midterm-3-2020-materiales-1.pdf

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Materiales Aeroespaciales I

2º Grado en Ingeniería Aeroespacial

Escuela Politécnica Superior. Campus de Leganés
Universidad Carlos III de Madrid

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Aerospace Materials I **2020/21**

Assessment Test III **B** **Grade:** [ ] **Points/10**

Surname and Name

Date:December 16th 2020

Important: Please write your last and first name before you start. Neither books nor any other extra material is allowed in the exam but the calculator. You may use the back of this sheet if needed. **Mark the right answer with a X in the table below. The correct answers will mark + 0.5 points while the incorrect answers will mark as -0.15 points**. Non answered questions will not mark nor positively nor negatively. The resulting mark will not be smaller than 0 in any case. **There is only one correct answer per question**. Good luck!

Part I (5 points)

	Answer					Answer			
Question	a	b	c	d	Question	a	b	c	d
1					6				
2					7				
3					8				
4					9				
5					10				

1. Which ionic structure has cubic packing of the negative ions and positive ions filling half of the tetrahedra interstitials	
(a)	Zn-blende structure
b	Fluorite structure
c	NaCl structure
d	CsCl structure

2. Which of the following factors are important in determine the packing of ions and cations (only one correct answer)	
a	Lattice energy
b	Valance and bond length
(c)	Relative size of anions and cations and electroneutrality
d	All of the above

3	Which of the following statements about ceramics is TRUE:
a	Slip casting can be used to form components with a high dimensional accuracy
(b)	Ceramic injection molding involves mixing a ceramic powder with a binder or wax
c	Sintering involves heating the ceramic compact above the melting point
d	The ceramic component after sintering is called a "green compact"

4. Which of the following statements is TRUE:	
a	Glasses are inorganic ionic solids the structure of a liquid
b	SiO_2 and Al_2O_3 are the main components of glasses and they are both glass formers
c	Glasses, like ceramics, have a distinct melting point
(d)	Mechanical properties of glasses, like those of ceramics, are influenced strongly by imperceptions and defects

5. Which of the following polymers is more likely to be crystalline?	
(a)	Polyethylene
b	Atactic Polypropylene
c	Epoxy resin
d	Styrene-butadiene (SB) copolymer

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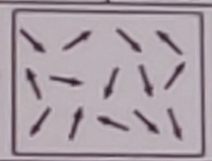
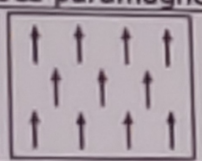
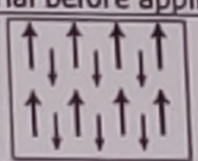
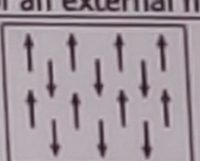
6. Which of the following statements is TRUE:	
a	Thermosetting polymers are usually crystalline
b	Thermoplastic polymers cannot be reheated
(c)	Deforming a polymer can increase their strength
d	Homopolymers contain more than one type of monomer

7	Which of the following processing method is more appropriate for thermosetting polymers
a	Thermoforming
(b)	Transfer molding
c	Extrusion
d	Blow molding

8	Indicate which of the following is NOT the function of the matrix in a fiber reinforced composite:
a	Transfer external load among fibers
b	Prevents chemical and abrasive degradation of the fibers
c	Keeps fiber orientation
(d)	Support the major part of the applied load

9	Which of the following statement is FALSE:
(a)	Prepegs cannot be assembled into laminated structures
b	Prepegs are resin-impregnated fiber forms (tape or fabric) which are manufactured by impregnating fibers with a controlled amount of resin
c	Laminar composites are prepared by piling of layers of oriented composite material
d	Prepregs with thermosetting resins have limited shelve life

10	Typical applications for composites in civil aircrafts are:
a	Turbine blades
(b)	Bulkheads and stringers
c	Engine cowlings, elevators and spoilers
d	Landing gear

9	Which picture describes paramagnetic material before application of an external field?							
(a)		b		c		d	

10	The linear coefficient of thermal expansion:
a	is high when atomic bonding is strong.
b	is not affected by allotropic changes.
(c)	is low when material shows a deep bonding energy well.
d	of iron is higher than that of lead; due to higher melting temperature.

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1. *(5 points)* Mark with an X the right answer, **there is only one correct answer per question.** (Correct answers mark as **+0.5**, incorrect ones mark as **- 0.15**, and non answered questions mark as **0**. The resulting mark will not be smaller than 0 in any case).

1	Indicate which one of the following statements related to thermoplastic properties is FALSE:
X	Processing of the thermoplastic polymers involves cross-linking between chains.
	They can be recycled and reused.
	Thermoplastics soften on heating and harden on cooling.
	They are commonly used as raw material for the manufacture of plastic bottles.

2	Crystallinity of a polymer is higher...
	if an atactic instead of an isotactic polypropylene is obtained.
	when a random copolymer instead of a block one is synthesized.
X	due to an increase in its molecular weight.
	when polymer with a more complex structure of monomer is formed.

