TUTORIAL 5

POLYMERS

1. a) Define the polymeric materials: (i) plastics and (ii) elastomers
   b) What are thermoplastic and thermosetting materials?
   c) Give reasons for the great increase in the use of plastics in engineering applications.

2. a) An injection-molding polycarbonate material has an average molecular weight of 25,000 g/mol. Calculate its degree of polymerization. (weight of mer = 254 g/mer)
   b) Calculate the average molecular ($M_m$) for a thermoplastic which has the following weight fraction ($f_i$) for the molecular weight ranges listed below.

<table>
<thead>
<tr>
<th>Molecular weight range (g/mol)</th>
<th>$f_i$</th>
<th>Molecular weight range (g/mol)</th>
<th>$f_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5000</td>
<td>0.03</td>
<td>20000 – 25000</td>
<td>0.24</td>
</tr>
<tr>
<td>5000 – 10000</td>
<td>0.10</td>
<td>25000 – 30000</td>
<td>0.12</td>
</tr>
<tr>
<td>10000 – 15000</td>
<td>0.17</td>
<td>30000 – 35000</td>
<td>0.08</td>
</tr>
<tr>
<td>15000 – 20000</td>
<td>0.23</td>
<td>35000 – 40000</td>
<td>0.03</td>
</tr>
</tbody>
</table>

3. a) During the solidification of thermoplastics, how do the specific volume vs temperature plot differ for noncrystalline and semicrystalline thermoplastics?
   b) What is glass transition temperature ($T_g$) and how does it affect the properties of polymers?
   c) How does the amount of crystallinity in a polymer affect: (i) its density and (ii) its tensile strength? Explain.

4. a) What is the vulcanization process for natural rubber? How does it affect its tensile strength?
   b) If 5 g of sulfur is added to 100 g of chloroprene rubber, what is the maximum fraction of the cross-link sites can be connected?
   c) A butadiene-acrylonitrile rubber is made by polymerizing one acrylonitrile monomer with three butadiene monomers. How much sulfur is required to react with 100 kg of this rubber to cross-link 20% of the cross-link sites?

5. a) What is stress relaxation of elastomeric materials?
   b) The stress on a sample of a rubber material at constant strain at 27°C decreases from 3.0 to 2.7 MPa in 3 days. (a) What is the relaxation time for this material? (b) What will be the stress on this material after (i) 10 days and (ii) 60 days?
6. a) Describe the injection-molding process and extrusion for thermoplastics.
b) What are the advantages and disadvantages of the injection-molding process?

7. Describe the compression molding process for thermosetting plastics and what are the advantages and disadvantages of this process?

CERAMICS

1. a) What are some properties common to most ceramic materials?
b) Distinguish between traditional and engineering ceramics and give examples of each.

2. a) What structural defects are the main cause of failure of polycrystalline ceramic materials?
b) How do (i) porosity and (ii) grain size affect the tensile strength of ceramic materials?
c) A reaction bonded silicon nitride ceramic has strength of 300 MPa and a fracture toughness of 3.6 MPa.m^{1/2}. What is the largest-sized internal flaw that this material can support without fracturing? (Y = 1)

3. a) Define a glass and what are some properties which make it indispensable for many engineering applications?
b) Describe the float-glass process for the production of flat glass products? What is its major advantage?
c) What is tempered glass? How is it produced? Why is tempered glass stronger in tension than annealed glass?

4. a) What are basic steps in the processing of ceramic products?
b) Describe the dry pressing method for producing ceramic products. What are the advantages of this method?
c) Describe the isostatic-pressing method for producing ceramic products.
d) What are the advantages of hot pressing ceramic materials?
e) What is reaction bonded process? What is the advantage and disadvantage of this process? Give the examples of ceramic product.