Chapter-1: Environmental Chemistry

Question ▶ 1

[Cylinder-1 withstand 200 atm pressure at 27°C and Cylinder-2 withstand 50 atm pressure at 37°C.]

[All Board- 2018]

a. Write dwon the Faraday's first law of electrolysis.. 1
b. "Semimolar solution is a standard solution" — Explain. 2
c. Calculate the amount of CH_4 that can be stored in cylinder- 1 at mentioned temperature and pressure? 3
d. Which cylinder is more suitable for transporting gas? Give rational explanation. 4

Answer to the question no. 1

a The amount of elements deposited or dissolved in an electrode is directly proportional to the amount of electricity passed through it.

b We know that, A standard solution is a solution containing a precisely known concentration of an element. The concentration of semimolar solution is 0.5M, which is known. So semimolar solution is a standard solution. For example, The molecular weight of Na_2CO_3 is 106. So if in 1000 mL solution $\frac{106}{2}$ or 53g is dissolved then the concentration of the solution will be 0.5 M. As we know the Concentration of solution is 0.5 M. So, semimolar solution is a standard solution.

c For cylinder–1

We know that,

$PV = nRT$

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

$\Rightarrow n = \frac{200 \times 110}{0.0821 \times 300}$

$\Rightarrow n = 893.219$ mol

Given,

$P = 200$ atm

[$\because$ withstand 200 atm]

$T = 27°C = (273 + 27)$ k

$= 300$ k

$V = 110$ L

$R = 0.0821$ LatmK^{-1}mol^{-1}

Here,

mole number, $n = 893.219$ mol

molecular weight, $M = 16$

Weight, $w = ?$

The amount of CH_4 in cylinder-1 will be,

$n = \frac{w}{M}$

$\Rightarrow w = n \times M$

$\Rightarrow w = 893.219 \times 16$

$\therefore w = 14291.51$g

d For cylinder-1

mole number,

$n_1 = \frac{P_1V_1}{RT_1}$

$= \frac{200 \times 110}{0.0821 \times 300}$

$= 893.219$ mol

Given,

Highest pressure withstand,

$P_1 = 200$ atm

Temperature, $T_1 = 27°C$

$= (27 + 273)$ k

$= 300$ k

Volume, $V_1 = 110$L

For cylinder–2

mole number,

$n_2 = \frac{P_2V_2}{RT_2}$

$= \frac{50 \times 200}{0.0821 \times 310}$

$= 392.91$ mol

Given,

Highest pressure withstand,

$P_2 = 50$ atm

Temperature, $T_2 = 37°C = 310$k

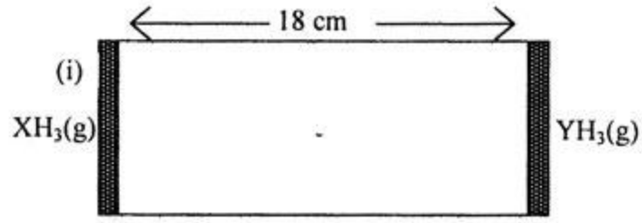
Volume $V_2 = 200$L

$\therefore n_1 > n_2$.

Although cylinder–1 has volume less than cylinder-2 it can contain much amount of gas.

Due to high pressure tolerance of cylinder–1 it is possible to transport more gas through cylinder–1 than cylinder–2.

Question ▶ 2



(ii) XH_3 + monobasic acid → salt

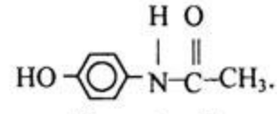
[Atomic number of 'X' and 'Y' are 5 and 7 respectively.]

[All Board- 2018]

a. Write the structural formula of paracetamol. 1
b. Why alcohol is water soluble — Explain. 2
c. Determine the absolute distance where two gas will be Combined? Give mathematical explanation. 3
d. Which concept define acidity and basicity of both compound? Explain. 4

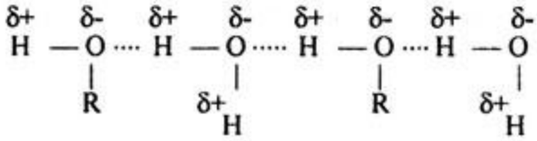
Answer to the question no. 2

a Structural formula of paracetamol:



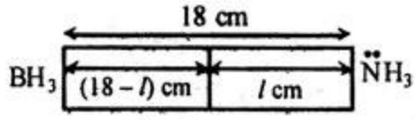
Paracetamol

b Low molecular weight alcohol such as methanol and ethanol are water soluble. Because alcohol molecules contain – OH group. Oxygen of – OH group has high electronegativity, hence attract the O–H bonded electron towards then. As a result polarity developed.



The force formed due to the formation of H-bond is responsible for the molecules of alcohol to get dissolved in water.

c According to stem, Atomic number of X and Y is 5 and 7 respectively. So X is B (Boron) and Y is N (Nitrogen). XH_3 and YH_3 Compounds are BH_3 and NH_3.



We know,

$$\frac{r_{NH_3}}{r_{BH_3}} = \sqrt{\frac{M_{BH_3}}{M_{NH_3}}}$$

$$\frac{\frac{lA}{t}}{\frac{(18-l)A}{t}} = \sqrt{\frac{13.8}{17}}$$

$$\Rightarrow \frac{l}{18-l} = 0.9$$

$$\Rightarrow l = 16.2 - 0.9\,l$$

$$\Rightarrow l(1+0.9) = 16.2$$

$$\Rightarrow l = \frac{16.2}{1.9} = 8.53 \text{ cm}$$

Here,

Molecular weight

$M_{NH_3} = 17, \quad M_{BH_3} = 13.8$

Let, both gas will meet at l distance from NH_3.

Diffusion rate,

$$r_{NH_3} = \frac{\text{volume of diffused gas}}{\text{time}}$$

$$= \frac{lA}{t}, \text{ A = Area}$$

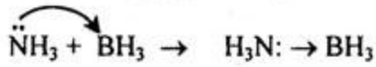
$\therefore$ Gas will meet at $(18 - l)$ distance from BH_3.

So, $r_{BH_3} = \frac{(18-l)A}{t}$

$\therefore$ From NH_3 end the gas will meet at 8.53cm distance.

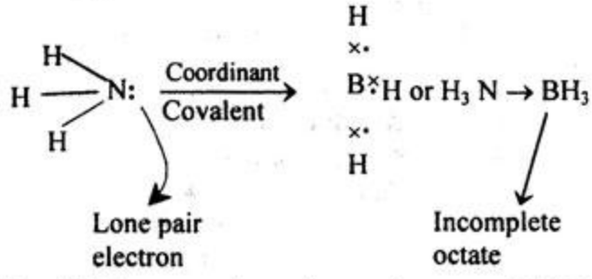
d In the stem, X and Y is B (Boron) and N (Nitrogen). So the Compounds are BH_3 and NH_3.

The Compounds Combine by following reaction.



In this case, $\ddot{N}H_3$ donates to a lone pair of electron to BH_3.

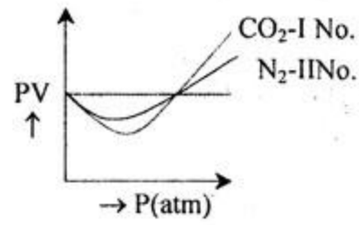
Because in BH_3 Compound Boron has incomplete octate. So it can accept electron.



Here NH_3 has capacity to donate electron and BH_3 has capacity to accept electron.According to lewis theory of acid base, compounds that can donate a lone pair of electrons are base. So, NH_3 is a base. And the compounds that can accept a lone pair of electrons are acid. So, BH_3 is an acid.

Therefore, Lewis theory can explain the acidic and basic property of XH_3 and YH_3.

Question ▶ 3



[D.B.-17]

a. What is Nitrogen Fixation? 1

b. Why $AlCl_3$ is Lewis acid? 2

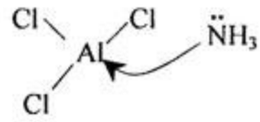
c. Why the graphs of both gas are curve rather horizontal? 3

d. Explain the impact of gas I in creating green house effect. 4

Answer to the question no. 3

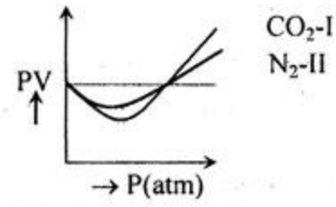
a The process by which free atmospheric nitrogen is converted to useful nitrogenous compound is known as Nitrogen Fixation.

b $AlCl_3$ is a Lewis acid. Because it can accept lone pair electron. From the structure of $AlCl_3$ it is clear that it has incomplete octate, of means it has deficiency of one pair electron. For that reason $AlCl_3$ accept lone pair electron to fill octate. So it is acidic.



Graph: Amagat's Curve

c In the stem, the gas I and II are CO_2 and N_2 respectively, which are real gas. The graphs for both gases are curve rather horizontal. It can be explained from Amaga's curve.



Graph : Amagat's curve

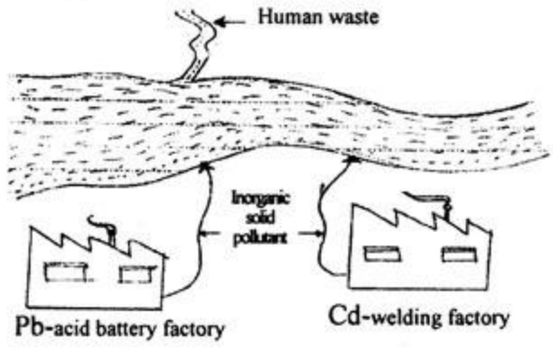
From the analysis of Amagat's Curve it is clear that the product of PV is constant with the change of pressure. As a result the graph of PV vs P is a parallel with X axis. But in real gas with the increase of pressure the value of PV changes. As CO_2 and N_2 are real gases hence with the increase of pressure the value of PV decreases first but after a while the value increases. At a point the value of PV became larger than RT. So the graphs turned into curves. For these gases with the increase of pressure the intermolecular attraction increases and volume decreases. At that point intermolecular attraction force gets priority. If pressure increased again the repulsion force between molecules activated. If repulsion force gets priority over attraction force then PV/RT > 1. So, isothermal graph become curve.

d In the stem, the gas I is CO_2. The atmospheric gases which cover the earth to prevent the radiated heat to pass out the outer space and make the earth surface and atmosphere warm are known as green house gases. These gases are– CO_2, CH_4, O_3, CFC, N_2O and water vapor etc. Among these CO_2 is the prime green house gas. Because this green house gas exist in

environment at a highest ratio (50%). Due to high population, urbanization and industrialization, the amount of CO_2 in environment is increasing day by day.

At present concentration of CO_2 in atmosphere is 390 ppm. After industrial revolution the concentration of CO_2 in environment has increased by 25%. Now CO_2 Concentration is increasing 1ppm/Year. That means every Year 9×10^9 ton CO_2 are being introduced into the environment. As a result the mean temperature of earth is increasing by 0.4% and due to green house effect it is becoming deleterious. CO_2 plays a vital role in preventing the radiated heat from the earth is surface to get get back to the outer space. Due to uncontrolled increase of CO_2 the earth getting warm day by day. Thus the effect of green house is increasing too.

Question ▶ 4



[D.B.-17]

a. What is acid rain? 01
b. Why r.m.s velocity is more suitable for determination of kinetic energy than mean velocity? 2
c. How can you determine the value of BOD of H_2O of the above stem? 3
d. How the inorganic pollutant of the stem affect the food chain? Explain. 4

Answer to the question no. 4

a The rain water in which pH is below 5.6 is known as acid rain.

b The kinetic energy obtained by r.m.s velocity is equal to the summation of kinetic energy of every individual molecules. But the kinetic energy obtained by using mean velocity is less than actual kinetic energy. For this reason, it is suitbale to use r.m.s velocity in determination of kinetic energy.

c To determine the BOD of water, at first water is saturated with oxygen at 20°C. The bacteria present in water oxidizets the organic compound within 5 days.

i. At first sample water is collected.
ii. 50 mL distilled water is taken in a bottle and (a) 1mL phosphate buffer (pH7.2) (b) 1 mL $MgSO_4$ solution ($22.gl^{-1}$), (c) 1mL $CaCl_2$ solution ($27.5gL^{-1}$) is added to it.
iii. Dilute the sample water and pass air so that the value of DO become 7 ppm. It is known as incubation. If the Value of BOD is higher than the DO then the water will be diluted by addition of diluting water. DO is determined by using half of the sample. The determined DO is D_1.
iv. The remaining half of the sample is stored in a tightly sealed bottle at 20°C for 5 days. After 5 days the DO is determined. Now the determined DO is D_2.
v. Diluted water is taken and value of DO is determined. Here the value of first DO is B_1 and after 5 days the DO is B_2.
vi. Then BOD of the sample can be determined by using following formula.

$$BOD = \frac{(D_1 - D_2) - (B_1 - B_2) \times f}{p} mgL^{-1}$$

Here, P → fraction of sample used.

F → ratio of regulated water with sample water.

d In the stem, the inorganic solid pollutants are Pb and Cd.

Association of Pb in food chain:

The Pb production and purification industry, alloy industry and battery industry contains a large amount of Pb. Moreover Pb is also used in gun industryies fossil fuel and canned food. Lead easily react with water and produces soluble $Pb(OH)_2$. So the surrounding soil and water of lead using industry polluted by Pb. Plants take some Pb containing compound along with other minerals through root. This causes association of Pb in life cycle of plant of that area and subsequently which enters into human body through food. Lead poisoning causes nausea, constipation, anaemia, insomnia, headache, anorexia etc. Due to lead poisoning enzymatic activity decreases which causes problem in metabolism. Pb prevents the synthesis of hemoglubin causes cell damage of kidney and brain. It causes decrease of IQ of children.

Association of Cd in food chain:

Purification of metal (Zn, Cu, Pb etc.), electroplating, iron, steel & plastic industry, and Ni-Cd battery industry causes Cd pollution of water. The surrounding soil and water of those industries are polluted by Cd. There is a possibility of Cd posioning if one takes food and fish from these regions. This causes hypertension and lung problems. Moreover tobaco absorbs Cd from soil that stored in soils which enter into human body through smoking. In human body Cd usually stored in kidney as a result regular activity kidney of damage. Cd replaces bone vital. component Ca^{2+} which causes weak and fragile bone and causes severe pain into the joint. Cd also replaces Zn from the enzyme. So, enzyme cannot do it's regular activity properly.

Question ▶ 5 The pressure and volume of a gas at O°C is given below:

Pressure (atm)	0.25	0.50	0.75
Volume (L)	2.80	1.40	0.93

[D.B.-16]

a. What is TDS? 1
b. Why pressure of real gas is less than ideal gas? 2
c. Find out the mole number of stated gas. 3
d. Will the stated gas follow Boyle's law? Give rational explanation. 4

Answer to the question no. 5

a The total amount of dissolved solid substance in water is known as Total Dissolved solid or TDS.

b According to fundamental theory of kinetics we know that, the gaseous molecules are in a continuous random movement. The molecules undergo in collisions with other molecules and with the wall of the container. This collision that exert pressure. It is thought the there is no attraction and repulsion forces between ideal gas molecules. But in case of real gas there is attraction and repulsion force. For this reason the molecules of ideal gas create higher number of collisions than real gas. So real gas exerts less pressure than ideal gas.

■ We know,

$PV = nRT$

$PV = \frac{N}{N_A} RT$

$N = \frac{PV}{RT} \times N_A$

$= \frac{0.25 \times 2.8 \times 6.023 \times 10^{23}}{0.0821 \times 273}$

$= 1.88 \times 10^{22}$

Here,
Pressure, P = 0.25 atm
Volume, V = 2.8 L
Temperature,
T = (0 + 273)K
= 273 K
$N_A = 6.02 \times 10^{23}$
Molar gas constant,
$R = 0.0821$ L atm mol^{-1} K^{-1}

∴ Number of molecules of stated gas is 1.88×10^{22}.

■ According to Boyle's law, We know, at a constant temperature the volume of a given mass of a gas is inversely proportional with the pressure.

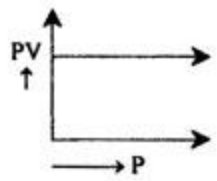
So, $V \propto \frac{1}{P}$ [when T constant]

$\Rightarrow PV = K$ ..... (i)

Now, if $P_1V_1 = K_1$, $P_2V_2 = K_2$, ... $P_nV_n = K_n$ then according to Boyle's law –

$P_1V_1 = P_2V_2 = ... = P_nV_n$

∴ The product of pressure and temperature is constant. The value of PV will not be changed with the change of pressure and volume.



Stated stem shows the Change of volume with pressure,

$K_1 = P_1V_1$
$= 0.25 \times 2.8$
$= 0.7$
$K_2 = P_2V_2$
$= 0.5 \times 1.4$
$= 0.7$
$K_3 = P_3V_3$
$= 0.75 \times 0.93$
$= 0.6975$
$= 0.7$

Here,
Pressure, $P_1 = 0.25$ atm
Volume, $V_1 = 2.80$ L
Pressure, $P_2 = 0.5$ atm
Volume, $V_2 = 1.4$ L
Pressure, $P_3 = 0.75$ atm
Volume, $V_3 = 0.93$ L

According to stem information, $K_1 = K_2 = K_3$
So, the product of PV will be constant even after the pressure and volume is changed at 0°C temperature.
∴ Above statement will follow Boyl'es law.

Question ▶ 6

1st experiment:

Name of the gas	Volume (L)	Pressure (atm)	Temperature
a	5.00	.6	25°C
b	3.75	.8	25°C

2nd experiment:

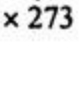
Name of the gas	Voluem (L)	Temperature
X	.5	27°C
Y	.7	25°C

[R.B.-17]

a. What is fuel cell? 1
b. Why phenol is aromatic compound? Explain. 2
c. Find out the number of molecules present in a gas. 3
d. Is it possible to convert behavior of gas of 2nd experiment same as 1st? Explain. 4

Answer to the question no. 6

a A fuel cell is an electrochemical cell that convert chemical energy of hydrogen or hydrogen containing fuel into electrical energy.

b We know, the compounds have (4n + 2) number of delocalized electron according to Huckel theory are known as aromatic compound, where n defines the number of ring. For  the value of n is 1. So according to Huckel rule number of delocalized π electrons = (4 × 1 + 2) = 6.

So phenol is an aromatic compound.

c We know,

$PV = nRT$

$\Rightarrow PV = \frac{N}{N_A} RT$

$\Rightarrow N = \frac{PVN_A}{RT}$

$= \frac{6 \times 5 \times 6.023 \times 10^{23}}{0.0821 \times 298}$

$= 7.385 \times 10^{23}$

∴ So number of a gas is 7.385×10^{23}.

Here, for a gas
volume, V = 5L
Pressure, P = 6 atm
Temperature, T
= (25 + 273)
= 298K
No of molecules, N =?
$N_A = 6.02 \times 10^{23}$
Molar gas constant
$R = 0.0821$ L atm mol^{-1} K^{-1}

d For 2nd experiment, the provided informations are incomplete. So 1 atm pressure is considered for 2nd experiment.
We know, for 1 mole gas,

We know,
for 1 mole a gas,

$Z_a = \frac{P_aV_a}{RT_a}$

$= \frac{6 \times 5}{0.0821 \times 298}$

$Za = 1.2276$

Again.
for 1 mole b gas

$Z_b = \frac{P_bV_b}{RT_b}$

$= \frac{8 \times 3.75}{0.0821 \times 298}$

$= 1.2276$

Here
For 1st experiment,
Volume of a gas, $V_a = 5$L
Pressure $P_a = 6$ atm
Temperature $T_a = 25°C$
$= 298K$
Volume of b gas, $V_b = 3.75$L
Pressure of b: $P_b = 8$atm
Temperature of b,
$T_b = 25°C = 298$ K
Molar gas constant,
$R = 0.0821$L atm mol^{-1} K^{-1}

In first experiment for a and b gas the value of Compressibility constant is $\left(\frac{PV}{RT}\right) > 1$.

So the intermolecular repulsion force will be more prevalent than attraction force. So the value of Z will be greater than 1.

Again,
We know for 1 mole X gas,

$Z_X = \frac{P_XV_X}{RT_X}$

$= \frac{5 \times 1}{0.0821 \times 300}$

$= 0.2032$

For 1 mole Y gas

$Z_Y = \frac{P_YV_Y}{RT_Y}$

$= \frac{7 \times 1}{0.0821 \times 298}$

$= 0.2864$

Here, for 2nd experiment,
Volume of X gas, $V_x = 5$L
Volume of Y " $V_Y = 7$L
Pressure of X gas, $P_x = 1$ atm
Pressure of Y gas, $P_y = 1$ atm
Temperature of X gas,
$T_x = (27 + 273)K = 300K$
Temperature of Y gas.
$T_Y = (25 + 273) = 298K$.

During 2nd experiment the value of compressibility constant is less than 1. In that case, if we increase the value of P, then at a certain time the value of Z will be greater than 1. By changing pressure it is possible to change the behavior of 2nd gas same as 1st gas.

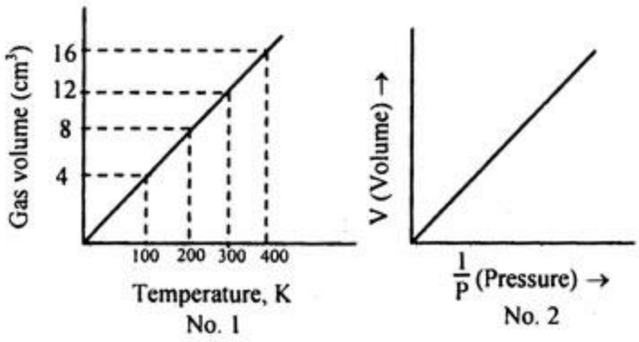
Now, let the pressure of X gas is 5 atm and Y gas in 5 atm.

Then, $Z_X = \frac{P_X V_X}{RT_X} = \frac{5 \times 5}{0.0821 \times 300} = 1.016$

And, $Z_Y = \frac{P_Y V_Y}{RT_Y} = \frac{5 \times 7}{0.0821 \times 298} = 1.43$

From the above explanation, we can conclude that, by increasing the pressure it is possible to convert the behavior gases of 2nd experiment same as the gases of 1st experiment.

Question ▶ 7



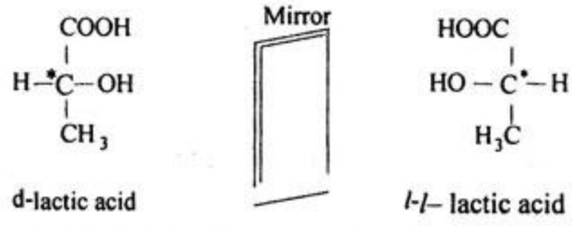
[R.B.-17]

a. What is functional group?
b. "Lactic acid is an optically active isomer." – Explain.
c. Which gaseous law supports graph 1? Prove.
d. How graph-2 supporting law affects in providing gas safety of gas cylinder? Explain.

Answer to the question no. 7

a The atom or group of atoms present in organic compound that determine the chemical and physical properties (mainly chemical reaction) are known as functional group.

b Lactic acid [$CH_3CH(OH)COOH$] is an optically active compound. It has two optically active isomers. One is d-Lactic acid and another is *l*-Lactic acid. The mirror images of the isomers are as following.



d-lactic acid *l-l*– lactic acid

Diagram: Two mirror image configuration of lactic acid

From the configuration of lactic acid it is clear that, Lactic acid has chiral centre and it's mirror image is not super imposable on it.

c From the graph it is observed that, the variable of X axis is temperature and variable of Y axis is volume. With the increase of temperature, volume increases periodically and a straight line is obtained.

According to Charle's law, we know at a constant pressure the volume of a given mass is directly proportional with the temperature.

So,

$V \propto T$

$\Rightarrow \frac{V}{T} = K$

$\therefore \frac{V_1}{T_1} = K_1, \frac{V_2}{T_2} = K_2, \frac{V_3}{T_3} = K_3, \frac{V_n}{T_n} = K_n$

According to Charle's law,

$\frac{V_1}{T_1} = \frac{V_2}{T_2} \ldots\ldots\ldots\ldots\ldots\ldots = \frac{V_n}{T_n}$

$\therefore$ The ratio of volume and temperature is constant.

