GOVERNMENT ZIRTIRI RESIDENTIAL SCIENCE COLLEGE

Subject : PHYSICS
Paper Name : Thermodynamics & Mathematical Physics
Paper No. : PHY/II/EC/03
Semester : II

A. Multiple Choice Questions:

1. If *C* be the root mean square velocity of the molecules, and ρ be the density of the gas. Then the pressure *P* exerted by the gas is
   a) $P = \frac{1}{3}\rho^2 C$
   b) $P = \frac{1}{2}\rho^2 C$
   c) $P = \frac{1}{3}\rho C^2$
   d) $P = \frac{1}{2}\rho C^2$

2. For oxygen, the density at *N.T.P.* is *16* x *0.000089 g/cc*. Then the root mean square velocity is
   a) $4.61x10^2\ cm/s$
   b) $4.61x10^3\ cm/s$
   c) $4.61x10^4\ cm/s$
   d) $4.61x10^5\ cm/s$

3. At high temperature, a diatomic gas molecule has vibrational degrees of freedom in addition to translational and rotational. Then the ratio $\frac{c_p}{c_v}$ is
   a) 1.29
   b) 1.4
   c) 1.33
   d) 1.67

4. In general gas equation *PV=RT*, Van der Waal introduced a correction factor $\frac{a}{V^2}$ in pressure. This term represent the
   a) effective area of molecules
   b) attractive force between molecules
   c) volume occupied by molecules
   d) mean velocity of gas molecules

5. Which of the following is true for the critical constants?
   a) $P_c = \frac{a}{27b^2}$, $V_C = 3b^2$, $T_C = \frac{8a}{27Rb^2}$
   b) $P_c = \frac{a^2}{27b}$, $V_C = 3b^2$, $T_C = \frac{8a^2}{27Rb}$
   c) $P_c = \frac{a^2}{27b^2}$, $V_C = 3b$, $T_C = \frac{8a^2}{27Rb}$

d) $P_c = \frac{a}{27b^2}$, $V_C = 3b$, $T_C = \frac{8a}{27Rb}$

6. In Carnot's cycle, the work done during isothermal compression is
   a) $-RT_2\ log_e\ \frac{V_4}{V_3}$
   b) $-RT_2\ log_e\ \frac{V_3}{V_4}$
   c) $RT_2\ log_e\ \frac{V_3}{V_4}$
   d) $RT_2\ log_e\ \frac{V_4}{V_3}$

7. The physical quantity related to the first law of thermodynamics is
   a) Energy
   b) Pressure
   c) Temperature
   d) number of moles

8. Transfer of heat from a colder body to hotter body is
   a) impossible
   b) possible by doing some external work
   c) possible when two bodies are kept contact
   d) none of the above

9. When *10 grams* of ice at 0^0C is converted into water at the same temperature *(latent heat of ice is 80 cal/gram)*. The change in entropy is
   a) 293 cal/K
   b) 0.293 cal/K
   c) 29.3 cal/K
   d) 2.93 cal/K

10. Which of the following is correct for Maxwell's thermodynamical relation?
    a) $\left(\frac{\partial V}{\partial S}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
    b) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial S}{\partial V}\right)_P$
    c) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$
    d) $\left(\frac{\partial P}{\partial S}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$

11. If $\vec{F}$ is a conservative force field, then the value of *curl* $\vec{F}$ is
    a) 1
    b) 0
    c) -1
    d) ∞

12. The expression for Gauss divergence theorem is
    a) $\iiint_S div.\vec{F}\, dS = \iint_V \vec{F}.\hat{n}\, dV$
    b) $\iiint_S curl\, \vec{F}\, dS = \iint_V \vec{F}.\hat{n}\, dV$
    c) $\iiint_V curl\, \vec{F}\, dV = \iint_S \vec{F}.\hat{n}\, dS$
    d) $\iiint_V div.\vec{F}\, dV = \iint_S \vec{F}.\hat{n}\, dS$

