始尺寸和形状的能力，就像减震器处理颠簸一样，是

a.Viscoelasticity 粘弹性

5-16 a problem with many plastics is that they often creep at room temperayure over time with fairly small loads

许多塑料的问题在于，它们经常在室温下以相当小的负荷蠕变

T

5-17 thermosetting plastics are not good for recycling because they cannot be softened for reprocessing

热固性塑料不利于回收，因为它们不能被软化以用于后处理

F

5-20 A ratio of strength to weight is

强度与重量的比例是

c. Specific strength 比强度

5-27the objective of vulcanizing rubber is

硫化橡胶的目的是

b.to increase hardness and chemical resistance 增加硬度和耐化学性

5-28 vulcanization of rubber uses sulfur to transform it into a thermosetting elastomer

橡胶的硫化使用硫将其转化为热固性弹性体

T

5-35 Thermoplasic rubbers process easier than most thermosetting rubbers

热塑性橡胶比大多数热固性橡胶更容易加工

T

5-36 the Energy loss through heating in elastomers, which creates problems in applications such as car tires, is called

弹性体加热引起的能量损失，这在汽车轮胎等应用中造成了问题,被称作

d. Hysteresis 滞后作用

5-40 Which advantages would adhesive bonding have over other joining methods?

粘合剂粘合与其他连接方法有哪些优点？

b. Light weight, load spreading, join sealing 重量轻，载荷分散，接合密封

5-46 loss-of-solvent curing of adhesives usually occurs more quickly than cooling of hot melts

无溶剂液体粘合剂固化通常比热熔体的冷却更快地发生

F

5-47 a. In the adhesive system, what three events that must occur to obtain a bonded joint?

在粘合剂体系中，获得粘合接头必须发生三件事情？

flow, wet and set 流动，湿润和凝固

b. what types of forces are involved in adhesion?

什么因素的力量参与粘附？

The wettability, surface free energy, polar groups, and roughness of the material to be bounded 待润湿材料的润湿性，表面自由能，极性基团和粗糙度。

Module 6 Ceramic Materials

6-2 Traditional ceramics are based primarily on natural raw materials of clay and silicates. They can be applied to clay products, glass, and cement; Advanced ceramics include artificial raw materials, exhibit specialized properties, require more sophisticated processing. They can be applied to structural, electronic and optical products.

6-5 Green density: bulk density of a compact prior to its densification.

Bulk density: ceramic's density includes material's porosity.

Theoretical density: density of a solid material, which takes into consideration a microstructure that contains no porosity.

Apparent density: dry weight divided by the difference between its bulk volume and its open-pore volume.

6-13 densification: also referred to as firing, is a process by which a particles compact is transformed into a ceramic part that has adequate properties to satisfy the needs of a specific application.

Sintering: heating the powder compact to a temperature below the melting temperature of its components, so that the grains of powder can be bonded together.

6-54 Devitrification: is the conversion of glass or other noncrystalline solids into polycrystalline solids.

Vitrification: is the conversion of polycrystalline solids into glass or other noncrystalline solids.(producing amorphous structures).

6-55 a. Soda-lime silica glass(soft glasses) b. Lead-alkali silica glass(soft glasses) c. Borosilicate glass(hard glasses)

Desirable characteristics: 1.Perfect elastic material(at any stress below breaking stress, glass will return to its original shape when the stress is removed.)

2. Transparency colors.

Self-assessment

6-1. B

6-3. A

6-4. B

6-5. F

6-6. T

6-7. A

6-8. C

补充: Soft glasses have lower heat resistance and higher CTE.

Hard glasses are lower in thermal expansion and higher in both heat resistance and silica content than soft glasses.

Module 7 Composite Materials

7-5：What do the abbreviations CMC, PMC and MMC stand for, respectively? CMC，PMC 和 MMC 分别代表什么缩写?

