Class 11 State of Matter Important Questions with Answers

Short Answer Type Questions

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

CO, H_20, CH_4, NO

Answer.
We know from Avogadro's law that at STP,
Volume of 1 mole gas = 22.4 L
1g CO = 22.4/28g L
1g H_2O = 22.4/18g L
1g CH_4 = 22.4/16g L
1g NO = 22.4/30g L

As a result,

(a) 1g CH 4 will take up the greatest volume.
(b) 1g NO will take up the smallest volume.

2. Physical properties of ice, water and steam are very different. What is the chemical composition of water in all the three states.
Answer.
Physical properties of ice, water and steam are very different because they are found in different states.

- Ice is found in solid,
- Water is found in liquid
- Steam found in vapour states.

The chemical composition of water in all the three states (ice, water and steam) is same, i.e., H_2O.

3. 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?

Answer.
Factors determining the state of matter are;
(i) Temperature

(ii) Pressure
(iii) Mass and Volume

4. Use the information and data given below to answer the questions (a) to (c):
o Stronger intermolecular forces result in higher boiling point.
o Strength of London forces increases with the number of electrons in the molecule.
o Boiling point of HF, HCI, 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, HCI, HBr and HI?
(b) Looking at the trend of boiling points of HCI, 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?

Answer.
We concluded from the information and data provided in the question that:

(a) Since molecules have permanent dipoles, dipole-dipole and London forces exist in HCl, HBr, and HI. London forces and hydrogen bonding are present in HF dipole-dipole interactions.
(b) Electronegativity decreases in the order of Cl > Br > I.
As a result, the dipole moment should decrease from HCl to HI. As a result, dipole-dipole interaction should decrease as the temperature rises from HCI to HI. However, as one moves from HCI to HI, the boiling point rises. This means that the forces of London are in control.
This is because the number of electrons in a molecule increases as the number of electrons increases, and in this case, the number of electrons increases from HCI towards HI.
(c) HF has the highest dipole moment attributes due to fluorine's high electronegativity and the presence of hydrogen bonding in HF. As a result, HF has a high boiling point.

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

Answer.
Under STP conditions, the volume occupied by 1 mole of each and every gas is 22.4L. Hence, the molar volume of nitrogen and argon at 273.15 K and 1 atm is 22.4 L.

6. 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?

Answer.
An ideal gas is a gas that obeys Boyle's law, Charles's law, and Avogadro's law.
A real gas would behave ideally under low pressure and high temperature.

The intermolecular attractions are minimal under these conditions, and the volume occupied by gas molecules is negligibly small in comparison to the total volume of the container.

7. 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 liquefy even on applying high pressure until it is cooled. Explain this phenomenon.

Answer.
The fact that two gases behave differently as their pressure increases indicates that they have different critical temperatures.

- Since "A" gas has a low critical temperature, it liquifies when pressure is applied.
- "B" gas has a high critical temperature, "B" needs to cool even when pressure is applied.

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

Answer.
The unit of R is determined by how p, V, and T are measured, as-

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

If pressure is measured in Pascal, per mole volume is measured in m^3, and temperature is measured in Kelvin, then the units of 'R' are Pa m^3 K^{-1} mol^{-1} (or) J K^{-1} mol^{-1}.
Since the joule is the unit of work done, 'R' represents the work done by the gas per mole per kelvin.

9. 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.

Answer.
This statement is correct for an ideal gas, and an ideal gas cannot be liquefied because there are no inter-molecular forces of attraction between the gaseous molecules.

10. 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 [$CH_3(CH_2)_4CH_3$]

Answer.
Only hexane [$CH_3(CH_2)_4CH_3$] is a non-polar molecule with only London dispersion forces in the list above. These forces are very weak because water and ethanol are both polar molecules with dipole-dipole interactions and H-bonding. However, because H-bonding interactions are much stronger

in water than in ethanol, it has stronger intermolecular forces than both alcohol and hexane. As a result, the increasing order of surface tension is Hexane < Alcohol < Water.

11. 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?

