UNIT 4: TUTORIAL ON GASEOUS STATE OF MATTER -2026

Please carry out all calculations using SI units. (1 atm = 1×10^5 Pa)

01. (a) State the properties of solid, liquid, and gaseous states of matter by considering their particle arrangement.

    (b) (1) State the Boyle's law.

    (2) Write a mathematical expression for the Boyle's law.

    (3) Plot graphs to depict the Boyle's law.

    (c) At a certain temperature the volume of a gas under a pressure of $1\text{x}10^5$ Pa is 2 m^3. Calculate the pressure of the gas that has a volume of 5 m^3 at the same temperature. (4×10^4 Pa)

02. (a) 1. Write down the Charles law.

    2. Write a mathematical expression for the Charles law.

    3. Plot graphs to depict the Charles Law.

    (b) 1. The volume of a gaseous sample at 17 ˚C at a certain pressure is 580 m^3. At constant pressure and at 100 ˚C, calculate the volume of the gas sample. (746 m^3)

    2. Calculate the temperature that is required to increase the volume of a gas by 10% which is stored at 27 ˚C and $1\text{x}10^5$ Pa. There is no change in pressure. (30 K or 30 ℃)

03. 1. Calculate the number of molecules of oxygen in a 1 dm^3 sample of oxygen at a pressure of $7.6\text{x}10^{-10}$ mm Hg at 0 ˚C.

    (2.65×10^{10})

    2. Ethane (C_2H_6) and Ethene (C_2H_4) gases are mixed in a container with a volume of 40 dm^3 at 400 K and 1.00 atm pressure. This would completely react with oxygen and will produce CO_2 and H_2O. The amount of oxygen required for the combustion was 130 g. Calculate the molar fractions of each gas in the initial mixture. ($X_{C2H6} \approx 0.67$)

04. a) 1. State important parameters to be stated when expressing a volume of a gas. Write the standard temperature and pressure.

    2. Combine the Boyle's and Charles laws to deduce the relationship. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

    b) 1. The volume of a gas at 15˚C and 760 torr is 20 dm^3. Calculate the volume of this gas at 50 ˚C and 800 torr. (21.3 dm^3)

2. The volume of a gas at -20 ˚C and 1.0×10^5 Pa is 5×10^{-4} m^3. When the temperature is increased to 40 ˚C the volume expanded to 2×10^{-3} m^3. Calculate the pressure of the gas. (3.09×10^4 Pa)

05. (a) 1. Write the Avogadro's law.

2. Explain the term standard molar volume using the above law.

3. At a certain temperature and pressure 15.0 g of CO_2 has a volume of 7.16 cm^3. Calculate the volume of 12.0 g of CH_4 in this temperature and pressure. (15.79 dm^3)

(b) 1. Describe an experiment that was used to determine the molar volume of oxygen.

2. how would you attempt modify this setup to determine the molar volume of carbon dioxide.

3. The values obtained from these experiments are different to that of the standard values. Give reasons.

06. (i) Use the three basic gas laws to deduce the universal gas equation. Explain what is meant by an ideal gas.

(ii) Write an equation for the compressibility factor for an ideal gas? Illustrate variation of compressibility factor with Pressure for an ideal gas using a graph.

(iii) What are the assumptions of 'Kinetic Molecular Theory'?

(iv) Explain why real gases deviate from the ideal behaviour.

(v) Different real gases tend to deviate from ideal behaviour on their own specific ways. Explain this statement.

07. a. Obtain the value for 1 atm in Pa.

b. Calculate the value for R in (a) SI Units (b) atm L K^{-1} mol^{-1}

c. How would you modify the ideal gas equation to find the molar mass, density and concentration of an ideal gas?

d. Calculate the molar mass of an ideal gas which weighs 2.12 g for a litre at 25 ˚C and 1.00 atm.

(52.52 g mol^{-1})

08. 1. The density of phosphorus vapour is 2.64 g dm^{-3} at 310 ˚C and 775 torr. Determine the molecular formula of this vapour assuming that it is an ideal gas. (P = 31){P_4}

2. There is He and O_2 in a gaseous mixture. The density of this mixture is 0.518 g dm^{-3} at 25 ˚C and 720 torr. Determine the percentage mass of He in this mixture. (O=16, He=4)

($\approx$32%)

09. a. Density of propane is 1.655 g dm^{-3} at 323 K and 1.01×10^5 N m^{-2}. Calculate the molar mass of propane. (44 g mol^{-1})

b. Calculate the volume of 0.250 mol of an ideal gas at 373 K and 1.25×10^5 N m^{-2} of pressure. (6.2×10^{-3} m^3)

c. Write the Dalton's Law for partial pressures.

d. Show that the Partial Pressure = Molar Fraction x Total Pressure.

e. A sample of 3 dm^3 CO_2 which was at 200 KPa was connected to a 10 dm^3 evacuated vessel and another 1 mol of N_2 was added to it. If there is no reaction between these gases calculate the final pressure if the temperature is maintained at 30 °C. (3.46×10^5 Pa)

