Section A

1. Polymers

a. The blow-moulded bottle is made from polyethylene terephthalate (PET).
Give two reasons why PET is suitable for this product.
It has good moisture and gas barrier properties
It is tough, and so won't break if dropped
It can be clear, so customers can see the contents of the bottle
Award credit for any any other sensible (and correct) answer
BPA free – non toxic
Recycleable
Doesn't react with water
Suitable for blow moulding

b. Name a suitable polymer for the injection moulded cap
polyethylene
HDPE

c. The printed label is made from paper. It goes all the way round the part of the bottle that is 120mm in diameter and overlaps by 10mm

I. State one reason why paper has been chosen for the label
It is easy to print onto
It is inexpensive
It is flexible and will wrap around the bottle
It is recyclable

II. State one reason why the printed label overlaps
Provides an overlapping contact area where adhesive can be applied to secure it around the bottle.

III. Calculate the length of the label including the 10mm overlap
$2\pi R = 2x \pi x 60 = 376.9mm$
$376.9 + 10 = 386.9mm$

d. 'Labels must inform and protect the customer.' Discuss this statement in relation to the fruit juice bottle label. (8)
Nutrient content (sugars, fat, calories, etc)
Recyclable/disposal details
Use by date, Best before date etc
Fruit content (customers could be allergic)
Type of plastic used
any special storage conditions
the country of origin, if required
marketing/branding
allergies

2. Design Engineering

a. Light – emitting diodes (LEDs) are often used instead of bulbs in many modern electronic devices. State one advantage and one disadvantage of using LEDs instead of bulbs in electronic devices (2 - one for ad and one for dis)
AD: Long service life
Energy efficiency
Resitance to impact and temperature – no filaments
Heat transfer – generate very small amounts of heat due to high performance and are therefore safer
Wide range of colours available
DIS: More expensive than other forms of lighting
They must be supplied with the same voltage and a constant flow of current
They can shift colour due to age and temperature

b. An LED is an example of an output component. Can you state another example of an input and an output component. (2)
INPUT – switch, LDR, solar cell
OUTPUT – motor, LED, buzzer, speaker

c. The solar light receives its energy from solar panels.

I. Calculate the fraction of total energy that is generated from renewable fuels. Give your answer as a fraction in its lowest form (1)
$6 + 77 + 98 + 70 + 84 = 335$
$84 \div 335 = 0.2507 = 25\% = 25/100 = ¼$ ✓
Also allowed 84/335 as doesn't easily go into lowest term

1 mark for analysing the data to identify the appropriate data to correctly calculate the answer.

II. Calculate the energy generated by hydroelectricity to the nearest decimal (2)

1:12 = 1 + 12 = 13 (✓)

84TWh÷13=6.46=6.5TWh (✓)

Or

6.5 TWh (✓)(✓)

1 mark for understanding the formula ratio

1 mark for calculating the answer from the overall renewable energy to the nearest decimal

award credit for any appropriate method of calculating

3. Sustainability

a. Complete the table below to show a sensible material that could be used to manufacture the parts of the products listed (3)

Trowel – hardwood such as ash or oak (accept only hardwood – one for hard and one for wood etc)

Watering can – thermopolymer such as HDPE (accept thermopolymer) also allowed aluminium, galvanised steel, copper

A ferrous metal such as galvanized steel (accept ferrous metal)

Blade – a ferrous metal such as high carbon steel, or stainless steel (accept ferrous metal)

b. The seed packet is made from foil-backed paper. State three qualities of foil-backed paper that make it suitable for a seed packet (3)

smooth paper surface for printing information

the foil makes the package waterproof so that the seeds will not get damaged

foil-backed paper is easy to cut, fold and join

Award credit for any other appropriate response

Easy to open – tears open easily

c. Give one positive and one negative impact of planned obsolescence: (2 – one for a pos and a neg)

POS: Medical syringes / disposable razors can stop infections

Manufacture of lightbulbs, etc stimulates the economy and creates employment

NEG: Cost to the consumer to replace old products as new technology (wireless charging, etc.) is introduced.

New software / OS and peripheral products must be purchased to enable users to use products already owned.

Increased use of energy / natural resources etc. to continue cycle of manufacture.

Section B

4. Insert questions

a. The trowel blades in Image A are made from metal and the handles are made from wood. Give two reasons why high carbon steel is a suitable material for the blades (2)

Hard
Tough
Retains a sharp edge

b. Give one advantage of using chloroflute over cardboard in this context.

