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## Section A

1

• Biobutanol

When burnt in combustion engine only carbon dioxide is produced. This decreases NOx production.

Fuels produced from sustainable materials such as corn

Reduction in Carbon monoxide

Fuels burn at lower combustion temps ~~less~~ because of the cooling effect of ~~the~~ alcohol fuels.

• Dimethyl Ether (DME)

Zero soot and particulate emissions

Lower NOx emissions - lower combustion temperatures

Sulphur free and metal free emissions

Bio butanol has lower auto ignition temperatures, making the engine easier to start when cold. Therefore not needing a rich air-fuel mixture to start.

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b) lower energy content means ~~more~~ a richer air/fuel mixture is needed meaning increased fuel consumption for the user, meaning less range on a tank of fuel

~~Alcohol~~ Alcohol fuels are corrosive causing wear on engine + fuel system components possibly leading to high maintenance costs.

DME has poor lubricating properties leading to wear on fuel injectors

larger fuel tanks will cause heavier vehicles. weight distribution of vehicle will be affected. This leads to poor handling

Forced Induction will be needed to run DME fuel, Higher vehicle costs for user

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c) fuel stations need to support these  
fuels at the pumps

Land space is taken up to ~~grow~~ grow  
crops for the fuels. Possibly leading  
to food shortages

Manufactures need to develop vehicles to  
use these fuels.

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Question 2

1) Ionic bonding is when atoms transfer electrons between each other

Atoms want to be balanced and have complete outer shells

An electron donor and electron receiver is required

- Covalent Bonding

This is when atoms share electrons but don't permanently transfer them

happens with atoms of the same element close to each other on the periodic table

- mostly happens with non-metals

- Metallic Bonding

metal atoms shed electrons from outer shell freely. This creates positively charged ions and a sea of free electrons (Delocalised)

- Valency of an atom can be measured by how many hydrogen atoms it can bond with

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b) Face centered cubic Dimension

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

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

$$a = 0.362 \text{ nm}$$

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

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

$$R = 1.274 \times 10^{-10} \text{ metres}$$

c) Point Defect - missing atoms when the lattice forms leaves vacancies in the structure, allowing distortion of surrounding atoms

- vacancies will occur naturally in crystalline structures. The amount can vary depending on temperature
- self interstitials defects occur when an atom has become positioned between the normal lattice structure atoms
- Substitutional Defect occurs when the original atom in lattice site of crystalline solid is replaced by different type of atom

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Line Defects, Dislocations  
caused by dislocations in the lattice,  
which are a defect in the structure

Dislocations allow layers of the lattice  
to slip relative to their adjacent  
layers.

Area Defects, Grain boundary  
Grain boundaries are the boundaries between  
the crystals in a material. Bonding  
structure changes.

Grain boundaries create area defects in  
the crystalline structure

Orientation of crystals will be different

Grain boundaries can help impede dislocations

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d) creep

Secondary creep Dislocation movement

- Defects within the crystalline structure will move towards the grain boundaries under load.

the stress applied to the structure causes the dislocations to move ~~as~~ as the crystalline structure settles

Dislocations will find their way to the triple points as they are the weakest

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### Question 4

g)

i) 7XXX = Zinc

- Heat treatable for increased strength.
- Alloy becomes brittle
- ~~Rarely~~ Rarely used alone

ii) First Digit '1' = Indicates steel type is carbon

3<sup>rd</sup> and 4<sup>th</sup> "45" = percentage of carbon  
= 0.45%

b) 3 Groups, • Particle-Reinforced

- Fibre-Reinforced
- Structural

Particle-Reinforced

- particulates are harder and stiffer than the matrix material
- particles are of macro, micro or nano-scale
- Concrete is a large particle composite
- Tire rubber: Matrix rubber is compliant  
Carbon particles are stiff

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Fibre reinforced

- Fibreglass
- carbon fibre
- High strength or stiffness and light weight
- Influenced by fibre orientation: Aligned, Random and woven fibres

Structural composites

- sandwich panel consists of faces + cores

Faces • Made from strong material often carbon fibre or aluminium

- Absorb most loading

Cores • Made from less dense material, often foam, aluminium or Nomex

- Cores resist deformations
- Resist bending
- Multi-ply carbon fibre
- Aluminium honey comb

$$c) \frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m}$$