Chapter 3

GASES

EQUATIONS TO DO THE NUMERICAL PROBLEMS

(1) $PV = K \quad P_1V_1 = P_2V_2$ (Boyle's law)

(2) $\frac{V}{T} = K \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$ (Charles's law)

(3) $K = C^\circ + 273.16$

(4) $C^\circ = 5/9\ [F - 32]$

(5) $F^\circ = 9/5\ [^\circ C] + 32$

(6) $V_T = V\left(1 + \frac{T}{273}\right)$ (Charles's law)

(7) $PV = nRT$ (General gas equation for n-moles of an ideal gas)

(8) $PV = RT$ (General gas equation for one mole of an ideal gas)

(9) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ (General gas equation)

(10) $d = \frac{PM}{RT}$ (General gas equation to calculate the density of an ideal gas)

(11) $P_t = p_A + p_B + p_C$ (Dalton's law of partial pressures)

(12) $p_A = X_A P_t,\ p_B = X_B P_t,\ p_C = X_C P_t$ or $p_i = X_i P_t$

(13) $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$ (Graham's law of diffusion in terms of densities of gases)

(14) $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$ (Graham's law of diffusion in terms of molar mass of gases)

(15) $PV = \frac{1}{3} mN\overline{c^2}$ (kinetic equation of gases)

(16) $\overline{c^2} = \frac{n_1c_1^2 + n_2c_2^2 + n_3c_3^2 + \ldots\ldots\ldots\ldots + n_n c_n^2}{n_1 + n_2 + n_3 + \ldots\ldots + n_n}$ (Mean square velocity)

(17) $c_{r.m.s.} = \sqrt{\frac{n_1c_1^2 + n_2c_2^2 + n_3c_3^2 + \ldots\ldots\ldots\ldots + n_nc_n^2}{n_1 + n_2 + n_3 + \ldots\ldots + n_n}}$ (Root mean square velocity of a gas)

(18) $c_{r.m.s.} = \sqrt{\frac{3RT}{M}}$ (Root mean square velocity of a gas related with temperature and molar mass of a gas)

(19) $\frac{PV}{RT} = Z$ (Compressibility factor)

(20) $\left(P + \frac{a}{V^2}\right)(V - b) = RT$ (Van der Waal's equation for one mole of a real gas)

(21) $\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$ (Van der Waal's equation for n moles of a real gas)

METHODS TO SOLVE VARIOUS NUMERICAL PROBLEMS

(1) If temperature and number of moles of an ideal gas are constant, the following equation is applied. It is deduced from Boyle's law

$$P_1V_1 = P_2V_2$$

(2) When the pressure and number of moles of an ideal gas are constant, then the following equation is applied. It is deduced from Charles's law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

(3) If we want to calculate the volume of a gas at any temperature at constant pressure and number of moles, then following relationship is given by Charles

$$V_T = V_0\left(1 + \frac{T}{273}\right)$$

V_0 is the volume of that gas at 0°C.

(4) If none of the parameters is constant to solve the numericals of a gas, then we use

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

(5) In order to calculate the value of general gas constant "R", we use the Avogadro's law, Boyle's law and Charles's law

$$R = \frac{PV}{nT}$$

(6) In order to calculate the number of moles of an ideal gas, we should know the P, V and T along with the suitable values of general gas constant R

$$n = \frac{PV}{RT}$$

(7) If we want to calculate the number of molecules of gas, then multiply the number of moles with N_A. The number of moles are calculated from point (6) given above.

(8) To determine the density of a gas, use the following relationship

$$d = \frac{PM}{RT}$$ **(Bahawalpur 2008)**

Be careful in selecting the units of P and M.

(a) If M is in g mole^{-1}, P is in atm and R is in 0.0821 dm^3 atm K^{-1} mol^{-1}, then 'd' comes out to be in g dm^{-3}.

(b) If M = kg mol^{-1}, P = Nm^{-2} and R = 8.3143 JK^{-1} mol^{-1}, then "d" comes out to be in kg m^{-3}.

(9) To determine the mass of the given gas, use the following relationship

$$m = \frac{PVM}{RT}$$

(10) To calculate the partial pressure of a gas, multiply the mole fraction with a total pressure of the mixture

$$p_i = X_i P_t$$

The mole fraction of a gas is ratio of number of moles of that gas to total number of moles of mixtures

$$X_i = \frac{n_i}{n_t}$$

(11) To get the pressure of the dry gas, subtract the aqueous tension from the moist gas

$$P_{dry} = P_{moist} - P_{(aq\ tension)}$$

Aqueous tension is the pressure of vapours of water at a given temperature.

(12) The comparison of rate of diffusion of gases can be done by knowing the densities of gases

$$\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$$

or, we should know the molar masses of gases.

