CHEMISTRY

WORKSHEET-13

STEP

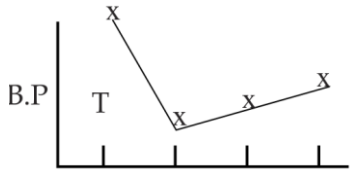
A PROJECT BY PUNJAB GROUP

Worksheet-13

(Physical Chemistry)

Liquids and Solids

Q.1 **The diagram shows the variation of the boiling points of hydrogen halides.**



What explains the higher boiling point of HF?

A) The high bond energy of HF

B) In HF there is H- bonding between HF molecules

C) The electronegativity difference between F and H is much higher than that of other halides

D) The effect of nuclear charge is much reduced in fluorine which polarizes HF molecule

Q.2 **All of the following factors affect vapour pressure of a liquid EXCEPT?**

A) Nature of liquid C) Surface area

B) Temperature D) Intermolecular forces

Q.3 **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

Q.4 **All of the following molecules show hydrogen bonding EXCEPT:**

A) HF molecules

B) Acetone and chloroform molecule

C) Water molecules

D) HCl molecules

Q.5 **Which one of the following types of intermolecular forces is the strongest one?**

A) Hydrogen bonding C) Debye forces

B) London dispersion forces D) Dipole dipole forces

USE THIS SPACE FOR SCRATCH WORK

Q.6 **Although HF is more polar than H_2O, but even then boiling point of H_2O is greater than that of HF. It is because of:**

A) HF is in the gaseous state

B) H_2O has two hydrogen bonds per molecule

C) HF is a weak acid

D) HF has one hydrogen bond per molecule

Q.7 **Which of the following is correct decreasing order of boiling point of given liquids?**

A) Water > Ethanol > HF > NH_3

B) Ethanol > HF > NH_3 > Water

C) NH_3 > HF > Water > Ethanol

D) HF > NH_3 > Ethanol > Water

Q.8 **The spontaneous change of a liquid into its vapours is called evaporation. Identify the incorrect statement about evaporation:**

A) It is natural and continuous

B) It is exothermic

C) It causes cooling

D) It is surface phenomenon

Q.9 **Mark incorrect statement about boiling point of water:**

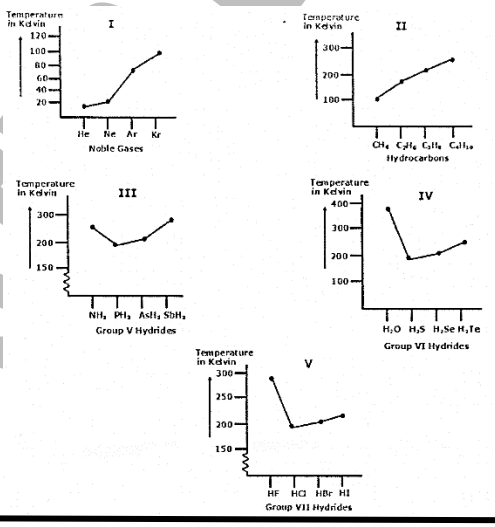
A) Boiling point of water is 120°C at 1489 torr pressure

B) Boiling point of water is 25°C at 23.7 torr pressure

C) Boiling point of water is 98°C at 700 torr pressure at the top of Murree Hills

D) Boiling point of water is 70°C at 323 torr pressure at the top of Mount Everest

Q.10 **Study the following graphs of boiling points of some substances:**



USE THIS SPACE FOR SCRATCH WORK

Which of the above graphs show that some members of the graph have hydrogen bonding?

A) I + V
C) III + IV + V
B) II + IV
D) I + II + III

Q.11 **Which of the following liquids has greater boiling point?**

A) Acetone
C) Diethyl ether
B) Water
D) Glycerol

Q.12 **A phenomenon in which a compound exists in more than one crystalline forms is called:**

A) Polymorphism
C) Isomorphism
B) Allotropy
D) Isomerism

Q.13 **Which of the following sets of solid elements A, B, C and D includes a giant metallic structure, a macromolecular structure and a simple molecular structure?**

A) Na, Mg, A*l*
C) Al, S*i*, S
B) C, S*i*, Sn
D) A*l*, S, Si

Q.14 **Face centered cubic structure is shown by:**

A) Cd
C) Ag
B) Na
D) Mg

Q.15 **Iodine is in the solid state and has greyish black colour. It has all of the following properties EXCEPT:**

