

Life Cycle Assessments and Recycling

Mark Scheme



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1. To decide whether it is better to recycle a product or manufacture it from scratch, scientists use Life Cycle Assessments or LCAs for short, to compare the energy use and pollution caused by both methods.

Circle the letter of the correct answer for each of the following questions.

- a) A life cycle assessment (LCA) looks at the environmental impact of a product.
Which stage of a product's life is **not** usually included in an LCA?

C – is the only correct answer.	1 mark
	Total: 1 mark

- b) Aluminium can be used to make drinks cans.
Why is recycling aluminium cans particularly important compared to recycling other materials?

B – is the only correct answer.	1 mark
	Total: 1 mark

- c) Paper bags and plastic bags have different environmental impacts.
According to most LCAs, what is a major disadvantage of paper bags compared to plastic bags?

C – is the only correct answer.	1 mark
	Total: 1 mark

- d) Which of the following is a valid environmental disadvantage of recycling?

A – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

2. A supermarket is deciding whether to sell milk in glass bottles or plastic (polymer) bottles. The figure below shows milk in a glass bottle and a plastic bottle.



The table below shows a summary of the life cycle assessment (LCA) for both types of bottle.

Life Cycle Stage	Glass Bottle	Plastic Bottle
Raw Materials	Sand	Crude oil
Manufacturing	Heated to 1600 °C to melt	Heated to 200 °C to mould
Transport	Heavy - high fuel use.	Lightweight - low fuel use
Disposal	Reusable many times; can be recycled	Can be recycled but often goes landfill
Biodegradable?	No	No

- a) Use the information in the table and your own knowledge to evaluate the environmental impact of both bottles and determine which bottle is better for the environment.

Glass bottles: • Raw materials: sand is processed to make glass. • Manufacturing: glass is heated to a very high temperature (1600°C) which requires a lot of energy. • Transport: Heavier than plastic, so transport uses more fuel / causes more pollution. • Disposal: Can be reused many times (which reduces impact). Plastic bottles: • Raw materials: Made from crude oil which is a finite resource. • Manufacturing: Lower melting point (200°C) so uses less energy to make. • Transport: Lighter, so transport creates less pollution. • Disposal: Often go to landfill / take a long time to decay / not biodegradable.	
Level 1 (1-2 marks): Simple statements quoting data from the table without linking to environmental impact	
Level 2 (3-4 marks): Detailed evaluation comparing both bottles across multiple life cycle stages with a clear conclusion	
	Total: 4 marks

- b) Extracting the raw materials for the plastic bottle has a different environmental impact than extracting raw materials for the glass bottle.

State **one** environmental impact caused specifically by extracting crude oil.

Extracting crude oil releases greenhouse gases / CO ₂	1 mark
	Total: 1 mark

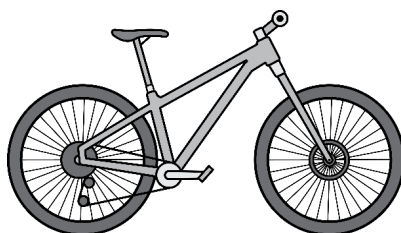
- c) Some parts of a life cycle assessment (LCA) can be measured using numbers, such as the energy used. However, other parts of an LCA depend on personal opinion.

Give **one** example of an environmental impact that is difficult to measure with a number.

Accept any one of the following:	
• Visual pollution (e.g. how ugly a landfill site or factory is). • The exact level of harm/damage caused to wildlife or habitats. • Noise pollution / odour from factories. • Littering.	
	Total: 1 mark

(Total for Question 2 is 6 marks)

3. Bicycles can be made from different materials depending on their intended use.
The figure below shows a mountain bike.



The table below shows information about two materials used to make bicycle frames: **steel** and **carbon fibre**.

- a) Evaluate the use of steel and carbon fibre for making bicycle frames.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple statements of fact from the table (e.g. "Carbon fibre is lighter" or "Steel is cheaper"). Little or no evaluation.
Level 2	3 - 4	Comparisons are made between steel and carbon fibre using the table. Some attempt at evaluating the 'best' material is made but may lack detail on environmental impact.
Level 3	5 - 6	A detailed comparison of the properties and life cycle impacts of both materials. The answer uses data from the table (e.g. strength, cost, disposal) to evaluate suitability and concludes which is better for a specific purpose (e.g. racing vs casual).

