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1. First Exam Question

Answer: The Spindle will require a material ~~with~~ that can ~~a large and~~ withstand a large amount of stress under a repeated load of acceleration and deceleration. The ~~material~~ property needed will be a high fatigue limit.

A material with a high friction coefficient should be needed to be able to grip the spindle and turn ^{the} wheels of the car.

Hardness would be needed so the slots/indents of the spindle don't wear out, ~~which would~~ ~~are~~

Torsion will be a ~~defecting~~ factor of a spindle when accelerating and decelerating.

Using a Young's modulus - density graph ~~we~~ I can select a stiff material that would suit this application.

I would recommend a polymer as the lightest option however steel offers an alternative to prevent ~~bend~~ torsion as it has a high bending strength, high temperature resistance against friction and elongation at rupture.

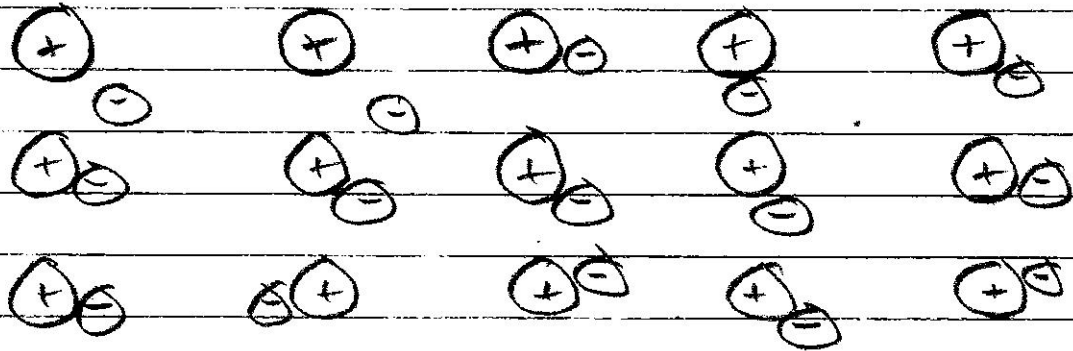
Hardened Steel/Steel

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2. Second Exam Question

a).

Answer:



This diagram represents metallic bonding with a valency of 1.

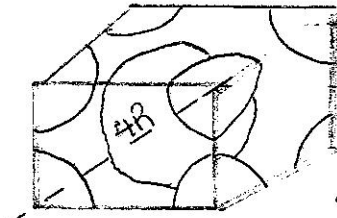
The '+' represents metal ions and the '-' represents the free floating electrons.

The electrons ~~attract~~ are attracted to the metallic ions through a process known as "electrostatic attractive force".

~~This means~~ Valency simply represents the amount of ~~elect~~ free floating electrons.

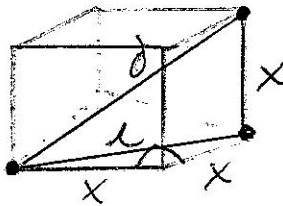
This means that a valency ~~with~~^{of} 2 is stronger due to its stronger "electrostatic attractive force".

b).



Body centered cubic (BCC) has 2 atoms in the 1 ~~unit~~ unit. Each corner measures $\frac{1}{8}$ of an atom. With 8 total corners and 1 atom in the ~~center~~ center. This can be calculated to $\frac{1}{8}(8) + 1 = 2$.

The BCC has a x axis of $\frac{4}{\sqrt{3}} R$.
~~The~~ The packing ratio for BCC can be worked out by using pythagoras.



$$l^2 = x^2 + x^2 \quad \leftarrow \text{working out } x \text{ axis}$$

$$l^2 + x^2 = d^2$$

$$x^2 + x^2 + x^2 = d^2$$

$$3x^2 = d^2$$

$$\sqrt{3}(x) = d \rightarrow \sqrt{3}x = 4R$$

$$x = \frac{4}{\sqrt{3}} R$$

BCC is a crystalline structure in metals.

$$\text{Packing ratio} = \frac{V_{\text{atom}}}{V_{\text{cube}}} = \frac{2 \left(\frac{4}{3} \pi R^3 \right)}{\left(\frac{4}{\sqrt{3}} R \right)^3}$$

$$= \frac{2(4) \left(\frac{1}{3} \right) \pi R^3}{4 \cdot 4 \cdot 4 \sqrt{3} \sqrt{3} \sqrt{3}}$$

$$= \frac{2(4) \left(\frac{1}{3} \right) \pi R^3}{\frac{16}{\sqrt{3}} \sqrt{3} R^3}$$

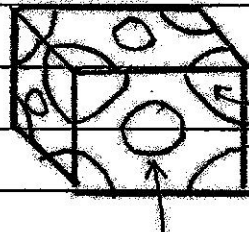
$$= \frac{2\pi \sqrt{3}}{\frac{16}{\sqrt{3}} \sqrt{3}}$$

$$= \frac{2\pi (\sqrt{3})}{16} = 0.6802$$

packing percentage = 68%

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b) Face center cubic ~~the~~ at (FCC) has
4 atoms.



corner = $1/8$ of an atom

Face of an atom = $1/2$ of an atom

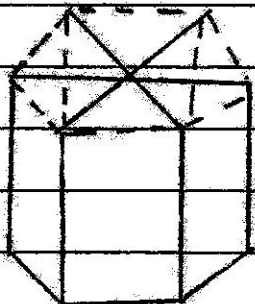
$$1/2 (6) + 1/8 (8) = 4$$

The packing ratio = 74% and can be worked
out using $4 \times \frac{4}{3} \pi R^3$

$$\frac{4 \times \frac{4}{3} \pi R^3}{\left(\frac{4}{\sqrt{2}} R\right)^3}$$

In a face centered cubic, atoms are
diagonally touching. FCC is also a crystalline
structure.

