Rayat Shikshan Sanstha's

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Department of Physics

Question Bank

Paper **VII**- DSC-D1 **Thermal Physics and Statistical Mechanics-II**

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Unit I- Chapter I- Thermodynamic Potentials

- **Multiple Choice Questions (Correct answer is shown in red color)**

1. The change in internal energy of system is

A) dU= TdS + PdV B) dU = TdS - PdV C) dU = SdT - PdV D) dU = SdT + PdV

2. Enthalpy H of thermodynamic system is .....

A) H=U+PV B) H=U-PV C) H=U+PT D) H= TdS - PdV

3. Helmholtz free energy is

A) F=U+TS B) F= U-TS C) F=T-US D) F = S-TU

4. Internal energy U and Helmholtz free energy F are related by equation

A) U=F+TS B) F=U+TS C) U=T+ FS D) U=S+FT

5. Gibb's function G

A) H+TS B) H-TS C) HT+S D) S-HT

6. ..... remains constant during throttling process.

A) Entropy B) Enthalpy C) Volume D) Pressure

7. In Joule-Thomson effect, at ordinary temperatures, show heating effect.

A) only hydrogen B) both hydrogen and helium

C) only helium D) oxygen

8. For an ideal gas, Joule-Thomson effect is..

A) zero B) positive C) infinite D) negative

9. The temperature at which Joule-Thomson effect changes its sign is known as.....

A) critical temperature B) neutral temperature

C) temperature of inversion D)transition temperature

10. In Joule-Thomson effect, temperature of inversion is

A) $T_i = \frac{2a}{Rb}$ B) $T_i = \frac{2b}{Ra}$ C) $T_i = \frac{R}{2ab}$ D) $T_i = \frac{ab}{2R}$

11. For hydrogen temperature of inversion is .....

A) 80° C B)-80°C C) 35 °K D) 50 °K

12. For helium, temperature of inversion is

A) -80° C B) 35 °K C) 80 °K D) 35° C

13. Clausius-Clapeyron's equation is

A) $\frac{dP}{dT} = \frac{L}{T(V_2 - V_1)}$ B) $\frac{dT}{dP} = \frac{L}{T(V_2 - V_1)}$ C) $\frac{dP}{dT} = \frac{T}{L(V_2 - V_1)}$ D) $\frac{dT}{dP} = \frac{T}{L(V_2 - V_1)}$

14. $C_p - C_v =$.....

A)$TE\alpha^2V$ B) $-TE\alpha^2V$ C) $\frac{1}{TE\alpha^2V}$ D) $\frac{1}{-TE\alpha^2V}$

15. For real gas, $C_p - C_v =$.....

A)$R\left(1 - \frac{2a}{RTV}\right)$ B) $R\left(1 + \frac{2a}{RTV}\right)$ C) $R\left(1 - \frac{RTV}{2a}\right)$ D) $R\left(1 + \frac{RTV}{2a}\right)$

16. $C_p/C_v =$.....

A)$\frac{E_S}{E_T}$ B) $\frac{E_T}{E_S}$ C) $E_S \cdot E_T$ D$\frac{1}{E_S \cdot E_T}$

17. First TdS equation is

A)$TDS = C_P dT + T\left(\frac{\delta P}{\delta T}\right)_V dV$ B) $TDS = C_V dT + T\left(\frac{\delta P}{\delta T}\right)_V dV$

C) $TDS = C_V dT - T\left(\frac{\delta P}{\delta T}\right)_V dV$ D) $TDS = C_P dT + T\left(\frac{\delta P}{\delta T}\right)_V dV$

- **Short Answer Questions**

1. Derive Clausius - Clapeyron equation.

2. Derive first and second TdS equations.

3. Derive second and second TdS equations.

4. Using Maxwell's thermodynamic relations, obtain an expression for C_P/C_V

5. Why do hydrogen and helium show heating effect at ordinary temperature?

6. Why Joule's Thompson effect is zero for an Ideal Gas

- **Long Answer Questions**

1. State and explain Joule's Thompson effect. Obtain an expression for change in temperature during Joule Thompson Effect.

2. Using Maxwell's thermodynamic relations prove that for ideal gas $C_P - C_V = R$ and for real gas $C_P - C_V = R\left(1 + \frac{2a}{RTV}\right)$

3. Derive Maxwell's thermodynamic relations.

4. Obtain expression for Joule's Thompson cooling produced in a gas assuming the gas obeys Van der Waal's equation. Obtain an expression for temperature of inversion of such a gas

Unit I -Chapter II- Theory of Radiation

- **Multiple Choice Questions (Correct answer is shown in red color)**

1.For perfectly black body coefficient of absorption is….