A) It is a molecular solid
B) It shows face centered cubic structure
C) It has strong London dispersion forces
D) I – I bond distance in the crystal lattice is less than that of iodine in the gaseous state

Q.16 **Mark the incorrect statement about diamond which is allotropic form of carbon:**

A) It has two dimensional structure
B) It shows face centered cubic structure
C) It is a type of covalent solid
D) It is a non-conductor

USE THIS SPACE FOR SCRATCH WORK

Q.17 **Identify the incorrect statement about giant structure of NaCl:**

A) It shows face centered cubic structure

B) It has four formula units per unit cell in the crystal lattice

C) The distance between two adjacent ions of different kind in the crystal lattice is 2.75A°

D) It is non-conductor in the solid state

Q.18 **All of the following pair of crystalline solids are correctly matched w.r.t type of bonding EXCEPT:**

Options	Crystalline solids	Nature of bonding
A)	Diamond, SiC	Covalent bond
B)	MgO, NaCl	Ionic bond
C)	Al, Zn	Metallic bond
D)	I_2, HCl	London dispersion forces

Q.19 **Which one of the following properties is not shown by molecular crystalline solids?**

A) They are soft

B) They have low densities

C) They all are soluble in non-polar solvents

D) They are mostly volatile

Q.20 **Which of the following statements about ionic solids, covalent solids and molecular solids is incorrect?**

Opt.	Properties	Ionic solids	Covalent solids	Molecular solids
A)	Example	NaCl, CaO	Diamond, SiC	I_2, CO_2, HCl, Ice
B)	Basic component	Ions	Atom	Molecule
C)	Electrical conductivity	Non-conductor in solid state	Non-conductor except graphite	Non-conductor except HCl in H_2O
D)	M.P and B.P	Very high M.Ps and B.Ps	Very low M.Ps and B.Ps	High M.Ps and B.Ps

Q.21 **In crystal lattice of ice, each O-atom of water molecule is attached to:**

A) Four H-atoms C) Two H-atoms

B) One H-atom D) Three H-atoms

USE THIS SPACE FOR SCRATCH WORK

Q.22 **In order to mention boiling point of water at 110°C, the external pressure should be:**

A) Any value of pressure

B) 765 torr

C) Between 760 torr an 1200 torr

D) Between 200 torr and 760 torr

Q.23 **Acetone and chloroform are soluble in each other due to**

A) Dipole-dipole interaction

B) Intermolecular hydrogen bonding

C) Instantaneous dipoles

D) All of these

Q.24 **Which one of the following is not a form of chemical bonding?**

A) Ionic bonding

B) Covalent bonding

C) Metallic bonding

D) Hydrogen bonding

Q.25 **Instantaneous dipole-induced dipole forces are also known as**

A) Van Der Waals forces

B) Hydrogen bonds

C) Dipole-dipole interactions

D) Covalent bonds

Q.26 **The structure normally associated with ionic bonding is:**

A) A giant lattice

B) A giant molecule

C) A regular arrangement of ions surrounded by a sea, or cloud, of electrons

D) A simple molecule

Q.27 **London forces are more effective at**

A) Low pressure

B) Low temperature

C) High pressure

D) High temperature

USE THIS SPACE FOR SCRATCH WORK

Q.28 Which one of the following statements about sodium chloride is incorrect?

A) It has a high melting point

B) It is brittle

C) It conducts electricity at room temperature

D) It is soluble in water

Q.29 London dispersion forces are the only present among the

A) Molecules of water in liquid state

B) Molecules of solid iodine

C) Atoms of helium in gaseous state at high temperature

D) Molecules of hydrogen chloride gas

Q.30 All of following acids have hydrogen bond in liquid state except

A) Hydrochloric acid

B) Sulphuric acid

C) Nitric acid

D) Hydrofluoric acid

Q.31 Which of the following statements is incorrect?

