2.6 Metallic Bonding, Alloys and Properties of Metals: 30-minute Pack

EDEXCEL 4CH1 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A simple model states that metals are 'giant lattices' of positive ions. Describe what is meant by a giant lattice in the context of metallic structure.

(Total for Question 1 is 2 marks)

2 Give two reasons, based on metallic structure, why metals are often shiny and ductile, naming the structural cause for each property in a metal like silver.

(Total for Question 2 is 3 marks)

3 Explain, using the metallic bonding model, why pure metals conduct electricity in the solid state with reference to electrons and ions.

(Total for Question 3 is 2 marks)

4 Explain how the metallic bonding model accounts for metals being good thermal conductors, mentioning particles involved.

(Total for Question 4 is 2 marks)

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5 Compare brass and bronze in terms of their typical metal constituents and one property difference that results from that composition, giving a named property.

(Total for Question 5 is 2 marks)

6 Explain briefly how adding a small amount of carbon to iron produces steel with greater hardness than pure iron, mentioning the effect on the iron lattice.

(Total for Question 6 is 3 marks)

7 A solid metal strip is connected between terminals L and R. Initially L is positive and R is negative. The battery connections are then reversed and current flows in the opposite direction. The strip keeps its shape throughout. State the direction of the net movement of delocalised electrons after reversal, explain why this reverses the current, and state whether the positive metal ions travel along the strip.

(Total for Question 7 is 3 marks)

8 A laboratory tests equal-sized strips made from a metal and an added element whose atoms are larger. Under identical conditions, the force needed for the same permanent bend is: 0% added element: 12 N; 4% added element: 24 N; 8% added element: 19 N. Percentages are by mass. A pupil claims that increasing the percentage of this element always increases resistance to bending. Use the results to assess this claim, then explain why the 4% alloy could resist bending more than the pure metal, referring to its arrangement of atoms and the movement of layers.

(Total for Question 8 is 3 marks)

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9 Two solid samples, S and T, both conduct electricity. Particle analysis finds copper and zinc atoms mixed throughout S, but only copper atoms in T. Classify each sample as a pure metal or an alloy, giving the compositional evidence for each. Explain why the electrical test alone cannot distinguish the two classifications.

(Total for Question 9 is 3 marks)

10 Explain, using the idea of lattice structure, dislocations and atomic size, why alloys are generally harder than the pure metal from which they are made. In your answer consider both substitutional and interstitial alloying and give clear links from structure to mechanical properties.

(Total for Question 10 is 6 marks)

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Mark scheme · 2.6 Metallic Bonding, Alloys and Properties of Metals: 30-minute Pack

Question 1

a regular repeating 3D arrangement of ions extending throughout the solid **B1**

the lattice contains many ions in a continuous structure rather than separate molecules **B1**

Answer: A regular repeating three dimensional arrangement of positive ions extending throughout the solid, forming a continuous structure rather than separate molecules

Question 2

shiny: presence of free electrons that reflect and re-emit light from the surface **B1**

ductile: layers of ions can slide and can be drawn into wires because bonding is non-directional **B1**

may mention non-directional metallic bonds allowing shape change without breaking the material **B1**

Answer: Shiny because free delocalised electrons reflect and re-emit light; ductile because non-directional metallic bonds allow layers of ions to slide so the metal can be drawn into wires

Question 3

states that delocalised electrons are present and mobile **B1**

explains that these mobile electrons carry charge through the solid when a potential difference is applied **B1**

Answer: Delocalised electrons are mobile throughout the lattice and so can move as an electric current when a potential difference is applied, carrying charge through the solid

Question 4

states delocalised electrons transfer kinetic energy quickly through the lattice **B1**

may also mention vibration of closely packed ions transferring energy between neighbours **B1**

Answer: Delocalised electrons transfer kinetic energy rapidly through the lattice and closely packed metal ions transfer energy by vibrations, so heat moves quickly through the metal

Question 5

states constituents: brass is copper and zinc; bronze is copper and tin **B1**

states a property difference, e.g. bronze is harder and more corrosion resistant than brass, or brass is more malleable and easier to shape **B1**

Answer: Brass is copper plus zinc, bronze is copper plus tin; bronze is typically harder and more corrosion resistant, while brass is more malleable

Question 6

carbon atoms fit into gaps in the iron lattice (interstitially) or alter the arrangement **B1**

this creates distortions and hinders movement of layers and dislocations **B1**

so more force is required to deform the metal and hardness increases **B1**

Answer: Carbon atoms occupy spaces in the iron lattice and distort it, hindering movement of layers and dislocations so more force is needed to deform the metal, increasing hardness

Question 7

after reversal, net electron movement is from L to R (towards the now positive terminal R) **B1**

reversing the net movement of negatively charged electrons reverses the direction of charge transfer and hence the current **B1**

positive metal ions do not travel along the solid strip; allow ions vibrating about fixed lattice positions **B1**

Answer: After reversal, delocalised electrons have a net movement from L to R, towards the now positive terminal. Reversing the movement of these negative charge carriers reverses the current. The positive ions remain in the lattice and do not travel along the strip.

Question 8

rejects the claim using the decrease from 24 N at 4% to 19 N at 8% (or equivalent explicit comparison) **B1**

larger added atoms distort the regular arrangement of the pure metal **B1**

the distortion obstructs layer movement, accounting for the greater force needed for the 4% alloy compared with the pure metal **B1**

Answer: The claim is not supported: increasing the added element from 4% to 8% reduces the bending force from 24 N to 19 N. In the 4% alloy, larger added atoms distort the regular arrangement. This obstructs layer sliding, so more force is needed than for the pure metal.

Question 9

S is an alloy because it contains copper mixed with zinc, rather than just one element **B1**

T is a pure metal because the analysis finds only copper atoms **B1**

both pure metals and metallic alloys can conduct through mobile delocalised electrons, so conduction alone cannot distinguish them **B1**

Answer: S is an alloy because copper and zinc are mixed throughout it. T is a pure metal because it contains only copper atoms. Both can have mobile delocalised electrons that carry charge, so electrical conduction alone does not distinguish a pure metal from an alloy.

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Question 10

Level 1 Simple statements about alloys with limited linkage to structure, or one correct mechanism given without development	**1-2**
Level 2 Clear description of one mechanism, substitutional or interstitial, and how it distorts the lattice to impede movement, with some linking to increased hardness	**3-4**
Level 3 Detailed explanation covering both substitutional and interstitial alloying, description of dislocations or layer movement being impeded by lattice distortions, and a convincing link to why these effects raise hardness and reduce malleability	**5-6**

Indicative content:

- Substitutional alloying: atoms of similar size replace metal atoms in the lattice creating local strain fields and disrupting regular slip planes
- Interstitial alloying: small atoms like carbon fit into gaps between metal atoms, causing larger lattice distortions
- Distortions interfere with movement of dislocations and the sliding of atomic layers, which are mechanisms for plastic deformation
- More energy or stress is required to move dislocations past obstacles, so the alloy is harder and less ductile
- Examples: brass (substitutional) and steel/iron-carbon (interstitial) and how each type produces lattice strain
- Comparison to pure metal where regular identical atoms allow easier dislocation motion and layer sliding, so pure metal is softer

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