SET – IV
                          ANSWER KEY

Q. 1   A)   **Select the correct alternative**
         (i)   c. Force & time
                                                                              2
         (ii)   a. lateral strain and longitudinal strain
                                                                              2
         (iii)   c. 36cm
                                                                              2
         (iv)   b. 180
                                                                              2
         (v)   b. Conservation of energy
                                                                              2
         (vi)   a. Only on initial and final temperature
                                                                              2

B)   **Answer in one sentence**
         (i)   Flow in which the fluid undergoes irregular fluctuations, or mixing   1
         (ii)   Any 2 lens defects are spherical, chromatic, coma, etc.   1
         (iii)   The pressure necessary to liquefy a gas at critical temperature.   1

C)   **Fill in the blanks**
         (i)   Constant
                                                                              1
         (ii)   Constant / uniform
                                                                              1
         (iii)   square root
                                                                              1
         (iv)   chromatic aberration.
                                                                              1
         (v)   Temperature
                                                                              1

Q. 2   A)   **Attempt ANY ONE**
         (i)   Figure and description
                                                                              2
                    Modulus of rigidity, $\eta = \frac{Tangential.stress}{Shear.strain} = \frac{T}{\varphi} = \frac{F}{2\pi r dr} \times \frac{L}{r\theta}$ 1

                    Torque $= dT = \frac{2\pi\eta\theta}{L}r^3.dr$, Couple required $= \frac{\pi\eta\theta}{2L}(a_2^4 - a_1^4)$ 5

         (ii)   Diagram and explanation   3
                    Y = longitudinal stress / strain. Extensions l = F/Y
                    Compression l' = -σF/Y along y an z axis.
                    Total change $e_x = e_y = e_z = F/Y (1 -2\sigma)$
                    Bulk modulus = K = F/ 3e simplifying we get y = 3k (1-2σ).   5

B)   **Attempt ANY ONE**
         (i)   Diagram and description and assumptions   3
                    net force along ends is $F = (p_1 - p_2)\pi r^2$ 1

                    F = modulus of rigidity X velocity gradient and simplify the eq for
                    velocity of flow: $v = \frac{(p_1 - p_2)}{4\eta l}(a^2 - r^2)$ 2

                    Simplify to get total flow of liquid $V = \frac{\pi(p_1 - p_2)a^4}{8\eta l}$ 2

         (ii)   Note on venturimeter   4
                    Lift of a plane   4

C)   **Attempt ANY ONE**
         (i) $Y = 2.032 \times 10^{11}$ N/m^2 , $\eta = 0.7 \times 10^{11}$N/m^2 2

		Formula and calculation of Poisson's ratio.	2
(ii)		$m_1 = 10$ Kg, $m_{21} = 12$ Kg, $a = \frac{m_2 - m_1}{m_1 + m_2} g$	2
		$T = m_1 g + m_1 a$ on m_1, T on m_2	2

Q. 3   **A)**

(i)   **Attempt ANY ONE**

Ray diagram and its Description.   3

Derive-Optical path difference $\Delta = 2\mu t \cos r$ 4

Effective O.P.D using stroke's theorem $= 2\mu \cos r \pm \lambda/2$ 1

(ii)   Diagram of Expt set up of Newton's rings, Description   4

Explain reflections in wedge shape of varying thickness using diagram to form rings.   4

B)   **Attempt ANY ONE (Unit II)**   8

(i)   Equivalent focal length of two thin lenses:

Coaxial lens system-Ray Diagram showing principal points.   3

Total deviation expression $\delta = \delta_1 + \delta_2$

And derive: $1/F = 1/f_1 + 1/f_2 - d/f_1 f_2$ 5

(ii)   Chromatic Aberration:

Definition-defect in lens due to prismatic action of lens   1

Ray diagram showing fr, fv.   2

Use expression $- 1/f_R = (\mu_R - 1) [1/R_1 - 1/R_2]$ 2

Derive: $f_R - f_v = \omega f_y$ 3

C)   **Attempt ANY ONE**   4

(i) $\mu = 1.57$ $\lambda = 5893 \times 10^{-10}$ m   2

$\beta = 1$ mm $= 1 \times 10^{-3}$ m

$\theta = \lambda/2\mu\beta = 1.876 \times 10^{-4}$ radian $= 38.7$ seconds   2

(ii) $f_1 = 10$ cm $f_2 = 20$ cm $d = 5$ cm

$1/F = 1/f_1 + 1/f_2 - d/f_1 f_2$ 2

$P = 12.5$ D, $\alpha = 2$ cm $\beta = 5$ cm   2

Q. 4   **A)**

(i)   **Attempt ANY ONE**

1. Correction to Pressure: 4

Consider the molecule of gas well inside the container. It is attracted by other molecules in all direction with same force and thus the net force acting on it is zero. But when it strikes the wall it gets pulled back by the other molecules of the gas. This results in the decrease in the momentum with which it collides with the wall and decrease in pressure. This correction to the pressure depends upon:

(i) Number of molecules striking a unit area per unit time of the walls of container and

(ii) The resultant inward cohesive force.

Each of these factors is proportional to the density of the gas.