A) The layers in graphite are held together by van der Waals forces

B) The boiling point of noble gases increases down the group

C) H_2O has higher than expected B.P. because of inter molecular Van der Waals forces

D) The greater the number of electrons in a molecule , the greater the van der Waals forces

Q.32 NH_3 show a maximum boiling point among the hydrides of V-A group elements due to

A) Enhanced electromotive character of nitrogen

B) Lone pair of electrons present on nitrogen

C) Pyramidal structure of NH_3

D) Very small size of nitrogen

USE THIS SPACE FOR SCRATCH WORK

Q.33 **Why is it difficult to cook food at high altitude as compared to at sea level?**

A) H-bonding in H_2O changes with height

B) Density of water decreases at the mountain

C) Temperature at the top of mountain is low

D) Boiling point of water decreases at the mountain

Q.34 **When water freezes at 0°C its density decreases dues to:**

A) Empty spaces present in the structure

B) Change of bond angles

C) Change of bond lengths

D) Cubic structure of ice

Q.35 **Which one of the following characteristic features is not shown by crystalline solids and amorphous solids?**

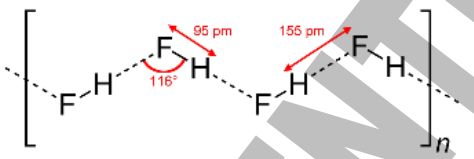
Opt.	Crystalline solids	Amorphous solids
A)	They have definite geometry	They do not have definite geometry
B)	They have sharp melting points	They do not have sharp melting points
C)	They show cleavage plan	They do not show cleavage plan
D)	They show isotropy	They show anisotropy

USE THIS SPACE FOR SCRATCH WORK

ANSWER KEY (Worksheet-13)							
1	B	11	D	21	A	31	C
2	C	12	A	22	C	32	A
3	C	13	C	23	B	33	D
4	D	14	C	24	D	34	A
5	A	15	D	25	A	35	D
6	B	16	A	26	A		
7	A	17	C	27	C		
8	B	18	D	28	C		
9	D	19	C	29	B		
10	C	20	D	30	A		

ANSWERS EXPLAINED

Q.1 **(B)** The highly electronegative atoms responsible for making hydrogen bonding are **Fluorine, Oxygen**, Nitrogen and rarely chlorine. The **size of Fluorine is small** and it is the most electronegativity element in the periodic table. Electronegativity of Fluorine is 4. **Hydrogen bonding** in **HF** is shown below.



- Since **hydrogen bonding is stronger than** dipole dipole forces therefore, HF exists in the liquid state **(BP of HF is 19.5°C)** while other halogen acids exist in the gaseous state.

Q.2 **(C)** **Vapour pressure** of a liquid is an intensive property which depends on nature of the substance and it does not depend on surface area. Other examples of intensive properties are M.P, B.P, viscosity, surface tension etc.

Q.3 **(C)** **London dispersion forces** are **weakest forces.** They are more significant in **non-polar molecules.** The elements of **VIIA and VIIIA groups** show London dispersion forces. All the halogens are non-polar diatomic molecules, but there is a **big difference** in their **physical states** at **room temperature. Fluorine** is a **gas** and boils at **(-188.1°C)** while iodine is a solid at room temperature which **boils** at **+184.4°C.** The polarizability of iodine molecule is **much greater than that of fluorine.**

Halogens	F_2	Cl_2	Br_2	I_2
Colours	Pale Yellow	Greenish Yellow	Reddish Brown	Greyish Black
Physical State	Gas	Gas	Liquid	Solid
Melting Points (°C)	–220	–101	–7.2	114
Boiling Points (°C)	–188.0	–34.6	58.5	184.4

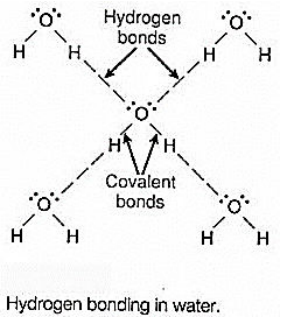
Q.4 **(D)** **Hydrogen bonding** is the **electrostatic force** of attraction **between** a highly **electronegative (N, O and F)** atom and partial positively charged hydrogen atom. **e.g. HF(ℓ), H_2O(ℓ), and in between Acetone (ℓ) and Chloroform** (ℓ) exist hydrogen bonding.

However **HCl shows** dipole dipole forces.

Q.5 **(A)** Hydrogen bonding is the strongest electrostatic force of attraction among all the others except ion dipole forces.

