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Design & Technology
Eduqas GCSE

Polymers: sources, origins, properties and footprint

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. What is the name of the process that separates crude oil into different parts by their boiling points?

A Cracking

B Fractional distillation

C Polymerisation

Q2. What happens during polymerisation?

A Small monomers join together to form long chain polymers

B Long chain polymers are broken down into monomers

C Crude oil is separated into fractions

Q3. Which plastic is made from plant starch (such as corn) and is used as 3D printing filament?

A PVC

B Nylon

C PLA

Q4. Which thermoplastic should never be laser cut because it gives off toxic fumes?

A Acrylic

B PVC

C Polypropylene

Q5. Which property makes plastics suitable for plugs and cable coatings?

A Good electrical insulation

B Good electrical conductivity

C High density

Q6. Which of these is an ecological impact of extracting crude oil?

A Improved soil fertility

B Lower carbon dioxide emissions

C Oil spills that pollute oceans and harm wildlife

Q7. This question is about where polymers come from.

Q7a. Give the source or origin of polymers. **(1 mark)**

Q7b. Name one process used to convert this source into a workable form. **(1 mark)**

Q7c. Using notes and/or sketches, describe the process you have named in Q7b. **(4 marks)**

Q8. This question is about the working properties of polymers.

Q8a. A puzzle toy is manufactured from polythene. State one reason why polythene is used to manufacture the puzzle. **(1 mark)**

Q8b. The parts of the puzzle are connected using flexible ball joints made from nylon. Identify a property of nylon that makes it suitable for a flexible ball joint. **(1 mark)**

Q8c. The main body of a drone is made from polypropylene. Give two disadvantages of using polypropylene for the main body of the drone. **(2 marks)**

Q9. PLA is a polymer commonly used in 3D printing. It is made from plant starch, such as corn.

Q9a. Designers are increasing the use of biopolymers in product packaging. What is a biopolymer? **(1 mark)**

Q9b. Give two reasons why thermoforming polymers are a good choice for 3D printing. **(2 marks)**

Q10. Analyse the benefits of using natural plastics instead of synthetic plastics. **(5 marks)**

Q11. A toy tower crane is made from High Impact Polystyrene (HIPS). The HIPS is produced from crude oil transported from Saudi Arabia. Explain two ecological impacts of oil extraction and processing. **(4 marks)**

Q12. An ice cream tub comes with a small polymer spoon that fits underneath the lid. Explain two reasons why a biodegradable polymer should be used to make the spoon. **(4 marks)**

Q13. A public bench is manufactured from recycled plastic products. Analyse the impact recycled plastics have on our ecological footprint. **(5 marks)**

Q14. Analyse how consumers' growing awareness of the impact of plastic waste is influencing manufacturers' use of the material. **(5 marks)**

Q15. Discuss how designers can improve and extend the life of polymer products to lessen their impact on our environment. **(6 marks)**

Answers

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

Q7a.

Crude oil (1). Also accept plants such as sugar cane or corn starch (biopolymers), coal or natural gas.

Q7b.

One of: fractional distillation (1), cracking (1) or polymerisation (1). Accept refining.

Q7c. (4 marks)

A description of the named process and how it turns the raw material into a workable form. Maximum of 2 marks if the process does not relate to Q7b. Credit both sketches and notes.

Marks	Descriptor
3 to 4	A well described process, in the correct order, using notes and/or sketches to show clear understanding.
1 to 2	One or two brief descriptive points, possibly with a simple sketch.
0	No attempt or nothing worthy of credit.

Indicative content:

- Fractional distillation: crude oil is extracted by drilling and taken by tanker or pipeline to a refinery. It is heated until it turns to vapour, which rises up a fractionating column. The column is hottest at the bottom and coolest at the top, so the parts (fractions) condense at different heights depending on their boiling points, e.g. petrol, diesel and naphtha

- Cracking: long chain hydrocarbons are broken down into shorter, more useful molecules (monomers such as ethene). Heat and catalysts are used to make this happen
- Polymerisation: thousands of small monomers are joined together into long chain polymers (e.g. ethene becomes polythene). Additives such as pigments, plasticisers and stabilisers are mixed in, then the plastic is extruded and cut into small pellets (granules) or formed into sheet, rod or tube

Q8a.

One mark for a correct reason related to manufacture, e.g. cheap (1), easily moulded (1), durable (1). Credit any other appropriate response.

Q8b.

One mark for a suitable property of nylon, e.g. durable (1), lightweight (1), hardwearing (1), self lubricating (1). Credit any other appropriate response.

Q8c.

One mark for each disadvantage, up to 2 marks. For example:

- Can be difficult to manufacture at high temperatures
- Can be difficult to bond (glue)
- Considered a tough plastic but can have poor impact resistance
- Suffers from UV degradation (breaks down in sunlight)
- Can catch fire and has a low flammable temperature

Q9a.

A polymer created from a renewable or natural resource (1). Accept a named example, e.g. plant starch, corn or seaweed.

Q9b.

One mark for each reason, up to 2 marks. Do not accept “can be reheated, reshaped or reused”.

