Materials Theory

Smart, Modern and composite materials

Name _____

Technology group _____

Smart materials

Smart materials are _____ that have one or more _____ that can be significantly changed in a controlled fashion by _____ stimuli, such as stress, temperature, moisture, ph, electric or _____ fields.

magnetic properties materials external

Complete the questions below

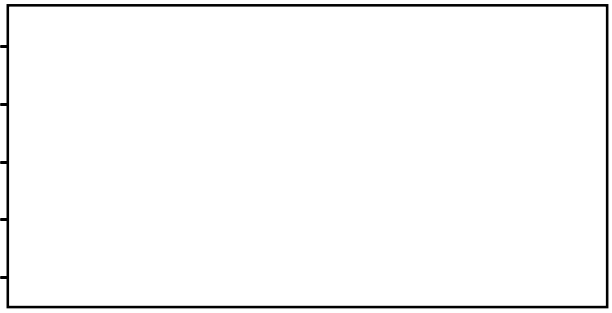
1. What is polymorph and how can it be used?

_____
_____
_____

2. SMA is also called _____

3. Using notes and sketches, describe a physical property of SMA.

_____
_____
_____
_____
_____



Smart materials

4. What are thermochromic inks? Include a description of one practical application.

_____

_____

_____

5. With the aid of notes and sketches, describe a practical application of hydrochromic inks.

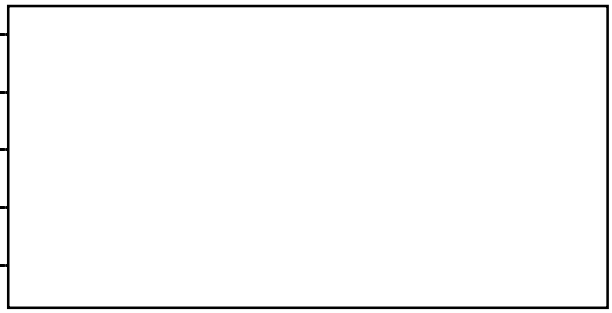
_____

_____

_____

_____

_____



6. What happens to photochromic inks when the UV level increases?

_____

_____

_____

7. Aroma pigments are often used in magazines. Describe an example.

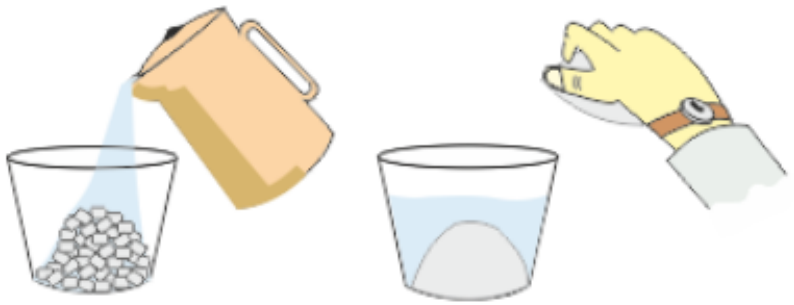
_____

_____

_____

SMART MATERIALS - POLYMORPH

Polymorph is a thermoplastic material that can be shaped and reshaped any number of times. Supplied as granules. Heated in hot water - at 62 degrees centigrade, the granules form a mass of 'clear' material that can be shaped into almost any form. On cooling it becomes as solid. Suitable for 3D modelling, as it can be shaped by hand or pressed into a shape through the use of a mould.



SMART MATERIALS
SHAPE MEMORY ALLOY (SMA)

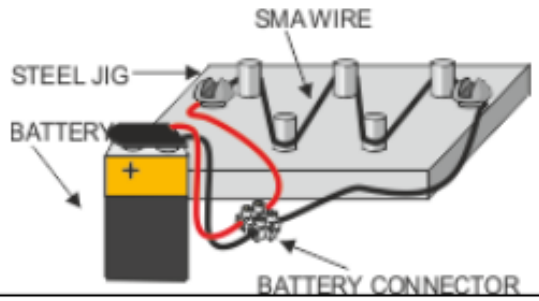
SMA wire also called 'Nitinol', as it is a composed of nickel and titanium. Looks like ordinary wire and has many of the same properties.
SMA has a memory - for example, if it is folded to form a shape and then heated above 90 degrees (centigrade) it returns to its original shape.

TWISTED SMA WIRE HEATED TO 90 DEGREES

RETURNS TO ORIGINAL SHAPE

SMART MATERIALS
SHAPE MEMORY ALLOY (SMA)

SMA can be 'programmed' to remember a shape. Clamp the SMA in position and pass an electric current through it. If the wire is now folded into another shape and then placed in hot water, it returns to the original 'programmed' shape.



