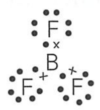
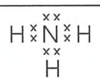
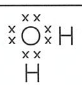
REVIEW QUESTIONS

Chapter 7: Intermolecular Forces

1. Draw the electron dot diagram for each of the following:

(a)	H_2O	(b)	OH^-
(c)	CO_2	(d)	NO_3^-
(e)	HCO_3^-	(f)	SO_4^{2-}
(g)	CH_3COOH	(h)	K_2CO_3

2. Predict the shape of each molecule mentioned by completing the table below:

ELECTRON DOT DIAGRAM	CENTRAL ATOM	NUMBER OF ELECTRON PAIRS ON CENTRAL ATOM	NUMBER OF LONE PAIRS ON CENTRAL ATOM	DIAGRAM AND NAME OF SHAPE
				
				
				
				
				
				

3. Use the general trends in electronegativity provided by the periodic table to rank the following covalent bonds in order showing increasing degree of ionic character.

F–O ; F–Si ; F–F ; F–C

4. Which of the following molecules contain bonds that are polar?

CO_2 ; NO_2 ; Cl_2 ; HCl ; CCl_4 ; H_2O ; Br_2 ; N_2

5. Complete the following table to indicate which of the following molecules are polar.

MOLECULE	DOES IT CONTAIN POLAR BONDS?	MOLECULAR SHAPE	IS THE MOLECULE POLAR?
CH_4			
CCl_2F_2			
H_2S			
HI			
PH_3			
$AsBr_3$			

6. Carbon and nitrogen are neighbours on the periodic table and so have similar electron configurations. Both form covalent molecular compounds with other non-metal elements.

   Explain why pure carbon has a melting point of approximately 3550°C while pure nitrogen has a melting point of –210°C.

7. Dry ice, or solid carbon dioxide sublimes (goes from a solid to gas) at a temperature of –78.5°C, whereas another group 14 element's oxide (SiO_2 or silica) has a melting point of 1610°C.

   Use your knowledge of bonding in solids to explain this large difference in melting points.

8. Graphite and diamond are allotropes of carbon.

   Properties of diamond: *very hard, brittle, has a very high melting point and is a poor conductor of electricity.*

   Properties of graphite: *soft, excellent lubricant, very high melting point and is a good conductor of electricity.*

   (a) Briefly explain why both diamond and graphite have very high melting points.

   (b) Explain why these two forms of carbon have such differing properties of electrical conductivity and hardness.

   (c) Use its structure and bonding to explain why graphite is able to act as a lubricant.

9. Name the intermolecular forces that would exist between molecules of the following gases. If there is more than one type, only name the most significant.

   (a) H_2 (b) N_2 (c) CO_2 (d) CO

   (e) HCl (f) H_2S (g) SO_2 (h) Cl_2O

   (i) Ar (j) He

10. H_2O has a boiling point of 100°C, HCl has a boiling point of –84.9°C and F_2 has a boiling point of –188°C.

(a) Name the van der Waals forces that exist between molecules of the three substances.

(b) What special circumstances would need to exist for dipole-dipole interactions to be classified as hydrogen bonds?

(c) If the only intermolecular forces present between the three substances were dispersion forces, which would probably have the lower boiling point – give a reason for your answer.

11. In the following pairs, the first substance mentioned has the higher boiling point. In each case give possible reasons why.

(a) H_2Te and H_2S (b) H_2S and Ar

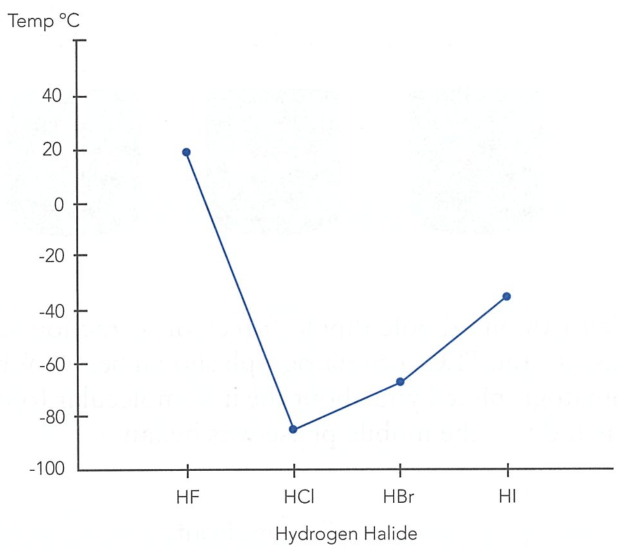
(c) H_2O and H_2S (d) H_2O and CH_4

12. Explain why HCl is more soluble in water than Cl_2.

13. The relative boiling points of the hydrogen halides is given in the graph below.

(a) Explain why the melting point of HF does not follow the trend of the other hydrogen halides.