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

(13) To calculate the root mean square velocity, we should know the temperature and molar mass of the gas

$$c_{r.m.s.} = \sqrt{\frac{3RT}{M}}$$

(14) If we know the Van der Waal's constants "a" and "b" and the gas is non-ideal, the following relationship is used to calculate the pressure of a real gase

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT.$$

DEFINITIONS

(May be used in short questions with examples)

(1) Absolute scale of temperature: **(D.G. Khan 2014)**

It is that temperature scale which starts from –273.16°C as zero. This is also called Kelvin scale of temperature. For example 0K is 273.16°C and 100 K is 373.16°C.

(2) Absolute zero: **(Gujranwala-2006, Multan 2014, B. Pur 2014)**

It is hypothetical temperature at which the volumes of all the gases become zero. Its value is –273.16°C. This temperature can never be achieved. It is theoretically achieved value by Charles's law.

(3) Aqueous tension:

The pressure of vapours of water at a particular temperature is called aqueous tension. Water vapours are always present in the air and exert pressure.

(4) Avogadro's law: **(Federal Board 2013, Lahore 2014)**

Equal volumes of all the gases at same temperature and pressure contain equal number of molecules. 10 mL of H_2, O_2, CH_4 separately at 0°C and 1 atm pressure contain equal number of molecules of each gas in their vessels.

(5) Boyle's law: **(Guj. 2013, Lahore 2014)**

The volume of given amount of a gas is inversely proportional to the pressure of the gas at a constant temperature. Mathematically PV = K or $P_1V_1 = P_2V_2$ at const. T and number of moles.

(6) Charles's law: (Lahore 2014, D.G. Khan 2014, Sahiwal 2014)

The volume of the given amount of a gas is directly proportional to the absolute temperature of the gas, at constant pressure. Mathematically $\frac{V}{T} = K$ or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ at constant P and number of moles.

(7) Critical pressure: (Sarg. 2010, D.G. Khan 2014)

It is the minimum pressure which is required to liquefy a gas at its critical temperature. It is different for different gases and is denoted by P_c.

(8) Critical temperature: (Sarg. 2010, D.G. Khan 2014, Rwp. 2014)

The temperature of a gas above which a gas cannot be liquefied, no matter how great the pressure is applied, is called critical temperature. It is different for different gases and is denoted by T_c.

(9) Critical volume: (Rwp. 2014)

The volume which is occupied by one mole of a gas at critical temperature and critical pressure is called critical volume. It is different for different gases and is denoted by V_C.

(10) Dalton's law of partial pressure: (Bahawalpur 2011)

Total pressure of mixtures of ideal gases is equal to the sum of individual partial pressures at a given temperature. So $P_t = P_{N_2} + P_{O_2} + P_{others}$ in the air.

(11) Diffusion: (Faisalabad 2013, B. Pure 2013, Sarg. 2014, B. Pur 2014)

The spontaneous mixing of the molecules of different gases by random motion and collision to form homogeneous mixture is called diffusion. The gases of balloon diffuse in air after its burst.

(12) Effusion: (Faisalabad 2013, B. Pure 2013, Sarg. 2014, B. Pur 2014)

The passage of gas molecules one by one without collision through a pinhole in a container into an evacuated space is called effusion.

(13) Gas laws:

Gas laws are the relationships between the volume of the given amount of the gas and prevailing conditions of temperature and pressure. Boyle's law, Charles's law and pressure temperature law are gas laws.

(14) Graham's law of diffusion: (Bahawalpur 2008)

(i) The rate of diffusion or effusion of a gas is inversely proportional to the square root of the density of the gas. $r \propto \frac{1}{\sqrt{d}}$ or $\frac{r_1}{r_2} = \sqrt{\frac{d_2}{d_1}}$

(ii) The rate of diffusion or effusion of a gas is inversely proportional to the square root of the molecular masses of the gas. $r \propto \frac{1}{\sqrt{M}}$ or $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$

(15) Ideal gas:

That gas which obeys gas laws like Boyle's law, Charles's law and Avogadro's law is called ideal gas. The ideal gas should obey the general gas equation i.e., PV = nRT.

(16) Isotherm:

A graph between pressure and volume of the gas at constant temperature and the number of moles is called isotherm. It is a parabolic curve. It is in the shape of a curve.

(17) Joule-thomson effect: (Lahore 2011, Lahore 2012)

The phenomenon of the change of temperature when a gas expands adiabatically from or region of high pressure to a region of low pressure is called Joule-Thomson effect. We can liquefy gas by this phenomenon.

(18) Liquefaction:

The process of conversion of a gaseous substance into the liquid state is called liquefaction of the gas. There are various methods for this process.

(19) Mean square velocity: (Guj. 2014)

It is the average of the squares of all the possible velocities of gas molecules.

$$\overline{c}^2 = \frac{c_1^2 + c_2^2 + c_3^2 + \ldots + c_n^2}{n}$$

(20) Mole fraction of gas:

It is ratio of number of moles of a gas to the total number of moles of all the gases in the mixture.

$$X_{N_2} \text{ (in air)} = \frac{n_{N_2}}{n_{N_2} + n_{O_2} + n_{others}}$$

(21) Non-ideal gas:

That gas which obeys the gas laws approximately is called a non-ideal gas. The general gas equation pV = nRT is obeyed approximately.