10. a. Combine Boyle's law and Charles law to show that {PV/T} is a constant.

b. At 27 ˚C and 1 x 10^5 Pa, the volume of a gas is 0.5 dm^3. Calculate the volume of this at 87 ˚C and 2.5 x 10^5 Pa. (0.26 dm^3)

c. The volume of a sample of gas, at 47 ˚C and 0.8 x 10^5 Pa is 0.4 dm^3. Calculate the pressure if the new volume is 0.9 dm^3 at 87 ˚C. (4×10^4 Pa)

11. Convert following volumes of gases to that of at standard temperature and pressure.

(a) 205 cm^3 of ideal gas at 27 ºC and 1.01x 10^5 N m^{-2} (186.55 mL)

(b) 355 cm^3 of ideal gas at 310 K and 1.25x 10^5 N m^{-2} (390.78 mL)

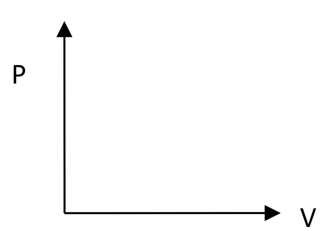
(c) 5.60 dm^3 of ideal gas at 425 K and 1.75 x 10^5 N m^{-2} (6.295 L)

12. (a) Calculate the molar mass of a particular gas having density of 2.26 g dm^3 at 25 ˚C temperature and 9.73 x 10^5 Pa pressure. (5.67 g mol^{-1})

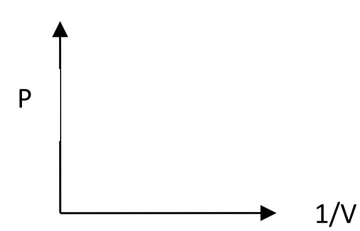
(b) If volume of Helium gas is 3.5 dm^3 at 0 ˚C and 9.75 x 10^4 Pa. Calculate the volume of Helium gas at 1x 10^5 Pa pressure at the same temperature. (3.4125 L)

13. (a) Plot the following graphs for an ideal gas at constant temperature.

(i) Pressure (P) vs Volume (V)

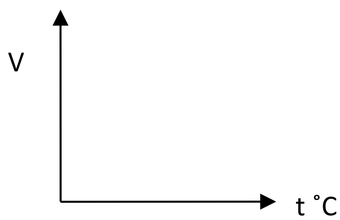


(ii) Pressure (P) vs (1/V)

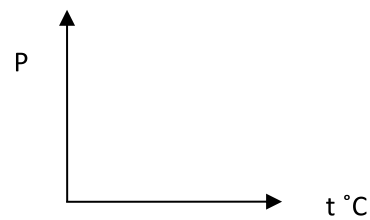


(b) Draw the following graphs

(i) Volume (V) vs temperature (t ˚C) of An ideal gas at constant pressure.



(i) temperature (t ˚C) vs Pressure (P) of N_2O_2 gas at constant volume (non-ideal gas).



(c) Inter molecular forces results in non-ideal behaviour of real gases. What are the two physical conditions that these intermolecular forces attain the maximum possible value.

(d) At 127 ˚C, and 1.013×10^5 Pa a liquid mass of 0.080 g can be converted into a gas inside a syringe with a volume of 8.1×10^{-5} m^3

(i) Find the molar mass of above solid material. (32.4 g mol^{-1})

(ii) If it is pure methanol, what is the reason for the difference between the authentic molar mass and calculated molar mass?

14. (i) During a laboratory experiment a student collects 1.95×10^{-4} m^3 of O_2. If this weighs 0.27 g at 23 ˚C under a pressure of 9.91×10^4 Pa, use the above data to calculate the value of the universal gas constant (R). {7.7375 J mol^{-1} K^{-1}}

(ii) Write the chemical equation for the formation of a white precipitate when CO_2 is bubbled through lime water. If 2.35 g of $CaCO_3$ is obtained during a certain experiment, calculate the volume of CO_2 bubbled at 15 ˚C, and 1.02×10^5 N m^{-2}.(551.6 mL)

15. 2.5 dm^3 of methane at 1.01×10^5 Pa and 7.50 dm^3 of ethane at 2.525×10^5 Pa and 0.5 dm^3 of propane at 2.01×10^5 Pa were introduced in to a 5.0 dm^3 flask. Calculate the partial pressures and the total pressure of the gases assuming they do not react with each other, and that the temperature remains constant throughout the process. (Total pressure = 4.49×10^5 Pa)

16. A gaseous mixture contains 40% of NH_3 and 25% of H_2 and 35% of N_2 by volume at 1.50×10^5 Pa pressure inside a ridged container.

