Chapter 3 – Answers to end of chapter questions

1

a

b

2

a Moving from left to right across the period, the bonding changes from ionic in NaCl and MgCl₂ to covalent in AlCl₃, SiCl₄, PCl₃ and SCl₂.

b Elements with one or two electrons in the outer shell lose these electrons to form ions (e.g. Na⁺ and Mg²⁺) in ionic compounds. Elements with 3 or more electrons in the outer shell form covalent bonds and gain further electrons in their outer shell.

3
4  a  C  2, 4;  N  2, 5;  O  2, 6;  F  2, 7
   
   b

   ![Molecular structures]

   c  CH₄ – tetrahedral with respect to atoms and tetrahedral with respect to negative centres around the C atom

   NH₃ – pyramidal with respect to atoms, but tetrahedral with respect to negative centres (3 shared pairs and 1 lone pair of electrons) around the N atom

   H₂O – V-shaped or non-linear with respect to atoms, but tetrahedral with respect to negative centres (2 shared pairs and 2 lone pairs of electrons) around the O atom

   HF – linear with respect to atoms, but tetrahedral with respect to negative centres (one shared pair and 3 lone pairs of electrons) around the F atom

   d  NH₄⁺ – tetrahedral with respect to atoms around the N atom

   NH₃ – pyramidal with respect to atoms around the N atom

   NH₂ – V-shaped or non-linear with respect to atoms around the N atom

5  a  One s orbital and 3 p orbitals.
   
   b  A
   
   c  A
   
   d  There are four regions of negative charge in the outermost shell of the central carbon atom. These regions of negative charge repel each other to get as far apart as possible. The shape that results is tetrahedral

6  a  X is 2, 7;  Y is 2, 8, 8, 1 and Z is 2, 8, 18, 6
   
   b  i  Ionic  ii  Covalent  iii  Ionic
   
   c

   ![Chemical structures]

   d  i  XY will have low volatility – ionic bonds between ions in lattice structure.

   X₂Z will have high volatility – weak intermolecular forces between separate molecules.

   ii  XY will conduct in the liquid phase but not as a solid.
X⁻(l) and Y⁺(l) ions can move to electrodes of opposite charge and conduct when liquid. In the solid phase, the ions are held in the lattice by oppositely charged neighbours.

X₂Z cannot conduct electricity in solid or liquid state as it has no ions or mobile electrons.

iii XY is soluble in water (a polar solvent) owing to the attraction of charged ions for polar water molecules.

X₂Z is insoluble in water. It will be polar but is unable to form strong enough attractions with water to dissolve in it.

7  a  Pentane is a linear molecule whilst 2,2-dimethylpropane is more spherical (globular). The linear molecules have greater possible surface areas of contact and therefore greater van der Waals attractions making the boiling point higher.

b  Greater surface area (van der Waals) attractions in pentane, pull the molecules closer together ‘on average’, so the density is greater for pentane.

c  2-Methylbutane has a structure in between the linear of pentane and the spherical of 2,2-dimethylpropane;

\[
\begin{align*}
\text{CH}_3 & \quad \text{CH} \quad \text{CH}_2 \quad \text{CH}_3 \\
& \quad \text{CH}_3
\end{align*}
\]

Its boiling point and density are therefore probably in between these two.

8  a  Ensure you draw and label axes including units, plot points accurately and then draw the line/curve of best fit.

b  NH₃ has significant H-bonding unlike PH₃ and AsH₃.

c  +13.3 ± 0.3 kJ mol⁻¹

d  +10 kJ mol⁻¹