(22) Partial pressure:

The pressure which is exerted by an individual gas in a gaseous mixture is called partial pressure of that gas.

$$p_{N_2} = X_N P_t$$

(23) Permanent gases:

Those gases which have low critical temperature are called permanent gases.

(24) Plasma state:

A fourth state of matter which is mostly consisted of gaseous charged particles is called plasma. 99% of the universe is made up of charged particles scattered in the vacuum and is called plasma.

(25) Root mean square velocity:

It is a square root of mean square velocity of a gas.

$$c_{rms} = \sqrt{\frac{3RT}{M}}$$

It is directly proportional to the square root of absolute temperature and inversely proportional to square root of molar mass of gas.

(26) Second definition of Charles's law:

The volume of the given mass of a gas increases or decreases by $\frac{1}{273}$ of its volume at 0°C for every 1°C rise or fall of temperature at constant pressure. This statement convinces us that at –273.16°C, the volume of gases will be zero.

(27) Triple point:

The temperature where three states of a substance coexist is called the triple point.

ANSWERS TO THE SHORT QUESTIONS

Boyle's Law

Q.1 Why is the Boyle's law applicable only to the ideal gases?
(Fd. 2009, F. Abad 2012, Guj. 2013)

بوائل کا قانون صرف آئیڈیل یا مثالی گیسوں پر ہی لاگو کیوں ہوتا ہے؟ -1

Ans: Boyle's law is applicable (لاگو ہونا) to those gases which have no forces of attractions among the molecules. Such gases are ideal (مثالی). So Boyle's law is applicable to only ideal gases. Its formula is PV = K when n and T are constant.

Q.2 When a gas obeys the Boyle's law, the isotherms for the gas can be plotted. How is it true? **(Guj. 2013)**

جب ایک گیس بوائل کے قانون کے مطابق کام کرتی ہے۔ تو اس کے لئے isotherms پلاٹ کیے جا سکتے ہیں۔ یہ کیسے صحیح ہے؟ -2

Ans: Isotherms are the graphs between pressure and volume at constant temperature and number of moles. This condition is fulfilled by Boyle's law. The word isotherm means "same temperature (مستقل درجہ حرارت)". They are curves. At higher temperature the curves go away from the axis.

Q.3 What are isotherms? What happens to the positions of isotherms when they are plotted at high temperature for a particular gas? **(Lahore 2014)**

آئسو تھرمز کیا ہوتے ہیں؟ جب زیادہ درجہ حرارت پر ان کو پلاٹ کیا جائے تو ان کی پوزیشن کو کیا ہوتا ہے؟ -3

Ans. Isotherms are the graphs between pressure and volume, when temperature is constant. These graphs are plotted keeping in view the Boyle's Law. There are curves.

When the isotherms are plotted at higher temperatures, then they go away from the axis (axis سے دور ہو جاتے ہیں). The reason is that, the volumes of the gases increase at high temperatures. In this way the points in the graph paper go away from the axis.

Q.4 The product of pressure and volume at constant temperature and number of moles is a constant quantity. Why?
(Multan Board 2004, Sarg. 2009, Fd.Abad 2009)

گیس کے دباؤ اور جسامت کا حاصل ضرب مستقل درجہ حرارت ایک مستقل مقدار ہے۔ کیوں؟ -4

Ans: When the temperature and number of moles of a gas are constant, then the increase of pressure decreases the volume in such a way that PV remains constant (PV = K). By doubling (دگنا کرنا) the pressure the volume becomes half. We can say that,

$P_1V_1 = P_2V_2 = P_3V_3$, at constant temperature and number of moles.

Q.5 Why do we get a straight line when pressures are plotted against inverse of volumes? This straight line changes its positions in the graph by varying the temperature. Justify it. **(B.Pur 2009, Guj. 2011, D.G. Khan 2014)**

-5 جب کسی گیس کے پریشر کا جسامت کی الٹی قیمت کے ساتھ گراف پلاٹ کیا جائے تو سیدھی لائن کیوں آتی ہے اور یہ سیدھی لائنیں درجہ حرارت بدلنے سے اپنی جگہ کیوں بدلتی ہیں؟

Ans. When the pressure of a gas is plotted against $\frac{1}{V}$, we get a straight line at constant temperature (مستقل درجہ حرارت پر). The reason is that P and $\frac{1}{V}$ are directly proportional to each other, with power unity on both variables. When the temp. changes then value of p changes for same $\frac{1}{V}$ value.