Answer.
If the pressure P of moist gas is given at temperature T, then the correction term that must be applied to the total pressure to obtain the pressure of dry gas is
$P_{Dry\ gas} = P_{Total}$ – Aqueous Tension

12. 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?

Answer.
The energy which arises due to motion of atoms or molecules in a body is Thermal energy.
It is a unit of measurement for the average kinetic energy of particles. It rises as the temperature rises.

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

Answer.
The two intermolecular forces that exist between HF molecules in liquid state are-
(i) Dipole - dipole interaction
(ii) Hydrogen - bonding

14. 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.

Answer.
The assumption only applies to ideal gases, not real gases. This is supported by the fact that gases in general (real gas) can be liquefied under specific temperature and pressure conditions. This clearly demonstrates that force of attraction exists in the molecules of a real gas.

15. Compressibility factor, Z, of a gas is given as Z = (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?

Answer.
Compressibility factor, Z, of a gas is given as Z = (pV/nRT)

(i) For an ideal gas, Z = 1. This is because pV = nRT.
(ii) For a real gas,

- When there is high pressure and low temperature Z > 1. This is because repulsion is more than attraction.
- When there is low pressure and high temperature Z < 1. This is because attraction is more than repulsion.

16. The critical temperature (T_C) and critical pressure (p_C) of $C0_2$ are 30.980°C and 73 atm respectively. Can $C0_2$ (g) be liquefied at 320°C and 80 atm pressure?

Answer.
CO_2 cannot be liquefied at 32°C under 80 atm pressure. This is due to the temperature being higher than the critical temperature of CO_2.

17. 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.
0_2, $C0_2$, H_2, He
(ii) Arrange the following gases in the decreasing order of magnitude of 'a'
Give reason.
CH_4, 0_2, H2

Answer.
(i) The volume of the molecules is proportional to their size. As a result, the value of 'b' rises in the following order:
$H_2 < He < O_2 < CO_2$
(ii) The magnitude of intermolecular attraction is represented by Van der Waal's constant 'a,' which increases with the size of the electron cloud in a molecule. The larger the electron cloud, the greater the polarisability of the molecule and the greater the dispersion forces.
$CH_4 > O_2 > H_2$

18. The relation between pressure exerted by an ideal gas (p_{ideal}l) and observed pressure (p_{real}l) is given by the equation
$P_{ideal} = P_{real} + (an^2/ V^2)$
(i) If pressure is taken in Nm^{-2}, number of moles in mol and volume in m^3, Calculate the unit of 'a'.
(ii) What will be the unit of 'a' when pressure is in atmosphere and volume in dm^3?

Answer.
(i) If unit of P is Nm^{-2},
Unit of V = m^3,
Number of moles, n = mol,

$$Nm^{-2} = Nm^{-2} + \frac{a \times mol^2}{(m^2)^3}$$

If two values with same units are added or subtracted then the units of result are same as added units.

$$Nm^{-2} = \frac{a \times mol^2}{(m^2)^3}$$

$$a = \frac{Nm^{-2} \times m^6}{mol^2}$$

$$a = Nm^{-2} \times m^6 \times mol^{-2}$$

(ii) When P is in atm,

$$a = atm \times dm^6 \times mol^{-2}$$

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

Answer.
Two phenomena that can be explained on the basis of surface tension are as follows-

(i) Rise or fall of the liquid in a capillary-(capillary action).
(ii) The spherical shape of small liquid drops.