From the stem,

$K_1 = \frac{V_1}{T_1} = \frac{4}{100} = 0.04$

$K_2 = \frac{V_2}{T_2} = \frac{8}{200} = 0.04$

$K_3 = \frac{V_3}{T_3} = \frac{12}{300} = 0.04$

$K_4 = \frac{V_4}{T_4} = \frac{16}{400} = 0.04$

Volume, $V_1 = 4\ cm^3$
Volume, $V_2 = 8\ cm^3$
Volume, $V_3 = 12\ cm^3$
Volume, $V_4 = 16\ cm^3$
Temperature, $T_1 = 100$ K
Temperature, $T_2 = 200$ K
Temperature, $T_3 = 300$ K
Temperature, $T_4 = 400$ K

$\therefore K_1 = K_2 = K_3 = K_4$ that means with the change of temperature and volume, the ratio of volume and temperature is constant.

d Boyle's law supports the graph-2. According to Boyle's law, at constant temperature the volume of a given mass is inversely proportional with the pressure.

So, $V \propto \frac{1}{P}$ [T Constant]

$\Rightarrow V = \frac{K}{P}$

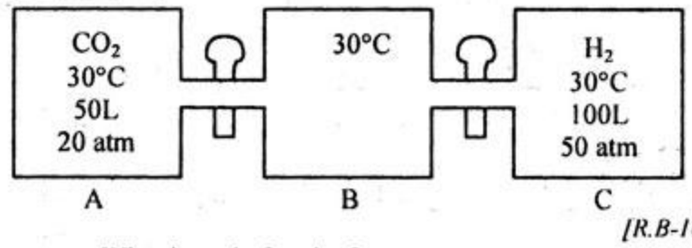
$\Rightarrow PV = K$ (Constant).

According to Boyle's law with increase of high pressure volume of gas decreases. The principal of gas cylinder is to store gas at high pressure volume. But mole number and temperature become constant. For example, During Compression of natural gas volume is converted to $\frac{1}{100}$ times at standard temperature and pressure.

For safety of cylinder the product of pressure and volume should be constant. But natural gas and other hydrocarbons are not ideal gas. For these gases Boyle's law is applicable only at high temperature and low pressure. But at low temperature and high temperature, the product of P and V is not constant.

So, For safety of gas cylinder it is important to apply Boyle's law. Means pressure should be applied so that PV = constant. Appropriate pressure should be applied at below critical temperature. If the temperature is much less than critical temperature low pressure will need. As critical temperature of CO_2 and CH_4 is higher than room temperature, so both gases can be liquified earily.

Question ▶ 8



[R.B-16]

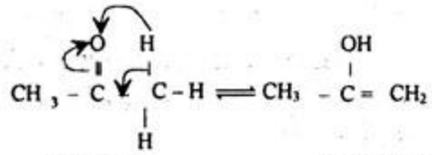
a. What is mole fraction? 1
b. "C_3H_6O shows tautomerism." Explain. 2
c. Find out the number of molecules of C container. 3
d. If stop cork is opened then which gas in the cylinder B will dominate regarding total pressure in the cylinder? Explain mathematically. 4

Answer to the question no. 8

a Mole fraction is the ratio of mole number of elements and total mole number of the mixture.

b If a dynamic equilibrium is produced between isomer of same molecular weight then the process is known as tautomerism. The isomers are known as tautomer.

C_3H_6O is acetone. Although acetone usually write as ketone but one proton from $-CH_3$ group is shifted to the carbonyl oxygen and forms carbon-carbon (C = C) double bond. It is a dynamic process.



Propanone Propenol–2

c Similar to the question no-5(c).

d Let, A and C gas is mixed in B container and pressure of mixture is P.

We know,

$$n_A = \frac{P_A V_A}{RT_A} = \frac{20 \times 50}{0.0821 \times 303} = 40.2 \text{ mol}$$

For A gas,
Pressure, $P_A = 20$ atm
Temperature, $T_A = 30°C = 303K$
Volume, $V_A = 50L$
Mole no. $N_A = ?$

Similarly,
We Know,

$$n_C = \frac{P_c V_c}{RT_c} = \frac{50 \times 100}{0.0821 \times 303} = 200.99 \text{ mol}$$

For C gas.
$P_c = 50$ atm
$T_c = 30°C = 303K$
$V_c = 100$ L

The partial pressure of gas is directly proportional with mole fraction of gas.

For A gas,

$P_A = X_A XP$

$$\Rightarrow \frac{P_A}{P} = x_A = \frac{n_A}{n_{total}} = \frac{40.2}{40.2+200.99} \times 100\% = 16.667\%$$

Similarly,

$$\frac{P_C}{P} = \frac{n_C}{n_A + n_C} = \frac{200.99}{40.2 + 200.99} \times 100\% = 83.333\%$$

So C gas will contribute 83.33%

and A gas will contribute 16.67% of the total pressure.

∴ C gas will dominate.

Question ▶ 9

24.63 atm 1200 K 1L 0.25 mol	50 atm 300 K 0.35L 0.1 mol
A gas	B gas

[Dj.B.-17]

a. What is pollutant? 1
b. Why melting point of nanoparticle less than normal compound? 2
c. Find out the mean kinetic energy of one molecules of A gas. 3
d. Which one of the above gas will show real gas behavior? Explain mathematically. 4

Answer to the question no. 9

a If the amount of certain substances are higher than normal range which causes detrimental effect on living system then the substances are known as pollutant.

b The melting point of nano particle are less than normal compound. Because the size of nanoparticles are extremely small and it has a very large surface area compare to normal compound. So phase change occurs at low temperature. For example, the melting point of nano gold particles (2.5 nm diameter) is V 300°C where the melting point of normal gold is 1016°C. Nanoparticles do not follow Newton's conventional law but they follow theory of Quantum mechanics.

c We know,

kinetic energy of one molecule of gas is,

$$E_k = \frac{3RT}{2N_A} = \frac{3 \times 8.314 \times 1200}{2 \times 6.023 \times 10^{23}} = 2.485 \times 10^{-20} J$$

Here,
For A gas
Temperature, T = 1200K
Molar gas
Constant,
$R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$
$N_A = 6.02 \times 10^{23}$
Kinetic energy of one molecule,
$E_k = ?$

∴ Kinetic energy of one molecule of gas is 2.485×10^{-20}J.

d From the given information in the stem it is possible to determine the value of compressibility constant Z to evaluate which one acts as real gas. Because compressibility constant expresses the ratio of actual volume of real gas and volume of ideal gas. If Z >1 then the gas is less compressable than ideal gas and if Z<1 then the gas is more compressable than ideal gas. If the value of Z is close to 1 then the gas acts like an ideal gas.

The value of Z denotes the extent of deviation of real gas.

We know,
For A gas

$$Z = \frac{PV}{nRT} = \frac{24.63 \times 1}{0.25 \times 0.0821 \times 1200} = 1$$

Here,
Pressure, P = 24.63 atm
Temperature, T = 1200 K
Volume, V = 1L
Molar gas constant,
$R = 0.0821 \text{ L atm K}^{-1}\text{mol}^{-1}$
Mole number, n = 0.25 mol
Compressibility constant,
Z = ?

As the value of Z is 1, it will act as ideal gas.

We know, for B gas,

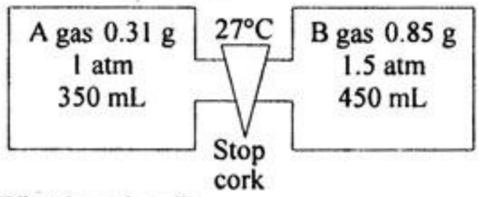
$$Z = \frac{PV}{nRT} = \frac{50 \times 0.35}{1 \times 0.0821 \times 300} = 0.711$$

As the value of Z is less than 1.
So it will act as a real gas.

Here,
Pressure, P = 50 atm
Temperature, T = 300 K
Volume, V = 0.35 L
mole number, n = 1 mol
Molar gas constant,
$R = 0.0821 \text{ Latm mol}^{-}\text{K}^{-1}$
Compressibility constant,
Z =?

∴ Among A and B gas, B gas will act as real gas.

Question ▶ 10



[Dj.B.-16]

a. What is real gas? 1

b. "C_3H_8O shown functional group isomerism." Explain. 2

c. Calculate the no. of molecules present in A gas when stop cork is closed. 3

d. Which gas among A and B has highest diffusion rate. Explain mathematically. 4

Answer to the question no. 10

a The gas which does not follow PV = nRT equation at any temperature and pressure is known as real gas. It follows PV = nRT equation only at high temperature and low pressure.

b Functional group isomerism occurs between two compounds with identical molecular formula different functional group.

For C_3H_8O it is possible to make two functional group isomer.

The isomers are.

1. $CH_3 - CH_2 - O - CH_3$ (Ether) (Functional group –O–)

2. $CH_3CH_2CH_2OH$ (Alcohol) Functional group (– OH)

c We know,

$PV = nRT$

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

$n = \frac{1 \times 350 \times 10^{-3}}{0.0821 \times 300}$

$= 0.0142$ mol

Here
Pressure, P = 1 atm
Volume, V = 350 mL = 350×10^{-3} L
Temperature, T = (27 + 273) = 300 K
Mole number, n = ?

1 mol gas contains 6.023×10^{23} molecules

$\therefore$ 0.0142 mol $= (6.023 \times 10^{23} \times 0.0142)$

$= 8.55 \times 10^{21}$ molecules.

So there are 8.55×10^{21} molecules in A gas when Stop Cork is closed.

d Among A and B the gas which has low molecular weight will have high diffusion.

If molecular weight of A gas is M_1,

$PV = \frac{w}{M_1} RT$

$M_1 = \frac{wRT}{PV}$

$= \frac{0.31 \times 0.0821 \times 300}{1 \times 350 \times 10^{-3}}$

$= 21.85$ g

Here,
For A Gas.
Weight, w = 0.31 g
Temperature, T = 300 K
Pressure, P = 1 atm
Volume V = 350×10^{-3} L
Molar gas constant,
R = 0.0821 L atm $K^{-1}mol^{-1}$

If molecular weight of B gas is M_2

$PV = \frac{w}{M_2} RT$

$\Rightarrow M_2 = \frac{wRT}{PV}$

$= \frac{0.85 \times 0.0821 \times 300}{450 \times 10^{-3} \times 1.5}$

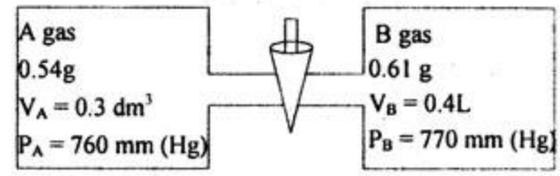
$= 31.016$ g

Here, For B gas
Weight, w = 0.85 g
Molar gas
Constant, R = 0.0821 Latm $mol^{-1}K^{-1}$
Temperature, T = 300 K
Pressure, P = 1.5 atm
Volume, V = 450×10^{-3} L

As $M_2 > M_1$,

So, Diffusion rate of A gas will be higher.

Question ▶ 11



[A and B gas mutually unreactive] *[C.B.-17]*

a. What is Lucas reagent?

b. How cromium pollutes environment?

c. Calculate the total pressure of the mixture at 30°C when key is opened.

d. Compare the diffusion rate of A and B gas at 25°C.

Answer to the question no. 11

a Lucas reagent is the mixture of concentrated hydrochloric acid and anhydrous $ZnCl_2$.

b Cromium is widely used in stainless steel and alloy. In photography cromium-trioxide is used to prevent corrosion. Cromium sulphate is being used in tanning industry and painting. The cromium waste disposed from these industry are thrown in surrounding river water. So water gets polluted. Again during rainy season cromium mixed with rain water and spread everywhere. Which causes soil pollution. Cromium is a non biodegradable heavy metal, so it easily associates with the food chain.

c Let, total pressure of mixture = P and partial pressure of A gas is P_2

We know,

$P_AV_A = P_2V$

$\Rightarrow P_2 = \frac{P_AV_A}{V}$

$= \frac{1 \times 0.3}{0.7}$

$= 0.43$ atm

Here,
For A gas.
Volume, $V_A = 0.3$ dm³
Pressure,
$P_A = 760$ mm (Hg)
$= \frac{760}{760}$ atm
$= 1$ atm
Total volume of mixture,
$V = V_A + V_B$
$= 0.3 + 0.4$
$= 0.7$ L

Again, let Partial pressure of B gas is P_B

So, We know,

$P_BV_B = P_3V$

$\Rightarrow P_3 = \frac{P_BV_B}{V}$

$= \frac{1.01316 \times 0.4}{0.7}$

$= 0.57894$ atm

Here,
For B gas
Volume, $V_B = 0.4$ dm³
Pressure, $P_B = 770$ mm(Hg)
$= \frac{770}{760}$ atm
$= 1.01316$ atm

$\therefore$ Total pressure, $P = P_2 + P_3$

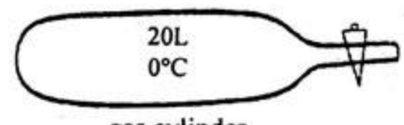
$= (0.43 + 0.58)$ atm

$= 1.01$ atm

$\therefore$ The total pressure at 30°C of gas mixture is 1.01 atm when the key is opened.

d Similar as creative question 10 (D).

Question ▶ 12



gas cylinder

[C. B. 2017]

a. What is Beer-Lambert law? 1
b. Why Cu does not react with diluted H_2SO_4? 2
c. Will the cylinder burst if temperature gradually increase to 25°C? Explain. 3
d. Gaseous law should apply to store 15kg gas to the cylinder. Explain. 4

Answer to the question no. 12

a The decreasing rate of the intensity of incident light is directly proportional to the concentration and thickness of cell solution.

b Dilute H_2SO_4 does not react with Cu. From the activity series of metal we see position of H_2 is upper than Cu. So, H_2 is more reactive than Cu. As Cu is less reactive so Cu can not replace H_2 from the H_2SO_4. For this reason Cu does not react with dilute H_2SO_4.

c The cylinder in the stem can withstand 20L gas at 0°C temperature.

We know, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

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

$= \frac{20 \times 298}{273}$

$= 21.832$ L

Here,
Initial temperature,
$T_1 = 0°C = (0 + 273)$ K $= 273$K
Initial volume, $V_1 = 20$ L
Final temperature,
$T_2 = 25°C = (25 + 273) = 298$K
Final volume, $V_2 = ?$

As calculated volume of gas at 25°C is 21.832L which is more than cylinder Capacity (20L). So the cylinder will burst.

d Gaseous laws such as Boyle's and Charles laws are used to liquify gas. The Principle of cylinder filling is to increase inter-molecular attraction between gaseous molecule. According to theory of kinetics, kinetic energy of gas molecules decreases if temperature decreases. At very low temperature the kinetic energy of gas molecules extremely decrease and molecules come close to each other. This causes increase of inter-molecular force and gas converted to liquid. Sufficient pressure is applied to compress gas to fill cylinder. According to Boyle's law increase of pressure causes decrease of volume. The main target of cylinder filling is to fill large amount of gas in a small volume. High pressure reduces volume but temperature and pressure become constant. During compression of natural gas the volume compressed to $\frac{1}{100}$ th of its initial volume. Cylinder preserves it at 200–248 atmospheic pressure.

But some gas does not liquify at high pressure. It should decrease temperature to liquify. According to theory of kinetics low temperature causes reduction of kinetic energy and volume of gas (Charles law). At very low temperature the molecules come close enough to liquify. From the above explanation, we can say gaseous laws are vital for cylinder filling.

Question ▶ 13

Volume (V) cm^3	Pressure (P) atm
10	2.1
7	3
5.25	4

Table: 1

Volume (V) L	Temperature (T) K
22.40	273
24.45	298
25.10	303

Table: 2

a. What is acid rain? 1
b. Why molarity depends on temperature? Explain. 2
c. Establish an idea of absolute temperature from the table–2 in the stem. 3
d. Is there any application of stem's table to fill gas cylinder? Explain. 4

Answer to the question no.13

a The rain water in which pH is below 5.6 is known as acid rain.

b At constant temperature, the no. of mole of solute present in 1L solution is known as molarity. The molarity of a solution depends on the volume of solution and mole number of solutes. As with the change of temperature the volume of solution changes. So, molarity will change with temperature. Hence, molarity or molar solution depends on temperature.

c At constant pressure the volume of a given mass of gas increases or decreases by $\frac{1}{273}$ part of its initial volume, for each degree celsius rise or fall in temperature.

According to law,

$V_t = V_0\left(1 + \frac{t}{273}\right)$

Volume of gas at 1°C $V_1 = V_0\left(1 + \frac{1}{273}\right)$

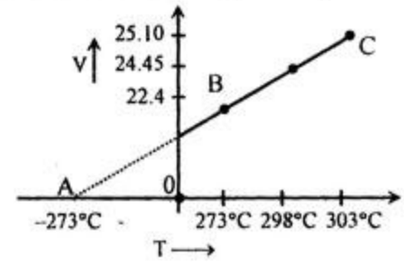
" " " " –273°C, $V_{-273} = V_0\left(1 + \frac{-273}{273}\right) = 0$

∴ The volume of gas is theoritically zero at – 273°C. It is known as absolute zero temperature.

From the table-2 it is clear that, volume of gas is directly proportional with temperature,

So, $V \propto T$

The value of volume and temperature from the table 2 are placed in Y axis and X- axis respectively to draw graph.



If the BC line extend backward it intercept X axis at A point. From the graph it is clear that at – 273°C volume becomes zero. So, –273°C temperature is absolute zero temperature.

d It is essential to liquify gas during cylinder filling. The intermolecular force of gaseous molecule can be increased by applying principle of gaseous law. In the stem, table-1 defines Boyle's law where table-2 defines Charles law.

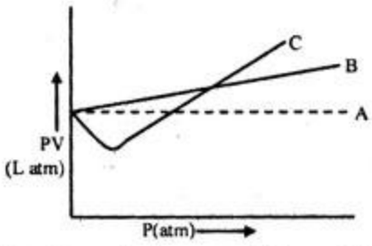
In table–1, pressure of the gas increases at constant temperature. If pressure is increased, according to Boyle's law $\left(V \propto \frac{1}{P}\right)$ W volume will be decrease. Thus, the molecules of gas come closer to each other. This inter molecular forces causes liquification of gas.

In table–2, temperature decreases at constant pressure. Sometimes it needs to decrease temperature to liquify gas because many gas do not liquify at room temperature. If

temperature decreases, kinetic energy of gas decreases which leads to increase intermolecular forces. This causes liquification of gas.

So, from the above explanation we can say, table in the stem are applicable during cylinder gas filling.

Question ▶ 14



C Gas is produced by thermal decomposition of $KClO_3$:

[Ctg.B.-17]

a. What is peptide bond? 1
b. "Alkyne–1 is acidic" explain. 2
c. Calculate the r.m.s velocity of C gas at S.T.P. 3
d. Why the graph of B and C gas is not identical to A graph? Explain. 4

Answer to the question no. 14

a The carboxyl group of one amino acid and amino group of another amino acid gets condensed with the elimination of water to form amide bond (– CONH–). This bond is known as peptide bond.

b Alkyne-1 (RC = CH) is acidic. Because carbon atom of alkyne–1 is sp hybridized. In sp hybridization the ratio of s and p is 1:1. As ratio of small s orbital is higher in sp hybridization, the bond electron of C–H shifted to Carbon nucleus. As a result the bond of hydrogen become weak. For this reason alkyne–1 can easily donate proton by breaking C–H bond. So alkyne–1 is acidic.

c C gas in the stem produced by thermal decemposition of potassium chlorate. So C gas is O_2.

$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

We know that,
r.m.s. Velocity,

$$C = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3 \times 8.314 \times 273}{32 \times 10^{-3}}}$$

$$= 461.29 \text{ ms}^{-1}$$

Here,
Molecular weight,
$M = 32 \text{g/mol}^{-1}$
$= 32 \times 10^{-3} \text{kg/mol}$
Temperature,
$T = 273K$
Molar gas constant,
$R = 8.314 JK^{-1}mol^{-1}$

∴ r.m.s. velocity of O_2 is $461.29 ms^{-1}$

d C gas in the stem is Oxygen. A gas in the stem is an ideal gas. So it follows Boyle's law (PV = K). So at constant temperature and different pressure for 1 mole gas the value of $\frac{PV}{RT} = 1$.

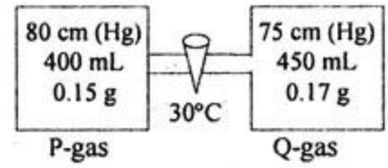
So the graph is parallel to X-axis. But B and C gas are real gas.

The reasons why the graph of B and C gas is not similar as A gas is given below.

i. For oxygen gas (C) with the increase of pressure the value of PV increase initially, and reach in a lowest value. After that, if pressure increased further, the value of PV overcome the value of RT. There is a concave part for such types of graph. For these gas, with increase of pressure inter molecular attraction increases and volume decreases. If pressure increased any further intermolecular repulsion become active between molecules. When repulsion force is more than attraction force the value of PV increases.

ii. For B gas (H_2/He) with the increase of pressure the value of PV increases. There is no concave part in the graph for these gases. Repulsion force prevalent for these gases is all the time.

Question ▶ 15



[Ctg. B. 2017]

a. What is racemic mixture? 1
b. Why CH_3COOH is weak acid than HCOOH? 2
c. Calculate the molecular weight of P gas. 3
d. If the total pressure of gas mixture is 102 kPa, find out whether the gases are ideal or not. Explain. 4

Answer to the question no. 15

a Racemic mixture is the equimolar mixture of two enantiomers.

b In HCOOH there H atom is atached to Carboxyl group and in CH_3COOH methyl group is attached to carboxyl group. Due to presence of electron donating – CH_3 group positive charge of carbon decreases. So ionisation of –OH also decreases.

From the Value of acid dissociation constant the acidity of both compounds can be Compared. As the Value of Ka for CH_3COOH (1.8×10^{-4}), so CH_3COOH is less acidic than HCOOH.

c We know,

$$PV = \frac{w}{M}RT$$

$$\Rightarrow M = \frac{wRT}{PV}$$

$$= \frac{0.15 \times 0.0821 \times 303}{\frac{80}{76} \times 0.4}$$

$$= 8.86$$

Here,
Weight, W = 0.15 g
Pressure, $P = 80 \text{ cm(Hg)} = \frac{80}{76} \text{ atm}$
Volume, V = 400 mL = 0.42
Molar gas constant,
$R = 0.0821 \text{ L atm mol}^{-1}K^{-1}$
Molecular weight, M = ?
Temperature, T = 30°C = 303K

∴ Molecular weight of P gas is 8.86.

d We Know,

From ideal gas equation,

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

Total mole number,

$$n = n_1 + n_2$$

$$\Rightarrow \frac{PV}{RT} = \frac{P_1V_1}{RT} + \frac{P_2V_2}{RT}$$

$$\Rightarrow PV = P_1V_1 + P_2V_2$$

∴ T is constant

$$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$$

$$= \frac{80 \times 400 + 75 \times 450}{850}$$

$$= 77.353 \text{ cm (Hg)}$$

Here,
For P gas,
Pressere, $P_1 = 80$ cm (Hg)
Volume, $V_1 = 400$mL
For Q gas,
Pressure, $P_2 = 75$ cm(Hg)

Volume, $V_2 = 450$mL
Total volume,
V = (400 + 450)mL = 850 mL
Total pressure = P.

Now, 1 atm = 76cm (Hg) = 101.325 kPa

$\therefore$ 1 cm (Hg) $= \frac{101.325}{76}$ kPa

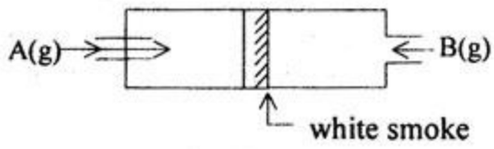
$\therefore$ 77.353 cm (Hg) $= \frac{77.353 \times 101.325}{76}$

$= 103.13$ kPa > 102 kPa

As the calculated pressure by using ideal gas equation is larger than claimed pressure, so the gases are not ideal gas.