   (i) Calculate the partial pressure of each gas. ($P_{NH3} = 6\times 10^4$ Pa, $P_{N2} = 5.25\times 10^4$ Pa, $P_{H2} = 3.75\times 10^4$ Pa)

   (ii) If NH_3 is absorbed using $P_2O_{5(s)}$, calculate the new partial pressures. Give reasons for your answers. (No change)

17. An airbag is a vehicle safety device containing NaN_3. During an automobile collision NaN_3 will decompose into N_2 and will inflate rapidly, thereby minimizing injuries caused by a sudden collision.

$$2NaN_{3(s)} \longrightarrow 2Na_{(s)} + 3N_{2\,(g)}$$

Find the volume of N_2 gas when 60.0 g of NaN_3 is decomposed at 80 ˚C and 823 mm Hg. (36.9 dm^3)

18. The first flask contains 200 cm^3 of oxygen at 200 mm Hg and the other flask contains 300 cm^3 of Nitrogen at 100 mm Hg. If these two flasks are connected, calculate the total pressure of the gaseous mixture assuming that the gases do not react with each other, and that the temperature remains constant. (140 mmHg)

19. (a) Volume of 0.71 g of an ideal gas at 227 ˚C temperature and 0.5 atm pressure is 0.821 dm^3. Calculate the relative molecular mass of the gas. (65.28)

   (b) Calculate the final pressure of the gas at 20 ˚C and 0.8 atm when temperature is increased up to 200 ˚C inside a sealed container. (1.291 atm)

20. (i) At 10 ˚C temperature and 1×10^5 N m^{-2} pressure, the density of air is 1.247 kg m^{-3}. Calculate the density of air at 25 ˚C of temperature and 3.5 $\times 10^5$ Nm^{-2} pressure. (4.145 kg m^{-3})

   (ii) Density of O_3 at 0 ˚C temperature and 1.0×10^5 Nm^{-2} pressure, is 2.15 kg m^{-3}. Calculate density of O_3 at 20 ˚C temperature and 1.0×10^5 Nm^{-2} pressure. (2 kg m^{-3})

21. If 0.100 mol of SO_2Cl_2 gas is heated to 473 K inside a rigid container of 20 L. The amount of SO_2Cl_2 that has reacted is 0.035, according to the following chemical equation.

$$SO_2Cl_2 \longrightarrow SO_{2(g)} + Cl_{2(g)}$$

   a. Calculate the molar fraction of each component. (X_{SO2Cl2}= 0.48, X_{SO2}= X_{Cl2}= 0.26)
   b. Calculate partial pressure of each component. (P_{SO2Cl2}= 2 x 10^4 Pa; P_{SO2}= 1.08 x 10^4 Pa)

22. Chemical formula of a hydrate is $MgSO_4.\mathbf{X}H_2O$. 54.2 g of this hydrate is heated until all the H_2O evaporates completely. Volume of water vapor at 120 ˚C temperature and 24.8 atm pressure is 2.00 dm^3. Determine the value for **X** giving assumptions used in the calculation. (Mg=24, S=32, O=16, H=1) {X = 7}

23. A H_2 containing ridged vessel of volume 0.5 dm^3 at 27 ˚C and 1.2 atm and another Helium containing ridged vessel of volume 1.5 dm^3 at 87 °C and 0.9 atm are connected and the mixture is allowed to mix well at 47 ˚C. Calculate the partial pressure of He and the total pressure of the mixture. (P_{He} = 0.32 atm, Total P= 0.92 atm)

24. A gas mixture contains 30% CO_2, 50% O_2 and 20% of CO by volume at 1.0×10^5 Nm^{-2} pressure.

a) Calculate the partial pressures of each component. (P_{CO2}= 3.0×10^4 Pa, P_{O2}= 5.0×10^4 Pa, P_{CO}= 2.0×10^4 Pa

b) If CO_2 is absorbed using NaOH pellets, calculate the new partial pressures of CO and O_2. (No change)

25. State the Avogadro law.

Show that the {volume ratio = molar fraction} using Avogadro theory for non-reacting gaseous mixture. Following data have been obtained for different gases at 20 ˚C temperature in a gaseous mixture.

Gas	**Partial pressure/ mmHg**
O_2	200
CO_2	150
CH_4	320
H_2	105

Calculate the percentage volume of H_2 in above gas mixture. (13.55 %)

26. If 4.00 dm^3 of methane at a pressure of 2.02×10^5 Nm^{-2}, 1.25 dm^3 of ethane at a pressure of 3.5×10^5 Nm^{-2} and 1.5 dm^3 of propane at a pressure of 1.01×10^5 Nm^{-2} were all pumped into an empty flask of 10 dm^3 of volume. Calculate partial pressure of each component and total pressure if the temperature remains constant. ($P_{methane}$ = 8.08 $\times10^4$ Pa, P_{ethane} = 4 $\times10^4$ Pa, $P_{propane}$ = 1.515 $\times10^4$ Pa, P_{total} = 1.3595 $\times10^5$ Pa)

27 (i) If 1.85×10^{-4} m^3 volume of vapor was formed when 0.427 g of liquid was vaporized at 100 ˚C temperature and 9.93×10^4 N m^{-2}. Calculate molar mass of the liquid if there is no decomposition. (72.08 g mol^{-1})

