5 States of Matter

I. Multiple Choice Questions (Type-I)

1. A person living in Shimla observed that cooking food without using pressure cooker takes more time. The reason for this observation is that at high altitude:

(*i*) pressure increases (*ii*) temperature decreases
(*iii*) pressure decreases (*iv*) temperature increases

Ans. (*iii*)

Explanation: Pressure at high altitude is low and this leads boiling at low temperature. Things take more time to boil.

2. Which of the following property of water can be used to explain the spherical shape of rain droplets?

(*i*) viscosity (*ii*) surface tension
(*iii*) critical phenomena (*iv*) pressure

Ans. (*ii*)

Explanation: The rain droplets are spherical because for a given volume, a sphere has minimum surface area and has lower state of energy.

3. A plot of volume (V) versus temperature (T) for a gas at constant pressure is a straight line passing through the origin. The plots at different values of pressure are shown in Fig. 5.1. Which of the following order of pressure is correct for this gas?

(*i*) $p_1 > p_2 > p_3 > p_4$
(*ii*) $p_1 = p_2 = p_3 = p_4$
(*iii*) $p_1 < p_2 < p_3 < p_4$
(*iv*) $p_1 < p_2 = p_3 < p_4$

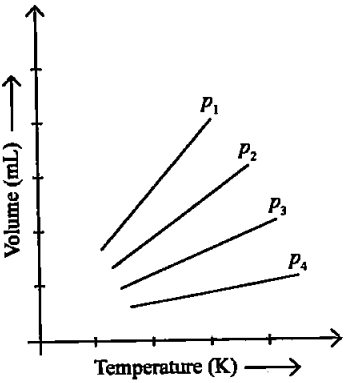


Fig. 5.1

Ans. (*iii*)

Explanation: At constant temperature, PV = Constant.

$$P_1V_1 = P_2V_2 = P_3V_3 = P_4V_4$$

If $V_1 > V_2 > V_3 > V_4$

Therefore $P_1 < P_2 < P_3 < P_4$

4. The interaction energy of London force is inversely proportional to sixth power of the distance between two interacting particles but their magnitude depends upon

(*i*) charge of interacting particles
(*ii*) mass of interacting particles
(*iii*) polarisability of interacting particles
(*iv*) strength of permanent dipoles in the particles.

Ans. (*iii*)

Explanation: Greater the polarisability of the interacting particles, greater is the magnitude of the interaction energy.

5. Dipole-dipole forces act between the molecules possessing permanent dipole. Ends of dipoles possess 'partial charges'. The partial charge is
(*i*) more than unit electronic charge
(*ii*) equal to unit electronic charge
(*iii*) less than unit electronic charge
(*iv*) double the unit electronic charge

Ans. (*iii*)

Explanation: Ends of the dipoles possess "partial charges" and these charges are shown by Greek letter *delta* (δ). Partial charges are always less than the unit electronic charge (1.6×10^{-19} C).

6. The pressure of a 1:4 mixture of dihydrogen and dioxygen enclosed in a vessel is one atmosphere. What would be the partial pressure of dioxygen?
(*i*) 0.8×10^5 atm (*ii*) 0.008 Nm^{-2}
(*iii*) 8×10^4 Nm^{-2} (*iv*) 0.25 atm

Ans. (*iii*)

Explanation: Partial pressure of O_2 = Mole fraction of O_2 × total pressure of mixture.

$$= \frac{4}{5} \times 1 \text{ atm} = 0.8 \text{ atm.} = 0.8 \times 10^5 \text{ Nm}^{-2} = 8 \times 10^4 \text{ Nm}^{-2}$$

7. As the temperature increases, average kinetic energy of molecules increases. What would be the effect of increase of temperature on pressure provided the volume is constant?
(*i*) increases (*ii*) decreases
(*iii*) remains same (*iv*) becomes half

Ans. (*i*)

Explanation: Kinetic energy of molecules is directly proportional to the temperature.

According to Gay-Lussac's law, at constant volume as the temperature increases, pressure also increases.

8. Gases possess characteristic critical temperature which depends upon the magnitude of intermolecular forces between the particles. Following are the critical temperatures of some gases.

Gases	H_2	He	O_2	N_2
Critical temperature in Kelvin	33.2	5.3	154.3	126

From the above data what would be the order of liquefaction of these gases? Start writing the order from the gas liquefying first.

