CHEMISTRY

WORKSHEET-12

STEP

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Worksheet-12

(A. Physical Chemistry)

States of Matter (Gaseous + Liquid)

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Q.1 **When sample of a gas is compressed at constant temperature from 15 atm to 60 atm, its volume changes from 76.0cm^3 to 20.5cm^3?**

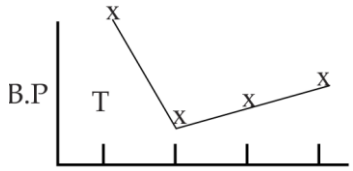
A) The gas behaves ideally

B) The gas behaves non-ideally

C) The volume of gas decreases

D) Gas is absorbed on the vessel walls

Q.2 **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.3 **Real gases show deviation from which of the following postulates of kinetic molecular theory (KMT) of gases:**

A) Gases exert pressure

B) With the increases of temperature, kinetic energy of the gas molecule increases

C) The collision among the gas molecules are perfectly elastic

D) The molecules of a gas a have no forces of attraction for each other

Q.4 **When oxygen gas volume decreases from 4.0dm^3 to 2.0dm^3, the pressure increases from 400 kP$_a$ to?**

A) 600 kP$_a$ C) 200 kP$_a$

B) 800 kP$_a$ D) 500 kP$_a$

Q.5 **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.6 **Which one of the following gases shows more non-ideal behaviour?**

A) O_2
C) N_2
B) CO_2
D) H_2

Q.7 **Which of the following equations is used for real gases?**

A) PV = nRT

B) $PV=\frac{1}{3}mNC^{\bar{2}}$

C) $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$

D) $\left(P_{obs}+\frac{n^2a}{v^2}\right)\left(V_{vessel}-nb\right)=nRT$

Q.8 **The gas laws can be summarized in the ideal gas equation PV = nRT. Which of the following statements is / are incorrect?**

A) One mole of any ideal gas occupies the same volume under the same condition of temperature and pressure

B) The density of an ideal gas at constant pressure is inversely proportional to temperature

C) Volume of a given mass of a gas increases two times if temperature is raised from 25°C to 50°C at constant pressure

D) Both A and B

Q.9 **Which one of the following mathematical expression does not correctly represent the behavior of an ideal gas?**

A) $PV_m \propto T$
C) $PM \propto dT$
B) $P \propto CT$
D) $P \propto \frac{1}{d}$

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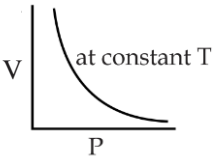
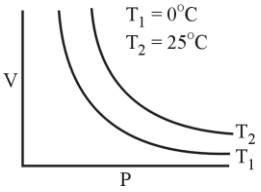
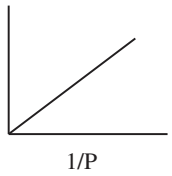
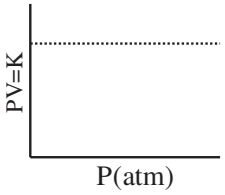
Q.10 **In which of the following isotherms volume increases?**

A) 

C) 

B) 

D) 

Q.11 **Which one of the following postulates of kinetic molecular theory (KMT) of gases explains Charles's law?**

A) Gases exert pressure

B) With the increase of temperature kinetic energy of the gas molecule increases

C) Gas molecules show elastic collision

D) No attractive forces among gas molecules

Q.12 **Under what conditions of temperature and pressure will a real gas behave like an ideal gas?**

Options	Temperature	Pressure
A)	Low	Low
B)	Low	High
C)	High	High
D)	High	Low

Q.13 **Which one of the following substances shows more than one kind of chemical bonding?**

A) Brass C) Copper

B) Diamond D) Water

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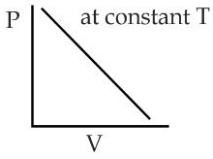
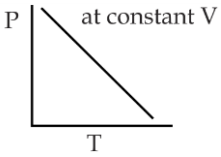
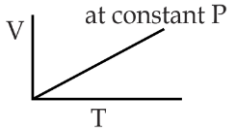
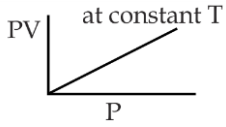
Q.14 **Which of the following diagram correctly describes the behavior of fixed mass of an ideal gas (T is measured in k)?**