Question ▶ 16 $NH_4Cl + CaO \xrightarrow{\Delta} A(g) + CaCl_2 + H_2O$

$C_2H_5OH + PCl_5 \longrightarrow B(g) + C_2H_5Cl + POCl_3$



[Ctg.B.-16]

a. What is ideal gas? 1

b. Why acid mixed water is called electrolytic conductor? 2

c. Explain conjugated acid and base on the basis of reaction occurred in the stem. 3

d. Which gaseous law supports the above stem? 4

Answer to the question no. 16

a The gases that follow Boyle's, Charles and Avogadro's law at any state are known as ideal gas.

b Pure water is non conductor. If little amount of acid is added to water then little it ionized to H^+ and OH^-. If electromotive force applied to it, H_2 and O_2 produce in the cathode and anode respectively. So due to movement of ion in acid mixed water, electricity passes.

$2H^+ + 2e^- \rightarrow H_2(g)$ [Cathode reaction]

$4OH^- \rightarrow 2H_2O + O_2(g) + 4e$ [Anode reaction]

So, acid mixed water is electrolytic conductor.

c The stem reactions are —

$NH_4Cl + CaO \xrightarrow{\Delta} NH_3(g) + CaCl_2 + H_2O$

$C_2H_5OH + PCl_5 \rightarrow HCl(g) + C_2H_5Cl + POCl_3$

So, A and B are NH_3 and HCl.

We know, the base formed by donating a proton (H^+) from an acid is known as conjugated base. And the acid formed by gaining one proton from acid is called conjugated acid.

In the stem tube NH_3 and HCl reacts as follow,

$NH_3 + HCl \rightarrow NH_4^+ + Cl^- \rightarrow NH_4Cl.$

Conjugated acid Conjugated base

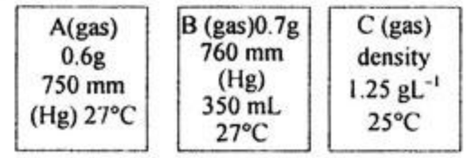
Here, HCl donates a H^+ and form Conjugated base (Cl^-). And NH_3 accepts a proton to form conjugated acid (NH_4^+).

d The reaction held in the stem tube follows Graham's diffusion law. In 1829 Tomas Graham stated that the rate of diffusion is inversely proportional to the root of density. So if molecule weight is high diffusion rate will be low.

In the stated stem NH_3 has travelled long distance than HCl to produce white fume of. NH_4Cl. Because the molecular weight of HCl (36.5) is higher than the molecular weight of NH_3 (17). NH_3 has low molecular weight so it's density will be less than density of HCl.

For this reason the diffusion rate of NH_3 will be higher.

Question ▶ 17



[S. B. 2017]

a. Waht is chiral carbon? 1

b. Which one is more basic among NH_3 and CH_3NH_2 and why? 2

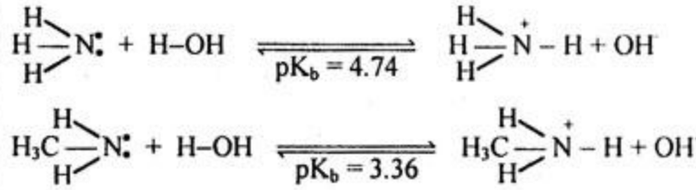
c. Determine the r.m.s. velocity of C gas. 3

d. Which one among A and B gas has higher diffusion rate at constant temperature?Explain mathematically. 4

Answer to the question no. 17

a The carbon which attached to for different group is known as chiral carbon.

b As Ammonia ($\ddot{N}H_3$) and methyl amine ($CH_3\ddot{N}H_2$) has lone pair electron in nitrogen they can accept proton. In aqueous solution NH_3 and CH_3NH_2 accept proton from water and produces respective conjugated base.



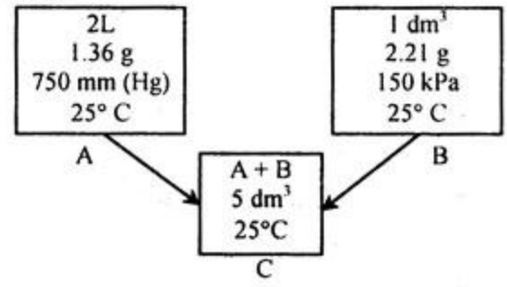
The positive charge of methyl ammonium ion is shared by nitrogen and carbon atom. So methyl ammonium ion is more stable than ammonium ion.

For this reason the reaction between methyl amine and H_2O is more forwarded than reaction between NH_3 and H_2O. As a result the concentration of OH^- increase and value of K_b also increase ($K_b = 4.4 \times 10^{-4}$, $Pk_b = 3.36$]. But for NH_3 and water it is not possible to increase ionization and so value of K_b is low ($K_b = 1.8 \times 10^{-5}$, $PK_b = 4.74$) . If the value of PK_b is low, the base is more basic. So methyl amine is more basic than ammonia.

c Similar as creative question 14(c)

d Similar as creative question 10 (d)

Question ▶ 18



A and B act as ideal gas. *[S.B.-16]*

a. What is conjugated acid? 1

b. Why phenol is acidic? 2

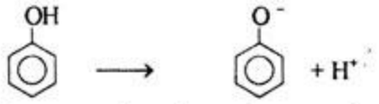
c. Determine the total pressure in C container. 3

d. Which gas has higher diffusion rate among A and B gas? Explain mathematically. 4

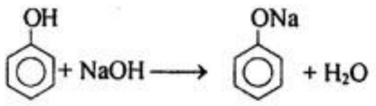
Answer to the question no. 18

a The acid formed by gaining one proton from a base is known as conjugated acid of that base.

b Phenol is acidic because the bond electrons of O–H shift to benzene ring through resonance. As a result O–H bond become weak. So phenol converted into phenate ion by donating proton (H^+).



Moreover, phenol produces water and salt with strong base NaOH.

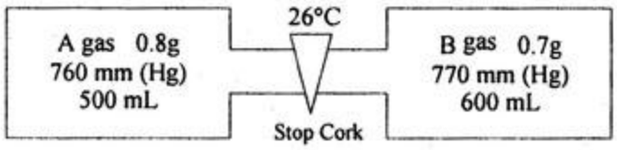


So, Phenol is acidic.

c Similar as creative question 11 (c)

d Similar as creative Question 10 (d)

Question ▶ 19

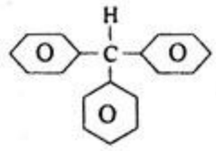


[J.B.-17]

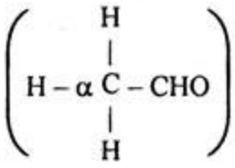
a. What is the structure of Triphenyl methane? 1
b. Why Ethanal gives aldol reaction but does not give cannizzaro reaction. 2
c. Calculate the total pressure of the mixture when stop cork is opened. 3
d. Which gas among A and B has higher diffusion rate at constant temperature and pressure. Explain mathematically. 4

Answer to the question no. 19

a The structure of Triphenyl methane:



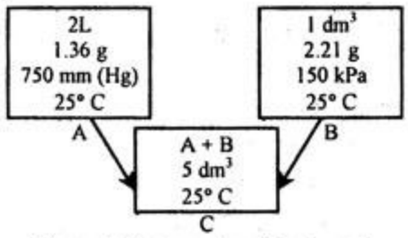
b We know, the aldehyde and ketone which has α – hydrogen give aldol reaction. If there is no α – hydrogen then aldehyde shows cannizzaro reaction.

From the structure of ethanal  it is clear that ethanal has hydrogen in α carbon. So ethanal gives aldol reaction but does not give cannizzaro reaction.

c Similar as creative Question 11 (c).

d Similar as creative Question 10 (d)

Question ▶ 20



[A and B gas act as ideal gas].

[J.B.-16]

a. What is conjugated acid? 1
b. Why ethyne is acidic? 2
c. Calculate the total pressure in C container. 3
d. Which gas among A and B has higher diffusion rate? Explain mathematically. 4

Answer to the question no. 20

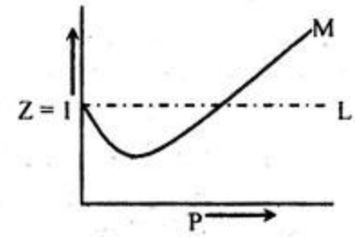
a The acid formed by gaining one proton from a base is known as conjugated acid of that base.

b Alkyne–1 (ethyne; HC ≡ CH) is acidic because carbon atom of is sp hybridized. In sp hybridization the ratio of s and p is 1 : 1. As ratio of small s orbital is higher in sp hybridization. The bond electrons of C – H shifted to carbon nucleous. As a result the bond of hydrogen became weak. For this reason ethyne-1 can easily donate proton by breaking C–H bond. So ethyne is acidic.

c Similar as creative question 11 (c)

d Similar as creative question 10 (d).

Question ▶ 21



'M' Gas is produced by thermal decomposition of limestone.

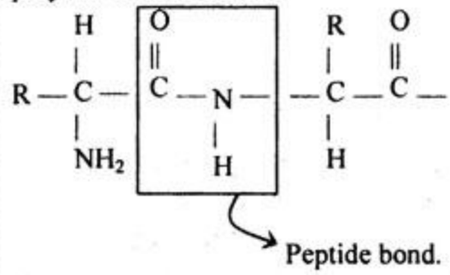
[B.B.-17]

a. What is ceramic? 1
b. Protein is a polymer of amino acid. Explain 2
c. Calculate the total kinetic energy of 5.5g M gas at 27°C. 3
d. Why one gas of the stem does not behave as ideal gas-Explain. 4

Answer to the question no. 21

a Ceramic is an inorganic solid substance produced from clay, feldspar and sand at high temperature.

b Protein is mainly a condensation polymer. In presence of organic catalyst (enzyme) peptide is formed in plant and animal body and subsequently peptide undergoes polymerization to form protein polypetide chain contains 100–400 molecules of amino acid monomer. So protein is called the polymer of amino acid.



c According to the stem M gas is produced by thermal decomposition of limestone.

So,

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2(g)$$
$$(M)$$

M gas is CO_2

We Know,
for n mole gas
kinetic energy,

$EK = \frac{3}{2} nRT$

$= \frac{3}{2} \times 0.125 \times 8.314 \times 300$

$= 467.66J.$

Here,
Temperature, $T = 27°C = 300K$
Molar gas Constnt,
$R = 8.314\ JK^{-1}mol^{-1}$
Molecular weight, $M = 44$
Mole number,
$n = \frac{5.5}{44} = 0.125$
Kinetic energy, $EK = ?$

∴ At 27°C total kinetic energy of M gas is 467.66 J.

d In the stated stem the graph of M and L gas is shown. Among two gas M is CO_2 which does follow ideal gas equation. The ideal gas equation is $PV = nRT$ Where $P \rightarrow$ pressure, $V \rightarrow$ volume, $n \rightarrow$ mole number, $R \rightarrow$ molar gas constant, $T \rightarrow$ temperature. Ideal gas follows this equation at any temperature and pressure.

At constont temperature the internal energy of ideal gas does not depend on volume. So $\left(\frac{\delta_u}{\delta_v}\right)_T = 0$,

Where, $u \rightarrow$ internal energy of gas

$V \rightarrow$ Volume of gas

$T \rightarrow$ Temperature of gas.

On the other hand, real gas does follow $PV = nRT$ equation. According to theory of kinetics the volume of gaseous molecules is negligible compared to volume of container.

But practically the volume of real gas molecules can not be ignored. For this reason at high pressure the volume of real gas molecules is higher than ideal gas. Secondly, according to theory of kinetics, there is no attraction and repulsion between gaseous molecules. But this can be different at high pressure. If pressure is increased, the molecules come together and hence attraction and repulsion force occur.

For this reason, real gas does not follow $PV = nRT$ ..... (i)

According to Vander Waal's theory,

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

Where a and b are constant.

From equation (i) and (ii).

Pressure of ideal gas = pressure of real gas (P) + $\frac{n^2a}{V^2}$. From above equation it is clear that the pressure of real gas is less than pressure of ideal gas.

Due to problem in pressure calculation M gas (CO_2) deviates from ideal gas behavior.

Question ▶ 22

1 atm 300 mL	1.5 atm 500 mL	T = 30°C
A-gas	B-gas	

[B.B.-16]

a. What is conjugated base? 1
b. What is the concentration of 0.15 M HCl at ppm unit? 2
c. Calculate the total pressure if A and B gas kept in a 1L container. 3
d. Which gas among 0.3g A and 0.85g B has higher diffusion rate. Explain. 4

Answer to the question no. 22

a The base formed by releasing one proton from a acid is known as conjugated base of that acid.

b Given,

Concentration of HCl $= 0.15$ M
$= 0.15\ molL^{-1}$ [1 mol HCl = 36.5g]
$= 0.15 \times 36.5\ gL^{-1}$
$= 0.15 \times 36.5 \times 10^3\ mg\ L^{-1}$
$= 5475\ mgL^{-1}$
$= 5475$ ppm

c Similar as creative question 11 (c)

d Similar as creative questions 10 (d)

Question ▶ 23

(i) $CuSO_4 + NH_4OH$ (excess) $\longrightarrow A + H_2O$
(ii) $AlCl_3 + H_2O \longrightarrow B$

[B.B.-16]

a. What is carbocation? 1
b. Why conjugated base of weak acid is strong? 2
c. Complete the stem reactions and name the main products. 3
d. Which acid-base theory is followed by A and B compound? Explain. 4

Answer to the question no. 23

a Positively charged carbon containing organic ion which is produced by heterolytic fission of covalent bond is called carbocation.

b The conjugated base of weak acid is strong. For example, following is a reversible reaction.

$$\underset{\text{Weak acid}}{HB} \rightleftharpoons \underset{\text{Proton}}{H^+} + \underset{\text{Base}}{B^-}$$

If HB is a weak acid then the equilibrium of the reaction will proceed to left. Opposite reaction that means association of proton with base will be higher. We know that, basicity of a base depends on capacity of base to take proton. So B^- will be a strong base. Therefore, conjugated base of weak acid is strong.

c The 1st reaction of the stem,

$$CusO_4 + NH_4OH_{(excess)} \rightarrow A + H_2O$$

If NH_4OH is added to $CuSO_4$ in little amount the blue colored basic $Cu(OH)_2$ precipitate is produced.

$$CuSO_4 + NH_4OH_{(insufficient)} \rightarrow Cu(OH)_2 + (NH_4)_2SO_4$$

If excess NH_4OH is added to this precipitate then deep blue solution of tetraammin cupric sulphate is produced.

$$Cu(OH)_2.CuSO_4 + (NH_4)_2SO_4 + NH_4OH_{(excess)} \longrightarrow [Cu(NH_3)_4]SO_4 + H_2O.$$

Tetraammine cupric sulphate.

Tetraammine cupric sulphate is known as Schweitzer's reagent.

The 2nd reaction of the stem,

$$AlCl_3 + 3H_2O \longrightarrow \underset{(B)}{[Al(H_2O)_6]^{3+}} + HCl$$

So the main product is Hexaaqua Aluminium (iii).

d According to Lewis theory, acid is a compound which can accept electron pair. On the other hand base is a compound which can share electron pair.

In the stem metal hydrated is produced in reaction (ii)

$$Al^{3+} + 6\left(:\ddot{O} - H\right) \longrightarrow \left[Al\left(:\ddot{O} - H\right)_6\right]^{3+}$$

Lewis acid (H) — Lewis base

Here, $\left(:\ddot{O} - H\right)$ donates electron pair.

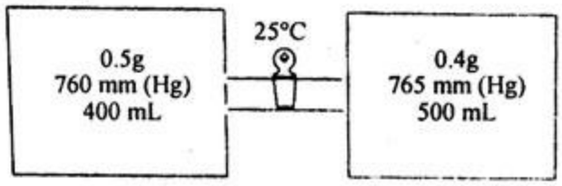
So it is Lewis base. And Al^{3+} can accept electron pair.

So it is Lewis acid. In the reaction (i) $[Cu(NH_3)_4]^{2+}$ is produced by reaction of NH_3 and Cu^{2+}.

$$Cu^{2+} + 4\ddot{N}H_3 \longrightarrow [Cu(NH_3)_4]^{2+}$$

Here NH_3 donates lone pair electron to Cu^{2+}.
So NH_3 is Lewis base and Cu^{2+} is Lewis acid.

Question ▶ 24



[RAJUK Uttara Model College, Dhaka]

a. What is chiral carbon? 1
b. Determine the value of R in SI unit. 2
c. After opening the stop cock, calculate the total pressure of the gas mixture. 3
d. Determine the number of molecules of the gas in vessel-A. 4

Answer to the question no. 24

a The carbon that attaches with 4 different atoms or groups is called chiral carbon.

b Value of R in S.I unit:

From ideal gas equation, We get

$PV = nRT$

$\Rightarrow R = \frac{PV}{nT}$ ..... (i)

At S.T.P for 1 mole gas,

$n = 1$ mole

Temperature, $T = 273K$

Pressure, $P = 1$ atm $= 101325$ Pa

Volume, $V = 22.4L = 22.4s \times 10^{-3}\ m^3$.

From, equation (i);

$$R = \frac{101325 \times 22.4 \times 10^{-3}}{1 \times 273}$$

$$= 8.314\ JK^{-1}\ mol^{-1}$$

$\therefore$ The value of R in S.I unit is $8.314\ JK^{-1}\ mol^{-1}$

c According to Dalton's law of partial pressure,

We get,

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$

$= \frac{400 \times 760 + 500 \times 765}{900}$

$= 762.78$ mm(Hg)

Here, for A gas,
Volume, $V_1 = 400$ mL
Pressure, $P_1 = 760$ mm (Hg)
For B gas,
Volume, $V_2 = 500$ mL
Pressure, $P_2 = 765$ mm (Hg)
For mixture,
Volume, $V = (400 + 500)$ mL
$= 900$ mL
Pressure, $P = ?$

$\therefore$ The Pressure of gas mixture is 762.78 mm(Hg) When stop corck is opened.

d We know,

$PV = nRT$

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

$= \frac{1 \times 0.4}{0.0821 \times 298}$

$= 0.01634935$ mol

Here, for A gas,
Weight, $W = 0.5$g
Pressure, $P = 760$ mm (Hg)
$= \frac{760}{760}$ atm
$= 1$ atm
Volume, $V = \frac{400}{1000}$ L
$= 0.4$ L
Temperature, $T = 25°C$
$= 298$ K
Molar gas Constant,
$R = 0.0821$ L atm $mol^{-1}K^{-1}$
No. of molecules, $n = ?$

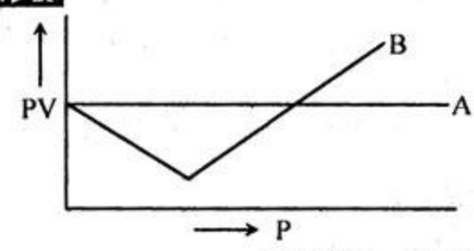
1 mole gas contains 6.02×10^{23} molecules

0.01634935 mole " " $(6.02 \times 10^{23} \times 0.01634935)$ "

$= 9.8472 \times 10^{21}$ molecules

$\therefore$ There are 9.8472×10^{21} molecules in A vessel.

Question ▶ 25



[RAJUK Uttara Model College, Dhaka]

a. What is ETP? 1
b. Write down the name of the following compounds in IUPAC system. 2
(i) $H_3C - HC = CH - CO - CH_3$
(ii) $H_3C - C(=O) - N(CH_3)(CH_3)$
c. If the molecular mass of gas-B is 32, then determine its root mean square velocity at 25°C. 3
d. In which condition gas-B mentioned in the stem will behave as the gas-A. Analyze. 4

Answer to the question no. 25

a ETP stands for Effluent Treatment Plant. It is the process of isolating hazardous pollutants from industrial waste water.

b (i) $\overset{5}{H_3C} - \overset{4}{HC} = \overset{3}{CH} - \overset{2}{C}O - \overset{1}{CH_3}$

Pent–3–ene–2–one

(ii) $H_3C - \overset{O}{\overset{\|}{C}} - N \begin{matrix} CH_3 \\ CH_3 \end{matrix}$

N, N – dimethyl ethanamide

c We know,

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

$$= \sqrt{\frac{3 \times 8.314 \times 298}{32 \times 10^{-3}}}$$

$$= 481.95 \text{ ms}^{-1}$$

Here, Molecular mass of B gas,
$M = 32 \text{ g} = 32 \times 10^{-3}$ kg
Temperature,
$T = 37°C = 298$ K
Molecular mass of B gas constant, $R = 8.314 JK^{-1}mol^{-1}$
Root mean square velocity,
$C_{r.m.s} = ?$

∴ The root mean square velocity of B gas is 481.95 ms^{-1} at 25°C.

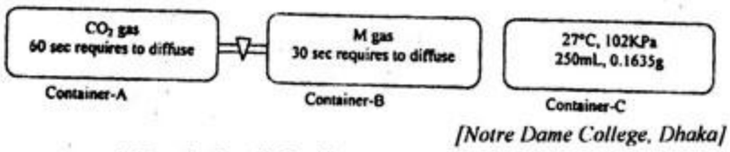
d In the stem the B gas is a real gas and A gas is an ideal gas. B gas deviates from ideal behavior because it does not follow theory of kinetics.

The equation for ideal gas is $PV = nRT$ and the equation for real gas is $\left(P + \frac{n^2a}{V^2}\right)(V - nb) = nRT$.

So the pressure exerted by real gas is not same as ideal gas and volume of real gas to move freely is not same as ideal gas. This deviation is due to intermolecular attraction and repulsion among gaseous molecules. If the temperature of real gas is increased the kinetic energy of the molecules and volume will be increased. As a result attraction between gas molecules will be decreased. So deviation will be minimized. Again, at low pressure, according to Boyle's law, volume of gas will be increased. As a result intermolecular attraction and repulsion will be decreased. So deviation will be eleminated.

From the above explanation we can say, at high temperature and law pressure real gas (B) behaves as ideal gas (A).

Ques. ▶ 26 Read the stem:



[Notre Dame College, Dhaka]

a. What is fossil fuel? 1
b. Troposphere is an upset atmosphere— explain. 2
c. 40% M gas is present when the stop cork is remained open, calculate its molecular mass. 3
d. Z vs P graph of gases in container A and C are not horizontal but curved— explain. 4

Answer to the question no.26

a A fossil fuel is a fuel formed by natural processes. Such as anaerobic decomposition of buried dead organisms. Containing energy origination in ancient photosynthesis.

b The troposphere is the lowest layer of earth's atmosphere and site of all weather on earth. It contains approximately 75 percent of the mass of the atmosphere. Natural disasters such as storm occurs in this region. All types of aeroplanes fly in this region. So troposphere is called an upset atmosphere.

c As 40% M gas is present in mixture when stop cork is opened, so the volume of B container would be 40% and volume of A container would be 60% of the total volume.