A) zero B)one C)infinite D)negative

2. The radiation consisting of all possible wavelengths corresponding to the temperature of an enclosure is….

A) full radiation B) visible region radiation

C) ultra violet radiation D) microwave radiation

3. For perfectly black body, coefficient of reflection and coefficient of transmission are.....

A) one and zero B) both one C) zero and one D) both zero

4. In black body radiation spectrum, as temperature is increased, the wavelength corresponding to

maximum energy shifts towards.....

A)shorter wavelength side B) longer wavelength side

C) infinite wavelength side D) zero wavelength side

5. In black body radiation spectrum, the maximum energy radiated……

A) increases with decrease in temperature

B) increases with increase in temperature

C) remains constant with increase in temperature

D) first increases and then decreases with increase in temperature

6. Wien's displacement law is…..

A) $\lambda_m^2 T$=constant B) $\lambda_m T^4$ = constant C) $\lambda_m T$ = constant D) $\lambda_m = T \times constant$

7. The black body radiation spectrum in shorter wavelength region can be verified by….

A) Wien's displacement law B) Stefan's law

C) Wien's distribution law D) Rayleigh Jeans law

8. The black body radiation spectrum in longer wavelength region can be verified by…….

A) Rayleigh-Jeans law B) Wien's distribution law

C) Planck's law D) Stefan's law

9. The black body radiation spectrum over the whole range of wavelengths can be explained by…..

A) Rayleigh-Jeans law B) Planck's law

C) Wien's displacement law D) Stefan's law

10. The area under black body radiation curve at temperature T °K is verified by….

A) Planck's law B) Wien's distribution law

B) Rayleigh-Jeans law D) Stefan's law

11. If K is specific intensity of radiation, the energy density of radiation inside the close enclosure is.....

A) $\frac{4\pi K}{c}$ B) $\frac{4\pi c}{K}$ C) $4\pi Kc$ D) $\frac{c}{4\pi K}$

12. The energy of Planck's oscillators is

A)kT B)nhν C) $\frac{1}{2}mv^2$ D) $\frac{1}{2}mw^2x^2$

13. Average energy of Planck's oscillator is .....

A) $\frac{1}{e^{\frac{h\nu}{kT}}-1}$ B) $\frac{h\nu}{e^{\frac{h\nu}{kT}}-1}$ C) $h\nu$ D) $e^{\frac{h\nu}{kT}-1}$

14. The energy radiated per second per unit area by perfectly black body at temperature T °K is proportional to

A) T B) T^2 C) T^3 D)T^4

15. Stefan's constant σ.....=Watt/m^2K^4

A) 5.67×10^{-8} B) 2.898×10^{-3} C) 5.67×10^{-3} D) 2.898×10^{-8}

16. Wien's constant b = ... mK.

A)5.67×10^{-8} B) 2.898×10^{-3} C) 5.67×10^{-3} D) 2.898×10^{-8}

17. Rayleigh-Jeans law is E_λ.....

A) $\frac{8\pi kT}{\lambda^5}$ B) $\frac{8\pi kT^4}{\lambda^4}$ C) $\frac{8\pi kT}{\lambda^4}$ D) $\frac{8\pi kT^4}{\lambda}$

- **Short Answer Questions**

1. What is black body? How it can be realized in practice?
2. Explain Ferry's black body.
3. Explain Wien's black body.
4. Derive Stefan's law from Planck's law.
5. Derive Rayleigh-Jean's law from Planck's law.
6. Derive Wien's displacement law from Planck's law.
7. Show that Planck's law reduces to Rayleigh-Jeans law for longer wavelengths.
8. Show that Planck's law reduces to Rayleigh-Jeans law for shorter wavelengths.
9. What is black body? How it can be realized in practice?

