

## Design & Technology

# Smart materials

### Materials required for questions

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- Pencil
- Rubber
- Calculator

### Instructions

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- Use black ink or ball-point pen
- Try to 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

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- Marks for each question are in brackets
- Read each question fully
- 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 Ultra Violet (UV) light?

- A**      Shape memory alloys
- B**      Reactive glass
- 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.** Smart materials have?

- A**      Properties that can significantly change
- B**      Good conducting properties
- C**      Weak covalent bonds

**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 smartphones 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** application 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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**Q13a.** Thermochromic pigments have many innovative applications. 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 glass is often used in the glazing of buildings. Discuss the benefits of using smart glass in this application **(3 marks)**

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[illegible]



**Q16.** Quantum tunnelling composites change from being electrical insulators to electrical conductors when pressure is applied to them. Give three advantages of using QTCs. **(6 marks)**

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**Q17a.** Describe how a piezo electric material work **(2 marks)**

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**Q17b.** Give a specific example of where piezo electric material may be used **(1 mark)**

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## Answers

Q1. A

Q2. B

Q3. B

Q4. A

Q5. A

Q6. C

Q7. B

Q8. B

Q9.

- Smartphones are thin (1) as developments in battery technology have allowed the miniaturisation of battery packs (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 consumers can use smartphones for a greater range of tasks/store more data, pictures, videos, music, games, etc. (1)
- Smart materials have been used to develop colour LCD screens (1) enabling clear/detailed/high-quality images (1), resulting in increased consumer appeal (1)
- Smart material is used in 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 phones (1), allowing improved looks, clean aesthetic lines/leading to easier use of phones /improved ergonomics (1)

Q10a.

- Phosphorescent pigments are manufactured from phosphors (1)
- Material absorbs light and emits it slowly over time (1)
- Pigment is often used in novelty toys, safety signs (1)

**10b.**

Application 1 – luminous watch

- Absorbs suns and artificial lights energy (1)
- In the dark, energy is slowly released (1)
- Light is actually also released during the day however we do not notice it (1)
- An advantage of it is the glow allows the user to read the time in the dark (1)
- It is also aesthetically pleasing (1)

Application 2 – glow in the dark toys

- Material it is made from contains phosphorescent pigment (1)
- Absorbs light energy during day time (1)
- Slowly releases energy in form of light (1)
- More apparent at night time (1)

**Q11.**

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

**Q12.**

- Polymorph is a thermoplastic material (1)
- Can be shaped and reshaped any number of times (1)
- Normally supplied as granules looking like small plastic beads (1)
- When heated with hot water, granules become a solid material that can be moulded (1)
- Applications include: ergonomic handles, 3D modelling (1)

**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)

Answers that state 'cheaper' or 'more expensive' unless qualified will not be accepted

**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)

**Q15.**

- The lenses will darken in sunlight (1) which means a second pair is not required (1) thus reducing the cost to the consumer (1)
- No need to change glasses as the user moves between environments (1) because the glasses will always have the correct level of tint (1) minimising eye strain (1)
- The user is likely to wear them all the time (1) so there is less chance of them being lost (1) reducing the need for costly replacements (1)
- Improved safety when driving (1) because the driver does not have to change glasses (1) when light levels change (1)

**Q16.**

- The high speed of reaction in the composite
- The small size of the composite required
- Low cost
- Simple to integrate
- High reliability
- Proportional response
- Range of sensitivities
- Easy to manufacture

One mark per bullet point

**Q17a.**

- Piezo electric materials generate a small electrical charge when the material is compressed or deformed. The process is also reversible so they can also change shape slightly when exposed to an electric current.

2 marks for a detailed description, 1 mark for a simple description

**Q17b.**

- Musical greetings cards
- Pressure sensors
- Ignition units for lighters, gas stoves and grills
- Ink jet printers
- Car air bags
- Buzzer applications