From Graham's Law of diffusion,

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

$$\Rightarrow \frac{\frac{V_1}{t_1}}{\frac{V_2}{t_2}} = \sqrt{\frac{M_2}{M_1}}$$

$$\Rightarrow \frac{\frac{40}{30}}{\frac{60}{60}} = \sqrt{\frac{44}{M_1}}$$

$$\Rightarrow = \frac{40}{30} = \sqrt{\frac{44}{M_1}}$$

$$\Rightarrow \frac{16}{9} = \frac{44}{M_1}$$

$$\Rightarrow M_1 = \frac{44 \times 9}{16}$$

$\therefore M_1 = 24.75$

Here,
Volume of M gas,
$V_1 = 40$
time of diffusion,
$t_1 = 30$ sec
Molecular weight,
$M_1 = ?$
volume of CO_2 gas,
$V_2 = 60$
time of diffusion,
$t_2 = 60$ sec
Molecular weight of CO_2,
$M_2 = 44$

d We know,

$$M = \frac{WRT}{PV}$$

$$= \frac{0.1635 \times 0.0821 \times 300}{\frac{102}{101.325} \times 0.25}$$

$$= 16$$

For C gas, Temperature,
$T = 27°C = 300$ K
Pressure,
$P = 102 \text{ kPa} = \frac{102}{101.325}$ atm
Volume, $V = 250 \text{ mL} = 0.25$ L
Weight, $W = 0.1635$ g
Molecular weight, $M = ?$

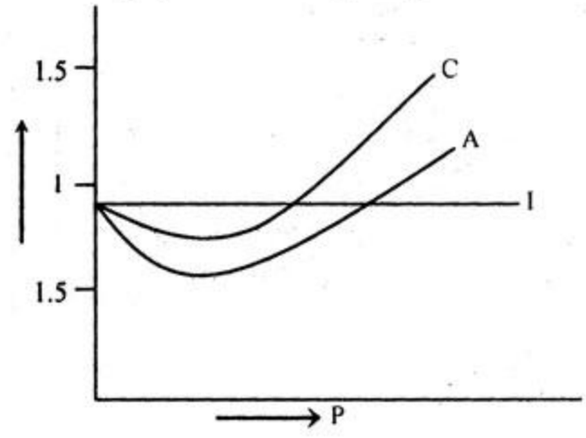
So in the stem A gas is CO_2 and C gas is CH_4. CO_2 and CH_4 both are real gas. So both gases deviate from ideal behavior.

We know, compressibility constant, $Z = \frac{PV}{nRT}$

For ideal gas, $Z = 1$

real gas, $Z > 1$ or $Z < 1$

The Z vs P graph for A and C gas is given below–

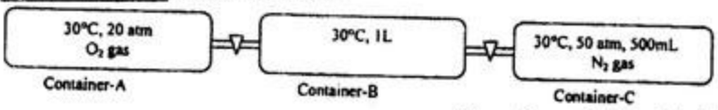


Graph : Z vs P

Here, the horizontal I line is for ideal gas. with the change of pressure the Z value for ideal gas is remain constant and it is 1. But for real gas (CO_2, CH_4) with increase of pressure, the intermolecular attraction among gaseous molecules decrease. So the product of PV decreases. and hence the value of Z decrease and it becomes $Z < 1$. If pressure increases further the real gas molecules come in closer and hence intermolecular repulsion activates. As a result volume increase and the product of PV also increase. For this reason Z value increases and becomes $Z > 1$.

So, Due to intermolecular attraction and repulsion the Z vs P graph for A and C gases are not horizontal but curved.

Question ▶ 27 Read the stem:



[Notre Dame College, Dhaka]

a. What is mole? 1

b. DO is inversely proportional to COD— explain. 2

c. Find the density of the gas kept in container-A of given stem. 3

d. If both stop corks are opened to mix the gases in container-B and the temperature of container-B is raised to 35°C, which gas will have more influence on the total pressure— analyze mathematically. [Volume of container-A is 400 mL] 4

Answer to the question no. 27

a Mole can be defined as the amount of a chemical substance that contains exactly 6.02×10^{23}.

Constitutive particles e.g. atoms, molecules, ions or electrons.

b DO is the amount of dissolved oxygen in water. It is needed for the existenae of aquatic life. On the other hand COD is the amount of oxygen needed to oxidize biodegradable and non-biodegradable pollutants present in water. To oxidize the pollutants oxygen is used from the dissolved oxygen. If the value of COD is large, more oxygen is needed to oxidize the pollutants. As a result large amount of oxygen is used from dissolved oxygen.

So amount of dissolved oxygen decreases. For this reason. DO is inversely proportional to COD.

c From Ideal gas equation,

We know,

$$d = \frac{PM}{RT}$$

$$= \frac{20 \times 32}{0.0821 \times 303}$$

$$= 25.73$$

Here, For Container A gas,

Temperature, T = 30°C = 303 K

Pressure, P = 20 atm

Gram molecular weight of oxygen, M = 32g

Molar gas constant,

$R = 0.0821$ L atm $mol^{-1}K^{-1}$

Density, d = ?

∴ The density of container A gas is 25.73 gL^{-1}.

d If both stop cocks are opened the total volume of mixture will be,

$$= \left(\frac{400}{1000} + 1 + \frac{500}{1000}\right) L$$

$$= 1.9 \text{ L}$$

For container A gas,

We know,

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

$$= \frac{20 \times 0.4}{0.0821 \times 303}$$

$$= 0.32159 \text{ mol}$$

Here, For Container A gas,

Temperature, T = 30°C = 303 K

Pressure, P = 20 atm

Gram molecular weight of oxygen, M = 32g

volume, v = 400 mL = 0.4 L

Mole no. n = ?

For Container C gas,

We know,

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

$$= \frac{20 \times 0.5}{0.0821 \times 303}$$

$$= 1.0049 \text{ mol}$$

Temperature, T = 30°C = 303 K

Pressure, P = 50 atm

volume, v = 500 mL

= 0.5 L

Mole no. n = ?

For mixture,

We know,

$$P_{O_2} V = n_{O_2} RT$$

$$\Rightarrow P_{O_2} = \frac{n_{O_2} RT}{V}$$

$$= \frac{0.3219 \times 0.0821 \times 308}{1.9}$$

$$= 4.284 \text{ atm}$$

Here,

Volume, V = 1.9L

Temperature, T = 35°C

= 308 K

mole no. of O_2

$n_{O_2} = 0.3219$ mol

mole no. of N_2

$n_{N_2} = 1.0049$ mol

Partial pressure of O_2, P_{O_2} = ?

Partial pressure of N_2, P_{N_2} = ?

Again,

$$P_{N_2} V = n_{N_2} RT$$

$$\Rightarrow P_{N_2} = \frac{n_{N_2} RT}{V}$$

$$= \frac{1.0049 \times 0.0821 \times 308}{1.9}$$

$$= 13.374 \text{ atm}$$

Total pressure = (4.284 + 13.374) atm

= 17.658 atm

As the partial pressure of N_2 in mixture is higher than partial pressure of oxygen, N_2 will have more influence on the total pressure.

Question ▶ 28

X	Y	Z (22 L)
25°C 770 mm (Hg) 980 mL	25°C 118 kPa 780 cm^3	25°C x + y

[Ideal School and College, Motijheel, Dhaka]

a. What is mole fraction? 1

b. What is the role of green house gas on global warming— explain it. 2

c. Calculate the pressure of gas mixture of the container 'Z' of the stem. 3

d. The rate of diffusion of which gas between 'X' and 'Y' is greater when the mass of the gases of the container are respectively 7.5g and 4.5g 4

Answer to the question no. 28

a Mole fraction is the ratio of mole no. of elements and total mole no. in a mixture.

c The green house gases are CO_2, N_2O, CH_4, O_3 CFC, $H_2O_{(g)}$. When the uv and IR rays come from sunlight, it can easily passed through ozone layer. The green house gases present in atmosphere allow the solar radiations of smaller wavelength to strikes the earth surface. Some of the radiated heat is reflected back from the outer surface. The green house gases absorb the reflected heat. As a result the reflected heat can not pass to the outer space. As a result the heat remains in atmosphere. Which is responsible for global warming.

c The gases of X and Y Container are mixed in Z container.

The volume of z container is 22L.

From Dalton's law of partial pressure,

We get,

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$

$= \frac{\frac{770}{760} \times 0.98 + \frac{118}{101.325} \times 0.78}{22}$

$= \frac{0.992895 + 0.908364}{22}$

$P = 0.864$ atm

Here, for X gas,

Volume, $V_1 = 980$ mL

$= \frac{980}{1000}$ L

$= 0.98$ L

Pressure, $P_1 = 770$ mm (Hg)

$= \frac{770}{760}$ atm

For Y gas,

Volume, $V_2 = 780\ cm^3$

$= \frac{780}{1000}$ L

$= 0.78$ L

Pressures, $P_2 = 118$KPa

$= \frac{118}{101.325}$atm

For mixture,

Volume, $V = 22$L

Pressure, $P = ?$

∴ The pressure of gas mixture in z container is .0864 atm.

d According to graham's diffusion law, the gas which molecular weight is higher has a lower diffusion rate.

We get,

From ideal gas equation,

$M_x = \frac{W_1RT_1}{P_1V_1}$

$= \frac{7.5 \times 0.0821 \times 298}{\frac{770}{760} \times 0.98}$

$= 184.81$

Here, for X gas,

Pressure, $P_1 = 770$ mm (Hg)

$= \frac{770}{760}$ atm

Volume, $V_1 = 980$ mL

$= 0.98$ L

Temperature, $T_1 = 25°C$

$= 298K$

Weight, $W_1 = 7.5$ g

∴ The molecular weight of X gas is 184.81.

Again,

We know,

$M_y = \frac{W_2RT_2}{P_2V_2}$

$= \frac{4.5 \times 0.0821 \times 298}{\frac{118}{101325} \times 0.78}$

$= 121.20$

Here,

For B gas,

Volume, $V_2 = 780\ cm^3 = 0.78$ L

Pressure, $P_2 = \frac{118}{101.325}$atm

Temperature, $T_2 = 25°C$

$= 298K$

Weight, $W_2 = 4.5$ g

∴ Molecular weight of Y gas 121.20

Now, $\frac{r_X}{r_Y} = \sqrt{\frac{M_Y}{M_X}}$

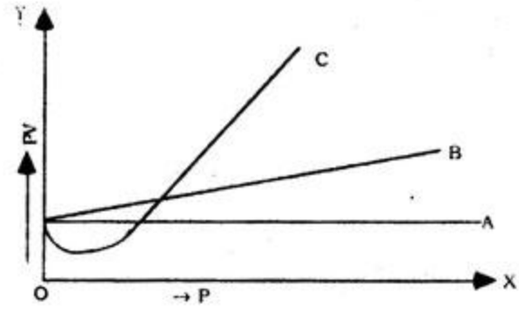
$= \sqrt{\frac{121.20}{184.81}}$

$\frac{r_X}{r_Y} = 0.81$

∴ $r_X : r_Y = 0.81 : 1$

∴ $r_X < r_Y$ So diffusion rate of Y gas is greater.

Question ▶ 29



[Ideal School and College, Motijheel, Dhaka]

a. What is storage cell? 1

b. Explain the nature of SO_4^{2-} ion. 2

c. Calculate the kinetic energy of 'C' at 23°C temperature where the vapour density of 'C' gas is 16. 3

d. On what condition 'B' gas of the stem will behave like 'C' gas and 'C' gas will behave like 'B' gas. 4

Answer to the question no. 29

a A cell that converts chemical energy into electrical energy by reversible chemical reactions and that may be recharged by passing a current through in it.

b Sulphate ion is obtained by deprotonation of both OH group of sulphuric acid. It is the conjugated base of bisulphate ion (HSO_4^-). the nature of SO_4^{2-} is basic because it can accept protons from acid.

$SO_4^{2-} + HCl \longrightarrow HSO_4^- + Cl^-$

Base Acid C. A C.B

Moreover, it produces hydroxide ion with water. So sulphate ion is basic in nature.

$SO_4^{2-} + H_2O \longrightarrow HSO_4^- + OH^-$

c We know,

Molecular weight = 2 × Vapor density

$= 2 \times 16$

$= 32$

As the weight of C gas is not mentioned in the stem, here the kinetic energy of 1 mole gas is determined.

We know

kinetic energy of 1 mole gas is–

$E_k = \frac{3}{2}RT$

$= \frac{3}{2} \times 8.314 \times 296$

$= 3691.416$ J

$= 3.69$ KJ

Here,

Temperature, $T = 23°C$

$= 296$ K

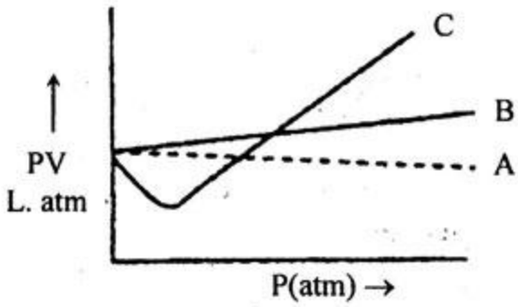
Molar gas Constant,

$R = 8.314\ JK^{-1}mol^{-1}$

So the kinetic energy of 1 mole C gas is – 3.69 kJ.

d In the stem graph, both B and C gas are real gas. For B gas with the increase of pressure the product of PV increase. But for C gas with the increase of pressure the product of PV decrease initially but at high pressure the product of PV Increases. By changing the temperature of gas it is possible to change the behave of B gas like as C gas. For B gas the volume of the gas is higher than the ideal gas. If the temperature of B gas is decreased then the volume of gas will be decreas and volume of PV will also be decreased. So at law temperature B gas will behave like as C gas. On the other hand for C gas is the product of PV decrease with the pressure. So the volume of C gas is lower than ideal gas due to intermolecular attraction force. If the temperature of the gas is increased the inter molecular attraction force will be decreased. So volume will be increase. At high temperature C gas will behave like as B gas.

Question ▶ 30



[St. Joseph School & College, Dhaka]

C gas is evolved by the pyrolysis of potassium chlorate

a. What is peptide bond? 1
b. "Alkyne-1 is acidic."— Explain. 2
c. Determine the RMS velocity of C gas at STP. 3
d. Analyse the reason behind dissimilarity of graphs of two gases 'B' and 'C' from 'A'. 4

Answer to the question no. 30

a The bond which is formed by condensation of carboxyl group of one amine acid and amino group of another amino acid is called peptide bond.

b Alkyne-1 (R – C ≡ CH) is acidic. Because 1 no carbon atom of alkyne-1 is sp hybridized. In sp hybridization the ratio of s and p is 1:1. As the ratio of small s orbital is higher in sp hybridization, the bond electrons of C – H shift to the carbon nucleus. As a result the bond between carbon and hydrogen becomes weak. For this reason, alkyne-1 can easily donate proton by breaking C – H bond.

So alkyne-1 is acidic.

c In the stem, C gas is evolved by the pyrolysis of potassium chlorate.

$2KClO_{3(s)} \longrightarrow 2KCl_{(s)} + 3O_{2(g)}$

So C gas is oxygen.

Determination of RMS velocity of oxygen.

We know,

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

$$= \sqrt{\frac{3 \times 8.314 \times 273}{32 \times 10^{-3}}}$$

$$= 461.29 \text{ ms}^{-1}$$

Here,

Temperature, T = 273 K

Molar gas constant, $R = 8.314 JK^{-1}mol^{-1}$

Gram molecular weight, M = 32g

RMS velocity, $C_{r.m.s} = ?$

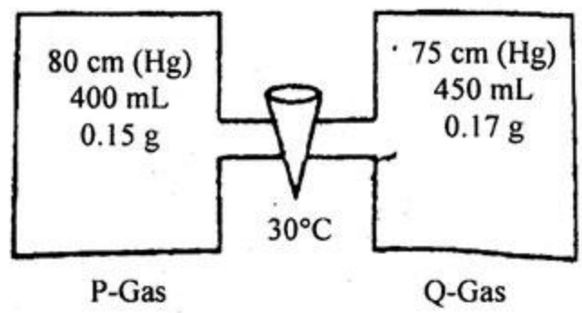
∴ The RMS velocity of C gas is 461.29 ms^{-1}

d In the stem, A gas is an ideal gas and both B and C gases are real gas. Real gases are deviated from ideal behavior.

The PV vs P graph is parallel to X axis. But for real gas with the increase of pressure the value of product of PV changes. Which is constant for ideal gas, The deviation is due to intermolecular attraction-repulsion among gaseous molecules and own volume of real gas molecules. For B gas, the value of product of PV increases with pressure. Because B gas is less compressible than ideal gas. With the increase of pressure the volume decreases at a lower extent than ideal gas. So the product of PV increases with pressure.

On the other hand, For C gas with the increase of pressure the product of PV decrease initially due to higher intermolecular attraction at high pressure. Further increase of pressure initiates intermolecular repulsion. As a result volume increased. Hence the product of PV also increased. So we can conclude that, due to intermolecular attraction and repulsion B and C gas deviated from ideal behavior.

Question ▶ 31



[St. Joseph School & College, Dhaka]

a. What is racemic mixture? 1
b. Why CH_3COOH is weaker acid than HCOOH? 2
c. Calculate the molecular weight of P-gas of the stem. 3
d. Analyse the two gases of the stem whether they are ideal or not if the pressure of the gas mixture is 102 kPa 4

Answer to the question no. 31

a Reacemic mixture is the equimolar mixture of two enantiomer.

b Acetic acid (CH_3COOH) is weaker acid. Than formic acid (HCOOH). Because there is a electron donating methyl group is acetic acid. In presence of methyl group due to positive inductive effect the partial positive charge of carbon decreases.

$$CH_3-\overset{\overset{O}{\|}}{C}-O-H \qquad H-\overset{\overset{O}{\|}}{C}-O-H$$

$k_a = 1.8 \times 10^{-5}$ $\quad$ $k_a = 1.8 \times 10^{-4}$

As a result ionization of O – H group also decreases. So acetic acid can not donates proton easily.

c From Ideal gas equation,

We get,

$$M = \frac{WRT}{PV}$$

$$= \frac{0.15 \times 0.0821 \times 303}{\frac{80}{76} \times 0.4}$$

$$= 8.862$$

∴ The Molecular weight of P gas is 8.862

Here, For Container P gas,

Pressure, $P = 80 \text{ cm (Hg)} = \frac{80}{76} \text{ atm}$

Volume, V = 400 mL

$$= \frac{400}{1000} L = 0.4 L$$

Weight, W = 0.15g

Temperature, T = 30°C

= (30 + 273) K

Molecular weight, M = ?

d From Dalton's law of partial pressure,

We get,

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$

$= \frac{80 \times 400 \times 75 \times 450}{850}$

$= 77353$ cm(Hg)

Here, for P gas,

Pressure, $P_1 = 80$ cm (Hg)

Volume, $V_1 = 400$ mL

For Q gas,

Pressures, $P_2 = 75$ cm (Hg)

Volume, $V_2 = 450$ mL

For mixture,

Volume, V= (400 + 450) mL=850 mL

Pressure, P = ?

$\therefore$ Pressure of mixture = 77.353 cm (Hg)

$$= \left(\frac{77.353}{76} \times 101.325\right) \text{KPa}$$

$= 103.13$ KPa

As the observed pressure (102 KPa) is not equal to Calculated pressure (103.13 KPa). So the gases are not ideal.

Question ▶ 32 Air is never found clean in nature, due to natural and man-made pollution. Gases such as CO, SO_2 and H_2S are continually released into the atmosphere through natural activities. Besides, solids or liquid particles are distributed throughout the environment.

[St. Joseph School & College, Dhaka]

a. What is acid rain? 1

b. Why is r.m.s velocity more suitable than average velocity in calculating kinetic energy? 2

c. How can the BOD of the sample water be determined? 3

d. Explain the effect of inorganic solid pollutants of the stem in food chain. 4

Answer to the question no. 32

a When the pH of rain water is below 5.6 then the rain is called acid rain.

b Similar to the question no-4 (b).

c To determine the BOD of water, the water sample is saturated with oxygen. Then the value of DO (Dissoved oxyzen) is determined. The water sample is then allowed to incubate five days for biodegradation of organic pollutants.

After five days, DO of water is determined. The difference is the value of BOD which denotes the amount of oxygen needed to biodegrade organic pollutants.

The value of DO of water can be determined by iodometric process. The process is given below.

(i) In alkine medium, Mn^{2+} ion is oxidized by dissolved oxygen of water to hydrated manganese.

(ii) Oxide :

$2Mn^{2+}_{(aq)} + O_{2(aq)} + 4OH^- \longrightarrow Mn(OH)_2$

Acidification of the solution and treatment with Iodide solution produces equivalent amount of I_2.

$2Mn(OH)_{2(s)} + 8H^+_{(aq)} + 4I^-_{(aq)} \rightarrow 2I_{2(a1)} + 2Mn^{2+}_{(aq)} + 6H_2O_{(l)}$

The liberated iodine is nitrated by standard thiosulphate solution.

$4S_2O_3^{2-}{}_{(aq)} + 2I_{2(aq)} \longrightarrow 2S_4O_6^{2-}{}_{(aq)} + 4I^-_{(aq)}$

So 1 mol $O_2 \equiv 2$ mol $Mn(OH)_2 \equiv 2$ mol $I_2 \equiv 4$ mol $S_2O_3^{2-}$

Process :

i. The sample water is collected

ii. 50 mL water is taken in a stoppered bottle and 1 mL phosphate buffer, 1 mL $MgSO_4$, 1 mL $CaCl_2$ and 1 mL $FeCl_3$ is added to it.

iii. The sample is diluted and oxygen is passed to make DO 7 ppm. If the value of BOD is greater than DO than dilution is needed. The half of the sample is taken and DO is determined. The DO is D_1.

iv. The reaming half of the sample is incubated for 5 days in stoppered bottle. The DO is determined. The DO is D_2.

v. The diluted sample is separated in two portion and DO of one portion is determined.

The DO is B_1. The another part is incubated for 5 days and DO is determine. The DO is B_2.

Now BOD can be determined by using following equation.

$$BOD = \frac{(D_1 - D_2) - (B_1 - B_2) \times f}{P} \text{ mgL}^{-1}$$

Here, $P \longrightarrow \frac{1}{10}$ th fraction of sample used.

$f \longrightarrow$ Ratio of regulated water with sample water.

d The several inorganic solid pollutants such as Pb, Cd, Cr associated in food chain.

Effects of Cadmium in food chain :

Cd pollution occurs Cd-Ni battery industry. It pollutes the soil and water of surrounding area. The Cd associated in human through various foods such as fish and vegetables. when taken. Tobacco tree stores Cd and associated in human during smoking. Cd is stored in kidney and responsible for kidney damage.

Effects of Pb in food chain :

Lead pollution occurs from the battery industry, alloy industry gun industry. Lead reacts with water and produces $Pb(OH)_2$ which is responsible for lead poisoning.

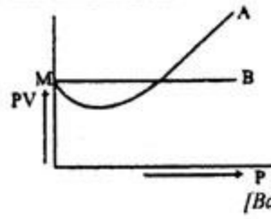
Trees absorb lead through root and lead associated in human body through food. In human. Lead cause nausea, loss of appetite, anemia, constipation. It also prevents synthesis of hemoglobin.

Effects of Chromium:

Chromium pollution occurs from the leather industry. waste water of leather industry contains large amount of chromium whcih mixed river and rain water. Aquatic animals takes chromium polluted water. Whcih then enters into human body through food chain.

Cr(vi) acts as carcinogen and responsible for long cancer.
It prevents the synthesis of RBC hance Causes anaemia.

Question ▶ 33



Mass of 50 molecules of 'A' gas is 2.656×10^{-21}g

[Bangladesh International School and College, Dhaka]

a. Define molar gas constant? 1
b. How does HSO_4^- act as both acid and base? 2
c. Calculate the root mean square velocity of 'A' gas at 37°C temperature. 3
d. Predict whether the gas 'A' mentioned in the stem is real or ideal, if it is real, analyze the causes of deviation from ideal behavior of the gas. 4

Answer to the question no. 33

a Molar gas Constant : Molar gas constant can be defined as the work done which is performed by increasing 1K temperature of 1 mole of a gas.

b According to Bronsted Lowry concept, the compound or ion that can donate proton (H^+) is acid and the compound or ion that can accept proton (H^+) is a base. HSO_4^- can act as both acid and base (amphoteric) because it can donate and accept proton.