Q.6 The plot of PV versus P is a straight line at constant temperature and with a fixed number of moles of an ideal gas. Why?
(M. Pur 2012, D. G. Khan 2012)

-6 جب گیس کا درجہ حرارت اور مولز کی تعداد نہ بدلے تو PV اور P کا گراف سیدھی لائن کیوں دیتا ہے؟

Ans: The product PV is a constant quantity (مستقل مقدار) when temperature and the number of moles are constant. So, when we plot a graph between pressure on x-axis and PV on y-axis, then a straight line parallel (متوازی) to the pressure axis is obtained. This is verification (تصدیق) of Boyle's Law.

Q.7 What are various unit of pressure? **(Lahore 200, Multan 2009, D.G. Khan 2011)**

-7 پریشر کی مختلف اکائیاں بیان کریں۔

Ans: Pressure is measured in mm Hg, atmospheres, Nm^{-2}, Pascals, bars and pounds $inch^{-2}$.

1 atm = 760 mm Hg = 760 torr = 101325 Nm^{-2} = 101325 Pa
= 101.325 kp = 1.01325 Bar = 14.7 pounds $Inch^{-1}$

Q.8 Greater the temperature of the gas closer the straight line of P versus $\frac{1}{V}$ to the pressure axis. Justify it. **(Lahore 2007)**

-8 جتنا درجہ حرارت زیادہ ہو گا اتنا ہی P اور $\frac{1}{V}$ کا گراف پریشر axis کے قریب ہو گا۔ کیوں؟

Ans: When the temperature of same gas is increased for the same number of moles, then the volumes increase at the same pressure. The inverse of volumes $\left(\frac{1}{V}\right)$ (جسامت کا الٹ) decrease at the same pressure. So the points for the graph lie at higher sites than at lower temperature.

Charle's Law

Q.9 Charles's law is not obeyed when the temperature is measured on Celsius scale. Justify it. **(Multan 2012)**

-9 اگر درجہ حرارت °C سکیل پر درج ہو تو چارلسز کا قانون لاگو نہیں ہوتا۔ یہ کیسے صحیح ہے؟

Ans: The foundation stone (سنگِ بنیاد) of Charles's law is the absolute scale of temperature (درجہ حرارت کی مطلق سکیل) which starts from –273°C. The volume of the gas at any temperature can be calculated from the equation

$V_T = V_o\left(1+\frac{T}{273}\right)$. Hence, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ is only obeyed, if temperature is substituted (کی جگہ رکھنا) in absolute scale. If temp. T is in °C, then definition of Charles's law does not hold.

Q.10 What is absolute zero? What happens to real gases while approaching it?
(Lahore 2005, Multan 2005, Gujranwala-2006, F. Abad 2008, B.P. 2008, Sarg. 2009, D. G. Khan 2012, F. Abad 2013)

-10 مطلق زیرو کیا ہوتا ہے؟ حقیقی (غیر مثالی) طور پر کام کرنے والی گیسیں جب مطلق زیرو کو پہنچتی ہیں تو ان کو کیا ہوتا ہے؟

Ans: It is the lowest possible temperature which would have been achieved (جو حاصل ہوتا تھا) if the substance remains in the gaseous state. All the real gases are converted to liquids above this temperature. This –273.16°C is called zero absolute (مطلق صفر) or zero Kelvin.

Q.11 A gas occupies 100 dm³ at 283 K. What will be its volume at – 273°C at constant pressure? (Lahore Board 2005)

-11 ایک گیس کے 283 K پر 100 سی سی جگہ لیتی ہے۔ 273°C- پر اس گیس کی جسامت کیا ہو گی؟

Ans: All the gases are converted into the liquid state before reaching – 273°C. It means that the concerned (متعلقہ) gas is liquid at – 273°C, so volume of this gas at – 273°C cannot be predicted (پیش گوئی کرنا).

Q.12 Throw some light on the factor 1/273 in Charles's law. (B. Pur 2012)

-12 چارلسز لاء میں ایک فیکٹر $\frac{1}{273}$ ہے اس پر روشنی ڈالیں۔

Ans. Factor of $\frac{1}{273}$ is very important in Charles's law. The volume of given mass of the gas increases or decreases by $\frac{1}{273}$ of its volume at 0°C. Following equation helps us to calculate the volume of gas at any temperature.

$$V_T = V_0\left(1+\frac{T}{273}\right)$$

Q.13 Justify that the volume of given mass of a gas becomes theoretically zero at –273°C.
(Model Paper-2006-07, Rwp. 2007, Sarg 2008, Rwp. 2009, Guj. 2010, B. Pur 2012, Lahore 2014)

-13 صحیح ثابت کریں کہ علمی طور پر ایک گیس کی جسامت 273°C- پر صفر کیوں ہو جاتی ہے؟

Ans: According to Charles's law, the volume of a given mass of the gas at 0°C increases or decreases by 1/273 of its original volume, when the temperature is increased or decreased by 1°C. In $V_T = V_0\left(1+\frac{T}{273}\right)$

when, $T = -273\ °C$, $V_{-273}°C = V_0\left(1-\frac{273}{273}\right) = 0$

Q.14 How do you explain that –273°C is theoretical temperature and is not attainable? (M. Pur 2012)

