

Semester-I Model Question

Model Questions For Semester-I B.Sc Chemistry Honours

(Physical Chemistry)

1. Write down the expression for the Maxwell's law of distribution of molecular velocities in a gas and discuss its qualitative features. Show how the law of distribution of kinetic energy among gas molecules can be obtained here from. 5
2. Starting from van der Waal's equation deduce an equation which is independent of the constants a and b. Explain the physical significance of the equation. 5
3. At 27⁰C the viscosity of carbon monoxide is 1.8×10^{-4} poise. Calculate its mean free path and collision diameter.
4. Write Maxwell's law of distribution of velocities of gaseous molecules. With diagrams discuss the effect of temperature on distribution curve. 1+4
5. From Maxwell's law deduce expression for mean of squares of velocities of a gas. 2
6. Obtain an expression for distribution of kinetic energy among gaseous molecules from Maxwell's law and represent it graphically. 3+1
7. The density of oxygen gas is 1.8×10^{-3} gm/ml and its coefficient of viscosity is 1.06×10^{-4} poise at a certain temperature. Calculate the translational kinetic energy per gm-mole of the gas if the mean free path of the gas is 1.2×10^{-5} cm. 5
8. Distinguish between compressibility factor and compressibility coefficient. 2
9. Express compressibility factor for a van der Waals' gas in terms of van der Waals' constant and pressure. 3
10. For a van der Waals' gas if $Z = 1.0025$ at 27⁰C and 1140 mm of Hg pressure and Boyle temperature of the gas. (Use only the first terms of Z expression)
11. Explain briefly the principle of equipartition of energy. 2
12. Write down the virial equation of a state. Find the expression for the second virial coefficient in terms of van der Waals' constant a and b. 3
13. Deduce an expression for the mean free path of the molecules of an ideal gas. Show that viscosity of an gas independent of pressure and directly proportional to the square root of absolute temperature. (3+4)
14. At 288K the viscosity of CO₂ is 1.7×10^{-5} s Calculate its mean free path.



Semester-I Model Question

15. State the postulate of Kinetic theory of gases and deduce the expression $PV = \frac{1}{3} mn\bar{c}^2$ where \bar{c} is the r.m.s speed and other terms have usual meaning 1.5 +3
16. From the principle of equipartition of energy calculate C_v for O_2 molecule. Why is the value higher than the experimental value (~ 5 cal/k/mol) at ordinary temperature? 2+2
17. Explain Amagat's curve with the help of van der Waals equation 3.5
18. Calculate the average kinetic energy per mole of the mixture when 2 moles of Helium having average speed 100 m/sec are mixed with 3 moles of hydrogen having r.m.s. speed 100 m/sec.
19. Write down the expression of Maxwell distribution function of molecular speed. What does a point on the Maxwell speed distribution curve represent? Illustrate the effects of i) pressure, ii) temperature and iii) molar mass on the speed distribution curve. 1+1+(1+1+1)
20. One uses average speed to calculate average kinetic energy of a molecule. Is it justified? State with reasons. If not calculate the percentage of error involved in the calculation.
21. Derive the pressure correction term of van der Waals' equation considering a finite size of the gas molecules. 3
22. What is the molar volume of N_2 gas at 500K and 600 bar? Given that virial coefficient (B) of N_2 (gas) at 500K is 0.0169 L/mol.
23. Obtain the reduced equation of state for van der Waals gas, assuming the expressions for critical constants. Explain the significance of the equation. 3+1
24. State with reasons whether the following statements are true or false
- v) Mean free path of gas molecules depends on the distance of closest approach.
 - (vi) The viscosity of a gas does not depend on temperature and pressure.
 - (vii) Distribution of energies in a gas cannot be determined from the Maxwell's distribution of velocities.
25. Explain what are meant by pressure and temperature of a gas according to kinetic theory.
26. Two flasks A and B of same volume containing equal masses of H_2 at 300 K and CH_4 at 600 K respectively. Calculate the ratio of the following quantities between the two flasks :
- (i) Number of molecules (ii) Pressure (iii) Rms velocity of molecules (iv) Total kinetic energy
27. State equipartition of energy principle and apply it to calculate the specific heat of a diatomic gas at ordinary temperature. Point out the limitations of this

