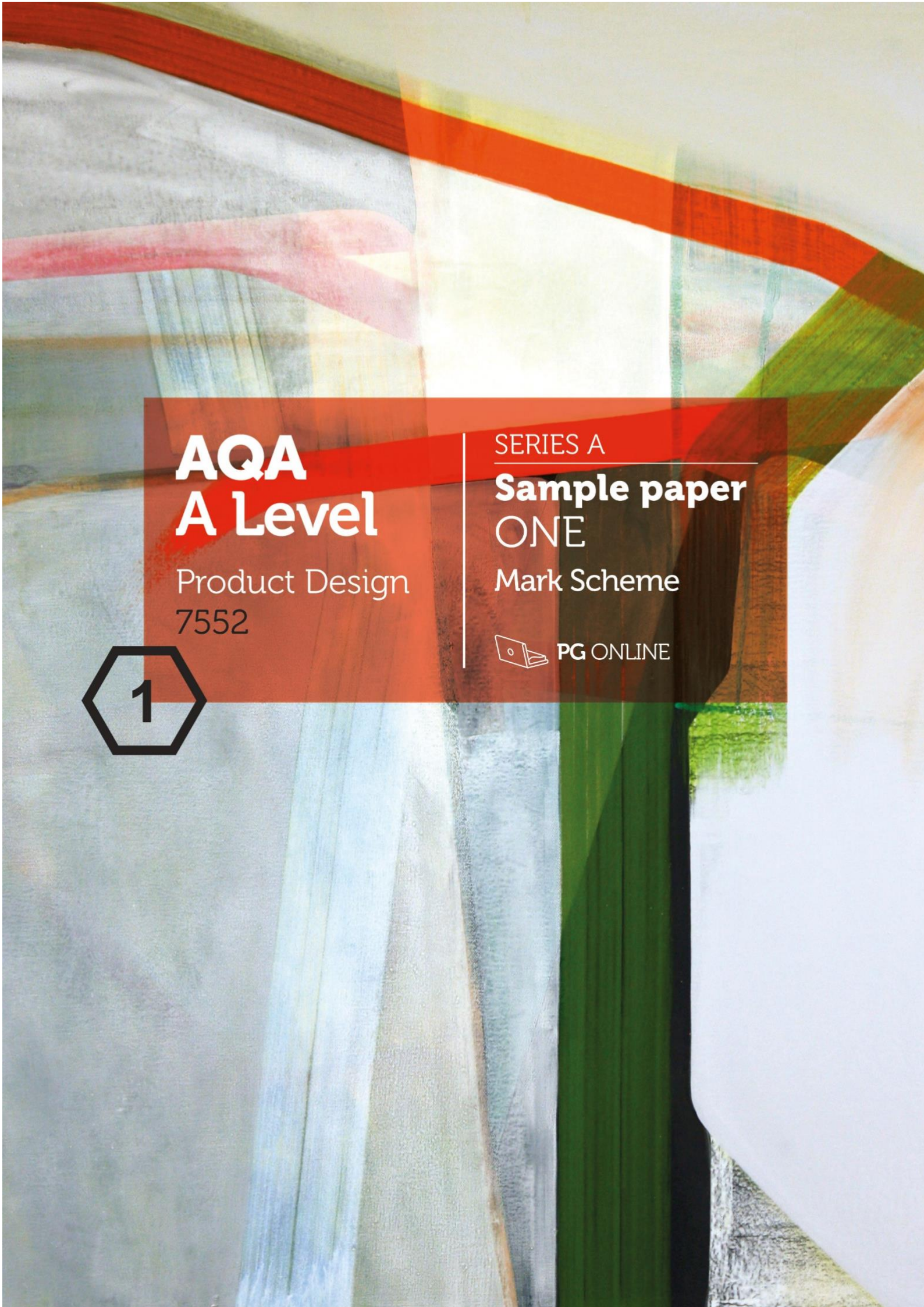

AQA A Level

Product Design 7552

1

SERIES A

Sample paper ONE

Mark Scheme

PG ONLINE

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A Level Design & Technology (Product Design)

Series A – Paper 1 mark scheme

This sample paper and mark scheme has been carefully compiled and checked to ensure parity with the AQA guidelines available. It is the normal process for the mark schemes of live papers to go through a standardisation process where students' responses are analysed and any answers not covered in the mark scheme are discussed and legislated for. As this is a sample paper only, this process has not been undertaken. Whilst this paper and mark scheme have been technically proofread, there may be additional responses that are worthy of marks. Teachers discretion should be applied in these circumstances.

