

Section A

Question 1

The box diagram for the silicon atom is as follows:



Each box corresponds to an atomic orbital. They are filled, in order of increasing energy, with pairs of electrons of opposed spin. The final step is the assignment of the last two electrons to the three 3p boxes, which each have the same energy. Hund's rule tells us that they must be put in different boxes with parallel spins (*Book 2, Section 4.4*).

Question 2

Structure 1 is only one of two resonance forms of benzene. By itself it suggests that the bond lengths should alternate around the benzene ring. In fact, all the bonds in benzene turn out to have the same length. If benzene is represented as a resonance hybrid,



all the bonds become identical in a state that lies between a single and a double bond. With this modification, Structures 2 and 3 also become identical (*Book 2, Section 5.4.4*).

Question 3

A close-packed array of spheres is shown in Figure 1.

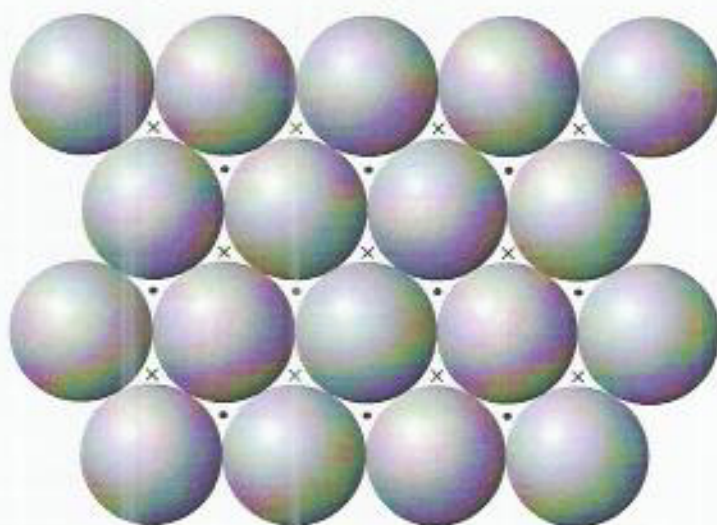


Figure 1 A close-packed layer of identical spheres.

There are two sorts of spaces in between the spheres — triangles pointing up (marked with a cross) and triangles pointing down (marked with a spot). A second layer is placed on top over the triangles pointing up; this is shown in Figure 2.

The third layer can then be added in two different ways:

If it is added directly over the first layer (repeating layers ABABAB...), we have hexagonal close-packing.

If the third layer is added so that it is not directly over the first or second layer, then we have cubic close-packing (repeating layers ABCABC...).