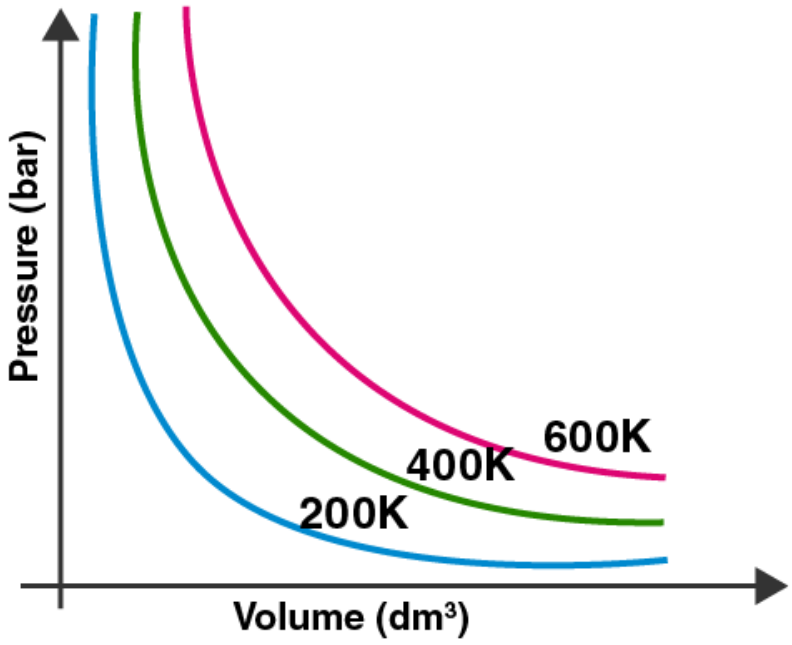
20. Viscosity of a liquid arises due to strong intermolecular forces existing between the molecules. Stronger the intermolecular forces, greater is the viscosity. Name the intermolecular forces existing in the following liquids and arrange them in the increasing order of their viscosities. Also, give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

Answer.
Hydrogen bonding is the intermolecular force that exists in water and glycerine.
Dispersion forces / London forces exist in the case of Hexane.
The viscosities of these liquids are in the following order:
Hexane < water < glycerine.
Glycerine has the strongest intermolecular forces, while hexane has the weakest (three OH groups).
As a result, hexane has the lowest viscosity and glycerine has the highest.

21. 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?

Answer.
Since the kinetic energy of the molecules can overcome intermolecular forces, the viscosity of a liquid decreases as temperature increases. As a result, the liquid can flow more freely.

22. 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.

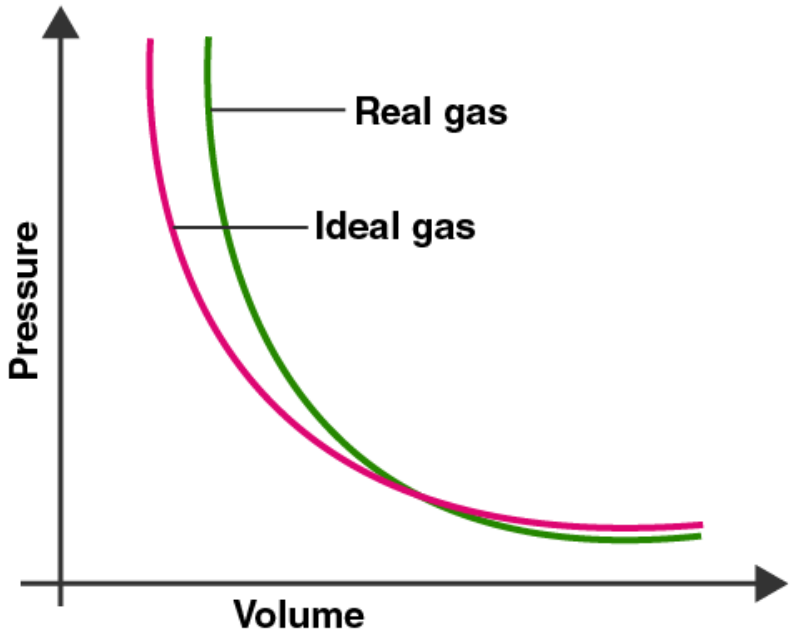


(i) How will the volume of a gas change if its pressure is increased at constant temperature?
(ii) At a constant pressure, how will the volume of a gas change if the temperature is increased from 200K to 400K?

Answer.
(i) When the temperature remains constant,
Boyle's law states that the pressure of a gas is inversely proportional to its volume. At constant temperature, increasing the pressure causes a decrease in volume.
When the pressure on a gas is increased while the temperature remains constant, the volume of the gas decreases.