Semester-I Model Question

28. Justify the modifications made by van der Waals to the ideal gas equation of state. Write down the units of van der Waals constants.
29. Define compressibility factor. How does it vary with pressure for a real gas? 2+4+4+4+2
30. Show that the existence of critical point leads to the principle of continuity of states. 3
31. Starting from the expression for Maxwell's distribution of velocities, derive an expression for distribution of energies. 5
32. Calculate the mean free path of CO_2 molecules at $27^\circ C$ and a pressure of 10^{-6} mm ($\sigma = 4.6 \text{ \AA}$).
- 33 a) The observed C_v/R values of diatomic gases at $25^\circ C$ are substantially lower than predicted values. Explain. 1.5
- 34.(a) Draw typical P vs V isotherm for real gases. Explain how the above lead to the concept of critical states and mention the salient features of critical state. Can a gas obeying the equation $P(V-b) = RT$ be liquefy? Justify. 2+2+1+2
- (b) Define compressibility factor Z of a gas. Deduce compressibility factor Z for a van der Waal's gas in terms of a, b, P, T . 1+3
- (c) The mean free path (λ) of nitrogen at $27^\circ C$ and a 1atm pressure is 10^{-5} cm. Calculate the collision diameter for nitrogen. 4
35. Calculate the mean free path of the molecules of a gas ($\sigma = 5.0 \text{ \AA}$) at 1 atmosphere and 300K.
36. (a) The critical temperature and pressure for gas X are 180 K and 50 atm respectively and for gas Y , they are 500 K and 40 atm respectively. Which gas has
- the smaller value of the van der Waal's constant 'b'?
 - the smaller value for the van der Waal's constant 'a'?
 - the larger critical volume?
37. Answer the following questions: 2+2+2+2
- "The equation, $W_{Rev} = \int p dV$ applies only to constant pressure process." — state with reasons whether the statement is true or false.
 - The heat of neutralization of strong acids by strong base are always the same. Explain.
 - Show that for an ideal gas $P-V$ curve for adiabatic reversible process is steeper than the same for isothermal reversible one



Semester-I Model Question

CHEMHT-1

- (iv) Show that isothermal free expansion of an ideal gas has to be adiabatic.
38. What do you mean by reversible and irreversible processes? Of the following quantities classify the path function or state function, (i) Enthalpy (ii) Work (iii) Heat capacity (iv) Heat.
39. Find a relation connecting temperatures and pressures of two states for a reversible adiabatic change of an ideal gas.
40. Define heat of reaction. For a reaction involving ideal gases only show how the heat of a reaction at constant pressure process differs from that at constant volume process. 4
41. 1 m^3 of an ideal monatomic gas at 273.2 K is expanded adiabatically and irreversibly from 10 atm to 1 in one step. Calculate the final temperature and work done by the gas.
(The symbols have their usual significance)
42. (a) Show that for an ideal gas i) $(\partial C_v / \partial V)_T = 0$; ii) $(\partial U / \partial P)_V = \beta C_v / \alpha$
(The symbols have their usual significance)
- (b) Consider the reaction, $H_2O(g) \rightarrow H_2(g) + O_2(g)$ $\Delta H^\circ = 241.75 \text{ kJ}$ at 291.15 K .
What would be the ΔH° at 298.15 K ? Over the small temperature range the effectively constant C_p values per mole are $C_p(H_2O) = 33.56$, $C_p(H_2) = 28.83$ and $C_p(O_2) = 29.12 \text{ JK}^{-1} \text{ mol}^{-1}$,
 $\Delta H^\circ =$ standard enthalpy of reaction. 4
43. Show that 2
i) $(\partial H / \partial P)_T = V(1 - \alpha T)$
44. (a) Derive the relation showing variation of heat of reaction with temperature.
Calculate the enthalpy of fusion of ice at -10°C . Given ΔH_f at $0^\circ = 6.02 \text{ kJ/mole}$. C_p ,
ice = 45.66 kJ/mol , C_p , water = 75.31 kJ/mole . 3+2
- (b) State and derive the barometric distribution law.
45. The heat of neutralisation of strong acids with strong bases are the same and equal to 13.7 k cal/mol , whereas that of weak acids and weak bases are different and always less than 13.7 k cal/mole — explain. 3
46. Show that isothermal reversible expansion of an ideal gas yields more work than that for a van der Waals¹ gas. 3



Semester-I Model Question

CHEMHT-1

Old 3. (a) Obtain a thermodynamic derivation for the difference ($C_p - C_v$) in terms of the quantities $(\partial U/\partial V)_T$ and $(\partial V/\partial T)_P$ 4

47. An ideal gas $C_v = 5R/2$ is expanded adiabatically against a constant pressure of 1 atm until it doubles in volume. If the initial temp, is 25°C , and the initial 5 atm, calculate final temperature; then calculate q , w , ΔU and ΔH per mole of gas for the transformation.

48. Derive the relation showing variation of heat of reaction with temperature.

Calculate the enthalpy of fusion of ice at -10°C . Given ΔH_f at $0^\circ = 6.02\text{kJ/mole}$. C_p , ice = 37.66kJ/mol , C_p , water = 75.31kJ/mole . 3+2