As Acid : $HSO_4^- + NH_3 \longrightarrow SO_4^{2-} + NH_4^+$
Acid Base

As base,
$HSO_4^{-1} + HCl \longrightarrow H_2SO_4 + Cl^-$
Base acid

c We know, 1 mole gas contains 6.02×10^{23} molecules

Here,
Weight of 50 molecules = 2.656×10^{-21}g

$\therefore$ " " 6.02×10^{23} " $= \frac{2.656 \times 10^{-21} \times 6.02 \times 10^{23}}{50}$

$= 331.978$

≈ 32

$\therefore$ Weight of 1 mole = 32 g

We know

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

$= \sqrt{\frac{3 \times 8.314 \times 310}{32 \times 10^{-3}}}$

$= 491.55\ ms^{-1}$

$\therefore$ The root mean square velocity of A gas is 491.55 ms^{-1}

Here,
Molecular weight,
M = 32 g
$= 32 \times 10^{-3}$ Kg
Temperature,
T = 37°C = 310 K
$C_{r.m.s} = ?$

d In the stem, A is a real gas because, according to Boyle's law with the change of pressure the product of PV is constant for ideal gas. But for A gas the value of PV change with the change of pressure. The causes of deviation of real gas are explained below–

i. According to law of kinetic, there is not inter molecular attraction and repulsion between gaseous molecular.

But it is not true for the real gas. With the increase of pressure volume of gas decreases as intermolecular attraction increase. It causes decreation of value of PV. When pressure increases further then the molecules are become close enough hence repulsion force activated between molecules. As a result volume increase and the value of PV also increase.

ii. According to law of kinetic the volume of space occupied by molecular is neglible compared to total gas volume. But it is not true for real gas. Real gas molecules have an own volume which is not negligible. As a result real gas molecules can not freely move in whole volume.

By analyzing the two deviations, Vander-Waal's established an equation for real gas.

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

Question ▶ 34 At 30°C temperature, 1.5atm pressure in a container of volume 5.0L nitrogen, oxygen and carbon-di-oxide remains mixed with other. Total mole number of gases is 30. The concentration of nitrogen and oxygen is $2molL^{-1}$ and $1.5\ molL^{-1}$.

[Bangladesh International School and College, Dhaka]

a. What is partial pressure? 1
b. Why is r.m.s. velocity better than average velocity? 2
c. What is the partial pressure of CO_2 gas in the mixture? 3
d. If nitrogen gas is separated from the mixture, partial pressure of remaining gases will be changed or not? Analyze it. 4

Answer to the question no. 34

a Partial pressure : The partial pressure of a gas can be defined as the pressure exerted by the gas if it alone occupies the whole volume of the container in which the mixture is kept.

b RMS velocity is the square root of the mean of the square of individual velocities of the gas molecules. On the other hand the arithmetic mean of the individual velocities of the molecules is called average velocity. RMS velocity is better than average velocity because kinetic energy depends on the square of velocity.

So by using value of r.m.s velocity it is possible to determine average kinetic energy of the molecular accurately. So r.m.s velocity is better than average velocity.

c Here,

Total volume V = 5L

Total mole number, n = 30 mol

Concentration of O_2, So_2 = 1.5 mol/L

" " N_2, S_{N_2} = 2 mol/L

We know,

$n_{O_2} = VS_{O_2}$

$= 5 \times 1.5$

$= 7.5$ mol

Again,

$n_{N_2} = VS_{N_2}$

$= 5 \times 2$

$= 10$ mol

$\therefore$ Mole number of CO_2, $n_{CO_2} = \{30 - (7.5 + 10)\}$

$= 12.5$ mol

We know,

Partial pressure = Mole fraction × Total pressure

$P_{CO_2} = X_{CO_2} \times P$

$= \frac{n_{CO_2}}{n} \times P$

$= \frac{12.5}{30} \times 149.3$

$= 62.208$ atm

$X_{CO_2} = \frac{\text{Mole no of } CO_2}{\text{Total mole number}}$

$\therefore$ Partial pressure of CO_2 is 62.208 atm.

d From the answer C we get,

Mole no of nitrogen, $n_{N_2} = 10$ mol

" " " oxygen, $n_{O_2} = 7.5$ mol

" " " CO_2, $n_{CO_2} = 12.5$ mol

Partial pressure of CO_2, $P_{CO_2} = 62.208$ atm

Partial pressure of oxygen,

$$P_{O_2} = \frac{n_{O_2}}{n} \times P$$

$$= \frac{7.5}{30} \times 149.3$$

$$= 37.325$$

If nitrogen gas is separated from the mixture, then total mole number of mixture is = (30 – 10) = 20 mol

Now,

Partial pressure CO_2,

$$P_{CO_2}V = n_{CO_2}RT$$

$$\Rightarrow P_{CO_2} = \frac{n_{CO_2}RT}{V}$$

$$= \frac{12.5 \times 0.0821 \times 303}{5}$$

$$= 62.2 \text{ atm}$$

Partial pressure O_2,

$$P_{O_2}V = n_{CO_2}RT$$

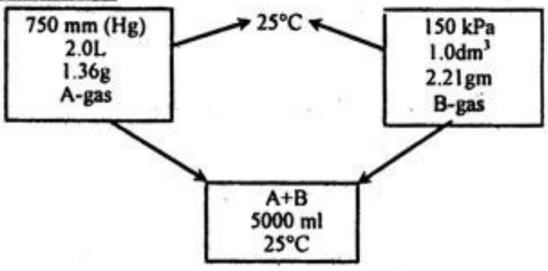
$$\Rightarrow P_{O_2} = \frac{n_{CO_2}RT}{V}$$

$$= \frac{7.5 \times 0.0821 \times 303}{5}$$

$$= 37.31 \text{ atm}$$

From the above analysis we see if N_2 is separated from the mixture, the partial pressure of the remaining gas will not be changed.

Question ▶ 35



[College of Development Alternative, Dhaka]

a. What is glass? 1

b. BF_3 is a Lewis acid— explain? 2

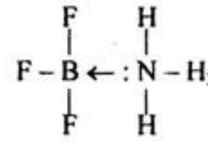
c. Calculate the total pressure of the gas mixture. 3

d. In between A and B gases which one will diffused more? 4

Answer to the question no. 35

a Glass is a non crystalline, inorganic, amorphous solid that is often transparent and produced from sand mainly.

b According to Lewis concept, the compound or ion that can accept lone pair electron is called acid. BF_3 is a Lewis acid. Because B has incomplete octate in BF_3. So B accepts electron pair to complete octate. So BF_3 is a Lewis acid.



$$F_3B \leftarrow NH_3$$

c From Dalton's law of partial pressure,

We know,

$$PV = P_1V_1 + P_2V_2$$

$$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$$

$$= \frac{\frac{750}{760} \times 2 + \frac{150}{101.325} \times 1}{5}$$

$$= \frac{1.9737 + 1.48}{5}$$

$$= \frac{3.454}{5}$$

$$= 0.691 \text{ atm}$$

Here,

For A container,

Pressure, $P_1 = 750$ mm (g) $= \frac{750}{760}$ atm

Volume, $V_1 = 2L$

For B container,

Pressure, $P_2 = 150$ KPa $= \frac{150}{101.325}$ atm

Volume, $V_2 = 1dm^3$

For mixture,

Volume, V = 5000 mL = 5L

Pressure, P = ?

∴ The total pressure of gas mixture is 0.691 atm.

d According to ideal gas equation,

We get,

$$M_A = \frac{W_1RT_1}{P_1V_1}$$

$$= \frac{1.36 \times 0.0821 \times 298}{\frac{750}{760} \times 2}$$

$$= 16.86$$

Here, For A gas,

Pressure, $P_1 = \frac{750}{760}$ atm

Volume, $V_1 = 2L$

Weight, $W_1 = 1.36g$

Temperature, $T_1 = 25°C = 298K$

Molecular Weight, M_A = ?

∴ Molecular Weight of A gas is 16.86

Again,

According to ideal gas equation,

$$M_B = \frac{W_2RT_2}{P_2V_2}$$

$$= \frac{2.21 \times 0.08201 \times 298}{\frac{150}{101.325} \times 1}$$

$$= 36.52$$

Here, For B gas,

Pressure, $P_2 = 150$ kPa $= \frac{150}{101.325}$ atm

Volume, $V_2 = 1dm^3$

Weight, $W_2 = 2.21$gm

Temperature, $T_2 = 25°C = 298k$

Molecular Weight, M_B = ?

∴ Molecular Weight of B gas is 36.52

According to Graham's diffusion law,

$$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$$

$$= \sqrt{\frac{36.52}{16.86}}$$

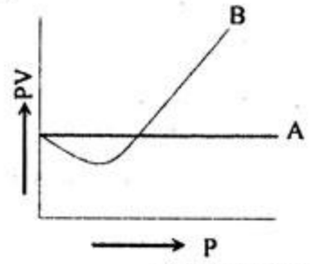
$\Rightarrow \frac{r_A}{r_B} = 1.4718$

$\therefore \quad r_A : r_B = 1.4718 : 1$

$\therefore \quad r_A > r_B$

So diffusion rate of A gas is higher than B gas.

Question ▶ 36



[College of Development Alternative, Dhaka]

a. What is fuel cell? 1

b. Methyl benzene is an aromatic hydrocarbon.— explain. 2

c. Derive the equation of the gas 'A' which is related to pressure; volume and temperature. 3

d. Why the nature of 'A' and 'B' gases are not same? Explain. 4

Answer to the question no. 36

a A fuel cell is an electro-chemical cell that converts chemical energy of hydrogen and hydrogen containing fuel into electrical energy.

b Methyl benzene (toluene) is an aromatic hydro carbon. According to Huckel rule the cyclic planar compound which has $4n + 2$ number of delocalized π electrons is called aromatic compound where n is ring number. Toluene CH_3  has six delocalized π electrons which follows Huckel rule [$4n + 2 = 4 \times 1 + 2 = 6$] when $n = 1$.

Again Toluene is  composed of only hydrogen and carbon. So methyl benzene (Toluene) is an aromatic hydrocarbon.

c In the stem, A is an ideal gas and B is an real gas. A gas follows Boyle's Charle's and Avogadro's law at any temperature and pressure. Derivation of ideal gas equation. According to Boyle's law,

At constant temperature, the volume of a given mass of gas is inversely proportional with the pressure. So

$V \propto \frac{1}{P}$ ..... (i)

[T constant]

Here,

$V \rightarrow$ Volume

$P \rightarrow$ Pressure

$T \rightarrow$ Temperature

According to Charle's law,

At constant pressure, the volume of a given mass of gas is directly proportional with the Temperature. So,

$V \propto T$ [P constant] ..... (ii)

According to Avogadro's law,

At constant temperature and pressure the volume of a gas is directly proportional to its mole number. So,

$V \propto n$ [P, T constant] ..... (iii)

From, equation (i), (ii) and (iii) we get,

$V \propto \frac{1}{P} T.n.$ [When V, P, T, n changes at a time]

$\Rightarrow V = R\frac{1}{P} T.n.$

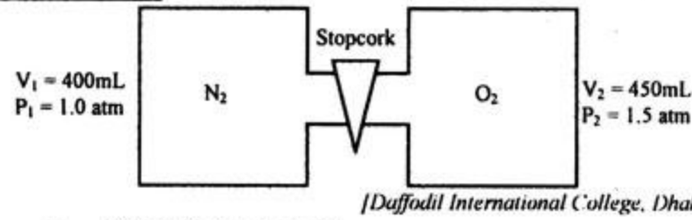
$\Rightarrow PV = nRT$

$\therefore \quad PV = nRT.$

It is the ideal gas equation which relates temperature, volume and pressure.

d The gas which follows ideal gas equation ($PV = nRT$) at any temperature and pressure is called ideal gas. It is a mythical concept. The gas which does not follow ideal gas equation ($PV = nRT$) at any temperature and pressure is called real gas. Practically all gas behave as real gas. In the stem A gas is an ideal gas. So it follows ideal gas equation and theory of kinetics. With the increase of temperature the product of PV become constant for ideal gas (Boyle's law). So PV vs P graph for A gas is parallel to x-axis. On the other hand, B gas is a real gas. With the change of pressure the product of PV changes. In the graph for A gas the PV decrease with increase of pressure initially. Because with increase of pressure inter-molecular attraction between gas molecules increase. So volume decrease at a large extent. Further increase of pressure activates inter molecular repulsion. As a result volume increase slightly. So the product of PV increase at high pressure. Due to inter molecular attractions and repulsion between molecules the nature of A and B gas are not same.

Question ▶ 37



[Daffodil International College, Dhaka]

a. What is Real gas? 1

b. Explain C_3H_6O shows tautomerism. 2

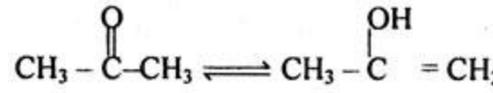
c. At 25°c temperature calculate the number of molecule of N_2 when the stop cork is closed. 3

d. The total pressure observed in the stem, does it follow Dalton's law of partial pressure? Analyze 4

Answer to the question no. 37

a The gas which does not follow ideal gas equation ($PV = nRT$) at any temperature and pressure is called ideal gas.

b We know, tautomerism is a type of isomerism in which a dynamic equilibrium is created between two isomers. It is usually occurred between ketone and unsaturated alkene C_3H_6O shows tautomerism as follow :



propanone prop-1-en-2-ol

Here, a dynamic equilibrium is created between ketone and unsaturated alcohol.

c In the stem, there is 400 nitrogen gas in container at 25°C and 1 atm pressure.

From ideal gas equation,

We know,

$P_1V_1 = n_1RT_1$

$\Rightarrow n_1 = \frac{P_1V_1}{RT_1}$

$= \frac{1 \times 0.4}{0.0821 \times 298}$

$= 0.01634935$ mol

$\therefore n_1 = 0.01634935$ mol

Here,

for nitrogen gas,

volume $V_1 = 400$ mL

$= \frac{400}{1000}$ L

Pressure, $P_1 = 1$ atm

Temperature, $T_1 = 25°C$

$= 298$

$\therefore n_1 = 0.01634935$ mol

Again,

1 mol nitrogen contains 6.02×10^{23} molecule

0.01634935 mol " " $(6.02 \times 10^{23} \times 0.01634935)$ "

$= 9.847 \times 10^{21}$ molecule

$\therefore$ There are 9.847×10^{21} molecules nitrogen gas in the stem.

d From Dalton's law of partial pressure,

We get,

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$

$= \frac{1 \times 400 + 1.5 \times 450}{850}$

$= \frac{400 + 675}{850}$

$= 1.2647$ atm

$\therefore P = 1.2647$ atm

Here,

for nitrogen gas,

Volume, $V_1 = 400$ mL

Pressure, $P_1 = 1$ atm

for oxygen gas,

Volume, $V_2 = 450$ mL

Pressure, $P_2 = 1.5$ atm

For mixture,

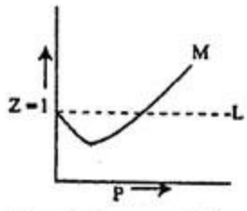
Volume, $V = (450 + 400)$ mL

$= 850$ mL

Pressure, $P = ?$

So, according to Dalton's law, the total pressure of the gas mixture is 1.2647 atm.

Question ▶ 38



'M' gas found from the decomposition of lime stone

[Daffodil International College, Dhaka]

a. What is ceramic? 1

b. Protein is polymer of amino acid — explain. 2

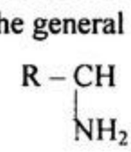
c. At 27°C temperature calculate the kinetic energy of 5.5g M gas of the stem. 3

d. One gas does not follow behaviour of ideal gas, analyze with equation. 4

Answer to the question no. 38

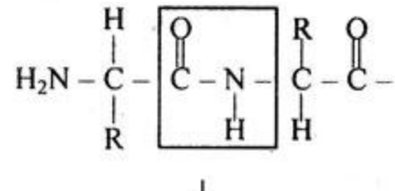
a Ceramic is a solid material comprising an inorganic compound of metal, non-metal, metalloid, which is produced from clay, silica, Feldspar at high temperature.

b Protein is a biomolecule. It is the polymer of amino acid. The general formula of amino acid is—



Carboxyl group of one amino acid condense with amino group of another amino acid by eliminating water molecule to form petide bond.

Lots of amino acid attached through peptide bond and form the structure of protein



Peptide bond

So, protein is polymer of amino acid.

c In the stem, M gas is produced from the decomposition of limestone

$\underset{\text{limestone}}{CaCO_{3(s)}} \rightarrow CaO(s) + \underset{(M)}{CO_2(g)}$

So M gas is carbon dioxide.

Determination of kinetic energy of 5.5g M gas :

We know,

$E_k = \frac{3}{2}nRT$

$= \frac{3}{2} \times \frac{W}{M} \times RT$

$= \frac{3}{2} \times \frac{5.5}{44} \times 8.314 \times 300$

$= 467.66$ J

Here,

Temperature, $T = 27°C$

$= 300K$

Weight, $W = 5.5$g

Molecular Weight, $M = 44$

Kinetic energy, $E_k = ?$

Molar gas, constant,

$R = 8.314 JK^{-1}mol^{-1}$

$\therefore$ Kinetic energy of 5.5g M gas is 467.66J.

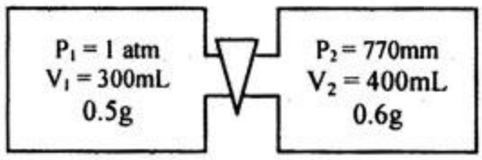
d In the stem graph, there are two gas. L gas is ideal gas. Because with increase of pressure the product of PV is constant. But for real gas product of PV is not constant. Because real gas does not follow theory of kinetics, there is no intermolecular attraction and repulsion force among gaseous molecules. But this is not true for real gas. There is intermolecular attraction between gaseous molecules. So with the increase of pressure volume decrease at a large extent than ideal gas. So product of PV decrease with pressure. Due to intermolecular attraction, real gas exerts lower pressure than ideal gas. Again, according to theory of kinetics, the own volume of gaseous molecules of ideal gas is negligible. But it is not true for real gas. Because real gas molecules have an own volume which is not negligible. As a result ideal gas molecules can not freely move into whole container.

By observing the two limitations, Vander Waals established an equation for real gas (M). The equation for real gas is—

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

The equation for ideal gas (L) is PV = nRT

Question ▶ 39



[Millennium Scholastic School & College, Bogura]

a. What is RMS velocity? 1
b. Determine value of R in SI unit. 2
c. What is the total pressure of the gas mixture? 3
d. At same temperature and pressure which gas has more diffusion rate? Analysis mathematically. 4

Answer to the question no. 39

a RMS Velocity :

The root mean square (r.m.s) velocity is the square root of the mean of the square of individual velocities of the gas molecular.

b Value of R is S.I. Unit :

From ideal gas equation we get,

PV = nRT

$\Rightarrow R = \frac{PV}{nT}$ ..... (i)

At STP for 1 mol ideal gas.

n = 1 mol

P = 1 atm = 10325 Pa

$V = 22.4L = 22.4 \times 10^{-3}\ m^3$

T = 0°C = 273 K

So from equation (i),

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

$$= \frac{101325 \times 22.4 \times 10^{-3}}{1 \times 273}$$

$$= 8.314 JK^{-1}mol^{-1}$$

∴ Value of R in S. I unit is $8.314 JK^{-1}mol^{-1}$.

c According to Dalton's law of partial pressure we get.

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$

$$= \frac{300 \times 1 + 400 \times \frac{770}{760}}{700}$$

$$= \frac{300 + 405.263}{700}$$

$\Rightarrow$ P = 1,0075

∴ P = 1.0075 atm

∴ Total pressure of the mixture is 1.0075 atm.

Here,
For A Container Pressure,
P_1 = 1 atm
Volume, V_1 = 300 mL
For B Container pressure,
Pressure, P_2 = 770 mm (Hg)
$= \frac{770}{760}$ atm
Volume, V_2 = 400 mL
For c mixture,
Total Volume, V = 700 mL
Total Pressure, P = ?

d According to Graham's diffusion law. The gas which molecular weight is higher has a lower diffusion rate.

Let the temperature for both gas is 25°C or 298 K.

Determination of molecular weight of container A gas:

According to ideal gas equation,

$$M_A = \frac{W_ART_A}{P_AV_A}$$

$$= \frac{2 \times 0.0831 \times 298}{1 \times 0.3}$$

$$= 40.78$$

For A gas,
Pressure, P_A = 1 atm
Volume, V_A = 300mL = 0.3L
Weight, W_A = 0.5g
Temperature, T_A = 25°C = 298 K
Molecular Weight, M_A = ?

∴ Molecular Weight of container gas is 40.78.

Determination of Molecular Weight of container B gas,

According to ideal gas equation,

$$M_A = \frac{W_BRT_B}{P_BV_B}$$

$$= \frac{5 \times 0.0821 \times 298}{\frac{770}{760} \times 0.4}$$

$$= 41.655$$

For B gas,
Pressure, P_B = 770 mm(Hg)
$= \frac{770}{760}$ atm
Volume, V_B = 400 mL = 0.4L
Weight, W_B = 0.69g
Temperature, T_B = 25°C = 298 K
M_B = ?

Molecular Weight of container B gas is 41.655

According to Graham's law,

$$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$$

$$\Rightarrow \frac{r_A}{r_B} = \sqrt{\frac{41.655}{40.78}}$$

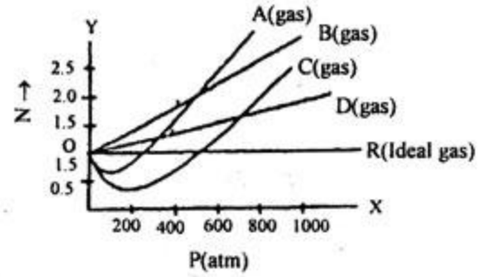
$$\therefore \frac{r_A}{r_B} = 1.01068$$

$\therefore r_A : r_B = 1.01068 : 1$

So, $r_A > r_B$

As Molecular Weight of Container A gas is lower so it will have more diffusion rate.

Question ▶ 40



Molecular mass of A, B, C, D are respectively 20, 2, 44, 4 and 2 is co-efficient of compressibility.

[Millennium Scholastic School & College, Bogura]

a. What is plasticity? 1
b. "Acid mixed water is an electrolytic conductor." — Why? 2
c. In which condition QD line is similar to QR of the stem? Explain. 3
d. Among A, B, C gases stated in the graph which one can be liquefied easily? Analyze. 4

Answer to the question no. 40

a Plasticity : Plasticity describes the deformation of a solid material undergoing non-reversible changes of shape in response to applied force.

b Pure distilled water is non-Conductor of electricity. If few drops of acid is added to water, the compounds separate into separate ion and having that small number of iron increase conductivity astronomically. When D electromotive force is applied to ion, H_2 and O_2 produce at cathode and anode respectively. So due to movement of ion acid mixed water is electrolytic conductor.

Reduction in cathode:

$$2H^+ + 2e^- \longrightarrow H_2$$

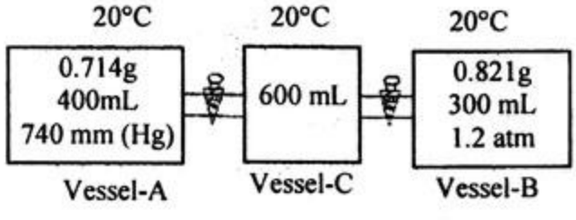
Oxidation in anode:

$$4OH^- \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^{-1}$$

c In the stem, QD line is for helium which is a real gas and QR line is for ideal gas. D gas is deviated from ideal behavior. We know, real gases deviated from ideal behavior due to inter molecular attraction or repulsion and due to molecules have own volume. In the stem, in case of D gas the value of PV increase with the increase of pressure. Because at high pressure intermolecular repulsion become active between molecules. So at low pressure repulsion in minimum. As a result the gas will show less deviation at low pressure and will behave like ideal gas. Again, if temperature is increased volume also increase. As a result the molecules become far away from each other. As a result repulsion will be minimum and deviation will be decreased. So we can conclude that at high temperature and low pressure, the repulsion is minimum. As a result the QD line will be similar as QR line.

d According to stem, the molecular weight of A, B, C gas are 20, 2 and 44 respectively. So A gas Ne, B gas is H_2 and C gas is CO_2 liquefaction of gas can be done by increasing pressure and decreasing temperature. But during applying pressure the temperature must be below the critical temperature. The critical temperature is the temperature of a gas above which the gas can not be liquefied by applying pressure. The critical temperature of Ne, H_2 and CO_2 are – 397.7°C, – 240°C and 31.1°C. The critical temperature of C gas (CO_2) is above room temperature. So CO_2 gas can be liquefied by applying pressure. But in case of Ne and H_2 the critical temperature is very low.
So, to liquefy Ne and H_2 it should decrease temperature below its critical point which is very difficult. As a result Ne and H_2 can not be liquefied by applying pressure at room temperature. Moreover, Joule Thomson effect is not effective for H_2 and Ne gas. So C gas (CO_2) can be liquefied easily among A, B, C gas.