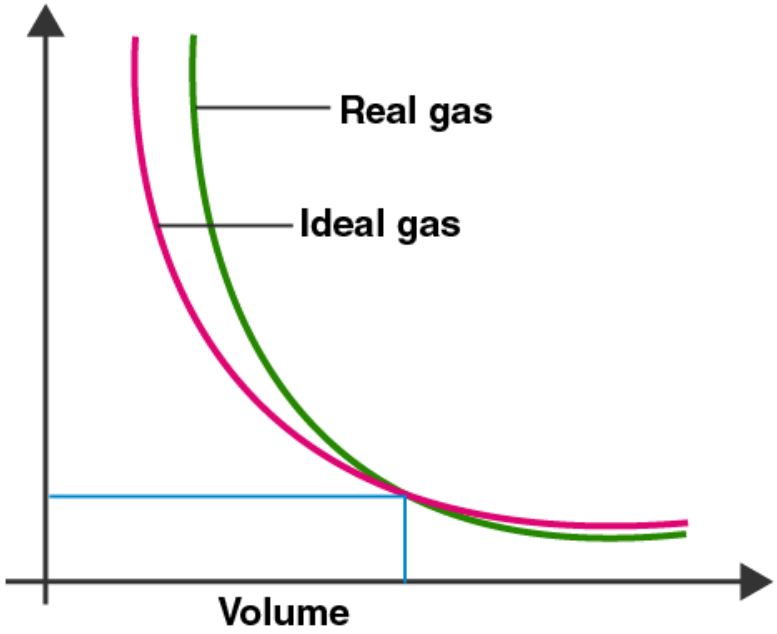
(ii) At constant pressure,
If the pressure remains constant, the volume of the gas is directly proportional to its temperature, according to Charles' law.
If the pressure remains constant, the volume of a gas increases as the temperature rises.

23. 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.



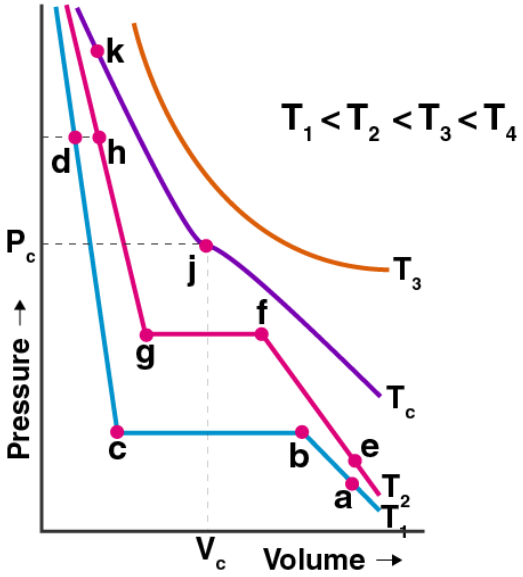
(i) Interpret the behaviour of real gas with respect to ideal gas at low pressure.
(ii) Interpret the behaviour of real gas with respect to ideal gas at high pressure.
(iii) Mark the pressure and volume by drawing a line at the point where real gas behaves as an ideal gas.

Answer.
(i) When the pressure is low, the two curves almost coincide. This demonstrates that at low pressure, the real gases deviate very little from ideal behaviour.
(ii) The curves are far apart at high pressure. This demonstrates that real gases exhibit large deviations at high pressure.
(iii) At point A, where the two curves intersect, the real gas behaves exactly like an ideal gas, with pressure and volume P1 and V1 corresponding to this point.



