

# Design & Technology

## A-Level

# Smart materials

## Multiple Choice

### Materials required for questions

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- Pencil
- Rubber
- Calculator

### Instructions

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- Use black ink or ball-point pen
- Try answer all questions
- Use the space provided to answer questions
- Calculators can be used if necessary
- Use a cross in the box to mark you answer



### Advice

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- 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)

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- |          |                                 |                          |
|----------|---------------------------------|--------------------------|
| <b>B</b> | Polyester resin                 | <input type="checkbox"/> |
| <b>C</b> | Medium density fibreboard (MDF) | <input type="checkbox"/> |

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

- |          |                     |                          |
|----------|---------------------|--------------------------|
| <b>A</b> | Shape memory alloys | <input type="checkbox"/> |
| <b>B</b> | Reactive glass      | <input type="checkbox"/> |
| <b>C</b> | Carbon nanotubes    | <input type="checkbox"/> |

**Q3.** What is the definition of a smart material?

- |          |   |                          |
|----------|---|--------------------------|
| <b>A</b> | A material that has been engineered to have additional properties           | <input type="checkbox"/> |
| <b>B</b> | A material whose physical properties change in response to external stimuli | <input type="checkbox"/> |
| <b>C</b> | A material that is available in large sheets                                | <input type="checkbox"/> |

**Q4.** Smart materials have?

- |          |  |                          |
|----------|--|--------------------------|
| <b>A</b> | Properties that can significantly change | <input type="checkbox"/> |
| <b>B</b> | Good conducting properties               | <input type="checkbox"/> |
| <b>C</b> | Weak covalent bonds                      | <input type="checkbox"/> |

**Q5.** What material is used to make dental braces?

**A** Nitinol

☐

**B** Zinc

☐

**C** Aluminium

☐

**Q6.** What properties does phosphorescent pigment have?

**A** Never ending light source

☐

**B** Absorbs heat, heat energy released in dark

☐

**C** Absorbs light and releases it in the dark

☐

**Q7.** Why might quantum tunnelling composites be used in a winter coat?

**A** They have excellent thermal capacity

☐

**B** Allow user to use electronics without hands

☐

**C** Protect user from UV radiation

☐

**Q8.** Reactive glass could reduce energy consumption by?

**A** Storing heat energy and turning it into electricity

☐

**B** Changing transparency with light to keep room temperatures constant

☐☐

**C**      Increasing incident light rays into houses creating more heat energy

**Q9.** Explain **three** features in the design of the smartphone shown in Figure 12 that have been impacted by smart materials and the miniaturisation of components **(9 marks)**

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**Q10a.** Phosphorescent pigments have many practical applications. What are phosphorescent pigments? **(2 marks)**

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**10b.** Describe **one** applications of phosphorescent pigments **(3 marks)**

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**Q11.** Shape Memory Alloys (SMA) are often used in fire alarms and air-conditioning units.

Explain the smart property of a Shape Memory Alloy (SMA) that makes it suitable for these applications. **(2 marks)**

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**Q12.** What is polymorph? Your answer must include a reference to a practical application **(3 marks)**

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**Q13.** Thermochromic pigments have many innovative applications.

**Q13a.** Outline the household applications of thermochromic pigments. **(4 marks)**

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**Q13b.** Discuss the advantages and disadvantages of thermochromic pigments. **(4 marks)**

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**Q14.** New technologies have transformed products in innovative ways.

Smart glasses often used in the glazing of buildings, discuss the benefits of using smart glass in this application **(3 marks)**

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## Answers

Q1. A

Q2. B

Q3. B

Q4. A

Q5. A

Q6. C

Q7. B

Q8. B

Q9.

- The phone is thin (1) as developments in battery technology have allowed the miniaturisation of the battery pack (1) while maintaining battery life/reducing weight/less bulky to carry (1).
- Increased functionality/storage capacity features, e.g. camera, torch, pay scan, etc. (1) due to miniaturisation of electronics (1) so the consumer can use it for a greater range of tasks/store more data, pictures, videos, music, games, etc. (1).
- Smart materials have been used to develop the colour LCD screen (1) enabling clear/detailed/high-quality images (1), resulting in increased consumer appeal.
- Smart material is used in the piezo-electric transducers (1), enables reasonable quality sound/music without the use of bulky speakers (1) so consumers can access their music anywhere (1).
- The development of touch screen technology (1) has reduced the need for physical buttons/keyboards on the phone (1), allowing improved looks, clean aesthetic lines/leading to easier use of the phone /improved ergonomics (1).

Q10a.

- Phosphorescent pigments are manufactured from phosphors
- Material absorbs light and emits it slowly over time
- Pigment is often used in novelty toys, safety signs

10b.

**Application 1 – luminous watch:**



- Absorbs suns and artificial lights energy
- In the dark, energy is slowly released
- Light is actually also released during the day however we do not notice it
- An advantage of it is the glow allows the user to read the time in the dark
- It is also aesthetically pleasing

#### **Application 2 – glow in the dark toys**

- Material it is made from contains phosphorescent pigment
- Absorbs light energy during day time
- Slowly releases energy in form of light
- More apparent at night time

#### **Q11.**

- A change in stimulus (temperature/electricity) (1)
- produces a change in shape/movement (1)

#### **Q12.**

- Polymorph is a thermoplastic material
- Can be shaped and reshaped any number of times
- Normally supplied as granules looking like small plastic beads
- When heated with hot water, granules become a solid material that can be moulded
- Applications include: ergonomic handles, 3D modelling

#### **Q13a.**

- Used as a safety indicator in products that might be used in the kitchen (1)
- Used as a safety indicator in products such as cutlery used by children (1)
- Used as a safety indicator in products used in the bathroom e.g. bath toys (1)
- Used on containers to register correct temperatures for the storage of foods (1)
- Used as a thermometer e.g. forehead thermometer/room thermometer/fish tank thermometer (1)
- Used for novelty effect e.g. décor/children's toys / mugs / cups (1)
- Used in food storage / fridges to indicate correct/safe temperature (1)
- Radiator warning label / sticker (1)

### **Q13b.**

#### **Advantages**

- Colour changes give an indication of safe temperature (1)
- Removes need for external thermometer (1)
- Encourages children to make safety checks (1)
- Gives novelty value (1)
- Clear visual warning / indication of temperature (1)
- Ease of use (1)
- Thermochromic temperature indicators are cheaper than conventional thermometers (1)

#### **Disadvantages**

- Difficult to achieve a precise temperature reading (1)
- Limited range of colours (1)
- Become less effective over time (1)
- Can lead to complacency (1)
- Can be slow to react for some applications (1)
- Products can be more expensive than conventional products (1)

\*Do not accept answers that state 'cheaper' or 'more expensive' unless qualified

### **Q14.**

- Provides shade from harmful UV rays reduce glare (1)
- Glass can change opacity properties / tint the window (by the application of electric input) (1)
- Provides privacy when made opaque (1)
- Can be used for energy saving windows to prevent heat passing (1)
- Can reduce secondary greenhouse emissions through excessive heating/a-c (1)
- Can be used for advertising/promotion/gimmick (1)
- Eliminates need to blinds/curtains (1)
- Reduces gold fish bowl effect in/out side (1)

- Allows control of natural light levels (1)