

Question 2.

a) The electronic configuration is the arrangement of electrons in the shells, this arrangement is determined by the maximum number of electrons in each shell. Incomplete shells, form valence electrons, these electrons can form bonds with other atoms in complete shell to try to be in balance. So, the valency is the capacity of an atom to give, accept or share electrons to achieve the stable state (complete the outer shell).

- Ionic bonding: The atom with more empty "spaces" in the outer shell give electrons to the atom with nearly complete outer shell.
- Covalent bonding: The atoms share pair of electrons and mostly happens with non-metals.
- Metallic bonding: The metals lose electrons to form positive ions and delocalised electrons. This form a metallic bond, which is a strong electrostatic attraction between positive ions and negative delocalised electrons.
"(it holds the metal together)"

b) $a = 0,362 \text{ nm}$

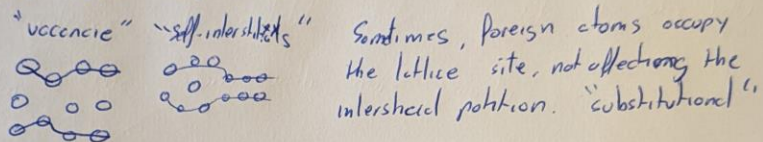
$\frac{a}{2} = R$

$$a = 2\sqrt{2} \cdot R ; \quad R = \frac{0,362}{2\sqrt{2}} = 0,128 \text{ nm}$$

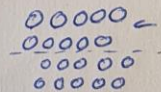
c) Crystalline structures suffer from 3 main types of defects:

- Point defects
- Line defects
- Area defects

- Point defect: Missing atoms leaves vacancies in the structure when the lattice forms, allowing distortion of surrounding atoms. Some happens with added atoms.



- Line defect: Are caused by dislocations in the lattice, which are a defect in the structure. These dislocations allow layers of the lattice to 'slip' relative to their adjacent layers. As the areas move, bonds between atoms break, with new bonds forming once the slip motion is completed. This slip effect produces a permanent plastic deformation of the structure.



- Area defect: Grain boundaries create area defects in a crystalline structure. Grain boundaries are the boundaries between the crystals in a material and they can help to impede dislocations. When the bonding structure changes, orientation of crystals will be different.



d) Creep is the deformation of a metal, under constant loading conditions occurring at elevated temperatures. It consists of 3 distinct phases:

- Primary (stage 1)
- Secondary (stage 2)
- Tertiary (stage 3)

These stages are caused by 3 different mechanisms:

- Grain rotation
- Dislocation Movement
- Cavitation

Dislocation Movement: This deformation phase is relatively predictable, defects within the crystalline structure will move towards the grain boundaries under load. These dislocations will generally find their way to the weakest links in the structure.

Question 4.

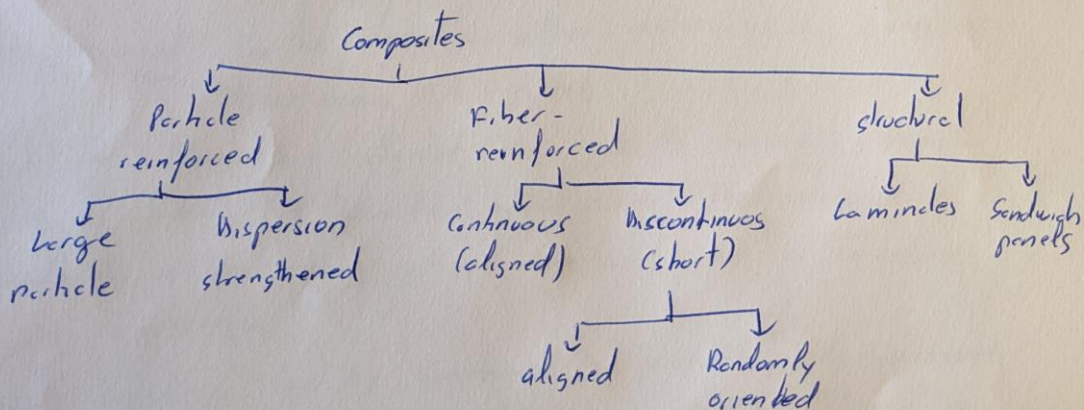
a) i) Zinc: It is heat treatable for increased strength, durable, cost effective. But the alloy becomes very brittle and lower toughness. It is rarely used alone.

ii) Steel 1045: The first number '1' indicates that the ~~steel~~ steel is carbon. The second '0' indicates that has no significant alloy components. The final two digits '45' indicate that this steel contains 0.45 percent carbon content.

b) Composites materials are materials made up from 2 or more distinct materials, combining the characteristics of both.