Waterproof
Easy to cut to size
Rigid
Lightweight
Available in a range of colours
Waterproof

c. Image C on the insert shows a cyclist Fig. 9 shows a close up of the gear mechanism.

I. State the type of motion that takes place when the cyclist turns the pedals.

Rotary

II. If the driver gear has 60 teeth and the driven gear has 12 teeth. Calculate the velocity ratio for this system.

60/12 = 5
ratio = 1:5

d. The person in **Image D** is wearing a black coat made from a natural fibre.

I. Identify one natural fibre

Wool
Cotton
Silk

II. Explain one property of natural fibres that make them suitable for the coat shown

Natural fibres have good thermal properties (✓), as the coat is worn outside this will offer warmth to the wearer. (✓)
Natural fibres offer good tensile strength (✓), so the coat will last and wear well over time. (✓)
Other properties of natural fibres might include:
good absorbency (for dying them)
soft to the touch (for comfortable wear).

Award credit for any other appropriate response
1 mark for identifying a suitable property for the coat.
1 mark for explaining why the property is suitable for the coat.
The property given may be appropriate, but if the explanation is not appropriate only one mark can be awarded. Answers must be appropriate for the context in the question: coat in image D

5. Designers make prototypes to show their designs to key stakeholders.

   a. Step by step – apply mark scheme below to questions (from sample paper)

Question			Answer	Marks	Guidance	
5	(a)		Indicative content of the most likely specific processes, tools, methods of accuracy, suitable finishing and materials for each product are shown in the table below. Allow step-by-step plans 1:1 or scaled final prototypes. The step-by-step plan should follow an appropriate order and should cover the following: **Materials and components**, e.g.; appropriate selection and preparation of specific materials and/or components. **Processes, techniques or skills, e.g.:** • *wasting methods* used to cut the materials (with allowances / tolerances as appropriate) – including accurate use of specific tools. • *deforming and reforming methods* used to shapes or strengthen materials and/or components – including accurate use of specific tools or equipment. • *methods of addition* used to join materials and/or components – including how	**12** **AO3** **2 x 1a** **1 x 2b** **AO4** **5 x 1c** **4 x 2c**	Candidates should present a clear step-by-step plan to demonstrate their understanding of the stages required to make a final prototype of their chosen product. If there is no evidence of an ordered plan, e.g. a list of unordered bullets they should not be rewarded with marks higher than a Level 1. Candidates can refer to manual, machine or CAD/CAM processes, but they must be appropriate for a school workshop not industrial manufacture. Candidates are not required to but may use sketches to support their answer. No marks should be awarded for the sketches themselves, but marks can be awarded appropriately for supporting annotation. _____ *A candidate operating at Level 3 could be accessing marks in a variety of ways. All but one of the AO4 marks and at least one of the AO3*	**Level 3 (9–12 marks)** The candidate demonstrates they have fully analysed the information given on the insert recognising all details required for making a final prototype. Their step-by-step stages will be comprehensive and well planned demonstrating excellent evaluation of how to undertake the making process. The candidate's plan will be fully detailed using appropriate terminology to demonstrate an excellent understanding of the workshop techniques and processes required to make their chosen product as a final prototype in a school workshop. They will demonstrate a thorough knowledge of how to work with specific tools and application of digital technology should be used (if appropriate). They should be clear on how to ensure a completely accurate outcome. Specific materials/components and finishes will have been clearly identified that are fully appropriate for both the processes being used and the prototype being made. **Level 2 (5–8 marks)** The candidate has adequately analysed the information given on the insert in that they have recognised some details required to make a prototype. Their step-by-step stages will be clear and some planning should be evident, demonstrating good evaluation of how to undertake the making process.

