2.31 Life Cycle Assessment, Recycling and Corrosion: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Aluminium and copper can both be recycled instead of being sent to landfill.

(a) State two reasons why recycling metals such as aluminium and copper is important. **(2)**

(Total for Question 1 is 2 marks)

2 Iron and steel objects can be protected from rusting using barrier methods.

(a) Name one barrier method that could be used to protect a steel bicycle frame from rusting. **(1)**

(b) Explain how this method prevents the bicycle frame from rusting. **(2)**

(Total for Question 2 is 3 marks)

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3 Table 1 gives the composition and properties of four alloys.

Table 1

Alloy	Main metals mixed	Property
Bronze	copper and tin	hard and resistant to corrosion by seawater
Brass	copper and zinc	harder than copper, resists corrosion, has an attractive gold colour
Low carbon steel	iron with a small amount of carbon	quite soft and easily shaped
High carbon steel	iron with a larger amount of carbon	very hard, but brittle

(a) Using Table 1, suggest which alloy would be most suitable for making a ship's propeller, and explain your choice. **(2)**

(b) Using Table 1, suggest which alloy would be most suitable for making the blade of a cutting tool, and explain your choice. **(2)**

(Total for Question 3 is 4 marks)

4 Scrap steel from old cars and appliances often contains a mixture of different steel alloys, as well as small amounts of other metals.

(a) Explain why recycling this mixed scrap steel can be more difficult than recycling scrap made of a single pure metal, such as aluminium drinks cans. **(2)**

(b) Suggest one method that could be used to separate magnetic steel scrap from non-magnetic metals, such as aluminium, before recycling. **(1)**

(Total for Question 4 is 3 marks)

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5 Glass bottles can either be recycled or sent to landfill, with new glass manufactured from raw materials (sand, limestone and soda ash) to replace them.

(a) Explain two advantages of recycling glass bottles, rather than manufacturing new glass bottles from raw materials. **(4)**

(Total for Question 5 is 4 marks)

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6 A drinks manufacturer commissions a life cycle assessment (LCA) comparing glass bottles with aluminium drinks cans. The LCA concludes that aluminium cans have a smaller overall environmental impact than glass bottles.

Evaluate the extent to which life cycle assessments, such as this one, can be considered fully objective and reliable when comparing the environmental impact of different products.

(Total for Question 6 is 6 marks)

7 In an industrial Haber process reactor, 28 tonnes of nitrogen gas reacts with an excess of hydrogen gas. (Relative formula masses: $N_2 = 28$, $NH_3 = 17$)

(a) Calculate the maximum theoretical mass of ammonia that could be produced from 28 tonnes of nitrogen, assuming the reaction goes to completion. **(3)**

(b) Because the Haber process reaction reaches equilibrium rather than going to completion, only 15% of the theoretical maximum mass of ammonia is actually produced in a single pass through the reactor. Calculate the actual mass of ammonia produced from this 28 tonnes of nitrogen in one pass. **(2)**

(Total for Question 7 is 5 marks)

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Mark scheme · 2.31 Life Cycle Assessment, Recycling and Corrosion: 30-minute Pack

Question 1

(a) it conserves the limited/finite amount of metal ore in the Earth oe (accept: reduces the amount of quarrying/mining needed) **B1**

(a) it uses much less energy than extracting the same amount of new metal from its ore oe (accept: reduces CO_2 emissions, or reduces waste sent to landfill) **B1**

(a) Answer: Any two of: conserves finite metal ores; uses much less energy than extracting new metal from ore; reduces CO_2 emissions; reduces landfill waste

Question 2

(a) any valid barrier method, e.g. painting; oiling/greasing; coating with plastic oe **B1**

(a) Answer: Any valid barrier method, e.g. painting, oiling/greasing, or coating with plastic

(b) it forms a physical coating/layer over the surface of the metal oe **B1**

(b) this stops oxygen and water from reaching the iron/steel underneath, so rusting cannot occur oe **B1**

(b) Answer: It forms a coating over the surface of the metal, which stops oxygen and water from reaching the iron/steel underneath, so rusting cannot occur