A) 

C) 

B) 

D) 

Q.15 **Which of the following liquids has greater boiling point?**

A) Acetone C) Diethyl ether

B) Water D) Glycerol

Q.16 **Calculate the density of carbon dioxide (CO_2) gas at 0^oC and 1atm pressure.**

A) $=\frac{1\times44}{0.0821\times273}gdm^{-3}$ C) $=\frac{1\times44}{8.3143\times273}gdm^{-3}$

B) $=\frac{1\times44}{0.0821\times298}gdm^{-3}$ D) $=\frac{1\times44}{1.987\times273}gdm^{-3}$

Q.17 **Which of the following molecules cannot form hydrogen bonding with each other?**

A) NH_3 C) CH_3OH

B) CH_3NH_2 D) CH_3COCH_3

Q.18 **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.19 **All of the following molecules show hydrogen bonding EXCEPT:**

A) HF molecules

B) Acetone and chloroform molecule

C) Water molecules

D) HCl molecules

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Q.20 **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

Q.21 **According to Boyle's law, the volume of a given mass of a gas is inversely proportional to pressure at constant temperature. Mathematically PV = k. The value of k depends on all of the following factors EXCEPT:**

A) Amount of the gas C) Nature of the gas

B) Rate of diffusion of the gas D) Temperature

Q.22 **Which one of the following gas laws can only be explained on the basis of Kelvin scale?**

A) Boyle's law C) Dalton's law

B) Charles's law D) Avogadro's law

Q.23 **Which of the following is/are application of general gas equation. It is used to determine?**

A) Molecular mass of a gas only

B) Density of a gas only

C) Both A and B

D) Neither A nor B

Q.24 **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.25 **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.26 **Which one of the following relationship is correct regarding van der waal's gas equation?**

A) $a_{NH_3} > a_{N_2}$ but $b_{NH_3} < b_{N_2}$

B) $a_{NH_3} < a_{N_2}$ but $b_{NH_3} < b_{N_2}$

C) $a_{NH_3} < a_{N_2}$ but $b_{NH_3} > b_{N_2}$

D) $a_{NH_3} > a_{N_2}$ but $b_{N_2} \geq b_{NH_3}$

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Q.27 **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.28 **Equal volumes of all the ideal gases at the same temperature and pressure contain equal number of molecules. This is in accordance to:**

A) Boyle's law C) Charles's law

B) Avogadro's law D) Dalton's law

Q.29 **Mark incorrect statement about boiling point of water:**

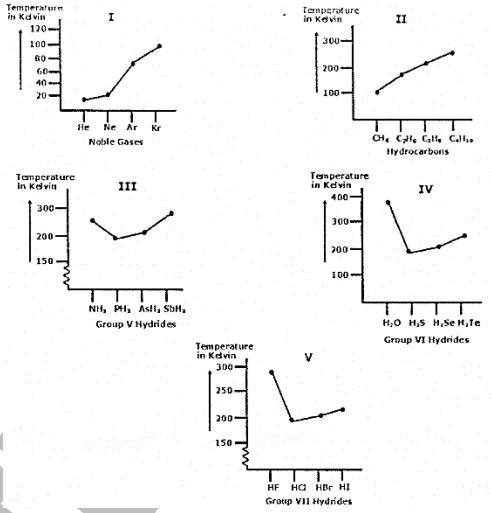
A) Boiling point of water is 120°C at 1489 torr pressure

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



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

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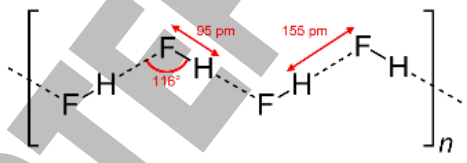
ANSWER KEY (Worksheet-12)							
1	B	11	B	21	B		
2	B	12	D	22	B		
3	D	13	D	23	C		
4	B	14	B	24	B		
5	C	15	D	25	A		
6	B	16	A	26	A		
7	D	17	D	27	B		
8	C	18	C	28	B		
9	D	19	D	29	D		
10	C	20	A	30	C		

ANSWERS EXPLAINED

Q.1 **(B)** With reference to **Boyle's law** with the **increase of pressure** form **15 atm to 60 atm (4 times),** then the volume of a gas should be **decreased ¼ times**. But in this case the decrease in volume is not according to **Boyle's law**. Therefore, the gas behaves **non-ideally**.