SMART MATERIALS
THERMOCHROMIC INKS

Thermochromic inks change colour in response to changes in temperature. These inks have serious applications such as in the food industry. They can be used to indicate when a packaged food has reached the correct temperature in an oven. They are also used in forehead thermometers.

SMART MATERIALS - HYDROCHROMIC INKS

Hydrochromic inks are those that change colour when they make contact with water.
A plastic moisture tester is pushed into the soil alongside the plant.

If the water content of the soil is at the right level, the colour of the moisture tester should remain blue. However, if the soil becomes dry, the colour changes to yellow.

SMART MATERIALS - PHOTOCHROMIC INKS

Photochromic ink darkens, as the light level increases. Some photochromic inks change colour. In fact, it is UV light that causes the darkening of the ink, which means the ink works best in natural light. This special ink has two main applications; sunglasses and spectacles.

MEDIUM UV LIGHT LEVEL

SMART MATERIALS - AROMA PIGMENTS

These are inks / paints that produce an aroma when scratched. They are popular in 'scratch and sniff' products, such as perfume samples etched into women's magazines. The reader scratches the sample aroma pigment, releasing an aroma matching the selected perfume.

HYDROCARBON - ENCAPSULATING POLYMERS

Polymers that absorb oil, forming a rubbery substance. They are environmentally 'friendly', developed to manage hydrocarbon-based liquid spills.
A potential practical application is at petrol / diesel fuel stations. If a spill at the pump takes place, a HC Polymer can be applied, absorbing the fuel, safely. It can then be used as a solid fuel and even burned.

Exam Question

This question is about materials technology.

2. (a) The sports training shirt below has been made using a thermochromic smart material.

Explain why a thermochromic smart material has been used. [3]

.....

.....

.....

.....

.....

Modern materials

Developments made through the invention of new or improved processes eg Graphene, Metal foams and Titanium.

1. What are nanomaterials? Include a general description of their use

_____
_____
_____
_____

2. What are Metal foam?

_____
_____
_____

3. List two physical properties of metal foams AND describe two practical applications

_____
_____
_____
_____
_____
_____

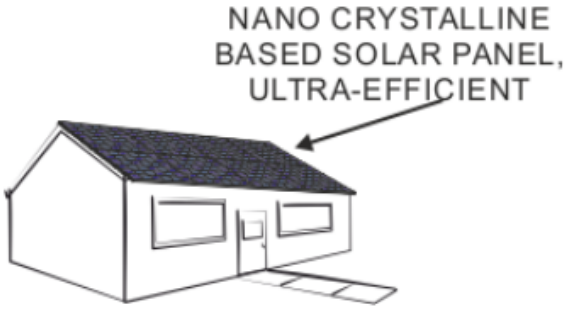
1. WHAT ARE NONOMATERIALS ?

A single particle of a nanomaterial, has an average size between 1 to 100 nanometres (nm), which is extremely small. 1 nano is regarded as equal to the distance across three atoms.

Some nanomaterials are special coatings use to protect surfaces and resist damage. They can be used on; Sporting equipment: Golf clubs, tennis racquets, lacrosse sticks, socks and phone displays.

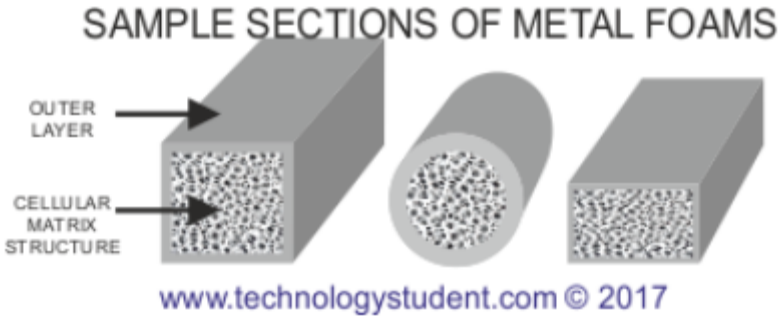
2. NANO-CRYSTALLINE MATERIALS

These are materials with a nano-grain size of less than 100nm.
One practical application is in ultra-efficient solar panels, manufactured from nano-crystalline materials, converting sunlight into electricity, very efficiently.



WHAT ARE METAL FOAMS ?

Metal foams are solid structures, usually composed of a dense outer layer, with the inner portion in the form of a matrix of pores. The foams possess the property of 'porosity', allowing air/gas and even liquids to pass through them and they are based on materials with a similar structure, such as natural bone, pumice stone and natural sponges. They have an internal cellular matrix structure. Aluminium, tantalum and titanium, are the metals that are commonly manufactured as foams.