Question ▶ 41



Distance of A and B are same from Vessel-C.

[The Millennium Stars School and College, Rangpur]

a. What is critical temperature? 1
b. How is SI unit used in the value of R? 2
c. The gases of vessel-A & B are mixed in vessel-C what will be the changes in pressure? Explain. 3
d. If stop-cock is opened up then which gas will reach at the vessel-C first between vessel-A and vessel-B gas? Analyze mathematically. 4

Answer to the question no. 41

a The temperature above which the gas can not be liquefied by applying pressure is called critical temperature.

b R is the moler gas constant from ideal gas equation, we get

$PV = nRT$

$$\Rightarrow R = \frac{PV}{RT} \quad \ldots\ldots\ldots\ldots \text{(i)}$$

At S.T.P for 1 mol ideal gas.

Mole no n = 1 mol

Temperature, T = 0°C = 273

Volume, $V = 22.4\ L = 22.4 \times 10^{-3} m^3$

Pressure, P 1 atm = 101325 Pa

So from equation (i),

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

$$= \frac{101325 \times 22.4 \times 10^{-3}}{1 \times 273}$$

$$= 8.314 JK^{-1}mol^{-1}$$

So value of R in S. I unit is $8.314 JK^{-1}mol^{-1}$.

c In vessel A there is 400 mL gas at 740 mm(Hg) pressure and 300 mL gas at 1.2 atm pressure in B vessel when gases of A and B vessel mixed in C vessel which volume is 600 mL pressure will be changed.

From the Dalton's law of partial pressure we get.

$PV = P_1V_1 + P_2V_2$

$$\Rightarrow P \times 600 = \frac{740}{760} \times 400 + 1.2 \times 300$$

$$\Rightarrow P \times 600 = 389.4736 + 360$$

$$\Rightarrow P = \frac{749.4736}{600}$$

$\Rightarrow P = = 1.249$ atm

$\therefore P = 1.249$ atm

Here,
For A vessel,
Volume, $V_1 = 400$ mL
Pressure, $P_1 = 740$ mm (Hg)
$= \frac{740}{760}$ atm
For B vessel,
Volume, $V_2 = 300$ mL
Pressure, $P_2 = 1.2$ atm
For C container,
Volume, V = 600 mL
Pressure, P = ?

$\therefore$ The pressure in C container will be 1.249 atm.

d If stop-cock is opened up the gas which has higher diffusion rate between A and B vessel gas will reach at C vessel first.

For vessel-A gas

From ideal gas equation
We get,

$P_A V_A = n_A RT_A$

$$\Rightarrow P_A V_A = \frac{W_A}{M_A} RT_A$$

$$\Rightarrow M_A = \frac{W_A RT_A}{P_A V_A}$$

Here,
Temperature, $T_A = 20°C = 293K$
Weight, $W_A = 0.714$ g
Volume, $V_A = 400\ mL = \frac{400}{1000} L$
$= 0.4$ L

$$= \frac{0.714 \times 0.0821 \times 293}{097368 \times 0.4}$$

$\therefore M_A = 45.767$

Molecular weight of A gas is 45.767

Pressure, $P_A = 740$ mm(Hg)

$$= \frac{740}{760} \text{ atm}$$

$= 0.97368$ atm

Molecular weight, $M_A = ?$

For vessel-B gas

From ideal gas equation

We get,

$$M_B = \frac{W_B R T_B}{P_B V_B}$$

$$= \frac{0.821 \times 0.0821 \times 293}{1.2 \times 0.3}$$

$= 54.86$

$\therefore M_B = 54.86$

Here,

Weight, $W_B = 0.821$ g

Pressure, $P_B = 1.2$ atm

Volume, $V_B = 300$ mL

$= 0.3$L

Temperature, $T = 20°C$

$= 293K$

Molecular weight, $M_B = ?$

Molecular weight of B gas is 54.86 according to Graham's diffusion law.

We get,

$$\frac{\gamma_A}{\gamma_B} = \sqrt{\frac{M_B}{M_A}}$$

$$= \sqrt{\frac{54.86}{45.767}}$$

$\gamma_A : \gamma_B = 1.095 : 1$

$\therefore \gamma_A > \gamma_B$

So diffusrion rate of A gas is higher than diffusion rate of B gas . A gas will reach in vessel-C first.

Question ▶ 42 $PV = nRT$

[The Millennium Stars School and College, Rangpur]

a. What is tanning? 1

b. How is metamerism different than tautormerism? Explain. 2

c. Establish a relation among partial pressure, mole fraction and total pressure by using stem's equation. 3

d. What changes are taken to follow the rules of real gases of the equation of the stem? Analyze. 4

Answer to the question no. 42

a Tanning is the process of converting animal skin into leather by soaking in a liquid containing tannic acid or by use of other chemicals.

b Metamerism is a type of isomerism occurs due to the different number of Carbon atoms one either side of functional group. In Metamerism isomers belong to same homologous series. Metamerism does not create equilibrium between isomers. For example, $CH_3COCH_2CH_2CH_3$ (pentanone-2)

and $CH_3CH_2COCH_2CH_3$ (pentanone-2) are metamers of each other.

c Relation among partial pressure mole fraction and total pressure:

Let, at constant temperature, T in a container of V volume there are n_1, n_2, n_3 ---------- etc mole mutually unreactive gases are present Respectively. The partial pressure of gases are P_1, P_2, P_3..... etc. respectively total pressure of the mixture is P and total mole number is n.

So, for the first gas according to ideal gas equation,

$P_1V = n_1RT$

$$\Rightarrow P_1 = \frac{n_1RT}{V} \quad \text{..... (i)}$$

Similarly for 2nd and 3rd gases,

We get,

$P_2V = n_2RT$

$$\Rightarrow P_2 = \frac{n_2RT}{v} \quad \text{..... (ii)}$$

$P_3V = n_3RT$

$$\Rightarrow P_3 = \frac{n_3RT}{v} \quad \text{..... (iii)}$$

For the gas mixture,

$PV = nRT$

$$\Rightarrow P = \frac{nRT}{v} \quad \text{.....(iv)}$$

So, dividing equation (i) by equation (iv) we get.

$$\frac{P_1}{P} = \frac{n_1}{n}$$

$$\Rightarrow P_1 = \frac{n_1}{n} \times P$$

$$\Rightarrow P_1 = X_1 \times P \left[\frac{n_1}{n} - \text{mole fraction of 2nd gas}\right]$$

Similarly,

$$P_2 = \frac{n_2}{n} \times P$$

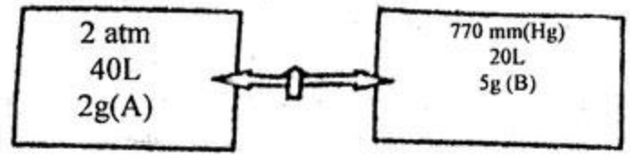
$$\Rightarrow P_2 = X_2 \times P \left[\frac{n_2}{n} - \text{mole fraction of 2nd gas}\right]$$

$\therefore$ Partial pressure = mole fraction x total pressure.

It is the relation among partial pressure, mole fraction and total pressure.

d Similar to the question no.- 21(d)

Question ▶ 43



Temperature = 25°C

[Cantonment English School and College, Chattogram]

a. What is ideal gas? 1

b. Why is water added to lead storage battery? 2

c. Calculate the total pressure of the mixture when stopcock is opened. 3

d. Which of the gases will have greater rate of diffusion? Analyze mathematically. 4

Answer to the question no. 43

a **Ideal gas :** The gas which follows Boyle's, Charle's and Avogadro's law at any temperature and pressure is called ideal gas.

b Before charging water is added to lead storage battery. Because water is lost from battery by evaporation during charging due to evaluation of heat. Moreover during charging electrolysis of water produces hydrogen and oxygen. As a result, amount of water decrease which makes sulphuric acid. Conentrated water also act as a dielectric barrier between two battery cells.

So water is added to lead storage battery before charging.

c When stopcock is opened the total volume of the mixtures will be (40 + 20) L = 60 L

According to Dalton's law of partial pressure, we get

$PV = P_1V_1 + P_2V_2$

$\Rightarrow P \times 60 = 2 \times 40 + \frac{770}{760} \times 20$

$\Rightarrow P \times 60 = 80 + 20.263$

$\Rightarrow P = \frac{100.263}{60}$

$\Rightarrow P = 1.67$

$\therefore P = 1.67$ atm

Here,

For A gas,

Pressure, $P_1 = 2$ atm

Volume, $V_1 = 40$L

For B gas,

Pressure, $P_2 = .770$ mm (Hg)

$= \frac{770}{760}$ atm

Volume, $V_2 = 20$L

For Mixture,

Volume, V = 60 L

Pressure, P = ?

So Pressure of the mixture will be 1.67 atm when stopcock is opened.

d According to Graham's law of diffusion the gas which molecular weight is lower will have higher diffusion rate.

According to ideal gas equation.

$M_A = \frac{W_A R T_A}{P_A V_A}$

$= \frac{2 \times 0.0831 \times 298}{2 \times 40}$

$\Rightarrow M_A = 0.61165$

$\therefore M_A = 0.61165$

For A gas,

Pressure, $P_A = 2$ atm

Volume, $V_A = 40$L

Weight, $W_A = 2$g

Temperature, $T_A = 25°C$

$= 298$ K

Molecular weight, M_A = ?

Molecular weight of A gas is 0.61165.

According to ideal gas equation.

$M_B = \frac{W_B R T_B}{P_B V_B}$

$= \frac{5 \times 0.0821 \times 298}{\frac{770}{760} \times 20}$

$\Rightarrow M_B = 6.037$

$\therefore M_B = 6.037$

For B gas,

Pressure, $P_B = 770$ mm(Hg)

$= \frac{770}{760}$ atm

Volume, $V_B = 20$L

Weight, $W_B = 5$g

Temperature, $T_B = 25°C$

$= 298$ K

Molecular weight, M_B = ?

Molecular weight of B gas is 6.037.

According to Graham's law.

$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$

$\Rightarrow \frac{r_A}{r_B} = \sqrt{\frac{6.037}{0.61165}}$

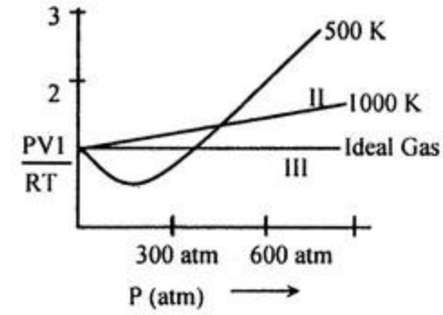
$\Rightarrow \frac{r_A}{r_B} = 3.1416$

$\therefore r_A : r_B = 3.1416 : 1$

$\therefore r_A > r_B$

So, A gas will have greater diffusion rate B gas.

Question ▶ 44 X is real gas which molecular mass is 28. At different temperatures, $\frac{PV}{RT}$ Vs. P curves of 'X' gas and a curve of an ideal gas are shown below:



[Mirzapur Cadet College, Tangail]

a. What is Graham's law of gas diffusion? 1

b. Why CO gas is called a silent killer? 2

c. Calculate the kinetic energy of one molecule of 'X' gas at its lower temperature of the stem. 3

d. Analyze the reasons for the variation of curves I and II with the curve III of the stem. 4

Answer to the question no. 44

a Graham law states, the rate of effusion of a gas at a given temperature inversely proportional to the square root of the density of its particles.

b This colorless and odorless gas in deadly poisonous for human beings as the affinity of hemoglobin of blood for CO gas is much greater than that of O_2. CO present in air combines with the hemoglobin of blood about 300 times more easily than does O_2 to from carboxyl hemoglobin.

$Hb + CO \rightleftharpoons HbCO$

Thus during our respiration the O_2 of air normally combine with hemoglobin to from oxy- hemoglobin.

$Hb + O_2 \rightleftharpoons HbO_2$

This oxy-hemoglobin transport oxygen to different cells of the body where gives up oxygen and absorbs CO_2 and return to the lungs where the absorbed CO_2 is released with our exhalation. If the percentage of CO in air increases, carboxy hemoglobin is produced instead of producing oxy- hemoglobin. As a result transport of O_2 in different parts of the body is inhibited causing acute anoxia and finally leads to death.

c According to the stem, Molecular mass of X gas is 28 g/mol.

Thus, M = 28 g/mol

Moles number, n = 1 mol

Lower temperature from curve of stem, T = 500 K

Universal gas constant, $R = 8.314$ JK^{-1} mol^{-1}

Kinetic energy, E_k = ?

We know, $E_k = \frac{3}{2} nRT$

$= (\frac{3}{2} \times 1 \times 8.314 \times 500)$ Joule

$= 6235.5$ Joule

Molecules of 1 mole gas $= 6.022 \times 10^{23}$

Thus, 6.022×10^{23} molecules of X have $E_k = 6235.5$ Joule

$\therefore$ 1 molecule of X have $E_k = \frac{6235.5}{6.022 \times 10^{23}}$ J molecule^{-1}

$= 1.0354 \times 10^{-20}$ J molecule^{-1}

Therefore, Kinetic energy of one molecule of X gas $= 1.0354 \times 10^{20}$ J

d The X gas stated in the stem is a real gas with molecular mass 28 g/mol. Thus X is the Nitrogen (N_2) gas. The curve (iii) of stem is curve of ideal gas and the curves (i) and (ii) are for real gas N_2. The reasons for the variation of curves (i) and (ii) with curve (iii) are analyzed as follows.

Postulate of kinetic theory says that the volume of space occupied by molecules is negligible compared with the total gas volume. To derive the ideal gas law from kinetic theory, we must assume that each molecule is free to move throughout the entire gas volume, V. At low pressures, where the volume of individual molecules is negligible compared with the total volume available, the ideal gas law is a good approximation. At higher pressures, where the volume of individual molecules becomes important, the space through which a molecule can move is significantly differently from V.

Postulate says that the forces of attraction between molecules (intermolecular forces) in a gas are very weak or negligible. This is a good approximation at low pressures, where molecules tend to be far apart, because these forces diminish rapidly as the distance between molecules increases. Intermolecular forces become significant at higher pressures, though, because the molecules tend to be close together. Because of these intermolecular forces, the actual pressure of a gas is less than that predicted by ideal gas behavior, As a molecule begins to collide with a wall surface, neighboring molecules pull this colliding molecule slightly away from the wall, giving a reduced pressure.

Question ▶ 45 At 27°C, two gases A and B are taken in two different containers. They can mix but do not chemically react.

Here, $V_A = 200$ cm^3; $V_B = 300$ cm^3; $P_A = 30$cm (Hg) and $P_B = 40$cm (Hg). *[Mirzapur Cadet College, Tangail]*

a. What is Dalton's law of partial pressure? 1

b. Why is soap misused for cleaning dirty cloth with $Ca(HCO_3)_2$ containing water? 2

c. What will be the total pressure, if the two containers are connected at the same temperature. 3

d. At which temperature the pressure of 'A' gas will be equal to that of 'B' gas in its own container?– Analyze mathematically. 4

Answer to the question no. 45

a The total pressure exerted is equal to the sum of the partial pressures of the individual gases this is the Dalton's law of partial pressure.

b $Ca(HCO_3)_2$ containing water is called hard water. Soaps are sodium or potassium salts of long chain fatty acids. When soap is added to hard water, the Ca^{2+} ions present in hard water react with soap. The sodium salts present in soaps are converted to their corresponding calcium and magnesium salts which are precipitated as scum. The insoluble scum sticks on the clothes and so the cleaning capacity of soap is reduced.

$Ca^{2+} + RCOONa \longrightarrow RCOOCa + 2Na^+$

Soap Calcium salt(scum)

Thus way Soap is misused for cleaning dirty cloth with $Ca(HCO_3)_2$ containing water.

c In the stem of figure-A,

Pressure, $P_A = 30$ cm (Hg)

Volume, $V_A = 200$ cm^3

In figure-B,

Pressure, $P_B = 40$ cm (Hg)

Volume, $V_B = 300$ cm^3

$\therefore$ Total Volume, $V = V_A + V_B = (200 + 300)$ cm^3 $= 500$ cm^3

We have,

$PV = P_AV_A + P_BV_B$

$\Rightarrow P = \frac{P_AV_A + P_BV_B}{V}$

$\Rightarrow P = \frac{30 \times 300 + 40 \times 300}{500} = 42$ cm(Hg)

The total pressure of two containers' are 42 cm(Hg).

d According to the instruction,

The pressure, P_A = the pressure, $P_B = P = 40$ cm(Hg).

The Volume, $V_A = 200$ cm^3

The Volume, $V_B = 300$ cm^3

Temperature, TA $= (27 + 273)$K $= 300$ K

We have, $\frac{P_AV_A}{T_A} = \frac{P_BV_B}{T_B}$

$\Rightarrow \frac{PV_A}{T_A} = \frac{PV_B}{T_B}$

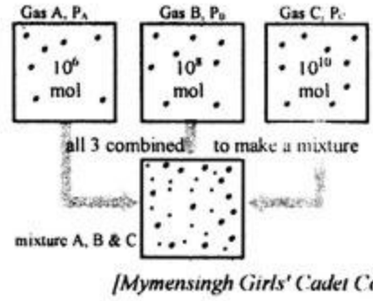
$\Rightarrow \frac{V_A}{T_A} = \frac{V_B}{T_B}$

$\Rightarrow T_B = \frac{V_B \times T_A}{V_A}$

$\Rightarrow T_B = \frac{300 \times 300}{200} = 450$ K

450K temperature the pressure of 'A' gas will be equal to that of 'B' gas in its own container.

Question ▶ 46 Observe the picture carefully and answer following questions.



[Mymensingh Girls' Cadet College, Mymensingh]

a. What is BOD? 1
b. Why is HS^- amphoteric? 2
c. If total pressure is 4 atm, Calculate P_A. 3
d. How could you establish the mathematical relationship among the pressure of given gasses in the stem? 4

Answer to the question no. 46

a The required amount of oxygen for the decomposition of organic micro organism in per litre contaminated water, the indicator number of that among of oxygen is called BOD (Biochemist Oxygen Demands).

b The substance who can acts as both acid and base is called amphoteric substance. HS^- react with base NH_3 and donate a proton (H^+), thus HS_2^- is a base here. On the other hand HS^- can accept proton from acid like HCl, thus HS^- acts as a base. Thus HS^- is a amphoteric substance

$HS^- + NH_3 \longrightarrow S^{2-} + NH_4^+$
Acid Base

$HS^- + HCl \longrightarrow H_2S + Cl^-$
Base Acid

c According to the stem, Moles number of Gas A,

$$n_A = 10^6 \text{ mol}$$

Moles number of Gas B, $n_B = 10^8$ mol

Moles number of Gas C, $n_c = 10^{10}$ mol

Mole fraction of gasA, $X_A = \frac{n_A}{n_A + n_B + n_C}$

$$\Rightarrow X_A = \frac{10^6}{10^6 + 10^8 + 10^{10}}$$

$$\Rightarrow X_A = \frac{10^6}{1.0101 \times 10^{10}}$$

$$\therefore X_A = 9.9 \times 10^{-5}$$

Total pressure, P = 4 atm

Pastial pressure of A, $P_A = X_A P$

$$\Rightarrow P_A = 9.9 \times 10^{-5} \times 4$$

$$\therefore P_A = 3.96 \times 10^{-4} \text{ atm}$$

d From the answer part–C, we have

Partial pressure of Gas A, $P_A = 3.96 \times 10^{-4}$

Mole fraction of gas B, $X_B = \frac{10^8}{10^6 + 10^8 + 10^{10}}$

$$= \frac{10^8}{1.0101 \times 10^{10}}$$

$$= 9.9 \times 10^{-3}$$

Portal pressure of gas B, $P_B = PX_B$

$$= 4 \times 9.9 \times 10^{-3}$$

$$= 3.96 \times 10^{-2}$$

Mole fraction of gas C, $X_c = \frac{10^{10}}{1.0101 \times 10^{10}}$

$$= 0.99$$

Portial pressure of gas C, $P_C = PXc$

$$= 4 \times 0.99$$

$$= 3.96$$

Thus, the total pressure, $P_A + P_B + P_C = 3.96 \times 10^{-4} + 3.96 \times 10^{-2} + 3.96$

$$\Rightarrow P_A + P_B + P_C = 3.99999$$

$$\Rightarrow P_A + P_B + P_C \equiv 4.0$$

$$\therefore P_A + P_B + P_C = P$$

This is the mathematical law for gases A, B and C

Question ▶ 47 (i) ClO_4^- (ii) H_2SO_4 (iii) CN^- (iv) $R–NH_2$

[Rajshahi Cadet college, Rajshahi]

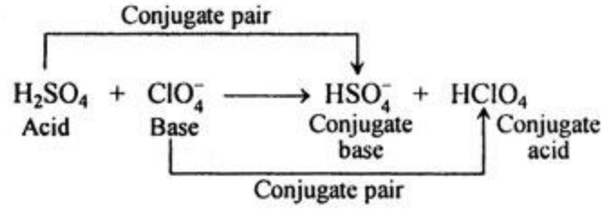
a. What is cooking liquor? 1
b. Whay is gypsum used in cement production? 2
c. Find out the conjugate acid and conjugate base of the reaction between (i) & (ii). 3
d. All Lewis bases are Bronsted bases. Analyze it with the help of (iii) & (iv). 4

Answer to the question no. 47

a The substances which are added to food products to make the food more attractive and to make a layer on food are called food liquor.

b Gypsum is mainly used for regulating the setting time of cement. During the manufacture of cement, upon the cooking of clinker a small (5%) amount of gypsum is introduced during the final grinding process. Gypsum is added to control the setting of cement, If not added the cement will set immediately after mixing of water leaving no time for concrete placing when cement as hydrated gypsum reacts with C_3 A quickly to generate calcium sulfoaluminate hydrate which deposits and forms a protection film on the cement particles to hinder the hydration of C_3A and delay the setting times of cement.

c According to the stem feaction between (i) and (ii) compounds is given below.



It is clear that H_2SO_4 donates a proton (acts as an acid) and form HSO^-_4 ion which has a tendency to accept a proton (can act as a base). Similarly ClO_4^- accepts a proton and acts as a base but it form $HClO_4$ ion which has a tendency to behave an acid. In other words an acid donates a proton and becomes a base and a base accepts a proton and becomes an acid. Therefore, in above reaction $HClO_4$ is conjugate acid of ClO_4^- base and HSO_4^- is conjugate base of acid H_2SO_4.

d The chemical species (iii) and (iv) stated in the stem are CN^- and $R - NH_2$ respectively.

According to the Lewis concept of acid and bases, the acid are those substance can accept at least a pair of electrons while base are those substances can donate at least a fair of electrons.

The stem's species CN^- and $R - NH_2$ are lewis base, because they have lone fair electrons at N-atom, therefore donation of lone fair is Possible for both substances.

$R - \ddot{N}H_2 + H^+ \longrightarrow R - N^+H_3$
Base Acid

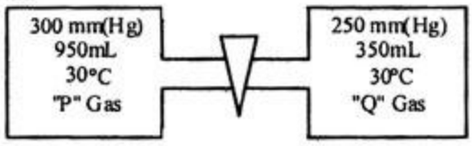
$C\ddot{\ddot{N}}^- + H^+ \longrightarrow HCN$
Base Acid

According to the Bronsted lowery concept, Acid is a proton doner and a base is a ptoton recceptor.

The chemical species CN^- and $R - NH_2$ both are proton acceptor that also shown in above two equation. Thus CN^- and $R - NH_2$ are Bronsted base.

Therefore stem's compund CN^- and $R - NH_2$ are bases according to both the theories.
So, All lewis bases are Bronsted bases.