Q.2 **(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.3 **(D) Real gases show deviation from the following postulates of KMT:**

The molecules of a gas a have no forces of attraction for each other. In fact, at high pressure and low temperature real gases deviate from above postulate as explained below:

i. **At high pressure** gas molecules come close to each other and in such condition effective volume of a gas molecules cannot be neglected which is against the postulates of KMT of a ideal gas **(Gases are ideal at low pressure and non-ideal at high pressure)**

ii. **At low temperature** K.E decreases and attractive forces develop between the gas molecules which is also against the postulates of KMT **(Gases show ideal behavior at high temperature and non-ideal behavior at low temperature)**

Q.4 **(B)** According to **Boyle's law,** mathematically

$$P_1V_1 = P_2V_2 \text{ (at constant n \& T)}$$

$$\therefore P_2 = \frac{P_1V_1}{V_2}$$

$$P_2 = 4 \times \frac{400}{2} = 800 \text{ kPa}$$

Q.5 **(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.6 (B) Greater is the **molar mass,** greater is the size. Therefore, greater is the **polarizability, stronger are intermolecular forces.** Thus greater is the deviation from the **ideal gas** behaviour. That is why **CO_2** gas shows more **non-ideal** behaviour as its molar mass is greater as compared to other gases.

Q.7 (D) $\left(P_{obs}+\frac{n^2a}{V^2}\right)(V_{vessel}-nb)$ This equation is van der Waal's gas equation. A real gas obeys this equation because real gas shows deviation from ideal gas behaviour at low temperature and high pressure.

Q.8 (C) **Charles's law** can only be explained on the basis of **Kelvin scale**, not on the basis of centigrade scale. Therefore, under the given condition the volume of a given mass of a gas would not increase two times by **increasing temperature** from **25^oC to 50^oC**.

Q.9 (D) **It is incorrect statement.** In fact, with the **increase of pressure** under the given condition **density of a gas also increases** i.e. $P \propto d$.

Q.10 (C) **Two isotherms** are obtained, one at **0^oC** and other at **25^oC** as shown in the figure. By keeping the temperature constant and again vary the pressure and volume and plot the isotherm. **It goes away from both the axes**. The reason is that at **higher temperature**, the volume of given mass of a gas increases. Similarly if we increase the temperature further, make it constant and plot another isotherm, it further goes away from the axis and thus volume of a gas increases as the isotherms move away from the axes.

Q.11 (B) According to **KMT** the average kinetic energy of a gas molecules varies directly as the absolute temperature of the gas. **i.e. ($T \propto K.E$)**. This **postulates** clearly explains **Charles's law**. According to this law, the volume of the given mass of a gas is directly proportional to the absolute temperature, when the **pressure** is kept **constant**.

Q.12 (D) A real gas behaves like an ideal gas under two conditions.

i. At high temperature kinetic energy of gas molecules increases, and intermolecular forces become almost negligible. (a = 0 i.e. "a" constant becomes insignificant) in van der waal's gas equation:

$$\left(P_{obs}+\frac{n^2a}{V^2}\right)(V_{vessel}-nb)=nRT \quad \textbf{(i)}$$

When a = 0 then $(P_i)\,(V_{vessel} - nb) = nRT$ **(ii)**

ii. At low pressure gas molecules move away from each other (b = 0 i.e. "b" constant becomes insignificant) in van der Waal's gas equation:

$(P_i)\,(V_{vessel} - nb) = nRT$ **(iii)**

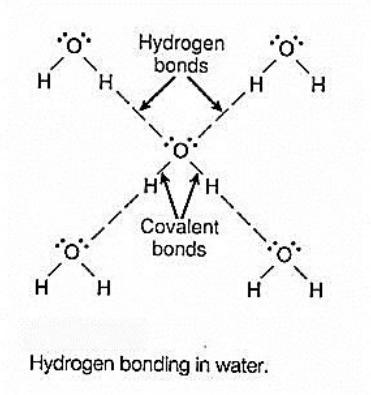
- When b = 0 then $(P_i)\,(V_{vessel}) = nRT$

$(PV) = nRT$ **(iv)**

The van der Waal's gas equation approaches the ideal gas equation PV = nRT as the values of these constants approach zero. The constant "a" provides a correction for the intermolecular forces. Constant "b" is a correction for finite molecular size and its value is the volume of one mole of the atoms or molecules of a gas.

