Time Allowed: 2 hours

Answer the following questions

Question 1 (6 marks)

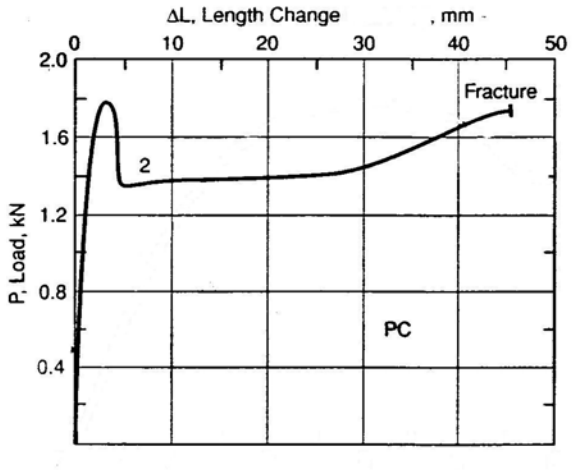
Indicate whether the following statement is True or False, and correct the false one.

1. The fatigue limit is defined for materials that will not fail through fatigue testing
2. Polymer matrix composites made of unidirectional and continuous fibers have isotropic behavior.
3. Aluminum alloys have a lower specific strength than steels.
4. Conductivity of metals decreases with increasing temperature
5. For amorphous materials like glass, the material is solid below T_m.
6. Materials having single crystal structure can't be produced artificially

Question 2(6 Marks)

Load displacement data from a tension test on polycarbonate (PC) are shown in the Figure below. The specimen had a rectangular cross section with original dimension of width 12.16 and thickness 2.32 mm. Displacement was measured over a gage length of 50 mm. Determine the following:

1. Upper yield strength σ_{ou}
2. Engineering fracture strength σ_f
3. Ultimate strength σ_u
4. Percent elongation at fracture



Question 3(6 Marks)

The fatigue data for a ductile cast iron are given as follows:

Stress amplitude (MPa)	Cycles to failure
248	1.10^5
236	3.10^5
224	1.10^6
213	3.10^6
201	1.10^7
193	3.10^7
193	10^8
193	3.10^8

1. Make an S-N plot (stress amplitude versus logarithm cycles to failure) using the above data.
2. What is the fatigue limit for this alloy?

This alloy is to be used for an automobile axle that rotates at an average rotational velocity of 750 revolutions/min. give the maximum lifetimes of continuous driving that are allowable for the following stress levels:

1- 250 MPa
2- 215 MPa

Question 4(6 Marks)

Copper and magnesium electrodes are placed in individual solutions containing their respective ions at a concentration of 1M for each solution. Given that the temperature of both solutions is 25 ^{o}C, answer the following**:**

1. Upon coupling the two electrodes, mention your expectation regarding the anode and the cathode of the cell.
2. Write the equation representing the total electrochemical reaction.
3. Calculate the potential of the resulting cell when these electrodes are coupled.

Question 5(6 Marks)

Suggest a manufacturing method for manufacturing each of the following products. Choose any two of the suggested manufacturing methods and make a simplified sketch for each of them**:**

1. A beam having a rectangular cross section, made from a polymer matrix composite having a thermosetting resin.
2. A flat aluminum sheet.
3. Ceramic substrates used for integrated circuits.
4. Containers made of a thermoplastic material.

You may use one of the following equations

$$\sigma = \mathrm{E}\,\varepsilon \quad ,\varepsilon = \frac{\Delta \mathrm{l}}{\mathrm{l}_0}, \quad \mathrm{E} = 2\mathrm{G}\,(1+\nu), \sigma = \frac{\mathrm{F}}{\mathrm{A}}, \quad CPR = \frac{\mathrm{KW}}{\rho\,\mathrm{At}}, \quad \sigma = \mathrm{n}|\mathrm{e}|\mu_{\mathrm{e}} + \mathrm{p}|\mathrm{e}|\,\mu_{\mathrm{p}} \qquad \%\mathrm{EL} = \frac{\mathrm{l_f} - l_0}{\mathrm{l}_0} \times 100$$

$$U_r = \frac{\sigma_y^2}{2E}\ ,\ \sigma_{\mathrm{m}} = \frac{\sigma_{\max} + \sigma_{\min}}{2},\ \sigma_{\mathrm{a}} = \frac{\sigma_{\max} - \sigma_{\min}}{2}, \mathrm{e} = \left|1.6.10^{-19} C\right|, E_c = E_f V_f + E_m(1 - V_f)$$

$$a_{BCC} = \frac{4R}{\sqrt{3}}, a_{FCC} = 2R\sqrt{2}, \mathrm{R} = \frac{\sigma_{\min}}{\sigma_{\max}}, \mathrm{P_{LM}} = \mathrm{T}(\log \mathrm{t_r} + 20), \mathrm{E_r}(t) = \frac{\sigma(t)}{\varepsilon_0}, \sigma = n|e|\mu_e, \sigma = n|e|\mu_p, \bar{M}_w = \sum w_i M_i$$

$$\frac{\mathrm{F}_f}{\mathrm{F}_m} = \frac{E_f V_f}{E_m V_m}, n_w = \frac{\bar{M}_w}{\bar{m}}$$

$$\bar{\mathrm{M}}_n = \sum x_i M_i, n_n = \frac{M_n}{\bar{m}}$$

Cu Cu2 + + 2e - (Standard electrode potential Vo = + 0.34 V)

Mg Mg2 + + 2e - (Standard electrode potential Vo = - 2.36 V)