(ii) Density of a gas at 90 ˚C temperature and 9.47×10^4 Nm^{-2} pressures is 1.434 kg m^{-3}. Calculate the molar mass of the gas. (45.7 g mol^{-1})

28. (i) An explosive volcanic eruption evolved a mixture of gas containing 65% of carbon dioxide (CO_2), 26.7% of sulphur dioxide (SO_2), 5.4% hydrogen chloride (HCl), 2.8% of hydrogen fluoride (HF), and 0.1% of Hydrogen sulphide (H_2S) by volume at 1.013×10^5 Pa (atmospheric pressure). Calculate partial pressures of each gas. (P_{CO2}= 6.58 $\times 10^4$ Pa, P_{SO2}= 2.7 $\times 10^4$ Pa, P_{HCl}= 5.47 $\times 10^3$ Pa)

(ii) Density of a hydrocarbon gas at a temperature of 20 ˚C and 1.013×10^5 Pa pressure is 1.22 kg $m^{-3.}$ Calculate the molecular formula of the hydrocarbon if the carbon content is 80.0%. (C_2H_6) P_{SO2}= 2.7 $\times 10^4$ Pa

29. (i) Write the kinetic molecular equation defining all the terms.

(ii) Calculate the kinetic energy of 1 mole of an ideal gas at 47 ˚C in Joules**.** Calculate the ratio of mean square root speeds between H_2 and HI gases at 47 ˚C. (H=1, I=127) (3.99 kJ mol^{-1}, 8:1)

30. (i) 0.84 g of N_2, 0.128 g of O_2, 0.40 g of Ar and 0.22 g of CO_2 is contained in 1.0×10^{-3} m^3 of air at 298 K temperature and 1.013×10^5 Pa pressure. Calculate the partial pressures of each gas. (P_{N2}= 6.2 $\times 10^4$ Pa)

(ii) 156 cm^3 of H_2 gas is collected by the reaction between Zn and HCl over water at 21 ˚C and 769 mmHg pressure. Calculate the mass of H_2 collected, if the saturated vapor pressure of water is 18.7 mmHg at the same temperature. (12.7 mg)

31. If a 7.63 g of a solid sample containing only Na_2CO_3 and $MgCO_3$ is allowed to react with excess of dilute HCl, the volume of CO_2 evolved is 1.67 dm^3 at 26 ˚C temperature and 1.24 atm pressure.

(i) Write a balanced equation for the reaction between Na_2CO_3 and $MgCO_3$ separately with dil. HCl.

(ii) Find percentile w/w ratio of Na_2CO_3 in the initial mixture. (Na=23, Mg=24, C=12, O=16) (≈40 %)

32. (a) Calculate the number of gas molecules in a cathode ray tube with a capacity of 100 cm^3 at 27 ˚C temperature and 1.8×10^{-5} mmHg pressure. (5.71 x 10^{13} molecules)

(b) Density of the 10.0 cm^3 of liquefied natural gas (pure CH_4) is 415 kg m^{-3} at -164 ˚C temperature and 1.013×10^5 Pa pressure. Calculate the volume of this natural gas at 20 ˚C temperature and 1.013×10^5 Pa pressure if the liquid vaporizes at the given temperature. (6230 cm^3)

33. (a) Identify all terms in the equation $PV=1/3\ mNC^2$ for an ideal gas. Derive an expression for the root mean square speed of an ideal gas using this equation.

(b) 7.55 g of impure NaCl (Cl^- contains only as NaCl) sample is reacted with excess MnO_2 and conc. H_2SO_4 as shown in the reaction below.

$$2\ NaCl + MnO_2 + 3\ H_2SO_4 \longrightarrow MnSO_4 + 2NaHSO_4 + 2H_2O + Cl_2$$

The volume of collected Cl_2 gas at atmospheric pressure (1×10^5 Pa) and 27 ˚C temperatures is 1.2 L in water. If 20% evolved Cl_2 is dissolved in water, calculate the percent purity of NaCl by weight. Saturated vapor pressure of water is 26.71 mmHg. (Na= 23, Cl=35.5) {46.5%}

34. 6.05 g of limestone having calcium carbonate as an impurity is reacted with excess of dil. HCl. The volume of evolved gas at 27 ˚C temperature and 1.0 atm pressure is 225 cm^3. Calculate weight percentage of purity for $CaCO_3$ if 10% of gaseous product is dissolved in the solution. (Ca=40, =12, O=16, Cl=35.5, H=1){16.5%}

35. (a) What is an ideal gas?

(b) Explain why real gases deviate from ideal gas behaviour at low T and high pressure.

(c) (i)Draw the speed distribution curve of a sample of a gas at temperature T.

(ii) Draw the speed distribution of molecules of the same gas at a temperature higher than T in the same graph.

36.(a) Derive the ideal gas equation using three main gas laws.