- Under these two conditions **van der Waal's gas equation** reduces to general gas equation (**PV = nRT**).

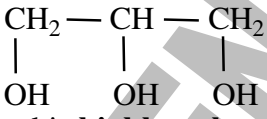
Q.13 (D) Water molecules have **covalent bonds** and **H-bondings** as shown in figure.



Hydrogen bonding in water.

Q.14 (B) **PV = nRT,** since **P, n** and **R** are **constant,** we have V = aT, a = $\frac{nR}{P} > 0$. Therefore, a plot of **V** vs **T** gives a **straight line** with a **positive gradient** $(\frac{nR}{P})$ passing through the **origin.**

Q.15 (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.16 (A) **Density of CO_2 gas**

$$= \frac{1\times44}{0.0821\times273} gdm^{-3}$$

= 0.7138g dm^3

Q.17 (D) **Propanone** shows dipole dipole forces but it does not show **hydrogen bonding** because **H-atom is not bonded** directly to a small and highly electronegative atom **such as N, O, and F**. While all others **A, B and C** show **hydrogen bonding.**

Q.18 (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.19 (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.20 (A) Hydrogen bonding is the strongest electrostatic force of attraction among all the others except ion dipole forces.

Q.21 (B) Rate of diffusion does not affect the value of k (proportionality constant).

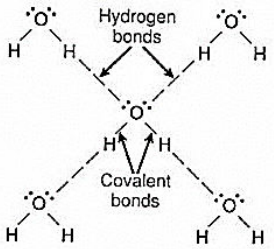
Q.22 (B) Charles's law can only be explained on the basis of Kelvin scale. It cannot be explained on the basis of centigrade scale.

Q.23 (C) General gas equation in the form of (PM = dRT) can be used to determine

- **Molecular mass of the gas** $(M = \frac{dRT}{P})$
- **Density of a gas by the formula** $(d = \frac{PM}{RT})$**.**

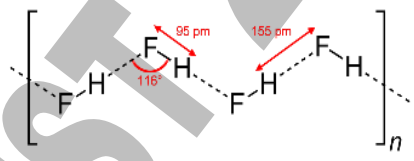
Q.24 (B) Greater is the number of hydrogen bondings, stronger are intermolecular forces and **greater** is the **boiling point of a liquid.** Since water molecules have **two hydrogen bonds** per molecule **as compared** to **HF** molecule (which has only one hydrogen bond), therefore the **boiling point 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.25 (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.26 (A) Since there is **hydrogen bonding in ammonia** and **London dispersion forces** in **nitrogen gas.**

- As hydrogen bond is **stronger than** London dispersion forces, therefore, the value of "a" constant of **ammonia** is greater than that of "**a" constant of nitrogen (a constant is a measure of strength of intermolecular forces). Intermolecular forces develop at high pressure and low temperature in the real gases.**
- On the other hand the value of "b" **constant** of nitrogen is **greater than that** of "**b" constant of ammonia (b constant is excluded volume at high pressure).**
- As we known that in **nitrogen molecules** there are weaker London dispersion forces as compared to hydrogen bonding in **ammonia,** so that is why **value of constant "b" for ammonia is less than that of constant "b" of nitrogen gas as shown in the table.**

Gas	"a" (atm dm^6 mol^{-2})	"b" (dm^3 mol^{-1})
NH_3	4.170	0.371
N_2	1.390	0.391

Q.27 (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.28 (B) Actually it is **definition** of **Avogadro's law. Mathematically it is shown as** $\mathbf{V \propto n(at\ constant\ T\ and\ P)}$.

Q.29 (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.30 (C) There is hydrogen bonding in option **"C" denoted by Roman letter III+IV+V.**

STEP

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