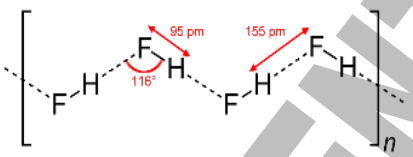
Q.6 (B) **Greater is the number of hydrogen bondings, stronger** are intermolecular forces and **greater** is the **boiling point of a liquid.** Since water molecules have **two hydrogen bonds** per molecule **as compared** to **HF** molecule (which has only one hydrogen bond), therefore the **boiling point of water (B.P = 100°C) is greater than that of HF liquid (B.P = 19.5°C) as shown in the structure.**

- **Hydrogen bonding in water as shown below:**



Hydrogen bonding in water.

- **Hydrogen bonding in HF as shown below:**



Q.7 (A) **Boiling point of a liquid depends on the strength of intermolecular forces.** So **stronger** are the intermolecular forces, **greater** is the **boiling point of a liquid.** The correct order of **decreasing boiling points of liquids** as shown in the tabular form:

Formula	Reason	Boiling point
(H_2O)	• **In water there are two hydrogen bonds per molecule.**	**B.P = 100°C (greater than the rest)**
Ethanol C_2H_5OH	• **Involves hydrogen bonding** • **Weaker than that of water**	**B.P = 78.26°C**
(HF)	• **In HF there is one hydrogen bond per molecule**	**B.P = 19.5°C**
(NH_3)	• **In NH_3 there is one hydrogen bond per molecule**	**B.P = -33.34°C**

Conclusion:

The correct decreasing order of boiling point of given liquids is as follow:

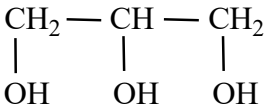
Water > Ethanol > HF > NH_3

Q.8 (B) In fact, it is endothermic process, water molecules absorb energy from the surrounding. As a result higher energy molecules come on the surface of a liquid from where they change into vapours. That is why evaporation causes cooling because temperature of the environment decreases.

Q.9 (D) It is incorrect statement. In fact, boiling point of water is 69°C at 323 torr pressure at the top of Mount Everest.

Q.10 (C) There is hydrogen bonding in option **"C" denoted by Roman letter III+IV+V.**

Q.11 (D) In glycerol there are three **OH-groups** attached with **three carbon** atoms as shown in the structure.



As glycerol is **highly polar molecule** due to the presence of **three OH-groups.** Thus they form stronger hydrogen bonds. So boiling point of **glycerol (290°C)** is higher than that of other liquids mentioned in the question. Boiling points of other liquids are, **acetone (56°C), diethyl ether (34.5°C) and water (100°C).**

Q.12 (A) A phenomenon in which a compound exists in more than one crystalline forms is called polymorphism. That compound which exists in more than one crystalline forms is called a polymorphic, and these forms are called polymorphs of each other. Polymorphs have **same chemical properties** but they **differ in the physical properties**. **e.g.** $CaCO_3$ shows **two crystalline** forms **trigonal and orthorhombic**. Polymorphs have same chemical properties, but they differ in the physical properties. The difference in physical properties is due to different structural arrangement of their particles.

Q.13 (C) These substances fulfill the condition because **Al** shows a giant **metallic structure**, **Si** shows **macromolecular structure** while **S** shows a simple **molecular structure.**

Q.14 (C) Ag shows **face centered cubic structure** while **Na** shows **body centered cubic structure, Cd** and **Mg** show **hexagonal closed packing structure.**

Q.15 (D) It is incorrect statement. **In fact, I – I bond distance in the crystal is greater than that of iodine in the gaseous state.**

- **Iodine** in the **solid** state is in the form of **crystal lattice.** Since **iodine molecules** have **greater size** so there is **greater polarizability greater charge** separation and thus there are stronger intermolecular force in the **iodine molecules.** So in the crystal lattice there is stretching in the iodine molecules due to greater polarizability.
- But in case of iodine in the gaseous state there is no polarizability, so iodine molecules are independent from each other.
- That is why **I – I (271.5ppm) bond length in crystal lattice is greater than that of iodine in the gaseous state i.e. (I – I)** has comparatively less bond length value **(266.6pm).**

Q.16 (A) In fact, **diamond has three dimensional** structure **but not two dimensional structure. Two dimensional structure** is **shown by graphite** (which is allotropic form of carbon).

