Stage 6 – Engineering Studies

# Material Science

This resource is designed to help students develop a fundamental understanding of atoms, atomic bonds and the effects that different bonds have on the physical and mechanical properties of materials.

## Outcomes

* **P1.2** explains the relationship between properties, structure, uses and applications of materials in engineering

[Engineering Studies Stage 6 Syllabus](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/technologies/engineering-studies-syllabus) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2011.

## Delivery strategies

This resource is adaptable and could be used in online platforms such as Google Classroom. Links to the videos and websites could be posted for students to access for learning at home. The activities and questions are designed for general preliminary materials content, but could be adjusted to suit module specific HSC materials content.

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| Focus area | Atomic bonding and physical properties |
| Syllabus Content | Students learn about:   * Classification of materials * Properties of materials   + Physical and mechanical properties * Structure of materials   + Atomic structure   + Bonding   + Crystalline and non-crystalline structures |
| Resources | [Introduction to Materials Science and Engineering UNSW](https://mats1192.teaching.unsw.edu.au/)  Complete module 1A atomic bonding and module 1B atomic packing |
| Activities/ questions | 1. What is an atom? 2. According to Bohr’s model which three particles make up an atom, and what type of charge does each particle carry? 3. The ionic compound Sodium Chloride (NaCl) has a fixed 1:1 ratio of sodium to chloride ions. Explain (relate cause and effect) how ionic bonds form between these ions. 4. Explain how covalent bonds form between atoms. 5. Explain metallic bonds, and why the properties of metals differ greatly from materials that are formed from ionic and covalent bonds. 6. What are secondary bonds and how are they different from primary bonds? 7. Draw a table and list the primary and secondary bonds generally found in metals, ceramics and polymers. 8. Diamond and graphite are both held together with covalent carbon bonds and have distinctly different physical and mechanical properties. By examining the structure of these materials suggest reasons for the differences in properties? 9. Identify the three most common crystal structures for metals. 10. What is an amorphous material? 11. What is a polycrystalline material? Give an example. |
| Suggested answers | Suggested answers.   1. An atom is the smallest particle of an element which has the distinguishing properties of that element. Atoms consist of a nucleus containing protons and neutrons, which is surrounded by electrons. 2. An atom is made of three particles, protons, neutrons and electrons. The nucleus of an atom is made up of protons and neutrons. Protons carry a positive charge and neutrons carry no charge. The nucleus is orbited by electrons which carry a negative charge. 3. In ionic bonds, electrons are transferred from one atom to another so that both atoms can have a completely full or empty valence shell. One atom becomes a cation (net positive charge) and the other atom will become an anion (net negative charge), as opposite charges attract the cation is attracted to the anion. 4. In covalent bonding, a stable electron configuration is achieved by sharing of electrons between neighbouring atoms. Two atoms that are covalently bonded will share at least one electron from each atom and use the shared electron to fill and create a shared stable valence shell. 5. In metallic bonding, the valence electrons are released to a common pool and become shared by all the atoms in the solid metal. This pool of electrons is often referred to as an electron ‘cloud’ or ‘sea’. Having lost its valence electrons each metal atom becomes a cation with a net positive charge becoming attracted to the negatively charged electron ‘cloud.’ Metallic generally exhibit good electrical and thermal conductivity due to the availability of delocalised electrons. 6. Secondary bonds are weak bonds that occur due to interactions between atomic or molecular dipoles. They differ from primary bonds as there are no direct electron exchanges. 7. See table below. 8. Diamond is the hardest natural substance, and this is due to the tetrahedral structure held together with strong carbon-carbon covalent bonds. Graphite has a two dimensional hexagonal structure where layers of graphite are held together by weak secondary bonds. 9. Face-centred cubic, body-centre cubic, hexagonal close-packed. 10. An amorphous material is a solid material with no regular crystalline structure. 11. A polycrystalline material is a material made of many smaller crystalline regions. An example is copper. |

Sample response for question 7

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| Material | Primary bonds | Secondary bonds |
| Metal | Metallic | NA |
| Ceramic | Covalent and ionic | NA |
| Polymer | Covalent | Van der Waals |