Question ▶ 48



[Rajshahi Cadet college, Rajshahi]

a. What is Galvanic cell? 1
b. Why can 'Cu' react with dil. HNO_3? Explain. 2
c. Calculate the number of molecules of "P" gas. 3
d. If temperature of the gases is increased at 50°C temperature, the total pressure of the gas mixture of "P" and "Q" is also increased when the cork is opened. Justify it mathematically. 4

Answer to the question no. 48

a A galvanic cell is on electrochemical cell that ge.ives electrical energy from spontanceous redox reaction taking place within the cell.

b Copper is an uncreative metal and does not react in normal condition with dilute acid. However, Cu reacts with dilute HNO_3. Because HNO_3 is an Oxidizing agent. The products are oxides of nitrogen instead of $H_2(g)$.

$Cu + 3HNO_3 \longrightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$

$3Cu + 8HNO_3 \longrightarrow 3\,Cu(NO_3)_2 + 3H_2O + 2NO$

c According to stem,

Pressure at container of P gas

$$P = 500 \text{ mm (hg)}$$
$$= \frac{500}{760} \text{ atm}$$
$$= 0.66 \text{ atm}$$

Volume, $V = 950$ mL
$$= \frac{950}{1000} \text{ L}$$
$$= 0.95 \text{ L}$$

Temperature, $T = 30°C$
$$= (273 + 30) \text{ K}$$
$$= 303 \text{ K}$$

Moles number, $n = ?$

From ideal gas equation we have

$$PV = nRT$$
$$\text{or, } n = \frac{PV}{RT}$$
$$\text{or, } n = \left(\frac{0.66 \times 0.95}{0.0821 \times 303}\right) \text{mol}$$
$$\text{or, } n = 0.0252 \text{ mol}$$

$\therefore$ Number P molecules $= (6.022 \times 10^{23} \times 0.0252)$ molecules
$$= 1.52 \times 10^{22} \text{ molecules}$$

d According to stem for P gas

$P_1 = 500$ mm (hg)

$V_1 = 950$ mL

For Q gas,

$P_2 = 250$ mm (hg)

$V_2 = 550$ mL

Total volume, $V = V_1 + V_2$
$$= (950 + 550) \text{ mL}$$
$$= 1500 \text{ mL}$$

Total pressure at $30°C = P$

We know $PV = P_1V_1 + P_2V_2$

$$\Rightarrow P = \frac{P_1V_1 + P_2V_2}{V}$$
$$\Rightarrow P = \frac{500 \times 950 + 250 \times 550}{1500}$$
$$\Rightarrow P = \frac{612500}{1500} \text{ mm (Hg)}$$
$$\therefore P = 408.33 \text{ mm (Hg)}$$

Again, Initial Temperature, $T_1 = 30°C$
$$= 303 \text{ K}$$

Initial Pressure, $P_1 = P = 408.33$ mm (Hg)

Final Temperature, $T_2 = 50°C$
$$= (50 + 273) \text{ K}$$
$$= 323 \text{ K}$$

Final Pressure, $P_2 = ?$

We also know,

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$
$$\Rightarrow \frac{P_2}{T_2} = \frac{P_1}{T_1}$$
$$\Rightarrow P_2 = T_2\frac{P_1}{T_1}$$
$$\Rightarrow P_2 = 323 \times \frac{408.33}{303} \text{ mm (Hg)}$$
$$\therefore P_2 = 435.28 \text{ mm (Hg)}$$

Thus, If the temperature of the gas mixture increased at 50°C. the total pressure changed from 408.33 mm (Hg) to 435.28 mm (Hg).

Question ▶ 49 Scientists Boyle, Charles and Avogrado did experiments on volume (V), pressure, (P) Kelvin temperature (T) and mole number (n) of different gases and established the laws of gases. *[Joypurhat Girls' Cadet College, Joypurhat]*

a. What do you mean by STP? 1
b. Find out the value of R in litre-atmosphere unit. 2
c. Establish the combined law by the laws of scientists stated in the stem. 3
d. Analyze and establish the idea of absolute zero temperature from the laws stated by the scientists in the stem. 4

Answer to the question no. 49

a STP stands for standard Temperature and Pressure. In this unit system T = 273 K, P = 1 atm and V = 22.4 L.

b From the equation of ideal gas we have,

$PV = nRT$ ..... (i)

P = 1 atm, V = 22.4 L, n = 1 mole, T = 273 K

From the equation no- (1)

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

$$= \frac{1 \text{ atm} \times 22.4 \text{ L}}{1 \text{ moL} \times 273 \text{ K}}$$

$= 0.0821 \text{ Latm } K^{-1}mol^{-1}$

Here,

P = Pressure, V = Volume,

n = mole number, T = Absolute temperature, and R = Universal gas constant.

c Scientists Boyle, Charles established the laws of gass. According to the boyle's law.

$V \propto \frac{1}{P}$ [When T constant] ..... (i)

Boyle's Law : It is state that volume is inversely proportional to pressure when Temperature is constant.

Charle's Law : At constant pressure, the volume of fixed mass of a gas is directly proportional to the absolute temperature.

$V \propto T$ when P is fixed ..... (ii)

Avogadro's Hypothesis: At same temperature ans pressure, equal volume of all gases [element or compound] contains equal number or molecules.

$V \propto N$ when P and T are fixed.

$\therefore V \propto n$ ..... (iii)

[$\therefore$ mole number is proportional to the number of molecules i.e.$n \propto N$]

From equation i. ii. and iii. we get,

$$V \propto \frac{1}{P} \times T \times n$$

$$\therefore V = R\frac{1}{P} \times T \times n \text{ [Where R is the molar gas constant]}$$

or, PV = nRT where R is molar gas constant

This is the ideal gas equation.

d The absolute zero temperature is a temperature when the volume of any gas is theoretically zero. The absolute temperature of gas is – 273°C. Boyle, Charles and Avogadro's law are stated for steam. But the idea of absolute zero is derieved from the charle's law. The charle's law states that– "At constant pressure, the volume of a define mass of a gas increases or decreases by $\frac{1}{273}$ part of its volume at 0°C, for each degree celsius rise or fall in temperature."

According to Charles law given earlier the volume of a given mass of a gas at temperature t°C is related to its volume at 0°C.

$$V = V_0\left(1 + \frac{t}{273}\right)$$

$$= V_0\left(\frac{273 + t}{273}\right)$$

At, absolute zero temperature,

t = – 273°C

$$\therefore V - 273 = V_0 + V_0 \times \frac{-273}{273} = V_0 - V_0 = 0$$

This, the idea of absolute zero temperature from the Charles law is established.

Question ▶ 50

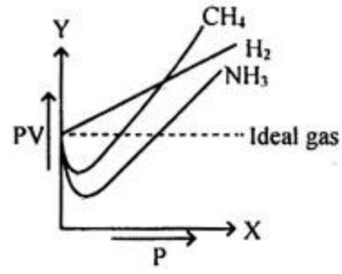


Figure: PV versus P graph

[Joypurhat Girls' Cadet College, Joypurhat]

a. What is real gas? 1

b. What is the relationship between pressure and volume at constant temperature? Which law belongs to this relationship? 2

c. The line shows constancy with the increase of pressure in the above graph— why? 3

d. The gases mentioned in the stem deviate differenty— explain in your own logic. 4

Answer to the question no. 50

a The gas that at all temperature of and Charles, pressure does not follow the gas laws Boyles, is known as real gas. H_2, N_2, O_2 are real gases. Real gases obeys gas laws only under law pressure and high temperature. Which is consider only vander waal's law.

b Boyle's law describe that the relationship between pressure and volume at constant temperature. The relationship is know as Boyle's law which states that at constant temperature the volume of a given mass of a gas is inversely proportional to the pressure.

$V \propto \frac{1}{P}$

Or, $V = \frac{k}{P}$

Where V is the volume, P is the Pressure of the gas and k is a constant of Proportionality. Whose value depends upon the mass and temperature of the gas.

c The line shows constancy with the increase of pressure in the above graph and it indicated the behaviour of ideal gas. In case of ideal gas, the actual volume of molecules at any temperature and pressure are considered as negligible with respect to the total volume. That's why it is said that, if the gas is ideal its molecules move freely. Scientist Amagat showed the characteristic of ideal and real gas nicely by Amagat's diagram. From the Amagat's diagram we know–

i. There is no intermolecular force attraction in between the molecules of the ideal gases.

ii. At all temperature and pressure ideal gases obey the Charles law.

iii. The volume occupied by the gaseous molecules is negligible as compared to the total volume occupied by the gas.

For the above reasons, the lines show constancy with the increase of Pressure in the above graph.

d The above graph shows the increasing of PV with P. The gases which are mentioned in the graph deviate differently. The gas which does not obey general gas equation and other gas laws at all temperatures and pressures is called non-ideal gas or real gas. From the chart, real gas are CH_4, H_2, NH_3. In case of low pressures and high temperatures, most of these real gas show ideal behavior. But, high pressures and low temperatures, the behavior of real gas are changed. Every real gas has its individual character. In the graph, the lines of different real gases are called Amagat's curve.

Different real gas values of PV big change with the change of P. PV increases steadily with the increase of P for small molecules, the PV at first decrease and reaches a minimum point then start to rise with the increase of pressure. In case of CH_4, NH_3 the compressibility factor, Z is less than 1. The compressibility actor of NH_3 is bigger than CH_4. In case of H_2, the compressibility factor, $\frac{PV}{RT} = Z$ is greater than 1. It's compressibility factor is less than above gases compressibility factor.

That's why the gases mentioned in the stem deviate differently from each other.

Question ▶ 51

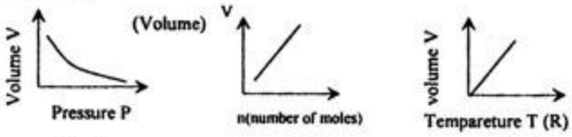


Fig-A Fig-B Fig-C

[Pabna Cadet College, Pabna]

a. What is absolute zero temperature? 1

b. Calculate the value of R in L-atm unit. 2

c. State the gas law of stem mention figures— A, B & C. 3

d. Is it possible to determine ideal gas equation from mention figures? Explain with logic? 4

Answer to the question no. 51

a Absolute zero temperature is a temperature when the volume of any gas is theoritically zero. The absolute temperature of gas is –273°C.

b From the equation of ideal gas we have,

PV = nRT ..... (i)

P 1 atm, V = 22.4 L, n = 1 mole, T = 273 K.

From the equation no-(1)

$$R = \frac{PV}{nT} = \frac{1 \text{ atm} \times 22.4 \text{L}}{1 \text{ amol} \times 273 \text{ K}} = 0.0821 \text{ Latm moL}^{-1}\text{K}^{-1}$$

P = Pressure, V = Volume, n = Mole number, T = Absolute temperature, R = Universal gas constant.

c The gas law of stem mentioned figure A indicates the law of Boyle, B indicates the law of Avogadro and C indicates the law of Charles.

Let pressure, volume and temperature of a fixed mass of gas be P, V and T respectively.

Boyle's Law : At constant temperature the volume of a fixed mass of gas is inversely proportional to its applied pressure.

$V \propto \frac{1}{P}$ when T is fixed

Charle's Law : At constant pressure the volume of a fixed mass of gas is directly proportional to the absolute temperature.

$V \propto T$ when P is fixed.

Avogadro's Hypothesis : At same temperature and pressure, equal volume of all gases [element or compound] contains equal number of molecules.

$V \propto N$ when P and T are fixed.

$\therefore V \propto n$

[$\because$ mole number is proportional to the number of molecules i.e. $n \propto N$]

d Yes, it is possible to determine ideal gas quation (PV = nRT) from mention figures in the stem. The mentioned figures are the Boyles, Charles' and Avogadro's Law.

Let pressure, volume and temperature of a fixed mass of gas be P, V and T respectively.

Boyle's Law : At constant temperature the volume of a fixed mass of gas is inversely proportional to its applied pressure.

Mathematical form : $V \propto \frac{1}{P}$ when T is fixed ..... (i)

Charle's Law : At constant pressure the volume of a fixed mass of gas is directly proportional to the absolute temperature.

Mathematical form : $V \propto T$ when P is fixed ..... (ii)

Avogadro's Hypothesis : At same temperature and pressure, equal volume of all gases [element or compound] contains equal number of molecules.

Mathematical form : $V \propto N$ when P and T are fixed ..... (iii)

$\therefore V \propto n$

[$\because$ mole number is proportional to the number of molecules i.e. $n \propto N$]

From equation, (i), (ii) and (iii) we get,

$V \propto \frac{1}{P} \times T \times n$

$\therefore V = R\frac{1}{P} \times T \times n$ [where R is the molar gas constant]

or, PV = nRT where R is the molar gas constant.
This is the ideal gas equation.

Question ▶ 52

Ideal Gas Equation		Van der Waal's Equation
P	becomes	$P + n^2a/V$
V	becomes	V-nb

Fig-A Fig-B

[Pabna Cadet College, Pabna]

a. What is SATP? 1
b. State Graham's law of diffusion? 2
c. What is the causes of deviation of fig-B from fig-A equation. 3
d. At 53°C volume of one mole of real gas is 5.7×10^{-2} L. If the vander waal's constants, a = 3.592 atm L^{-2} mol^{-2} and b = 4.267×10^{-2} $Lmol^{-1}$, what is pressure of the gas? 4

Answer to the question no. 52

a SATP stands for Standard Ambient Temperature and Pressure. Int his method, temperature and pressure are considered as 25°C or 298K. 10^2 kPa and 24.8L are considered as volume.

b Graham's Law of diffusion is stated.

Graham's Law : At a given temperature and pressure the rate of diffusion of a gas is inversely proportional to the square root of its density.

Mathematically this law can be xpressed as, $r \propto \sqrt{\frac{1}{d}}$

Where r is the rate of diffusion and d is the density of the gas. If r_1 and r_2 represent the rate of diffusion of gases.

c In the stem, figure A is ideal gas equation and figure B is Vander Waal's equation.

Ideal gas differs from real gas for its individual characteristics. The causes of deviation of Vander Waal's equation from ideal gas equation is given below. Vander Waal's applied the following corrections to the ideal gas equation.

1. Volume correction :

The volume occupied by the molecules cannot be neglected in comparison to the total volume. In case of ideal gas, the volume of gases cannot be negligible. This means that the molecules of real gases are not free to move in whole of volume V but the free volume is less than the observed volume. In other words, the volume of gass is less than the observed volume. Vander Waal's suggests a simple correction term which was subtracted from the observed volume. Therefore, correct volume is thus by applying these two correction in the ideal gas equation PV = RT we get, $(P + \frac{a}{V^2})$ (V–b) = RT for one mole of the gas and for n mole gas the equation stands $(P + \frac{an^2}{V^2})$ (V–nb) = RT. It is theoretically and mathematically proved that the real gas deviated from ideal gas.

d In the stem,

Temperature, T = 53°C = (53 + 273) K = 326 K

Volume, V = 5.7×10^{-2} L

the value of a and b is

a = 3.592 atm L^{-2} mol^{-2}, b = 4.267×10^{-2} $Lmol^{-1}$

According to the Vander Waal's correction law,

$(P + \frac{a}{V^2})(V-b) = RT$

$\Rightarrow \{P + \frac{3.592}{(5.7 \times 10^{-2})^2}\} (5.7 \times 10^{-2} - 4.267 \times 10^{-2}) = 0.082 \times 326$

$\Rightarrow (P + 1105.5709) \times 0.01433 = 26.732$

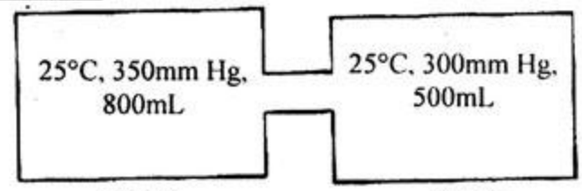
$\Rightarrow 0.01433\ P + 158.42831 = 26.732$

$\Rightarrow 0.01433\ P = 10.8891$

$\therefore P = 759.8861$

According to the Vander Waal's equation, the pressure is 759.8861 atm.

Question ▶ 53



[Rangpur Cadet College, Rangpur]

a. What is Amagat's Curve? 1
b. Electrochemical equivalent of Cu is 0.000329 g/C—— What do you mean by this? 2
c. What will be the total pressure at 40°C temperature if stopcork is opened? 3
d. Analyze which law of gases will be appropriate in cyclinderzing the two gases, A and B. 4

Answer to the question no. 53

a At definite temperature, curved lines obtain for the ideal gas by drawing a graph PV versus P, these curved lines are called Amagat's curve.

b The electrochemical equivalent of Cu is 0.000329 g/C, it means if one coulomb electricity passes through the electrolytic compound Cu^{2+}; then 0.000329g Cu will be deposited in the electrode.

c Given in the stem,

The presure of A gas, P_A = 350 mm(Hg)
The volume of A gas, V_A = 800 mL
The pressure of B gas, P_B = 300 mm(Hg)
The volume of B gas, V_B = 500 mL

Total volume in overall gaseous mixture,

V = (800 + 500) mL
= 1300 mL

and total pressure, P = ?

Now, following the Dalton's partial pressure law,

$PV = P_AV_A + P_BV_B$

or, $P = \frac{P_AV_A + P_BV_B}{V}$

$= \frac{350 \times 800 + 300 \times 500}{1300}$ mm (Hg)

= 330.7692 mm(Hg)

It's the total pressure at 25°C temperature, the pressure has to be determined at 20°C temp.

According to the law of Gay–Lussac,

$\frac{P}{T} = \frac{P_1}{T_1}$

or, $P_1 = \frac{P}{T} \times T_1$

$= \frac{330.7692 \times 313}{298}$ mm(Hg)

= 347.4187 mm(Hg)

Here,
P = 330.7692 mm(Hg)
T = (25 + 273)K
= 298K
P_1 = ?
T_1 = (40 + 273)K
= 313K

d In cylindering the compressed natural gas and liquified natural gas, the gas laws are being applied.

Applying Boyle's law and Charles's law, gases can be compressed or liquified. Gases are compressed or liquefied by increasing the intermolecular attractive forces.

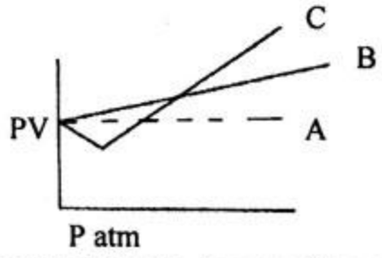
The ways to increase intermolecular attractive forces are–

1. Application of pressure 2. Reduction of temperature,

According to Boyle's law $\left(V \propto \frac{1}{P}\right)$, application of high pressure causes the reduction of volume. The purpose of gas cylindering is to decrease a large volume of gas to a smaller volume by compressing or by liquification.

Applying Boyles' law, the gas molecules are brought very close to each other. This induces the intensive intermolecular forces. Application of a definite amount of pressure causes an optimum quantity of intermolecular forces so that the gas gets compressed or liquified. Gases cannot be liquified by application of pressure only. Besides, in application of pressure, temperature reduction is also required. According to Charles's law, decrease of temperature reduces the volume ($V \propto T$). At a very low temperature, volume-decrease brings the gaseous molecules closer to each other. At this stage, the kinetic energy of molecules cannot overcome the intermolecular force. Because of the effect of the intermolecular forces, the gases undergo liquification. Therefore, the Boyle's law and Charles' law will be appropriate in cylindering the two gases A and B the following in stem.

Question ▶ 54



(Here, C gas is produced by the decomposition of potassium chlorate) *[Rangpur Cadet College, Rangpur]*

a. What is ETP? 1
b. 1-alkyne are acidic— explain. 2
c. Calculate the RMS velocity of C gas at STP. 3
d. Analyze why the graph of B and C gases are not similar to that of A. 4

Answer to the question no. 54

a ETP Or Effluent Treatment Plant is one type of waste water treatment method which is particularly designed to purify industrial waste water for its reuse from the harmful effect caused by the effluent.

b See the question no-14(b).

c Following the stem, from the dissociation of C gas, $KClO_3$–

$KClO_3 \rightarrow KCl + O_2$ (g).

We get, C gas is the O_2.

At STP,

Temperature, $T = 273K$

The molecular weight of O_2, $M = 32g/mol$

$= 32 \times 10^{-3}$ kg/mol

$R = 8.314\ JK^{-1}\ mol^{-1}$

$\therefore$ The RMS velocity of O_2 will be,

$$C = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3 \times 8.314 \times 273}{32 \times 10^{-3}}}\ m/s$$

$= 461.2878$ m/s

d See the question no– 14(d)

Question ▶ 55

Table-1 (1 mol N_2 at 2 atm pressure)	
Volumes V (L)	Temperature °C
22.5	30
24.4	60
26.3	90
28.2	120

Table-2 (A gas at 0°C T)	
Pressure (atm)	Volumes V(L)
0.20	4.50
0.40	2.25
0.60	1.50
0. 80	1.125

[Cumilla Cadet College, Cumilla]

a. What is BTU of coal? 1
b. Why is CH_3COOH weaker than HCOOH? 2
c. Explain the conception of absolute zero temperature from stem table–1 date. 3
d. Will stem table-2 gas data follow Boyle's law? Analyze with justification. 4

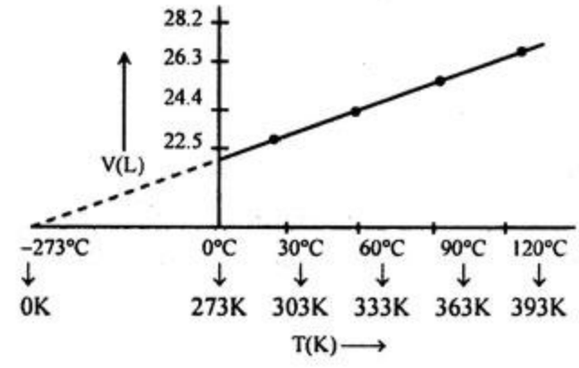
Answer to the question no. 55

a The amount of produced heat in the burning of one pound coal is assume to be it's heat generation efficiency. This heat, when expressed in British thermal unit (BTU) is called BTU of coal.

b In HCOOH acid, H particle is attached with the carboxyl radical and in CH_3COOH acid, methyl ($-CH_3$) radical is a attached with the carboxyl radical. As the methyl radical is positively charged, the partial positive charge of existing carbon in CH_3COOH is reduced ; as a result the ionization of –OH radical is reduced as well.

A part from this, the acidity of both HCOOH and CH_3COOH can be differentiated from the value of reduction constant Ka. The value of Ka for CH_3COOH is 1.8×10^{-5}. As the value of Ka for HCOOH acid is less than 1.8×10^{-4}, it can be said that CH_3COOH acid is weaker than HCOOH acid

c In table-1 of the stem, different volume of N_2 gas in different temperature is given in a fixed pressure (2 atm). If we draw a graph using the values in a fixed pressure, the graph will be,



According to the Charles law, increasing or decreasing the temperature of a fixed weighing gas at a constant pressure by

1°C will change the volume of the gas by $\frac{1}{273}$ times of it's determined volume in 0°C temperature.

If the volume is V_0 in 0°C and V_t in t°C, then according to the law,

$$V_t = V_0 + \frac{V_0}{273}t$$

If the obtained straight line is extend back wards, it intersect temperature at –273°C.

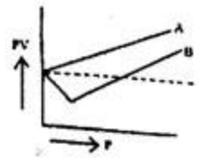
In this temperature,

$$V_{-273} = V_0 + \frac{V_0}{273}(-273) = V_0 - V_0 = 0$$

Therefore, the volume becomes zero theoritically in this state. This –273°C temperature is known as absolute zero temperature. The minimum cogitable temperature in which, the volume of gas becomes theoritically zero is the absolute zero temperature.

d Similar to the question no-5 (d).

