

10.3 Using materials

Name: _____ Class: _____ Date: _____

Total: 31 marks**KEY WORDS** corrosion • alloy • composite

Objective

Prevent corrosion, know the named alloys, and compare material classes. Chemistry only.
Original questions for spec statements 4.10.3.1–4.10.3.3.

1 Key knowledge and worked examples

Corrosion – destruction by chemical reaction with the environment; iron rust needs **oxygen and water**. Prevention: barriers (**grease, paint, coating**) and **sacrificial zinc** (galvanising – the zinc corrodes even over scratches); stainless steel resists by alloying; aluminium's own oxide layer protects it.

Alloys (harder than pure metals – distorted layers):

Alloy	Composition	Use
bronze	copper + tin	statues/coins
brass	copper + zinc	instruments/fittings
gold jewellery	Au + Ag/Cu/Zn; 24 carat = 100 % , 18 carat = 75 %	jewellery
high-carbon steel	Fe + C (high)	cutting tools – strong, brittle
low-carbon steel	Fe + C (low) – soft, shaped easily	car bodies
stainless steel	Fe + Cr + Ni	cutlery – hard, corrosion-resistant
aluminium alloys	low density	aircraft

Materials: **soda-lime glass** (sand + sodium carbonate + limestone); **borosilicate** (sand + boron trioxide – higher m.p.); **clay ceramics** (wet clay shaped then fired). **LD/HD poly(ethene)** – same monomer, different conditions. **Thermosoftening** melt (recyclable); **thermosetting** do not (cross-linked). **Composites** = matrix/binder + reinforcement (fibreglass, concrete, carbon fibre).

Worked example (3 marks). Explain sacrificial protection of an iron fence by zinc.

Zinc is more reactive than iron; exposed to oxygen and water, the zinc oxidises in-

stead of the iron; even where the coating is scratched, the nearby zinc still corrodes preferentially – the iron is protected.

Rust controls. Compare equal iron samples/time: damp air, dry air, and boiled water covered with oil. Only the first supplies both water and oxygen. LD poly(ethene) is more branched than HD, so chains pack less closely; production conditions change structure even with the same ethene monomer. Choose unfamiliar materials from supplied density, strength, brittleness, temperature and cost data; strength alone is not toughness.

2 Practice

2.1 What two substances does iron need to rust? [2]

2.2 Give the composition of brass. [1]

2.3 What two components make a composite? [2]

3 Exam-style questions

3.1 Explain why stainless steel is chosen for cutlery, using its composition. [3]

3.2 An 18-carat gold ring weighs 12 g. Calculate the mass of gold present. [2]

3.3 Explain the difference between thermosoftening and thermosetting polymers in structure and behaviour. [4]

3.4 Three clean iron nails are kept for the same time: A in damp air; B in dry air; C in boiled water covered by oil. Predict which rusts and explain how the controls test the conditions needed. [4]

3.5 Both a painted iron panel and a zinc-coated iron panel are scratched. Compare protection at each scratch using barriers and relative reactivity. [4]

3.6 Low-density and high-density poly(ethene) use the same monomer. Explain how different production conditions can give different properties. Why does melting a thermosoftening sample not mean its covalent chains have been broken? [4]

3.7 Fictional candidates for a light beam are: metal A, density 7.8 g/cm^3 and strength 500 units; fibre-resin B, density 1.6 g/cm^3 and strength 600 units; ceramic C, density 2.4 g/cm^3 and strength 650 units but brittle. Select a candidate for low mass and resistance to bending fracture, justify using data, name B's two components, and give one missing design factor. [5]

Solutions

Authored marking guidance for these original questions.

2.1 Oxygen (or air) and water.

2.2 Copper and zinc.

2.3 A matrix/binder surrounding a reinforcement of fibres or fragments.

3.1 Stainless steel contains iron with chromium and nickel; the alloying elements make it hard and resistant to corrosion – it survives washing and contact with food acids.

3.2 18 carat = 75 % gold; $0.75 \times 12 = 9$ g.

3.3 Thermosoftening polymers have separate chains with no cross-links; on heating the intermolecular forces weaken and the polymer melts – it can be remoulded and recycled. Thermosetting polymers have strong covalent cross-links between chains; the network prevents melting; sufficiently strong heating can decompose it.

3.4 A rusts because both oxygen and water are available. B lacks water; C has reduced dissolved oxygen after boiling and oil limits oxygen entry. Comparing otherwise similar nails/time shows both oxygen and water are needed, rather than just a vague difference in exposure. The intended prediction assumes the stated controls work.

3.5 Paint forms a barrier but the scratch exposes iron to oxygen/water. Zinc is more reactive than iron and oxidises preferentially, giving sacrificial protection at a nearby scratch while suitable contact/zinc remains. Neither protection lasts without limit.

3.6 Both use ethene, but different conditions give different branching/chain packing, affecting density and properties. Thermosoftening allows separate chains to move as intermolecular attractions are overcome; covalent backbone bonds need not break for melting. HD chains pack more closely than the more branched LD model.

3.7 B is a defensible selection: lower density than A/C and high supplied strength, while brittle C is less suitable for bending fracture demands. B has a resin matrix/binder and reinforcing fibres. Missing factor such as cost, service temperature, actual toughness/fatigue or durability must be checked. The table does not certify a real engineering design; strength alone is not toughness. Accept another conditional choice only with explicit defensible data/limitation reasoning.