A-level
DESIGN AND TECHNOLOGY: PRODUCT DESIGN
7552/2

Paper 2 Designing and Making Principles

Mark scheme

June 2019

Version: 1.0 Final

I196a7552/2/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

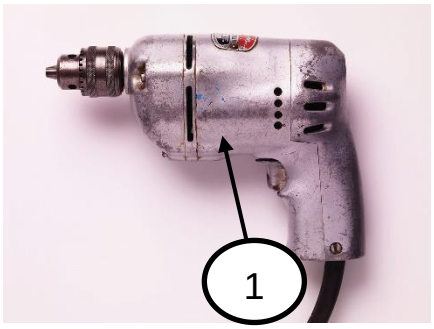
An answer which contains nothing of relevance to the question must be awarded no marks.

Glossary for maths

If a student uses a method which is not explicitly covered by the mark scheme the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

[a, b]	Accept values between a and b inclusive.
For π	Accept values in the range [3.14, 3.142]

As a general principle, a correct response is awarded full marks.

Qu	Part	Marking Guidance	Total marks	AO
1		**Figures 1** and **2** show two power drills. **Figure 1**  **Figure 2**  **Figure 1 Die cast mains powered drill** / **Figure 2 Injection moulded cordless drill** Casing material: Die cast aluminium / Injection moulded ABS Power supply: 230 V mains power / 9.6 V rechargeable battery pack Chuck operation: Chuck key / Keyless chuck Casing joined by: Flat head screws / Security fasteners Centre of mass: Labelled 1 / Labelled 2 Compare the two drills shown. In your answer you should refer to: • ergonomic factors • design safety.	12 marks	AO31A 6 marks AO31B 6 marks

Level	Marks	Description
3	9–12 marks	The response provides detailed analysis and comparison of both drills, referring with technical details to both ergonomics and design safety. The response makes judgements regarding the design of both products using the full range of data provided
2	5–8 marks	The response provides a good comparison of the two drills referring to both reference points. The response makes analytical judgements regarding the design of both products referring to some aspects of the data provided.
1	1–4 marks	The drills are compared in basic terms with limited use of the data provided. Responses may refer to elements such as material properties without linking these to the bullet points.
	0 marks	No response worthy of credit.

Indicative content:

Ergonomic features:

- Figure 1 shows a simple cast handle design whereas Figure 2 shows in mould texture applied to increase grip for the user.
- Figure 1 is a mains powered drill, whereas Figure 2 is powered by a battery pack improving the ergonomics of the design as it is not restricted by access to a power supply.
- Figure 1 requires additional tools (chuck key) to insert a drill bit, whereas Figure 2 is a keyless chuck which makes use easier for consumers.
- Figure 1 is die cast aluminium which is a thermal conductor, whereas Figure 2 is an injection moulded thermoplastic body, which is a thermal insulator. This means the body will not heat up or cool down with changes to environmental conditions.
- The centre of mass in Figure 1 would make the drill front heavy increasing strain on the wrist while drilling.
- The handle position on Figure 2 is such that weight distribution is centralised and strain is reduced.
- Figure 2 shows a contrasting black font used for torque settings to stand out against the silver background increasing ease of use for the user.

		Design safety: • The use of an electrical conductor for the body of a mains powered drill is not ideal due to the risk of wiring issues. • The use of a standard screw fixing on Figure 1 increases the risk of the user disassembling the product and accessing live wiring. • Figure 2 has a flat base to allow it to stand when not in use and make it easy to pick up. • Figure 1 would have to be lent down making access harder when picking up. • Reference to secure fastenings preventing tampering *or* loosening due to vibration while in use. **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.		

<table>
<tr>
<td>2</td>
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<td>
Evaluate the impact of the Waste Electrical and Electronic Equipment (WEEE) Directive on manufacturers of portable electronic hand tools.
<table>
<tr><th>Level</th><th>Marks</th><th>Description</th></tr>
<tr><td>3</td><td>5–6 marks</td><td>The response gives a detailed evaluation of the impact of the WEEE directive on portable electronic hand tool manufacturers. The response shows a detailed awareness of the requirements for a manufacturer to conform with the directive and relates them specifically to the product context.</td></tr>
<tr><td>2</td><td>3–4 marks</td><td>The response gives a good evaluation of how the WEEE directive affects manufacturers of portable electronic hand tools. The response identifies key responsibilities for manufacturers which may be directly related to the product context.</td></tr>
<tr><td>1</td><td>1–2 marks</td><td>The response gives a basic evaluation of the WEEE directive and the impact of the directive manufacturers.</td></tr>
<tr><td></td><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>
Indicative content:

Manufacturers are required to provide information for consumers on the correct disposal of appliances.
Manufacturers must ensure all appliances covered by the WEEE directive display the specific symbol for Electrical and Electronic Equipment (crossed out wheelie bin).
Manufacturers must provide dismantling guides and recommendations for easy dismantling and material recovery for the recycling industry.
Manufacturers must organise a take back scheme either directly or indirectly.
Manufacturers must comply with restrictions in the use of hazardous substances stated in the RoHS (Restriction of Hazardous Substances) Directive. This has led to the reduction in use of heavy metals such as cadmium and mercury in rechargeable batteries and the development of Li ion batteries.
The WEEE (Waste Electrical and Electronic Equipment) is an EC Directive to manufacturers, requiring them to be registered on the national register of manufacturers.
Manufacturers are required to make regular declarations of the materials they place on the market.

Note: This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.
</td>
<td>6 marks</td>
<td>AO31A
3 marks

AO31B
3 marks</td>
</tr>
</table>

3		Explain **four** ways that cordless power tools can be designed to be disassembled. 1 mark for each way effective disassembly is promoted. 1 mark for each explanation (shown in italics). **Indicative content:** • Replace over-moulded components with in mould texture applied during injection moulding, *this reduces the cost of disassembly due to reduced components.* • Replace all adhesives with clip and mechanical fastenings, *this aids disassembly and recycling due to reduced number of components and lack of separation needed during recycling*. • Label all polymer components with appropriate SPI codes, *this will aid recycling due to easier identification of individual component materials*. • Ensure all components are produced from single materials to aid disassembly. *This aids sorting during recycling.* • Label all electronic components to aid disassembly. *This allows identification of specific materials.* • Use standardised security fastenings for ease of disassembly. *This allows recyclers to separate components easily.* • Remove unnecessary applied finishes, *these may prevent recycling due to contamination.* • Provide disassembly instructions with or on the product *in the form of embossing on the products* or *written step by step guidance*. • Reference to modular design, *parts are easily dismantled and can be reused on other products.* • Use of SMA for active disassembly *parts can be separated without human interaction.* **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.	4 × 2 marks	AO42B 8 marks

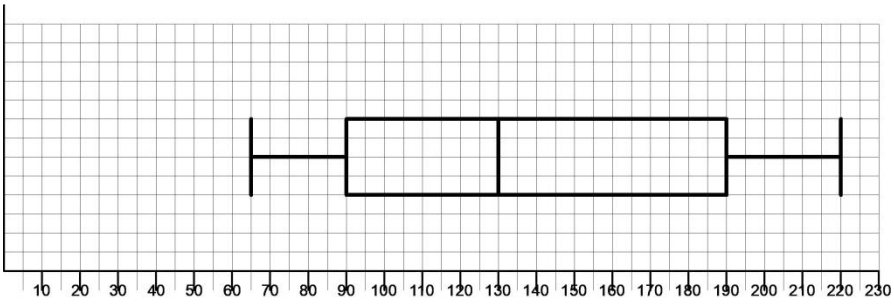
4		The battery life of a rechargeable battery was tested in a handheld electronic device. The test was repeated 11 times with a new battery each time. The results are shown in the table below. On the grid below draw a box plot to show the results.	4 marks	AO42C

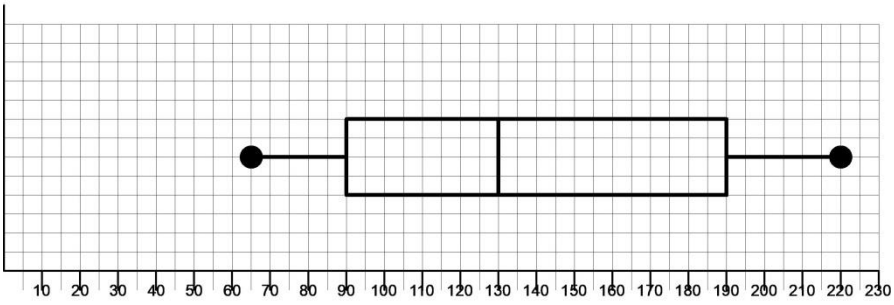
	1	**2**	**3**	**4**	**5**	**6**
Battery Life (in minutes)	65	110	180	130	90	220