3	The most suitable process for manufacturing a thermoplastic sheet of a certain shape with a high quality and good durability is:
	Injection molding
	Blow molding
	Extrusion
X	Thermoforming

4	Indicate which of the following statements is TRUE:
	Ceramics present better properties in tension than in compression. False
	Ceramics exhibit high elastic modulus and high thermal shock resistance.
	SiO_2 is a glass modifier which decreases viscosity to lead better glass workability.
X	Ceramics are good electrical and thermal insulators.

5	A ceramic material with a zinc blende structure presents...
	a coordination index of 6.
X	cations occupying half of the tetrahedral interstitial sites of the FCC unit cell.
	anions located at the lattice sites of a hexagonal close-packed unit cell.
	cations occupying all the octahedral interstitial sites of the FCC unit cell.

6	CaO presents a "rock salt" structure. Identify the coordination index for O^{2-} ions:
	8
	3

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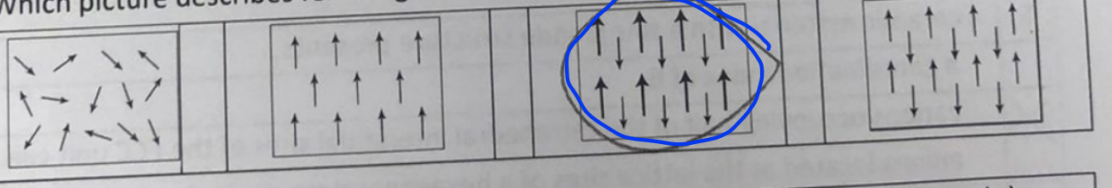
	4
X	6

7	For fabrication of ceramic layers, _____ process involves the casting the slurry onto a flat moving carrier surface.
X	Tape casting
	Slip casting
	Ceramic injection moulding
	Extrusion

8	Which type of fiber is the Kevlar 29?
	Carbon fibre
X	Aramid fibre
	Glass fibre
	Boron fibre

9	When stress is applied perpendicular to fibers in a continuous fibers reinforced composite:
	Fibers are subjected to higher deformation.
X	Matrix is subjected to higher deformation.
	Fibers are subjected to higher stresses.
	Matrix is subjected to higher stresses.

10	Select the method for processing of composites in which reinforcement is introduced into spray of melt droplets:
	Rheocasting
	Melt stirring
X	Spray co-deposition
	Squeeze casting

11	Which picture describes ferrimagnetic material before application of an external field?
	

12	Indicate which statement is TRUE regarding the thermal expansion coefficient (α)
	Ceramics do not experience thermal expansion
	A stronger atomic bond conveys a higher thermal expansion
X	It can change abruptly during phase transformations
	Metals with high melting temperatures have higher thermal expansion coefficients

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Part II (5 points)

A composite material has a 55 % in volume of unidirectional graphite-HM fibers in an epoxy matrix.

a) (1.5 points) Estimate the density and elastic modulus of the composite considering stresses parallel to the fibers.
b) (1.5 point) Estimate the % in weight of the fiber.
c) (1 point) If 50% of the graphite fibers are replaced with Kevlar fibers, estimate the specific elastic modulus and the specific tensile strength in the longitudinal direction in this new hybrid composite.
d) (1 point) Calculate the elastic modulus under stresses perpendicular to the fibers for the composite a).

Material	Density g/cm^3	Elastic modulus GPa	Tensile strength, MPa
Epoxy resin	1.23	3.5	70
Graphite-HM fiber	1.86	390	2400
Kevlar-49 fiber	1.44	131	3700

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$V_{gf} = 0{,}55 \rightarrow V_m = 0{,}45$

a) ρ_c , E_c b) W_f c) 50% graphite → kevlar E_{sp} , σ_{sp} ?

d) E isostress ⊥ fibre → case a)

Material	Density g/cm³	Elastic modulus GPa	Tensile strength, MPa
Epoxy resin	$\rho_m = 1.23$	$E_m = 3.5$	$\sigma_m = 70$
Graphite-HM fiber	$\rho_{gf} = 1.86$	$E_{gf} = 390$	$\sigma_{gf} = 2400$
Kevlar-49 fiber	$\rho_{gk} = 1.44$	$E_{kf} = 131$	$\sigma_{kf} = 3700$

a) $\rho_c = \rho_m V_m + \rho_{gf} V_{gf} = 0{,}45 \cdot 1{,}23 + 0{,}55 \cdot 1{,}86 \rightarrow \rho_c = 1{,}5765\ g/cm^3$

$E_c = E_m V_m + E_{gf} V_{gf} = 0{,}45 \cdot 3{,}5 + 0{,}55 \cdot 390 \rightarrow E_c = 216{,}075\ GPa$

b) $W_F = \frac{W_{gf}}{W_{gf} + W_m} = \frac{\rho_{gf} V_{gf}}{\rho_{gf} V_{gf} + \rho_m V_m} = \frac{1{,}86 \cdot 0{,}55}{1{,}86 \cdot 0{,}55 + 1{,}23 \cdot 0{,}45} \rightarrow W_F = 0{,}6489$

c) $V_{gf} = 0{,}275$, $V_{kf} = 0{,}275$, $V_m = 0{,}45$

$E_{sp} = \frac{E_c}{\rho_c} = \frac{144{,}85\ GPa}{1{,}461\ g/cm^3} \rightarrow E_{sp} = 99{,}1\ \frac{GPa \cdot cm^3}{g}$ $\quad \sigma_{sp} = \frac{\sigma_c}{\rho_c} = \frac{1709\ MPa}{1{,}461\ g/cm^3} \rightarrow \sigma_{sp} = 1169{,}7\ \frac{MPa \cdot cm^3}{g}$

