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Section A

Question 1

a) One type of alternative fuel that is being seen as an alternative is hydrogen. hydrogen can help with the new regulations coming into affect by reducing the emissions being produced to zero with only water deposit coming out of the tail pipe.

A study by Aston martin working with a hydrogen manufacturer in Germany found that using hydrogen has the ability to reduce greenhouse gas emissions by between "50-80" percent using there process of gathering hydrogen from raw glycerol.

Another type of fuel that could be used is bio ethanol, this type of fuel is produced from waste products of farm animals, as well as food such as corn, which can be regrown and easily reproduced.

b) The impact that these fuels could have on the end user is an reduced cost as the switch to bio ethanol will allow them to keep their current ICE powered car without having to spend more on a newer more Euro compliant model, However users of hydrogen will have to look at the cost of a hydrogen car when compared to a conversion of their current vehicle. Currently there is only 1-2 options for hydrogen cars this being the Toyota Mirai and the Hyundai Nexo, both of which are quite expensive, £50,000 for the Mirai and £70,000 for the Nexo, therefore using bio fuel based fuel is a better option for now

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- C) With regards to hydrogen fuel, there needs to be fuel pumps which can safely distribute this fuel type to the user, the current infrastructure built for hydrogen fuel stations is only 11 total, however big fuel companies such as Shell have committed to installing facilities but that will take time to appropriate the sights to build them. Along with fueling stations the use of bioethanol fuel needs lots of agricultural property in order to mass produce waste product and food such as corn to meet the demand of being an alternative replacement to petrol & diesel. environmentally with bio fuels, companies have started to use food products to produce high protein which can be used to feed animals, which creates a recycle loop to harvest waste products to make more fuel.

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Section B

Question 2

a) Ionic Bonding is when an atom transfers electrons between another atom, this is done as atoms like to stay in a balanced state.

Metallic Bonding: the difference with this bonding is that instead of sharing electrons across shells, metal atoms will shed electrons from their outer shell freely, doing this creates positively charged ions and delocalised electrons.

The valency of an atom is when an atom is checked to see how many hydrogen atoms can bond with the regular atom.

b) $a = 0.362 \text{ nm}$ or $0.362 \times 10^{-9} \text{ m}$

$R = ?$

4 atoms = FCC
Per unit

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

$$R = \frac{1}{\sqrt{2}} \times 0.362 \times 10^{-9} = 2.56 \times 10^{-10} \text{ m} = 0.256 \text{ nm}$$

c) Point defect: This type of defect is when atoms are missing from the lattice structure, this creates vacancies in the structure which will distort the atoms.

- Another point defect is self-interstitials, this is when an atom becomes lodged within the normal lattice structure.
- Substitutional point defects can occur when a different atom type replaces one of the already existing atoms in a structure.

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Line defects - Dislocation: This line defect is caused when there is a dislocation of the lattice occurs from a defect in the structure. When a dislocation occurs layers of the lattice will move, this causes new bonds to form once the movement stops. This has a permanent effect of plastic deformation of the structure.

Area defects - Grain boundary: With structures you will have areas where the boundary of two crystalline structures meet. This grain boundary can collide changing the bonding structure of that material. With this defect comes a benefit, a grain boundary can help impede dislocations from occurring.

d) The Secondary stage of creep looks at the material deforming over time and how it stabilises and works. In a linear manner, this stage the creep is able to be predicted and monitored.

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Question 3

a) Casting: This manufacturing process is an older technique which has different benefits to its use, one such benefit being the ability to make large intricate shapes such as engine blocks, however this tends to leave poor finish on the material.

Forging: This process uses a combination of heat & pressure to change a material to whatever desired shape is needed. benefit to this is allowing a variety of components to be manufactured, However this is a costly process and may not be suitable for smaller manufactures. Also the die cast will need changing after a long period which is another expense.

Extrusion: The process of extrusion involves pushing a material into a shape mold, which makes a desired shape. Benefit to this is it, allows for complex shapes to be made while having little material waste, however it requires low melting point alloys and brittle materials struggle to be extruded.

b) 3 Stages of FMEA Include:

Likelihood of detection: This looks at how likely the failure of a product will occur Ranked on a scale of 1 to 10, good way to identify failures.

Severity number: The severity of potential failure on a scale of 1 being no issue to 10 being likely to happen

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Risk priority number: RPN is used to create a plan on how to address failures identified in the...
RPN calculation -

$$RPN = \text{Likelihood of detection} \times \text{Severity number} \times \text{probability of occurrence}$$

d)

$$a = 3 \text{ mm} = 0.003 \text{ m}$$

$$\sigma = 625 \text{ MPa} = 625 \times 10^6 \text{ Pa}$$

$$E = 200 \text{ GPa} = 200 \times 10^9 \text{ Pa}$$

$$G_c = ?$$

$$K_{II} = \sigma \sqrt{\pi a} = 625 \times 10^6 \sqrt{3.14 \times 0.003} \\ = 60.67 \times 10^6 \text{ Pa} \sqrt{\text{m}}$$

$$K_{II} = \sqrt{G_c E} \quad \longleftrightarrow \quad K_{II}^2 = G_c E \quad \longleftrightarrow \quad K_{II}^2 = G_c E$$

$$G_c = \frac{K_{II}^2}{E} = \frac{(60.67 \times 10^6)^2}{200 \times 10^9}$$

$$= \underline{18405.24} \text{ or } 1.84 \text{ kJ/m}^2$$

c) D =

$$h =$$

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

$$p =$$

$$T =$$