Indicative content:																		
Steel <table><tr><th>Pros</th><th>Cons</th></tr><tr><td>Steel is cheap or cheaper.</td><td>Steel is heavy.</td></tr><tr><td>It's easy to recycle.</td><td>Steel can rust or corrode.</td></tr><tr><td>Iron, steel's raw material is abundant.</td><td>Steel has a lower relative strength.</td></tr></table> Carbon Fibre <table><tr><th>Pros</th><th>Cons</th></tr><tr><td>Carbon fibre is very strong</td><td>It is very expensive.</td></tr><tr><td>It's very light weight.</td><td>It's difficult to recycle.</td></tr><tr><td>It will not corrode or rust.</td><td>It's made from crude oil.</td></tr></table> Conclusion: - Steel is better for everyday/cheap bikes because it is recyclable and affordable. - Carbon fibre is better for professional racing because it is light and strong, despite the cost and waste issues.		Pros	Cons	Steel is cheap or cheaper.	Steel is heavy.	It's easy to recycle.	Steel can rust or corrode.	Iron, steel's raw material is abundant.	Steel has a lower relative strength.	Pros	Cons	Carbon fibre is very strong	It is very expensive.	It's very light weight.	It's difficult to recycle.	It will not corrode or rust.	It's made from crude oil.	
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		Total: 6 marks																

The handle-bars of the bicycle are often made from aluminium.
Aluminium is a very reactive metal, yet it does not corrode easily in the rain.

b) Explain why aluminium is resistant to corrosion.

An explanation to include the following:	
Aluminium has a protective oxide layer.	1 mark
Allow: forms a layer of aluminium oxide.	
Which prevents further reaction / corrosion.	1 mark
Allow: stops oxygen/water reaching the metal.	
	Total: 2 marks

The bicycle chain is made of steel.

Paint is a common method of rust prevention, but it is not suitable for a bicycle chain.

c) Suggest a suitable method for protecting the chain and give one reason why it is chosen.

Method: oiling or greasing.	1 mark
Reasons: any one of the following:	
- Acts as a lubricant (reduces friction). (Because) paint would rub off / crack (due to movement). - It creates a barrier to oxygen/water (but allows movement).	1 mark
	Total: 2 marks

(Total for Question 3 is 10 marks)

4. Aluminium is a useful metal used to make drinks cans.

a) Bauxite is a finite resource.

Explain what is meant by the term 'finite resource'.

An explanation to include:	
It's resource that will run out / is being used up faster than it can be replaced.	1 mark
Allow: non-renewable.	
	Total: 1 mark

b) Use the data in the table to calculate the percentage of energy saved by recycling aluminium rather than extracting it from bauxite. Show your all of your working.

Energy saved = $280 - 14 = 266$	1 mark
$(266 \div 280) \times 100 = 95 \%$	1 mark
	Total: 2 marks

c) Describe the general process used to turn old metal cans into new metal blocks ready for manufacturing.

A description to include the following:	
We melt the (waste) aluminium.	1 mark
We then recast / mould into new blocks / objects.	1 mark
	Total: 2 marks

d) Aside from saving energy and conserving bauxite, suggest two other environmental advantages of recycling aluminium cans.

Accept any two of the following:	
- Conserves finite ores / bauxite. - Reduces mining / quarrying (which damages landscape). - Reduces landfill waste. - Reduces CO₂ emissions / pollution associated with extraction.	
	Total: 2 marks

A local council collects plastic and metal for recycling.

e) Explain why the collected waste must be separated into different types of material before it can be processed.

An explanation to include:	
So, that they can be melted / processed separately.	1 mark
Allow: because different materials have different melting points / properties'.	
Allow: to prevent contamination of the recycled material.	
	Total: 1 mark

(Total for Question 4 is 8 marks)

5. Poly(ethene) is a plastic produced from crude oil. Millions of poly(ethene) bags are used every day.

After use, these bags can either be disposed of in landfill sites or recycled.

Evaluate the environmental advantages and disadvantages of recycling plastic bags compared to making new plastic bags from crude oil.

In your answer, you should consider:

- The raw materials used.
- The energy and processes involved.
- The impact on landfill.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple statements about recycling being 'good' or plastic being 'bad'. Limited scientific detail.
Level 2	3 - 4	Both methods are discussed with some comparison of energy or materials. The answer may focus more on one aspect (e.g., just landfill issues) than a full life cycle overview.
Level 3	5 - 6	A coherent and detailed evaluation of both methods (recycling vs making new bags). The answer considers raw materials, energy, and environmental impact (landfill), and reaches a justified conclusion.

Indicative content:	
Making new bags (from crude oil): • Raw materials: Plastic is made from crude oil, which is a finite (non-renewable) resource. Extraction of oil can cause pollution (e.g., spills). • Processing: The production involves fractional distillation, cracking, and polymerisation. These processes require large amounts of energy. • Disposal: If disposed of in landfill, plastic does not biodegrade. It takes up space for hundreds of years and can harm wildlife. Recycling plastic bags: • Raw Materials: Recycling uses waste plastic, which conserves crude oil reserves. • Processing: The process requires collection, transport, washing, melting, and remoulding. This still uses energy (for transport and heating), but generally less energy than making new plastic from scratch. • Disposal: Recycling drastically reduces the amount of waste going to landfill. Conclusion/Evaluation: • Recycling is generally better for the environment because it saves finite resources and reduces landfill waste. • However, the environmental cost of collecting, transporting, and separating the waste must be considered (as vehicles produce CO₂).	
	Total: 6 marks

(Total for Question 5 is 6 marks)