(b) 1.12 L of CO_2 is collected at 10 ˚C temperature and 2.0 atm pressures by thermally decomposing 10.00 g of pure $CaCO_3$. Calculate the gas constant **R** using above experimental data. (Ca=40, O=16, C=12) {7.915 $Jmol^{-1}K^{-1}$}

(c) Discuss the reason for the difference between values of “experimental R” and “theoretical R”?

37. (a) What are the conditions at which the real gases tend to behave as ideal gases? Describe why real gases deviate from ideal gas behaviour.

(b) Give three differences between gaseous and solid state of matter based on the motion and arrangement of constituting particles?

(c) Derive the relationship between Molar mass (M), Density (d), pressure(P), temperature(t) and gas constant (R) with respect to an ideal gas.

(d) 3.75 g of gas contains a volume of 27 dm^3 at 47 ˚C temperature and 0.7 atm pressure. Calculate the molar mass of the gas using above relationship. (Assume ideal behaviour). {5.278 g mol^{-1}}

38. (a) Derive the Daltons' theory of partial pressure of gases using the universal gas equation.

(b) The gas 'X' occupies in a 2 dm^3 vessel at 300 K temperature and 1 atm pressure. Another gas 'Y' occupies a volume of 4 dm^3 in another vessel at 1 atm pressure and at the same temperature. If these two vessels are connected,

(i) Calculate the final pressure (1×10^5 Pa)

(ii) Partial pressure of 'Y' in the 2 dm^3 vessel (6.67×10^5 Pa)

(iii) Mole fraction of 'X' in the mixture. $(\frac{1}{3})$

(iv) Mole fraction of 'Y' if the temperature is increased to 310 K. $(\frac{2}{3})$

Assuming 'X' and 'Y' behave ideally and that they do not react with each other.

(C)(i) Show the deviation of real gases using the compressibility factor for a small range of pressure.

39. 3.20 g of O_2 gas is contained in a container of volume V at 0 °C temperature and 1.12 atm pressure. This is connected to another container which is fully evacuated having the same volume V. The temperature of a system is increased to 17 ˚C and 3.0 g of gas 'X' is pumped at this temperature until pressure is changed to 1.00 atm. Calculate the molecular mass of 'X' assuming O_2 behaves ideally. (O=16) Note: No reaction takes place between 'X' and O_2 and assume that no expansion of the container due to changes in the temperature. (2.04 g mol^{-1})

40.(a) (i) Derive the equation PV = nRT for an ideal gas using main gas laws.

(ii) Gas mixture containing 4.0 g of H_2 and a certain amount of He gas is kept in a container at 273 ˚C temperature and 2 atm pressure. The system attains standard conditions after introducing 5.0 g of additional H_2. If the new volume of the gas mixture is exactly double of its initial volume, calculate the mass of He present in the mixture. (H=1, He=4) Assume that H_2 and He behave ideally. (2 g)

(b) If you provided with a sample of propyne gas, how would you demonstrate that it does not behave ideally using an experimental method.

(c) The pressure of O_2 gas cylinder of 200 L is 30 atm at 21 ˚C temperature. Find the mass of O_2 that should be removed for the pressure to become 20 atm at the same temperature. (81.82 mol)

41. (a) 5.65 g of N_2 is confined in a flask having a volume of 15.0 dm^3. 4.8 g of O_2 is confined in a flask having a volume of 5.0 dm^3. These flasks are connected by a tap with a negligible volume. Calculate the partial pressures of each gas and total pressure of the gas mixture if the final temperature is 27 ˚C. (P_{N2}= 2.49 x10^4 Pa, P_{O2}=1.87x10^4 Pa, P_{total}=3.74 x10^4 Pa)

(b)(i) Calculate the amount of $KClO_3$ needed to collect 1.8 dm^3 of O_2 at 22 ℃ temperature and 760 torr pressure. Water vapor pressure is 19.8 torr at 22 ˚C. (K=39, O=16, Cl=35.5) {5.95 g}

(ii) Calculate the volume of O_2 needed for the complete combustion of 1 mole of CS_2 at standard temperature and pressure. Calculate the volume of CO_2 and SO_2 formed. (V_{O_2}= 67.24 L, V_{CO_2}=22.4 L, V_{SO_2}=44.8 L)

42. 1.58 g of NH_4HCO_3 is heated up to 127 ˚C in a closed vessel. If it is completely dissociated in to NH_3, H_2O and CO_2, If the final pressure inside the container is 4.9x10^4 Pa calculate the volume of the container. (H=1, N=14, O=16, C=12) (4.07 x10^{-3} m^3)

43. Composition of air as a volume percentage is N_2 = 78%; O_2 = 21%; Ar = 0.95% ; CO_2 = 0.05%

a. Find the composition of air (W/W)
b. Calculate the density of air at 25 ˚C temperature and 1 atm pressure

a. (75.4 %, 23.3 %, 1.31 %, 0.76 %) b. 1.18 kg m^{-3}

44. 2.00 g of gas 'A' is confined in a container at 25 ˚C temperature and 1 atm pressure**.** When 3.00 g of gas 'B' is pumped into same container after evacuating the gas the same temperature and pressure was obtained. Calculate the ratio between the molar masses of A and B assuming ideal gas behavior. (M_A: M_B = 2:3)