- Mouldable and easy to shape; can be extruded when heated
- Available in different colours, or can be dyed a specific colour

- Can be transparent
- No adhesive needed, as the layers stick together once cooled
- Low cost compared to other materials
- Good strength to weight ratio
- Low melting point, so less heat and energy is needed

Q10. (5 marks)

Indicative content (not prescriptive):

- Natural plastics break down in a few months rather than hundreds of years, reducing landfill and litter
- They can be composted; the compost improves soil fertility and helps plants grow
- Less energy is needed to make them, and there is no need to find, extract and transport crude oil
- They reduce the use of crude oil, a finite resource, and are made from plants that can be regrown
- Fewer greenhouse gases are produced during manufacture
- They are non-toxic and do not release methane or harmful chemicals when they break down, protecting wildlife and ecosystems
- They help tackle plastic waste in the oceans

Band	Marks	Descriptor
3	4 to 5	A coherent answer with detailed, relevant knowledge and understanding of the benefits of natural plastics over synthetic plastics. Relevant examples and a well-developed, logical chain of reasoning, sustained throughout.
2	2 to 3	Some coherence, with partial knowledge and understanding. Mostly relevant examples and a logical chain of reasoning that may not be sustained throughout.
1	1	Basic knowledge and understanding. Limited relevant examples or logical chain of reasoning.
0	0	Incorrect or irrelevant answers.

Q11.

Any two explanations: an effect of crude oil extraction or processing (1) and a linked justification (1). For example:

- Extracting, processing and transporting crude oil creates emissions (1), which contribute to global warming or harm people's health (1)
- Crude oil is transported by sea (1), which increases the risk of accidents and oil spills (1)
- Extraction and processing can pollute the local environment (1), poisoning the land and wildlife (1)

Q12.

Any two explanations: a reason (1) and a linked justification (1). For example:

- The spoons can be composted (1), which reduces the waste going to landfill or incineration (1)
- Biodegradable polymers are made from sustainable resources (1), so there will always be resources available to make them (1)
- It reduces the demand for oil (1), so current oil stocks last longer (1)
- The spoons may be dropped as litter (1), but over time they will break down and decompose, reducing their environmental impact (1)

Q13. (5 marks)

Indicative content (not prescriptive). Both positive and negative points are preferred, but a detailed, analytical answer on the positives alone can still be credited.

Negative

- Lots of discarded plastic never makes it to the recycling centre
- Collection vehicles are heavy polluters, particularly during slow, stop-start collections
- Not all plastics collected can or will be recycled; the percentage recycled is still very low
- Recycling itself creates pollution, with harmful gases escaping into the atmosphere
- Plastics are broken down during recycling and escape as microplastics into the environment and water courses

Positive

- Repurposing plastic stops the whole product ending up in landfill
- Recycling products into “plastic lumber” (like the bench) reduces the need to harvest natural timber
- Some recycled plastics replace other resources and fossil fuels such as oil

Band	Marks	Descriptor
3	4 to 5	A coherent answer with detailed, relevant knowledge and understanding of the ecological footprint of recycling plastics. Relevant examples and a well-developed, logical chain of reasoning, sustained throughout.
2	2 to 3	Some coherence, with partial knowledge and understanding. Mostly relevant examples and a logical chain of reasoning that may not be sustained throughout.
1	1	Basic knowledge and understanding. Limited relevant examples or logical chain of reasoning.
0	0	Incorrect or irrelevant answers.

Q14. (5 marks)

Answers should show that consumers and manufacturers know traditional materials, particularly plastics, harm the environment. Indicative content:

- Plastic waste has been in the media spotlight (ocean plastic, microplastics, harm to wildlife), increasing public awareness
- Consumers are demanding more environmentally friendly products, so alternatives to traditional plastics must be found
- Manufacturers are switching to recycled, bio-based or biodegradable plastics, or replacing plastic with paper and card
- Single use plastics such as straws, bags and cutlery are being reduced, charged for or banned
- Designers apply the 6Rs, e.g. reducing packaging and offering refills
- Designers look for more sustainable ways to design products, and manufacturers promote their ethical approach to increase sales

Band	Marks	Descriptor
3	4 to 5	A clear understanding of the environmental need for more sustainable products in place of traditional materials. May mention the 6Rs, current environmental issues, consumer demand for greener products and the media spotlight.
2	2 to 3	Some understanding of the call for more sustainable materials and how consumers want to be greener. Mentions some current or general sustainability issues, but less detail than band 3.
1	1	Little understanding and very limited detail, but references one of the issues above.
0	0	Incorrect or irrelevant answers.

Q15. (6 marks)

Indicative content (not prescriptive):

- Use thermoforming polymers, as they can be recycled, whereas thermosetting polymers cannot
- Improve the quality of raw materials and construction so products last longer
- Design products that can be repaired, and include spare parts to encourage repair
- Make products easy to care for and maintain
- Design fewer fad or fashionable products, so consumers are less likely to throw away a working product
- Use sustainable polymers, e.g. bio-plastics that decompose and do not use a finite resource
- Use polymers made from recycled products, and natural pigments for colour
- Use oxo-degradable polymers, which contain additives that help them decompose with oxygen and sunlight
- Manufacture locally to reduce transport and CO_2 emissions, and use greener energy in manufacture
- Educate people about the harm of throwing away polymer products and encourage the 6Rs

However:

- Bio-plastics still take many years to biodegrade and can give off gases

- Oxo-degradable polymers tend to fall into small pieces rather than fully decompose
- Social media and technology promote design obsolescence; people may still want the latest product
- Crops for bio-plastics may be grown with pesticides and fertilisers that are toxic to ecosystems

Band	Marks	Descriptor
3	5 to 6	A coherent answer with detailed, relevant knowledge and understanding of how designers can extend the life of polymer products. Relevant examples and well-developed, substantiated judgements in a logically structured response.
2	3 to 4	Some coherence, with partial knowledge and understanding. Mostly relevant examples and partly substantiated judgements in a generally well structured response.
1	1 to 2	Basic knowledge and understanding. Limited relevant examples or judgements, with little structure.
0	0	Incorrect or irrelevant answers.