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BENG Mechanical & Manufacturing Eng

COURSE CODE : ACMA4000

1) THE material used in the packaging needs to be water tight and air tight in order to prolong the shelf life of the product. this can be achieved by sealing the product around the snacks. therefore the material needs to be sealable. the material also needs to be easily manufactured in order to minimise costs. avoiding polluting plastics and using easily recyclable and/or biodegradable materials will satisfy the target customer that cares about the environment. the material needs to be able to take a print in order to display an eye catching design.

PET Plastic is one possible solution that can provide a sturdy packaging at low cost that will keep the food fresh. this material is fully recyclable and can be mass produced. this material is not ideal however for printing, so attaching a fully recyclable paper label would be a good choice.

Aluminium foil is another example of an appropriate choice as this could be easily sealed in mass production. they can be sealed with heat to make an air tight environment.

1) Cont.

The aluminum will often be accompanied by plastic that a label can be printed on. When choosing this plastic it is important to select a fully recyclable material. to ensure the packaging is fully recyclable.

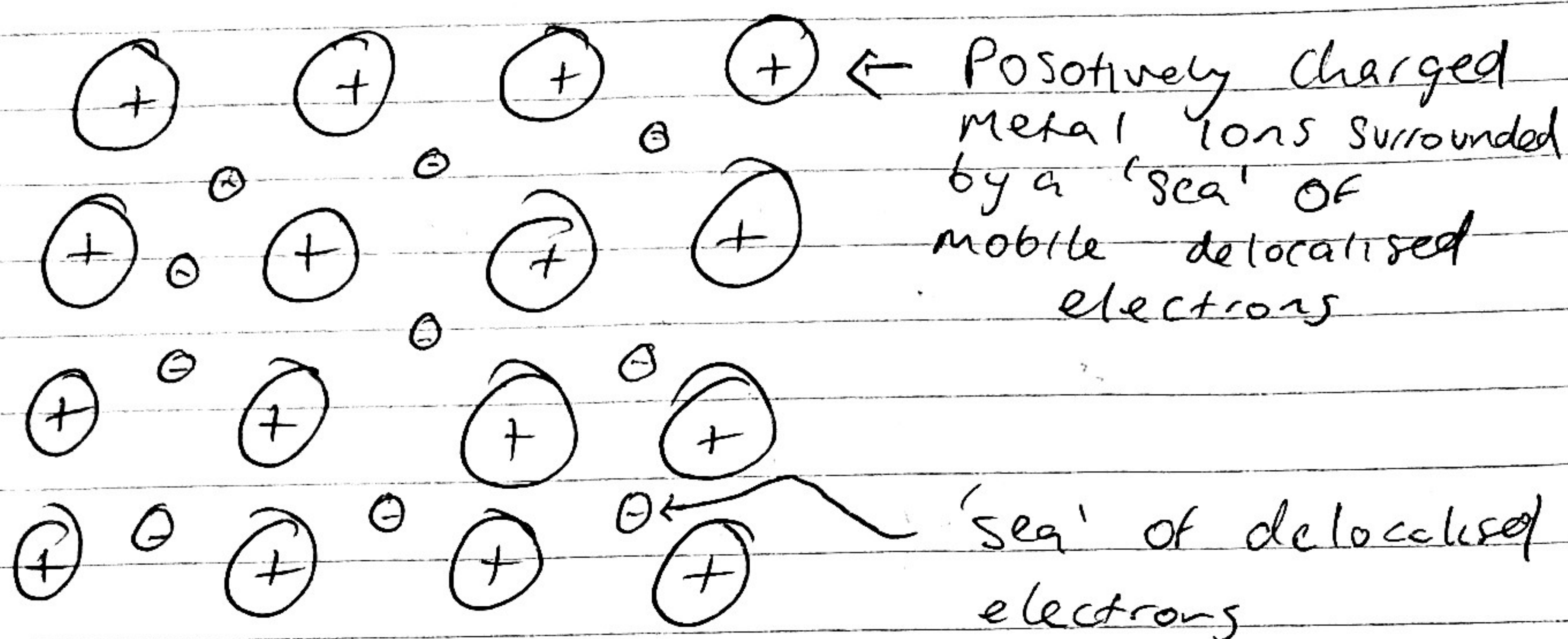
another important property of the material is the material needs to be strong enough to not break in transit. this would break the seal and ruin the snack.

typically properties that are ~~be~~ detrimental to the environment are detrimental to the profit margin. So a balance needs to be found where a good profit margin and environmental impact can be maintained.

