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Question 2:

2a). Ionic bonding is when atoms transfer electrons between each other. due to the atom always wanting to have a complete outer shell of electrons. To complete ionic bonding, an electron donor and an electron receiver is required. Generally, metals are donors and non-metals are receivers. Valency numbers determine this. The valency of an atom is measured by how many hydrogen atoms it can bond with. The group number shown on the periodic table is the valency number of an element.

Covalent bonding is when atoms share electrons but don't permanently transfer them. This often occurs with atoms of the same element or elements of the same close to each other in the periodic table. it is rare for metals and often happens with non-metals. it is possible for metals and non-metals to form a covalent bond.

Metallic bonding is slightly different in that it works from metal atoms shedding electrons from their outer shell. This creates positively charged ions and a sea of free electrons known as delocalised ~~ions~~ electrons. These ions form a tightly packed lattice structure with the electrons filling the gap. The number of atoms in each structure isn't set.

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2b). Copper = Face Centered Cubic

$$\therefore \text{Face Centered Cubic dimension} = a = 2\sqrt{2}R$$

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

$$0.362 = 2\sqrt{2}R$$

$$\frac{0.362}{\sqrt{2}} = \frac{0.362}{2\sqrt{2}} = R$$

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

2c). Point defects:

Vacancies: Vacancies are missing atoms in the atomic structure that when the lattice forms cause vacancies in the structure, allowing distortion of surrounding atoms.

Self interstitials: occur when an atom has become positioned between the normal lattice structure atoms.

Substitutional: Occurs when the original atom in the structure is replaced by an different type of atom. and unlike an interstitial defect, any foreign atoms should occupy the lattice site only and not the interstitial position.

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Line defects :

dislocations: Caused by dislocations in the lattice, which are a defect in the crystalline structure. They allow the lattice to slip relative to their adjacent layers. As they move, bonds between atoms break with new bonds forming once the slip motion is done. This process causes a permanent plastic deformation of the structure.

Area defects :

Grain Boundary: Create area defects in the crystalline structure. Grain boundaries are between crystals in a material. This causes a change in bonding structure. This causes a different orientation of crystals. These grain boundaries can help impede dislocations.

2d). Three Stages of creep are :

- Primary, secondary and tertiary

The Primary Phase is when the material has initial deformation due to loadings. due to work hardening the rate of strain on the component slows.

During the Secondary Phase of creep, the material deformation stabilises and becomes linear. This stage is predictable.

The final, tertiary stage of creep shows the material experience a huge deformation due to continued loading. This is commonly the point before failure.

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Question 4:

4ai). The main alloying element of Txxx aluminium is Zinc. It is typically used in aircraft engineering and offers properties like it is heat treatable for increased strength which means it is very useful in aerospace engineering. This alloy becomes very brittle which suggests that the life cycle of the components may be shorter than alternative options.

4aii).

1st digit = dictates the type of steel

Third and fourth digits = dictate the carbon content of the steel in question.

4b). There are three classification groups of composites:

- Particle reinforced
- Fibre reinforced
- Structural

Particle reinforced composites are commonly harder and stiffer than the matrix material. Particles are on either macro, micro, or nanoscopic scales. Improving the mechanical behaviour of a particle reinforced composite depends on the interface bonding in the material. There are large-particle and dispersion strengthened particle reinforced composites. Large particle is referring to the interaction with the matrix material is not on the atomic level. Dispersion strengthened composites refer to materials with particle size of around 0.01-1 microns.

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and their smaller particles form bonds ~~with~~ on atomic or molecular levels to their surrounding matrix. This restricts plastic deformation. Concrete is the best example of a large particle composite.

Fibre-reinforced composites are commonly used in the automotive industry. The most common examples would be Fibreglass and carbon fibre. These composites are high in strength and stiffness, they are commonly measured in terms of their specific strength and ratio of modulus of elasticity to specific gravity. They are produced with high specific strength and modulus and are commonly sub-classified by fibre length. Short fibres are too short to produce a significant improvement in strength. Often they are either ~~not~~ produced with aligned fibres, random fibres or woven fibres which all offer differing characteristics and properties.

aligned:

- fibres are long
- highly effective along fibre direction
- fibre lengths $15\times$ greater than critical length desirable

Random:

- easier and cheaper to produce
- composite will be isotropic

Woven:

- composite isotropic to loading
- much higher strength than random fibres

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Structural composites are made up of both composite and homogenous materials. Combined, these create a material with combined properties. Common examples are multi-ply carbon fibre and aluminium honeycomb. Structural composites consist of faces and cores.

Faces are made of strong materials, normally carbon fibre or aluminium, even plywood is sometimes used. The faces of the composite absorb most of the in-plane loading.

Cores are made from much less dense material, often a foam, aluminium or nomex. Cores are able to resist deformation in a perpendicular direction to the face plane. They can also resist bending while honeycomb cores are often seen and are constructed of hexagonal cells which are interlocked to form a very strong structure whose axis is perpendicular to the face material.

- 4c). Vol of fibre = 0.45
modulus of elasticity fibre = 65 GPa
modulus of elasticity matrix = 3.2 GPa
Cross Section Area = 300 mm²
Stress = 30 MPa

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$$E_F = 65 \times 10^9$$

$$E_m = 3.2 \times 10^9$$

$$\text{Fibre Vol} = 45\% \quad V_m = 55\%$$

$$\text{Area} = 300 \times 10^{-6}$$

$$E_{cl} = E_m V_m + E_F V_F$$

$$E_{cl} = (3.2 \times 10^9 \times 0.55) + (65 \times 10^9 \times 0.45)$$

$$E_{cl} = 31.01 \times 10^9 \text{ Pa}$$

$$\frac{F_F}{F_m} = \frac{E_F V_F}{E_m V_m}$$

$$\frac{F_F}{F_m} = \frac{(65 \times 10^9 \times 0.45)}{(3.2 \times 10^9 \times 0.55)}$$

$$\frac{F_F}{F_m} = \frac{29.25 \times 10^9}{1.76 \times 10^9}$$

$$F_F = 14.34 F_m$$

$$F_F = 9000.1 \text{ N}$$

$$F_F = 9000.1 \text{ N}$$

$$F_m = 627.62 \text{ N}$$

Total load F_c needs to be

$$\sigma = 30 \text{ MPa} = 30 \times 10^6 \text{ Pa}$$

$$F_c = \sigma A_c = (30 \times 10^6) \times 300 \times 10^{-6}$$

$$F_c = 9000 \text{ N}$$

Total load is sum of F_F and F_m

$$F_c = F_F + F_m$$

$$F_m = \frac{F_c}{F_F} = \frac{9000}{14.34} = 627.62 \text{ N}$$

$$\therefore F_F = 14.34 \times 627.62 = 9000.1 \text{ N}$$

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Question 1

1a). alternative fuels:

- biobutanol
- ~~ethanol~~ hydrogen

The use of biobutanol and hydrogen as fuels is a much more environmentally friendly option while also reducing emission output drastically. Using these alternative fuels will help to reduce the amount of fossil fuels being used for fuel production, therefore ensuring that vehicles are much cleaner running, which contributes toward meeting Euro VI emissions standards in 2025.

1b). The use of such fuels can have a significant impact on the user due to the practicality of acquiring fuel when needed if compared to already existing fuel options. The use of hydrogen would require all new vehicles to be fitted with hydrogen fuel cells which instantly drives the cost of vehicles upward. Fuel stations would need to be fitted with capability to provide hydrogen fuel.