Life cycle assessment

5.10.2.1 · Chemistry · revision notes

How a life cycle assessment (LCA) measures the environmental impact of a product at each stage of its life, why an LCA is not completely objective, and how to compare products such as plastic and paper shopping bags. Questions on Paper 2 often give you a table of data to interpret, calculate from and evaluate.

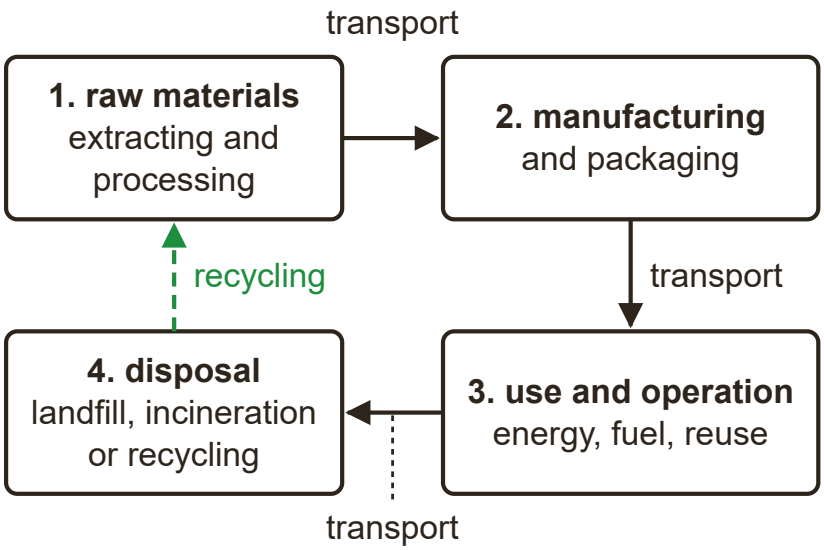
Key facts

- LCA stages: raw materials → manufacturing and packaging → use → disposal (+ transport at each stage)
- Pollutant effects need value judgements, so an LCA is not purely objective
- Plastic bag: from crude oil (finite), reused many times, not biodegradable
- Impact per use = total impact ÷ number of uses
- Easy to quantify: water, resources, energy sources, some wastes
- Selective or abbreviated LCAs can be misused, e.g. to support advertising claims
- Paper bag: from trees (renewable), reused fewer times, biodegradable

Notes

The stages of an LCA

- A **life cycle assessment (LCA)** assesses the environmental impact of a product at each stage of its life:
- 1. **Extracting and processing raw materials** (e.g. mining ores, drilling for crude oil, felling trees).
- 2. **Manufacturing and packaging**.
- 3. **Use and operation** during its lifetime (e.g. fuel or electricity used, how many times it is reused).
- 4. **Disposal** at the end of its useful life (landfill, incineration or recycling).
- **Transport and distribution** at each stage are included too.



Assess the impact at every stage, including transport between them.

What can and cannot be measured

- Fairly easy to measure: the use of water, resources and energy sources, and the production of some wastes (e.g. mass of carbon dioxide released).
- Hard to measure: the effects of pollutants. Giving them a numerical value requires **value judgements**, so an LCA is **not a purely objective** process.
- **Selective** or **abbreviated** LCAs look at only some stages or impacts. They can be **misused** to reach a conclusion decided in advance, e.g. to support claims in advertising.

Plastic and paper shopping bags

- **Plastic bags** (poly(ethene)) are made from crude oil, a finite resource. They are light, strong and can be reused many times. They are not biodegradable, so they last a long time in landfill or as litter, but they can be recycled.
- **Paper bags** are made from trees, a renewable resource. In most LCAs, making a paper bag uses more energy than making a plastic bag, and paper bags are heavier to transport. They are weaker, so they are reused fewer times, but they are biodegradable and easily recycled.
- Which bag has the lower impact depends on the data, especially how many times each bag is used. Compare them per use.

How to answer each type of question

Name and apply the stages of an LCA

1 to 4 marks | **Grade 4**

1. Learn the four stages in order.
2. Link each stage to the product in the question with a specific example.
3. Remember that transport happens at every stage.