2)
a)

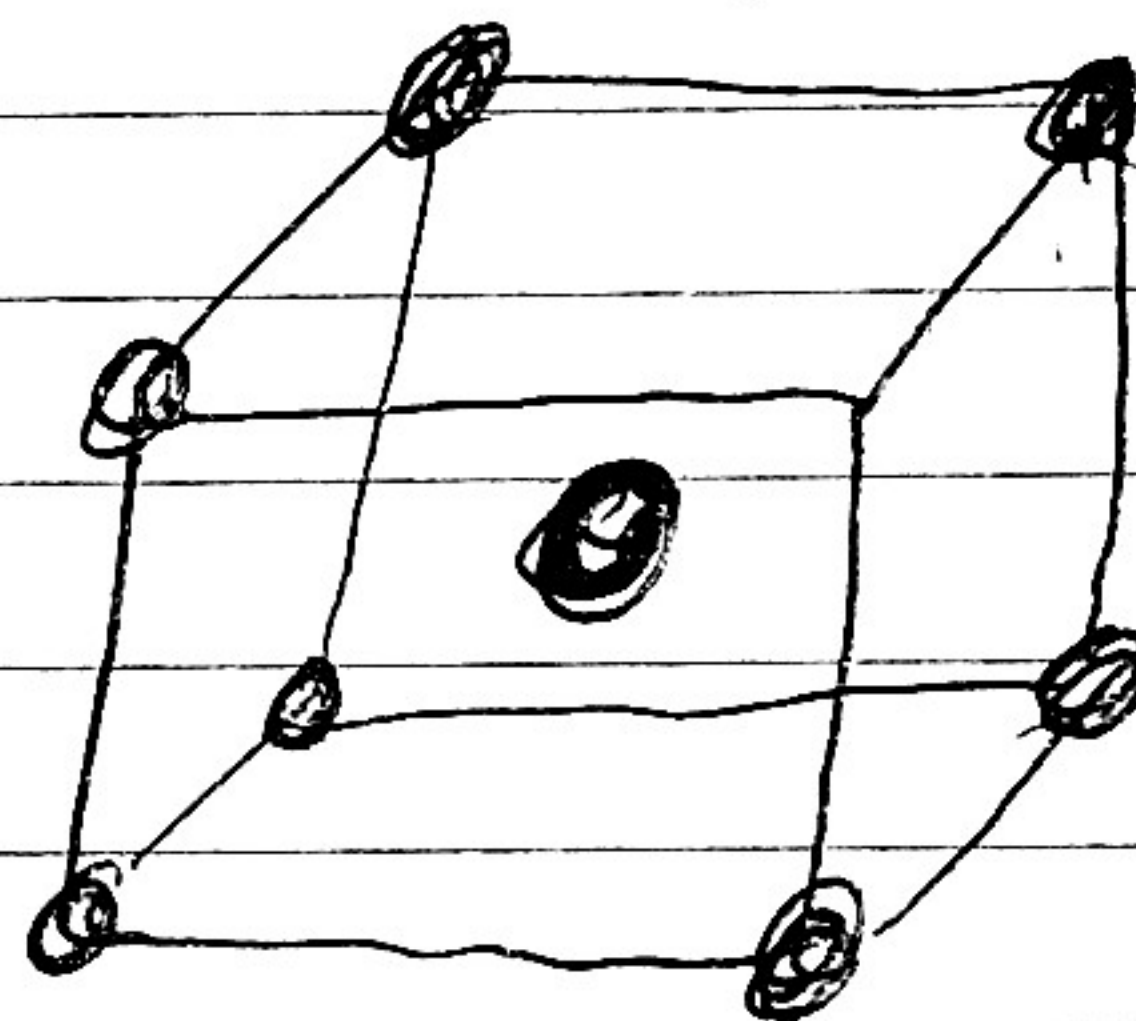
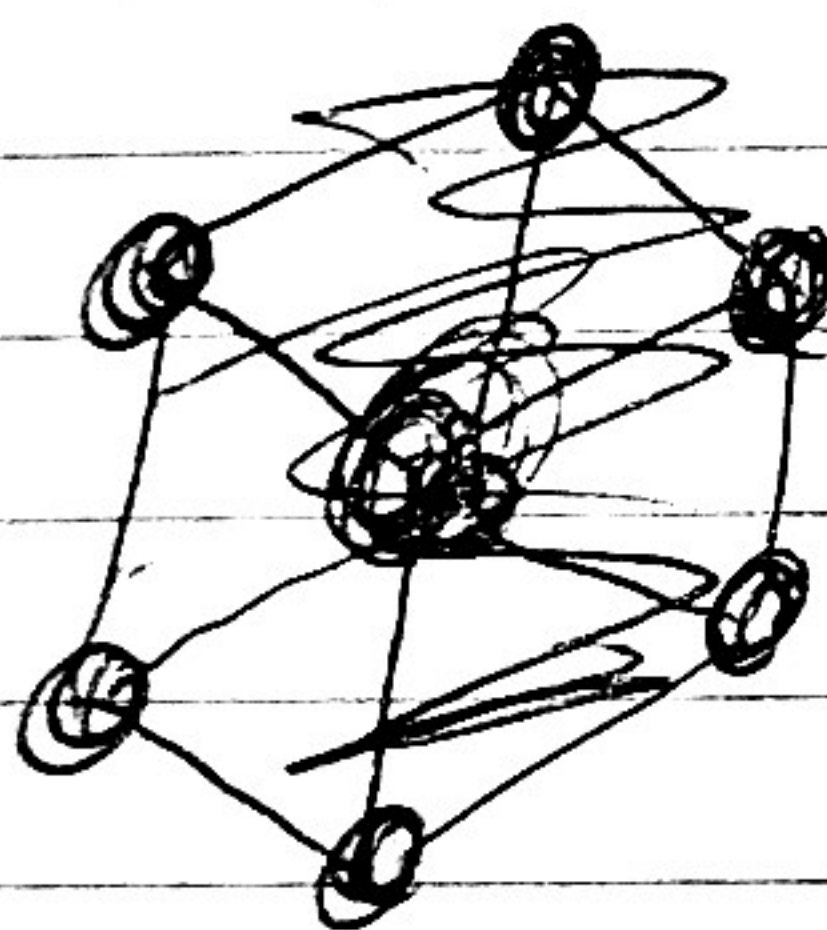
Metallic bonding is the attraction of positive ions in a regular lattice and the delocalised electrons. delocalised electrons are free to move throughout the entire structure.