Question 3

(a) bronze cao **B1**

(a) because it is hard and resists corrosion by seawater oe **B1**

(a) Answer: Bronze, because it is hard and resists corrosion by seawater

(b) high carbon steel cao **B1**

(b) because it is very hard, so it can hold a sharp cutting edge oe **B1**

(b) Answer: High carbon steel, because it is very hard, so it can hold a sharp cutting edge

Question 4

(a) the exact composition of the mixed scrap is not known or uniform, so the properties of the alloy recycled from it cannot be accurately controlled oe **B1**

(a) different metals/alloys may need to be separated (e.g. by density or using magnets) before recycling, which adds cost and complexity oe **B1**

(a) Answer: The exact composition of mixed scrap is not known or uniform, so the properties of the recycled alloy cannot be controlled; the different metals may also need to be separated first, adding cost and complexity

(b) using a strong magnet/electromagnet to attract and remove the steel oe **B1**

(b) Answer: Using a strong magnet (or electromagnet) to attract and remove the steel

Question 5

(a) recycling glass uses less energy than manufacturing new glass, because crushed recycled glass melts at a lower temperature than the raw materials oe **B1**

(a) using less energy reduces the amount of fossil fuel burned, which reduces carbon dioxide emissions oe **B1**

(a) recycling conserves the finite/limited raw materials (e.g. sand, limestone) needed to make new glass oe **B1**

(a) recycling reduces the amount of glass waste sent to landfill oe (any two developed advantages, up to 2 marks each, for full marks) **B1**

(a) Answer: Any two developed advantages, e.g. recycling uses less energy (crushed glass melts at a lower temperature), reducing CO_2 emissions; and recycling conserves finite raw materials such as sand and limestone, and reduces landfill waste

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Question 6

Level 3 A detailed and coherent evaluation that discusses both the quantifiable (numerical) aspects of an LCA and the aspects that require value judgements or are difficult to measure, with clear links between them and a reasoned conclusion about objectivity. The answer is logically structured throughout, using scientific terminology accurately. **5-6**

Level 2 Relevant points about the objective (quantifiable) and/or subjective (value-judgement) aspects of an LCA are given, with some explanation, but the discussion is not fully balanced or the conclusion is not fully justified. The answer has some structure. **3-4**

Level 1 Basic or isolated statements are given, for example simply stating that LCAs are useful or that they can be biased, with little or no explanation or supporting reasoning. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Objective/quantifiable aspects: factors such as energy use, water use and CO_2 emissions during manufacture, transport and disposal can be measured and compared numerically, giving the LCA an objective, evidence-based element.
- Subjective aspects: some environmental impacts, e.g. the effect of litter on wildlife, habitat damage from mining/quarrying, or the visual impact of waste, are difficult to measure numerically and require value judgements about their relative importance, introducing subjectivity.
- Assumptions and system boundaries: different assumptions made when carrying out the LCA, e.g. the system boundary chosen, assumed transport distances, or the assumed method of disposal/recycling rate, can significantly change the result, so two LCAs of the same products could reach different conclusions.
- Possible bias: because the LCA was commissioned by the manufacturer, there is a risk of selective use of data, or of the assessment being used to support a conclusion that favours the manufacturer's own product or commercial interests (sometimes called greenwashing).
- Reliability: a fully reliable and unbiased LCA requires independent verification and full transparency about the assumptions and data sources used.
- Conclusion: LCAs provide useful, partly quantitative evidence for comparing products, but they are not fully objective, because some factors cannot be reliably quantified and must be judged, and the party commissioning the LCA may introduce bias.

Question 7

(a) moles of N_2 = 28 / 28 = 1 (using tonnes as the mass unit) oe **M1**

(a) mole ratio of N_2 : NH_3 is 1 : 2, so moles of NH_3 = 2 oe **M1**

(a) mass of NH_3 = 2 x 17 = 34 tonnes cao **A1**

(a) Answer: 34 tonnes

(b) 34 x 0.15 oe, ft from (a) **M1**

(b) 5.1 tonnes cao **A1**

(b) Answer: 5.1 tonnes

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