

## 10.2 Life cycle assessment and recycling

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 30 marks

KEY WORDS life cycle assessment

• recycling

### Objective

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Carry out and critique life cycle assessments, and evaluate recycling. Original questions for spec statements 4.10.2.1–4.10.2.2.

### 1 Key knowledge and worked examples

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**LCA stages:** 1) extracting and processing **raw materials**; 2) **manufacturing and packaging**; 3) **use and operation**; 4) **disposal** – transport at every stage. Energy, water, resources and waste are quantified from suitable data, with uncertainty; pollutant effects need **value judgements** – so an LCA is **not purely objective**; selective LCAs can be misused to support advertising claims.

**Reduce, reuse, recycle** – cuts limited-resource use, energy use, waste and mining impact. Glass bottles **reused**; glass crushed and remelted; metals **melted and recast**; **scrap steel in the blast furnace** cuts iron-ore extraction. Separation effort depends on the final product's requirements.

**Worked example (3 marks).** Give one advantage and one limitation of LCAs for comparing paper and plastic bags.

Advantage: comparing energy, water and waste per stage identifies which bag has the smaller resource footprint. Limitation: pollutant effects require value judgements, so the assessment is not purely objective; and a selective LCA can be biased to favour a pre-chosen conclusion.

### 2 Practice

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2.1 List the four stages of a life cycle assessment. [4]

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2.2 Why are LCA results for pollutant effects less objective than energy figures? [1]

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**2.3** Give one example of reuse (not recycling). [1]

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### 3 Exam-style questions

**3.1** Explain why recycling aluminium is worthwhile even though collecting it costs energy. [4]

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**3.2** A manufacturer claims its bags are green, citing an LCA of the disposal stage only. Evaluate the claim. [3]

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**3.3** Compare reuse and recycling for glass bottles, giving one benefit of each. [4]

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**3.4** For the same shopping task, disposable bags use 12 energy units per task. A reusable bag needs 30 units to make and 1 unit to clean per task. Find the first whole number of tasks at which the reusable bag uses less energy. Give one limitation of using this result as a complete environmental verdict. [5]

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**3.5** New production of a stated batch uses 50 MJ; recycling the same batch to the same quality uses 8 MJ including collection. Calculate the percentage energy saving. Explain why the phrase “recyclable” alone does not prove this saving happens. [4]

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**3.6** Paper bag A uses less water but more energy than plastic bag B over the same service. A seller announces A is “best for the environment” and omits its transport data. Evaluate this conclusion using two different limitations. [4]

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## Solutions

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Authored marking guidance for these original questions.

**2.1** Raw material extraction and processing; manufacturing and packaging; use and operation; disposal at end of life.

**2.2** Allocating numbers to pollutant effects requires value judgements.

**2.3** Refilling/returning glass bottles for the same use.

**3.1** Aluminium extraction from ore is extremely energy-intensive – electrolysis of molten alumina; recycling avoids ore electrolysis but still needs collection, sorting and remelting; compare the avoided extraction energy with collection/processing; suitable recycling usually lowers the total, but the boundary matters; and less bauxite quarrying – less environmental damage.

**3.2** A single-stage LCA is selective/abbreviated; it omits manufacture, raw materials and use, where the burdens may differ greatly; selective LCAs can be misused to support pre-determined advertising conclusions, so the claim is unjustified as stated.

**3.3** Reuse – washing and refilling bottles avoids the energy of remelting and keeps the original product whole; recycling – crushed glass (cullet) melts at a lower temperature than raw materials, saving energy, and copes with bottles that break or are not returnable.

**3.4** Disposable total =  $12n$ , reusable total =  $30 + n$ ; equality  $30 + n = 12n$ , so  $n = 30/11 = 2.73$ . The reusable option is lower from 3 complete tasks: 33 versus 36 units. This compares energy only; other impacts/actual reuse/cleaning assumptions or omitted stages can alter the overall verdict.

**3.5** Saving =  $50 - 8 = 42$  MJ; percentage =  $(42/50) \times 100 = 84\%$ . Recyclable describes a possible processing route; actual collection/sorting/suitable facilities and user behaviour determine whether recycling happens. Use the original production energy as the saving baseline.

**3.6** Water and energy have different outcomes and ranking them needs stated priorities/value judgements. Missing transport makes the stated whole-life comparison incomplete; include all stages under the same service/boundary before a qualified conclusion. A measured water advantage does not automatically prove every environmental impact is lower.