Question			Answer	Marks	Guidance	
			to ensure accuracy. **Tools and digital** technology, e.g.; all tools required to fulfil the processes and techniques being used. **Accuracy**, e.g.; appropriate measuring and marking /setting out and/or preparation of moulds, jigs, decoration or templates to ensure accuracy **Finishing**, e.g.; methods used for tidying up, preparing and finishing the materials / products so that they are suitable to be presented to a stakeholder.		*marks for planning their approach, or all AO3 marks and at least six of the AO4 demonstrating a broad knowledge and understanding of principles related to workshop skills.* *A candidate operating at Level 2 could be accessing marks in a variety of ways, but they should cover at least one of the AO3 marks for planning their approach and at least four AO4 marks, that sufficiently demonstrate enough of their knowledge and understanding of principles related to workshop skills.* *A candidate operating at Level 1 could be accessing marks in a variety of ways. They have not undertaken any analysis of the information on the insert, or planned their approach (AO3), but demonstrate some understanding of the materials and/or processes used to make a prototype(s), or they have done some analysis of the information (AO3) but have not demonstrated much*	The candidate's plan will offer some detail and use of appropriate terminology to demonstrate adequate understanding of the workshop techniques and processes required to make their chosen product as a final prototype in a school workshop. They will demonstrate a good knowledge of how to work with tools that may not always be specific and digital technology may be used (if appropriate). They should have some understanding of how to ensure accuracy in their outcome. Most specific materials/components and finishes should have been identified that are mostly appropriate for both the processes being used and the prototype being made. **Level 1 (1–4 marks)** The candidate has not fully analysed the information given in the Insert and/or planning is limited or not evident showing little evaluation of how to undertake the making process. The candidate's plan will lack any details and demonstrate a limited understanding of the workshop techniques and/or processes required to make their chosen product as a final prototype in a workshop. The response will demonstrate a basic level of skill and/or knowledge of the candidate in relation to their own workshop experiences and knowledge of tools and processes to offer little / no support to their response.

Question			Answer	Marks	Guidance	
					knowledge of the materials or making processes.	Specific materials/components and finishes may not be fully appropriate or identified. **Level 0 (0 marks)** No response or no response worthy of credit.

Indicative Content, e.g.:					
Product 4: Retractable barrier (polymers)	• HIPS • Styrofoam	• Making moulds • Using the moulds to vacuum form the casing • 3D printing / laser cutting • Heat bending	• Files • Drill • CNC laser cutter • 3D printer	• Measuring to scale • templating	• File, sand and polish edges • Black paint
Product 5: Toilet sign (metals)	• Aluminium • Mild steel	• Bending panels • Welding /pop riveting sections together • Drilling holes to attach brackets • Applying imagery	• Pillar drill • Sheet metal bending machine • Arc welding machine	• Measuring to scale • Drilling/cutting templates	• Spray painting • Paints
Product 6: Flower planter (timbers)	• Pine • Fir	• Turning ball ends • Sawing and sanding • Doweling the ball ends	• Wood lathe • Jigsaw/bench saw • Pillar drill • Countersink bit	• Using jigs/templates for panel cutting/drilling • Using a lathe template	• Stain, varnish, preservative • Ensuring no sharp edges
Award credit for any other appropriate response acknowledging that materials that are suitable for a prototype may differ to those used to make the actual product.					

Specific materials and components you would use to make the prototype (2)

The processes, techniques or skills you would use (2)

Tools you would use, including digital technology as appropriate (2)

How you would ensure accuracy when making the prototype (2)

How you would finish it to present it to stakeholders. (2)

Holistic overview (2)

b. What things might you do as a designer to keep your stakeholder involved in the design process, and how might this help?

THINGS YOU CAN DO

- Schedule regular conference calls with the stakeholder during the design and research stage, gather their feedback to inform adjustments and design decisions;
- Make prototype(s) and conduct user trials / ergonomic testing with the stakeholder to inform the design process;
- Use online resources (Surveymonkey, etc.) to gather opinions, needs and desires from the stakeholder;
- Invite the stakeholder to focus group meetings to gather feedback that can guide design decisions;
- Use VR, CAD modelling and simulations in order to give the stakeholder a clear vision of the product before manufacture, thus enabling the stakeholder to test and handle the product in a capacity.
- The stakeholder can be consulted on their desired colours scheme / material choice / finish etc. vis Skype and Facetime;
- 3D printed models can be produced to illustrate scale, shape and size to the stakeholder- facilitating useful feedback;
- Ergonomic testing can be undertaken with high quality prototypes produced by the designer.

HOW MIGHT THIS HELP

- The stakeholder will feel that they have had a valid input into the design process / sense of ownership;
- The stakeholder is more likely to use and value the product, thus reducing the likelihood of disposal / use of landfill;
- The stakeholder is less likely to reject the product if they have had a significant input into its design direction;
- 3D printed iterations and prototypes can be tested by the stakeholder in their intended environment, thus helping to identify flaws and ensure a better functioning product is made;
- RSI, injuries and poor function is less likely if a prototype has been mad and teste by the stakeholder.

See top of p4 in textbook.

- Listen to Feedback
- Share Projects & Roadmaps
- Focus groups, questionnaires

c. Discuss the advantages and disadvantages of using CAD modelling as a form of prototyping.