13. In curvilinear coordinate system, the gradient of the scalar function ϕ is given by
    a) $\vec{\nabla}\phi = \sum_{i=1}^{3} \frac{\hat{e}_i}{h_i}\frac{\partial \phi}{\partial u_i}$
    b) $\vec{\nabla}\phi = \sum_{i=1}^{2} \frac{\hat{e}_i}{h_i}\frac{\partial \phi}{\partial u_i}$
    c) $\vec{\nabla}\phi = \sum_{i=1}^{3} \frac{h_i}{\hat{e}_i}\frac{\partial \phi}{\partial u_i}$
    d) $\vec{\nabla}\phi = \sum_{i=1}^{2} \frac{h_i}{\hat{e}_i}\frac{\partial \phi}{\partial u_i}$

14. The expression for the divergence of a vector field in cylindrical coordinate system is
    a) $\vec{\nabla}.\vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(F_1) + \frac{1}{r^2}\frac{\partial F_2}{\partial \theta} + \frac{\partial F_3}{\partial z}$
    b) $\vec{\nabla}.\vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(rF_1) + \frac{1}{r^2}\frac{\partial F_2}{\partial \theta} + \frac{\partial F_3}{\partial z}$
    c) $\vec{\nabla}.\vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(rF_1) + \frac{1}{r}\frac{\partial F_2}{\partial \theta} + \frac{\partial F_3}{\partial z}$
    d) $\vec{\nabla}.\vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(F_1) + \frac{1}{r}\frac{\partial F_2}{\partial \theta} + \frac{\partial F_3}{\partial z}$

15. In *n*-dimensional space, the total number of different components that a symmetric tensor of rank two can have is
    a) $\frac{n(2n+1)}{2}$
    b) $\frac{n(n+1)}{2}$
    c) $\frac{n(n+2)}{2}$
    d) $\frac{(n+1)}{2}$

16. The rank of the matrix $A = \begin{bmatrix} 1 & 5 & 4 \\ 0 & 3 & 2 \\ 2 & 13 & 10 \end{bmatrix}$ is
    a) 2
    b) 3
    c) 1
    d) 4

17. The sum of the eigen values of the matrix $\begin{bmatrix} 3 & 2 & 1 \\ 1 & 3 & 2 \\ 4 & 1 & 5 \end{bmatrix}$ is

a) 21
b) 10
c) 11
d) 20

18. If $A = \begin{bmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{bmatrix}$, then $A^{-1} = \begin{bmatrix} 1 & -1 & 0 \\ -2 & 3 & -4 \\ -2 & 3 & x \end{bmatrix}$. What will be the value of *x*?
a) 2
b) -2
c) 3
d) -3

19. If *A* is a nilpotent matrix of order *n*, then
a) $A^n = 0$
b) $nA = 0$
c) $A = nI$, *I is identity matrix*
d) none of the above

20. Which of the following property of matrix is correct?
a) multiplication is not commutative
b) multiplication is associative
c) multiplication is distributive over addition
d) all of the above

21. The value of $\beta\left(\frac{1}{2}, \frac{1}{2}\right)$ is
a) $\sqrt{\pi}$
b) 1
c) -1
d) $-\sqrt{\pi}$

22. From the relation between beta and gamma function, which of the following is correct
a) $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$
b) $\beta(m,n) = \Gamma(n,m)$
c) $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{(m+n)}$
d) $\beta(m,n) = \frac{\Gamma(m+n)}{\Gamma(m)\Gamma(n)}$

23. The value of $\int_0^{\pi/2} \sqrt{\tan\theta}\ d\theta$ is
a) $\frac{1}{2}\Gamma\left(\frac{3}{4}\right)\Gamma\left(\frac{1}{4}\right)$
b) $\frac{3}{2}\Gamma\left(\frac{1}{2}\right)\Gamma\left(\frac{1}{4}\right)$

c) $\frac{1}{2}\Gamma\left(\frac{3}{4}\right)\Gamma\left(\frac{5}{4}\right)$
d) $\frac{3}{4}\Gamma\left(\frac{3}{4}\right)\Gamma\left(\frac{1}{4}\right)$

24. From the beta and gamma function, the value of $\int_0^\infty \frac{x^4(1+x^5)}{(1+x)^{15}}dx$ is
    a) 5005
    b) 5500
    c) $\frac{1}{5005}$
    d) $\frac{1}{5500}$

