

Design & Technology

Edexcel GCSE

Smart Materials

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. A smart material is one which

- A** conducts electricity
- B** protects against fire
- C** reacts to a stimulus

Q2. Identify the smart material used to darken windows in bright sunlight.

- A** Thermochromic pigment
- B** Photochromic pigment
- C** Shape memory alloy

Q3. Nitinol is a shape memory alloy made from which two metals?

- A** Nickel and titanium
- B** Iron and carbon
- C** Copper and zinc

Q4. Which stimulus makes quantum tunnelling composite (QTC) conduct electricity?

- A** Heat
- B** Light
- C** Pressure

Q5. Which product would most likely use a thermochromic pigment?

- A** A baby feeding spoon
- B** A sunglasses lens
- C** A pressure-sensitive switch

Q6. What does it mean when the change in a smart material is "reversible"?

- A** It can only be used once
- B** It changes back when the stimulus is removed
- C** It changes colour twice

Q7. This question is about smart materials.

Q7a. Write the letter of the correct description next to each smart material in the table below. **(3 marks)**

A A material that changes colour when exposed to UV light

B A material that changes from an insulator to a conductor

C A material that changes colour when exposed to heat

Photochromic	
Thermochromic	
Quantum tunnelling composite	

A shape memory alloy (SMA) has been used to make a pair of glasses frames.

Q7b. Explain why a shape memory alloy has been used for the glasses frames. **(2 marks)**

Q8. Decorative wire flowers are bent into shape using a bending jig. Prototype wire flowers were made using shape memory alloys (SMAs) to test the design before producing the final product from copper wire.

Explain one reason for using SMAs to make the prototype wire flowers. **(2 marks)**

Q9. The body of a kettle is made from a smart material. As the water boils, the kettle changes colour from blue to red.

Q9a. State the name of the smart material used for the kettle body. **(1 mark)**

Q9b. Discuss why consumers would purchase a kettle that changes colour when in use. **(3 marks)**

Q10. Some wall stickers contain a phosphorescent pigment that glows in the dark.

Q10a. Phosphorescent pigment is a smart material. Identify one other smart material. **(1 mark)**

Q10b. Describe two other ways designers are using smart materials in products to improve their functionality or benefit the users. **(4 marks)**

1

2

Answers

Q1. C

Q2. B

Q3. A

Q4. C

Q5. A

Q6. B

Q7a.

One mark for each correct response (3 marks). Only acceptable responses:

- Photochromic: A (changes colour when exposed to UV light)
- Thermochromic: C (changes colour when exposed to heat)
- Quantum tunnelling composite: B (changes from an insulator to a conductor)

Q7b.

Answers must relate to shape memory alloys and be relevant to the glasses frames. 1 mark for a reason and 1 mark for an appropriate explanation. For example: shape memory alloys have elastic properties (1), which allow the frame to be bent without breakage or damage (1); buckled frames can be returned to their programmed shape (1). Credit any other appropriate response.

Q8.

Any one reason for using SMAs (1 mark) and a linked justification of that reason (1 mark):

- If they have been bent into a shape that is not right/not big enough they can be heated (1), which means they go back to their original shape/can be used again to test a new shape/saves resources (1)
- Once the correct shape/size/profile has been achieved, the material can be heated (1), which means it will go back to its original shape/can be used for something else (1)
- It is easier to reset/straighten SMA wire than copper wire (1) because it can be heated rather than pulled through a die (1)

Q9a.

Thermochromic (1 mark). Only acceptable response.

Q9b.

Up to 3 marks for a clear discussion. Maximum 1 mark for simply listing one reason; maximum 2 marks for multiple reasons without a clear discussion. Full marks for a discussion of the impact that makes the customer choose the kettle. For example:

- Changing colour indicates the water in the kettle is still hot (1) and doesn't need to be reheated (1); in the long term this could save on electricity bills (1)
- Changing colour on boiling acts as a safety feature (1), warning the consumer of the temperature of the water inside (1), preventing accidental burns (1)
- Other reasons: novelty; aesthetics; child safety/educational; can be switched off before boiling for water needed at a lower temperature

Q10a.

One from (1 mark): thermochromic, photochromic, self-healing material, shape memory alloy (SMA) or shape memory polymer, super hydrophobic, BioLogic fabric. Accept any named smart material other than phosphorescent.

Q10b.

Two ways described (4 marks). For each: 1 mark for showing understanding of what the smart material is/does, and 1 mark for describing how it improves the function of the product/benefits the user. E.g.:

- Thermochromic paints and polymers change colour with temperature (1), e.g. a baby spoon lets a parent know when food is too hot; thermometers; clothing (1)
- Hydrochromic ink/paint changes colour when wet (1), e.g. murals that brighten streets, benches that warn when wet (1)
- Self-healing paint/coatings/concrete (1) repair fine cracks before they worsen, e.g. scratches in cars (1)
- Nanotechnology fibres protect against odour and bacteria (1), e.g. medical textiles, wound dressings, sportswear (1)
- Super hydrophobic coatings repel water (1), keeping surfaces or fabrics clean and avoiding corrosion (1)