

## Teaching resource 5

### Forms of Carbon: Diamond

You will need:

30 black carbon C<sup>k</sup>

40 grey straws

Diamond, one of the hardest known materials, has a structure combining simplicity and complexity. It is based on the elementary tetrahedral carbon atom built into a cubic lattice with a sophisticated symmetry.

By building models of carbon it is possible to demonstrate the basic carbon-carbon bonding, the unit cell which is the repeating unit of the lattice, and the dense layers of linked atoms which create the surfaces and observed form of natural diamond crystals. The overall shape of the diamond crystal is octahedral. Each carbon atoms' valence electrons are in the hybridised state  $sp^3$  resulting in covalent bonds directed tetrahedrally – this creates diamond's' strong symmetrical structure.

To create a basic diamond structure make a 'puckered' ring of six four-pronged carbon centres using grey straw – alternate atoms will be raised up as in Figure 1. Then build further similar rings of atoms and add straws to the upwards pointing prongs of the raised atoms as shown in Figure 2. Make a further hexagon (Figure 3) and add this to the upwards pointing straws shown in Figure 2. Finally make Figure 4 and build the layers together as shown in Figure 5.

You have made a fragment of diamond crystal – note that the edge atoms still have spare prongs – in reality these would be joined onto further atoms to the edge of the crystal.

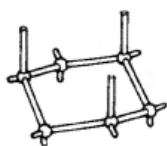


Figure 1

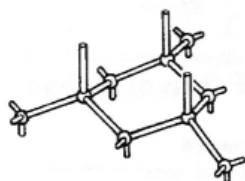


Figure 3 – Layer B

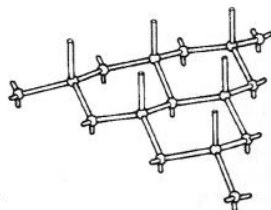


Figure 2 – Layer A

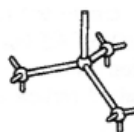


Figure 4 – Layer C

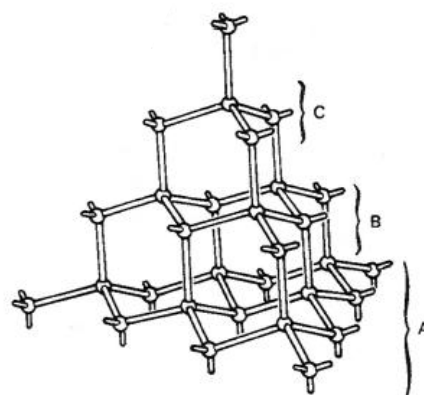


Figure 5

## Study questions

5.1 How many near neighbours does each carbon atoms have?

5.2 What is the coordination number of the carbon atoms in diamond?

Turn the model over so that a new side forms the base: count the number of atoms in the puckered layer which forms the base – repeat this for all sides.

5.3 In how many different orientations can the structure be seen to have puckered layers running through it?

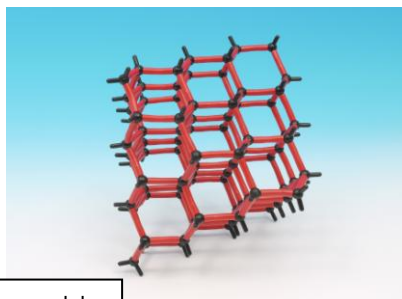
5.4 What is the overall shape of the model?

5.5 Why is diamond such a hard substance?

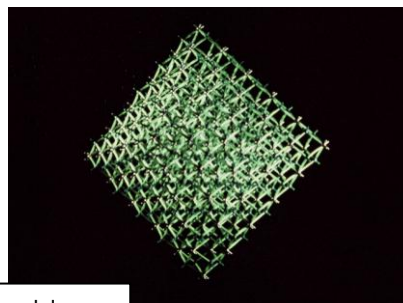
The structure of diamond belongs to the cubic system. The tetrahedron and the cube are closely related. Moreover the layers of atoms in the crystal repeat – the fourth layer is vertically over the first, the fifth over the second etc - such a sequence always leads to cubic symmetry.

→ Look out for related teaching aids for other forms of carbon to compare structure.

Further insight into the structure of diamond can be gained by making larger models using the Colourwave and Proview crystal building kits.



Colourwave model



Proview model

Products which can be used for this demonstration:

0046 Orbit Basic Structures Class Set | 0026 Orbit Basic Structures Individual Set |  
0047 Orbit Organic/Inorganic Class Set | 0027 Orbit Organic/Inorganic Individual Set  
0048 Orbit Lattices Class Set | 0028 Orbit Lattices Individual Set  
0049 Orbit Biochemistry Class Set | 0029 Orbit Biochemistry Individual Set  
0041 Large Class Set  
1245 Diamond Colourwave model | 0087 Diamond Minit Proview model

Or you can order sufficient individual atoms from the Orbit, Minit or Unit systems for your individual needs.

Answer to study questions: 5.1 Four 5.2 Four 5.3 Four planes 5.4 Tetrahedron 5.5 The whole structure is a giant molecule.  
Mechanical breakage involves breaking chemical bonds between atoms.