Fig 1.1



b)

BCC (Body centred cubic)



In this arrangement, there is a sphere in every corner of the cube + 1 sphere in the centre of the cube

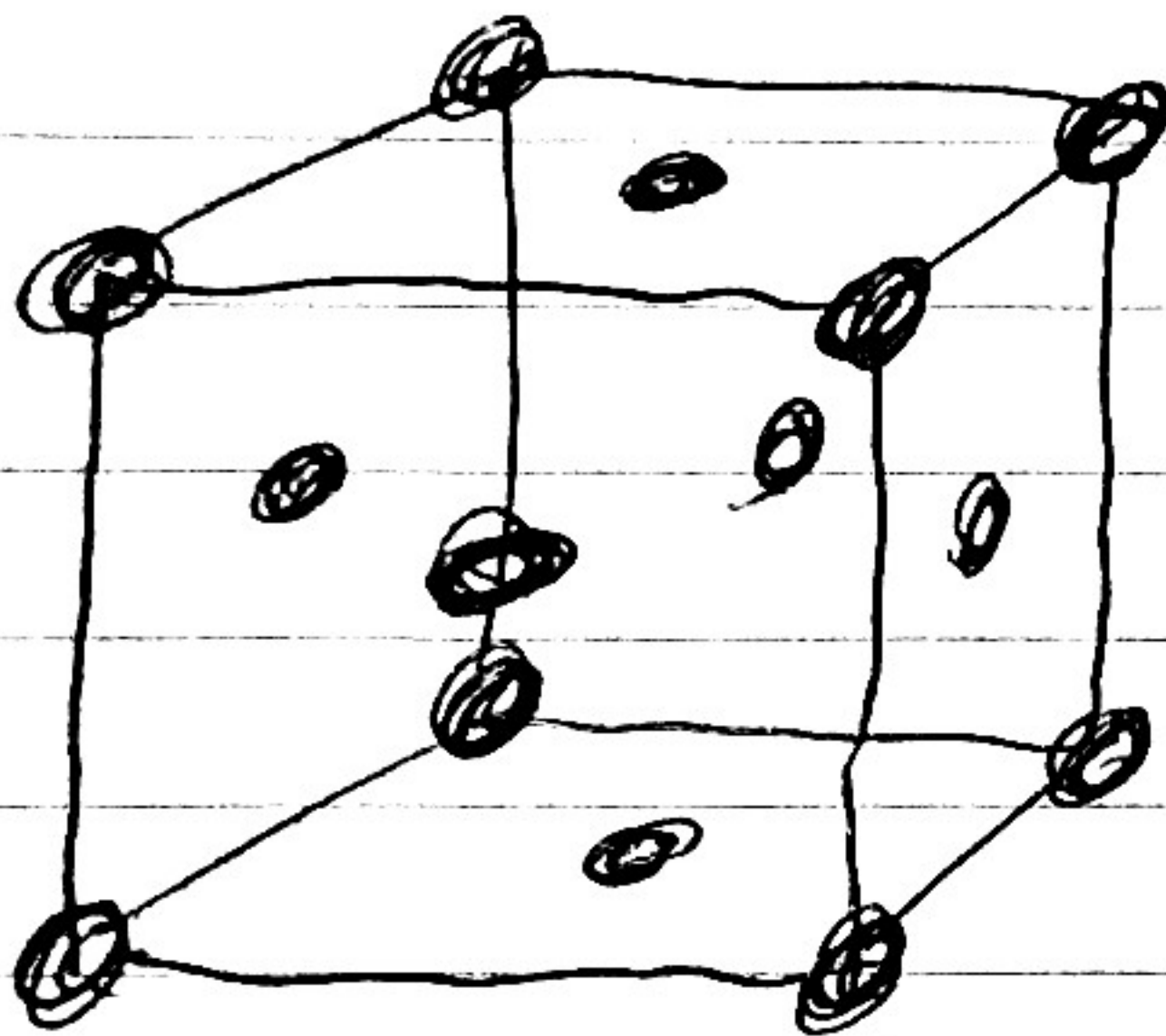
26) cont

there is a total of 9 spheres intersecting the cube,

$8 \times \frac{1}{8}$ of a sphere in each corner
+ 1 whole sphere in the centre

the packing ratio of BCC is 0.68 which is not as tight as other arrangements

FCC (face centred cubic)