Instructions for level of response marking

Descriptors are provided for different levels of response along with appropriate marks for each level. Read through a student's answer, annotating to show the qualities that have been achieved, before applying the level based mark scheme.

Determining a level

Start with the lowest level of response in the mark scheme and assess if the different qualities indicated have been met. If they have, move to the next level and check to see if these have been met. Continue the process until you can match the level with the answer. With repetition it becomes easier and quicker to work up through the levels of the mark scheme.

The principle of 'best fit' should be adopted and if small elements of a level are missing but the majority has been covered, then this is the appropriate level to award.

Determining a mark within a level

Having decided on the level, the mark within the level must be determined. Use the descriptors to help with this along with the indicative content. Where there is any doubt, it is advisable to read back through the answers again and reapply it to the indicative content. Students do not need to cover all of the indicative content to reach the top marks. Additionally the indicative content is not designed to be exhaustive and alternative appropriate answers may well be taken into consideration.

Student answers that do not contain any relevent content must be awarded zero marks.

1. **Award 1 mark for a relevant performance characteristic and a further 1 mark for a relevant explanation up to a maximum of 2 marks for each paper or board.**

[2 x 4 marks]

Indicative content: accept alternative responses worthy of credit

Bleed proof paper:

- A specially treated paper to ensure the ink in marker pens does not run or spread to parts of a drawing where it is not wanted
- Edges to inked drawings are crisp on bleed proof paper
- Pens flow smoothly across the sized surface
- Can extend the life of the pens, as not porous like cartridge paper
- Transparency of the pages allows layered rendering over sketches

Corrugated cardboard:

- Compliant material, easy to cut, fold and crease
- Flutes give structural integrity/impact resistance to protect contents
- Easy to recycle, suitable for single use packaging
- Biodegradable to reduce environmental impact of single use packaging
- Lightweight to reduce transport costs/makes product easier to carry
- Easy to print on for product recognition/advertising

Foil backed card:

- The laminated board provides the benefits of more than one material
- Foil layer resists moisture and reflects heat, while card layer provides rigidity and an easy surface to print on
- Foil lining is impermeable, protecting the contents from light, air, odour and bacteria, ideal for storage of liquid foods and beverages
- Easily cut, creased and folded into 3D form

Mount board:

- Easy to recycle, suitable for prototyping
- Biodegradable to reduce environmental impact when disposed of
- Good strength to weight ratio, ideal for lightweight prototypes
- Available in a range of colours to represent different features of the model
- Suitable for use with a variety of non-toxic glues
- Cost effective material for modelling when compared to foam board

2. **Award 1 mark for a basic response and a further 1 mark for additional detail.** **[2 marks]**

Wastage involves cutting away or removing material (1) to create the desired shape/form (1).

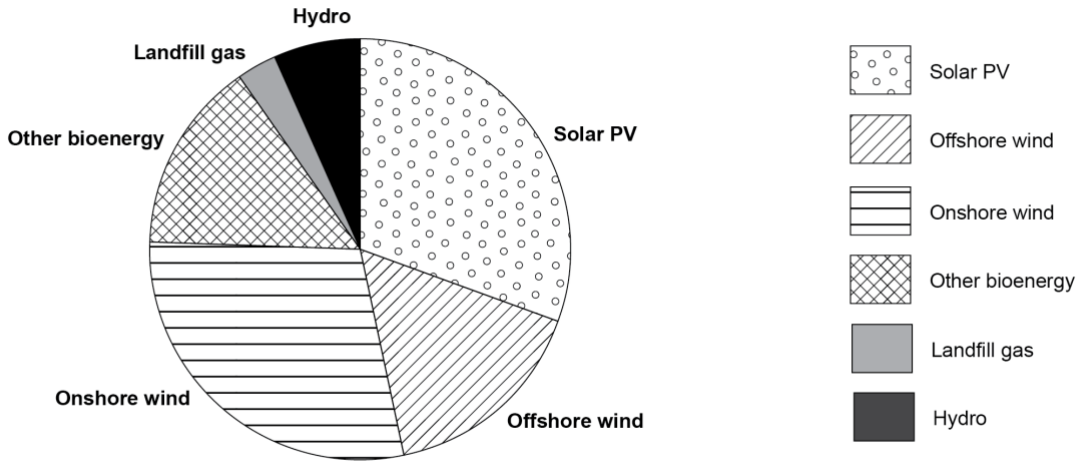
3. **Award marks as stated: Accept incorrect responses based on errors carried forward from part (a) if calculations are correct.**

