Review for the Final Exam

Outline:

- Mechanical Properties
- Ceramic Materials
- Polymer Materials
- Optical Properties
- Thermal Properties

Question 1: *Mechanical Properties*

Below are tabulated the tensile stress-strain data for several materials.

Material	Yield Strength (MPa)	Tensile Strength (MPa)	Strain at Fracture	Fracture Strength (MPa)	Elastic Modulus (GPa)
A	310	340	0.35	295	210
B	100	120	0.40	105	150
C	415	550	0.15	500	310
D	700	850	0.14	720	210
E	Fractures before yielding			650	350

1. Which of these materials will experience the greatest percent area reduction? Why?
2. Which of these materials is the strongest? Why?
3. Which of these materials is the toughest? Why?
4. Which of these materials is the stiffest? Why?
5. Which of these materials has the highest modulus of resilience? Why?

Question 2: *Ceramic Materials*

A ceramic material, in the form of a circular bar with radius 5mm, is tested in 3 point bending. The length between the support points is 50mm.

- If the load required to cause fracture is 2380N, determine the flexure strength of this ceramic.
- If this material has a fracture toughness K_{IC}, of 4.5 $MNm^{-3/2}$ what is the size of the longest internal deflect? Assume the geometric parameter Y is equal to 1.
- If this material has value for σ_0 and n of 441MPa and 3.75 respectively, what is the fraction porosity of this material?
- Knowing that the Modulus of Elasticity for the non porous material, E_0, is 400 GPa, what is the modulus of this porous ceramic?

Question 3: *Polymers*

We have a polyethylene sample containing 4000 chains with molecular weights between 0 and 5000 g/mol, 8000 chains with molecular weights between 5000 and 10,000 g/mol, 7000 chains with molecular weights between 10,000 and 15,000 g/mol, and 2000 chains with molecular weights between 15,000 and 20,000 g/mol. Determine both the number and weight average molecular weights.

SOLUTION

First we need to determine the number fraction x_i and weight fraction f_i for each of the four ranges. We can then use Equations (14-3a) and (14-3b) to find the molecular weights.

Question 3: *Solution*

Number of Chains	Mean M per Chain	x_i	$x_i M_i$	Weight	f_i	$f_i M_i$
4000	2500	0.191	477.5	10×10^6	0.0519	129.75
8000	7500	0.381	2857.5	60×10^6	0.3118	2338.50
7000	12,500	0.333	4162.5	87.5×10^6	0.4545	5681.25
2000	17,500	0.095	1662.5	35×10^6	0.1818	3181.50
$\sum = 21{,}000$		$\sum = 1.00$	$\sum = 9160$	$\sum = 192.5 \times 10^6$	$\sum = 1$	$\sum = 11{,}331$

Note: the weight average molecular weight is larger that the number average molecular weight.

Question 4: *Optical Properties*

A light-emitting diode display made using a GaAs-GaP solid solution of composition 0.4 GaP-0.6 GaAs has a direct bandgap of 1.9 eV. What will be the color this LED display?

SOLUTION

The wavelength of the light emitted is related to the bandgap by:

$$E_g = h\nu = (hc/\lambda)$$

where h = Plancks constant (6.63×10^{-34} J-s, 4.41×10^{-15} eV-s), c = speed of light (2.998×10^8 m/s), λ = wavelength of light (m). We can put in the values of E_g, c and h and calculate the wavelength λ.

Therefore, $\boldsymbol{\lambda}$ = 0.652 $\boldsymbol{\mu}$m or 652 nm. This is the wavelength of red light, and, therefore, the LED display would be red in color.

Question 5: *Thermal Properties*

A ceramic coating is to be applied to a 1020 steel plate. The ceramic has a fracture strength of 4000 psi, a modulus of elasticity of 15×10^6 psi, and a coefficient of thermal expansion of 10×10^{-6} 1/°C. What is the maximum temp. change that can be allowed without cracking the ceramic.

SOLUTION: If only the coating is heated (i.e. *the steel remained at a constant temperature*), the maximum temperature change would be:

However, the steel also expands. Its coefficient of thermal expansion (Table 19.1) is 11.8×10^{-6} 1/°C and its modulus of elasticity is 30×10^6 psi. The net coefficient of expansion is:

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