CMC: ceramic-matrix composite 陶瓷基复合材料　PMC: polymer-matrix composite 聚合物基质复合材料　MMC: metal-matrix composite 金属基复合材料

7-8:List the functions of a matrix and a coupling agent in a composite.列出复合材料中的基体和偶联剂的功能。

matrix has a considerably lower density, stiffness(modulus),and strength than the reinforcing fiber material, but the combination of the two main constituents(matrix and fiber)produces high strength and stiffness, while still possessing a relatively low density.基体与增强纤维材料相比具有相当低的密度，刚度（模量）和强度，但两种主要组分（基质和纤维）的组合产生高强度和刚度，同时仍然具有相对低的密度。Coupling agent　provides a flexible layer at the interface between fiber and matrix that will improve their adhesion and reduce the number of voids trapped in the materials.偶联剂在纤维和基体之间的界面处提供了柔性层，其将改善它们的粘附并减少材料中所捕获的空隙的数量。

7-9:Understand the term voids. How do the voids in the matrix affect the properties of a composite?了解术语 voids。基体中的 voids 如何影响复合材料的性能？

Voids, air pockets in the matrix, are harmful because the fiber passing through the void is not supported by the matrix. Under load, the fiber may buckle and transfer the stresses to the weaker matrix, which could crack.基体中的气泡，气穴是有害的，因为通过空隙的纤维不受基质支撑。在负载下，纤维可能会弯曲并将应力传递到较弱的基质，从而可能破裂。

7-12：Define the terms interface and interphase.定义术语界面和界面。

Interface: a surface that forms a common area or boundary similar in many respects to grain boundaries between any two constituents in a monolithic material.形成公共区域或边界的表面在很多方面类似于整体材料中的任何两种成分之间的晶界。Interphase is the region formed between two interfaces. Interphase 是两个接口之间形成的区域。

7-13 Defined the terms:(a)preimpregnation; (b)prepreg; (c)preforms; (d)lamina; (e)laminate; (f)bulk molding compound(BMCs); (g)sheet molding compounds(SMCs)定义术语:（a）预浸渍;（b）预浸料坯;（c）预成型坯;（d）薄板;（e）层压板;（f）块状模塑料（BMCs）;（g）片状模塑料（SMC）

（a）fibers can be saturated with resinous material through a process called preimpregnation. 纤维可以通过称为预浸渍的过程被树脂材料浸透。(b)The preimpregnated fibers are called prepregs.预浸渍纤维称为预浸料坯。(c)preforms are custom-shaped, resin-bonded mats for reinforcement of molded parts with complex shapes.预制件是定制形状的，树脂粘合的垫子，用于增强具有复杂形状的模制部件。(d)A lamina is a flat arrangement of unidirectional fibers or woven fibers in a matrix.薄片是基质中单向纤维或编织纤维的扁平排列(e)a laminate is a stack of lamina with various orientations of the directions of the principal materials in the lamina.层压板是层压板中具有主要材料方向的各种取向的层压板。(f)bulk molding compound(BMCs)are a premixed material of short fiber preimpregnated with resin and various additives. 块状模塑料（BMCs）是用树脂和各种添加剂预浸渍的短纤维的预混材料(g)sheet molding compounds(SMCs)are impregnated, continuous sheets of composite material.片状模塑料（SMC）是浸渍的复合材料的连续片材。

7-14 List some advantages and disadvantage of using prepregs.

——Some important advantages of using prepregs are the elimination of the handling of liquid resins, the simplification of the manufacturing of reinforced plastic forms and shapes, and the savings in cost with small production lots. A few disadvantages are the elimination of room-temperature cures, the need for refrigerated storage, and the additional cost over dry-blended or undispersed materials. The last disadvantage must be weighed against the use of higher mold pressures and longer molding cycle times for undispersed material to effect the required dispersion of the reinforcement throughout the matrix material to attain the optimum properties of the composite.

7-21 Give the trade name for an aramid, or aromatic, polyamide fiber. What are the structure and property characteristics of the fiber?

——Kevlar. The rodlike nature of the molecules classifies Kevlar as a liquid-crystalline polymer characterized by its ability to form ordered domains in which the stiff, rodlike molecules line up in parallel arrays. These domains orient and align themselves in the direction of flow during processing, causing a high degree of alignment parallel to the fiber axis and resulting in anisotropy, with high strength and tensile modulus in the fiber-longitudinal direction.

7-27 Define the terms specific tensile strength and specific stiffness (or specific modulus).

——Specific tensile strength, the ratio of the tensile strength of a fiber material to its weight density, is an indicator of structural efficiency, given the relative load-carrying ability of equal weight density, is an indicator of structural efficiency, given the relative load-carrying ability of equal weights of material.

——Specific stiffness is a ratio of the modulus of elasticity (of tensile stiffness) to the weight density of the fiber.

7-28 Why do the materials in fiber form have much higher strength and stiffness than the same materials in bulk form? Cite one example of the case.