(a) Mathematical calculations **[2 marks]**

1 mark	Correct total capacity calculation for 2015: 2000 + 1000 + 4500 + 9000 + 5000 + 9500 = 31,000
1 mark	Correct calculation of percentage of solar PV: $\frac{9500}{31\,000}$ × 100 = 30.6% Rounded to 31% Do not penalise if answer is correct but has not been rounded.

(b) Mathematical calculations **[4 marks]**

1 mark	Correct calculation: Solar PV: Use of 31% from part (a), or use of the fraction $\frac{9500}{31\,000}$ or Offshore wind: Use of the fraction $\frac{5000}{31000}$
1 mark	For finding either Solar PV: 0.31 × 360, or $\frac{9500}{31\,000}$ × 360 or Offshore wind: $\frac{5000}{31000}$ × 360 = 58.06°, or $\frac{5000}{31000}$ × 100 = 16.12%
1 mark	Answer which rounds to Solar PV: 110° or Offshore wind: 58°
1 mark	Accurate / correct proportioned sectors for 2015 shown as a pie chart. Allow +/- 2° of error. Allow sections to be drawn in either order.



4. **Award marks as shown.**

   (a) **Award 1 mark for a relevant specific manufactured board** e.g. Veneered MDF, veneered chipboard, faced plywood, Conti Board, (accept hardboard as it is suitable for back panel or drawer base) **[1 mark]**

   (b) 1220mm × 2440mm **[1 mark]**

   (c) **Award 1 mark for a relevant point and a further 1 mark for clarification or explanation up to a maximum of 2 marks for each requirement.** **[4 marks]**

   Indicative content: accept alternative responses worthy of credit

   Aesthetics:

   - Veneer improves the surface appearance of an unattractive manufactured board
   - Create the impression of a natural wood at a lower cost
   - Available in a range of colours/finishes to co-ordinate interior decor
   - Smooth flat surfaces to touch; providing a protective layer which is easy to clean
   - Manufactured boards made in large format allowing many parts to be machined with matching grain effect

   User requirements:

   - Consistent material thickness; ensures product fits together properly / product is easy to assemble
   - Manufactured board is more stable than natural timber / parts should not swell/shrink; drawers will open and close smoothly
   - Parts are of a consistent quality; ensures easy/effective assembly/disassembly
   - Boards are manufactured to more precise tolerances in terms of size/thickness etc; ensures smooth opening and closing of drawers

5. **Award up to 2 marks for correct definition and a further 1 mark for a relevant material:** **[3 marks]**

   Definition: A polymer that, once cured/set/cast (1) and cannot be reshaped (1).

Relevant material: Urea formaldehyde (UF) / Melamine formaldehyde (MF) / Polyester resin / Epoxy resin (1) accept alternative thermoset polymers if named.