(*i*) H_2, He, O_2, N_2 (*ii*) He, O_2, H_2, N_2

(*iii*) N_2, O_2, He, H_2 (*iv*) O_2, N_2, H_2, He

Ans. (*iv*)

Explanation: Higher is the critical temperature, more easily the gas liquefied.

9. What is SI unit of viscosity coefficient (η)?

(*i*) Pascal (*ii*) Nsm^{-2}

(*iii*) $km^{-2}\ s$ (*iv*) $N\ m^{-2}$

Ans. (*ii*)

10. Atmospheric pressures recorded in different cities are as follows:

Cities	Shimla	Bangalore	Delhi	Mumbai
p in N/m^2	1.01×10^5	1.2×10^5	1.02×10^5	1.21×10^5

Consider the above data and mark the place at which liquid will boil first.

(*i*) Shimla (*ii*) Bangalore

(*iii*) Delhi (*iv*) Mumbai

Ans. (*i*)

Explanation: Boiling point of liquid is directly proportional to atmospheric pressure.

In Shimla lowest pressure hence the boiling of liquid in Shimla will be first.

11. Which curve in Fig. 5.2 represents the curve of ideal gas?

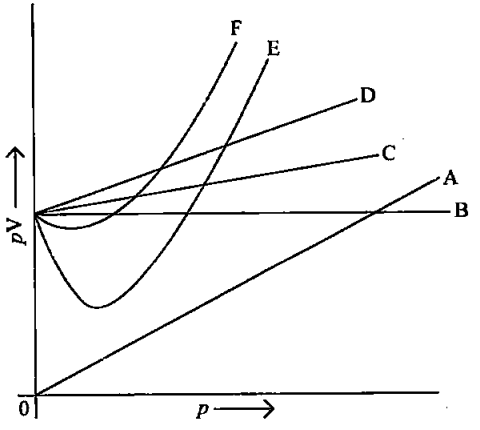


Fig. 5.2

(*i*) B only (*ii*) C and D only

(*iii*) E and F only (*iv*) A and B only

Ans. (*i*)

Explanation: For an ideal gas PV = Constant at all pressures.

12. Increase in kinetic energy can overcome intermolecular forces of attraction. How will the viscosity of liquid be affected by the increase in temperature?
(*i*) Increase (*ii*) No effect
(*iii*) Decrease (*iv*) No regular pattern will be followed

Ans. (*iii*)

Explanation: The kinetic energy of the molecules increases with the increase in temperature which can overcome the intermolecular forces and liquid starts flowing, hence viscosity decreases.

13. How does the surface tension of a liquid vary with increase in temperature?
(*i*) Remains same (*ii*) Decreases
(*iii*) Increases (*iv*) No regular pattern is followed

Ans. (*ii*)

Explanation: Surface tension is inversely proportional to the temperature. The kinetic energy of the molecule increases with the increase of temperature and therefore, the intermolecular attraction decreases.

II. Multiple Choice Questions (Type-II)

In the following questions two or more options may be correct.

14. With regard to the gaseous state of matter which of the following statements are correct?
(*i*) Complete order of molecules
(*ii*) Complete disorder of molecules
(*iii*) Random motion of molecules
(*iv*) Fixed position of molecules

Ans. (*ii*), (*iii*)

Explanation: In gaseous state, molecules are in random motion and molecules are disorderly arranged. Entropy of gases is very high.

15. Which of the following figures does not represent 1 mole of dioxygen gas at STP?
(*i*) 16 grams of gas
(*ii*) 22.7 litres of gas
(*iii*) 6.022×10^{23} dioxygen molecules
(*iv*) 11.2 litres of gas

Ans. (*i*), (*ii*) and (*iv*)

Explanation: 1 mole of O_2 at STP occupies 22.4 litre volume, has molar mass = 32g and contains 6.023×10^{23} molecules of O_2.

16. Under which of the following two conditions applied together, a gas deviates most from the ideal behaviour?
(*i*) Low pressure (*ii*) High pressure
(*iii*) Low temperature (*iv*) High temperature

Ans. (*ii*), (*iii*)

Explanation: Gases which obey $PV = nRT$ at all conditions of temperature and pressure are called as ideal gases. Gases under high pressure and low temperature deviate from $PV = nRT$. These gases are called real gases.