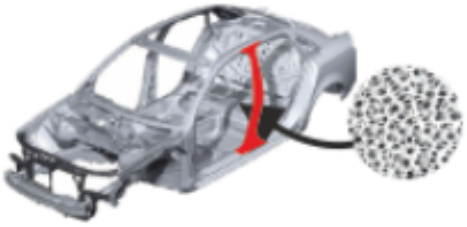
ENHANCED PROPERTIES OF METAL FOAMS

Metal foams have enhanced physical properties compared to their solid form. For instance, aluminum metal foam has an even lower thermal conductivity, than the solid or tube versions. Metal foams can be recycled in the same way as other metals.

POROUS
LEIGHTWEIGHT
HIGH COMPRESSIVE STRENGTH
LOW THERMAL CONDUCTIVITY

PRACTICAL APPLICATION - METAL FOAMS

A LOAD BEARING STRUCTURE
COMPRESSIVE STRENGTH



IMPACT ABSORPTION
CRUMPLE ZONES

LOW CONDUCTIVITY
HANDLES TO POTS

VIBRATION ABSORPTION
PIPE BRACKETS

Composite Materials

Composite materials (composites), are materials composed of ___ or more component parts. These component parts may have different _____ or chemical _____ and when carefully inspected, they appear as separated parts _____ together forming a _____ material.

Two Composite properties physical bonded

1. What is a composite material?

_____
_____
_____

2. How are the physical properties of a composite material superior that those of a single material?

_____
_____
_____

3. Describe one advantage of the composite 'steel reinforced concrete' over normal concrete?

_____
_____
_____

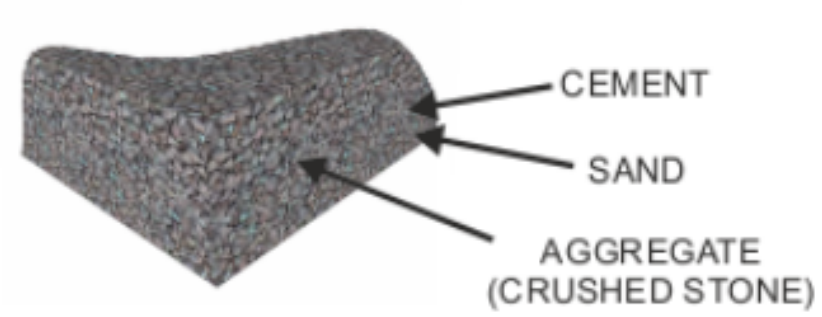
WHAT ARE COMPOSITE MATERIALS ?

Composite materials, also called Composites. Composed of two or more materials, that have different properties. The materials are bonded together and their properties are combined.

Composite materials combine the physical properties of the individual materials they are made up of, forming a superior material.

KEVLAR - REINFORCED CONCRETE
PLYWOOD - GLASS REINFORCED FIBRE
CARBON FIBRE

COMPOSITE MATERIALS - CONCRETE



Used in construction, roads, brick laying, building and many more.
Concrete is composed of a number of materials, that combine to form this versatile building material. Most concrete is made up of Portland Cement, aggregates (gravel, crushed stones) and sand. Water is added to the mix.

COMPOSITE MATERIALS - STEEL REINFORCED CONCRETE

Concrete is weak when put under tension. If reinforced with steel rods, it is can withstand tensile forces.

Reinforced concrete has long steel rods passing through its length, adding great strength to the final composite material. Able to resist tensile forces.

Used for bridge building, skyscrapers and general large scale construction.

COMPOSITE MATERIALS GLASS REINFORCED PLASTIC(GRP)

Composed of strands of glass and woven to form a flexible fabric. Placed in a mould and polyester resin is added, followed by a catalyst (to speed up the reaction). Allowed to dry/cure.
The resulting material is strong and light. Can be sanded and painted.

Used for canoes, car bodies, small swimming pools, water tanks, surfboards, small boat hulls.

COMPOSITE MATERIALS
CARBON FIBRE REINFORCED POLYMER (CFRP)

Carbon fibre is woven into a textile material. Epoxy resin is added and allowed to cure.

The resulting material is very strong and light. An improvement on glass fibre reinforced plastic, although much more expensive.

Uses; Aerospace, expensive sports cars, competition bicycles and motorbikes.

COMPOSITE MATERIALS - KEVLAR

Kevlar® is a liquid, converted into a fibre (called aramid fibres) and woven into a textile material. Extremely strong, lightweight, corrosion and heat resistant.

Has a high tensile strength to weight ratio, far exceeding steel, carbon fibre and specialist alloys.

Uses when combined with other materials: bullet proof jackets, armour for military vehicles and planes. Formula 1 fuel tanks.