45. (a) Define what is meant by the term 'partial pressure'

(b) 200 cm^3 of Hydrogen gas at 20 ˚C temperature and 100 kPa pressure and 150 cm^3 of Helium at 200 kPa pressure and same temperature are pumped into a 500 cm^3 volumed container maintaining the temperature constant at 20 ˚C. Calculate the partial pressures of each gas and total pressure of the mixture. (P_{H2}= 40 kPa, P_{He}= 60 kPa, P_{Total}= 100 kPa)

(c) 40 cm^3 volume of a vapor is obtained from 0.206 g of a sample **X** at 373 K temperature and 1 atm pressure. Calculate the molar mass of **X**? (159.7 g mol^{-1})

46. What is an ideal gas? State two conditions where real gases behave as ideal gases.

0.200 g of gas is confined in a flask with a volume of 96 cm^3 at 20 ˚C temperature and $1.02x10^5$ Pa pressure. Calculate the molar mass of gas. (49.75 g mol^{-1})

47. (a) Give a balanced equation for the reaction between Al and NaOH.

(b) 1 g of an alloy containing Al and Mg is reacted with excess of NaOH at 25 ˚C **t**emperature and $1.01x10^5$ Pa pressure. Calculate the percentage amount of Al in the alloy if 1 dm^3 of H_2 is collected by reacting the sample. (72 %)

48. This question refers to an experimental method to determine the molar volume of a gas. 360 ml of CO_2 is collected at 27 ˚C temperature and 750 mmHg pressure, when 1.5 g of Calcium carbonate is completely heated. Calculate the molar volume of CO_2 at standard temperature pressure. Give reasons for the difference in experimental value with respect to the theoretical value. ($R_{calculated}$ =23.09 L mol^{-1})

(49) H_2 and He gases are confined in a vessel of constant volume at 0 ˚C temperature and 0.89 atm pressure. The pressure of the system is increased to 1.65 atm upon addition of 0.03 mole of CH_4 followed by heating up to 107 ˚C. If the partial pressure of H_2 is twice as much as He at the beginning, calculate the molar fraction of He at the end of the experiment. (0.3)

Note: assume the ideal gas behaviour of H_2, CH_4 and He.

50)(a) Write Boyle's and Charle's law. Derive ideal gas equation using these two laws and the Avogadro's' laws

(b) A gas mixture containing He and O_2 occupies a volume of 7.76 dm^3 in a closed flask at 280 K temperature and $1.50x10^5$ Pa pressure. There is also a piece of Magnesium inside this flask. When it is ignited, Magnesium will get oxidized in the flask consuming all O_2. The temperature and pressure of the system after the reaction is 327.5 K and $0.702x10^5$ Pa respectively.

i) Calculate the mass of He assuming that the volume of Mg and MgO is negligible. (0.8 g)

ii) Calculate the mass of the MgO formed in the flask. (He=4, Mg= 24) (6 g)

(c)Ammonium dichromate (VI) thermally dissociates as follows

$$(NH_4)_2Cr_2O_7 \longrightarrow N_2 + 4H_2O + Cr_2O_3$$

If you are provided with pure Ammonium dichromate (VI), design an experiment to determine the gas constant (R) experimentally.

51. (a) Derive the equation PV = nRT using three main gas laws and calculate the value of R using SI units. How do you modify the equation to explain the behaviour of a non-ideal gas? Explain your Answer.

Calculate the density of a gas at 29.5 $^\circ C$ temperature and 30.4×10^5 N m^{-2} pressure. The molar mass of the gas is 16 g mol^{-1}. {19.34 kg m^{-3}}

52. (a) 31.2 g of NO and 20.0 g of O_2 is confined in a 2×10^{-2} m^3 flask at 27 $^\circ C$ temperature. Calculate the difference between the initial and final pressures after the reaction between NO and O_2 to form NO_2 has taken place.

$$2NO + O_2 \longrightarrow 2NO_2 \qquad (1.29 \times 10^5 \text{ N m}^{-2})$$

(b) Write a balanced equation for the reaction between KI and H_2SO_4 which produces K_2SO_4, I_2, H_2S and H_2O.

Calculate the volume of H_2S during the reaction between excess of H_2SO_4 and 16.8 g of KI at standard temperature pressure. (KI=166){ 280 mL }

53.(a) Derive Dalton's law of partial pressures using PV= nRT.

(b) A gas mixture which contains 75.0 % N_2 and 25.0 % O_2 by volume has a pressure of 1×10^5 Nm^{-2} at 300 K temperature. Assume the ideal gas behaviour and calculate the

(i) Partial pressure of O_2 in the mixture.

