

ACMA4000 Exam

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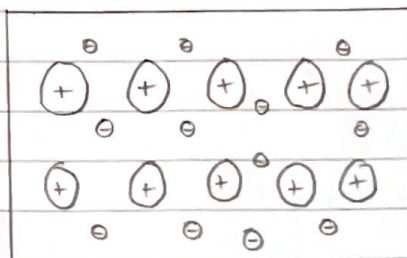
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Question 1

One of the mechanical material properties that the spindle of a vehicle electric motor is that it would need to be tough. The reason for this is that when the vehicle is accelerating and decelerating the material of the spindle will be subjected to a large amount of energy. Therefore, the material will need to withstand the shock without fracturing. Another property that would be required is fatigue limit. As the material will be put under repeated loads it is important that the material can withstand the stress exerted from these repeated loads. The material selected for the motor spindle should also have a good shear strength in order for it to be able to withstand the stress of the vehicle accelerating and decelerating. It is also important to consider the effect temperature would have on this material. As the spindle will move at fast speeds it will become hot. This requires a material that is insensitive to high temperatures. A suitable material for this application would be steel as the mechanical properties include hardness, toughness and fatigue strength. Also, steel alloys could be considered for the spindle. To manufacture the spindle a casting process could potentially be used or even a machining process. Steel is a machinable material which means the spindle could be manufactured using a lathe or multiple axis CNC machine. Brass may be another suitable material for the spindle and is suitable for die casting.

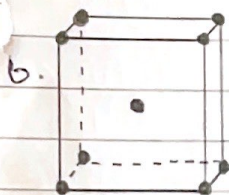
Question 2.

a. Metallic bonding is when electrons in the outer shell of a metal atom are attracted to the positive metal ions. The electrons in the outer shell are free moving which allows for the force of attraction. This can be seen in the below diagram.

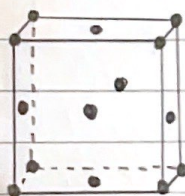


Metallic Bonding

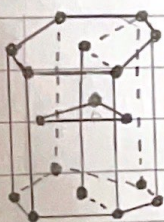
Metals with a valency of 2 are usually stronger than metals with a valency of 1 because they have a greater number electrons in the outer shell making the metallic bonding stronger.



Body Centered Cubic Structure (BCC) has an atom centered in the body of the cube. ~~It also has~~ It also has atoms at each corner.

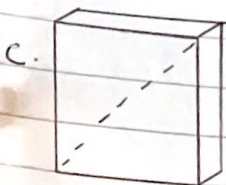


Face Centered Cubic Structure (FCC) has atoms at each corner and face of the cube.



Hexagonal Close Packed (HCP) structure has a hexagon on top and bottom of the structure with a triangle in the middle. There are atoms at each corner.

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$$s^2 + s^2 = (4r)^2$$

$$2s^2 = 16r^2$$

$$s^2 = 8r^2$$

$$s = \sqrt{8} \times r$$

Length of side of cell in terms
of r

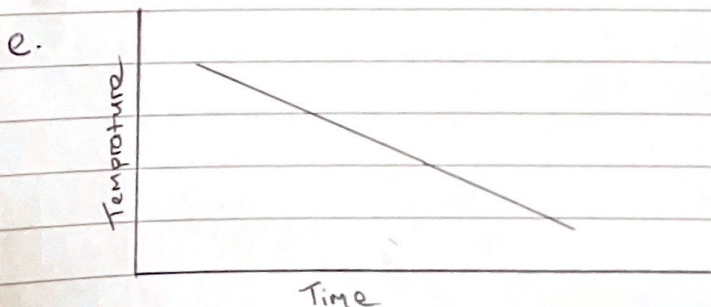
$$\text{Volume of cell} = s^3 = \sqrt{8}^3 \times r^3$$

$$\text{Number of atoms} = 8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4 \text{ atoms}$$

$$\text{Volume of atoms} = 4 \times \frac{4\pi}{3} r^3 = \frac{16\pi}{3} r^3$$

$$\text{Packing Ratio} = \frac{\frac{16\pi}{3} r^3}{\sqrt{8}^3 \times r^3} = \frac{16\pi}{3\sqrt{8}^3} = 0.74$$

d. At 400°C the lead and tin would be in a liquid form. Then at 250°C the lead and tin would be in a ~~liquid~~ ^{liquid} form. According to the phase diagram at 180°C is a transition period where the lead and tin starts to move from a ~~liquid~~ ^{liquid} to a solid form. Finally at 50°C the lead and tin is fully a solid. ~~99%~~ 99% tin would create the alloy with the lowest melting point.



Question 3

- a) For this particular application I would be looking at the composites class of material. The reason for this is that it maximises stiffness and density while still being super lightweight. I would also consider the metals and technical ceramics classes for the racing car chassis as they too have both a high stiffness and density to ensure the chassis does not break.
- b) I would reject the elastomers class due to the severe lack of stiffness making it unsuitable for this application. I would also reject the foams class as the low density would cause the chassis to break extremely easily. Natural minerals would also be ruled out as they would be difficult to manufacture into a racing car chassis.
- c) The merits of using carbon fibre frames are that they are strong while also being lightweight. The manufacturing process is more difficult compared to lower cost steel space frames. The merits of steel space frames are that they are stiff and dense however, due to the higher density they are heavier than carbon fibre frames.
- d) During the welding process the base metal is welded by the filler metal. Welding produces a greater residual stress in the joint compared to ~~soldering~~ brazing. However, brazing creates lower strength joints compared to welding.

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- e) Another alternative joining method that could be used is bonding. Also, Fastening could be used to join the space frame chassis. This would involve using fastenings including rivets, nuts, washers and bolts.