Classified into 3 groups:

- Particle - Reinforced
- Fiber - Reinforced
- Structural



Question 4

b) "Part Two"

Particle reinforced: Is a less effective means of strengthening than fiber reinforcement. Particulate reinforced composites achieve gains in stiffness primarily, but also can achieve increases in strength and toughness thanks the particles added in the matrix.

- large particles: Interaction with the matrix material is not on the atomic level. For example concrete.
- Dispersion strengthened: Hard and tiny particles (less than $0.1 \mu m$) are evenly distributed in the matrix material. The particles strengthening affects the movement of dislocations in the material structure.

~~Particulate~~
Particle reinforced composites find applications where high levels of wear resistance are required. The principal advantage, specially with large particles is their low cost and ease of production and forming.

Fiber reinforced: Can be classed as either continuous (long fibres) or discontinuous (short fibres)

when the fibres are aligned they provide maximum strength but only along the direction of alignment. The composite is considerably weaker along other directions and is therefore highly anisotropic.

This anisotropy can be overcome by randomly aligning ~~fibres~~ fibres in all directions. This, however, is a less effective strengthening technique but has the advantage of increased formability and reduced cost.

Question 4

b) "Part Three"

To overcome the problem of the 2 orientations mentioned before, a woven fibre can be the solution, been much stronger than random fibres, but, too expensive to produce ~~and~~. Depending on fibre density & in a single direction, they can produce less strength than aligned fibres.

Fiber reinforced is heavily used in fiberglass and carbon fibre.

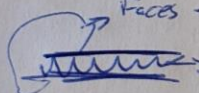
Structural: Are made up of both composite and homogeneous materials. Combined, these create material with properties from both.

The composite properties are not only dependent on the material properties, but the geometric construction of the composite.

- Laminar composites: Made up of sheets of a material. The direction and orientation of the sheets are tailored to give the overall composite the desired properties.
- Sandwich: It consists of 2 parts:

- Face: Made from strong material.
- Core: Made from a less dense material.

Faces → absorb most of the in-plane loading.

 Core → Resist bending.

Question 4

c) Fibre = 45% $\sigma = 30 \text{ mPa} = 30 \cdot 10^6 \text{ Pa}$

$$E_f = 65 \text{ GPa}$$

$$E_m = 3,2 \text{ GPa}$$

$$A_{\text{area}} = 300 \text{ mm}^2 = 0,0003 \text{ m}^2$$

$$E_c A_c = E_m A_m + E_f A_f$$

$$E_c = 65 \cdot 0,45 + 3,2 \cdot 0,55$$

$$E_c = 31,01 \text{ GPa}$$

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m} ; \quad \frac{F_f}{F_m} = \frac{65 \cdot 0,45}{3,2 \cdot 0,55} = 16,619 ; \quad F_f = 16,619 F_m$$

$$F_c = F_f + F_m$$

$$F_c = \sigma \cdot A$$

$$F_c = \sigma \cdot A ; \quad F_c = 30 \cdot 10^6 \cdot 0,0003 = 9000 \text{ N}$$

$$F_c = F_f + F_m ; \quad 9000 = 16,619 F_m + F_m ; \quad F_m = \frac{9000}{17,619} = 510,812 \text{ N}$$

$$F_f = 16,619 F_m ; \quad F_f = 16,619 \cdot 510,812 = 8489,1849 \text{ N}$$

$$\boxed{\begin{array}{l} F_m = 510,812 \text{ N} \\ F_f = 8489,1849 \text{ N} \end{array}}$$

Question 1

a) b) c)

Hydrogen:

Is considered to be the ideal source since its only emissions at low burn temperature is water vapour (H_2O).

At higher burn temperatures it will produce an amount of NO_x , the quantity of which increases with the increase of in burn temperature.

Hydrogen is a volatile chemical, carrying such a fuel often perceived as dangerous. However ~~advances~~ advances in ~~the~~ technology could make carrying and refuelling hydrogen less of an obvious hazard.

Hydrogen engines need to run lean due to its volatile nature. But this power loss produced by running lean can be compensated by fitting a super/turbo charge.

Currently there is minimal infrastructure for hydrogen to ~~support~~ support its usage, which can lead to problems.

The main arguments against it, is the manufacturing of the fuel, since the process to ~~at~~ liquefy and cooled under pressure uses large amounts of energy, and once liquefied more energy is required to maintain it at this temperature.

Question 1

a) b) c) ("Port Two")

Dimethyl Ether (DME)

Dimethyl Ether is a new fuel being proposed as a replacement for diesel fuel. It has the following properties:

- Sulphur and metal free emissions
- Zero soot
- Low NO_x
- Faster burn rates than diesel
- Can employ existing LPI technology

Problems:

- Poor lubricating properties (high wear fuel system)
- ~~Has~~ Low calorific value. (big tank)