17. Which of the following changes decrease the vapour pressure of water kept in a sealed vessel?

(*i*) Decreasing the quantity of water
(*ii*) Adding salt to water
(*iii*) Decreasing the volume of the vessel to one-half
(*iv*) Decreasing the temperature of water

Ans. (*ii*), (*iv*)

Explanation: On adding salt to water, surface area available for water molecule to vaporize is decreasing, therefore vapour pressure decreases. Vapour pressure is directly proportional to the temperature, hence the vapour pressure decreases on lowering the temperature.

III. Short Answer Type

18. If 1 gram of each of the following gases are taken at STP, which of the gases will occupy (*a*) greatest volume and (*b*) smallest volume?

CO, H_2O, CH_4, NO

Ans. According to Avogadro's law :

Volume of 1 mole gas = 22.4 L at STP.
Volume of 1g CO = 22.4/28g L at STP (Molar mass of CO = 28 g/mol)
Volume of 1g H_2O = 22.4/18g L at STP (Molar mass of H_2O = 18 g/mol)
Volume of 1g CH_4 = 22.4/16g L at STP (Molar mass of CH_4 = 16 g/mol)
Volume of 1g NO = 22.4/30g L at STP (Molar mass of NO = 30 g/mol)

(*i*) 1 g CH_4 will occupy maximum volume.
(*ii*) 1g NO will occupy minimum volume.

19. Physical properties of ice, water and steam are very different. What is the chemical composition of water in all the three states?

Ans. Water having same chemical composition exist in three physical states, solid, liquid and gas. In these states molecules are arranged in different manner therefore physical properties are different.

20. The behaviour of matter in different states is governed by various physical laws. According to you what are the factors that determine the state of matter?

Ans. Mass, volume, temperature and pressure are the factors which determines the different states of matter.

21. Use the information and data given below to answer the questions (*a*) to (*c*):

- Stronger intermolecular forces result in higher boiling point.
- Strength of London forces increases with the number of electrons in the molecule.

- Boiling point of HF, HCl, HBr and HI are 293 K, 189 K, 206 K and 238 K respectively.
  (*a*) Which type of intermolecular forces are present in the molecules HF, HCl, HBr and HI?
  (*b*) Looking at the trend of boiling points of HCl, HBr and HI, explain out of dipole-dipole interaction and London interaction, which one is predominant here?
  (*c*) Why is boiling point of hydrogen fluoride highest while that of hydrogen chloride lowest?

Ans. (*a*) In HCl, HBr and HI dipole-dipole and London forces are present but in HF besides these, intermolecular hydrogen bonding is also present.
(*b*) Electronegativity decreases from Cl to I so, dipole moment decreases from HCl to HI. As the boiling point is increasing from HCl to HI, it means London forces are predominant. London force is directly proportional to number of electrons in molecule.
(*c*) HF has the highest eletronegativity as a result has highest dipole moment and also has hydrogen bonding therefore, HF shows highest boiling point.

22. What will be the molar volume of nitrogen and argon at 273.15 K and 1 atm?

Ans. As the conditions given are of STP and at STP volume occupied by 1 mole of gas called molar volume and it is equal to 22.4 L. Hence, the volume of N_2 and argon at 273.15 K and at 1 atm is 22.4 litre.

23. A gas that follows Boyle's law, Charle's law and Avogadro's law is called an ideal gas. Under what conditions a real gas would behave ideally?

Ans. Real gases behave ideally at low pressure and high temperature.

24. Two different gases 'A' and 'B' are filled in separate containers of equal capacity under the same conditions of temperature and pressure. On increasing the pressure slightly the gas 'A' liquefies but gas B does not liquify even on applying high pressure until it is cooled. Explain this phenomenon.

Ans. It is based on the critical temperature. Since, gas A liquefies easily, this suggests that gas A is below its critical temperature. Gas 'B' does not liquefy even on applying high pressure. Therefore, the gas 'B' is above its critical temperature.

25. Value of universal gas constant (R) is same for all gases. What is its physical significance?

Ans. $R = PV/nT$. Unit of R depends on which P, V and T are measured. If pressure in pascal, volume in m^3 and temperature in kelvin, then unit of R is Pa m^3 K^{-1} mol^{-1} or $Jmol^{-1}$ K^{-1}. Joule is the unit of work done therefore, R is the work done by the gas per mole per kelvin.

26. One of the assumptions of kinetic theory of gases states that "there is no force of attraction between the molecules of a gas." How far is this statement correct? Is it possible to liquefy an ideal gas? Explain.