——The strength of glass in bulk form, such as plate glass, is only a few megapascal, yet in fiber form this figure rises to around 3.5 GPa. Structural steel (plain-carbon steel) in bulk form has a tensile strength around 0.5 Gpa, but in fiber form the value is 4 GPa.

7-29 Define the term fiber loading. What is the relation between the strength of the composites and the fiber loading (the volume fraction of fiber)?

——Fiber loading refers to the amount of reinforcement in a composite material. The strength of the composite is directly proportional to the volume of fiber (volume fraction) present. In addition to the fiber loading, the arrangement or orientation of the fibers plays a major role in the strength of the given product.

7-30:If continuous fiber are oriented such that their length is in the direction (longitudinal) of the loading, this type of arrangement is known as directionally oriented.

7-31:等应变：E(c)=E(f)V(f)+E(m)V(m),条件：both the fibers and the matrix will stretch or deform the same amount in withstanding the tensile load. 等应力：1/E(c)=V(f)/E(f)+V(m)/E(m), 条件：the load, F(c),act transversely as opposed to longitudinally or parallel to the long axis of the fibers. The fibers and the matrix each resist the load equally.

7-32:1.A gradual decrease in the slope of the stress-strain curve(modulus of elasticity, E) occurs during cyclic loading. 2.Elevated temperatures normally reduce the performance of matrix-dominated composites (stress carried mainly by the matrix material).Fiber fatigue properties are better than those of the polymer matrix. 3.Moisture and chemical exposure can greatly affect the polymer matrix. 4.Notch sensitivity in high-cycle tensile-fatigue conditions is less than for metals. 5.There are considerably fewer matrix-dominated properties than fiber-dominated properties. Hence tensile, compressive, and shear stresses in the interlaminar(through-the-thickness) direction, being matrix dominated, should be kept to a minimum.

7-35:we have divided this ever-increasing variety of composites into fiber ,laminated sandwich, particulate, flake, and filled.

7-37:Such composites are stronger at high temperature than at low temperatures, have high specific strength and good resistance to thermal shock, and are self-lubricating. Application such as in rocket propulsion components, brakes, hypersonic leading edges of flight vehicles, heating element, and structural components. These composites are stronger and stiffer than steel and less dense than aluminum

7-43 What is a laminar composite ? Give several examples of laminar composites.(什么是层状复合材料?给出层状复合材料的几个例子。)p360

Consist of layers (lamina) of at least two different solid materials bonded together so the fiber orientation runs at different angles.

Some example of laminar composites are clad metals , safety glass and plywood.

7-49 What is a hybrid composite ? List the four basic types of hybrids. (什么是混杂复合材料？列出混杂复合材料的四种基本类型)p367

Hybrid composites，which combine two or more different fibers in a common matrix , greatly expand the range of properties that can be achieved with advanced composites. They can cost less than materials reinforced only with graphite or boron.

Four basic types of hybrids:

Interply (层间混杂)

Intraply(层内混杂)

Interply/ intraply(层间/层内混杂)

Superhybrids(超混杂)

7-53 What are the two stages involved in the processing of most fiber composites ?（大多数纤维复合材料的加工过程中涉及到的两个阶段是什么?）p371

Two stages:

Layup or combining of the reinforcement and matrix materials

Molding or curing stage

Curing

The drying or polymerization of the resinous matrix to form a permanent bond between the fibers and the matrix material.

Occurs unaided or by the application of heat and/or pressure.

7-56 Understand the three kinds of closed molding methods : compressing molding ; injection molding ; resin transfer molding.(理解三种闭式模压成型方法:模压成型；注射模塑；转移模塑法。)p372

Compression molding uses TS resins placed in a cavity of a matched mold in the open position. The mold is closed , pressure is applied ,the material is heated to cause cross-linking ,and when complete ,the mold is opened.

Injection molding is used to form molten thermoplastic(TP) and thermosetting(TS) matrix materials in a closed mold, where they are held until the materials solidify.

Resin transfer molding (RTM) differs from RIM in that a reinforcement is molded with the resin; the equipment , However ,is basically the same.

7-60 What is the difference between resin transfer molding(RTM) and resin injection molding(RIM)

Resin transfer molding (RTM) differs from RIM in that a reinforcement is molded with the resin; the equipment , However ,is basically the same.