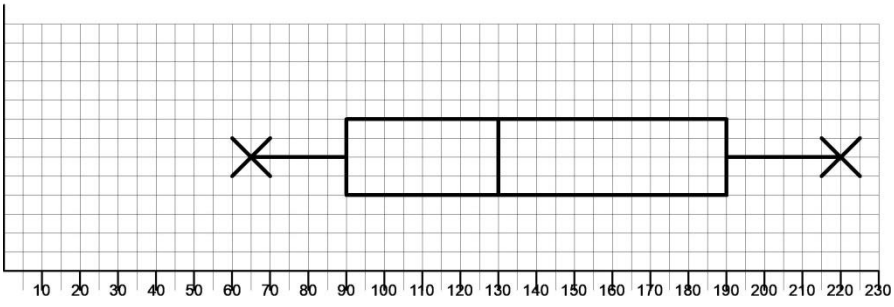
	7	**8**	**9**	**10**	**11**
Battery Life (in minutes)	150	75	90	190	210

Calculation of median	130	B1 (Value seen) (written or plotted)
Calculate Lower quartile	90	B2 (Value seen) (written or plotted)
Calculate upper quartile	190	B3 (Value seen) (written or plotted)
Correct box plot	SEE Box plot below	A1 (follow through)
For the correct box plot award full marks		4 marks

Accept any of the three alternative box plots:







<table>
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<td>5</td>
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When producing a die cut package three different, independently occurring faults are possible with these probabilities:

Fault A: 1/100
Fault B: 1/100
Fault C: 1/500

A and B are minor faults which must be monitored but will only fail Quality Control if both faults are seen on a single product.

C is a critical fault and any product suffering from this fault will fail quality control.

If a batch of 10 000 packages are produced, calculate how many products would be expected to fail quality control.
<table>
<tr><td>Calculate probability of Fault A and B</td><td>1/100 × 1/100 or 0.01 × 0.01 = 1/10000 or 0.0001</td><td>M1</td></tr>
<tr><td>Calculate probability of Fault A and B or C</td><td>1/100 × 1/100 + 1/500 = 21/10000
or
0.01 × 0.01 + 0.005 = 0.0021 or 2.1 × 10^{-3}
1/10000 + 1/500 = 21/10000</td><td>M2</td></tr>
<tr><td>Calculate expected number of failures</td><td>21 products
or 21</td><td>M3</td></tr>
<tr><td colspan="2">For the correct answer award full marks</td><td>3 marks</td></tr>
</table>
</td>
<td>3 marks</td>
<td>AO42C</td>
</tr>
</table>

6		State **four** ways a manufacturer may use quality assurance procedures and policies to reduce the rate of errors during die cutting of packaging nets. 1mark for each method of quality assurance. Accept methods of reducing process errors only. **Indicative content:** • Setting material quality tolerances (moisture levels on supplied materials) • Set regular intervals for blade changes to avoid blunt edges • Set tolerances for cutting blade pressures • Set appropriate material thickness tolerances • Set regular blade alignment checks • Regular staff training • Setting regular visual inspections • Simulating production runs prior to manufacture • Only accepting supplies from companies conforming to ISO9001 **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.	4 marks	AO42C

<table>
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<td>7</td>
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<td>
Figure 3 shows a submarine. (Shown in Question Paper)

Explain the specific virtual modelling techniques that may be used to test the design of a submarine before production.

<table>
<tr><th>Level</th><th>Marks</th><th>Description</th></tr>
<tr><td>3</td><td>5–6 marks</td><td>The response gives a detailed explanation of specific virtual modelling techniques that are related directly to the submarine context given.</td></tr>
<tr><td>2</td><td>3–4 marks</td><td>The response gives a good explanation of virtual modelling techniques that are appropriate for the submarine context given.</td></tr>
<tr><td>1</td><td>1–2 marks</td><td>The response gives a basic explanation of virtual modelling techniques that could be used for most product modelling situations, including the submarine context.</td></tr>
<tr><td></td><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• CFD: Computational Fluid Dynamics used to simulate pressures and the flow of liquids around the submarine to prevent the need to test in deep water.
• FEA: Finite Element Analysis used to simulate force loadings on individual components and assess the risk of collapse/failure without risking human life.
• By inputting material properties weight distribution and overall mass calculations can be observed.
• Assembly models can be used to ensure components fit accurately.
• Visibility from port holes can be simulated using VR models
• Virtual testing can be used to test electronic control systems prior to production.
• Hydraulic and pneumatic systems can be simulated with mechanisms prior to operation.
• Internal control panels and access can be modelled in VR.