ADVANTAGE

- Mistakes can be edited on the model before they go to manufacture
- Less use of natural resources with a CAD model;
- Little energy use in comparison to 3D printing / model making;
- Renderings can be emailed as an attachment to clients around the globe, cutting unnecessary travel and emissions;
- CAD simulations can be used for modelling to test in hazardous environments;
- Eliminates the expense and labour of producing a prototype – increases profits.

DISADVANTAGE

- CAD modelling will not always account for variables. Weather, atmospheric conditions, humidity can affect performance / fuel consumption. CAD simulations cannot always be reliable;
- Consumers often like to handle the product, especially for ergonomic testing. This is impossible with a CAD model;
- CAD software is very expensive, often requires expensive upgrades / new and more powerful machines to run it, and so is not accessible to all;
- Staff need to be very flexible / require regular CAD training which is expensive.

d. It is said that we live in a 'throwaway' culture. Discuss the ways in which built-in product obsolescence contributes to a 'throwaway' culture.

Once a product stops working it is thrown away
It is often cheaper to replace a product than to repair it
New and improved models/products are released by companies to entice new sales
Often some of the new models are cheaper than the older models
Replacement parts are often withdrawn by companies meaning that you cannot get spare parts
Some parts are designed to break/wear out before other parts so the product becomes unusable
New and developing technology and features mean people want the latest/newest products and gadgets
Generally acceptable amongst a large section of society / lazy / lack of knowledge to fix / repair things
Reliance on built in obsolescence to generate / perpetuate consumer cycle

6. You should use the same product you chose for Question 5 to answer this question.

a. Materials need to be sourced and processed in order to be used to make products.

One mark for identifying an appropriate source and up to three marks for a description.
In relation to the specific material stated. Answers could answers include:
Natural and manmade timbers
Sourced from tress (✓) and a description of the conversion to workable materials. (✓)(✓)(✓)
Ferrous and non-ferrous metals
Sourced from metal ores such as bauxite, gold and iron ore (✓), and a description of its conversion to workable material. (✓)(✓)(✓)

Thermo and thermosetting polymers
Sourced from oils (✓) and a description of the conversion to workable materials. (✓)(✓)(✓)

7. Discuss the impact on society of new and emerging technologies (8)

POSITIVE

- New and emerging technologies facilitate globalisation (transactions with suppliers / consumers worldwide is enabled by the internet);
- Carbon emissions are cut by the use of Skype / Facetime for international calls / meetings meaning flights are not required;
- People can watch movies online – DVDs etc. don't need to be made / distributed / disposed of;
- Internet shopping reduces the need for consumers to make journeys by car;
- Increased access to huge no. of books and vast amount of information for people – enables study & learning;
- Robots and AI have revolutionised the car industry, enabling more choice and mass customisation for the consumer;
- Biometrics have enhanced security – especially at airports;
- VR can be used for training in hazardous environments (pilots / space exploration, etc.)

NEGATIVE

- Increased unemployment caused by drones / AI / robots in workplace;
- Safety – drones haven't been fully tested for deliveries in urban areas;
- People become addicted to social networks causing health issues;
- People can become victims of cyber bullying / computer viruses / online fraud;
- Illegal downloads threaten artists' livelihoods;
- Internet shopping can create pollution – people encouraged to buy things they don't need, often from abroad, thus creating carbon emissions (distribution & manufacture). The internet nw produces 2% of the world's pollution.

Industry

- the design and organisation of the workplace including automation and the use of robotics
- buildings and the place of work
- tools and equipment.

Enterprise

Enterprise based on the development of an effective business innovation:

- crowd funding
- virtual marketing and retail
- co-operatives
- fair trade.

Sustainability

The impact of resource consumption on the planet:

- finite
- non–finite
- disposal of waste

People

- How technology push/market pull affects choice.
- Changing job roles due to the emergence of new ways of working driven by technological change.

Culture

- Changes in fashion and trends in relation to new and emergent technologies.
- Respecting people of different faiths and beliefs.

Society

How products are designed and made to avoid having a negative impact on others:

- design for disabled
- elderly
- different religious groups.

How the critical evaluation of new and emerging technologies informs design decisions

That it is important to consider scenarios from different perspectives and considering:

- planned obsolescence
- design for maintenance
- ethics
- the environment.
- Computers take away our decision-making skills

- Manual jobs will be replaced by machines
- Jobs created to program and design new technologies.