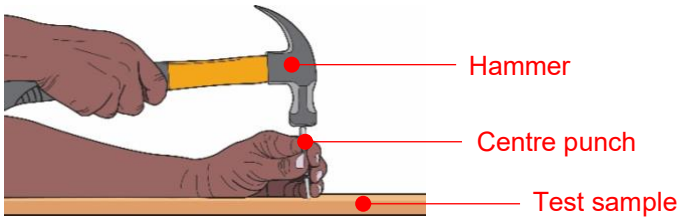
6. **Award marks as stated.**

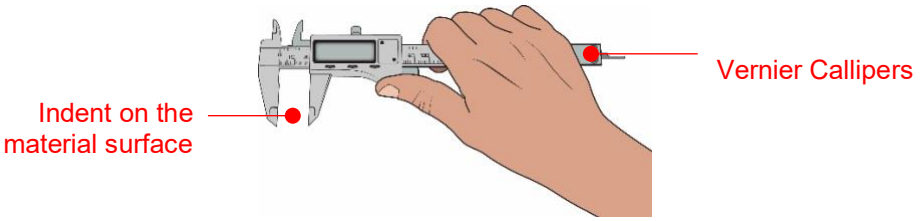
5 marks	Excellent annotated and clear sketches communicating full understanding of conducting a fair and accurate workshop test.
4 marks	Good sketch(s) with clear supporting notes of an appropriate workshop test.
3 marks	Sketch with some details and appropriate notes added. Lacking notes and/or detail in places**.**
2 marks	Simple sketch and a simple note added.
1 mark	One simple correct detail without a sketch / simple vague sketch with no notes.
0 mark	Nothing worthy of credit.

(a) Hardness test **[5 marks]**

Indicative content:

- Performed using hammer, centre punch and Vernier callipers
- Drop hammer from identical height or using a swing jig/rig to keep force of impact consistent
- See comparative difference in size of centre punch indentations between tested materials





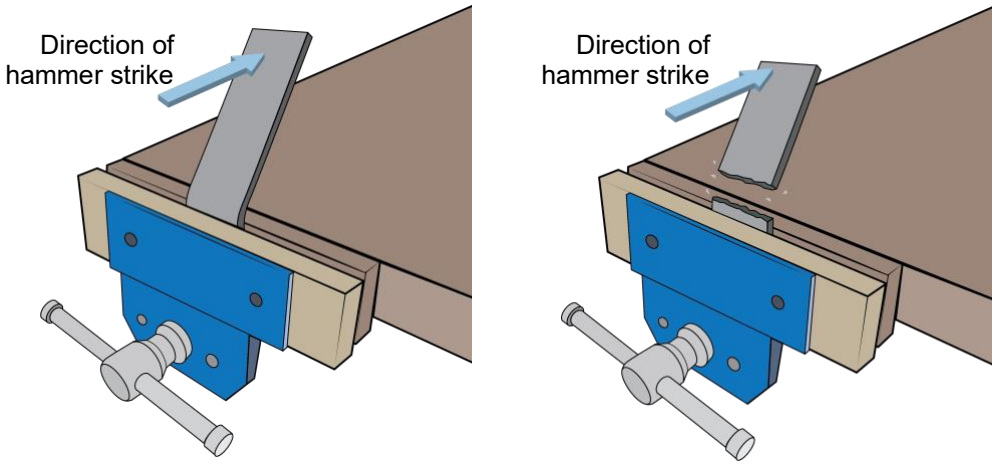
Measure the diameter of the dent

Award marks for equivalent tests that would be carried out in a testing laboratory e.g. Janka test.

(b) Toughness test **[5 marks]**

Indicative content:

- Set-up test material in vice
- Strike test material from a constant distance using hammer/mallet
- Use of swing/jig to keep force of impact constant
- Test pieces must be identical in all dimensions and located in the same position in the vice
- Compare how much each test sample bends
- Students may comment on / sketch differing levels of toughness



Tough Brittle

Award marks for equivalent tests that would be carried out in a testing laboratory e.g. Charpy / Izod test.

7. **Award marks as stated**

(a) Mathematical calculations

i) **[3 marks]**

1 mark	Use of correct formula and correct substitution: Circumference of external curve as a full circle $C = \pi \times D$ $C = \pi \times 500$, or $2 \times \pi \times 250$ C = 1,571 mm (or equivalent) or C = 1570.79632679 Accept both rounding to a whole number at this stage or later
1 mark	Length of 180° of external curve: 180 / 360 × 100 = 50% of full circle circumference
1 mark	Length of external curve:

	1,571 × 50 / 100 = 785.5 mm. Rounded to 786mm or C = 785.398163397 rounded to 785mm

ii) **[2 marks]**

1 mark	Adding component lengths together: 1500 + 786 + 600 + 125 + 700 = 3,711 mm
1 mark	Two side frames each with 7 veneers: 3711 × 7 × 2 = 51,954 mm. Accept answer in metres e.g. 51.95m

(b) Mathematical calculations **[2 marks]**

1 mark	Area of veneer: 51.95m × 0.1m wide = 5.195 m² Plus 15 %: 5.195 × 1.15 = 5.97425 = 5.97 m²
1 mark	£20.45 × 5.97 = 122.0865 = £122.09

8. **Award 1 mark for a correct application.**

Award 1 mark for simple description or 2 marks for a detailed description.

