

Question 1.

Material properties for the novel snack:-

1. Light / low density (as its carried around by people enjoying outdoor activities).
2. Recyclable (outdoor people enjoy the environment they are in).
3. cheap / cost effective (disposable packaging cannot be expensive)
4. Porous surface (to ~~allow~~ absorb print ink for the design).
5. Readily available (a material that is easy to procure, something in abundance)

The material I would use to package this novel snack would be cardboard, for the following reasons:-

1. It is very durable and can be manipulated into any shape without using a great deal of energy.
2. It prevents moisture from infiltrating the product.
3. It is cheaper than plastic, so profit margins would be greater then using plastic.

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4. It is widely used to package food, proving its use.
5. It is fully recyclable, a winner for outdoor people.
6. It is incredibly light (low density).
7. It is porous, so holds ink well. (as in labelling)
8. It is also biodegradable, so if it was discarded in the outdoor environment, it would eventually breakdown and become no risk to wildlife.

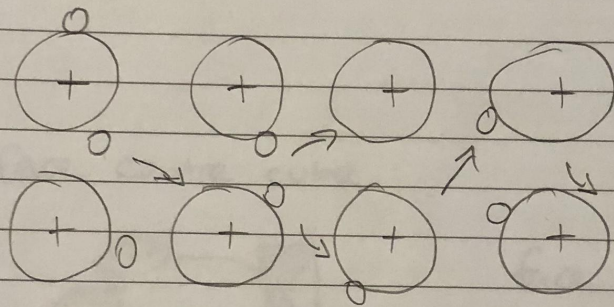
Because cardboard is recyclable, its manufacture is reduced significantly (from new), CO₂ emissions are far less than manufacturing the same amount ~~or~~ in another packaging material.

To summarise, I'd use cardboard to package & label my snack product. It is readily available, cheaper than plastic, recyclable, lightweight, can be printed on, strong, and is already proven to be a very reliable product in the food manufacturing sector.

Question 2.

- a) Metallic bonding is the movement of electrons between metal atoms. Metal atoms have outer shells with electrons in them, they are free to move (this is known as delocalised).

Metallic bonds are what gives metal its mechanical properties, such as strength, ductility, and also electrical conductivity (electron flow is electricity).



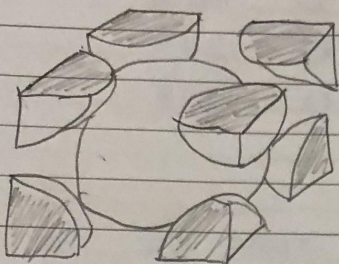
When the outer shells, or electron orbitals, overlap, electrons are shared between the atoms, hence electron movement.

Valency is related to how many electrons there are in the outer shell, ~~the~~ electron orbital, and how they react with other electrons.

So, a metal with a valency of 2 is stronger than metals with a valency of 1 because it has twice the combining power, as ~~a~~ a valency of 2 is double the valency of 1, its bond is stronger.

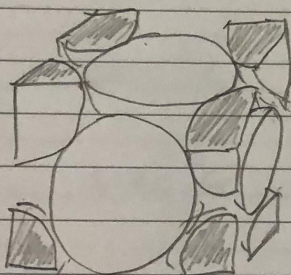
Question 2 continued.

b) i) Base centre cube



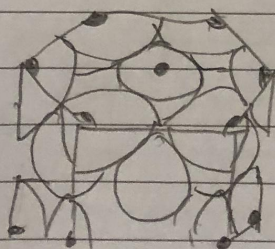
Base Centre cube, 1 atom positioned in the centre, with a section of an atom in each corner of the cube. These corners are sharing atoms with other cubes in the material.

ii) face centre cube.



face centred cubes, tighter packed than BCC, no atom in the centre but on the side faces of the cube. all corners and faces of a FCC are sharing atoms with other cubes in the material.

iii) Hexagonal close packed



Hexagonal close packed (which is really hard to draw by the way!!!) are layers of packed overlies, atoms are packed really close.

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Question 2 continued.

c) Packing ratios of :-

HCP is 0.74

FCC is 0.74

BCC is 0.68

d) The state of the mixture at 1800°C is liquid.

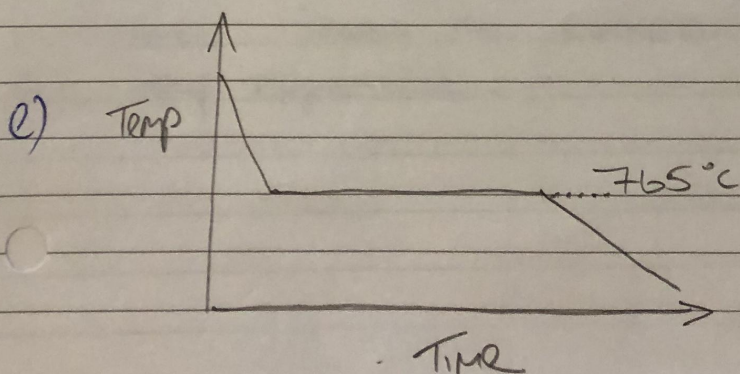
When cooled slowly, the following phases are observed at these temperatures:-

1650°C starting to change from liquid to solid. ($\beta + L$)

800°C Now a solid ($\beta \text{ Ti}$)

600°C Now at Ti_2Ni_2 .

