Chapter4rth

LIQUIDS AND SOLIDS

TEXT BOOK EXERCISE

Q.1. Multiple choice questions.

London dispersion forces are the only forces present among the:

(a) molecules of water in liquid state
(b) atoms of helium in gaseous state at high temperature
(c) molecules of solid iodine
(d) molecules of hydrogen chloride gas

Acetone and chloroform are soluble in each other due to

(a) intermolecular hydrogen bonding
(b) ion-dipole interaction
(c) instantaneous dipole
(d) all of the above

NH_3 shows a maximum boiling point among the hydrides of Vth group elements due to

(a) very small size of nitrogen
(b) I one pair of electrons present on nitrogen.
(c) enhanced electronegative character of nitrogen
(d) pyramidal structure of NH_3

When water freezes at 0^oC, its density decreases due to

(a) cubic structure of ice
(b) empty spaces present in the structure of ice
(c) change of bond lengths
(d) change of bond angles

In order to mention the boiling point of water at 110^oC, the external pressure should be

(a) between 760 torr and 1200 torr
(b) between 200 torr and 760 torr

(c) 765 torr
(d) any value of pressure

Ans: (i) c (ii) a (iii) c (iv) b (v) a

Q.2. Fill in the blanks.

i The polarizability of noble gases _____ down the group and results in the increase in their

ii _____boiling points is developed in acetone and chloroform when they are mixed together.

iii Exceptionally weak _____ of HF is due to strong hydrogen bonding present in it.

iv The concept of dynamic equilibrium is the ultimate _____ of all reversible systems.

v H_V of C_6H_{14} should be _____ than that of C_2H_6.

vi During the formation of ice from liquid water there is a _____ % increase in volume.

vii The rate of increase of vapour pressure of water _____ at high temperatures

viii A layer of ice on the surface of water _____ the water underneath for further heat loss.

ix Evaporation is a _____ process.

x Liquid crystals are used in the display of _____ devices.

Ans: (i) increases (ii) H-bonding (iii) acidic strength (iv) result / goal (v) greater (vi) 9 (vii) increases (viii) insulates or prevents (ix) cooling (x) electrical.

Q.4. (a) What type of intermolecular forces will dominate in the following liquids.

(i) Ammonia, NH_3 (ii) Octane, C_8H_{18} (iii) Argon, Ar (iv) Propanone, CH_3COCH_3 (v) Methanol, CH_3OH

(b) Propanone (CH_3COCH_3), propanol ($C_3CH_2CH_2OH$) and butane have very similar relative molecular masses. List them in the expected order of increasing boiling point. Explain your answer.

Answers:

In ammonia (NH_3) hydrogen bonding will dominate. It is due to high E.N of Nitrogen

Octane (C_8H_{18}) has weak Vander Waal's Forces but no hydrogen bonding.

Argon has wear London dispersion forces.

Propanone (acetone, CH_3COCH_3) has dipole-dipole interactions.

Methanol (CH_3OH) has hydrogen bonding. It is due to high E.N of oxygen

(a) The increasing order of boiling points is Butane < Propanone < Propanol

The propanol (CH_3-CH_2-CH_2-OH) has hydrogen bonding. So it has maximum boiling point.Propanone has dipole-dipole interaction while butane has no such forces.

Q.5. Explain the following with reasons.

In the hydrogen bonded structure of HF, which is the stronger bond: the shorter covalent bond

or the longer hydrogen bond between different molecules.

In a very cold winter the fish in garden ponds owe their lives to hydrogen bonding?

Water and ethanol can mix easily and in all proportions.

The origin of the intermolecular forces in water.

Answer:

The hydrogen bonded structure of HF is shown in figure. The fluorine has maximum electro negativity.The shorter covalent bond. H-F is shorter than longer hydrogen bond H---F.When winter comes, then temperature falls down. The water at 4^oC has maximum density. So it goes to the bottom of pond. The surface water freezes into ice. During ice formation the water molecules

get regular arrangements due to H-bonds. In these arrangements there are many empty spaces and ice occupies 9% more volume than liquid water. Thus ice has less density and floats on water. Moreover ice is an insulator of heat. So it prevents underneath water from freezing. Therefore fish and other aquatic animals live (survive) under thick blanket of ice.Both water and Ethanol (C_2H_5OH) show H-bonding with each other. It is the reason that they can mix easily in all proportions.The oxygen atom has small size and high electro negativity. There is high electro negativity difference between oxygen and hydrogen. This high E.N difference between O-atom and H-atom is the origin of intermolecular forces in water.

Q.6. **(a)** Briefly consider some of the effects on our lives if water has only a very weak hydrogen bonding present among its molecules.

(b) All gases have a characteristic critical temperature. Above the critical temperature it is impossible to liquefy a gas. The critical temperatures of carbon dioxide and methane are 31.14^oC and -81.9^oC, respectively. Which gas has the stronger intermolecular forces? Briefly explain your choice?

Answer:

(a) If water had only very weak hydrogen bonding, then its freezing point would be less than 0^oC of ice would not have been less than liquid water. These facts would create problems for human beings and aquatic animals.