[3 x 3 marks]

Indicative content: Piezo electric material

Applications include: Greetings cards (with sound), musical instruments, touch switches, car air bag sensors, alarms, lighters, ultrasound, sonar, (quartz) watches, wearable technology, LED torches, mobile phone speakers. Accept any other suitable application.

Explanation: Converts mechanical energy into electrical energy (and vice versa) / when squeezed/squashed they give off an electrical charge or move/vibrate when electrical charge is applied (1), which can be used as an electric input e.g. trigger an alarm, turn a device on / which can create vibrations e.g. in an alarm, ultrasound (1).

Shape memory alloy (SMA)

Applications: Dental braces, biological uses e.g. stents, glasses frames, fire alarms, anti-scald valves, nitinol engines. Used in the active disassembly of products. Accept any other suitable application.

Explanation: Can be programmed to remember a specific shape (1) will return to their programmed shape at a given temperature/electrical current passes through e.g. slowly applying pressure/contracting in response to body temperature, straightening glasses frame, triggering switch, restricting flow (1).

Photochromic glass

Application: Reactive lenses in spectacles/glasses, reactive glass in windscreens/buildings. Accept any other suitable application.

Explanation – Change darkening in response to UV light levels (1), automatic / easy to use / increases safety as user can see more clearly in bright/low light (1).

9. **Award marks as shown.**

(a) **Award 1 mark for each suitable property and a further 1 mark for a relevant explanation up to a maximum of 6 marks.** **[6 marks]**

Thermal insulator (1), protect against extreme temperatures (1) e.g. fire fighter, astronaut.

Lightweight (1), suitable for clothing as gives user freedom to move (1).

(Woven structure makes it) impact resistant (1), force of impact dispersed along fibres protecting the user from harm (1).

Chemical resistant (1), protect the user from any contact with hazardous chemicals (1).

Hard wearing / strong (1), provides reliable protection (1).

Flexible (1), comfortable to wear (1).

Abrasion resistance (1), protects the user from scrapes, grazes (e.g. protective/cut proof gloves, protective motor cycling clothing) (1).

(b) **Award up to 2 marks for a correct definition and a further 2 marks for a correct explanation up to a maximum of 4 marks.** **[4 marks]**

PMC is a mouldable putty made from precious metal particles (1), water and a non-toxic organic binder (1).

Once formed into the desired shape, PMC is fired (1), shrinkage occurs as the water and binder are burnt off (1).

10. Award marks as shown.

(a) Blow moulding (1). **[1 mark]**

(b) Polypropylene (PP) / Polyethylene terephthalate (PET) / HDPE / LDPE (accept any other chemical resistant polymer) (1). **[1 mark]**

(c) **Award 1 mark for each relevant point and a further 1 mark for a relevant explanation up to a maximum of 4 marks.** **[4 marks]**

Material must become soft and flexible when heated up (1) for extrusion and for blow moulding process (stretching/inflation of parison) to work (1).

Rapid cooling of the polymer (1) to speed up production process (1).

Thermoplastics can be recycled (1) so waste materials/faulty bottles can easily be reprocessed / reused in-house (1).

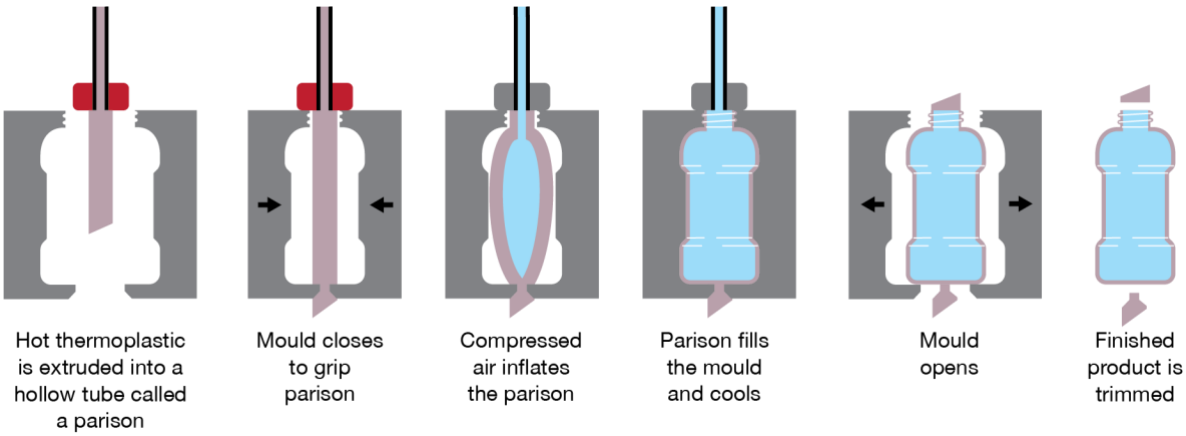
Thermoplastics have the flexibility (1) to be formed into a 3D shape such as a bottle (1).