Note: This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.
</td>
<td>6 marks</td>
<td>AO42C</td>
</tr>
</table>

8		Define the term Total Quality Management (TQM). 1 mark for reference to TQM being a method for improvement of QA or production processes 1 mark for information regarding the responsibility/involvement of all members of the workforce/company. **Indicative content:** TQM refers to continuous improvement within a company. This continuous improvement is the responsibility of all members of the company/organisation at all levels.	2 marks	AO42A

9		For a specific application, give **two** reasons why a go no-go gauge would be used. 1 mark for a specific application Example situations: hole diameter, component height, component width etc. Max 2 marks for explaining why a go no-go gauge would be used in the specific application 1 mark per reason • Checking a dimension is within a tolerance range • The accurate use of a go no-go gauge requires little training. • A go no-go gauge is quicker than a digital device such as a Vernier caliper. • A go no-go gauge requires infrequent recalibration. **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.	3 marks	AO42B

10		State **three** characteristics associated with products from the Memphis postmodern design group. **1 mark per key characteristic** Characteristics should be specific enough to be recognisable as linked to the Memphis movement and not generic to a range of styles/movements. • Use of bold colour schemes. • Simplistic use of geometric forms to produce complex juxtapositions. • Use of zoomorphic or anthropomorphic forms to create 'friendly' designs. • The production of 3D art forms rather than purely functional products. • Use of pattern as a surface decoration. • Use of modern unconventional materials. **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.	3 marks	AO42A

<table>
<tr>
<td>11</td>
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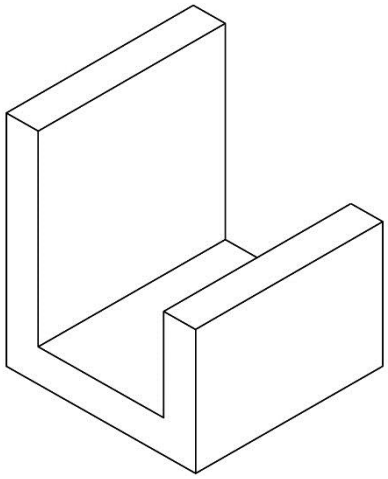
<td>
Describe the methods used by manufacturers to conserve energy and materials during product development and manufacture.
<table>
<tr><th>Level</th><th>Marks</th><th>Description</th></tr>
<tr><td>3</td><td>7–9 marks</td><td>The response shows a detailed understanding of methods used during product development and manufacture to conserve energy and materials. The response describes areas such as pre-production tests/simulations to minimise waste and sustainable energy solutions.</td></tr>
<tr><td>2</td><td>4–6 marks</td><td>The response shows a good understanding of methods used by manufacturers to conserve energy and/or materials The response refers to areas such as sustainable energy solutions and methods of minimising waste material.</td></tr>
<tr><td>1</td><td>1–3 marks</td><td>The response provides a basic description of how manufacturers may conserve energy or materials. The response refers to areas such as renewable energy sources and recycling material waste.</td></tr>
<tr><td></td><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>
Indicative content:

CAD modelling to simulate material tessellation prior to cutting on CNC machinery.
Greater use of CNC machinery for greater accuracy and therefore less waste.
Low energy lighting factories.
Electrical equipment going into standby when not in use.
PIR sensors in lighting.
Use of renewable sources of power.
Use of recycled materials wherever possible.
Use of rapid prototyping to produce testable prototypes before full scale production.
Use of Mould Flow Analysis to check mould designs will fill prior to investment.
Reduction of parts (combination) to reduce assembly requirements.
Use of redistribution production techniques wherever possible.
The use of reusable metal moulds when forming products removes the need for reproduction.
Manufacturing plants make use of renewable energy sources, such as solar/wind to power factories.
Use of cavity wall insulation on buildings to reduce heat loss and the amount of energy required to heat buildings.

</td>
<td>9 marks</td>
<td>AO42B</td>
</tr>
</table>

		• CAD simulation can be used to calculate the most efficient tool paths to reduce machining times. • Manufacturers may aim to reduce the thickness or volume of some components to make savings in the amount of materials used. **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.		