Example. A company carries out a life cycle assessment for glass drinks bottles.
Give **two** stages of the life cycle assessment. For each stage, give **one** environmental impact of the bottles at that stage. (4 marks)

Model answer. Any two stages, each with a matching impact, e.g.: extracting raw materials (1): quarrying sand and limestone damages the landscape (1); manufacturing (1): heating the furnace burns fuel, releasing carbon dioxide (1); use (1): heavy bottles need a lot of fuel to transport / washing for reuse uses water and energy (1); disposal (1): bottles in landfill take up space / recycling uses energy for collection and melting (1).

Calculate and compare using LCA data

3 to 5 marks | **Grade 5**

1. Pick out the data for each product from the table.
2. Add up stages or divide by the number of uses, as the question asks.
3. Compare the answers directly, quoting the numbers.
4. Bring in your own knowledge (finite or renewable, biodegradable) if the question asks for it.

Example. The table gives some LCA data for two types of shopping bag.

Bag	Carbon dioxide released over the whole life cycle (g)	Average number of uses
Paper bag	150	3
Reusable plastic bag	240	20

(a) Calculate the mass of carbon dioxide released per use for each bag. (2 marks)
(b) A shop says that paper bags are better for the environment. Use your answers and your own knowledge to evaluate this claim. (3 marks)

Model answer.

(a) Paper: 150 ÷ 3 = 50 g per use (1); plastic: 240 ÷ 20 = 12 g per use (1).
(b) The plastic bag releases less carbon dioxide per use (12 g compared with 50 g), so these data do not support the claim (1). However, paper comes from trees, a renewable resource, whereas plastic is made from crude oil, a finite resource (1). Paper bags are biodegradable, but plastic bags last a long time in landfill or as litter (1).

Explain the limits of an LCA

2 to 3 marks | **Grade 8**

1. Say which parts are easy to measure: energy, water, resources, some wastes.
2. Say that pollutant effects are hard to give values to, so value judgements are needed.
3. For misuse: a selective LCA leaves out stages to support a claim decided in advance.

Example. A company that makes paper bags publishes an LCA that includes only the disposal stage.
(a) Suggest why the company included only this stage. (1 mark)
(b) Explain why even a full LCA is not a completely objective process. (2 marks)

Model answer.

(a) Paper bags are biodegradable, so the disposal stage makes them look better than plastic bags / the other stages might show a bigger impact for paper bags, so leaving them out supports the company's advertising (1).

(b) Some effects, such as the harm caused by pollutants, are difficult to give numerical values to (1), so value judgements have to be made, and different people may judge them differently (1).

Don’t lose marks

- Forgetting transport, or missing out the use stage.
- Saying paper bags are always better 'because they are biodegradable', ignoring manufacture and the number of uses.
- Comparing total impacts for products that are used a different number of times. Divide by the number of uses.
- Saying an LCA is 'unreliable' when you mean it is not fully objective because it needs value judgements.

More tips

Memory tricks

- An LCA is a life story: 'born' (raw materials), 'made' (manufacture), 'lives' (use), 'dies' (disposal), with a journey (transport) between each.
- Things you can measure are objective; harm you have to judge needs value judgements.
- Always compare per use: a bag used 20 times spreads its impact over 20 trips.
- If only one stage is shown, suspect a selective LCA.

Exam technique

- When given an LCA table, quote the numbers and do the arithmetic; 'evaluate' also needs a conclusion.
- Bring in your own knowledge where asked: finite or renewable raw materials, biodegradability, recycling.
- In 'explain' questions about LCAs, 'value judgements' is the key phrase examiners look for.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Name the four stages of an LCA

Extracting and processing raw materials, manufacturing and packaging, use and operation, and disposal.

Grade 4

State what an LCA is used for

To assess the environmental impact of a product over its whole life, including transport at each stage.

Grade 5

Compare plastic and paper bags using an LCA

Plastic bags come from crude oil (finite) but can be reused many times; paper bags come from trees but are reused less.

Grade 5

Calculate totals from LCA data tables

Add up the values for each stage, and compare products per item or per use.

Grade 7

Explain why LCAs are not fully objective

Giving numerical values to the effects of pollutants needs value judgements.

Grade 8

Explain how selective LCAs can be misused

Leaving out stages or impacts can support a conclusion decided in advance, for example in advertising.

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