Thermosets are too brittle for a product of this shape/form (1) as walls are too thin (1).

A preform or parison is used in blow moulding (1) this must be kept warm/reheated to perform the moulding process (1).

(d) **Award marks for detail in either sketches or notes. Both notes and sketches needed for access to all 6 marks. Award marks as shown.** *If students have identified and alternative polymer process such as injection moulding or rotational moulding, allow marks for error carried forward as long as they have made it clear how a **hollow** bottle could be made.* **[6 mark]**

- Correct identification of hot thermoplastic material input (1)
- Correct identification of parison/preform (1)
- Correct detail of air blown in (1)
- Tube inflating to take shape of the mould (1)
- Split mould for manufacture of shape (1)
- Trimming of 'flash' or sprue or tail / finished product is released from mould (1)



11. **Award marks as shown.** **[9 marks]**

7-9 marks	The response demonstrates excellent understanding. Full and comprehensive explanation as to how computer systems are used to plan and control manufacturing, reduce waste and meet consumer demand.
4-6 marks	The response demonstrates some understanding and gives detail in places as to how computer systems are used to plan and control manufacturing, reduce waste and meet consumer demand. Some areas may not be covered in detail.
1-3 marks	The response provides a basic explanation as to how computer systems are used to plan and control manufacturing, reduce waste and meet consumer demand. One or more areas may not be covered.
0 marks	Nothing worthy of credit.

Indicative content: Lists are not exhaustive

Plan and control manufacturing:

- Modular and cell production – machines set-up in groups or a series / distinct teams of workers to carry out a sequence of operations

- Kanban can be used to ensure all assembly components (e.g. nuts and bolts, electronic components) are replenished in good time so as not to interrupt production
- Just in time (JIT) – use of RFID tags/QR codes/barcodes to track items on the production line / to track inventory / to ensure new stock is ordered as parts are used
- Flexible manufacturing systems (FMS) including CNC and robotics to manufacture different products at different times, to reduce labour, increase safety, quality, consistency and efficiency
- Quick response manufacturing (QRM) – switching production lines between a 'family' of products produced by a company, use of CAD/CAM modern technology e.g. 3D printing
- Automatic guided vehicles (AGVs) to move materials and products around a factory efficiently
- Use of Computer Integrated Manufacturing (CIM) and Product Data Management (PDM) as long as their specific reference to planning and control are linked

Reduce waste:

- Use of CAD to reduce waste in planning and nesting/tessellation of parts
- Use of CNC to precisely control tool paths, reduce human error
- Use of standard and bought-in component to reduce material waste, time and energy 'in house', makes best use of specialist manufacturers within the industry
- Computer controlled management of waste recycling systems i.e. what to recycle and when
- Just in time (JIT) – reduce need for storage so no energy required to light and heat storage facilities
- Computer environmental control of the workspace – automatic heating, lighting reduces unnecessary energy consumption

Meet consumer demand:

- Use of ICT systems allowing customers to place orders to individual specifications in real time
- Orders may be placed online anywhere in the world directly with the factory
- Tracked products can be distributed straight from the factory, reducing lead times
- Tracked products allow customers to follow the progress of their order through manufacturing and distribution

12. **Award 1 mark for a named biodegradable polymer and a further 1 mark for each a relevant environmental factor up to a maximum of 3 marks. [3 marks]**

Named biodegradable polymer: Corn starch polymers / potatopak / biopol (bio-batch additive) / polylactide (PLA) / polyhydroxyalkanoate (PHA) / Polyhydroxybutyrate (PHB) / lactide / glycolide (Lactel and ecofilm) (1). Accept alternative correct response.