-14 اب کیسے ثابت کریں گے کہ 273°C- ایسا علمی درجہ حرارت ہے جس کو حاصل نہیں کیا جا سکتا۔

Dalton's Law of Partial Pressures

Q.21 Why pilots feel uncomfortable breathing at high altitude and divers cannot use normal air? **(Sarg. 2010, Sarg. 2011, Guj 2012, D.G. Khan 2014)**

-21 پائیلٹس اونچی اڑان کے دوران سانس میں دشواری اور غوطہ خور عام ہوا میں سانس کیوں نہیں لے پاتے؟

Ans: It is due to low partial pressure (جزوی دباؤ جو کم ہو) of O_2 in the upper atmosphere. The pressure inside the lungs is greater than the partial pressure of O_2 in the air.

The pilots feel suffocation all attitudes.

At the depth of water the pressure is high so the partial pressure of O_2 increases below water. The % of O_2 in diver's tank should be less than normal.

Q.22 State Dalton's law of partial pressures. Give its expression.
(Gujranwala Board 2005, Lahore 2009, Faisalabad 2011, Guj. 2011, M.Pur 2012, B. Pur 2014, Sarg. 2014, Lahore 2014)

-22 ڈالٹن کا جزوی دباؤ کا قانون بیان کریں اور اس کی مساوات دیں۔

Ans: The total pressure exerted by the mixture of gases is equal to the sum of individual partial pressures at a given temperature. Let there be a mixture of three gases

$$P = p_{H_2} + p_{O_2} + p_{CH_4}$$

$$P = n_t \frac{RT}{V} \quad \text{where} \quad n_t = n_{H_2} + n_{O_2} + n_{CH_4}$$

The formula for partial pressure of any gas is $p_2 = PX_i$ when P is total pressure and X_i is mole fraction of that gas.

Q.23 How do you say that the pressure of the dry gas is equal to the difference of total pressure and aqueous tension of H_2O?
(Multan 2011, Guj 2012, Sarg. 2014, Lahore 2014)

-23 آپ یہ کیسے کہیں گے کہ خشک گیس کا دباؤ ٹوٹل دباؤ اور پانی کے بخارات کے دباؤ کا حاصل نفی ہوتا ہے؟

Ans: Some gases prepared in the laboratory are to be collected over water (پانی کے اوپر جمع کرنا ہوتی ہیں). So, water vapour join the gas. In order to get the pressure of the pure gas, we have to subtract (نفی کرنا) the vapour pressure of water (aqueous tension) from the total pressure.

$$P_t = P_{gas} + \text{aqueous tension}$$

$$P_{gas} = P_t - \text{aqueous tension}$$

Graham's Law of Diffusion

Q.24 Lighter gases diffuse more rapidly than heavier gases. Give reason.
(Rwp. 2005, Rwp 2007, F. Abad 2007, Guj. 2008, Sargodha 2008, Guj. 2009, Bahawalpur 2011, R. Pindi 2012, D. G. Khan 2012, D.G. Khan 2013)

-24 ہلکی گیسیں بھاری کے مقابلہ میں تیزی سے نفوذ کرتی ہیں۔ وجہ بتائیں۔

Ans: At a given temperature the average K.E. of different gas molecules are same. Since their masses are different, so their velocities will also be different. The lighter molecules will have greater velocities and so they will diffuse rapidly (تیزی سے نفوذ کریں گی).

The equation is $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$.

Non-ideal Behaviour of Gases

Q.25 Gases deviate more from the general gas equation at 0°C and deviate to less extent at 100°C. Why? (Mirpure Board 2004, Lahore 2008, Multan 2013)

-25 جنرل گیس کی مساوات استعمال کرنے سے گیسیں 100°C کے مقابلہ میں 0°C پر زیادہ انحراف کرتی ہے۔ کیوں؟

Ans: Actually in kinetic molecular theory of gas, we suppose that there are forces of attraction. At 0°C, the forces of attractions are dominant (غالب) and gases become non-ideal (غیر مثالی). At high temperature attractive forces become less dominant and gases behave ideally (مثالی).

Q.26 The actual volume of O_2 gas at room temperature and 1 atm. pressure is negligible as compared to volume occupied by one mole of this gas. But this actual volume is not negligible at high pressures. Justify it.

-26 O_2 کی ایک مول کی اصلی جسامت S.T.P پر اس جسامت کے مقابلہ میں نظر انداز کرنے کے قابل ہے۔ جو اس نے گھیری ہوئی ہے۔ یہ اصلی جسامت اس وقت نظر انداز نہیں کی جا سکتی جب گیس پر دباؤ بہت زیادہ ہو۔ صحیح ثابت کریں۔

Ans: At ordinary temperature and pressure, there are almost no forces of attractions among the molecules of O_2. The actual volume of the gas molecules is negligible (نظر انداز کرنے کے قابل) as compared to the volume of vessel.