Ans. For an ideal gas this statement is correct and an ideal gas cannot be liquefy because there are no intermolecular forces of attractions between the gaseous molecules.

27. The magnitude of surface tension of liquid depends on the attractive forces between the molecules. Arrange the following in increasing order of surface tension:

water, alcohol (C_2H_5OH) and hexane [$CH_3(CH_2)_4CH_3$)].

Ans. In the given molecules water and alcohol are polar, hexane is non polar. Water and alcohol being polar have dipole-dipole interaction and intermolecular hydrogen bonding. H-bonding is stronger in water therefore magnitude of surface tension is more in water than alcohol. On the other hand hexane has weak London dispersion forces only.

Hexane < Alcohol < Water.

28. Pressure exerted by saturated water vapour is called aqueous tension. What correction term will you apply to the total pressure to obtain pressure of dry gas?

Ans. If the pressure 'P' of moist gas is given at temperature T, then to get pressure of dry gas 'P_1' = P – aqueous tension at temperature T.
When the gas is collected by the downward displacement of water, it is moist.

$$\text{'P'}_{\text{moist gas}} = \text{'P'}_{\text{dry gas}} + \text{Aqueous tension}$$

29. Name the energy which arises due to motion of atoms or molecules in a body. How is this energy affected when the temperature is increased?

Ans. The energy which arises due to the motion of atoms or molecules in a body is known as thermal energy and it is a measure of average of kinetic energies of all the particles.
It increases with increase in temperature.

30. Name two intermolecular forces that exist between HF molecules in liquid state.

Ans. In liquid HF hydrogen bond and dipole-dipole interactions are present.

31. One of the assumptions of kinetic theory of gases is that there is no force of attraction between the molecules of a gas.
State and explain the evidence that shows that the assumption is not applicable for real gases.

Ans. Real gases can be liquefy by cooling and applying high pressure on the gas. This proves that forces of attraction exist between molecules.

32. Compressibility factor, Z, of a gas is given as $Z = \frac{pV}{nRT}$

(*i*) What is the value of Z for an ideal gas?

(*ii*) For real gas what will be the effect on value of Z above Boyle's temperature?

Ans. (*i*) Z is a compressibility factor and for an ideal gas z = 1.

(*ii*) Above Boyle's temperature, real gases show positive deviation *i.e.*, Z > 1.

33. The critical temperature (T_c) and critical pressure (p_c) of CO_2 are 30.98°C and 73 atm respectively. Can CO_2 (g) be liquefied at 32°C and 80 atm pressure?

Ans. CO_2 gas cannot be liquefied above 30.98° C and 73 atm. pressure. However, high temperature and high pressure may be applied on CO_2 gas hence it cannot be liquefied at 32°C and 80 atm pressure.

34. For real gases the relation between *p*, V and T is given by van der Waals equation:

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

where '*a*' and '*b*' are van der Waals constants, '*nb*' is approximately equal to the total volume of the molecules of a gas.

'*a*' is the measure of magnitude of intermolecular attraction.

(*i*) Arrange the following gases in the increasing order of '*b*'. Give reason.

$$O_2, CO_2, H_2, He$$

(*ii*) Arrange the following gases in the decreasing order of magnitude of '*a*'. Give reason.

$$CH_4, O_2, H_2$$

Ans. (*i*) Volume is proportional to the size of the molecules. Hence, value of 'b' increases in the following order:

$$H_2 < He < O_2 < CO_2$$

(*ii*) Van der Waal's constant '*a*' represent the magnitude of intermolecular attraction and it increases with the increase in the size of electron cloud in a molecule. Greater the size of electron cloud, greater is the polarisability of the molecule and greater is the dispersion forces.

$$CH_4 > O_2 > H_2$$

35. The relation between pressure exerted by an ideal gas (p_{ideal}) and observed pressure (p_{real}) is given by the equation

$$p_{ideal} = p_{real} + \frac{an^2}{V^2}$$

If pressure is taken in Nm^{-2}, number of moles in mol and volume in m^3, calculate the unit of '*a*'.

What will be the unit of 'a' when pressure is in atmosphere and volume in dm^3?

