

KATHMANDU UNIVERSITY  
End Semester Examination  
August/September, 2017

Marks Scored:

Level : B.Sc.

Year : II

Exam Roll No. :

Time: 30 mins

Registration No. :

SEP 01 2017  
Course : PHYS 212

Semester : II

F. M. : 20

Date :

SECTION "A"

[20Q × 1 = 20 marks]

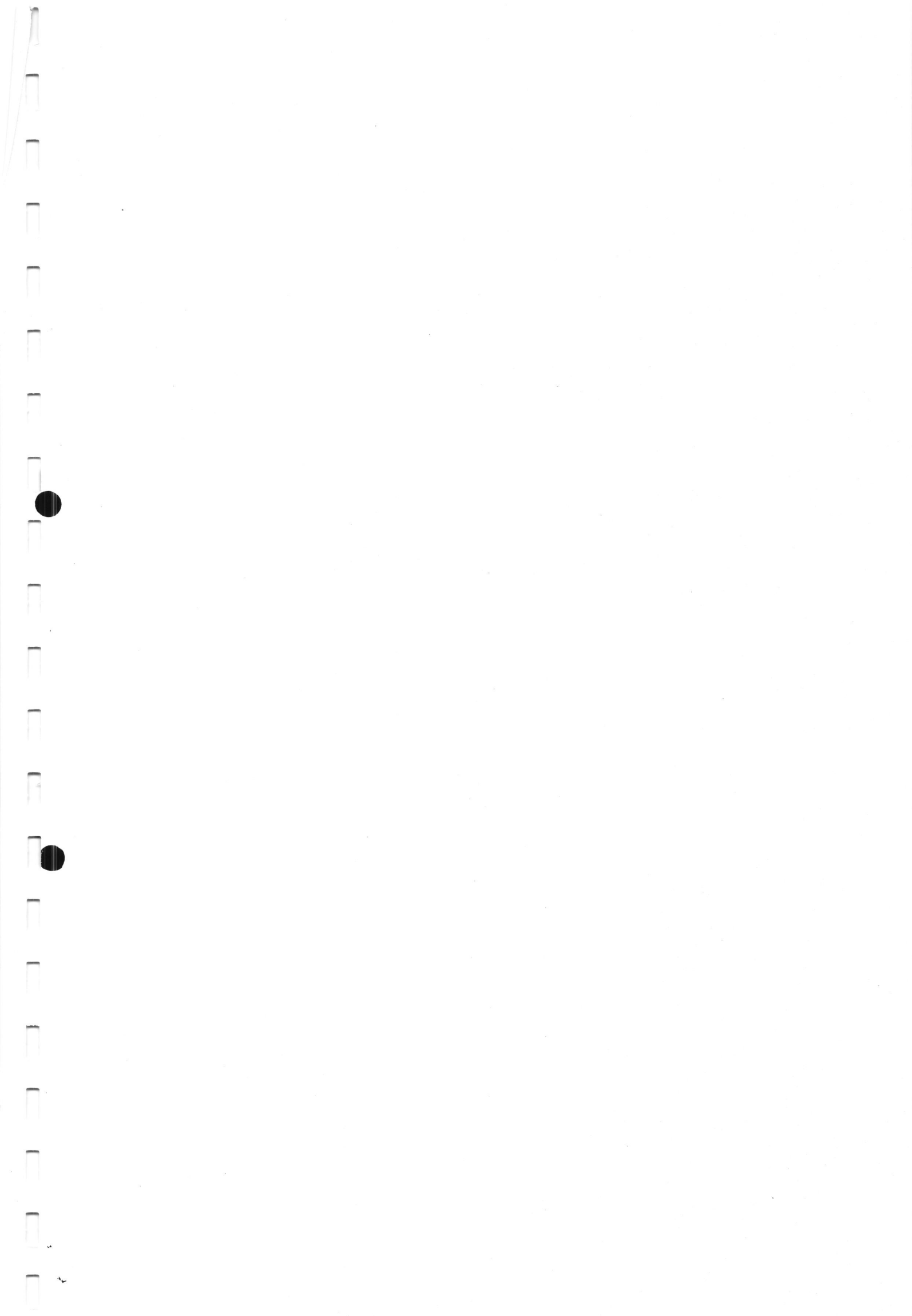
Choose and tick the most appropriate answer. The symbols have their usual meanings.

