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| **250** | **Modern materials** | Modern materials are those that have been developed through the invention of new and improved processes (for example **graphene, metal foams** and **titanium)**,  Or that can be altered to perform a particular function (such as **liquid crystal displays, nanomaterials** and **coated metals).** |

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| **251** | **Graphene** | Graphene is the lightest known compound. |
| 252 | It is stiff and strong (200 times stronger than steel). | |
| 253 | Is thin (1 atom thick) | |
| 254 | Conducts electricity and heat. | |
| 255 | Uses include aircraft parts, artificial joints and sports equipment. | |

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| **257** | **Liquid crystal displays (LCDs)** | The liquid crystals respond to electrical input from an electrode to block or allow a back light to shine through and generate various colours to form images on the screen. |
| 258 | It is compact, low energy use, has a sharp image and bright. | |
| 259 | There is a restricted viewing angle. | |
| 260 | Uses include TV screens, watches, and computers. | |

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| **256** | Graphene could improve the performance of the products it is used in**.** |

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| **261** | **Nanomaterials** | Nanomaterials are less than 1-100 nanometres thick. One nanometre is one-billionth of a metre. Nanomaterials are used as thin films or surface coating, such as self-cleaning glass or insulation. |
| 262 | Nanomaterials improve the properties of materials (increased strength, conductivity, hardness, waterproofing, fire retardance). | |

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| **268** | **Coated metals** | Metals can be coated with other materials to protect them, improve performance or for aesthetic reasons. Examples of coating are: |
| 269 | **Zinc (galvanising)** protects steel from rusting | |
| 270 | **Teflon (PTFE)** provides non-stick coating for kitchen pans. | |

**1.3 Smart materials**

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| **271** | These materials have properties that respond to external stimuli and change in a controlled manner. |

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| **263** | **Titanium** | Titanium is a lightweight metal with low density. |
| 264 | It is corrosion resistant. | |
| 265 | Has a good strength to weight ratio. | |
| 266 | Is stiff and tough. | |
| 267 | Uses include aircraft parts and artificial joints. | |

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| **276** | **Photochromic pigments or particles**  These pigments: | Pigments in the form of compounds are added to materials such as polymers and paints. The pigments change colour due to exposure to ultraviolet rays. The change in colour is reversed when the stimulus is removed. |
| 277 | Can help create multi-use products. | |
| 278 | Can be slow to react and expensive. | |

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| **272** | **Shape memory alloys** | Metallic alloys such as Nitinol can be bent. Heat will make the alloy return to its original shape. Nitinol is programmed (heated to 540oC ) and when deformed will reform at 70oc (hot water. Shape memory alloys: |
| 273 | Save space and require fewer parts. | |
| 274 | Are expensive. | |
| 274 | Wear out after time. | |
| 275 | Shape memory alloy tubes can be compressed and inserted into arteries by surgeons. The tubes return to their original shape and hold arteries open. | |

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| **280** | **Thermochromic pigments** | **Power pigments are added to other materials, such as polymers and paints. These pigments change colour due to temperature changes. The change can be reversible or permanent to show that a certain temperature has been reached. Use of these pigments can:** |
| 281 | Improve safety | |
| 282 | Detect and indicate change. | |
| 283 | Decay over time | |

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| 284 | A non-toxic thermochromic pigment changes colour when hot liquid is poured in. |

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| **279** | **Photochromic lenses have particles that darken in sunlight to add protection.** |

**1.3 Smart materials cont**

**1.3 Composite materials**

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| 287 | Composite materials | Composite materials are produced by combining two or more different materials to create a material that has enhanced properties. |

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| **297** | **Plywood** | Plywood is a manufactured board formed from layers of veneers bonded together by glue, so it forms a flat sheet |
| 298 | It is stable in all directions. | |
| 299 | It is available in large sheets. | |
| **300** | **Each layer is 90 degrees** | |
| 301 | Veneers of wood bonded together with glue | |
| 302 | Always an odd number of layers. | |

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| **292** | **Carbon fibre reinforced plastic (CPR)** | **Plastic is reinforced with strands or woven fibres of carbon and built up in layers.**  **Uses include racing car parts and body armour.** |
| 293 | It has an excellent strength to weight ratio. | |
| 294 | It is very rigid, with a greater rigidity than glass fibres. | |

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| **288** | **Glass reinforced plastic (GRP0** | Plastic is reinforced with strands or woven fibres of glass and built up layers. Uses include canoes, car bodies or rigid pond liners. |
| 289 | It has a good strength to weight ratio and is rigid. | |
| 290 | It is cheaper than carbon fibres. | |
| 291 | It can be coloured with resins. | |

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| **295** | Carbon fibre reinforced plastic (CRP) is used for safety in the body of a Formula 1 car. |

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| 303 | Plywood comes in a range of thicknesses, for instance 3mm, 6mm, 9mm. ‘Ply’ tells you the number of layers in the board. |

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| **296** | When working with glass or carbon reinforced materials, care must be taken not to breath in the fumes or dust. The fibres can cause respiratory issues. |

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| 304 | Fibres of special materials can be spun to make enhanced fabrics. All technical textiles need a base fabric (cotton, wool, polyester, nylon), which is then woven, knitted, sewn, cut or braided with the strands. |

**1.3 Technical textiles**

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| **285** | Photochromic pigments change the colour in sunlight which indicates the level of UV light . |

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| **305** | **Conductive fabrics** | These fabrics (also know as e-textiles) include conductive materials (often carbon, titanium, nickel, or copper) strands that are woven, knitted, sewn, cut or braided into the fabric. They can conduct electricity and connect electronic components and can be used in clothing to incorporating lights or controls, or in athletic garments with heart rate monitors. |

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| **306** | **Fire resistant fabrics** | These fabrics are based on **aramid** fibres, which are heat resistant. They are used when there is a need for a higher level of insulation and for materials to resist fire for a set period of time; for example home furnishings and specialist clothing, such as welding overalls. |