Ans. Given that $p_{ideal} = p_{real} + an^2/V^2$

(*i*) $a = pV^2/n^2$

if unit of $p = Nm^{-2}$

Unit of V = m^3, number of moles (*n*) = mol

Unit of '*a*' = $Nm^{-2} (m^3)^2/(mol)^2 = Nm^4 mol^{-2}$

(*ii*) If unit of p = atm, unit of V = dm^3, unit of n = mol
Then units of 'a' = pV^2/n^2 = atm $(dm^3)^2/(mol)^2$ = atm dm^6 mol^{-2}

36. Name two phenomena that can be explained on the basis of surface tension.

Ans. (*i*) Capillary action, *i.e.* rise or fall of the liquid in capillary tube.
(*ii*) Spherical shape of liquid drops.

37. Viscosity of a liquid arises due to strong intermolecular forces existing between the molecules. Stronger the intermolecular forces, greater is the viscosity. Name the intermolecular forces existing in the following liquids and arrange them in the increasing order of their viscosities. Also give reason for the assigned order in one line.
Water, hexane ($CH_3CH_2CH_2CH_2CH_2CH_3$),
glycerine (CH_2OH $CH(OH)$ CH_2OH)

Ans. Viscosity is least in hexane and maximum in glycerine, because in hexane only weakest London forces exist but in water and glycerine dipole–dipole interaction and extensive H–bonding are present.
Strongest intermolecular forces are in glycerine.
Order of viscosity: Hexane < water < glycerine.

38. Explain the effect of increasing the temperature of a liquid, on intermolecular forces operating between its particles, what will happen to the viscosity of a liquid if its temperature is increased?

Ans. As the temperature increases, kinetic energy of the molecule increases which can overcome intermolecular forces and hence the viscosity decreases.

39. The variation of pressure with volume of the gas at different temperatures can be graphically represented as shown in Fig. 5.3.
On the basis of this graph answer the following questions.
(*i*) How will the volume of a gas change if its pressure is increased at constant temperature?
(*ii*) At a constant pressure, how will the volume of a gas change if the temperature is increased from 200K to 400K?

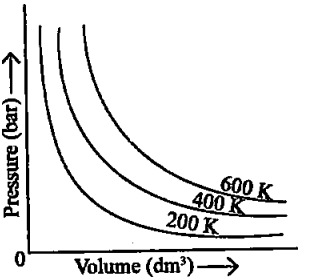


Fig. 5.3

Ans. (*i*) At constant temperature, according to Boyle's law, pressure of the gas is inversely proportional to its volume. If pressure is increased, then the volume is decreased at constant temperature *e.g.*, at 200 K when pressure increases from p_1 to p_2, volume decreases from v_1 to v_2 ($v_2 < v_1$).
(*ii*) According to Charles's law, volume of the gas is directly proportional to its temperature if pressure is kept constant. At constant pressure, if temperature is increased from 200 K to 400 K, the volume of the gas increases.

40. Pressure versus volume graph for a real gas and an ideal gas are shown in Fig. 5.4. Answer the following questions on the basis of this graph.

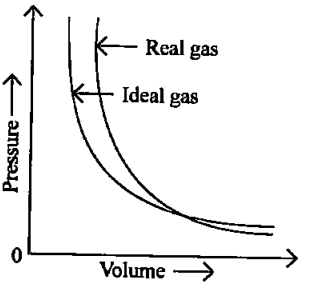


Fig. 5.4

(*i*) Interpret the behaviour of real gas with respect to ideal gas at low pressure.

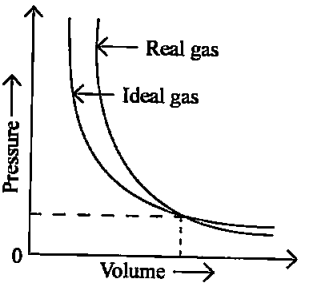
(*ii*) Interpret the behaviour of real gas with respect to ideal gas at high pressure.

(*iii*) Mark the pressure and volume by drawing a line at the point where real gas behaves as an ideal gas.

Ans. (*i*) At low pressure real gases show very small deviation from ideal behaviour because both the curves almost coincide each other.

(*ii*) At high pressure real gases show large deviation from ideal behaviour as the curves are far apart.

(*iii*) At one point the curves intersect each other and shows real gases behave like ideal gas.