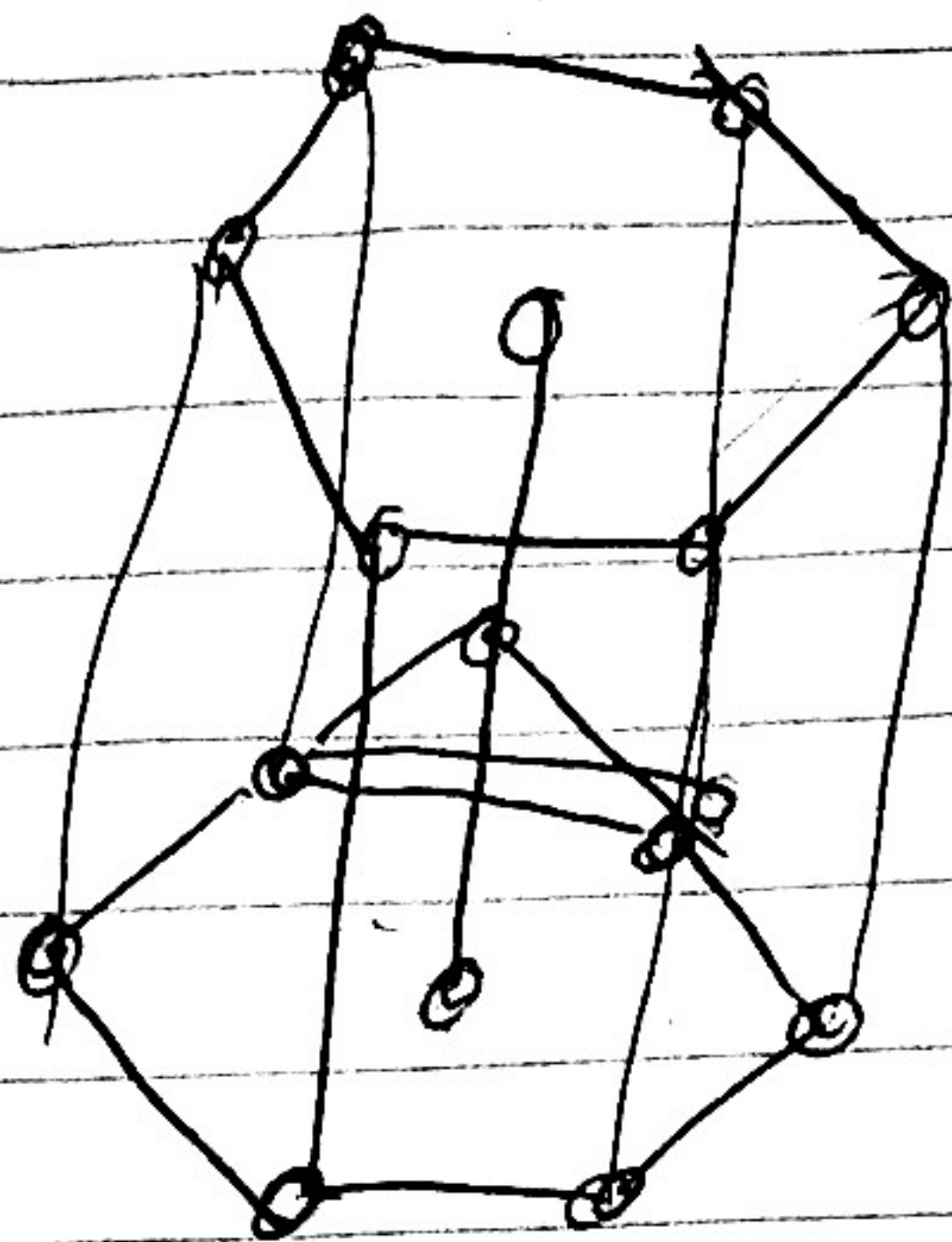
In this arrangement, spheres are located at each corner of the cube and in the centre of each face

there are 14 spheres that intersect this cube

$8 \times \frac{1}{8}$ in each corner
 $6 \times \frac{1}{2}$ on each face

the packing ratio is 0.74

HCP (Hexagonal close packed)



