2019

PHYSICS

(Major)

Paper : 2.2

(Heat and Thermodynamics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following as directed : 1×7=7

(a) When the finite size of the molecules of a gas is taken into account, will the pressure of the gas on the wall of the container increase, decrease or remain unchanged?

(b) What is the probability $P(x)$ of a molecule travelling a distance x without any collision?

(c) How does diffusion coefficient (in case of self-diffusion) depend on the molecular mass?

(d) What is the importance of the Brownian motion?

(e) The first law of thermodynamics inculcates three related ideas. What are they?

(f) A system consists of two parts having entropies of 4 cal/K and 6 cal/K. The entropy of total system is

(i) (6+4) cal/K

(ii) (6−4) cal/K

(iii) (6×4) cal/K

(iv) 6/4 cal/K

(Choose the correct option)

(Continued)

(g) Does an ideal gas show Joule-Thomson effect?

2. Answer any *four* of the following : 2×4=8

(a) Callendar's formula regarding platinum temperature t_p is given by

$$t - t_p = \left\{\left(\frac{t}{100}\right)^2 - \left(\frac{t}{100}\right)\right\}$$

Find an expression for k, if

$$R_t = R_0(1 + \alpha t + \beta t^2)$$

(b) Estimate the size of an He atom assuming its mean free path to be $28 \cdot 5 \times 10^{-6}$ cm at NTP, given that density is 0·178 gm/lit at NTP and mass of an He atom is 6×10^{-24} gm.

(c) From Planck's law of radiation, deduce Rayleigh-Jeans law.

(Turn Over)

(d) Calculate the amount of work done during adiabatic expansion of a gas.

(e) Give the Gibbs-Helmholtz equation for a reversible cell. What is its significance? When is the reaction endothermic?

3. Answer the following questions : 5×3=15

(a) Show that the Joule-Thomson coefficient μ for an ideal gas is zero and for van der Waals gas

$$\mu = \frac{1}{C_p}\left[\frac{2a}{RT} - b\right]$$ 5

Or

(b) Establish the coefficient of viscosity as

$$\eta = \frac{m\bar{c}}{3\sqrt{2}\pi\sigma^2}$$

where the symbols have their usual meaning.

Show that the coefficient of viscosity is independent of pressure. 4+1=5

(c) (i) What are the characteristics of reversible and irreversible process?

(ii) State the limitation of first law of thermodynamics. (2+2)+1=5

(d) A Carnot engine works between ice point and steam point. It is desired to increase the efficiency of the engine by 20% by making (a) the temperature of the source constant and (b) the temperature of the sink constant. Calculate change in temperature in the two cases. 2½+2½=5

Or

(e) Derive van der Waals equation of state

$$\left[p + \frac{a}{V^2}\right](V - b) = RT$$ 5

4. Answer the following questions : 10×3=30

(a) Develop Fourier's theory for one-dimensional heat flow. What will be the modification for a perfectly 'lagged bar'? 9+1=10

Or

(b) What is absolute scale of temperature? Derive Kelvin's expression for absolute thermodynamic scale of temperature. Show that the ideal gas scale and the thermodynamic scale are identical. Is negative temperature possible in this scale? 1+6+2+1=10

(c) Derive the relations

(i) $\left(\frac{\delta S}{\delta V}\right)_T = \left(\frac{\delta P}{\delta T}\right)_V$

(ii) $\left(\frac{\delta P}{\delta T}\right)_{SAT} = \frac{L}{T(V_2 - V_1)}$

where the symbols have their usual meaning. 5+5=10

Or

(d) Derive Einstein formula regarding Brownian motion of suspended tiny particles. 10

(e) Write short notes on the following (any *two*) : 5×2=10

(i) Carnot theorem

(ii) Second law of thermodynamics

(iii) Thermodynamic potential

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