7-63 Understand the composite fabrication method of pultrusion

Pull a fiber or a bundle of continuous filaments through a resin system for impregnation.

The fiber/resin bundle travels through a heated curing die, while polymerization occurs.

A composite structure emerges from the exit end of the die.

7-64 D

Self-assessment

书上选择 7-1~7-4： D C A B

7-5 C 7-13 B 7-15 A

7-23 Regardless of the name given to the processing method for producing fiber-reinforced plastic products, two stages are included in most of them. Name these two stages.

Layup or combining of the reinforcement and matrix materials

Molding or curing stage

补充：

How is the fiber loading related to the orientation of fiber in the composite？（复合材料中纤维的取向与纤维的负荷强度有什么关系？）P346

If all fibers are placed parallel to each other, a maximum number can be attained. In fiber loadings, a maximum of about 85% can be achieved. A load range of between 50 and 75% can be reached if half the fibers are arranged at right angles to each other, while a random arrangement permits a range of only 15 to 50%.As the direction of an applied load moves 90。 to the fiber orientation, the strength of a directionally oriented fiber composite decreases to about 20 to 30% of the longitudinal direction. Alternating layers of continuous fibers at various angles provide full strength at these various directions.

The abbreviations and the Chinese meaning of MMC、PMC、CMC、BMC、SMC、DBC、GRP、SiC(MMC、PMC、CMC、BMC、SMC、DBC、GRP、SiC 的全称及其中文翻译.)

MMC: metal matrix composite 金属基复合材料

PMC: polymer matrix composite 聚合物基复合材料

CMC: ceramic matrix composite 陶瓷基复合材料

BMC: bulk molding compound 块状模塑料

SMC: sheet molding compound 片状模塑料

DBC: dough molding compound 团状模塑料

GRP: glass fiber-reinforced plastics 纤维增强塑料

SiC: 碳化硅

Understand the composite fabrication methods of filament winding and pultrusion（理解复合材料纤维缠绕和拉挤成型的制作方法）P376

Filament winding: Filament winding and tage winding, which produce the highest specific strengh and glass content by weight of composite parts(loading up to 85 by weight.)are generally limited to parts with mound, oval or tapered inner surfaces, although external shapes are unlimited. The continuous glass strand or filament is usually passed through a resin bath prior to winding onto a revolving mandrel. The mechanical as well as other properties of a filament-wound product can be changed by altering the wind angle ,an angle measured between the axis of the mandrel and the lay of the filaments. The tangent of this angle equals the ratio of the circumference of the mandrel and the pitch of the filaments. As the angle increases to 90, the hoop tensile strength increases and the axial tensile strength decreases.

Pultrusion： Pultrusion is a composite fabrication method by which an extremely long fiber-reinforced, polymer-matrix material can be produced by pulling a fiber or a bundle of continuous filaments through a resin system for impregnation and then through a heated curing die. The fiber resin bundle travels through the curing die , polymerization occurs , and a composite structure emerges from the exit end of the die .

Discuss the factors influencing the properties of the fiber-reinforced composites (讨论影响纤维增强复合材料性质的因素)

Fiber

1.Continuous lengths

2.Defects or flaws

3.Shape, size & distribution

4.Loading 填充量

5.orientation

6.strength

Matrix:

1.ability to adhere to the fibers influencing

2. inherent toughness fiber strength coupling agent adhesion between fibers and matrix

Coupling agent: adhesion between fibers and matrix

Processing aspect: The degree to which the fibers are saturated with wet matrix, leaving few or no voids

Module 8 Biomaterials

8-1. A
8-2. B
8-3. C
8-4. D
8-5. E
8-7. Metallic biomaterials, ceramic biomaterials, polymeric biomaterials, composite biomaterials.
8-9. Hemocompatibility and tissue compatibility.
8-12. Inert biomaterials; resorbable biomaterials; biomaterials with resorbable and bioactive properties in combination.
8-64. A
8-65. B
8-66. D
8-67. E
8-68. G
8-69. F
8-70 C
8-71. H
8-99. Degradation specifically refers to bond cleavage, so it’s a chemical process.
Erosion refers to depletion of material, and it’s a physical phenomenon depending on dissolution and diffusion processes.
补充
1,2.略 见黄书 8-64~8-71
3. Surface eroding polymers: polyanhydrides
   Bulk eroding polymers: PLA, PLGA
Plants and shell of crustaceans(e.g. crabs and shrimps)