HCP refers to layers of spheres packed so that spheres in alternating layers overlap one another. Hexagonal close packed is a slip system, which is a close packed structure

this is common among elemental metals
the packing ratio is 0.74

c) BCC ratio = 0.68
HCP ratio = 0.74

d) Liquid

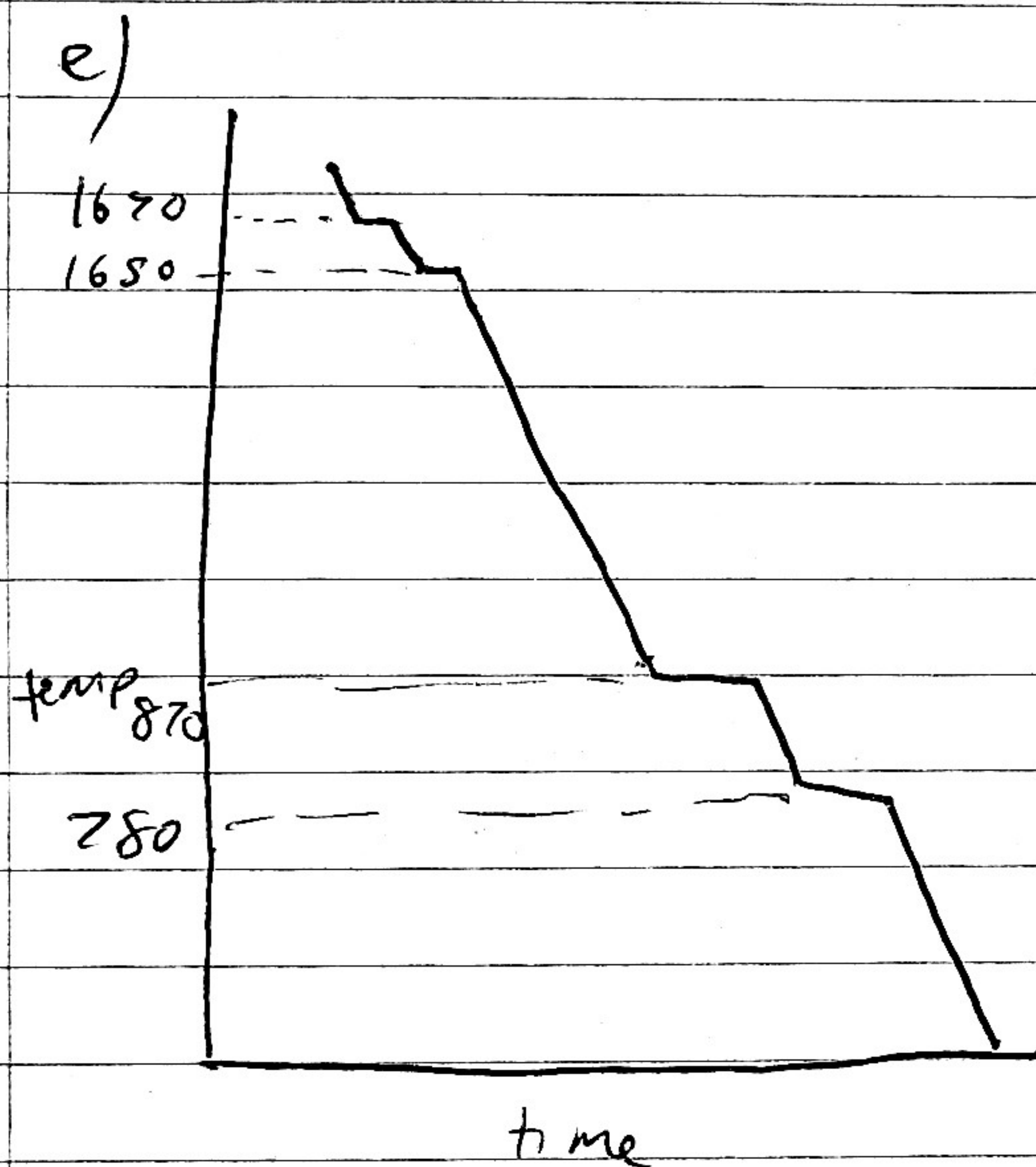
e) at 1650 the mixture is on a boundary line between (β Ti) and $\beta + L$. β Ti represents titanium in BCC arrangement and $\beta + L$ is a phase where both β titanium and liquid exist at the same time so on this boundary line the solution would be mostly β titanium + some liquid

at 800° the solution consist of both β titanium and α titanium, α titanium is HCP so at this

d) cont ..

