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**Ceramics - Fundamentals**

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**Acknowledgement**

Mr John Gibson is a highly regarded educator and engineer. John taught Industrial Arts at a number of high schools before taking a position at Sydney Teachers’ College, then University of Sydney. He had an engineering education consultancy and has extensive experiencing working with NESA on Engineering Studies syllabus development and the HSC examination committee. The STEM Industry School Partnerships (SISP) Program asked John for his responses to the iTeachSTEM topic discussion questions. SISP is grateful to John for submitting these example discussion responses.

# Ceramics

# Define a ceramic material.

Ceramics are generally high temperature, strong, but brittle materials with predominately ionic bonds. The core structure is developed from the silica oxide tetrahedron (Si02), aluminium oxide (AI203),or boron dioxide.

1. **Describe the different types of ceramics in terms of composition/structure.**

* the ceramic group has a wide range of examples due to large variations in composition and structure
* structure can vary from pure crystalline ceramics to amorphous structures (glass)
* their properties can vary from high melting points to high hardness

1. **Describe the different types of ceramics in terms of properties.**

Examples: clay-based ceramics (hard), electro-optic ceramics, optical properties, ceramic nitrides (AIN) (Hardness), Cermets (WC hardness), crystalline ceramics (Corningware).

1. **Describe the advantages of common ceramics – brick, tile, glass and concrete, as construction materials.**

* brick: dry-pressed, extruded, or wire cut, porous, strong (compression)
* roof tile: cast from liquid cement, porous, low strength
* glass (float): hard, transparent, brittle
* Concrete: cast slab, easily formed, durable, strong

1. **Describe common shaping methods used for a clay based ceramic:**

* potter’s wheel – clay placed on a rotating table, the clay is formed to shape with the potter’s hands; after drying, the product is fired to high temperature in a kiln
* jiggering/jollying – forming plate and dish shapes, mass production
* hydrostatic processing – alumina in powder form placed in mould and compressed, final shape fired to required temperature

# Concrete

1. **What are the properties of concrete that make it suitable for civil structures?**

* ease of forming
* high hardness
* very high compressive strength, tensile strength about 1/10th
* porosity
* durability

1. **What features would be shown and labelled when drawing a macrostructure of concrete?**

* macrostructure: would show the relationship between the principal components
* aggregate: rough angular stone unreacted
* sand: fine rounded grains on unreacted sand
* cement: main chemically reacted series of complex compounds binds the aggregate and sand together
* reinforcement streel (unreacted): bound by the cured cement

# Bricks

1. **What material is used in common house bricks?**

* Kaolin clay: complex Fe-Al, Silicon dioxide
* Feldspar: hydrous Alumino Silicates
* Quartz: Silicon oxide

1. **How are brick manufactured?**

* modern dry-pressed bricks: correct balance of clay minerals is prepared (low water content). The components are mixed thoroughly then fed into a press having the frog or surface features included
* individual bricks are pressed, fed to the kiln for firing

1. **What features would be drawn and labelled in a macrostructure of a ceramic brick?**

* ceramic brick macrostructure: a mixture of unreacted compounds bound together by a glassy phase

# Glass

1. **What glass is used in common window glass?**

* float

1. **How is common window glass manufactured?**

* float glass: continuous process – batch of prepared minerals measured and fed into furnace, components begin to melt and mix to form glass
* gas produced during melting is controlled
* the glass is fed into a separate chamber part filled with molten tin. The glass cools whilst floating on the molten tin

1. **What features would be drawn and labelled when drawing a microstructure of glass?**

* amorphous structure (non-crystalline): no grains for crystals, micro gas bubbles, possible minute remnant of untreated mix

1. **Describe a common shaping method used for window glass.**

* rolled glass: sheet glass softened in a furnace, passed between rollers to required thickness