10. Explain Ferry's black body.

11. Explain Wien's black body.

12. Derive Stefan's law from Planck's law.

13. Derive Rayleigh-Jean's law from Planck's law.

14. Derive Wien's displacement law from Planck's law.

- **Long Answer Questions**

1. Derive Planck's radiation law in terms of frequency and wavelength.

2. Give the experimental study of black body radiation spectrum.

3. Obtain an expression for the energy density of radiation inside the close enclosure.

Unit II -Chapter I- Classical Statistics

- **Multiple Choice Questions (Correct answer is shown in red color)**

1. Phase space is combined …….space.

A) position and moment B) position and momentum

C) moment and momentum D) velocity and momentum

2. The volume of a cell in phase space is.....

A)$\hbar$ B)$\hbar^2$ C))$\hbar^3$ D))$\hbar^4$

3. Many different..... may correspond to the same macrostate.

A) microstates B) phase densities C) phase points D) space points

4. The microstates which are allowed under given restriction are called…..

A) allowed microstate B) accessible microstate

C) permitted microstates D) occupied microstates

5. For the distribution to be most probable,.....

A) W = 0 B) lnW=0 C) δ (In W) = 0 D) δW = 0

6. The entropy has its maximum value for a thermodynamic assembly in..... state.

A) an equillibrium B) a normal

C) an inequillibrium D) an excited

7. The relation between entropy (S) and probability (W) is....

A) S=kW B) S=WlnK C) S=klnW D) S=W/K

8. If W, M and G are total probability, thermodynamic probability and a priori probability of any distribution then.....

A) W=M+G B) $W = M \times G$ C) $W = \frac{M}{G}$ D) $W = \frac{G}{M}$

9. Stirling formula is….

A) $\ln n! = nln\, n - n$ B) $\ln n! = nln\, n - 1$

C) $\ln n! = n - nln\, n$ D) $\ln n! = nln\, n + 1$

10. $n_i = g_i e^{-\alpha} e^{\frac{-u_i}{KT}}$ is…law.

A) Maxwell-Boltzmann Distribution B) Fermi-Dirac

C) Bose-Einstein D) Planck's

11. In Maxwell-Boltzmann distribution law, ν.β.....

A)kT B) $2kT$ C) $\frac{1}{kT}$ D) $\frac{1}{2kT}$

12. The most probable speed of gas molecules at temperature T°K is…….

A) $\sqrt{\frac{2kT}{m}}$ B) $\sqrt{\frac{3kT}{m}}$ C) $\sqrt{\frac{8kT}{\pi m}}$ D) $\sqrt{\frac{2kT}{\pi m}}$

13. The average speed of gas molecules at temperature T°K is…..

A) $\sqrt{\frac{2kT}{m}}$ B) $\sqrt{\frac{3kT}{m}}$ C) $\sqrt{\frac{8kT}{\pi m}}$ D) $\sqrt{\frac{2kT}{\pi m}}$

14. The r.m.s. speed of gas molecules at temperature T°K is

A) $\sqrt{\frac{2kT}{m}}$ B) $\sqrt{\frac{3kT}{m}}$ C) $\sqrt{\frac{8kT}{\pi m}}$ D) $\sqrt{\frac{2kT}{\pi m}}$

15. If Vrms and Vmp and most probable speeds of gas molecules respectively then.....

A) $V_{rms} = V_{mp}$ B) $V_{rms} = 2V_{mp}$ C) $V_{rms} = \sqrt{\frac{3}{2}} V_{mp}$ D) $V_{rms} = \sqrt{\frac{2}{3}} V_{mp}$

16. If $\bar{V}$ and Vmp are average and most probable speeds of a gas molecules respectively then.....

A) $\bar{V} = V_{mp}$ B) $\bar{V} = 2V_{mp}$ C) $\bar{V} = \frac{1}{\sqrt{\pi}} V_{mp}$ D) $\bar{V} = \sqrt{\frac{2}{\pi}} V_{mp}$

17. If $\bar{V}$, Vmp and Vrms are average, most probable and r.m.s. speeds of gas molecules then

A) $V_{mp} < V_{rms} < \bar{V}$ B) $V_{mp} < \bar{V} < V_{rms}$

C) $V_{mp} > \bar{V} > V_{rms}$ D) $V_{mp} > V_{rms} > \bar{V}$

- **Short Answer Questions**

1. What is Phase space. Show that the volume of a cell in the phase space is of the order of h^3.
2. Explain microstate and macrostate.
3. Define thermodynamic probability. How microstates and macrostates are related through the thermodynamic probability.
4. Define microstate, macrostate and accessible microstate.
5. Explain a priori probability and thermodynamic probability.
6. Obtain an expression for thermodynamic probability.
7. Derive an expression for the total probability of a particular distribution.
8. Write note on “entropy” and “probability.”
9. Show that entropy of system is given by $S = k \ln W$.
10. Show that the average speed of gas molecules at temperature T is $\frac{2}{\sqrt{\pi}}$ times its most probable speed.
11. Show that the r. m. s. speed of gas molecules at temperature T is $\sqrt{\frac{3}{2}}$ times its most probable speed.

- **Long Answer Questions**

1. Derive Maxwell- Boltzmann distribution law of energies. Draw the Maxwell- Boltzmann energy distribution curve.
2. Using Maxwell- Boltzmann distribution law obtain an expressions for most probable speed,

average speed and r. m. s. speed of gas molecules.