25. Which is not correct for gamma function?
    a) $\Gamma(1) = 1$
    b) $\Gamma(n+1) = n!$
    c) $\Gamma(n+1) = n\Gamma(n)$
    d) $\Gamma(0) = 1$

B. Fill up the blanks:

1. According to the law of equipartition of energy, the average kinetic energy associated with each degree of freedom is _____

2. The rate of flow of heat through a metal bar of area of cross-section $1m^2$ when temperature gradient is $1^oC/m$ under steady state is called _____

3. Given that $T_C = 132\ K, P_C = 37.2\ atmos$ and *R per mole* is *82.07* cm^3 *atmos* K^{-1}, the Van der Waals constant b = _____

4. The efficiency of Carnot's engine working between steam point and ice point is _____

5. In a cycle of reversible process, the entropy of a system remains _____

6. The expression for Clausius-Clapeyron's equation is _____

7. The divergence of the vector $\vec{V} = (xyz)\hat{\imath} + (3x^2y)\hat{\jmath} + (xz^2 - y^2z)\hat{k}$ at $(2,-1,1)$ is _____

8. The velocity of a fluid at any point is a contravariant vector of rank _____

9. Kronecker delta is a mixed tensor of rank _____

10. If *H* is a *Hermitian matrix*, then e^{iH} is a _____ matrix.

11. The eigen values of the matrix $\begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ are _____

12. If the order of matrix *A* is *m* x *p*, and the order of *B* is *p* x *n*. Then the order of the matrix *AB* is _____

13. The value of the integral $\int_0^{\pi/2} sin^p\theta\ cos^q\theta\ d\theta$ is _____

14. The value of the integra $\int_0^{\pi/2} sin^6\theta\ d\theta$ is _____

15. The value of $\Gamma\left(\frac{1}{2}\right)$ is _____

Key Answers

A. Multiple Choice Questions:

1. *c)* $P = \frac{1}{3}\rho C^2$
2. *c)* $4.61x10^4\ cm/s$
3. *a) 1.29*
4. *b) attractive force between molecules*
5. *d)* $P_c = \frac{a}{27b^2}$, $V_C = 3b$, $T_C = \frac{8a}{27Rb}$
6. *b)* $-RT_2\ log_e\ \frac{V_3}{V_4}$
7. *a) Energy*
8. *b) possible by doing some external work*
9. *d) 2.93 cal/K*
10. *c)* $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$
11. *b) 0*
12. *d)* $\iiint_V div.\vec{F}\ dV = \iint_S \vec{F}.\hat{n}\ dS$
13. *a)* $\vec{\nabla}\phi = \sum_{i=1}^{3} \frac{\hat{e}_i}{h_i}\frac{\partial \phi}{\partial u_i}$
14. *c)* $\vec{\nabla}.\vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(rF_1) + \frac{1}{r}\frac{\partial F_2}{\partial \theta} + \frac{\partial F_3}{\partial z}$
15. *b)* $\frac{n(n+1)}{2}$
16. *a) 2*
17. *c) 11*
18. *d) -3*
19. *a)* $A^n = 0$
20. *d) all of the above*
21. *b) 1*

22. *a)* $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$

23. *a)* $\frac{1}{2}\Gamma\left(\frac{3}{4}\right)\Gamma\left(\frac{1}{4}\right)$

24. *c)* $\frac{1}{5005}$

25. *d)* $\Gamma(0) = 1$

B. Fill up the blanks:

1. $\frac{1}{2}kT$
2. Thermal conductivity
3. *36.41 cm^3*
4. *26.81 %*
5. Constant/unchanged
6. $\frac{dP}{dT} = \frac{L}{T(V_2 - V_1)}$
7. *14*
8. *one*
9. *two*
10. unitary
11. *1, 1, 3*
12. *m* x *n*
13. $\frac{\Gamma\left(\frac{p+1}{2}\right)\Gamma\left(\frac{q+1}{2}\right)}{2\,\Gamma\left(\frac{p+q+2}{2}\right)}$
14. $\frac{5\pi}{32}$
15. $\sqrt{\pi}$