**Design & Technology**

**Smart materials**

**Materials required for questions**

* Pencil
* Rubber
* Calculator

**Instructions**

* 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**

* 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 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.** 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)**

1.

2.

3.

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

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

**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)**

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

**Q13a**. Thermochromic pigments have many innovative applications.Outline the household applications of thermochromic pigments **(4 marks)**

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

**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)**

**Q15.** Photo-chromic lenses are popular for people who wear glasses to help with their eyesight. Explain **three** advantages to of purchasing glasses with photo-chromic lenses rather than standard lenses. **(9 marks)**

**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)**

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

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

**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