(b) Why is the melting point of HI greater than the melting point of HBr?



14. The boiling points of water and iodine are 100°C and 184°C respectively. The most significant intermolecular forces in water are hydrogen bonds while in iodine only dispersion forces exist. Explain how it is possible for a substance exhibiting dispersion forces only, to have a higher boiling point than a substance having hydrogen bonds between molecules.

15. Classify each of the following solvents as polar or non-polar:

Petrol, ammonia, ethanol, kerosene, turpentine, methylated spirits

16. Classify the following solutes as ionic, polar or non-polar:

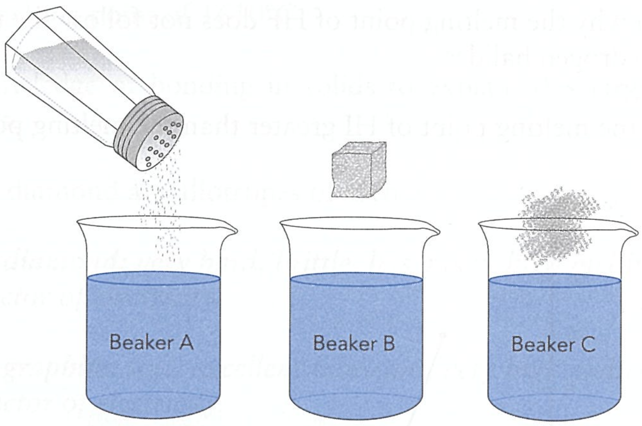
Sugar, copper (II) sulfate, ammonium chloride, ammonia, sodium hydroxide, carbon, sulfur, hydrogen chloride, hydrogen sulfide, methane, silver chloride.

17. Three beakers of water, labelled A, B and C, were placed onto a bench. Sodium chloride was dissolved in beaker A, sugar was dissolved in beaker B, and iodine crystals were dropped into beaker C (very little of the iodine dissolved).

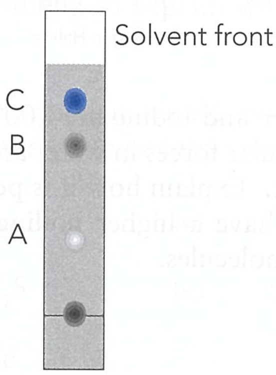
(a) Indicate the forces of attraction that exist within the water in each beaker once the solid has been added to the water.

(b) In which beaker are the forces of attraction between solid particles not significantly decreased by the attraction between the water molecules and the solid particles?

(c) Draw a diagram to show the interactions between the particles in salt and water that cause the salt to dissolve in the water.



18. Silica gel which exhibits dipole-dipole forces of attraction was used as the stationary phase for the TLC chromatograph shown below. What information does this chromatograph tell you about the intermolecular forces exhibited by molecules A, B and C if the mobile phase was hexane?



FOR THE EXPERTS

19. Cholesterol is a waxy, non-polar substance found in many foods. Almost all cells in the body can make cholesterol but the liver is especially efficient at producing and distributing it.

Lipoproteins are complex molecules that have a lipid section that is non-polar and a protein section that is polar. Lipoproteins enable cholesterol to be transported around the body in the blood.

(a) Given that blood is 92% water, comment on the solubility of cholesterol in blood. Explain your answer.

(b) Lipoproteins are soluble in blood and can dissolve cholesterol. Explain how this is possible.

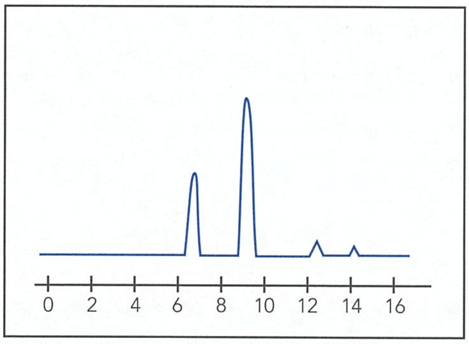
Lipoproteins are classified by their density, the greater the percentage of protein the higher the density, the greater the percentage of lipid the lower the density.

HDL	High Density Lipoproteins
IDL	Intermediate Density Lipoproteins
LDL	Low Density Lipoproteins
VLDL	Very Low Density Lipoproteins

LDLs are primarily responsible for transporting cholesterol around the body, too many LDLs in our diet can result in cholesterol being deposited on artery walls.

HDLs tend to remove excess cholesterol from the blood stream and reduce the amount of cholesterol deposited on artery walls. It is suggested by Health authorities that the ratio of LDL to HDL in the blood be between 3.2 and 3.6 and this represents an average coronary risk factor.

