

Question 2

A)

Ionic bonding is when atoms transfer electrons between each other. This is due to atoms wanting to be balanced by having complete outer shells. Generally metals are electron donors and non-metals are the receivers. Covalent bonding share electrons as well but don't permanently transfer them. This process normally happens with atoms of the same element or elements close to each other on the periodic table. This process mostly happens between non-metals. Metallic Bonding instead of sharing electrons across the shell, they freely shed them from the outer shell. This creates positively charged ions known as delocalised electrons. Ions form a closely packed structure where electrons fill the gaps. The valency of an atom denotes its combining power, it can be calculated by how many Hydrogen atoms it can bond with.

B)

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

$$\cancel{aR = 2\sqrt{2}}$$

$$\cancel{R = \frac{2\sqrt{2}}{a} = \frac{2\sqrt{2}}{0.362 \times 10^{-9}}}$$

~~R =~~

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

$$\div 2\sqrt{2}$$

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

$$R = \frac{a}{2\sqrt{2}} = \frac{0.362 \times 10^{-9}}{2\sqrt{2}}$$

$$R = 0.128 \text{ nm}$$

C) Line defects are caused by dislocations in the lattice, which have a defect in the structure. This can be caused by vacancies, self-interstitials and substitutional defects. Self-interstitial defects occur when an atom has become positioned between the normal lattice structure atoms. Dislocations allow layers of the lattice to 'slip' relative to their adjacent layers. This causes the bond between atoms to break, with new bonds forming once slip motion is complete. The slip effect produces a permanent plastic deformation of the structure.

- Grain boundaries create area defects in a crystalline structure. They are the boundaries between the crystals in a material. This causes bonding structure to change and orientation of crystals will be different. Grain boundaries can help in dislocations.

Point defect such as vacancies is when a missing atom in the lattice form leaves vacancies in the structure, allowing distortion of surrounding atoms. Vacancies naturally occur and are unavoidable. The amount of vacancies varies depending on

- temperature up to melting point. Other point defects include self-interstitials and substitutional defects.

D)

Secondary creep is known as dislocation movement. Dislocations within the structure move towards the grain boundaries under load. Stress applied to the structure causes the dislocations to move as the structure settles. Dislocations will find their way to the triple points as they are the weakest, this makes the deformation stage relatively predictable.

a)

Casting is an Ancient technique where pouring liquid metal into a mould, cooled and then extracted. Allows for large intricate shapes with a short production run. But has a poor dimensional control whilst being labour and energy intensive. Forging is the combination of heat and pressure to transform a billet into desired shape. This allows for a variety of components that can be made, but has high initial cost and the dies wear out. Extrusion process ~~also~~ creates complex shapes whilst ^{being} excellent for structural members. However the process can have defects and low melting point alloys.

b)

RPN, first stage is likelihood of detection. This is ~~not~~ how likely it is that a failure will be detected before catastrophic issue. They are ranked 1-10, where 1 is the absolute certainty of detecting the failure and 10 is ~~the~~ likelihood to detect the problem. The ~~second~~ stage is probability of occurrence for each failure mode, identify the probability of the failure happening in the lifetime of the product. They are ranked on how likely the failure to occur with 10 being unavoidable occurrence and 1 being very unlikely. The second stage is ranking the severity of the potential failure on a numeric scale 1-10, with 10 being the worst.

c) $D = 10 \text{ mm}$ $h = 1.5 \text{ mm}$ $r = 0.5 \text{ mm}$ $P = 55 \text{ Pa}$

$$h_r = \frac{1.5}{0.5} = 3 \quad \sqrt{h_r} = \sqrt{3} = 1.73$$

$$C_1 = 0.935 + (1.922 \times 1.73) + (0.004 \times 1.73) = 4.267$$

$$C_2 = -0.352 - (5.327 \times 1.73) + (0.086 \times 1.73) = -9.619$$

$$C_3 = 0.754 + (6.281 \times 1.73) + (0.121 \times 1.73) = 11.411$$

$$C_4 = -0.138 - (2.876 \times 1.73) + (0.031 \times 1.73) = -5.060$$

$$\frac{2h}{D} = \frac{2 \times 1.5}{10} = 0.3$$

$$k_t = 4.267 + (-9.619 \times 0.3) + (11.411 \times 0.3^2) + (-5.060 \times 0.3^3)$$

$$k_t = \boxed{2.272}$$

ii) $\sigma_{\text{max}} = P \times k_t$
 $= 55 \times 2.272$
 $= \boxed{124.96 \text{ Pa}}$

d) $a = 3.5 \text{ mm} = 0.0035 \text{ m}$ $\sigma = 625 \text{ MPa} = 625 \times 10^6 \text{ Pa}$
 $E = 200 \text{ GPa} = 200 \times 10^9 \text{ Pa}$

$$k = \sigma \sqrt{\pi a}$$

$$= 625 \times 10^6 \times \sqrt{\pi \times 0.0035}$$

$$= 65.537 \times 10^6$$

$$G_c = \frac{k_c^2}{E} = \frac{(65.537 \times 10^6)^2}{200 \times 10^9}$$

$$\boxed{G_c = 21.475 \text{ k Pa m}}$$

$$k_c = \sqrt{G_c E}$$

$$k_c^2 = G_c E$$

Two different alternative fuel types can be used to fight against new Euro vii emissions standards. The proposed options are hydrogen and ~~Bio~~ bioethanol.

~~Bio~~ ethanol intake

A study from the Engineer shows bioethanol is made using yeast fermentation, followed by distillation. It can be mixed with petrol at up to 5% inclusion, this can be used on ordinary unleaded petrol cars. It is one of the most fuel efficient processes available. About 80% of the energy in the fuel is employed in the sugar manufacturing process. As a result integration with a sugar factory demonstrates GHG emissions saving of over 70% when compared to petrol. Biofuels reduce the consumption of fossil fuels and thus reduce carbon dioxide emissions as the fuel source is carbon neutral. Whilst still producing carbon dioxide it will be a reduced amount compared to standard fossil fuels.

The Marshal states that hydrogen could be a solution to the problem as when hydrogen is burnt the only by-product is water. Also due to it being so light it rapidly dissipates, which means a hydrogen fire will go out while petrol fire remains alight. This will help hydrogen meet the euro standards due to the drastic decrease in carbon dioxide and tail pipe emission. Hydrogen is ~~not~~ still has tail pipe emission of water, meaning under new EU legislation production of them would have to be protected until 2030.

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Question 1 continued

For hydrogen new technologies will have to be put in place. A company called ITM Power has developed a cost effective way of using low cost off peak or green electricity to split water into hydrogen and oxygen to fill up a domestic car with hydrogen. This technology would require great government investment to implement it whereas the foundations of bioethanol have already in petrol stations. It would be best for the greater government investment to be seen to help with the process of getting hydrogen as well as electric vehicles onto the road. Doing this will greatly help tackle Euro vii guidelines as well as help with vehicle carbon dioxide emissions.