Question ▶ 56



$M_A = 33.35$

$M_B = 75.36$

[Cumilla Cadet College, Cumilla]

a. What is partial pressure? 1

b. Write charging and discharging reaction of Lead storage battery? 2

c. Compare the stem two gas RMS velocity at 25°C. 3

d. Analyze why stem two gas line are differ from dot line. 4

Answer to the question no. 56

a The partial pressure of a constituent gas or vapor in a mixture is defined as the pressure exerted if it alone occupies the whole volume of the vessel in which the mixture is kept (at the same temperature).

b The charging and discharging reactions of lead-acid storage battery are as follows :

On the verge of charging, the cycle is turned in opposite direction. Lead sulphate and water is converted electro-chemically into Lead, Lead oxide and H_2SO_4 by an external charger.

Anode reaction : $PbSO_4(s) + H^+(aq) + 2e^- \longrightarrow Pb(s) + HSO_4^-(aq)$

Cathode reaction : $PbSO_4(s) + 2H_2O(l) \longrightarrow PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^-$

On the verge of discharging, Lead-di-oxide (positive plate) and Lead (negative plate) react with sulphuric acid and produce Lead sulphate, water and energy.

Anode reaction : $Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$

Cathode reaction : $PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \longrightarrow PbSO_4(s) + 2H_2O(l)$

Whole reaction : $Pb(s) + PbO(s) + 2H_2SO_4(aq) \longrightarrow 2PbSO_4(s) + 2H_2O$

c We know,

RMS velocity of any gas, $C = \sqrt{\frac{3RT}{M}}$

Molecular weight of A and B gas of stem respectively are,

$M_A = 33.35$ g/mol $= 33.35 \times 10^{-3}$ kg/mol

$M_B = 75.36$ g/mol $= 75.36 \times 10^{-3}$ kg/mol

Temperature, $T = (25 + 273)$ K $= 298$ K

If the RMS velocity of these two gases are C_A and C_B respectively,

$$\frac{C_A}{C_B} = \frac{\sqrt{\frac{3RT}{M_A}}}{\sqrt{\frac{3RT}{M_B}}} = \frac{M_B}{M_A} = \frac{75.36 \times 10^{-3}}{33.35 \times 10^{-3}}$$

Or, $\frac{C_A}{C_B} = 2.26$

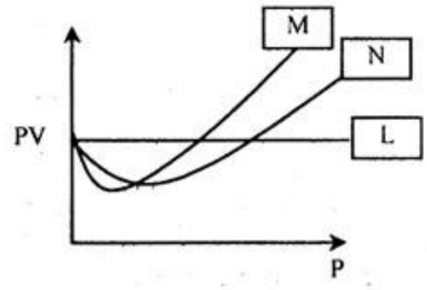
$\therefore C_A = 2.26 \times C_B$

Therefore, it can be said that the RMS velocity of gas-A is 2.26 times of the RMS velocity of gas-B.

d Similar to the question no-14(d).

Question ▶ 57 i. $CaCO_3 \longrightarrow M$

ii. $CH_3CH_2OH + Na \longrightarrow N$



[Feni girls Cadet College, Feni]

a. What is COD? 1

b. Calculate the value of R in S.I unit. 2

c. Why do the graphs of M and N are not like as L? Explain it. 3

d. M gas is responsible for global warming and acid rain. Analyze it. 4

Answer to the question no. 57

a The COD or Chemical Oxygen Demand is defined as the mg of oxygen required to completely oxidise the bio-degradable and non-biodegradable pollutants in one litre of water.

b We know,

$PV = nRT$

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

or $R = \frac{101325 \times 22.414 \times 10^{-3}}{1 \times 273.15}$

$= 8.314$ NmK^{-1} mol^{-1}

$= 8.314$ NmK^{-1} mol^{-1}

At STP,

Volume, $V = 22.414$L

$= 22.414 \times 10^{-3}$m^3

Pressure, $P = 101325$ Pa

$= 101325$ Nm^{-2}

Temperature, $T = 273.15$ K

Mole number, $n = 1$ mol

So, The value of R is 8.314 JK^{-1} mol^{-1} following the S.I unit.

c Similar to the question no-21 (d).

d Get from the following stem,

$$CaCO_3 \rightarrow CaO + CO_2$$
$$(M)$$

So, the M gas is responsible for the global warming and acid rain.

The role of CO_2 in creating green house effect is the highest (50%). The presence of CO_2 in the atmosphere is essential. Plants absorb CO_2 which react with H_2O in presence of sunlight and chlorophyll to produce carbohydrate and O_2. Oxygen is released into the atmosphere. The animal kingdom takes up O_2 from the atmosphere and releases CO_2 into the atmosphere. Thus the balance of CO_2 and O_2 in the atmosphere is maintained. But due to combustion CO_2 is gradually increasing. For example, forest fire and eruption of volcanoes release a large amount of CO_2 in the air. As a result, the balance between CO_2 production and utilisation by photosynthesis is not maintained. If this increase (~0.4% per year) continues, the average global temperature will increase by about 3.8°C. This will endanger the natural balance of the earth.

The pH of pure water is 7.0. But the pH of rain water is generally between 5 to 6. During rain, atmospheric CO_2 reacts with water to form a weak carbonic acid (H_2CO_3). Because of being weak, rain water becomes slightly acidic.

$$H_2O + CO_2 \rightleftharpoons H_2CO_3$$

Question ▶ 58

300 mm (Hg), 800mL, 27°C	P + Q	250 mm (Hg), 500mL, 27°C
P		Q

[Feni girls Cadet College, Feni]

a. What is lewis base? 1
b. How heavy metal ions are entered into human body? 2
c. Calculate the number of molecules of "P" gas. 3
d. Determine the total pressure of the gas mixture when the cork in open. 4

Answer to the question no. 58

a A compound or ionic species which can donate an electron pair to an acceptor compound is called lewis base.

b Cows, goats etc. eat grass, plants and leaves of plants. Again human being eat fruits, vegetables, meats and milk of animals. Through this process food energy transfarred to human body from the plants. This process is known as food chain. Heavy metals such as As, Cr, Pb, Cd, Hg are associated with food chain by different ways. Through food chain these heavy metals enter into human body and causes toxicity.

c Given in the stem,

The pressure of gas, P = 300 mm (Hg)
$= \frac{300}{760}$ atm (Hg) = 0.3947 atm
Volume, $V = 800 \times 10^{-3}$ L
Temperature, T = (27 + 273) K = 300 K
$R = 0.082$ L atmK^{-1} mol^{-1}
n = ?

We know,

$PV = nRT$

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

$= \frac{0.3947 \times 800 \times 10^{-3}}{0.082 \times 300}$ mol

= 0.0128 mol

Again following the Avogadros number,

1 mol of gas contains 6.022×10^{23} molecules
∴ 0.0128 mol " " " $6.022 \times 10^{23} \times 0.0128$ "
$= 7.708 \times 10^{21}$ molecules

Therefore, the molecule's number of P gas is 7.708×10^{23} molecules

d The total volume of the gaseous mixture when the cork in open,

V = (800 + 500) mL = 1300 mL
Total pressure P = ?

Given,

The pressure of P gas, P_1 = 300 mm(Hg)
Volume, V_1 = 800 mL
The pressure of Q gas, P_2 = 250 mm(Hg)
Volume, V_2 = 500 mL

Now, get from the Dalton's partial pressure law,

$PV = P_1V_1 + P_2V_2$

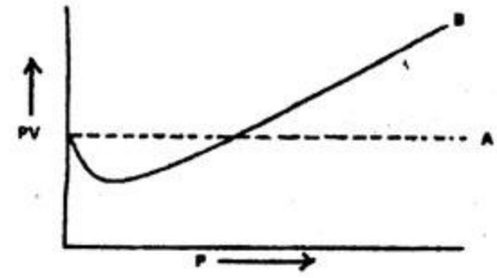
or, $P = \frac{P_1V_1 + P_2V_2}{V}$

$= \frac{300 \times 800 + 250 \times 500}{1300}$ mm(Hg)

= 280.769 mm (Hg)

So, the total pressure at the gaseous mixture will be 280. 769mm (Hg).

Question ▶ 59



[Faujdarhat Cadet College, Chattogram]

a. What is conjugate base? 1
b. Why methyl orange is used in the titration of strong acid and week base? 2
c. Deduce the equation for gas A in the stem. 3
d. Explain the causes for the deviation of behavior of gas B from that of gas A. 4

Answer to the question no. 59

a The base created by reducing a proton (H^+) from an acid is called the conjugate base of that acid.

b The saline water created from the reaction of a strong acid and a weak base reproduce that acid and base by getting hydrolysed. As a result, the pH becomes less than 7 at the end point. While crossing the end point, the pH changes from 7 to 3.5. The pH range for methyl orange is 3.1–4.4. That is why methyl orange is used in titration of strong acid and weak base.

c The graph in the stem is Amagat's curve. In this graph, A-line indicates idea gas. An equation is demonstrated below, for this gas.

The relation that indicates the ratio of changes of pressure, temperature and mole numbers with the change of volume of a gas by combining the three major equation of an ideal gas i.e. Boyle's Low, Charle's Law and Avogadro's-law is known as the ideal gas equation or ideal gas law. In each of these three laws, effect of volume by other variable is expressed only. Like,

According to Boyle's Law, $V \propto \frac{1}{P}$, when n, T is constant

According to Charle's Law, $V \propto T$, when n, T is constant

According to Avogadros-Law, $V \propto n$, when P, T is constant

Combining these three laws we get,

$V \propto \frac{nT}{P}$ or, $PV = nRT$, where n, T, P are variable. This is the ideal gas equation.

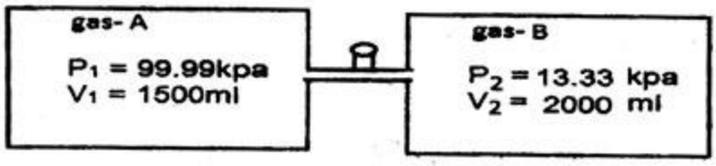
For 1 mole gas, n = 1. Then ideal gas equation for one mole gas becomes, $PV_m = RT$.

V_m = Molar Valume.

The R in "PV = nRT" is called molar gas constant or universal gas constant. Because in case of `1 mol of any gas, molar volume is the same in same temperature and pressure; hence R will be same for every gas.

i Similar to the question no-21(d)

Question ▶ 60



Here, A and B gases are diatomic and their molecular weight are 32 and 28 respectively

[Faujdarhat Cadet College, Chattogram]

a. What is electrophile? 1

b. Does C_2H_5OH give iodoform reaction? Explain? 2

c. If the two containers are connected, determine the pressure of the mixture. 3

d. "Fixation of gas 'B' in land plays an important role for plants". Justify the statement. 4

Answer to the question no. 60

a The reactants that have electron attraction and recieves electron at time of organic reaction, are called electrophile.

b Compounds contraining aceto radical ($H_3C-\overset{\overset{O}{\|}}{C}-$) or the alcohols that get oxidized by halogen and converted into CH_3CO–radical attached connected compounds give iodoform reaction. In the stem, the stated compound (Ethanol) gets oxidized by I_2 and turned into ethanal.

$CH_3-CH_3-OH + I_2 \longrightarrow CH_3CHO + 2HI$

In the presence of I_2, ethanol reacts with conc. NaOH at 60°C temperature and forms iodoform.

$$CH_3-\overset{H}{\underset{}{C}}=O + I_2 + NaOH \rightarrow CHI_3 + H-\overset{\overset{O}{\|}}{C}-ONa + NaI + H_2O$$

(Iodoform)

c Similar to the question no- 11(c)

d The B gas of the stem is actually nitrogen (N_2), whose molecular weight is 28.

N_2 is the main nutrition for trees or crops. Trees absorb nitrogen (N_2) after it been mixed with soil by nitrogen fixation. When thunderstorm occurs, 3000°C of temperature is produced which connects N_2 and O_2 of atmosphere and forms nitric oxide. Then after getting cold and reaches 50°C, it turn into nitrogen-di-oxide. This nitrogen-di-oxide mix with rain water and create nitric acid. This nitric acid then falls on earth as acid rain. It reacts with various elements of soil like, CaO, $CaCO_3$ and forms calcium nitrate.

Thunderstorm : $N_2 + O_2 \overset{3000°C}{\rightleftharpoons} 2NO$

Oxidation : $2NO(g) + O_2 \overset{50-1000°C}{\rightleftharpoons} 2NO_2(g)$

Absorption in water : $2NO_2 + \frac{1}{2}O_2 + H_2O \rightleftharpoons 2HNO_3$

Mitigation on the ground : $CaCO_3 + 2HNO_3 \rightleftharpoons Ca(NO_3)_2 + CO_2 + H_2O$

$Ca(NO_3)_2$ (solution) $\xrightarrow[\text{By roots}]{\text{Tree accepts}}$ Plant protein

As this metal nitrate is soluble in water, plants take it by their roots. It works as plant protein in plant body which is fundamental nutration for plants.

From the discussion above, it can be said that, the fixation of B-gas of the stem is very important process for crops and plants.

Question ▶ 61

1	2	3
100 mL H_2 t = 25°C P = 101.325 kPa	50 mL N_2 t = 25°C P = 101.325 kPa	40 mL O_2 t = 25°C P = 101.325 kPa

[Sylhet Cadet College, Sylhet]

a. What is conjugate base? 1

b. Why is the pressure of real gases less than that of ideal gases? 2

c. If above three gases are pumped into a 250 ml flask, then what will be the total pressure of the gas mixture at given temperature. 3

d. If the gases mixture of 250 ml flask in heated at 30°C temperature then whether the total pressure of a the mixture will be changed or not? Analyze mathematically. 4

Answer to the question no. 61

a Conjugate base is a substance formed when an acid loses a hydrogen ion.

b See the question no-5(b)

c Similar to the question no-11(c)

d Suppose the total pressure of the mixture, P.

According to Dalton's partial pressure law,

$PV = P_1V_1 + P_2V_2 + P_3V_3$

Or, $P = \frac{P_1V_1 + P_2V_2 + P_3V_3}{V}$

$= \frac{101.325\,(100 + 50 + 40)}{250}$

$= 77.007$ atm

Given,

$P_1 = P_2 = P_3 = 101.325$ kPa

$V_1 = 100$ mL

$V_2 = 50$ mL

$V_3 = 40$ mL

$V = 250$ mL

$\therefore P = ?$

If the flask is heated by the increasing of temperature then the gaseous pressure will be increased at definite volume.

We know,

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

Or, $P_2 = \frac{P_1 T_2}{T_1}$

$= \frac{77.007 \times 303}{298}$

$= 78.2991$ atm

Here,

$P_1 = 77.007$ atm

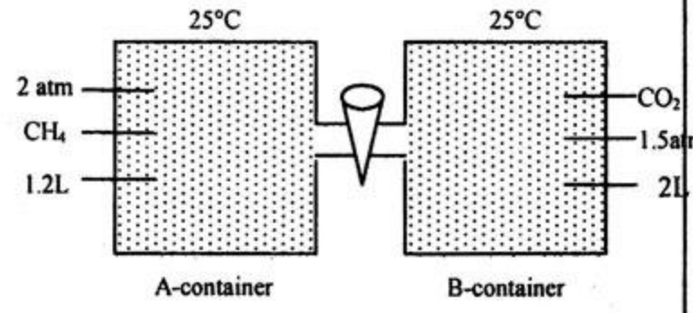
$T_1 = 25°C = (273 + 25) = 298$ K

$T_2 = 30°C = (273 + 30) = 303$ K

$P_2 = ?$

At 30°C temperature, the total pressure of the mixture will be 78.2991 atm.

Question ▶ 62 Observe the following stem and answer the questions given below:



[Jhenaidah Cadet College, Jhenaidah]

a. What is CFC? 1

b. Why is RMS velocity more suitable to determine the kinetic energy of gas than average velocity? 2

c. Calculate the total pressure of the mixture. 3

d. Analyze the diffusion rates of both gases. 4

Answer to the question no. 62

a Hydrocarbon whose some or most hydrogen atoms have been replaced by chlorine and fluorine atoms called CFC.

b See the question no- 4(b)

c Similar to the question no- 11(c)

d Similar to the question no- 10(d)

Question ▶ 63

i. $CuSO_4 + NH_4OH$ (excess) $\longrightarrow A + H_2O$.

ii. $AlCl_3 + H_2O \longrightarrow B$ *[Jhenaidah Cadet College, Jhenaidah]*

a. Write the Vander Waal's equation of real gas. 1

b. What is meant by critical temperature of CO_2 is 31.1°C? 2

c. Calculate total number of nitrogen atom in the compound of 'A'. 3

d. Which theory of the acid-base is being followed in the compounds, A and B? Analyse with appropriate reasons. 4

Answer to the question no. 63

a Vander Waal's equation– $(P + \frac{n^2 a}{V^2})(V - nb) = nRT$

b The critical temperature of CO_2 is 31.1°C, means CO_2 can not be liquefied over the 31.1°C temperature, even high pressured is applied. But CO_2 can be liquefied at the temperature below 31.1°C within a definite pressure.

c By completing the reaction (i), We get–

$CuSO_4 + 4NH_4OH$ (excess) $\longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

1 mol 4 mol (A) 1mol 4 mol

So, the A compound is tetra ammin cupric sulfate. The A compound exhists 4 mol N_2 atoms.

So, the nitrogens atom number is–

$N = 4N_A$

$= 4 \times 6.022 \times 10^{23}$

$= 2.4088 \times 10^{24}$

Here,

N_A = Avogadro number

$= 6.022 \times 10^{23}$

Therefore, A compound has 2.4088×10^{24} nitrogen atoms.

d The two reactions following the stem are–

$CuSO_4 + 4NH_4OH \longrightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

(A)

$AlCl_3 + 6H_2O \longrightarrow [Al(H_2O)_6]\,Cl_3$

(B)

According to the Lewis theory, Lewis acid is a species that can accept a pair of electron from another atom to form a new bond. Cu^{2+} ion accepts one pair of electron from NH_3 molecule and turned into $[Cu(NH_3)_4]^{2+}$ forming co-ordinate bond.

$Cu^2 + 4 : NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$

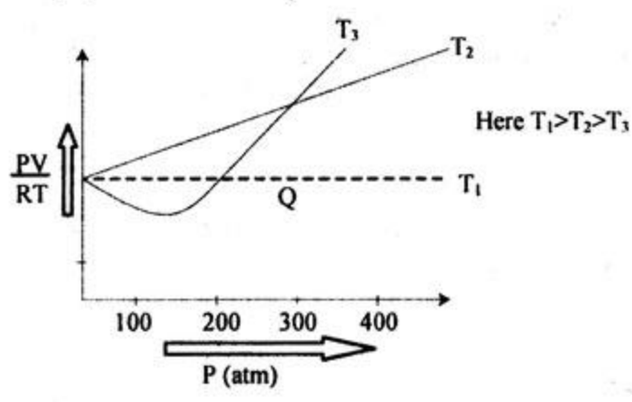
As amonia donates pair of electron, so it is Lewis base. Other hand, Cu^{2+} accepts electron and so is a Lewis acid, the aqueous solution of NH_3 and SO_4^{2-} (comple monetary ion of Cu^{2+}) produce $[Cu(NH_3)_4]SO_4$ and H_2O at the first reaction following the stem.

Again $AlCl_3$ is a Lewis acid. Because, the ligand of its aqueous solution accepts pair of electron from H_2O donor molecule.

$Al^{3+} + 6H_2\ddot{O}: \longrightarrow [Al(H_2O)_6]^{3+}$

From the analysis mentioned above, it is clear that the acid base theory is followed in the compounds A and B.

Question ▶ 64 Read the stem carefully and answer the following questions–



[Barishal Cadet College, Barishal]

a. What is called partial pressure? 1

b. HSO_4^- acts both as an acid and a base– Explain it. 2

c. Find out the volume of 160 gm stated gas by mass at point Q in the figure. 3

d. When will lines T_2 and T_3 mix with dotted line T_1? Analyze logically. 4

Answer to the question no. 64

a The partial pressure of a constituent gas or vapor in a mixture is defined as the pressure exerted if it alone occupies the whole volume of the vessel in which the mixture is kept (at the same temperature).

b The chemical substances or compounds that are able to react both as an acid or a base are called amphoteric substances. Bi-sulphate (HSO_4^-) ion act as an amphoteric substance.

1. $HSO_4^- + H_3O^+ \rightleftharpoons H_2SO_4 + H_2O$

Here, HSO_4^- ion recieves proton from H_3O^+ and act as base.

2. $HSO_4^- + OH^- \rightleftharpoons H_2O + SO_4^{2-}$

Here, HSO_4^- ion donates proton to hydroxyl ion and act as acid.

c The gas shown in the figure is Nitrogen (N_2). Whose molecular mass, M = 28

We know,

$PV = ZnRT$

$\Rightarrow PV = Z.\frac{wRT}{M}$ $[\because n = \frac{w}{M}]$

$\Rightarrow V = Z\frac{wRT}{PM}$

$= 1 \times \frac{160 \times 0.0821 \times T}{400 \times 28}$ .....(i)

At point Q,

Pressure, P = 400 atm

$Z = \frac{PV}{RT} = 1$

Given weight, w = 160 g

Volume, V = ?

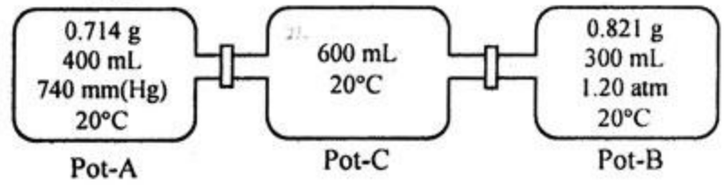
Here, T is unknown, that is to say that to determine the volume of 160 g Nitrogen, enough data is not given in the stem. But at a very high temperature, straight line T_2 of the graph will match straigh line T_1. As a result, temperature will be very high at point Q. For N_2, this temperature will be close to 1000°C. Hence by assuming T = 1000°C or 1273 K, from equation (i) we get, V = 1.493 L.

d In the stems figure T_3 and T_4 both are real. They behave as ideal gas under the following condition.

i. At high temperature, real gas will behave like ideal gas. At high temperature, the kinetic energy of gaseous molecules increase. Hence, the volume of gases increase because of decrease of intermolecular force. The molecules of gas remain separated enough from each other. The total volume of molecules are considered negligible compared to the volume of the container. For ideal gas, volume of gas molecules are negligible compared to the volume of the container.

ii. At low pressure, the real gas behaves like an ideal gas. Because, at low pressure, volume of gas increases. If the volume increases, the molecules get separated apart from each other, the molecules do not have any intermolecular force. We know from kinetic theory of gases, that the molecules of ideal gas do not show any intermolecular force.

Question ▶ 65 Read the stem carefully and answer the following questions—



Here: Distance of Pot A and Pot B is same from Pot C

[Barishal Cadet College, Barishal]

a. What is called mole fraction? 1

b. Freon-II causes ozone layer depletion. Explain it. 2

c. Find out the total pressure if pot-A and pot-B is placed in pot-C. 3

d. If stop cork is opened up then which gas will reach at pot C first between pot-A and pot-B gas. Analyze mathematically. 4

Answer to the question no. 65

a The ratio of the mole number of an individul element in a mixture and the total mole number of that mixture is called the mole fraction of that element.

b Freon-11 is $CFCl_3$ (Trichloro-fluro-methane). When $CFCl_3$ reaches atmospheric stratosphere, UV-ray light breaks the C–Cl bond and produces chlorine atoms consist of free electrons. As negatively charged Cl atom or free redical is more active, reacting with the ozone mole (O_3), it produces free radical chlorine monoxide ($\dot{ClO}$) first and then, O2. Then the free radical $\dot{ClO}$ reacts with the oxygen atom and produces oxygen (O_2) and chlorine atoms ($\dot{Cl}$).

$CFCl_3 \xrightarrow{UV} C\dot{F}Cl_2 + \dot{Cl}$

$O_3 + \dot{Cl} \longrightarrow \dot{ClO} + O_2$

$ClO + O \longrightarrow \dot{Cl} + O_2$

In this case, Cl atom works as a prototypical force and creates three molecules of oxygen by breaking two ozone molecules. The atomic period of these Cl^- atoms in stratosphere is about two years. A single Cl^- atom can break upto one million ozone molecules during this time. Therefore Freon-11 depletes ozone layer.

c See the creative question answer No 11(c)

d Similar to creative question answer no 10(d).