IV. Matching Type

41. Match the graphs between the following variables with their names:

Graphs	Names
(*i*) Pressure vs temperature graph at constant molar volume.	(*a*) Isotherms
(*ii*) Pressure vs volume graph at constant temperature.	(*b*) Constant temperature curve
(*iii*) Volume vs temperature graph at constant pressure.	(*c*) Isochores
	(*d*) Isobars

Ans. (*i*) → (*c*); (*ii*) → (*a*); (*iii*) → (*d*)

Explanation:

(*i*) The graph at constant molar volume is called isochore.

(*ii*) The graph at constant temperature is called isotherm.

(*iii*) The graph at constant pressure is called isobar.

42. Match the following gas laws with the equation representing them.

Column I	Column II
(*i*) Boyle's law	(*a*) $V \propto n$ at constant T and p
(*ii*) Charles' law	(*b*) $p_{Total} = p_1 + p_2 + p_3 + \ldots$ at constant T, V.

(*iii*) Dalton's law	(*c*) $\frac{pV}{T}$ = constant
(*iv*) Avogadro law	(*d*) $V \propto T$ at constant *n* and *p*
	(*e*) $p \propto \frac{1}{V}$ at constant *n* and T

Ans. (*i*) → (*e*); (*ii*) → (*d*); (*iii*) → (*b*); (*iv*) → (*a*)

Explanation:

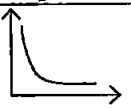
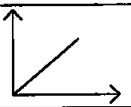
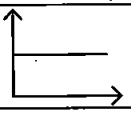
(*i*) **Boyle's law:** The pressure of the gas is inversly proportional to its volume (T constant).

(*ii*) **Charles' law:** Volume of the gas is directly proportional to its temperature(pressure constant).

(*iii*) **Dalton's law:** At constant V and T, total pressure of the gaseous mixture of two or more non reacting gases is equal to the algebraic sum of their partial pressures.

(*iv*) **Avogadro law:** It states that equal volumes of all gases, under the same conditions of temperature and pressure, contain equal number of molecules. $V \propto n$.

43. Match the following graphs of ideal gas with their co-ordinates:

Graphical representation	*x* and *y* co-ordinates
(*i*) 	(*a*) *p*V vs. V
(*ii*) 	(*b*) *p* vs. V
(*iii*) 	(*c*) *p* vs. $\frac{1}{V}$

Ans. (*i*) → (*b*); (*ii*) → (*c*); (*iii*) → (*a*)

Explanation:

(*i*) Pressure of the gas is inversely proportional to its volume (T constant)

(*ii*) Pressure of the gas is directly proportional to 1/V.

(*iii*) Product of pressure and volume is always constant. PV= constant.

V. Assertion and Reason Type

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

44. Assertion (A) : Three states of matter are the result of balance between intermolecular forces and thermal energy of the molecules.

Reason (R) : Intermolecular forces tend to keep the molecules together but thermal energy of molecules tends to keep them apart.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*i*)

Explanation: Both the factors, *i.e.*, intermolecular forces and thermal energy decide the state of matter. Balance is required in these two factors.

45. Assertion (A) : At constant temperature, pV vs V plot for real gases is not a straight line.

Reason (R) : At high pressure all gases have $Z > 1$ but at intermediate pressure most gases have $Z < 1$.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*ii*)

Explanation: At constant temperature pV vs V plot for real gases is not a straight line because intermolecular forces of attraction are present in real gases.

46. Assertion (A) : The temperature at which vapour pressure of a liquid is equal to the external pressure is called boiling temperature.

Reason (R) : At high altitude atmospheric pressure is high.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*iii*)

Explanation: Assertion is correct but reason is wrong because at high altitude pressure is low.

47. Assertion : Gases do not liquefy above their critical temperature, even on applying high pressure.

Reason : Above critical temperature, the molecular speed is high and intermolecular attractions cannot hold the molecules together because they escape because of high speed.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*i*)

Explanation: Both A and R are correct. Reason for A is also correct. Gases do not liquefy above their critical temperature even on applying high pressure because the molecular speed is high and intermolecular forces of attraction cannot hold the molecules together.

48. Assertion (A) : At critical temperature liquid passes into gaseous state imperceptibly and continuously.

Reason (R) : The density of liquid and gaseous phase is equal to critical temperature.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*i*)

Explanation: Both A and R are correct and reason for A is also correct. At critical temperature density of liquid becomes equal to its vapour phase. Due to which liquid changes into gaseous state imperceptibly and continuously.

49. Assertion (A) : Liquids tend to have maximum number of molecules at their surface.

Reason (R) : Small liquid drops have spherical shape.