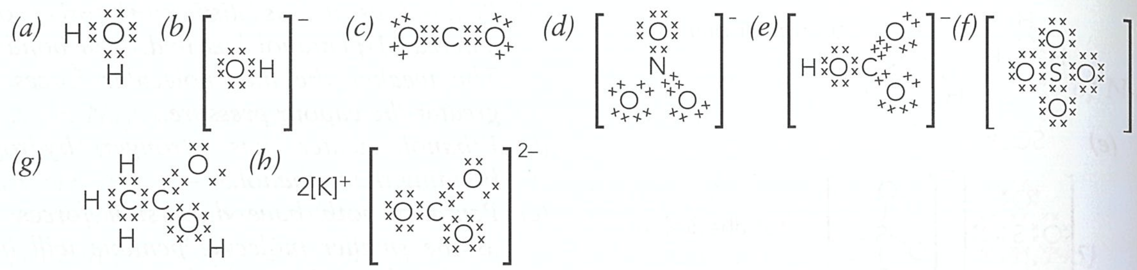
Analysis of lipoproteins in the blood of a person using HPLC produced the following results



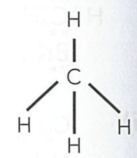
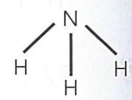
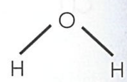
(c) Given that the two larger peaks represent LDL and HDL and the stationary phase was highly polar, predict which of the two peaks was the LDL peak and which was the HDL peak. Explain your answer.

(d) Comment on the relative amounts of LDL and HDL in the person's blood.

Review Questions

1. 

2.

	CENTRAL ATOM	NUMBER OF ELECTRON PAIRS	NUMBER OF LONE PAIRS	DIAGRAM AND NAME OF SHAPE
HCl	–	–	–	H—Cl linear
BeI_2	Be	2	0	I — Be — I linear
BF_3	B	3	0	 triangular planar
CF_4	C	4	0	 tetrahedral
NH_3	N	4	1	 pyramidal
H_2O	O	4	2	 bent

3. *F – F ; F – O ; F – C ; F – Si*

4. CO_2 , NO_2 , *HCl* , CCl_4 , H_2O

5.

MOLECULE	DOES IT CONTAIN POLAR BONDS?	MOLECULAR SHAPE	IS THE MOLECULE POLAR?
CH_4	Yes	tetrahedral	No
CCl_2F_2	Yes	tetrahedral	Yes
H_2S	Yes	bent	Yes
HI	Yes	linear	Yes
PH_3	Yes	pyramidal	Yes
$AsBr_3$	Yes	pyramidal	Yes

6. *The bonding holding the atoms to each other throughout the crystal lattice in carbon is covalent. This strong bonding gives carbon such a high MP. The attractive force holding the molecules to other molecules throughout the* N_2 *crystal lattice is weak dispersion force. The very low strength of this attraction causes* N_2 *to have a very low MP.*

7. *In dry ice the intermolecular forces are weak whereas in SiO_2 the bonding throughout the lattice is very strong.*

8.
(a) *Bonding in both diamond and graphite is strong covalent bonding. High temperatures are needed to break these bonds and cause melting to occur.*
(b) *Diamond is a poor conductor because all valence electrons are localised in strong covalent bonds. This also explains the hardness of diamond. Graphite is a good conductor because one electron per atom is delocalised and capable of moving throughout the lattice.*
(c) *Carbon atoms in graphite bond in such a way as to form sheets of carbon atoms. The attractive force between these sheets is weak and they are able to slide over each other. This gives graphite lubricant properties.*

9. (a) *dispersion* (b) *dispersion*
(c) *dispersion* (d) *dipole-dipole*
(e) *dipole-dipole* (f) *dipole-dipole*
(g) *dipole-dipole* (h) *dipole-dipole*
(i) *dispersion* (j) *dispersion*

10. (a) *H_2O – hydrogen bonds ; HCl – dipole-dipole forces ; F_2 – dispersion forces.*
(b) *A highly electronegative atom (F, N or O) is bonded to a hydrogen atom.*
(c) *H_2O because it has a much smaller mass than the other molecules, bent shape.*

11. (a) *H_2Te has the higher molar mass – stronger dispersion forces.*
(b) *H_2S exhibits dipole-dipole forces, Ar has weaker dispersion forces / similar masses.*
(c) *H_2O exhibits hydrogen bonding, H_2S exhibits weaker dipole-dipole forces.*
(d) *H_2O – stronger hydrogen bonds than CH_4 with dispersion forces.*

12. *When HCl is placed in water it ionises forming H^+ and Cl^-. These are highly soluble. Cl_2 is a non-polar molecule and is not very soluble in the polar solvent (water).*

13. (a) *HF exhibits strong hydrogen bonding while the others exhibit weaker dipole-dipole forces.*
(b) *Because it has a greater molar mass which leads to stronger dispersion forces.*

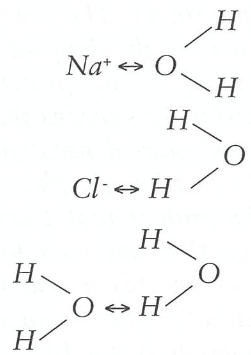
14. *For molecules with very large molar masses the strength of dispersion forces becomes quite significant as indicated by high boiling point of I_2.*

15.

