IG.C6 Metallic Bonding, Alloys and Properties of Metals

EDEXCEL 4CH1 · Calculator allowed · about 40 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Describe, in the context of a metal lattice, what is meant by the term 'delocalised electron' in metallic bonding.

(Total for Question 1 is 1 mark)

2 State the charge on the metal ions in the metallic lattice model used to explain metallic bonding in a piece of copper.

(Total for Question 2 is 1 mark)

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)

5 Describe why many metals have high melting points, using the metallic bonding model and referring to forces between particles.

(Total for Question 5 is 2 marks)

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6 State two physical properties of metals that are explained by layers of ions being able to slide over each other in the metallic lattice.

(Total for Question 6 is 1 mark)

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7 Explain why pure metals can be hammered into thin sheets but alloys are generally harder and less malleable, using the idea of layers and atomic arrangement.

(Total for Question 7 is 2 marks)

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8 Name one common alloy and state its main components, for example an alloy used in everyday objects and its constituent metals or carbon.

(Total for Question 8 is 1 mark)

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9 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 9 is 2 marks)

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10 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 10 is 2 marks)

11 State why metals do not conduct electricity as ions in the molten state by the ions, but do conduct when molten, referencing which particles move.

(Total for Question 11 is 1 mark)

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12 A bar of pure aluminium is more easily bent than an aluminium alloy used for aircraft. Describe a structural reason for this difference, referring to atom sizes and lattice defects.

(Total for Question 12 is 2 marks)

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13 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 13 is 3 marks)

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14 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 14 is 3 marks)

15 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 15 is 6 marks)

Mark scheme · IG.C6 Metallic Bonding, Alloys and Properties of Metals

Question 1

- **B1** an electron that is free to move through the lattice and is not attached to a single atom
- **Answer: An electron that is free to move through the metal lattice and is not attached to any one atom**

Question 2

- **B1** positive (cations)
- **Answer: Positive (metal ions, cations)**

Question 3

- **B1** 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
- **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

- **B1** states delocalised electrons transfer kinetic energy quickly through the lattice
- **B1** may also mention vibration of closely packed ions transferring energy between neighbours
- **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

- **B1** states there are strong electrostatic attractions between positive ions and delocalised electrons
- **B1** explains that a lot of energy is needed to overcome these strong attractions to separate the ions
- **Answer: Strong electrostatic attraction between positive ions and the sea of delocalised electrons requires a large input of energy to break, so many metals have high melting points**

Question 6

- **B1** malleability or ductility or both
- **Answer: Malleability and ductility**

Question 7

- **B1** pure metal has regular layers of identical atoms that can slide over each other
- **B1** in an alloy different sized atoms distort the lattice and stop layers sliding, making it harder and less malleable
- **Answer: Pure metals have regular layers of identical atoms that can slide, allowing malleability, but alloys contain atoms of different sizes which distort the lattice and hinder sliding so they are harder and less malleable**

Question 8

- **B1** one correct alloy and components, e.g. brass = copper and zinc; bronze = copper and tin; steel = iron and carbon
- **Answer: Example: Brass, made of copper and zinc**

Question 9

- **B1** 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
- **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 10

- **B1** 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
- **Answer: A regular repeating three dimensional arrangement of positive ions extending throughout the solid, forming a continuous structure rather than separate molecules**

Question 11

- **B1** delocalised electrons still move and conduct in the molten state; conduction is by electrons not ions in metals
- **Answer: Because conduction in metals is by delocalised electrons which remain mobile when molten, so the molten metal conducts electricity**

Question 12

- **B1** alloy contains atoms of different sizes or extra elements that create lattice distortions
- **B1** these distortions impede the movement of dislocations and layers, making the alloy stronger and less easily bent
- **Answer: Alloying adds atoms of different sizes that distort the lattice and create defects which impede dislocation motion, so the alloy is stronger and less easily bent than pure aluminium**

Question 13

- **B1** 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
- **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 14

- **B1** 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
- **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 15

- **Level 1** (1-2): Simple statements about alloys with limited linkage to structure, or one correct mechanism given without development
- **Level 2** (3-4): Clear description of one mechanism, substitutional or interstitial, and how it distorts the lattice to impede movement, with some linking to increased hardness
- **Level 3** (5-6): 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
- **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