Point the mixture is completely solid however there is a mix between BCC titanium and HCP titanium with some nickel also

at 600° the mixture is fully solid and the titanium is fully HCP structured, there is some nickel in the substance too



as temperature crosses phase boundaries energy is released from the substance maintaining the temperature for a short period of time before the temperature continues falling.

3.

a) The most appropriate classes of materials would be composites or metals. Technical ceramics have the best $Ym/density$ ratio however they are very brittle and not suitable for this application. Composites have the best $Ym/density$ ratio between them and metals however they may not be strong enough for this application with perhaps the exception of carbon fibre however this is highly expensive. Metals whilst they are more dense than composites provide the strength required of a race car chassis. particularly if this is an off road race car. Metals are also the most easily machined and joined material of the two. If composites were used, metal inserts would still be required where a high tolerance part is needed i.e. thread.

b) Natural materials is an example of a class that I wouldn't consider as they have a tendency to be flammable which is very undesirable in this setting as race cars have been known to crash and catch on fire. Technical ceramics ~~with~~ would be a group to avoid as they can be very brittle and

b) cont

would not withstand the stress that a race car chassis endures. ~~the best group~~ when this is despite being the best group when the $Y_m/\text{density}$ graph is considered. All properties need to be considered when choosing a material group for a particular application.

c) Carbon fibre is superior to steel in terms of $Y_m/\text{density}$, it is far lighter and provides more than adequate strength to the chassis. Although carbon fibre is far more expensive and the ability to manufacture complex parts with carbon fibre is way outmatched by steel. Steel is far cheaper and also provides adequate strength. However steel is far heavier and in racing ~~not~~ weight translates negatively to speed. Steel is easily machinable and joinable. You could produce practically any part you wanted to. Carbon fibre needs to be made into 1 piece and cannot be joined. This means it is difficult and expensive to make

c) cont

Complex parts. even when using carbon fibre, steel is required to make complex parts like threads that need to be machined to a high tolerance. these parts are inserted into the carbon fibre.

d) due to the high heat generated by the weld the weld changes the properties at the base metal in the heat affected area, this can negatively affect the fatigue strength and ductility of the affected area.

brazing is more desirable as you can join two different metals. brazing affects the dimensions of the metal less than welding and also provides a nicer finish to the product.

brazing does not melt the base metal so the properties of the base metal are not affected whereas in welding the metal melts and cools in varying rates causing discrepancies in grain size and therefore material properties.

e)

one alternative would be to bond between materials in the chassis. this is useful as bonds can be applied between any 2 materials and is not exclusive to metals like welding is. bonding would be ideal for carbon fibre for example the bond is only as good as the adhesive so a high quality of adhesive is required.

alternatively fasteners could be used such as rivets or nuts/bolts. these methods require less process than welding/brazing however are not as permanent. in this instance we want a permanent strong bond.

a combination of both methods described would be best to create a strong join. bonding + rivets is a typical method used in industry.

It.

a) the material needs to be airtight to preserve the air reserve.

the it also needs to be strong enough to withstand both the internal pressure of air, as well as the pressure from the water its submerged in.

the tank needs to be light enough to allow the diver to freely manoeuvre underwater.

the tank needs to be machinable so that fittings such as valves and pipes can be attached to the tank. the material must have a high degree of corrosion resistance as it is frequently submerged in salt water.

b) 6062 T6 AL

- with the lowest density, this is desirable when the diver is manoeuvring around however the yield stress is particularly low so this may not be adequate for the high pressures it will experience.

Steel Alloy 1020 - this has the lowest yield stress of the group and joint highest density so is a clear 'no go' when selecting for this purpose.

b) cont. .

low density + high yield stress are important here. This material is the opposite of that. It's used in car bodies which are designed to crumple on impact to protect the driver from impact force - ~~to~~ which is the opposite of the requirements for this example.