Long Answer Type Questions

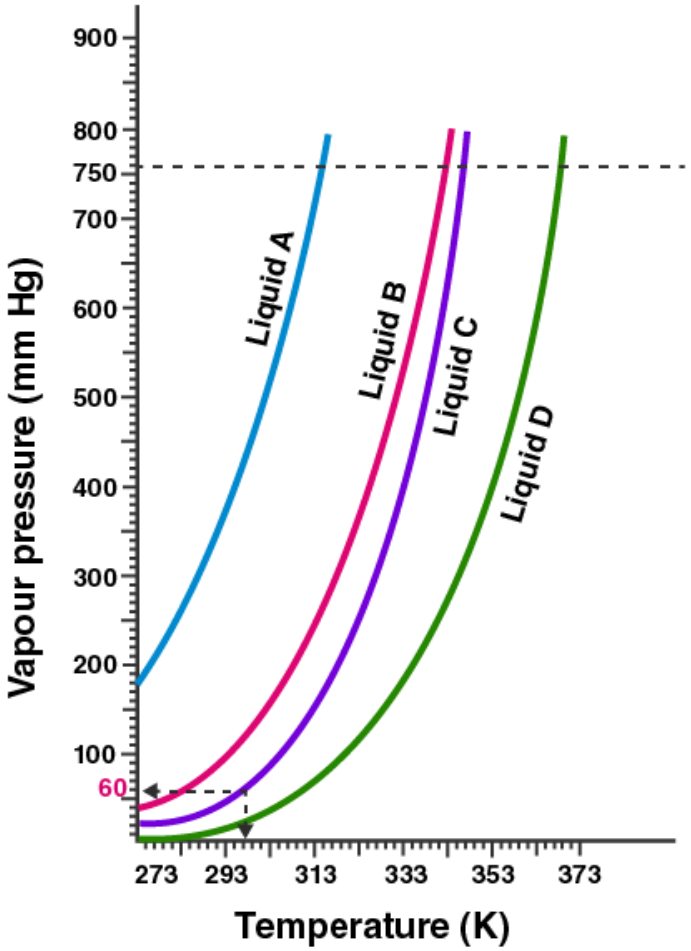
1. Isotherms of carbon dioxide at various temperatures are represented In Fig. 5.5. Answer the following questions based on this figure.



(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 the temperature is T_2.
(iv) Will condensation take place when the temperature is T_3.
(v) What portion of the isotherm at T_1 represent liquid and gaseous CO_2 at equilibrium?

Answer.
(i) CO_2 will exist in gaseous state between the points a and b at temperature T_1.
(ii) The plot becomes linear at point b, phase transition, i.e., liquefaction begins, and CO_2 is completely liquefied at point c.
(iii) At T_2 temperature, g is the point at which CO_2 is completely liquefied.
(iv) T3 > Tc, Condensation will not occur at T_3 temperature.
(v) Liquid and gaseous CO_2 are in equilibrium between b and c.

2. The variation of the 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) The pressure cooker is used for cooking food at the hill station. Explain in terms of vapour pressure why is it so?

Answer.
(i) The boiling point of liquid A is approximately 315 K, while the boiling point of liquid B is approximately 345 K. (approx.)
(ii) Because the pressure in the vessel is constantly increasing, liquid C will not boil in the closed vessel
(iii) The graph indicates Temperature equal to 60mm of hg = 313 K As a result, liquid D will boil at 313 K.
(iv) Since the atmospheric pressure is low at high altitudes, water boils at low temperatures on hills. We already know that a liquid boils when its vapour pressure equals atmospheric pressure. Because a pressure cooker raises the boiling point of water and its heat content, food cooks faster.

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

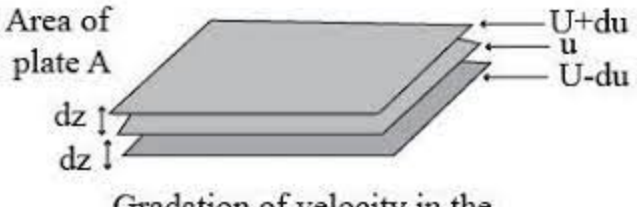
Answer.
The boundary between the liquid phase and gaseous phase disappear on heating a liquid up to critical temperature in a closed vessel because at the critical point the densities of liquid and the vapour become equal. The fluid at this stage is called 'supercritical fluid

4. Why does sharp glass edge become smooth on heating it upto its melting point In a flame? Explal which property of Muds is responsible for this phenomenon.