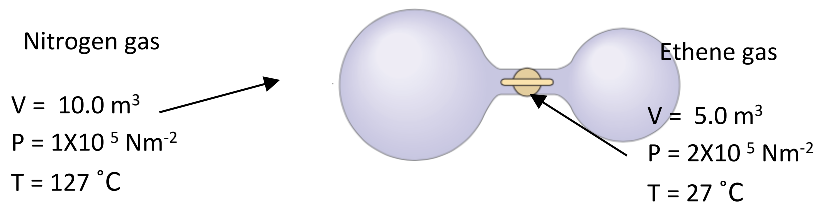
(ii)The density of the gas mixture. (Atomic mass of N=14, O =16) (1.16 Kg m^{-3})

(c) You are provided with a real gas. You do not know the molecular mass of this gas. How do you demonstrate the non-ideal behaviour of this gas?

(d) Briefly explain the experimental procedure of determining the volume of 1 mol of oxygen (molar volume) in your lab. Explain the method to determine the molar volume of Oxygen at standard temperature and pressure.

54. (a) (1) Write the Avogadro's law. What systems obey this law?

(1) A and B bulbs are connected to each other. At the beginning the tap connecting the two bulbs are closed. Bulb A contains N_2 (g) and Bulb B contains Ethene $\{C_2H_4\}$ (g). The two gas bulbs are kept under the conditions given below.



The tap was opened, and the two gases were allowed to mix independently and completely. However, the temperature of each bulb is kept constant at their initial temperatures. Assume that both N_2 and C_2H_4 behave ideally, and that the volume of the tap is negligible and calculate the following in SI units

(1) Number of C_2H_4(g) moles initially present in bulb B
(2) Number of N_2 (g) moles initially present in bulb A.
(3) Total amount of gas in both bulbs.
(4) Final pressure of the gas mixture in bulb B
(5) Final partial pressure of C_2H_4 (g) in bulb A.

(400.9 mol, 300.7 mol, 701.6 mol, 1.4×10^5 Pa, 8×10^4 Pa)

55. 1.2 g of a mixture that contains $NaHCO_3$ and Na_2CO_3 requires 3.00 cm^3 of 6.00 mol dm^{-3} HCl to react completely. (M (Na_2CO_3) =106); M ($NaHCO_3$) = 84)

(1) Write a balanced equation for the reaction between $NaHCO_3$ and Na_2CO_3 with HCl
(2) Total number of HCl moles required for the reaction.
(3) Calculate the masses of Na_2CO_3 and $NaHCO_3$ in the sample.
(4) Total number of CO_2 moles eliminated.
(5) Volume of eliminated CO_2 at 25 ˚C and 1.013x10^5 Pa

(1.8×10^{-2} mol, 0.53 g, 0.672 g, 1.3×10^{-2} mol, 0.318 dm^3)

56. (1) At 273 K and 1.01x10^5 Nm^{-2} the density of H_2 gas is 8.96x10^{-2} g dm^{-3}. Calculate the root mean square speed of H_2 molecules under these conditions. (1838.9 ms^{-1})

(2) Calculate the root mean square speed of Ar at standard temperature and pressure. (Ar = 40) {412.5 ms^{-1}}

(3) Calculate the kinetic energy of 1 mol of any ideal gas at 1000 K. (12471 J mol^{-1})

(4) Calculate the ratio between root mean square speeds of oxygen and xenon at 27 ˚C. (O=16, Xe=131) {2.023:1}

57. A person exhales about 5.8×10^2 L of carbon dioxide per day (at STP). The carbon dioxide exhaled by an astronaut is absorbed from the air of a space capsule by reaction with lithium hydroxide, LiOH.

$2LiOH(s) + CO_2(g) \rightarrow Li_2CO_3(s) + H_2O(l)$

How many grams of lithium hydroxide are required per astronaut per day? (Li= 7){360.78 g)

58. Pyruvic acid, $HC_3H_3O_3$, is involved in cell metabolism. It can be assayed for (that is, the amount of it determined) by using a yeast enzyme. The enzyme makes the following reaction go to completion:

$HC_3H_3O_3(aq) \rightarrow C_2H_4O(aq) + CO_2(g)$

If a sample containing pyruvic acid gives 21.2 mL of carbon dioxide gas, CO_2, at 349 mmHg and 30 ℃, how many grams of pyruvic acid are there in the sample? (0.034 g)

59. Liquid oxygen was first prepared by heating potassium chlorate, $KClO_3$, in a closed vessel to obtain oxygen at high pressure. The oxygen was cooled until it liquefied.

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

If 170 g of potassium chlorate reacts in a 2.50 L vessel, which was initially evacuated, what pressure of oxygen will be attained when the temperature is finally cooled to 25℃? Ignore the volume of solid product. (2061.3 Pa)

60. Raoul Pictet, the Swiss physicist who first liquefied oxygen, attempted to liquefy hydrogen. He heated potassium formate, $KCHO_2$, with KOH in a closed 2.50 L vessel.

