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Design & Technology
Eduqas GCSE

Polymers: forces, stresses, reinforcing and stiffening

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 force pulls a material apart and stretches it along its length?

A Compression

B Tension

C Torsion

Q2. Which force is a twisting force, like turning a screwdriver?

A Torsion

B Shear

C Bending

Q3. Bending is a combination of which two forces?

A Torsion and shear

B Shear and tension

C Tension and compression

Q4. What is meant by "creep" in thermoforming plastics?

A Slowly stretching under a constant load

B Softening permanently when heated

C Cracking under a sudden impact

Q5. Why do moulded plastic products have ribs and webs?

A To make them easier to recycle

B To add stiffness without adding much weight or thickness

C To improve their colour

Q6. Which composite is made from carbon fibre in epoxy resin?

A GRP

B Kevlar composite

C CFRP

Q7. A child's high chair has four legs, a seat and safety straps. Identify the force acting on each of the following parts of the high chair when in use.

Q7a. Legs **(1 mark)**

Q7b. Seat **(1 mark)**

Q7c. Straps **(1 mark)**

Q8. An archer has pulled back the string of a bow, ready to fire an arrow. Describe what forces are acting on the bow and arrow before it is fired. **(3 marks)**

Q9. This question is about the effects of forces on products.

Q9a. A desk lamp is manufactured from urea formaldehyde. Its adjustable support arm is in compression. Explain one possible effect of the compressive force acting on the support arm. **(2 marks)**

Q9b. A toy tower crane has a jib held up by jib ties. The jib ties are in tension. Explain one possible effect of the tension acting on the jib ties and jib. **(2 marks)**

Q10. This question is about stiffening products and materials.

Q10a. Products such as bicycles need to have structural strength. Identify two methods that designers use to ensure the structural strength of a product. **(2 marks)**

Q10b. Describe two ways materials can be stiffened. You may use examples in your answer. **(4 marks)**

Q10c. The chassis of a drone is made using plastic laminates. Explain why the chassis uses plastic laminates in its construction. **(2 marks)**

Q11. This question is about reinforcing materials.

Q11a. Explain how materials can be improved by being reinforced. Give examples. **(3 marks)**

Q11b. Explain how Kevlar fibres are processed and arranged to give this material its unique properties. **(2 marks)**

Q12. This question is about fibre reinforced plastics.

Q12a. A tennis racket is made from carbon fibre reinforced plastic (CFRP). State two properties of CFRP that make it suitable for the tennis racket. **(2 marks)**

Q12b. A manufacturer is considering using carbon fibre for the main body of an electrically powered hand drill. Explain two benefits of using carbon fibre for the main body of the drill. **(4 marks)**

Q12c. When manufacturing fibreglass (GRP), the glass fibre matting is coated with a mixture of resin and catalyst, in the ratio of 100 g of resin to 2 ml of catalyst. Calculate how much catalyst would be added to 650 g of resin. **(2 marks)**

Q13. A ride-on toy for young children is made from polypropylene (PP). Explain how the toy can be designed to withstand the forces and stresses of use by children. **(3 marks)**

Answers

Q1. B
Q2. A
Q3. C
Q4. A
Q5. B
Q6. C

Q7.

1 mark for each correctly named force:

- Legs: compression or bending (1)
- Seat: compression (1)
- Straps: tension (1)

Q8. (3 marks)

Accept bending, compression, tension, torsion and shear. Do not accept gravity, friction or elastic.

Marks	Descriptor
3	Two or more force locations identified, with a full description of how they act on the bow and arrow before it is fired.
2	One force location correctly identified and clearly described on part of the bow or arrow.
1	Two simple forces identified but not clearly linked to part of the bow or arrow, or an outline of some action in the bow or arrow.
0	No response or nothing worthy of credit.

Indicative content:

- The bow string is pulled back, so it is under tension
- The bow is bent, so it is under a bending force (tension on one side, compression on the other)
- The arrow is under compression until the archer lets go
- The bow is under compression from the archer's hand

Q9a.