(*i*) Both A and R are true and R is the correct explanation of A.
(*ii*) Both A and R are true but R is not the correct explanation of A.
(*iii*) A is true but R is false.
(*iv*) A is false but R is true.

Ans. (*iv*)

Explanation: A is false but R is true. Liquid try to reduce number of the molecules and tends to reduce surface tension at their surface that's why liquid drops have spherical shape.

VI. Long Answer Type

50. Isotherms of carbon dioxide at various temperatures are represented in Fig. 5.5. Answer the following questions based on this figure.

(*i*) In which state will CO_2 exist between the points *a* and *b* at temperature T_1?

(*ii*) At what point will CO_2 start liquefying when temperature is T_1?

(*iii*) At what point will CO_2 be completely liquefied when temperature is T_2.

(*iv*) Will condensation take place when the temperature is T_3.

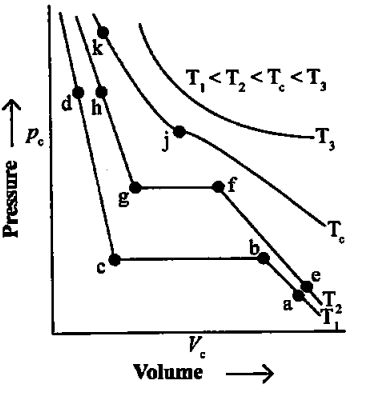


Fig. 5.5

(*v*) What portion of the isotherm at T_1 represent liquid and gaseous CO_2 at equilibrium?

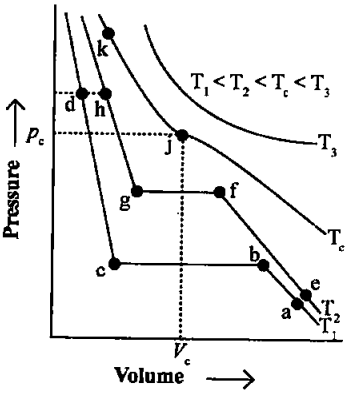
Ans. (*i*) CO_2 will exist in gaseous state between the points a and b at temperature T_1.

(*ii*) At point *b*, the plot becomes linear, phase transition, i.e liquefication starts and CO_2 gets completely liquefied at point *c*.

(*iii*) At temperature T_2, g is the point at which CO_2 will be completely liquefied.

(*iv*) $T_3 > T_c$. Condensation will not take place at T_3 temperature.

(*v*) Between b and c, liquid and gaseous CO_2 are in equilibrium.



51. The variation of vapour pressure of different liquids with temperature is shown in Fig. 5.6.

(*i*) Calculate graphically boiling points of liquids A and B.

(*ii*) If we take liquid C in a closed vessel and heat it continuously. At what temperature will it boil?

(*iii*) At high altitude, atmospheric pressure is low (say 60 mm Hg). At what temperature liquid D boils?

(*iv*) Pressure cooker is used for cooking food at hill station. Explain in terms of vapour pressure why is it so?

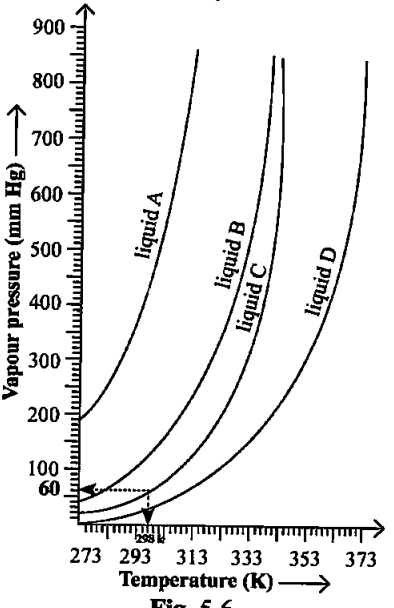


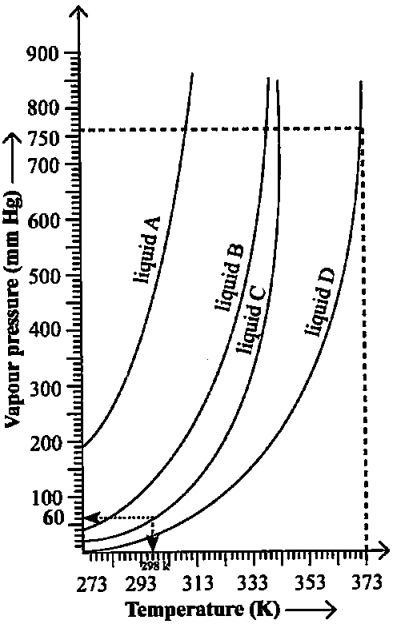
Fig. 5.6

Ans. (*i*) Boiling point of A = 315 K approximately.
Boiling point of B = 345 K approximately.

