1. Translate the following terms into Chinese. (50%)
   (a) Lattice Defects
   (b) Electromagnetic Radiation
   (c) Viscoelastic Properties of Polymers
   (d) Polyethylene
   (e) Nucleation
   (f) Creep Test
   (g) Ultimate Tensile Strength
   (h) Electronegativity
   (i) Refraction
   (j) Dielectric Constant

2. Briefly describe the operating mechanisms of light emitting diode (LED) in Chinese. (10%)

3. Briefly describe what you know about liquid crystal in Chinese. (10%)

4. Compare the differences in the changes of elastic constant with increase in temperature for high density polyethylene (a highly crystalline polymer) and low density polyethylene (an amorphous polymer). Show your answer (elastic constant versus temperature) using an X-Y plot. (10%)

5. Compare microcrystalline, amorphous, nanocrystalline, and single crystal materials in terms of increasing order in atomic arrangement. (10%)

6. An alloy composed of 90Al-10Ti (wt%) is melted at 1400°C, and then slowly cooled to 600°C and annealed at this temperature for a very long time. What are the constituting phases at this temperature and what are the approximate weight percentages and volume percentages of these constituting phases? (Al: 2.7 g/cm³, Al₃Ti: 3.3 g/cm³, Al₂Ti: 3.5 g/cm³, TiAl: 3.9 g/cm³) (10%)
What is Inside an LED?

The most important part of a light emitting diode (LED) is the semi-conductor chip located in the center of the bulb as shown above. The chip has two regions separated by a junction. The $p$ region is dominated by positive electric charges, and the $n$ region is dominated by negative electric charges. The junction acts as a barrier to the flow of electrons between the $p$ and the $n$ regions. Only when sufficient voltage is applied to the semi-conductor chip, can the current flow, and the electrons cross the junction into the $p$ region.

In the absence of a large enough electric potential difference (voltage) across the LED leads, the junction presents an electric potential barrier to the flow of electrons. When sufficient voltage is applied to the chip across the leads of the LED, electrons can move easily in only one direction across the junction between the $p$ and $n$ regions. In the $p$ region there are many more positive than negative charges. In the $n$ region the electrons are more numerous than the positive electric charges. When a voltage is applied and the current starts to flow, electrons in the $n$ region have sufficient energy to move across the junction into the $p$ region. Once in the $p$ region the electrons are immediately attracted to the positive charges due to the mutual Coulomb forces of attraction between opposite electric charges. When an electron moves sufficiently close to a positive charge in the $p$ region, the two charges "re-combine".

Each time an electron recombines with a positive charge, electric potential energy is converted into electromagnetic energy. For each recombination of a negative and a positive charge, a quantum of electromagnetic energy is emitted in the form of a photon of light with a frequency characteristic of the semi-conductor material (usually a combination of the chemical elements gallium, arsenic and phosphorus). Only photons in a very narrow frequency range can be emitted by any material. LED's that emit different colors are made of different semi-conductor materials, and require different energies to light them.
What are Liquid Crystals?

Liquid crystal materials generally have several common characteristics. Among these are a rod-like molecular structure, rigidity of the long axis, and strong dipoles and/or easily polarizable substituents.

The distinguishing characteristic of the liquid crystalline state is the tendency of the molecules (mesogens) to point along a common axis, called the director. This is in contrast to molecules in the liquid phase, which have no intrinsic order. In the solid state, molecules are highly ordered and have little translational freedom. The characteristic orientational order of the liquid crystal state is between the traditional solid and liquid phases and this is the origin of the term mesogenic state, used synonymously with liquid crystal state. Note the average alignment of the molecules for each phase in the following diagram.

![Diagram of solid, liquid crystal, and liquid phases]

It is sometimes difficult to determine whether a material is in a crystal or liquid crystal state. Crystalline materials demonstrate long range periodic order in three dimensions. By definition, an isotropic liquid has no orientational order. Substances that aren't as ordered as a solid, yet have some degree of alignment are properly called liquid crystals.

mesogen • 液晶原
Glass Transition Temperature and Melting Temperature of Polymers

If an amorphous polymer is heated it eventually will reach its glass transition temperature. The polymer now is in its rubbery state. The rubbery state lends softness and flexibility to a polymer.

Comparison with Melting

<table>
<thead>
<tr>
<th>Glass Transition</th>
<th>Melting</th>
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<tbody>
<tr>
<td>Property of the amorphous region</td>
<td>Property of the crystalline region</td>
</tr>
<tr>
<td>Below T&lt;sub&gt;j&lt;/sub&gt;: Disordered amorphous solid with immobile molecules</td>
<td>Below T&lt;sub&gt;c&lt;/sub&gt;: Ordered crystalline solid</td>
</tr>
<tr>
<td>Above T&lt;sub&gt;j&lt;/sub&gt;: in its rubbery state</td>
<td>Above T&lt;sub&gt;c&lt;/sub&gt;: Disordered melt</td>
</tr>
</tbody>
</table>

Approximate glass transition and melting temperatures of polyethylene are shown below:

<table>
<thead>
<tr>
<th>Polymer</th>
<th>T&lt;sub&gt;j&lt;/sub&gt; (°C)</th>
<th>T&lt;sub&gt;c&lt;/sub&gt; (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>-125</td>
<td>110</td>
</tr>
</tbody>
</table>