304 stainless. a reasonably high yield stress however joint highest density. This density may be an ok compromise as the diver is operating under water so won't feel the weight as much. The material is ideal for corrosion resistance and its use in storage tanks shows it has the sealability and machinability required for this application.

Pre preg carbon fibre - by far the best yield strength to density ratio. Just looking at these stats this is the clear winner however the high cost and lack of machinability may mean this is not an appropriate material. It may be difficult to achieve a seal with this material which is a fundamental requirement of a dive tank.

b) cont

Out of these materials I would select 304 Stainless steel for its adequate yield stress and density, and its excellent machinability and corrosion resistance

c) The design rule states that a safety factor of 2 must be maintained.

The hoop stress must not exceed half of the yield ~~hoop stress~~ strength

d) i)

$$t = \frac{2Pd}{\sigma_{\text{yield}}}$$

$$= \frac{2 \times (20 \times 10^6) \times 0.1}{510 \times 10^6}$$

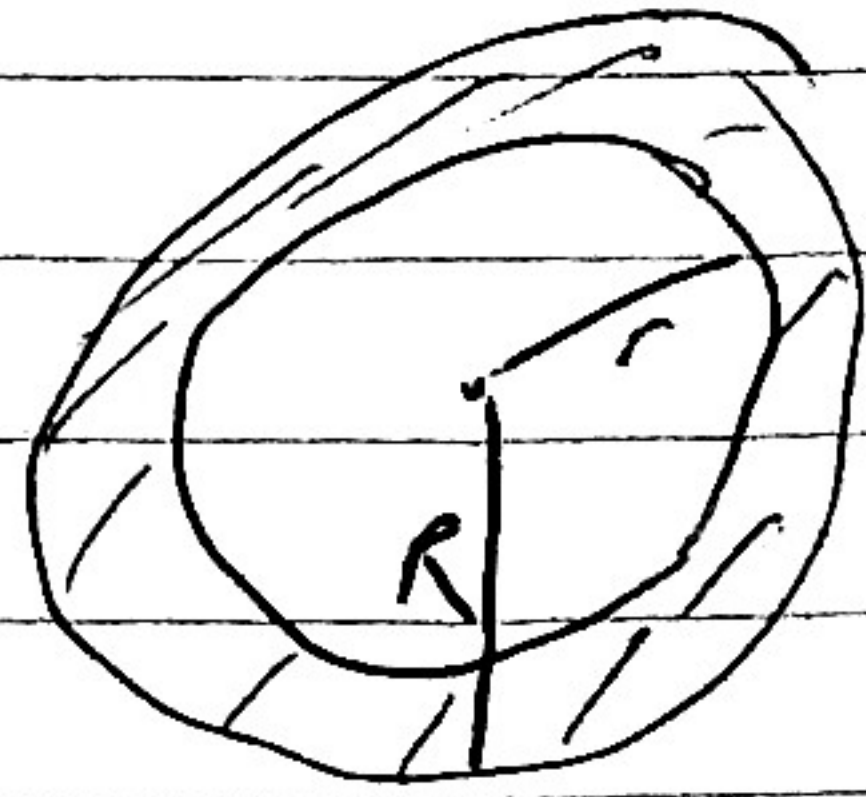
$$= 0.0078 \text{ m}$$

$$= 7.8 \text{ mm}$$

ii)

$$A = \pi (R^2 - r^2)$$

$$r = 0.1 - 0.0078 = 0.0922$$



$$= \pi (\text{too } 0.1^2 - 0.0922^2)$$

$$= 4.71 \times 10^{-3} \text{ m}^2$$

$$\times L = 4.71 \times 10^{-3} \times 0.6$$

$$= 2.826 \times 10^{-3} \text{ m}^3$$

$$\times \text{density} = 2.826 \times 10^{-3} \times (1.74 \times (1,000,000))$$

$$= 4917.24 \text{ g}$$

$$= 4.917 \text{ kg}$$

+ 2 end caps

$$4.917 \times (2 \times 1) = 6.917 \text{ kg}$$