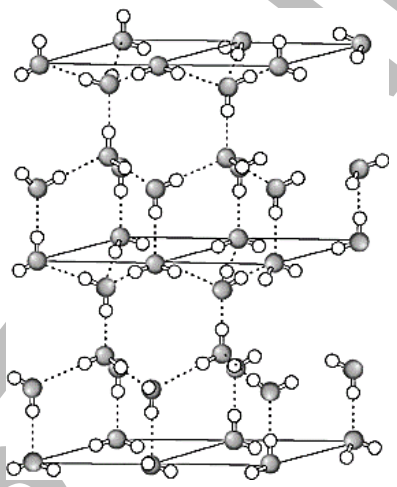
Q.17 (C) In crystal lattice of **NaCl,** the **distance between two nearest ions of the same kind i.e., Cl^- ions is 5.63A°. So the distance between two adjacent ions of different kind is 5.63/2 = 2.815A°, but not 2.75A°.**

Q.18 (D) In fact, iodine molecules **have stronger London dispersion forces** in the **solid state.** But **HCl** has dipole-dipole forces because it is polar molecule whereas **iodine is a non-polar molecule.**

Q.19 (C) **It is incorrect option.** In fact **polar molecular** crystals are **soluble** in **polar solvents e.g. HCl** in **H_2O** while **non-molecular solids** are **soluble** in **non-polar solvents e.g. iodine** is **soluble** in **carbon tetrachloride solvent.**

Q.20 (D) Covalent solids like **diamond, SiC, $(SiO_2)_n$** have **high melting and boiling point** as **compared** to **ionic compounds e.g. melting boiling** of **diamond is 3550°C** whereas **melting point of NaCl** is **801°C.**

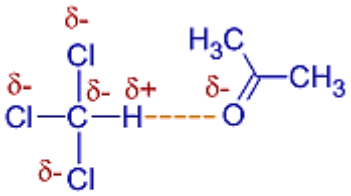
Q.21 (A) **The presence of two hydrogen atoms and two lone electron pairs in each water molecule results in a three-dimensional tetralhedral structure in ice. Each oxygen atom in ice is surrounded tetrahedrally by four others. Hydrogen bonds link each pair of oxygen atoms shown in figure.**



- That is why in crystal lattice of ice each O-atom of water molecule is attached to four H-atoms.
- Empty spaces are created in the structures as shown in the figure. That is why when water freezes, it occupies 9% more space and its density decreases.
- The result in that ice floats on water. The structure of ice is just like that of a diamond because each atom of carbon in diamond is at the center of tetrahedron just like the oxygen of water molecules in ice.

Q.22 (C) **In order to mention boiling point of water at 110°C, the external pressure should be between 760 torr an 1200 torr.**

Q.23 (B) **Acetone and chloroform are soluble in each other due to intermolecular hydrogen bonding.**



hydrogen bonding between chloroform and acetone

Q.24 (D) **Hydrogen bonding is not a form of chemical bonding.**

Q.25 (A) **Instantaneous dipole-induced dipole forces are also known as van der Waals forces.**

Q.26 (A) **The structure normally associated with ionic bonding is a giant lattice.**

Ionic compounds have regular structures, called giant ionic lattices. In a giant ionic lattice, there are strong electrostatic forces of attraction acting in all directions between the oppositely charged ions. The structure and bonding of ionic compounds explain their properties.

Q.27 (C) London forces are more effective at high pressure.

Q.28 (C) It is incorrect statement. The correct statement is as follow:

NaCl conducts electricity in the molten state.

Q.29 (B) London dispersion forces are the only present among the molecules of solid iodine.

Q.30 (A) Hydrochloric acid does not have hydrogen bonding in liquid state.

Q.31 (C) It is incorrect statement. The correct statement is as follow:

H_2O has higher than expected B.P. because of inter molecular hydrogen bonding.

Q.32 (A) NH_3 show a maximum boiling point among the hydrides of V-A group elements due to enhanced electromotive character of nitrogen.

Q.33 (D) It is difficult to cook food at high altitude as compared to at sea level because boiling point of water decreases at the mountain.

Q.34 (A) When water freezes at 0°C its density decreases dues to empty spaces present in the structure and thus 9% volume of ice increases.

Q.35 (D) It is incorrect statement. The correct statement is as follow:

Crystalline solids	Amorphous solids
They show anisotropy Some of the crystals show variation in physical properties depending upon the direction. Such properties are called anisotropic properties and the phenomenon is referred to as anisotropy.	They show isotropy Some of the solid substances do not show variation in physical properties by changing in the direction. Such properties are called isotropic properties and the phenomenon is referred to as isotropic.

STEP

A PROGRAM BY PUNJAB GROUP