The mixture is cooling from a liquid state, through to a solid state, passing through α and β titanium. The eutectoid reaction, $\beta \rightarrow \text{Ti}_2\text{Ni}_2$ occurs when the temperature drops below 765°C .



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Question 3.

a) For the racing car chassis, I would select Aluminium Alloy. reasons being:-

1. Lightweight, for racing car speeds.
2. Corrosion resistant, in case it is raining.
3. Strong; to sustain huge stresses acting on it.
4. Ductile, can be formed without losing strength.
5. Not brittle, so won't shatter on impact.
6. High strength-to-weight ratio, ideal for such a purpose as a racing car.

b) I wouldn't choose any wood, in case a crash causes a fire. I wouldn't choose any ceramics as they are too brittle and would shatter on impact. B4C looked an obvious choice at first, but it is very expensive and difficult to machine and form.

c) Carbon fibre, as a property to use in a racing car, is low in weight, has a high tensile strength, is very stiff and also has a high temperature tolerance, ideal to complement a steel chassis. But very expensive.

Question 3 continued.

c) Steel space frames are cheaper, and work well with the carbon fibre tubes as the weight is balanced out between the two materials. It is heavy (high density), but if used with carbon fibre, then this property is acceptable.

d) When we weld together steel components, we are subjecting the base and parent metal to extreme heat. The heat zone will go expansion - contraction during the weld + cooling process. It can cause embrittlement, cracking, etc. which affects the fatigue strength, and ductility.

Brazing is a better quality because it is using a lower melting point metal to 'bond' the base and parent metal together, thus reducing chances of embrittlement and cracking.

e) Two other alternatives to join a space frame chassis to each other would be bonding using adhesive or glue, or using fasteners, such as rivets or bolts.

Adhesives have improved a lot over the years, it is a lightweight alternative.

Rivets are stronger but they have a greater density.

Question 4.

a) The material to be selected to manufacture a cylinder needs to have the following properties:-

- low density, as the diver needs to bear the full weight of the cylinder.
- Corrosion resistant, its going into the sea!!
- Ductile, to form it into a cylinder. (malleable).
- Yield strength, high elasticity to cope being under pressure holding the gas.

b) Aluminium = Yield strength is suitable, density is favourable. Already used in lightweight circumstances such as aeroplanes. Also corrosion resistant.

Steel Alloy = lower yield strength but adequate. Maybe too heavy for this application, corrodes.

Stainless Steel = Significant yield strength, maybe too heavy. Although already used as storage tanks, a diver needs to transport it on his/her body, so must be lightweight.

Carbon Fibre = Impressive yield strength, very low density, but so expensive.

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Question 4 continued.

b) if I were to choose one of these materials, I would choose aluminium, because its low density, strong, ductile, and a proven performer in applications of high stress such as aircraft.

c) ?

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

$$P = 20 \times 10^6 \text{ Pa}$$

$$d = 100 \times 10^{-6} \text{ m}$$

$$\sigma = 241 \times 10^6 \text{ Pa. (Al)}$$

$$= \frac{2 \times 20 \times 10^6 \times 100 \times 10^{-6}}{241 \times 10^6}$$

$$= \frac{2 \times 2000}{241 \times 10^6}$$

$$= \frac{4000}{241 \times 10^6} = 16.6 \times 10^{-6} \text{ m} / 16.6 \text{ mm.}$$

ii) End caps $1 \text{ kg} + 1 \text{ kg} = 2 \text{ kg}$ total.

Circumference $C = \pi d = \pi \times 100 \times 10^{-6}$
 $= 1.885 \times 10^{-6}$

Please ignore.

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Question 4 continued.

work out Circumference $C = \pi d$

$$\begin{aligned} &= \pi \times 100 \times 10^{-6} \\ &= 314.2 \times 10^{-6} \end{aligned}$$

length of cylinder is 600mm
width of material is 314.2mm.
width of material is 16.6mm

$$\text{Area} = l \times w \times d$$

$$\begin{aligned} &= (600 \times 10^{-6}) \times (314.2 \times 10^{-6}) \times (16.6 \times 10^{-6}) \\ &= 0.188 \text{ m}^3 \end{aligned}$$

Aluminium is 2.7 g/cm^3

so,

$$\begin{aligned} &= (2.7 \times 10^3) \times (0.188 \times 10^3) \\ &= 5.076 \text{ kg.} \end{aligned}$$

Plus 2 caps at 1kg each = 7.076 kg