3. Derive Maxwell-Boltzmann law of momenta.

Unit II -Chapter II- Quantum Statistics

- **Multiple Choice Questions (Correct answer is shown in red color)**

1. Quantum statistics is based on the idea of ..... exchange of energy between the systems.

A) continuous B) discrete C) no D) non-uniform

2. According to Quantum theory, the radiation of frequency v, has a quantum of energy

A) $h\nu$ B) $\frac{h\nu}{2}$ C) $h\nu^2$ D) $2h\nu$

3. Bose-Einstien statistics is applicable to ....

A) identical, indistinguishable particles of zero or integral spin.

B) identical, distinguishable particles of any spin.

C) identical, indistinguishable particles of any spin.

D) identical indistinguishable particle of half spin.

4. Bose-Einstein statistics is obeyed by .....

A) electrons B) gas molecules C) photons D) neutrons

5. The Bose-Einstein distribution law is given by equation.....

A) $n_i = \frac{g_i}{e^{\frac{u_i}{KT}} - 1}$ B) $n_i = \frac{g_i}{e^{\alpha} e^{\frac{u_i}{KT}}}$ C) $n_i = \frac{g_i}{e^{\alpha} e^{\frac{u_i}{KT}} + 1}$ D) $n_i = \frac{g_i}{e^{\alpha} e^{\frac{u_i}{KT}} - 1}$

6. The momentum of photon of frequency v is

A) $h\nu$ B) $\frac{h\nu}{c}$ C) $\frac{c}{h\nu}$ D) $m\nu$

7. The energy distribution in black body radiation spectrum can be explained by

A) M-B statistics B) M-E statistics C) B-E statistics D) F-D statistics

8. Bosons are particles with….

A) zero or integral B) half C) any D) negative

9. The radiations inside the hollow enclosure maintained at temperature T °K, constitutes.....

gas.

A) electron B) photon C) ideal D) neutron

10. Fermi-Dirac distribution law is given as ....

A) $n_i = \frac{g_i}{e^{\frac{u_i}{KT}}-1}$ B) $n_i = \frac{g_i}{e^{\alpha}e^{\frac{u_i}{KT}}}$ C) $n_i = \frac{g_i}{e^{\alpha}e^{\frac{u_i}{KT}}+1}$ D) $n_i = \frac{g_i}{e^{\alpha}e^{\frac{u_i}{KT}}-1}$

11. Fermi-Dirac statistics is applicable to identical and indistinguishable particles with .....

spin.

A) zero B) integral C) half D) any

12. Fermi-Dirac distribution law is obeyed by..... Jay electrons

A) photons B) ideal gas C) helium gas D) electrons

13. The energy of highest filled quantum state of an electron at O °K is called

A) Fermi energy B) free energy C) average energy D) band gap energy

14. Fermi energy of electrons at O °K is $u_{f.....}$

A) $\frac{h^2}{2\square}\left(\frac{3\square\square}{8\square}\right)^{2/3}$ B) $\frac{h^2}{2\square}\left(\frac{3\square}{8\square\square}\right)^{2/3}$ C) $\frac{h^2}{2\square}\left(\frac{3\square\square}{8\square}\right)^{3/2}$ D) $\frac{h^2}{2\square}\left(\frac{3\square\square}{8\square}\right)^{2/3}$

15. If u_f, is the Fermi energy of electrons at O °K, its average kinetic energy is .....

A) $\frac{3}{5}\square_{\square}$ B) $\frac{3}{4}\square_{\square}$ C) $\frac{5}{4}\square_{\square}$ D) $\frac{4}{5}\square_{\square}$

16. The rest mass of photon is

A) infinity B) zero C) finite but small D) negative

17. Electrons are

A) Bosons B) photons C) fermions D) neither Bosons nor fermions

18. The gas molecules follows..... statistics.

A) M-B B) F-D C) B-E D) Quantum

19. Fermi-Dirac distribution law is applied in .....

A) band theory of solids

B) black body radiation spectrum

C) free electron theory of metals

D) theory of specific heat

- **Short Answer Questions**

1. What is electron gas? Obtain an expression for Fermi energy of electron at $0^{o}K$.
2. Give comparison between MB- BE and FD statistics

- **Long Answer Questions**

1. Obtain an expression for Fermi - Dirac Distribution Law.
2. What is photon gas? Assuming that Photons obey B-E distribution law, obtain an expression for number of electrons in a electron gas having energy between υ and $\upsilon + d\upsilon$.
3. Obtain an expression for Bose-Einstein's Distribution Law.
4. What is electron gas? obtain an expression for number of electrons in a electron gas having energy between u and u + du.