**Design & Technology**

**AQA A-Level** Logo

Description automatically generated with low confidence

**Performance characteristics of polymers**

**Materials required for questions**

* Pencil
* Rubber
* Calculator

**Instructions**

* Use black ink or ball-point pen
* Try 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
* Try to answer every question
* Don’t spend too much time on one question

**Good luck!**

**Q1.** Which thermoplastic is commonly used for plastic bags and packaging films due to its flexibility?

**A** HDPE

**B** LDPE

**C** PET

**Q2.** Which thermoplastic is known for its toughness and is used in LEGO bricks and automotive parts?

**A** ABS

**B** PMMA

**C** PVC

**Q3.** Which thermoset is used for electrical fittings and adhesives due to its excellent insulation properties?

**A** Polyester resin

**B** Urea formaldehyde (UF)

**C** Epoxy resin

**Q4.** Why are thermosets like epoxy resin unsuitable for recycling through melting?

**A** They dissolve in water

**B** They are too expensive

**C** They undergo permanent chemical bonding (cannot be remelted)

**Q5.** Compare and evaluate the suitability of Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA) for the manufacture of a 3D printed component **(6 marks)**

**Q6.** Explain why polypropylene (PP) is an appropriate material for the manufacture of an ice cream container **(6 marks)**

**Q7**. Explain why High Impact Polystyrene (HIPS) is an appropriate material for the manufacture of a protractor **(6 marks)**

**Answers**

**Q1**. B

**Q2**. A

**Q3**. B

**Q4**. C

**Q5**.

ABS

* ABS is a crude oil-based polymer which comes from a finite resource.
* ABS is a tough material that can be used to create a 3D printed component with good resistance to impact.
* ABS can be pigmented to produce a filament with a wide range of bright and bold colour options.
* 3D printing often creates waste material in the form of rafts and supports. Although ABS can be recycled, it would more than likely be disposed of and contribute to landfill.

PLA

* PLA is a bio polymer that is engineered from natural and renewable resources.
* PLA is a brittle material so may create a component with poor impact resistance.
* PLA is becoming increasingly available in a wider range of colour options in line with ABS.
* Rafts and support material in PLA will eventually biodegrade and have a reduced environmental impact when disposed of.

General

* ABS has a higher melting point than PLA which means it requires more energy to print in ABS than PLA.
* ABS can give off toxic fumes when heated and can often require extraction and filtration.
* ABS requires a 3D printer to have a heated bed to improve adhesion when printing whereas PLA is generally an easier material to work with.
* The lower melting point of PLA makes it unsuitable for the manufacture of a component that may be exposed to friction or higher working temperatures.

**Q6.**

* PP has an excellent resistance to fatigue meaning that it will not break or tear with the constant removal and refitting of the lid
* PP is a food safe polymer making it suitable to contain the ice cream
* an ice cream container will potentially have a short lifespan so PP is suitable as it can be recycled
* PP can be injection moulded or vacuum formed which is necessary to achieve the close tolerances needed for the ice cream lid to securely click in place
* PP remains relatively flexible at low temperatures allowing the lid of the container to ‘snap’ over the rim of the ice cream container
* PP is a thermoplastic that is readily recycled, an essential property for a product with a short lifespan
* PP is a tough material that will withstand the likely impact that occurs in transit from supplier to store, store to consumer
* PP has a naturally milky appearance but can be easily pigmented allowing it to represent a variety of brands
* PP is available in a variety of grades; some are clear and would be appropriate for ice cream containers that wish to display the colour of the ice cream.

**Q7.**

* HIPS has excellent optical properties and can be translucent allowing for clear visibility through the product, essential for use.
* HIPS has a good level of hardness allowing it to resist scratching when stored in a pencil case, and preventing the surface from being obscured.
* HIPS is a rigid polymer that maintains the thin flat shape of the protractor so that it can be used to measure angles on drawings accurately.
* HIPS is a shatter resistant polymer that prevents the product from cracking if exposed to impact such as a bag getting dropped.
* HIPS has a low melting point which makes it particularly suitable for the injection moulding process used to manufacture the protractor.
* HIPS can be easily injection moulded which is appropriate for the scale of the market.
* HIPS can be easily printed on allowing for the application of the angle increments and text needed for the protractor.