$\rho_c = V_{gf} \cdot \rho_{gf} + V_{kf} \cdot \rho_{kf} + V_m \rho_m = 0{,}275 \cdot 1{,}86 + 0{,}275 \cdot 1{,}44 + 0{,}44 \cdot 1{,}23 \rightarrow \rho_c = 1{,}461\ g/cm^3$

$E_c = V_{gf} E_{gf} + V_{kf} E_{kf} + V_m E_m = 0{,}275 \cdot 390 + 0{,}275 \cdot 131 + 0{,}45 \cdot 3{,}5 \rightarrow E_c = 144{,}85\ GPa$

$\sigma_c = V_{gf} \sigma_{gf} + V_{kf} \sigma_{kf} + V_m E_m = 0{,}275 \cdot 2400 + 0{,}275 \cdot 3700 + 0{,}45 \cdot 70 \rightarrow \sigma_c = 1709\ MPa$

d) $\frac{1}{E_\perp} = \frac{V_m}{E_m} + \frac{V_{gf}}{E_{gf}} \rightarrow \frac{1}{E_\perp} = \frac{0{,}45}{3{,}5} + \frac{0{,}55}{390} \rightarrow E_\perp = 7{,}69\ GPa$

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2. *(5 points)* Consider a carbon fiber reinforced polyester composite with 55% volume fraction of continuous aligned fibers:

(a) *(1.25 p)* Determine the modulus of elasticity in the longitudinal and transverse directions.

(b) *(1.25 p)* If a cylindrical rod 19 mm in diameter of this composite is stressed in the longitudinal direction to 60 MPa, determine the forces in the fiber and matrix phases, respectively. Assume isostrain conditions.

(c) *(1.25 p)* Estimate the specific tensile strength of the composite.

(d) *(1.25 p)* If the rod was originally 1.2 m long, estimate its extension under the previous applied stress in the longitudinal direction.

Material	E (GPa)	σ (MPa)	ρ (g/cm³)
Polyester	E_m = 3.4	σ_m = 69	ρ_m = 1.3
Carbon fiber	E_f = 350	σ_f = 3500	ρ_f = 1.8

$V_f = 0,55 \rightarrow V_m = 0,45$

a) $E_{//}$ & $E_{\perp}$

b) $\emptyset = 19mm$, longitudinal 60MPa. ¿ F_m, F_f ?

c) σ_{sp}

d) $l_0 = 1,2m$. ¿ Δl ?

a) $E_{//} = V_f E_f + V_m E_m = 0,55 \cdot 350 + 0,45 \cdot 3,4 \rightarrow$ **$E_{//} = 194,03$ GPa**

$\frac{1}{E_\perp} = \frac{V_f}{E_f} + \frac{V_m}{E_m} = \frac{0,55}{350} + \frac{0,45}{3,4} \rightarrow$ **$E_\perp = 7,467$**

b) $\sigma_{app} = 60$ MPa $\rightarrow F_{applied} = \sigma_{app} \cdot Area \rightarrow F_{app} = 60 \times 10^6 \cdot \pi \left(\frac{19 \times 10^{-3}}{2}\right)^2$

$F_{app} = 17011,72$ N

$\frac{F_f}{F_c} = \frac{E_f V_f}{E_c} = \frac{350 \cdot 0,55}{194,03} = 0,992 \rightarrow$ **$F_f = 16.877,57$ N**

$\frac{F_m}{F_c} = \frac{E_m V_m}{E_c} = \frac{0,45 \cdot 3,4}{194,03} = 0,0078 \rightarrow$ **$F_m = 134,15$ N**

↳ $F_{app} - F_f$

c) $\sigma_{SP} = \frac{\sigma_c}{\rho_c} = \frac{\sigma_m V_m + \sigma_f V_f}{\rho_m V_m + \rho_f V_f} = \frac{69 \cdot 0,45 + 3500 \cdot 0,55}{1,3 \cdot 0,45 + 1,8 \cdot 0,55}$ $\frac{MPa}{g/cm^3}$

$\sigma_{specific} = 1241 \cdot \frac{MPa \cdot cm^3}{g}$

d) $\varepsilon = \boxed{\frac{\sigma_{app}}{E_{//}} = \frac{\Delta l}{l_0}} \rightarrow \frac{60MPa}{194,03GPa} = \frac{\Delta l}{1,2m} \rightarrow \frac{60MPa}{194030MPa} = \frac{\Delta l}{1,2m}$

$\Delta l = 3,71 \times 10^{-4} m = 0,37mm$

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