

Chemical Bonding

Question 1

- (d) Account for the difference in the shapes of the boron trifluoride (BF_3) molecule and the ammonia (NH_3) molecule.

Question 2

- (a) Define *electronegativity*. (6)
Ammonia (NH_3) and silane (SiH_4) are small molecules, each of which has four electron pairs in the valence shell of the central atom.
Account for the difference in bond angle between the two molecules, 107.3° in ammonia and 109.5° in silane. (6)
Use electronegativity values to determine which bond, the N–H bond in ammonia or the Si–H bond in silane, is the more polar. (3)
Which of the two substances has hydrogen bonding between its molecules? Justify your answer. (6)
Give the reason why a molecule with polar bonds can be non-polar. (4)

Question 3

- (e) How many (i) sigma bonds, (ii) pi bonds, result from sharing of the valence electrons between the atoms in a molecule of nitrogen?

Question 4

- (a) Distinguish between *intramolecular* bonding and *intermolecular* forces. (7)
Explain each of the following in terms of intramolecular bonding *or* intermolecular forces *or* both.
(i) The boiling point of hydrogen (20 K) is significantly lower than that of oxygen (90.2 K).
(ii) Iodine has a very low solubility in water.
(iii) When a charged rod is held close to a thin stream of water flowing from a burette, the stream of water is deflected. (18)

Question 5

- (d) Give the shape and the corresponding bond angle for a molecule of formula QX_4 where Q is an element from Group 4 of the periodic table.

Question 6

- (d) Distinguish between sigma (σ) and pi (π) covalent bonding.

Question 7

- (b) (i) Distinguish between *ionic bonding* and *polar covalent bonding*. (7)
- (ii) Why do ionic substances conduct electricity when molten or dissolved in water but not in the solid state? (6)
- (iii) Ammonia is polar covalent and is water-soluble.
Show that the ammonia molecule (NH_3) has polar covalent bonding.
Describe the processes involved when ammonia dissolves in water. (12)

Question 8

State which of the following compounds contain intermolecular hydrogen bonds:

- (i) hydrogen chloride, HCl , (ii) water, H_2O , (iii) ammonia, NH_3 . Justify your answer. (9)
- Suggest a reason why the boiling point of ammonia ($-33\text{ }^\circ\text{C}$) is significantly lower than that of water ($100\text{ }^\circ\text{C}$). (4)

Question 9

- (b) (i) Use a dot and cross diagram to show the bonding in an ammonia, NH_3 , molecule. (7)
- (ii) Use electron pair repulsion theory to determine the shape of the ammonia molecule. Explain clearly why the bond angle in ammonia is only 107° . (9)
- (iii) Hydrogen bonding occurs between ammonia molecules. What are *hydrogen bonds*? Draw a diagram illustrating hydrogen bonding in ammonia. (9)

Question 10

- (b) Define *electronegativity*. (6)
- (i) Describe using dot and cross diagrams the bonding in the water molecule. (9)
- (ii) What is the shape of the water molecule?
Which of the following angles, 104° , 107° , 109° , 120° or 180° would you expect to be closest to the bond angle in the water molecule?
Explain your answer. (12)
- (c) The diagram on the right shows a thin stream of water flowing from a burette. What would you observe if a charged rod was brought close to the thin stream of water? Explain your answer. (9)