$KCHO_2(s) + KOH(s) \rightarrow K_2CO_3(s) + H_2(g)$

If 50.0 g of potassium formate reacts in a 2.50 L vessel, which was initially evacuated, what pressure of hydrogen will be attained when the temperature is finally cooled to 25 ℃? (5.89×10^5 Pa)

61. A 24.9 mL volume of hydrochloric acid reacts completely with 55.0 mL of aqueous Na_2CO_3. The reaction is

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l) + 2NaCl(aq)$$

The volume of CO_2 formed is 159 mL at 23 °C and 727 mmHg. What is the molarity of the HCl solution? (0.496 mol dm^{-3})

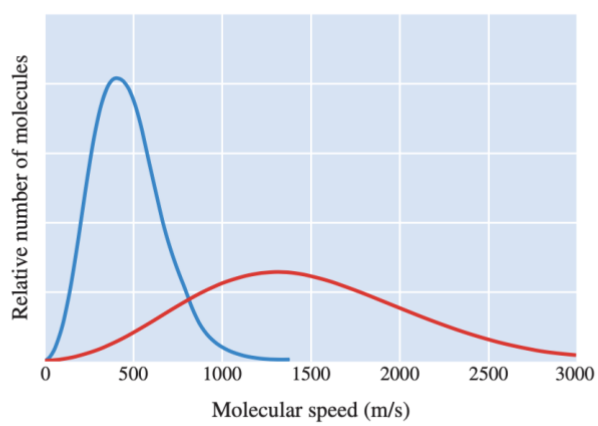
62. A 15 mL volume of hydrochloric acid reacts completely with a solid sample of $MgCO_3$. The reaction is

$$2HCl(aq) + MgCO_3(s) \rightarrow CO_2(g) + H_2O(l) + MgCl_2(aq)$$

The volume of CO_2 formed is 141 mL at 27 °C and 731 mmHg. What is the molarity of the HCl solution? (0.724 mol dm^{-3})

63. A 41.41 mL sample of a 0.1250 M acid reacts with an excess of Na_2CO_3 to form 150.0 mL CO_2 at 646 mmHg and 27 °C. If the acid is either HCl or H_2SO_4, which is it? (H_2SO4)

64. The graph below represents the distribution of molecular speeds of hydrogen and neon at 200 K.



a. Match each curve to the appropriate gas.

b. Calculate the root mean square speed (in m/s) for each of the gases at 200 K.(Ne =20)

c. Which of the gases would you expect to have the greater diffusion rate at 200 K?

d. Calculate the temperature at which the root mean square speed of the hydrogen gas would equal to that of the Neon at 200 K.

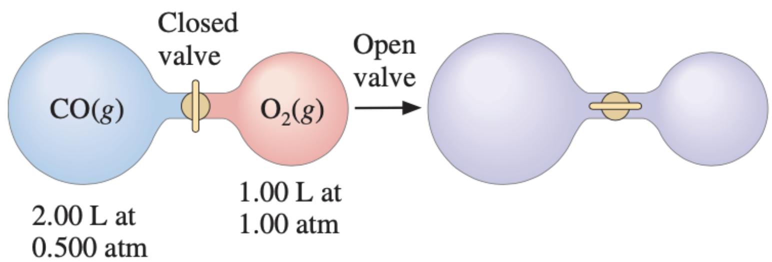
(1579.3 ms^{-1}, 499.4 ms^{-1}, H_2, 141.4 K)

65. A submersible balloon is sent to the bottom of the ocean. On shore, the balloon had a capacity of 162 L when it was filled at 21.0 °C and standard pressure. When it reaches the ocean floor, which is at 5.92 °C, the balloon occupies 18.8 L of space. What is the pressure on the ocean floor? ($8.75\times 10^5\ Pa$)

66. Carbon monoxide, CO, and oxygen, O_2, react according to

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

Assuming that the reaction takes place and goes to completion, determine what substances remain and what their partial pressures are after the valve is opened in the apparatus represented in the accompanying figure. Also assume that the temperature is fixed at 300 K. ($P_{O2} = 1.67 \times 10^4\ Pa$)



67. Suppose the apparatus shown in the figure accompanying question 66 above contains H_2 at 1 atm in the left vessel separated from O_2 at 2 atm in the other vessel. The valve is then opened. If H_2 and O_2 react to give H_2O when the temperature is fixed at 300 K, what substances remain and what are their partial pressures after reaction? (O_2 remains, $3.32 \times 10^5\ Pa$)

68. If it takes 3.52 s for 10.0 mL of helium to effuse (leak) through a hole in a container at a particular temperature and pressure, how long would it take for 10.0 mL of oxygen, O_2, to effuse from the same container at the same temperature and pressure? (Note that the rate of effusion can be given in terms of volume of gas effused per second.) {9.96 s)

69. Calculate the temperature of which hydrogen molecules, H_2, have the same rms speed as nitrogen molecules, N_2, at 455 ℃? (-221 ℃)

70. Calcium carbide reacts with water to produce acetylene gas, C_2H_2. Calculate the volume (in liters) of acetylene produced at 26 ℃ and 684 mmHg from 0.050 mol CaC_2 and excess H_2O. (1.38 L)

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$$