12		**Figure 4** shows a low carbon steel component with a volume of 11 100 mm^3 The density of low carbon steel is 7.85 g/cm^3 The component is to be hot dip galvanised. The galvanising process increases the mass of the component by 5% Calculate the mass of the galvanised component in grams. Show your working out. **Figure 4** **Isometric view** 	3 marks	AO42C

Conversion of density into g/mm^3 or Conversion of volume into cm^3	$7.85g/cm^3$ = $0.00785g/mm^3$ or 7.85×10^{-3} or 11 100 = $11.1cm^3$	M1
Calculate the mass prior to galvanising *(application of volume x density calculation)*	11 100 x their 0.007 85 = their 87.135 grams	M2
Calculate the mass once galvanised	87.135 x 1.05 = [91, 91.5] grams	A1
For the correct answer award full marks		3 marks

13		Compare the two radios shown in **Figures 5** and **6**. In your answer you should refer to developments in: • microelectronics • materials.	12 marks	AO31A 6 marks AO31B 6 marks

Figure 5

Figure 6

	Figure 5 Fabricated plywood valve radio (1950s)	**Figure 6 Injection moulded digital radio (2015)**
Button/control material	Thermoset polymer	TPE
Electronics	Thermionic valves	Integrated circuits
Main casing material	Fabricated plywood	Injection moulded thermoplastic
Information display	No display	LCD screen

Level	**Marks**	**Description**
3	9–12 marks	The response compares the two radios in detail with clear technical references to both of the stated bullet points. The response makes analytical judgements regarding the design of both products using the full range of data provided.
2	5–8 marks	The response compares both radios with clear references to at least one of the bullet points. The response makes analytical judgements regarding the design of both products referring to some aspects of the data provided.
1	1–4 marks	The response compares the radios in basic terms with reference to one of the bullet points. Limited use is made of the data

		provided.	
	0 marks	No response worthy of credit.	

Indicative content:

Developments in microelectronics:

- Figure 5 uses analogue electronics including manually tuned radio stations.
- Figure 6 uses digital electronics and allows the user to search/skip between stations and also use preset frequencies.
- Digital signal improved quality of reception and offers a far greater range of stations.
- Figure 6 benefits from developments in LCD Display technology allowing less buttons due to menu functions.
- The miniaturisation of components with development of transistors and Integrated circuits enabled the production of compact and portable products.
- The greater energy efficiency associated with Transistors allowed smaller devices without the risk of overheating.
- Figure 5 is constructed with Delicate valves making the product fragile and unreliable.
- Figure 5 relies on mechanical switches and buttons to operate.
- Figure 6 uses switches requiring much less movement/force and with more discrete profiles.

Developments in materials:

- Figure 5 was designed using natural woods and was seen as a piece of furniture not designed to be moved.
- Figure 5 Simple wood fabrication methods required many individual components adding cost a complexity to assembly.
- Figure 6 is produced using injection moulding techniques which can include internal supports and reduce assembly costs.
- Figure 6 is suitable for mass production in a range of colours and finishes.
- Figure 6 is produced using thermoplastics allowing complex forms to be produced in single pieces.
- Figure 5 uses standardised electronic switches/knobs due to the cost of designing individual parts.

Note: This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.

14		State **three** reasons why a designer may use a focus group. 1 mark for each stated reason. • To gain feedback on design concepts. • To observe user interactions with products. • To gather suggestions for product improvements. • You are able to gain a range of views from a focus group which is not possible from a single user. • To gain constructive criticism from the focus group prior to production of the design. • Focus groups can be held with specific demographics relevant to the product being designed and assessed. • If a product is being designed for a demographic group the designer is unfamiliar with, working with a focus group is essential to gain a better insight of the demographics needs. • To decide the most appropriate price point for a product. **Note:** This indicative content is not exhaustive: other creditworthy responses should be awarded marks as appropriate.	3 marks	AO42A

15		**Figure 7** shows a label often found on electronic products. Explain the meaning of the label shown in **Figure 7**. **Figure 7**  1 mark per relevant point • The label is an eco-label known as the EC energy label. • The label displays the energy efficiency rating of the product as A+ • Explanation of A+++ to D grade scale • The label gives product specific information (e.g. sound produced, water usage, energy used.) **Indicative content:** **Although the EC energy label can also be found on public buildings, reference to these should not be accepted as the question states electronic products are the focus.** The EC energy label is a compulsory label for use on household appliances to assist consumers in making choices based on energy efficiency.	2 marks	AO42A