(b) Because critical temperature of CO_2 is higher than that of CH_4, SO, SO_2 has stronger intermolecular forces and CH_4 has very weak intermolecular forces.

Q.7. **Three liquids have the properties mentioned against their names.**

NO **water**

propanone **pentane**

i	**Molecular formul**		**H_2O**	
	C_3H_6O	**C_5H_{12}**		
ii	Relative molecular mass (amu)		**18**	
	58	**72**		
iii	**Enthalpy change of vaporization (KJ mol^{-1})**		**14.1**	
	31.9	**27.7**		
iv	**Boiling Point (^oC)**		**100**	**56**
		36		

(a) What type of intermolecular force predominates in each liquid ?
(i) In water (ii) In propanone (iii) In Pentane
(b) What do you deduce about the relative strength of these forces in the liquids? Justify your conclusions.
(c) If the liquids are shaken together in pairs,
(i) Which pair would be unlikely to mix ?
(ii) Explain this immiscibility in terms of the forces between the molecules.
(iii) Choose one of the pairs that mix and say whether the enthalpy change on mixing would be positive or negative.

Answer:

(a) Water has hydrogen bonding, propanone has dipole-dipole interactions and pentane (C_5H_{12}) has London dispersion fores.

(b) From boiling points and enthalpy of vaporizations of three liquids we deduce that
H-bonding in water is very strong
Dipole-dipole interactions in propanone are weak
London dispersion forces in pentane are very weak.

(c)

i. The pair (water + pentane) would be unlikely to mix.
ii. Water is polar molecule and pentane is non-polar molecule or water has H-bonding and pentane has very weak London dispersion forces so this pair of liquids is immiscible.

iii. Water and Propanone mix into each other because both liquids are polar. The process of mixing is an exothermic process and some heat will evolve. Therefore enthalpy change will be negative.

Q.8. Describe the various forces responsible for keeping the particles together in the following elements and compounds and their effect on physical properties making use of the data below:

Substances	Formula	Molar Mass (a.m.u)	M.P (^oC)
Neon	Ne	20	-248
Argon	Ar	40	-189
Water	H_2O	18	0
Sodium fluoride	NaF	42	993
Diamond	C	12	3350

Answer:

Neon:

Neon is a noble gas. It has very weak London dispersion Forces. Thus it has the least melting point (-248^oC).

Argon:

Argon is also a noble gas. It has very weak London dispersion Forces. But it has high polarizability than that of Neon. So its melting point is higher (-189^oC) than neon (-248^oC).

Water:

Water has hydrogen bonding. Due to strong intermolecular forces melting point of ice (water) is high.

Sodium Fluoride:

Sodium fluoride has ionic bond. The positive (Na^+) and negative (F^-) ions are strongly held by electrostatic forces. It is the reason that melting point of NaF is very high.

Diamond:

In diamond there is SP^3 hybridization. Each carbon atom is bonded with four other carbon atoms. A huge network structure is formed. From this network structure a single unit can not be removed. It is the reason diamond has very high melting point (3350^oC).

Q.9. The boiling and molar masses of hydrides of some first row elements are tabulated below:

Substance	Boiling Point (K)	Molar Mass (g mol^{-1})
CH_4	109	16
NH_3	240	17
H_2O	373	18

Suggest reasons for the difference in their boiling points in terms of the type of molecules involved and the nature of the forces present between them.

Answer:

CH_4:

CH_4 is non polar molecule. It has only weak London dispersion Forces. It the reason that CH_4 has very low boiling point (109 K or -164^oC).

NH_3:

NH_3 is a polar molecule. It has hydrogen bonding and dipole-dipole interactions. It is the reason that boiling point of NH_3 is high (240 K or -33^oC).

H_2O:

H_2O is a polar molecule. It has hydrogen bonding and dipole-dipole interaction. Because oxygen is more electronegative than

Nitrogen. So wager has greater hydrogen bonding than ammonia. It is the reason H_2O has higher boiling point (373 K or 100°C).

Q.10. Explain the term saturated vapour pressure. Arrange in order of increasing vapour pressure: 1dm^3 water, 1dm^3 ethanol, 50cm^3 water, 50cm^3 ethanol and 50cm^3 of ether.

Answer:

See page No.

50cm^3 ether > 50cm^3 ethanol = 1dm^3 ethanol > 1dm^3 H_2O = 50cm^3 H_2O

Q.11. While a volatile liquid standing in a breaker evaporates, the temperature of the liquid remains the same as that of its surrounding. It the same liquid is allowed to vapourize into atmosphere in an insulated vessel, its temperature falls below that of its surrounding. Explain the difference in behaviour.

Answer:

When a liquid evaporates in a beaker, it causes cooling. Now heat from surrounding enters into the liquid. It is the reason temperature remains same. But when a liquid is present in an insulated vessel, then evaporation of liquid causes cooling. But heat can not enter into liquid from surrounding due to insulated vessel. It is the reason that the temperature of liquid falls below that of surrounding.