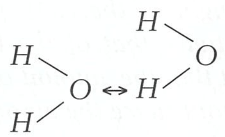
NON-POLAR	POLAR
petrol	ammonia
kerosene	ethanol
turpentine	methylated spirits

16. *Ionic: copper (II) sulfate, ammonium chloride, sodium hydroxide, silver chloride.*
Polar: sugar, ammonia, hydrogen chloride, hydrogen sulfide.
Non-polar: carbon, methane, sulfur.

17.
(a) *Beaker A:* $Na^+ \leftrightarrow Cl^-$



Beaker B:



sugar ↔ *water*

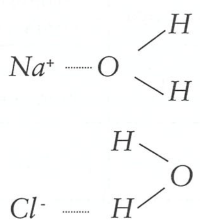
sugar ↔ *sugar*

Beaker C: *iodine* ↔ *iodine*

water ↔ *water*

(b) *Beaker C (I_2 does not dissolve)*

(c)



18. *The relative height that the molecules travelled up the stationary phase gives is inversely related to the strength of the interactions between the molecule and the stationary phase. That would indicate that A would have the greatest dipole-dipole interaction with the stationary phase and is likely to the be the most polar molecule and C the least polar.*

For the Experts

19\.

(a) *Cholesterol non-polar and so would have a low solubility in water and blood.*

(b) *The protein region of the lipoprotein is polar and responsible for the lipoprotein being soluble in water and consequently blood. The lipid region of lipoprotein is non-polar and responsible for attractions between the lipoprotein and the cholesterol. The combination of the two attractions allows for the cholesterol to be carried through the blood by the lipoproteins.*

(c) *The protein region is the polar region of the lipoprotein. The greater the percentage of protein in the lipoprotein, the greater the polarity of the lipoprotein and the greater its density. This means that HDLs are more polar and more dense than LDLs.*
As the stationary phase is highly polar, the lipoprotein that travelled more slowly through the stationary phase would be the more polar, this would be the HDL. The peak at 6.5 would be the HDL and the peak at 9.5 would be the LDL.

(d) *The height of the LDL peak appears to be about twice that of the HDL which would suggest that the amount of LDL in the blood was about twice the amount of HDL.*

CHP 8: THEORY AND GASES

Chapter Questions

8.1

	SOLID	LIQUID	GAS
Shape	fixed	that of container to level surface	takes up complete volume of container
Volume	fixed	fixed	volume of container
Density	high	high	low
Ease of compression	incompressible	almost incompressible	easily compressed
Ease of diffusion	negligible	slow	readily diffuses
Ease of flow	negligible	flows	flows rapidly

8.2

(a) *There is a lot of space between gas particles.*

(b) *Particles in solids are very close together.*

(c) *Particles in solids are held in fixed positions and cannot flow, unlike the particles in gases and liquids.*

8.3

(a) *Gases* (b) *Solids / liquids* (c) *Gases*

8.4 In the gas phase molecules are widely spaced and it requires very little force to reduce this distance of separation, i.e. gases are easy to compress.

8.5 No, gases tend to behave with very similarly so long as they are not at temperatures or pressures likely to cause a phase change.

8.6. The gas particles are small enough to escape through the walls of the balloon.

8.7 The over ripe banana emits a gas which can be smelt. According to the kinetic theory these gas particles will be in a constant state of motion and will gradually spread throughout a room.

8.8

DESCRIPTION	TEMP (°C)	TEMP (K)
Boiling point of helium	-269	4
Boiling point of oxygen	-183	90
Melting point of mercury	-39	234
Melting point of ice	0	273
Normal laboratory temperature	25	298
Normal body temperature	37	310
Boiling point of water	100	373
Melting point of aluminium	660	933
Melting point of NaCl	751	1024
Melting point of tungsten	3422	3695

8.9

(a)

(i) *He atom 2m , 500 ms^{-1}*
H_2 molecule m , 500 ms^{-1}
Since KE = ½mv^2, He atom has greatest KE (twice that of H_2)

(ii) *The effect of halving the speed of the He atom reduces its KE to ¼ of what it was. H_2 unchanged, hence it has the greatest KE (twice that of He).*

(b) *No. The heavier molecule (O_2) will be travelling a little slower since the average KE (KE = ½mv^2) must be the same for both.*