Design & Technology
(Product Design)

DTBase©

OCR A-Level

Smart and Modern Technologies in Products (6.3a)

Materials required for questions

- Pencil
- Rubber
- Calculator

Instructions

- Use black ink or ball-point pen
- Try answer all questions
- Use the space provided to answer questions
- Calculators can be used if necessary
- For the multiple choice questions, circle your answer

Advice

- Marks for each question are in brackets
- Read each question fully
- Try to answer every question
- Don’t spend too much time on one question

Good luck!

Q1. Which **one** of the following is a smart material?

A Shape memory alloy (SMA)

B Polyester resin

C Medium density fibreboard (MDF)

Q2. Which one of the following materials will respond quickly to a change in ultraviolet (UV) light?

A Shape memory alloys

B Photochromic materials

C Carbon nanotubes

Q3. What is the definition of a smart material?

A A material that has been engineered to have additional properties

B A material whose physical properties change in response to external stimuli

C A material that is available in large sheets

Q4. What material is used to make dental braces?

A Nitinol

B Zinc

C Aluminium

Q5. The glasses in the image below have been manufactured with smart materials.

Q5a. Identify two smart materials that could have been used in the manufacture of the glasses to improve their usability and function. Justify each of your answers **(4 marks)**

Q5b. Identify and explain one negative implication of using smart materials in the manufacture of the glasses. **(3 marks)**

Q6. The image below shows a walkie talkie.

Identify one smart that could be used in the design of the walkie-talkie shown in the image. Justify how this smart material would improve the design. **(2 marks)**

Q7. State three different stimuli that can cause a change in the property of a smart material. **(3 marks)**

Q8. Photo-chromic glass is one type of smart material that reacts to ultraviolet (UV) light. Reactive glass is another form of modern smart material. Explain two benefits and one drawback of reactive glass. **(9 marks)**

Q9. Explain how the inclusion of smart materials in electronic products aids the end-of-life disassembly. **(4 marks)**

Q10. Explain how shape-memory alloys are used in medical procedures to perform functions that conventional materials could not achieve. Include in your answer:

- How the material works
- One specific medical application
- The functional benefit it provides over traditional materials

(6 marks)

Answers

Q1. A
Q2. B
Q3. B
Q4. A

Q5a.
Possible smart materials may include:

- Nickel titanium (Nitinol/shape memory alloy/SMA) in frame of the glasses (1). It can be bent (sat on) and will not break (1).
- Photochromic pigments in lens (1). They could be added to turn the glasses into sunglasses in the UV light (1).
- Self-healing material or coatings (1). This can prevent corrosion and self-heal after small cracks/scratches from impact of being dropped/used outdoors (1).
- Polymorph in nose pads (1). This can be used to shape to different people's noses/prevent slippage (1).

Any other valid suggestion of a smart material that changes/reacts to stimuli and changes – must be related to improving functionality and usability of glasses.

Q5b.
Possible negative implications may include:

- Adding smart materials in the manufacture of the glasses may make the glasses harder to be recycled (1) as the materials will not be as pure (1), therefore will be harder to reform and re-use. (1)
- The materials may take longer to decompose (1) Glasses have become items that are regularly changed and updated (1), so they are more likely to have a short shelf life (1).
- This will be a more complex manufacturing process (1) which would increase the cost (1) making the glasses more expensive/ give the company less profit (1)
- Any other valid suggestion.

Q6.
Possible smart or modern materials may include:

- Phosphorescent pigment (1) could be used to make the walkie-talkie glow in the dark (1).
- Any other valid suggestion

Q7.
State three different stimuli that can cause a change in the property of a smart material.

One mark per relevant point.

A change in response to:

- light
- temperature
- electricity
- pressure.

This list is not exhaustive. Accept any other valid responses.

Q8.
Any two explanations of a benefit and one explanation of a drawback that include identification of the benefit/drawback (1) and linked justifications of that benefit/drawback (1) + (1).

Benefits:

- Reactive glass turns opaque / clears when an electrical current is applied (1) providing immediate change between privacy / protection and clear glass (1) unlike photochromic glass which slowly tints in reaction to UV light/ is not controllable (1)
- The application of current / opacity can be automatically controlled (1) as switching can be via control circuits (1) which can react to external stimuli via sensors (1)
- Reactive glass can be used to provide user safety (1) by reducing light to a safe level that will not damage eyesight / distract the user (1) in applications such as autodimming rear view mirrors, welding visors etc (1)
- No requirement for curtains/blinds (1) providing initial/replacement cost savings / allowing a choice of aesthetic approach (1) and ongoing savings on maintenance/cleaning (1)
- Allows control of solar heat gain (1) reducing air conditioning costs (1) and providing a more comfortable user environment / reducing environmental impacts (1)
- Changes instantly from clear to opaque and opaque to clear (1) making it ideal for situations where privacy is needed (1) therefore allowing more efficient working / use of the building (1)

Drawbacks:

- The default state of reactive glass is clear or opaque / transparent (1) therefore if the circuit is broken / power is lost (1) the glass will immediately change resulting in an unwanted / unexpected change (1)
- High cost of reactive glass installations (1) has an impact on construction budgets (1) and may be unaffordable for many clients / end users (1)
- Reactive glass has a limited service life (1) so may degrade in performance after 10/20 years (1) meaning that it will need to be replaced, unlike standard glass that should last the life of the building (1)
- Reactive glass requires the power to be constantly on to remain 'in state' (1) this results in electricity usage / costs (1) increasing the running cost of the building / impacts on operational budgets (1)

Accept any other appropriate response

Q9.

Indicative content

- Shape memory polymers (SMP) and shape memory alloys (SMA) are starting to be used to replace traditional polymer fixings.
- Active disassembly at the end of a product's life reduces the amount of human interaction needed at this phase of the product lifecycle.
- At the end of the product's useful life the product may be heated or exposed to an electric current. These stimuli cause a change in shape of the fixing or fastening.
- The reduction in size of the fixing or fastening or the adjustment in shape of a cantilever clip etc would allow for the fixing to become loose.
- The contraction of the SMA or SMP component would enable either partial or complete removal of the joint.
- The product may be vibrated to help separate the device into component parts. This list is not exhaustive. Accept any other valid responses.

Q10.

- How it works: Nitinol (Nickel-Titanium alloy) "remembers" a trained shape and returns to it when heated to a specific temperature (e.g., body temperature).
- Medical application: Self-expanding vascular stents.
- Functional benefit: The stent can be compressed, inserted via catheter, then expands automatically in the blood vessel without mechanical

opening—minimally invasive, reduces surgery risk and recovery time compared to permanent rigid implants.

- Why conventional materials can't do this: Traditional metals (e.g., stainless steel) are not thermally responsive and cannot self-deploy in this way.
- Additional benefit: Nitinol is biocompatible and flexible, reducing vessel damage.