Environmental factor:

Biodegradable polymers degrade faster with the action of UV rays (sunlight) (1)
Biodegradable polymers degrade faster with the presence of water (1)
Biodegradable polymers degrade faster with the presence of enzymes present in soil (1)

13. **Award 1 mark for each relevant point and a further 1 mark for a relevant explanation up to a maximum of 4 marks.** **[4 marks]**

Indicative content:

- Computational fluid dynamics (CFD) – used for testing wind resistance, aerodynamics and the flow of liquids within and/or around a product
- Finite element analysis (FEA) – used to analyse weaknesses/stress points in components
- Virtual simulations – view assemblies from different angles, architectural walk-throughs, colour/texture schemes including PCB testing of components and circuits
- Simulations allow designer to check a product will function/be compatible with other parts before machine tooling is made
- Simulations allow the client to get a clearer idea of how the final product will look; this helps manage expectations as well as allow opportunities for any necessary alterations to be made before production starts
- Can be used to carry out various non-destructive tests; more economical and efficient way of testing which also has environmental benefits as a physical prototype is not required
- Generative design used to provide engineering solutions minimising material use
- Use of mixed reality, augmented reality and virtual reality allowing immersive design and non-immersive virtual testing

14. **Award marks as shown.** **[12 marks]**

9-12 marks	Full and comprehensive comparison between and evaluation of the cars in terms of materials, manufacturing processes and how material choice affects use, care and disposal. Reference to correct and specific materials and manufacturing processes.
5-8 marks	Evidence of comparison between and evaluation of the cars with reference to specific manufacturing processes and choice of materials in relation to use, care and disposal. Reference to relevant materials and processes.
1-4 marks	Limited consideration of manufacturing and/or material choice. Response includes generalisations rather than reference to specific manufacturing processes and material choice.
0 marks	Nothing worthy of credit.

Indicative content: Lists are not exhaustive

Polypropylene car

- Identification of thermoplastic properties; thermoplastic, tough, durable, colourful, self-finishing, good chemical resistance
- Reference to advantages of rotational moulding, most parts manufactured from this one process; increases time efficiency
- Rotational moulding gives a variable wall thickness / does not make most efficient use of material compared to options with injection moulding e.g. use of webs and fins etc. to add strength

- Highly suited to mass manufacture using automated systems; high set-up costs but reduced labour costs and efficient, reliable manufacture
- Use of pigments in the polymer make PP self-finishing; no need for application of a coloured finish and another production stage adding cost
- Car designed for outdoor use, use of PP creates a waterproof product (which will not rust), however, UV light will fade the pigment unless stabilisers are added
- PP is tough and durable and does not mark easy when subjected to use by children
- Chemical resistant and wipe clean; easy to wipe down and sanitise
- Safety labelling/symbols can be incorporated into the mould which reduces chance of safety/care instructions being lost (if it were a removable a sticker)
- PP is recyclable at the end of life, although, parts made from different materials must be easy to disassemble
- PP is tough and durable; product will last a long time, could be reused by another child when the original owner has finished
- PP is resistant to insect and fungal attack
- PP is lightweight and so easy to move by the child/parent
- Will not degrade easily so will take many decades to decay in landfill
- Both products are made from non-renewable materials

Mild steel car

- Correct identification of features of press forming process; use of jigs and templates during fabrication, better suited to batch production
- A wider range of manufacturing processes used, adding to time and cost of manufacture e.g. pressing, welding, riveting, turning and casting
- Paint / powder coat finish required to add colour and protection which adds to manufacturing time; metal surface need careful preparation e.g. degrease, priming, under coating etc.
- Toxins in paints damage the environment
- Paint finish could chip off and be difficult to maintain if not powder coated
- Mild steel chassis will dent more easily than PP car
- Not suited to prolonged outside use as ferrous metals will rust as paint finish degrades
- QA and QC will need to be more frequent due to the increased number of stages in fabrication
- Steel is not as flexible as PP which could pose a greater safety risk for children
- More complicated to separate all the separate parts at the end of life e.g. metal from rubber on the wheels etc., adding to cost
- Metal will degrade faster than PP and will biodegrade
- Both products are made from non-renewable materials

15. **Award marks as stated**

(a) Mathematical calculations **[2 marks]**

1 mark	Use of Pythagoras and correct substitution: $a^2 = 40^2 + 120^2$ $a^2 = 1600 + 14{,}400$

	a = √16,000
1 mark	Correct answer: a = 126.49mm Round up to 127 mm Do not penalise if answer is correct but has not been rounded.

