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Automotive materials and sustainability

code: ACHA6012

date: 13/05/22

Section A

1) a)

One type of fuel alternative is hydrogen, hydrogen can be produced from diverse domestic resources with the potential for near zero greenhouse emissions, once produced and stored into the vehicle, only water vapour and warm air are emitted.

Another type of fuel is ethanol, ethanol has the potential to reduce greenhouse emissions by 19-48% compared to petrol which has been tested by EESI where the USA already use E10 and E15 which reduce the particulate matter emissions. which suggest higher ethanol blends have positive effects for health.

c) For hydrogen fuel, The UK only have 12 refuel charging stations. Due to the increase in cost of ~~own~~ buying the vehicle, investment needs to be made to increase charging stations. For hydrogen to become more environmentally friendly the production element needs improvements →

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The UK produce 'grey' hydrogen which results in no carbon capture, the improvement to this would be "green" hydrogen where the energy used to split hydrogen atoms from oxygen is produced by renewable sources such as wind mills, solar where in the USA 'energy board' have reduced the price of hydrogen per kg due to more development in green hydrogen. Where cost of hydrogen in USA on average \$10 where the average in UK is £12.50 per kg.

Development in production process from grey to green and infrastructure stations ^{would} see a reduction in hydrogen cost which would increase vehicle sales which would result in reduction of greenhouse emissions. ~~These vehicles would~~

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Section B

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a) Ionic bonding occurs when transfer of electrons take place, one atom donates one or more electrons to another atom. Due to electrons having negative charge, this leaves the donating atom electron deficient and the other electron rich. The ions then attract each other through electrostatic forces of attraction (due to being opposite charged).

covalent bonding occurs when atoms share pairs of electrons.

metallic bonding occurs in metals, this leads to giant structures of metal atoms which is arranged in a regular pattern. The outer shell electrons of metals are delocalised and so metallic structure is a regular arrangement of charged ions with negative electrons between (held together by electrostatic forces of interaction)

b) face centred cubic due to 4 atoms per unit cell

$$a = 2\sqrt{2}R \rightarrow R = \frac{0.362 \times 10^{-9}}{2\sqrt{2}} = 1.28 \times 10^{-10} \text{ m}$$

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c) point defect include a defect area such as self-interstitials, this defect occurs when an atom has become positioned between the normal lattice structure atoms. Another defect is substitutional defect, this occurs when the original atom in the lattice site of a crystalline solid is replaced by a different type of atom

Line defect are caused by dislocation in the lattice which are a defect in the structure. Dislocations allow layers of the lattice to slip relative to their adjacent layers, as the areas move, the bonds between atoms break with new bonds being formed once the slip motion is complete. This slip motion effect causes a permanent plastic deformation of the structure

Grain boundary creates area defects in a crystalline structure, this boundary are boundaries between the crystals in a material. Grain boundary can assist to impede dislocation defect

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d) the mechanism that control the Speed of creep in the Secondary phase is Dislocation Movement

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a

b) ~~There are three stages~~ One stage is Detection (D) this is the likelihood of failure before it causes catastrophic issue which can be ranked 1-10 (10 being worst)

Another stage is severity (S) this ranks the severity of potential failure on a numeric scale 1-10 (10 being worst)

final stage is probability of occurrence (P) this is how likely the identified failure will occur which is ranked 1-10 (10 being most likely).

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c) i) $D = 10 \text{ mm} \rightarrow 0.010 \text{ m}$

$h = 1.3 \text{ mm} \rightarrow 0.0013 \text{ m}$

$r = 0.5 \text{ mm} \rightarrow 0.0005 \text{ m}$

$f = 55 \text{ Hz}$

$h_{cr} = \frac{1.3}{0.5} = 2.6$

$\sqrt{h_{cr}} = \sqrt{2.6} = 1.61$

$h_{cr} = 0.13$

$C_1 = 4.04$

$C_2 = -8.9$

$C_3 = 10.55$

$C_4 = -4.7$

~~$k_r = 4.04$~~

$k_r = 2.34$

d) $a = 3.3 \text{ mm}$

$\sigma = 625 \text{ MPa}$

$E = 200 \text{ GPa}$

$k = \sigma \sqrt{\pi a} \rightarrow 625 \times 10^6 \sqrt{\pi \times 0.0033}$
 $= 63.64 \times 10^6$

$G_c = \frac{k_c^2}{E} \rightarrow \frac{(63.64 \times 10^6)^2}{200 \times 10^9}$
 $= 20.25 \times 10^3 \text{ Pa m}$