When the pressure is increased for O_2, then molecules come close to each other. Collisions become move frequent (بار بار ہونا). Forces of attraction start dominating (غالب ہونا شروع ہوتی ہیں). Actual volume remains no more negligible (اصلی جسامت کو نظر انداز نہیں کیا جا سکتا).

Q.27 Hydrogen and helium are ideal at room temperature, but SO_2 and Cl_2 are non-ideal. How do you explain it? (Rwp. 2010, Lahore 2012, Rwp. 2013)

-27 H_2 اور He کمرہ کے درجہ حرارت پر آئیڈیل ہوتی ہیں لیکن SO_2 اور Cl_2 نان آئیڈیل ہیں۔ کیوں؟

Ans. H_2 and He have very low boiling points. So at room temperature, they are far away from their boiling points. At room temperature, the attractive forces are absent. So they behave ideally.

SO_2 and Cl_2 have boiling points close to room temperature, but are below 0°C. At room temperature, they are not far away from their boiling points. Sufficient attractive forces are present at room temperature. So they are non-ideal.

Liquefaction of Gases

Q.28 How the critical temperature is an essential criteria to be considered for the liquefaction of gases? (Rwp. 2008, Fd. 2009, B. Pur 2012, Guj 2012, Multan 2013, Rwp. 2014)

-28 گیسوں کی مائعات میں تبدیلی کے لئے پیچیدہ درجہ حرارت T_c کا جاننا کیوں ضروری ہے؟

Ans: Gases can be liquefied by increasing the pressure and decreasing the temperature. The temperature of a gas should reach the critical temperature (پیچیدہ درجہ حرارت) on or below that to make the gas liquid. Gas can never be liquefied, how much the pressure is applied if the gas is above the critical temperature.

Q.29 Why the non-polar gases like H_2 and He have a very low critical temperatures while polar gases like NH_3 and SO_2 have critical temperatures, sufficiently above room temperature?

-29 نان پولر گیسیں H_2 اور He کے T_c کی قیمتیں بہت کم ہیں۔ لیکن پولر گیسیں کی T_c کی قیمت زیادہ رکھتی ہیں۔ کیوں؟

Ans: H_2 and He are consisted (مشتمل ہونا) of small-sized molecules, and have low polarizabilities (پولز بنانے کی صلاحیت). They have least forces of attractions among themselves. In order to liquefy them, their temperatures have to bring close to absolute zero.

NH_3 and SO_2 have attractive forces even at room temperature. In order to liquefy them their temperature may be above the room temperature.

Q.30 In Joule-Thomson effect sudden expansion of the gas molecules needs energy. Why?

(Faisalabad 2010, Lahore 2010, Lahore 2011, Lahore 2012, Guj 2012, D.G. Khan 2013, Sarg. 2014, Guj. 2014)

-30 جول تھامسن کے اثر کے تحت گیسیں جب اچانک پھیلتی ہیں تو ان کو انرجی کیوں درکار ہوتی ہے؟

Ans: In the compressed state (دبی ہوئی حالت میں), there are sufficient (خاص) attractive forces among the molecules of the gas. During sudden expansion (اچانک پھیلاؤ), the energy is required to overcome the intermolecular attractions. Moreover, the molecules need extra energy to run away in vacuum (خلا میں دور بھاگنے کے لئے انرجی چاہیے).

Q.31 Joule-Thomson effect is operative in the Linde's method of liquefaction of air. How? **(Lahore 2007, Faisalabad 2010, Lahore 2010, Guj 2012, D.G. Khan 2013)**

-31 لنڈے کے گیسوں کو مائع بنانے سے جول تھامسن کے اثر کا عمل دخل ہے۔ کیسے؟

Ans: In Linde's method the gas is compressed to 200 atmospheric pressure. These compressed gases are suddenly (اچانک) allowed to expand through a nozzle. This sudden expansion of the gas and the consequent (فوراً بعد) cooling is called Joule-Thomson effect and this effect is operative (اثر دکھانا) in Linde's method of liquefaction.

Non-ideal Behaviour of Gases

Q.32 Why the gases deviate from ideal behaviour at high pressure and low temperature?

(D.G. Khan-2006, Multan 2007, B.Pur 2009, Faisalabad 2010, Sargodha 2010, Guj. 2010, Faisalabad 2011, Multan 2012, D. G. Khan 2012, F. Abad, 2012, B. Pure 2013, D.G. Khan 2013, Sarg. 2014, B. Pur 2014, Multan 2014)

-32 زیادہ پریشر اور کم درجہ حرارت پر گیسیں نان آئیڈیل کیوں ہیں؟

Ans: When the temperature of the gases are low, the attractive forces become dominant (غالب), so gases don't obey the gas laws. When the pressure of the gases are high, collisions (تصادم) become more frequent and force of attraction are created. Moreover, the actual volume of the gas molecules are no more negligible as compared to the volume of the vessels.