Answer.
Surface tension is the phenomenon responsible for this. The melted glass tends to take the minimum surface area that is sphere or spherical. On heating, the glass melts and it tends to take a round shape at the edge which has a minimum area.

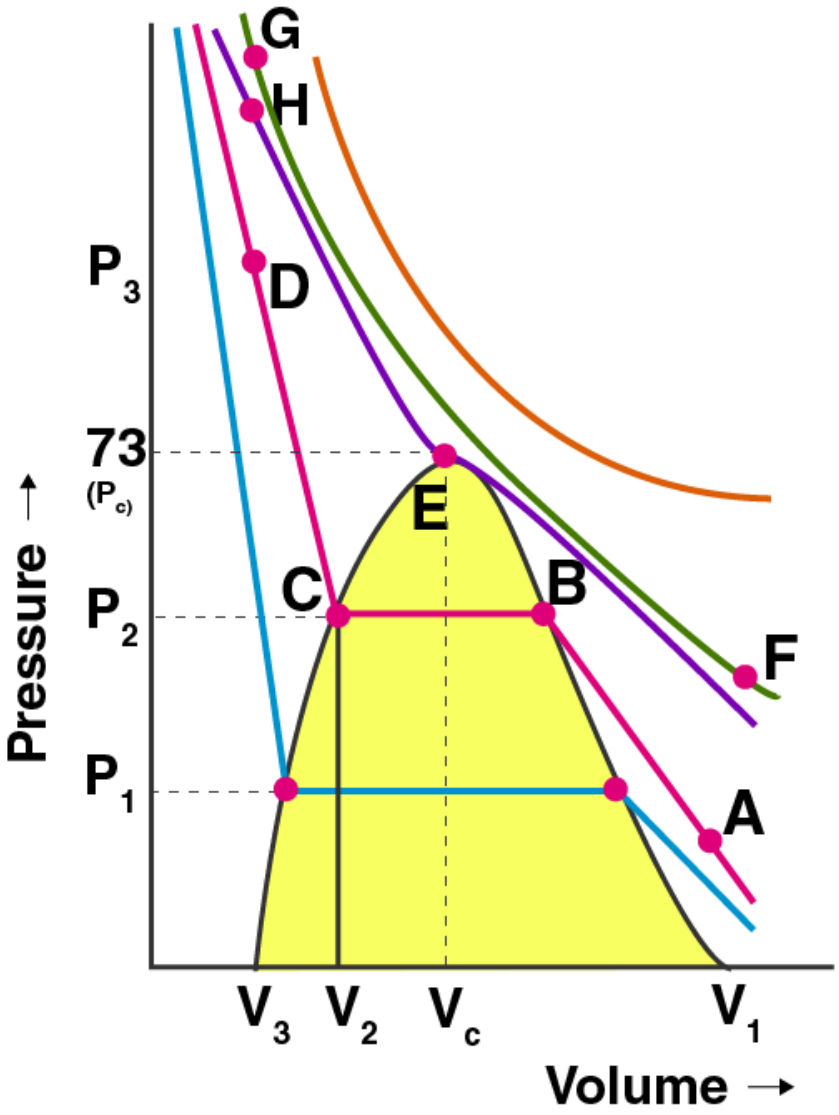
5. Explain the term 'laminar flow'. Is the velocity of molecules the same in all the layers in laminar flow? Explain your answer.

Answer.
Laminar flow is described when all the fluids (gas or liquid) flow in the layers form.
When the liquid flows on the surface the layer of liquid which is in immediate contact with the surface is stationary. The velocity of the subsequent upper layers increases as the distance of the layers increases from the fixed layer which is stationary and in direct contact with the surface.



Gradation of velocity in the laminar flow

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



Answer.

In the diagram, we can move from A to F vertically by increasing the temperature, and then to G by compressing the gas at constant temperature along the isotherm, which causes the pressure to rise. Lower the temperature to move vertically down towards D.

We get liquid as soon as we cross point H on the critical isotherm. When the process is carried out at the critical temperature, the substance is always in one phase.

This is referred to as state continuity between the gaseous and liquid states.