

Page 1 of 7

13/05/22

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Section B

Question 2

a) Ionic bonding is when ~~atoms~~ ^{electrons} are transferred between ^{atoms} ~~even other~~ where an electron donor and receiver are required. The donor becomes positively charged and receiver negatively charged. *

Covalent bonding is when atoms share electrons but don't permanently transfer them. This is typical with non metals.

* Ionic bonding generally has the metal as the donor and non metal as receiver

Metallic bonding shed electrons from the outer shell freely creating a sea of delocalised electrons. The ions create a closely packed structure as positively charged and electrons are fill the gap negatively charged.

Valency is how many of an atom is its combining power which is measured by how many hydrogen atoms it can bond with. e.g. a carbon atom has a valency of 4 as its outer shell can combine with 4 hydrogen atoms.

Page 2 of 7

5/13/05/22

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Automotive Materials and Sustainability ACH46012

Question 2

b) Face centred cubic

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

$$a = 0.362 \times 10^{-9} \text{ m}$$

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

$$\left(\frac{a}{2}\right)^2 = 2R^2$$

$$\left(\frac{a}{2}\right)^2 = R^2$$

$$\left(\frac{a}{4}\right)^2 = R^2$$

$$R = 9.08 \times 10^{-11} \text{ m}$$

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

$$\left(\frac{a}{2}\right)^2 = 2R^2$$

$$\frac{\left(\frac{a}{2}\right)^2}{2} = R^2$$

$$R = 1.63 \times 10^{-10} \text{ m}$$

c)

Point defects - ~~vacancies~~ missing atoms when the lattice structure is formed leaves vacancies in the structure allowing ~~other~~ surrounding atoms to be distorted.

the amount of vacancies varies depending on temperature.

- self interstitials occur when an atom has become positioned between the normal lattice structure

- substitutional defects occur when the original atom in the lattice structure of the crystalline solid is replaced by a different type of atom

Page 3 of 7

13/05/22

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Automotive Materials and Sustainability ACHA 6012
(continued)

line defects

- Dislocations allow layers of the lattice to slip relative to their adjacent layers as the ~~atom~~ areas move bonds between atoms break with new bonds forming after the motion is complete ~~and~~ causing permanent deformation.

area defects

- Grain boundary ~~is an area defect that~~ is the boundary between the crystals in the material. If there is a defect the bonding structure changes with orientation of crystals that are different and can help impede dislocations.

- d) secondary creep is caused by ~~dislocation~~ dislocation movement which ~~is~~ is when dislocations in the crystalline structure ~~are~~ are moved towards grain boundaries under load. ~~resulting~~

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Question 4

a) i) 7xxx refers to zinc as the main alloying element. This allows the alloy to be heat treatable for increased strength and becomes very brittle

ii) 1st digit means carbon steel type
2nd means and is carbon
3rd and 4th mean the carbon concentration as a percentage
meaning 45 is 0.45% carbon.

b) particle reinforced
~~these are~~ ~~structure~~ the particulates are harder and stiffer than matrix material can be either large particle or dispersion strengthened. Large particle is non atomic interaction and used for applications such as concrete. Dispersion strengthened is on atomic level of bonding to matrix from matrix to particle and resists plastic deformation.

fibre reinforced

is typically used in high strength to weight ratio applications with materials such as carbon fibre and fibre glass. They use low density fibre and matrix materials. Matrix materials are often ductile.

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4b continued)

structural composites

These are made up of composites and homogenous materials. For example multiply carbon fibre or aluminium honey comb. Multiply carbon fibre as an example is made up of multiple sheets with the fibre direction and orientation to be crossed to give higher strength.

c) V_f Fibre Volume 0.45

V_m Matrix Volume 0.55

E_f ~~Em~~ $65 \times 10^9 \text{ Pa}$

E_m $3.2 \times 10^9 \text{ Pa}$

$A_f = V_f \times A = 1.35 \times 10^{-4} \text{ m}^2$

$A_m = V_m \times A = 1.65 \times 10^{-4} \text{ m}^2$

$A = 0.0003 \text{ m}^2$

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} = \frac{65 \times 10^9 \times 0.45}{3.2 \times 10^9 \times 0.55} = 16.61$$

$$\frac{F_f}{F_m} = 16.61 \rightarrow F_f = 16.61 F_m$$

$$F_c = F_f + F_m \quad F_c = \sigma \times A = 30 \times 10^6 \times 0.0003$$

$$F_c = 9000 \text{ N}$$

$$(F_c) \quad 9000 \text{ N} = 16.61 F_m + F_m$$

$$F_c = 17.61 F_m \rightarrow \frac{9000}{17.61} = F_m = 511.07 \text{ N}$$

4c Continued)

$$F_c = 9000 \text{ N} \quad \boxed{f_m = 511.07 \text{ N}} \quad F_f = ?$$

$$F_c = F_f + f_m \rightarrow F_f = F_c - f_m$$

$$F_f = 9000 - 511.07 = 8488.93 \text{ N}$$

$$\boxed{F_f = 8488.93 \text{ N}}$$

Section A

1.

LPG

One fuel that would help to meet these new regulations is LPG. Liquid petroleum gas which rather than using liquid injection into combustion, it uses gas vapour. The effect of this method can give results of 30% lower Carbon monoxide; 50% NOx nitrous oxide and for one litre burnt of petrol is 2.3kg CO₂ produced and equivalent amount LPG is 2.0kg produced.

LPG

According to the article by engineering solutions, a BTCC team called monotone converted their car from petrol to LPG. The result was that the car was still able to run the same amount of boost and RPM limit. However the calorific value of petrol to LPG means that for the same amount of fuel

Page 7 of 7

13/05/22

Page Oscar Politt 1900412

Automotive Materials and Sustainability ACHA6012

I continued (LPG)

~~needed~~ the comparatively the car needed a larger fuel tank. Applying this to an average road car the practicality is good allowing for the engine to run at its normal parameters with the only inconvenience being a ~~an~~ bigger and heavier fuel tank. ~~3%~~ LPG 3% of cars today are LPG so a lot of the infrastructure is there already ~~with~~ and considering petrol and LPG are essentially the same with LPG vaporised ~~on~~ in combustion. The only need for LPG to support more cars are ~~an~~ more filling systems however this is not impossible with the petrol infrastructure that could be shared.

DME

~~one~~ Another fuel that could replace conventional fuels to help meet new emissions regulations is DME. Dimethyl Ether. This would help meet regulations as it is proven to reduce emissions by 27% CO, ~~52%~~ ~~and~~ however it has a higher NOx content. It also gives the user more MPG. It is manufactured by converting coal or natural gas to syngas. ~~this also~~ Many countries are developing a DME market such as China, South Korea, Japan and Germany. It also allows for countries to depend less on oil and gas products for energy needs.