Chapter 4 – Answers to end of chapter questions

1  a An atom is the smallest part of an element which can ever exist. A molecule is the smallest part of an element or a compound which can exist alone under ordinary conditions. An ion is a charged particle formed from one or more atoms by loss or gain of one or more electrons.
   b i Cu atoms   ii CO₂ molecules   iii a giant molecule of C atoms
   c See sections 4.10 and 4.13

2  a A   b D   c C   d B   e E

3  a D   b C   c B   d E   e D   f E

4  a A and D
   b B
   c C
   d C₆₀
   e It has delocalised electrons between the layers its layers of covalently bonded atoms. These electrons can carry electrical charge.
   f C and E
   g Four from: flexible, strong, transparent, conducts heat, conducts electricity.
   h One from: strong composite materials, solar cells, light-emitting diodes, touch panels
   i One from: miniature electrical wires, molecular-sized needles, drug delivery systems.

5  a Energy saving for 1 kg = 255 MJ – 15 MJ = 240 MJ
   So energy saving for 1000 kg = 240 MJ × 1000 = 240 000 MJ
   b Four from: saves reserves for the future, saves fuels, saves money, reduces waste, less land is used for mining bauxite ore and for waste disposal.

6  a 1.0 g ÷ 0.03 g ≈ 33 mobile phones.
   b 7 t = 7000 kg = 7 × 10⁶ g of gold mined each day.
   This amount of gold is in 7 × 10⁶ × 33 = 231 × 10⁶ mobile phones.
   c If gold were obtained from mobile phones only, and not mined, 231 × 10⁶ mobile phones would be required each day to extract the same amount of gold as is mined. Assuming 7 × 10⁹ phones worldwide, and gold being extracted from 231 × 10⁶ used phones daily, the supply of mobile phones would last for (7 × 10⁹) ÷ (231 × 10⁶) = 30 days. This indicates that the supply of gold from recycled mobile phones could not keep up with demand, and explains why gold is still extracted from mines as well as used mobile phones.
7  a A material which will scratch or mark another when the two are rubbed together  
   b $2C + SiO_2 \rightarrow CSi + CO_2$  
   c It is cheaper.  
   d It provided a cheap abrasive for the manufacture of machines.

8  a SiO$_2$ forms a giant (3-D) molecule of covalently bonded Si and O atoms with a very high melting point. CO$_2$ forms separate small CO$_2$ molecules in which the carbon atom is strongly bonded to two oxygen atoms, but there are only very weak van der Waals forces between separate CO$_2$ molecules. Therefore CO$_2$ has a very low melting point.  
   b Ca$^{2+}$O$^{2-}$ (s) has double charges on the constituent ions, whereas Na$^+$Cl$^-$ (s) has single charges.  
   c Water is polar and can H-bond. Hexane is non-polar. Glucose is polar and can H-bond. Cyclohexane is non-polar. Glucose can form Glu–H$_2$O attractions similar in strength to H$_2$O–H$_2$O attractions and therefore mixes readily with and dissolves in water. The Glu–Glu bonds are, however, much stronger than possible Glu–hexane attractions and so glucose does not dissolve in hexane. Cyclohexane being non-polar has only weak intermolecular cyclohexane–cyclohexane attractions so it cannot penetrate the H$_2$O–H$_2$O hydrogen-bonded attractions, but it can mix readily and easily with hexane which has similar weak intermolecular attractions.

9  a c.p. – most metals except alkali metals, Fe and Mn  
   b.c.c. – alkali metals, Fe and Mn  
   b i Higher density in c.p. structure – atoms closer ‘on average’  
      ii Higher melting point in c.p. structure – atoms closer and therefore more strongly bonded  
      iii Greater malleability in b.c.c. structure – atoms not so strongly bonded and therefore able to move over each other more easily

10 a XCl$_x$ – ionic, YCl$_y$ – covalent bonds between Y and Cl atoms within YCl$_y$ molecules, but van der Waals bonds between the separate YCl$_y$ molecules.  
   b Positive X$^+$ ions are strongly bonded to Cl$^-$ ions in lattice, which leads to high melting and boiling points. Separate YCl$_y$ mols are only held together by weak van der Waals forces so have low melting and boiling points.  
   Ions in XCl$_x$ form attractions to polar water molecules so they dissolve in and mix with water easily. The attractions of the oppositely charged ions for each other means that XCl$_x$ will not dissolve in non-polar hexane.  
   Molecules of YCl$_y$ can form similar attractions to hexane as for each other so they mix with and dissolve in hexane easily. But H-bonded water molecules will not mix with YCl$_y$ because the water molecules are too strongly attracted to each other.
11  a  C
    b  B
    c  When a substance melts its particles leave their fixed positions. Instead of vibrating on the spot, they move around each other.

12  a

\[
\frac{pV}{T} = \frac{pV}{T}
\]

b

\[p = \text{dissociating gas} \quad \text{ideal gas}
\]

13  a  Molecules of an ideal gas occupy negligible volume. Molecules of an ideal gas exert no forces on each other and collide with each other, and the walls of their container, without transferring energy.

b  

i  At low pressures the molecules occupy a smaller fraction of the volume of the container than they do at higher pressures. At low pressures the molecules are further apart, and so exert less force on each other than they do at high pressures.

ii  At high temperatures the molecules are moving faster. They are least likely to condense to form a liquid.

c  Helium has smaller particles than oxygen. A helium atom has only two electrons, so cannot have instantaneous dipoles.

14  \[\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}, p_1 = p_2, \quad \frac{975}{278} = \frac{V_2}{298}, \quad V_2 = 1045 \text{ cm}^3\]

\[\therefore \text{ The balloon will burst.}\]
15  a  \( p_A + p_B = 800, \ 800 \times 300 = p_A \times 400, \ \therefore p_A = 600 \text{ mm Hg} \)

\[ \Rightarrow p_B = 200 \text{ mm Hg} \]

b  i  He,   ii  HCl

c  Helium behaves most like an ideal gas because it exists as single atoms, so its particles are closest to having negligible volume. The particles are non-polar, and cannot have instantaneous dipoles, so the forces between the particles are closest to exerting no forces on each other.

HCl behaves least like an ideal gas because its particles are biggest. The particles are polar, and so exert attractive forces on each other.

16  \( pV = nRT \),  \( pV = \frac{m}{M} RT \),  \( 0.25 \times 1 = \frac{0.5}{M} \times 0.082 \times 364 \)

\( M_t = 60 \)