(b) Mathematical calculations **[3 marks]**

1 mark	Correct use of formula and correct substitution: tan x = 120/40 (or equivalent) or sin x = 120/127 (or equivalent) or cos x = 40/127 (or equivalent)
1 mark	Rearrange equation: x = $\tan^{-1}$ 3 or x = $\sin^{-1}$ 0.94 (or equivalent) or x = $\cos^{-1}$ 0.32 (or equivalent)

1 mark	Correct angle: x = 71.57° or x = 70.89° or x = 71.64° Rounded up to 71 or 72° Accept ECF from question 15(b) if calculation is correct.

(c) **Award marks as stated.** **[8 marks]**

6-8 marks	Full and comprehensive evaluation covering several specific advantages and disadvantages in detail. Clear reference to batch production techniques and fully justified points with examples linked to the bird table.
3-5 marks	Detailed evaluation covering several specific advantages and at least one disadvantages in some detail. Reference to batch production and some justified points with reference to at least two elements of the bird table.
1-2 marks	Limited evaluation with little reference to batch production techniques or the bird table. Points lack justification.
0 marks	Nothing worthy of credit.

Indicative content: Lists are not exhaustive

Advantages:

- Increase accuracy and speed of manufacture e.g. a jig could be set up to cut/abrade struts at the correct angle; this could reduce waste due to human error and save labour costs
- Jigs can be used to machine several pieces in one operation; efficiency, such as cutting struts, stem length, upper frame and roof pieces
- The ability to clamp workpieces securely means that cutting speed and depths can be set or increased with confidence, additionally the angles for the roof could be determined without the need to remeasure each time
- Can increase safety due to not holding workpiece by hand, especially useful for cutting angles on roof and struts
- Enables several different workers to perform the same complex tasks/operations with consistency, like cutting strut and roof angles and accurate joining procedures such as the base assembly
- Jigs can be used to perform several different operations e.g. the struts could be measured/marked, cut and drilled using one jig

- Jigs (e.g. drilling jigs) can often be bought-in and can be adapted for use in other projects
- Ability to produce bird tables in larger numbers to the same high standard

Disadvantages

- Specific bespoke jigs for the bird table will take time / materials to manufacture; manufacturer has to weigh up the savings to be made by making the jig compared to the time / materials required to make the jig
- Bought-in jigs add to set-up costs therefore making jigs specifically for the bird table assembly may be more efficient however time and resources are still used
- If jigs are made or set-up inaccurately then all parts made with them will be faulty. This would be particularly important for roof and strut lengths and angles
- Jigs are subject to wear and tear so become less accurate with use; performing checks on jigs should be added to the QA/QC schedule

16. **Award up to 2 marks for correct definition.**

Then award 1 mark for a suitable advantage, 1 mark for a suitable disadvantage and a further 1 mark for each relevant explanation up to a maximum of 4 marks. [6 marks]

Definition: A company integrates/consolidates elements of the manufacturing/supply chain under one company (1) so reliance on external suppliers is reduced (1).

Advantages:

- Fixed prices for parts and services as these are set internally, external suppliers may change prices / are affected by global financial markets
- Supply of parts and services is more reliable, external suppliers can go into liquidation
- Improved consistency and quality of product, QC/QA measures are set in-house to suit exact needs of parent company
- Capitalises on the added value subassemblies/components/services bring to a product by keeping profits in-house
- Used on different areas of supply chain (raw material, processing, manufacture, distribution, retail)
- Gives a company more control over the manufacturing and distribution process
- Can give strategic advantages over competitors

Disadvantages:

- Core business is diluted/diversifies which can result in a lack of skills/experience
- Increased administration and complex business structure
- Very high capital outlay to acquire/setup subsidiary companies/suppliers
- Increased risk of company failing if all elements are not controlled accordingly

END OF MARK SCHEME