Q.33 Water vapours do not behave ideally at 273 K. Why? **(Lahore 2012, Guj. 2013, Guj. 2014)**

-33 پانی کے بخارات 273 K پر آئیڈیل گیس کی طرح عمل کیوں نہیں کرتے؟

Ans: When water vapours are present at 273 K (0 C°), there are sufficient forces of attractions among its molecules at 0°C (freezing point of water). Due to this reason water vapours behave non-ideally at 273 K.

Q.34 Give two causes for deviation of gases from ideality?

(Lahore Board 2004, F. Abad, Lahore 2009, Guj. 2009, Sarg. 2011, Bahawalpur 2011, Lahore 2012, D.G. Khan 2013)

-34 دو وجوہات بتائیں کہ گیسیں آئیڈیل سلوک سے انحراف کیوں کرتی ہیں؟

Ans: The causes are due to two faulty assumptions (نقص دار مفروضے):

(i) Actual volume of the gas molecules is negligible as compared to the volume of vessel.

(ii) There are no forces of attraction among the molecules of gases.

These two postulates (مفروضے) are correct when the temperature is high or pressure is low.

Q.35 SO_2 is comparatively non-ideal at 273 K but behaves ideally at 327 K. Why?
(Rawalpindi 2007, Multan 2007, Multan 2008, Rwp. 2008, Lahore 2011, Rwp. 2013, Lahore 2013, F. Abad 2014)

-35 SO_2 گیس 273 K پر 327 K کے مقابلہ میں نان آئیڈیل ہے۔ کیوں؟

Ans: SO_2 gas is close to its boiling point at 273 K. So, at 273 K, attractive forces are dominating and make the gas non-ideal. But when the temperature of the gas is 327 K, then forces of attractions are less dominant (کم غالب ہیں) and gas behaves ideally.

Van der Waal's Equation

Q.36 How the behaviour of real gases is given by van der Waal's equation?

-36 وانڈروال کی مساوات کس طرح حقیقی (غیر مثالی یا نان آئیڈیل) گیسوں کے سلوک کو بتاتی ہے؟

Ans: The constant 'a' and 'b' called van der Waal's constants give the quantitative measurements of attractive forces and sizes of the gas molecules ('a' اور 'b' مالیکیولز کے درمیان کشش کی قوت اور ان کے سائز کی مقداریں بتاتے ہیں). These parameters are very important for the real gases (حقیقی گیسیں).

Q.37 Why the pressure correction is done by van der Waal?

-37 وانڈروال گیس کے پریشر میں تبدیلی کیوں لایا؟

Ans: The pressure is exerted due to collisions on the walls of vessel. Attractive forces decrease the intensity of collisions (تصادموں کی شدت). So the observed pressure on the walls is less than the ideal pressure. Lessened pressure (کم شدہ دباؤ) is added in observed pressure to get ideal pressure. **(Rwp-2007, Multan 2009)**

Q.38 Why the volume correction is done by van der Wall?

-38 وانڈروال گیسوں کی جسامت میں تبدیلی کیوں لایا؟

Ans: The molecules of a gas do occupy certain volume, which is not available (میسر ہو) to the gas molecules in the vessel. This is called excluded volume (جو جسامت باہر نکال دی گئی ہو) and should be subtracted from the volume of vessel to get the free volume available to gas moelcules

$$V_{free} = V_{vessl} - b$$

Q.39 Why the excluded volume (b) is more than molar volume (V_m) of the gas?

-39 منفی کی ہوئی جسامت (b) مولر والیم (V_m) سے زیادہ کیوں ہوتی ہے؟

Ans: Excluded volume 'b' is the volume of one mole of the real gas in the highly compressed state (بہت زیادہ دباؤ کی حالت میں). But molar volume (V_m) is that volume when the same gas is liquefied and molecules are touching each other every moment.

So $b = 4\,V_m$

Q.40 Why, some amount of pressure should be added in the measured pressure of the non-ideal gas to get the ideal pressure of gas?

-40 گیس کے آئیڈیل حالت کے پریشر کو حاصل کرنے کے لئے ہم کچھ پریشر پیمائش شدہ پریشر میں جمع کیوں کرتے ہیں؟

Ans: The forces of attractions hinder (روکنا) the molecules to collide the walls of the vessel, with that force which should have been in the absence of attractive forces. It means that certain amount of pressure should be added in the measured pressure to get the ideal pressure.

So $P_i = P + P'$

Q.41 Pressure of NH_3 gas at given conditions (say 20 atm pressure and room temperature) is less when calculated by Van der Wall's equation than that calculated by general gas equation. Why? (Lahore 2012)

-41 NH_3 گیس کو جب 20 atm پر رکھا جائے تو اس کا دباؤ وانڈروال کی مساوات سے کم آئے گا نسبتاً اس کے جو جنرل گیس مساوات سے نکالا جائے گا۔ کیوں؟

Ans: NH_3 is a polar gas and has forces of attractions in its molecules when the pressure is high. It shows non-ideal behaviour at high pressures. The factors 'a' and 'b' become dominant at this pressure and van der Waal's equation gives less pressure than that calculated by general gas equation.