Hexagonal close packed (HCP)



HCP allows alternative layers
of atoms arranged in a hexagon
pattern. The under layer has
a triangular form then the layer
under that goes back to hexagonal.

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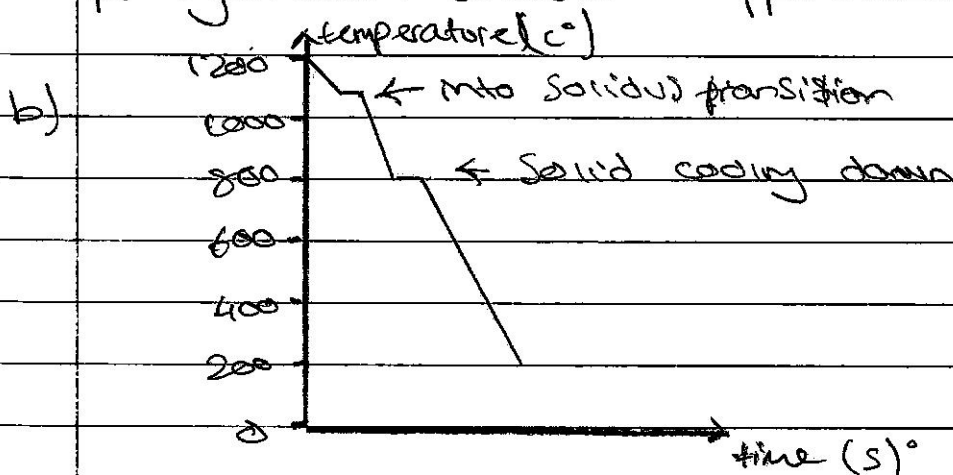
c). ~~Phase diagram~~... ~~71.9~~ Eutectic point = 71.9

a). At 1200 both copper and silver are in liquid form.

At 850, silver is a mixture of solid and liquid also called "Slush"

Copper follows more liquid but is also entering a transition of becoming a solid.

At 300 degrees, silver is ~~set~~ ~~solid~~ pretty much solid. Copper is definitely solid.



From 1000 - 800 silver enters a "Slushy" phase of cooling down into a solid.

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4 Fourth Exam question

- a). Scuba divers descend to low depth where the pressure increase on any object below sea level. This means the scuba tanks and ~~gas must be pressurised correctly~~ will need to be secure against the pressure of oxygen trying to escape the tank.

The tank must resist deformation and contain the O_2 supply.

The tank must also be dent proof so a ~~low~~ high grade level of hardness is needed.

The tank must also be light so the diver doesn't sink with the tank.

- b). 6062 T6 Aluminium - The Yield Strength of 241 MPa is fairly low and when under pressure, it would likely fracture relatively quick compared to other options. However it is pretty light allowing for better movement.

Steel Alloy 4020 - Hot rolled - is worse than 6062 T6 Aluminium due to its even lower yield strength and increased weight.

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304 Stainless Steel (UNS S30400) - with a density of 7.9 g/cm^3 and Yield Strength of 510 MPa which is double the Yield Strength of the last two options.

I would pick this material as it's density to Yield Strength ratio is great for scuba diving. High yield strength to resist fracturing and high density which will help resist the collapsing pressure.

$$d) \quad \sigma = \frac{20 \times 10^6 \times 80}{4 \times ?} \rightarrow t = \frac{2Pd}{\sigma_{\text{yield}}}$$

~~Volume = $\pi \times r^2 \cdot h$~~ $t = \frac{2 \times 20 \times 10^6 \times 80}{\sigma_{\text{yield}}}$

~~$V = \pi \times 8^2 \times 50 \text{ cm}$~~

~~$V = 10053.1 \text{ cm}^3$~~

~~the~~ Volume = $\pi \times r^2 \cdot h$

$$V = \pi \times 8^2 \times 50$$

$$V = 628.32 \text{ cm}^3$$

$$\sigma = \frac{20 \times 10^6}{628.32} = 0.0806 = 0.081$$

$$t = \frac{2 \times 20 \times 10^6 \times 8}{0.081} \quad t = \frac{399}{0.081}$$

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Third Exam Question

- a). The principle of embodied carbon is to multiple the quantity by ~~the~~ the materials carbon factor for the duration of the material.

This can be calculated by this equation:

Material Quantity (kg) $\times$ carbon factor ($\frac{\text{kgCO}_2}{\text{kg}}$).

= to the amount of carbon stored within.

Includes manufacturing and transport to the sum total.

- b) Scaffolding needs to be light, have great strength and must be durable.

Scaffolding must also be somewhat elastic to prevent defects with the materials.

These are pertinent considerations.

- c). Bamboo has a low density to ^{high} young's modulus ratio. ~~the~~ This means that it is extremely light but very elastic and stiff.

Bamboo is also cheap and easy to transport.

It is also ~~selectively~~ relatively low on a carbon footprint as the can be found naturally grown, very quickly too.

Bamboo density per kg/m^3 is just under 1000 or around 800 kg/m^3 and around 30 GPa.

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Bamboo ~~young~~ strength to density is also great. At around 800 kg/m^3 and 80 MPa . This ~~matter~~ makes bamboo a reliable material choice.

4. Although mild steel tubing is more expensive and heavier. In the long term, steel is more durable, and has less of a bending motion.

Mild steel can also be repair relatively easy, where as bamboo can deteriorate and ~~some~~ fractures are not repairable.

Over maintenance time and down time with mild steel would be less.

Steel would also be able to carry more weight and can be designed to hold bolts and screws without damaging the structure.