An effect (1) and a linked justification (1). For example:

- The arm might bend if its section is not big enough (1), so it could not support the lampshade and might collapse or break (1)
- The force on the arm causes a shearing action on the pivot (1), which could make the hinge shear or break (1)
- The arm is drilled and bears onto a pivot point (1), so the UF could split at this weak point (1)

Q9b.

An effect (1) and a linked justification (1). For example:

- The jib ties might stretch if they are not big enough (1), so they cannot support the jib and it collapses or breaks (1)
- The tension causes a shearing action on the pivots or attachment points (1), which could make them shear or break (1)
- If the load is too heavy, the tension may be too great (1), so the jib ties might snap (1)

Q10a.

Two from (1 mark each): triangulation; layering or laminating; plastic webbing or ribs; reinforcing; choosing a strong form such as a tube or square section; named joints that give extra strength. Credit any other method that provides structural strength.

Q10b.

A maximum of 2 marks for each way: 2 marks for two simple points or one point clarified in detail (for example with an example); 1 mark for one simple point. For example:

- Webbing and ribs: extra material added to stiffen polymer products, e.g. chair underframes, so they resist bending when loaded
- Laminating: building up layers to form a composite, e.g. plywood or CFRP, increasing strength, rigidity and impact resistance
- Bending, folding or curving: a curved or folded shape is stiffer than flat sheet, e.g. a tubular chair frame or corrugated card
- Fillets: a curved radius where two sides of a moulding meet strengthens the corner and reduces stress

- Bosses: thickened areas on a moulding to take a screw thread without making the whole part thicker
- Triangulation: makes structures such as bridges stiffer and more resistant to forces

Q10c.

Must refer to strength and rigidity. 2 marks for an answer with detail, e.g. laminating plastics builds up strength and rigidity without adding much weight, so the chassis resists twisting and flexing, which is ideal for a drone. 1 mark for an answer lacking detail, e.g. laminating makes it stronger, giving the drone a stable base.

Q11a.

3 marks: two or more detailed points, or one detailed point and two simple points. 2 marks: one method explained in detail or two simple points. 1 mark: one simple point. For example:

- Composites: two or more different materials combined to get the best properties of each, e.g. CFRP or GRP
- Ribbing and webbing in polymer products reduce the material used and the weight while increasing stiffness, e.g. food packaging
- Lamination: layers bonded together, e.g. glulam timber beams resist bending; laminating paper improves tear and moisture resistance
- Concrete reinforced with steel bars to resist tensile forces
- Fabrics: interfacing in collars and cuffs, rivets in jeans, double stitched or flat felled seams
- Fillets and gussets strengthen corners and joints

Q11b.

1 mark for each simple correct point, or 2 marks for one point explained in detail or with an example. "Strong" must be qualified. For example:

- Arranged as a non-woven mat (1) or in layers (1)
- Woven (1), or spun into ropes (1)
- Woven into a net-like, interlocking structure that resists penetration, e.g. knife or bullet resistant body armour (2)
- Treated with chemicals to make the fibres more flexible, e.g. easier to move in when worn as clothing (2)

Q12a.

Any two (1 mark each): tough, lightweight, good wear resistance, durable, impact resistant, easily moulded. Accept any other valid property.

Q12b.

Any two benefits (1) with a linked justification (1). Accept durable, hardwearing or tough. For example:

- It is lightweight (1), so the drill is not too heavy to hold and the user can work longer without tiring (1)
- It can be formed into complex shapes (1), so smooth, sleek, ergonomic forms can be made (1)
- It has an excellent strength to weight ratio (1), so although it is light it can cope with normal use (1)

Q12c.

650 ÷ 100 = 6.5, and 6.5 × 2 (1) = 13 ml (1). Award full marks for the correct answer without working.

Q13. (3 marks)

Up to 3 marks: three identified points, or two identified points and an explanation. For example:

- Ribbing or a honeycomb structure inside the moulding reinforces the 3D parts while keeping the weight down
- A monocoque (one piece shell) structure spreads the load across the whole body
- Reinforced, rounded corners mean the parts last longer when handled and knocked by children
- Thicker or deeper sections where the child sits make the toy stiffer under load
- UV stabilisers stop the polypropylene degrading and becoming brittle when used outdoors
- Polypropylene is tough, so it bends rather than breaking under impact