Q.42 What is the physical significance of van der Wall's constants, 'a' and 'b'. (Multan 2013)

-42 وانڈروال کے فیکٹرز 'a' اور 'b' کی طبعی اہمیت کیا ہے؟

Ans. Van der Waal has modified (ترمیم کرنا) general gas equation.

$(P + \frac{a}{V^2})(V - b) = RT$ (van der Waal's equation for one mole of gas)

The factor 'a' is for the attractive forces present among the molecules of the gas. Greater the polarity (پولر بنا) of a gas, greater the attractive forces, greater the 'a' factor.

The factor 'b' is related with the volume of gas molecules which they occupy in the vessel and that volume is not available to the gaseous molecules. This is called excluded volume.

Q.43 Derive the units of 'a' and 'b'. (D.G. Khan 2011, Faisalabad 2013, Sahiwal 2014)

-43 'a' اور 'b' کی اکائیاں اخذ کریں۔

Ans: $p' = \frac{an^2}{V}$, $a = \frac{P'V^2}{n^2}$

$a = \frac{atm \times (dm^3)^2}{(mol)^2} = atm\ dm^6\ mol^{-2}$

b is excluded volumes so its units are $dm^3\ mol^{-1}$.

S.I. units

$a = Nm^4\ mol^{-2}$

$b = m^3\ mol^{-1}$

Q.44 The amount of pressure which is decreased due to the forces of attraction is given by a/V^2 where 'a' is the van der Waal's constant and V is the volume of the vessel. How?

-44 گیس کے غیر مثالی پن کو دور کرنے کے لئے جو پریشر ٹھیک کرنا ہوتا ہے اس کی قیمت $\frac{a}{V^2}$ ہے۔ اس کو صحیح ثابت کریں۔

Ans: The pressure p is proportional to the number of molecules which are hitting on the walls of the vessel/area/sec. The number of molecules/area/sec is proportional (متناسب ہے) to the density (کثافتِ اضافی) of the gas. P' (lessened pressure (دباؤ کم ہو گیا ہے)) depends upon the number of molecules which are attracting each other.

$$P' \propto (\text{density})^2$$

Since, $\text{density} \propto \frac{\text{number of moles of gas}}{\text{volume occupied by the gas}} \propto \frac{n}{V}$

$$(\text{density})^2 \propto \frac{n^2}{V^2}$$

So $$P' \propto \frac{n^2}{V^2} \quad \text{or} \quad P' = a\frac{n^2}{V^2}$$

Plasma State

Q.45 What are characteristics of plasma?

(Sarg 2008, Multan 2008, B.P. 2008, B.pur 2009, Lahore 2011, Multan 2012, M. Pur 2012, F. Abad 2012, D.G. Khan 2013, B. Pur 2014, D.G. Khan 2014, Rwp. 2014, F. Abad 2014, Multan 2014)

-45 پلازمہ کی صفات بتائیں۔

Ans: The motions of particles in the plasma generate electrical currents from within plasma density. In this way the plasma is a unique (اپنی مثال آپ) fascinating (لبھانے والی) and complex state of matter. The plasma is neutral overall.

Q.46 Where is plasma found?

(Sarg 2008, B.P. 2008, B.Pur 2009, Guj. 2009, Mtn. 2009, Multan 2011, F. Abad 2012, B. Pur 2014, D.G. Khan 2014, F. Abad 2014, Multan 2014)

-46 پلازمہ کہاں پایا جاتا ہے؟

Ans: It is the most abundant form of matter in the universe. It is stuff (جس سے وہ بنے ہوں) of stars. Our sun is 1.5 million km ball of plasma. On earth, it occurs in flames, auroras (انوارِ قطبی) and fluorescent (چمکنے والی) tubes.

Q.47 What are application of plasma?

(Rwp. 2008, Sargodha 2008, Lahore 2011, Rwp. 2011, B.Pur 2012, D. G. Khan 2012, Rwp 2012, F. Abad 2012, Guj 2012, B. Pure 2013, Lahore 2013, D.G. Khan 2013, B. Pur 2014, Lahore 2014, D.G. Khan 2014, Guj. 2014, Sahiwal 2014)

-47 پلازمہ کے استعمالات پر روشنی ڈالیں۔

Ans: (i) Glowing plasma inside the bulb (ii) Neon signs (نیو آن کے اشارے جو اشتہارات کے لئے مستعمل ہیں)

(iii) Processing of semi-conductors (ایسے موصل جو بڑے درجہ حرارت پر کام کریں)

(iv) Stertlization of medical products.