(*ii*) In a closed vessel liquid C will not boil because pressure is kept on increasing.

(*iii*) Temperature corresponding to 60 mm Hg = 296 K.

(*iv*) A liquid boils when vapour pressure of liquid becomes equal to atmospheric pressure. On hills water boils at low temperature, because atmospheric pressure is low at high altitude.
But when pressure cooker is used, the vapour pressure of water is increased due to which water boils at even low temperature within a short period of time.



52. Why does the boundary between liquid phase and gaseous phase disappear on heating a liquid upto critical temperature in a closed vessel? In this situation what will be the state of the substance?

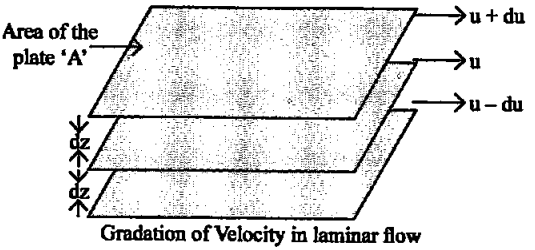
Ans. In a closed vessel, below the critical point, the surface of separation between the liquid and its vapour is clearly visible. At the critical point, the densities of the liquid and that of the vapour becomes equal and boundary of separation disappears. The fluid is called supercritical fluid These supercritical fluids dissolve many organic substances.

53. Why does sharp glass edge become smooth on heating it upto its melting point in a flame? Explain which property of liquids is responsible for this phenomenon.

Ans. On heating, glass melts and the surface of the liquid tends to take the rounded shape at the edges which has minimum surface area. This is called fire polishing of glass.

54. Explain the term 'laminar flow'. Is the velocity of molecules same in all the layers in laminar flow? Explain your answer.

Ans. When a liquid flows over a fixed surface, the layer of molecules in the immediate contact of surface is stationary. The velocity of the upper layer increases as the distance of layers increases from the fixed layer. This type of flow in which there is regular gradation of velocity in passing from one layer to the next is called laminar flow.



Gradation of Velocity in laminar flow

55. Isotherms of carbon dioxide gas are shown in Fig. 5.7. Mark a path for changing gas into liquid such that only one phase (i.e., either a gas or a liquid) exists at any time during the change. Explain how the temperature, volume and pressure should be changed to carry out the change.

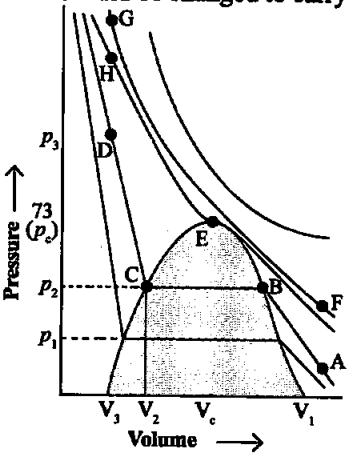
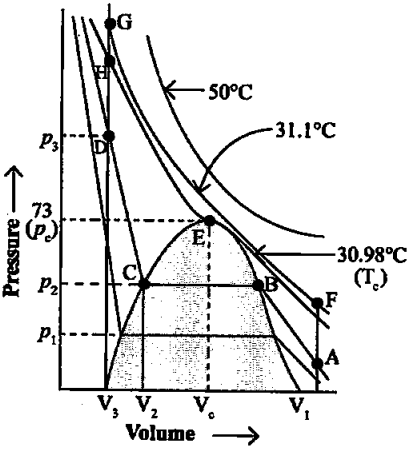


Fig. 5.7

Ans. In the given figure, we can move from A to F vertically by increasing the temperature, then we can reach the point G by compressing the gas at constant temperature along the isotherm, the pressure will increase. Now, move vertically down towards D by lowering the temperature. As soon as we cross the point H on the critical isotherm, we get liquid. If process is carried out at the critical temperature, substance always remains in one phase. This is called continuity of state between the gaseous and the liquid state.



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