- The ratio of specific heat of a gas at constant pressure to constant volume is ' $\gamma$ ', the change in internal energy of one mole of a gas when the volume changes from  $V$  to  $2V$  at constant pressure  $P$  is:  
[a]  $\frac{R}{\gamma - 1}$                       [b]  $PV$                       [c]  $\frac{PV}{\gamma - 1}$                       [d]  $\frac{\gamma PV}{\gamma - 1}$
- The slope of isothermal to adiabatic curves are related as :  
[a] Isothermal curve slope = adiabatic curve slope  
[b] Isothermal curve slope =  $\gamma \times$  adiabatic curve slope  
[c] Adiabatic curve slope =  $\gamma \times$  Isothermal curve slope  
[d] Adiabatic curve slope =  $\frac{1}{2} \times$  Isothermal curve slope
- Which of the following is not a Maxwell thermodynamical relation:  
[a]  $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$                       [b]  $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$   
[c]  $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$                       [d]  $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial T}{\partial V}\right)_P$
- The change in boiling point of water when the pressure is increased from 1 to 2 atmosphere is:  
[Given: specific volume of water and steam at  $100^\circ\text{C}$  are 1 and  $1601 \text{ cm}^3/\text{gm}$ . Latent heat of steam =  $540 \text{ cal/gm}$ . Boiling point of water at 1 atmospheric pressure =  $100^\circ\text{C}$ ]  
[a] 26.313 K                      [b] 2.6313 K                      [c] 263.13 K                      [d] 2.6313  $^\circ\text{C}$
- A gas is expanded through certain process. It is found that the enthalpy in the initial equilibrium state is equal to the enthalpy in the final equilibrium state. The process is:  
[a] Adiabatic expansion                      [b] Isobaric expansion  
[c] Joule expansion                      [d] Joule-Thomson expansion
- The second virial coefficient  $B$   
[a] varies in a different manner for different gases.  
[b] is positive at low temperature.  
[c] is zero at Boyle temperature.  
[d] is higher than first virial coefficient.
- If  $T_i$  is the temperature of inversion,  $T_B$  is Boyle temperature and  $T_c$  is the critical temperature, then:  
[a]  $T_i < T_B < T_c$                       [b]  $T_i > T_B > T_c$                       [c]  $T_B > T_i > T_c$                       [d]  $T_c > T_B < T_i$

8. The phenomenon of Brownian movement may be taken as evidence of :  
 [a] Kinetic theory of matter. [b] Electromagnetic theory of radiation.  
 [c] Corpuscular theory of light. [d] Photoelectric phenomenon.
9. If two gases at absolute temperatures  $T_1$  and  $T_2$  are mixed. There is no loss of energy. If masses of molecules are  $m_1$  and  $m_2$  and the number of molecules in the gases are  $n_1$  and  $n_2$  respectively, then the temperature of the mixture is :  
 [a]  $T = \frac{n_1 T_1 + n_2 T_2}{n_1 + n_2}$  [b]  $T = \frac{n_1 + n_2}{n_1 T_1 + n_2 T_2}$   
 [c]  $T = n_1 T_1 + n_2 T_2$  [d]  $T = \frac{m_1 T_1 + m_2 T_2}{m_1 + m_2}$
10. In a system in thermal equilibrium at absolute temperature  $T$ , two states with energy difference  $4.83 \times 10^{-21}$  occur with relative probability  $e^2$ . The value of temperature  $T$  is  
 [a] 175 K [b] 170 K [c] 17.5 K [d] 1.70 K
11. The phase diagram of harmonic oscillator of mass  $m$  and spring constant  $k$ , having energy  $E$  is:  
 [a] the circle of radius  $\sqrt{2mE}$   
 [b] the circle of radius  $\sqrt{\frac{2E}{k}}$   
 [c] ellipse of semi-minor axis  $\sqrt{2mE}$  and semi-major axis  $\sqrt{\frac{2E}{k}}$   
 [d] ellipse of semi-minor axis  $\sqrt{\frac{2E}{k}}$  and semi-major axis  $\sqrt{2mE}$
12. The Grand canonical ensemble is:  
 [a] the collection of independent assemblies having same energy  $E$ , volume  $V$  and number  $N$  of system.  
 [b] the collection of independent assemblies having the same temperature  $T$ , volume  $V$  and number  $N$  of identical particles.  
 [c] the collection of independent assemblies having the same temperature  $T$ , volume  $V$  and chemical potential  $\mu$ .  
 [d] the collection of independent assemblies having the same temperature  $E$ , volume  $V$  and number  $\mu$  of identical particles.
13. Photon is :  
 [a] classical particle [b] Boson [c] Fermions [d] intermediate particle
14. According to Debye theory of specific heat of solid, the number independent modes of vibrations lying between  $\nu$  to  $\nu + d\nu$  is  
 [a]  $4\pi V \left[ \frac{1}{C_1^3} + \frac{2}{C_t^3} \right] \nu^2 d\nu$  [b]  $4\pi V \left[ \frac{1}{C_1^3} + \frac{1}{C_t^3} \right] \nu^2 d\nu$   
 [c]  $4\pi V \left[ \frac{1}{C_1^2} + \frac{2}{C_t^2} \right] \nu^2 d\nu$  [d]  $4\pi V \left[ \frac{1}{C_1} + \frac{2}{C_t} \right] \nu^2 d\nu$
15. The Einstein's frequency ' $\nu_E$ ' for copper for which  $\theta_E = 230\text{K}$  is: [Given  $h = 6.6 \times 10^{-34}$  joule-sec; Boltzmann's constant  $k = 1.37 \times 10^{-23}$  joule/K]  
 [a]  $4.77 \times 10^{12} \text{sec}^{-1}$  [b]  $47.7 \times 10^{12} \text{sec}^{-1}$  [c]  $4.77 \times 10^{11} \text{sec}^{-1}$  [d]  $47.7 \times 10^{10} \text{sec}^{-1}$

