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ACHA6012

Automotive

Materials and
Sustainability

13/05/2022

Automotive Materials and sustainability: ACHA6012
Exam:

Section B.

Q 2:

a) Ionic Bonding is described as the atoms of a material transferring electrons between each other.

covalent Bonding on the other hand only occurs when two atoms share their valence electrons, but don't permanently transfer them. Metallic Bonding forms when metal atoms are getting rid of the electrons from their outer shell freely. The main differences between these 3 types of Bonding are:

Ionic:	covalent:	metallic:
- Bonding energy higher than metallic	- Has a very low conductivity	- Bonding energy is lower than other types of Bonding.
- It has a lower conductivity than other types	- Has a much higher Bonding energy than metallic	- Has a high conductivity (electrical and thermal).
- Bond is not directional	- Bonding is directional	- Bond is non-directional.

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Question 2

b). copper has a face centered cubic dimension.

equation: $a = 2\sqrt{2}R$

$a = 0.362 \text{ nm}$

rearranged for $R = \frac{a}{2\sqrt{2}} = R$

$a = 3.62 \times 10^{-10} \text{ nm}$

$R = \frac{a}{2\sqrt{2}}$

$R = \frac{3.62 \times 10^{-10}}{2\sqrt{2}}$

$R = 1.28 \times 10^{-10} \text{ m}$

$R = 12.8 \text{ nm}$

c)

point defects = atom missing or irregularly positioned.
It will result in self interstitial atoms, interstitial impurity atoms or substitution impurity atoms.

Linear defects: Groups of atoms irregularly positioned.
It will result in dislocations in the crystalline structure.

Area defects: Impurities or interfaces between homogeneous regions of the material. It results in external surfaces sticking out, grain boundaries.

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Question 2

d). The 3 stages of creep:

Phase 1: Is described as the first initial deformation due to load

Phase 2: Initial deformation is stabilised, creep is evolving in a controlled manner (predictable stage of creep).

Phase 3: Rapid deformation of material prior to failure

The dislocation movement is the stage that controls the rate of minimum creep.

Question 4:

a) 1: 7000 series aluminium group have the highest strength in all aluminium grades. 7000 Series Alu has Zinc as main component making the alloy have a good thermal conductivity with high tensile and yield strength. It is also corrosion resistant. On the other hand, Zinc in aluminium can't be mixed with other alloys such as tin or lead, the alloy can lose its corrosion resistant property. Also, the alloy of Alu and Zinc can lose its tensile strength making it more fragile when exposed to high temps.

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Question 4:

a) 11:

In the case of Steel 1045, the 3rd and 4th digit of the grade tells that this metal contains 0.45 percent of carbon content.

b) Composites can be classified in 3 groups:

- Particle-Reinforced: the structure of particle reinforced composites is divided in two groups: Large particle and Dispersion strengthened. Particle-Reinforced composites can achieve higher structural strength than other types of composites as well as wear resistance. Particle-Reinforced composites are generally lower in cost and easier to produce and use. (asphalt for road surface, concrete in building). It could however end up being heavier than other composites.
- Fiber-Reinforced: is a type of composite used more often in the automotive industry for its high strength / stiffness / weight ratio (carbon fiber, fibreglass). Fiber Reinforced composites can have different structures. such as aligned fibers (better distribution of the load across the material); Random fibers (easy and cheap but rigidity is lower than aligned fibers) and Woven fibers (isotropic to loading, more expensive to produce).

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b) Structural composites: is described as an assembly of a composite and a homogeneous material. It bring rigidity to the material by adding 1 or multiple layers of composite (laminar) (Aluminium honey-comb).

$$\begin{aligned} c) \quad A_c &= 300 \text{ mm}^2 = 0,0003 \text{ m}^2 \\ A_F &= 0,0003 \times 0,45 = 135 \times 10^{-6} \text{ m}^2 \\ A_M &= 0,0003 \times 0,55 = 165 \times 10^{-6} \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{equation to start} \quad E_c A_c &= E_F A_F + E_M A_M \\ &= E_c = \frac{E_F A_F + E_M A_M}{A_c} \end{aligned}$$

$$E_c = \frac{65 \times 10^9 \times 135 \times 10^{-6} + 3,2 \times 10^9 \times 165 \times 10^{-6}}{0,0003}$$

$$E_c = 3,101 \times 10^{10} \text{ Pa.}$$

$$\frac{F_F}{F_M} = \frac{E_F V_F}{E_M V_M} = \frac{65 \times 10^9 \times 135 \times 10^{-6}}{3,2 \times 10^9 \times 165 \times 10^{-6}} = 16,62$$

$$F_F = 16,62 F_M$$

$$F_c = F_F + F_M$$

$$F_c = 30 \times 10^6 \times 0,0003 = 9 \text{ kN}$$

$$F_c = 16,62 F_M + F_M \neq F_c = F_F + F_M$$

$$F_c = 16,62 F_M + 1 = 17,62 F_M$$

$$F_M = \frac{F_c}{17,62} = \frac{9 \times 10^3}{17,62} = 510,78 \text{ N}$$

Question 4

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c)

$$F_m = 510.78 \text{ N}$$

$$F_f = F_c - F_m = 9 \times 10^3 - 510.78$$

$$F_f = 8.48 \times 10^3 \text{ N}$$

$$\text{Force on fibre element} = 8.48 \times 10^3 \text{ N}$$

$$\text{force on matrix element} = 510.78 \text{ N.}$$

Section A:

Question 1:

a) The two new types of fuel that can be used after Euro 7 emission standard could be biofuel and Algal fuel as their production is greener and has a lower emission rate than conventional fuels.

b) ~~The~~ Bio fuels and algal fuel, due to their high technology ~~needed~~ and the fact ~~up~~ being a lot more expensive to produce ~~might end~~ fuels. compared to today's