Q.13. What are liquid crystals? Give their uses in daily life.

Ans: The turbid liquids with some degree of order are called liquid crystals. The liquid like crystals which exist between melting temperature and clearing temperature are called liquid crystals.First of all liquid crystals were discovered in 1888 by Frederick Reinitzer an Austrain botanist. He was studying an organic compound cholesteryl benzoate. This compound turns milky liquid at 145°C and becomes a clear liquid at 179°C. By cooling, the reverse process occurs and liquid crystals are formed. The liquid crystals are composed of long rod like molecules. They

have some degree of order. On the basis of ordering, the liquid crystals are of three types.

(i) Nematic (ii) Smectic (iii) Cholestric

Properties:

(i) Liquid crystals are always isotropic.
(ii) They have optical properties.
(iii) They have fluidity, surface tension, viscosity etc.
(iv) Their properties are in between liquids and crystals.

Uses of Liquid Crystals:

(i) Liquid crystals are used as solvents in chromatography.
(ii) Liquid crystal screens are used in oscillographic and TV displays.
(iii) Liquid crystals are used in thermometers.
(iv) Liquid crystals are used in electrical circuits to find out potential failure.
(v) Liquid crystals are used in the display of digital watches, calculators and laptop computers.
(vi) Liquid crystals are used as temperature sensors. When white light is reflected from liquid crystal then its colour changes. When temperature changes, the colour of reflected light also changes. Thus temperature is accurately measured.
(vii) Liquid crystals are used to locate infection, tumors and breast cancer. They are also used to detect blockage of veins and arteries. These parts are warmer than other tissues. When liquid crystal is painted on them, they produce blue coloured spots. Thus indication of any problem is easy.

Q.14. Explain the following with reasons.

(i) Evaporation causes cooling.
(ii) Evaporation takes place at all temperatures.

(iii) Boiling needs a constant supply of heat.

(iv) Earthenware vessels keep water cool.

(v) One feels sense of cooling under the fan after bath.

(vi) Dynamic equilibrium is established during evaporation of a liquid in a closed vessel at constant temperature.

(vii) The boiling point of water is different at Murree hills and at Mount Everest.

(viii) Vacuum distillation can be used to avoid decomposition of sensitive liquid.

(ix) Heat of sublimation of a substance is greater than that of heat of vaporization.

(x) Heat of sublimation of iodine is very high as compared to other halogens.

Answer:

(i) The reason is that during evaporation first of all high energy molecules leave the liquid and low energy molecules are left behind. So temperature of the liquid falls and cooling is produced. To continue the evaporation heat moves from surrounding to the liquid. Thus temperature of surrounding also falls. For example when we put spirit on our hands then spirit evaporates and hand feels cooling.

(ii) Evaporation is a surface process. It takes place at all temperatures. When high energy molecules come at the surface of liquid, they escape out of surface. However by increasing temperature, the average K.E of molecules increases. Hence rate of evaporation increases by increasing the temperature.

(iii) When we supply heat to a liquid, then K.E of molecules and rate of evaporation increase. At boiling point the K.E of molecules becomes maximum. Thus heat supplied at boiling point is used to break intermolecular forces. So there is no increase in K.E of molecules. Hence temperature remains

constant at boiling point. It is the reason that boiling needs a constant supply of heat.

(iv) Earthenware vessels have pores in them. Water evaporates from these pores and causes cooling. During evaporation, the escaping molecules get energy from neighbours to overcome intermolecular forces. Thus temperature of remaining water decreases. In the old earthenware's pores are blocked with dust. So water can not evaporate. Thus they do not keep water cool.

(v) One feels sense of cooling under the fan after bath. It is due to evaporation process. After a bath some water molecules are present on the body. These molecules get heat from the body and evaporate. Thus body feels cooling.

(vi) See page No. 139

(vii) Atmospheric pressure is different at Murree hills and at Mount Everest. Due to different atmospheric pressure boiling point of water is different at two places. At Murree hills atmospheric pressure is 700 torr and boiling point of water is $98^{o}C$. At Mount Everest the atmospheric pressure is further reduced and boiling point of water is $69^{o}C$.

(viii) The distillation which is carried out at low pressure is called Vacuum distillation. It has many advantages.

(i) It decreases the time for distillation.

(ii) It decreases fuel cost for distillation.

(iii) It prevents decomposition of compounds

For example B.P of glycerine is $290^{o}C$. Pressure of 760 torr but at this temperature glycerine decomposes. Hence distillation of glycerine is impossible at $290^{o}C$. Therefore its vacuum distillation is done at $120^{o}C$ at reduced pressure of 50 torr.

(ix) In sublimation a substance directly changes into vapours. It is two steps process (Solid liquid vapours) on other hand vaporization is single step process. It is the reason heat of

sublimation of a substance is greater than that of heat of vaporization.

(x) Iodine has biggest atomic size than other halogens (F_2, Cl_2, Br_2). So I_2 has high polarizability. Due to high polarizability Iodine has greater London dispersion forces. It is the reason that heat of sublimation of Iodine is very high