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16. In the general gas equation  $PV = RT$ , Vander Waal introduced a correction factor  $\frac{a}{V^2}$  in pressure. This term represents \_\_\_\_\_
17. According to Dulong and Petit's law the product of atomic weight to and atomic heat of an element at constant volume is equal to \_\_\_\_\_ cal/gm atom  $^{\circ}\text{C}$ .
18. BE Statistics and FD Statistics approaches to MB Statistics at \_\_\_\_\_ temperature and \_\_\_\_\_ pressure.
19. The degeneracy of gas is given by the relation  $\frac{1}{D} = \frac{T_f}{T}$ . The degeneracy is prominent if \_\_\_\_\_
20. During emission and absorption process of photons in black body chamber, the constraint that no more valid is \_\_\_\_\_



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SECTION "B"

[5Q × 4 = 20 marks]

1. Show that the coefficient of diffusion of a gas is proportional to  $T^{3/2}$ .
2. Draw Andrew's curves for a gas at different temperatures and obtain expressions for critical constants  $T_c$ ,  $P_c$  and  $V_c$ .

OR

Define Boyle point. Show that for all gases obeying Vander Waal's equation, the Boyle temperature is  $T_B = \frac{a}{Rb}$ .

3. Prove that according to the law of equipartition of energy, the energy associated with each degree of freedom is  $\frac{1}{2}kT$ . Show that for a gas possessing 'n' degree of freedom, the ratio of specific heats is  $\left(1 + \frac{2}{n}\right)$ .
4. Derive an expression for specific heat capacity of solids using Einstein's theory.
5. Calculate the Fermi energy in electron volts for sodium assuming that it has one free electron per atom. Given density of sodium =  $0.97\text{gm/cm}^3$ , atomic weight = 23.

OR

A Carnot engine absorbs heat from a source at 600 K and rejects heat to a sink at T K. The heat given by this engine is absorbed by another engine which rejects heat to another sink at 200 K. If the works produced by the two engines are equal, calculate the temperature T.

SECTION "C"

[5Q × 7 = 35 marks]

6. Prove Maxwell's second thermodynamical relation:

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial S}{\partial V}\right)_P$$

From it, establish Clausius-Clapeyron relation:

$$\left(\frac{\partial P}{\partial T}\right) = \frac{L}{T(V_2 - V_1)}$$

And find out the effect of pressure on boiling point of a liquid and melting point of a solid.

7. What is Joule-Thomson effect? How this expansion differs from adiabatic and Joule expansion. In case of Joule-Thomson effect, verify the relation:

$$dT = \frac{1}{C_p} \left[ \frac{2a}{RT} - b \right] dP$$

Where  $dT$  gives the change in temperature of a Vander Waal gas due to Joule Thomson expansion.

8. The number of molecules in energy  $\epsilon$  and  $\epsilon + d\epsilon$  is given by

$$2\pi n \left( \frac{1}{\pi kT} \right)^{3/2} \epsilon^{1/2} e^{-\epsilon/kT} d\epsilon$$

Deduce the expression for the following:

- (i) The most probable energy.
- (ii) The number of molecules containing the most probable energy.
- (iii) The mean energy.

OR

Calculate the fraction of oxygen molecules within 1% of the most probable velocity at NTP. What is the effect of changing (i) the gas to hydrogen? (ii) the temperature to  $500^\circ\text{C}$ ?

9. What is Fermi gas? Obtain an expression for the zero point energy and its corresponding pressure of ideal Fermi gas when degeneracy is more prominent.
10. What is meant by black body radiation? Using Bose-Einstein statistics, show that total energy density within the frequency range  $\nu$  to  $\nu + d\nu$  is given by

$$U_\nu d\nu = 8\pi h \left( \frac{\nu}{c} \right)^3 \frac{d\nu}{(e^{h\nu/kT} - 1)}$$

Obtain Rayleigh Jean's law and Wien's law from above relation. Also Obtain Stefan's law.