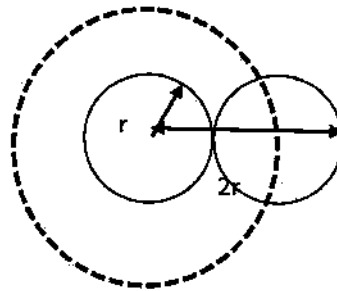$$\therefore Correction\ to\ pressure, p \propto \rho^2 \propto 1/V^2$$

$$p = \frac{a}{V^2}$$

Where a is constant and V is volume of the gas.

$$\therefore Corrected\ or\ real\ pressure = P + p = \left(P + \frac{a}{V^2}\right)$$

2. Correction to Volume:

Due to the finite size of the gas molecules, the actual space available for the molecule is less than the actual volume of the vessel.

4

Here r is the radius of each gas molecule.

$$Volume\ of\ the\ molecule, x = \frac{4}{3}\pi r^3$$

The center of each molecule can approach each other only by a minimum distance of $2r$. Volume of sphere of influence of each molecule, s is

$$s = \frac{4}{3}\pi (2r)^3 = 8\frac{4}{3}\pi r^3 = 8x$$

Volume available for 1st molecule $= V$
Volume available for second molecule $= V - 8x = V - s$
$\therefore$ Volume available for n^{th} molecule $= V - (n-1)s$
$\therefore$ Average space available for each molecule $=$

$$\frac{V + (V-s) + (V-2s) + \cdots + (V - (n-1)s)}{n}$$

$$= V - \frac{s}{n}(1 + 2 + 3 + \cdots + (n-1))$$

$$= V - \frac{ns}{2} + \frac{s}{2}$$

$s/2$ can be neglected in comparison with $ns/2$.

$$= V - 4nx = V - b$$

Therefore Van der Waals equation for state is given by:

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

(ii) From the first law of thermodynamics,

$$dQ = dU + PdV \ldots \ldots \ldots (i)$$
$$dU = C_V dT \ldots \ldots \ldots (ii)$$

For one mole

$$PV = RT$$

Differentiating

$$PdV + VdP = RdT \ldots \ldots \ldots (iii)$$

For adiabatic process, $dQ = 0$.

$$\therefore \frac{C_V}{R}(PdV + VdP) + PdV = 0$$

$$C_V(PdV + VdP) + (C_P - C_V)PdV = 0$$

Q. P. Code:

$$Let\ \frac{C_P}{C_V} = \gamma$$

$$\frac{dP}{P} + \gamma \frac{dV}{V} = 0$$

therefore $PV^\gamma = constant.$ **5**

$$P_1 V_1^\gamma = P_2 V_2^\gamma$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^\gamma$$ **3**

$$\gamma = 1.653$$

B)

Attempt ANY ONE

(i) Work done, $W = \int_{V_1}^{V_2} P dV$

Considering one gram molecule of the gas,

$$PV = RT$$

$$\therefore P = \frac{RT}{V}$$

$$W = \int_{V_1}^{V_2} \frac{RT}{V} dV$$ **5**

$$W = RT \times 2.303 \log_{10} \frac{V_2}{V_1}$$

$$P_1 V_1 = P_2 V_2$$

$$\therefore \frac{V_2}{V_1} = \frac{P_1}{P_2}$$

$$\therefore W = RT \times 2.303 \log_{10}\left(\frac{V_2}{V_1}\right)$$ **3**

$$W = 556.69\ J$$

(ii) Lets assume,   **4**

$$U = U(V, T)$$

$$\therefore dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV \dots \dots (i)$$

We know from the first law of thermodynamics,

$$dQ = dU + PdV$$

Substituting for dU,

$$dQ = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV + PdV$$

$$\therefore \frac{dQ}{dT} = \left(\frac{\partial U}{\partial T}\right)_V + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \frac{dV}{dT} \dots \dots \dots (ii)$$

If the gas is heated at constant volume,

$$\frac{dQ}{dT} = C_V$$

And

$$\frac{dV}{dT} = 0$$

$$\left(\frac{\partial U}{\partial V}\right)_T = C_V \dots \dots \dots \dots (iii)$$

When the gas is heated at constant pressure,   **4**

$$\frac{dQ}{dT} = C_P$$

$$\therefore C_P = \left(\frac{\partial U}{\partial T}\right)_V + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \left(\frac{\partial V}{\partial T}\right)_P$$

$$\therefore C_P = C_V + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \left(\frac{\partial V}{\partial T}\right)_P$$

$$C_P - C_V = \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \left(\frac{\partial V}{\partial T}\right)_P$$

Since internal energy depends only on temperature,

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

Using $PV = RT$ we can show,

$$P\left(\frac{\partial V}{\partial T}\right)_P = R$$

$$\therefore C_P - C_V = R$$

C)

(i) **Attempt ANY ONE**

(i) $P_1 = 1$ atm   4

$V_1 = V$ and $V_2 = V/2$ 2

The sudden compression is an adiabatic process
For an adiabatic process

$$PV^\gamma = constant$$

$$\therefore P_1 V_1^\gamma = P_2 V_2^\gamma$$

$$\therefore P_2 = P_1 \left(\frac{V_1}{V_2}\right)^\gamma = 2.636 \ atm$$

(ii) Also for adiabatic process   2

$$TV^{\gamma-1} = constant$$

$$\therefore T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$\therefore T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 395.9 \ K$$

(ii) For 1st partition: 2

$$P_1 V_1 = n_1 R T_1 \ \ldots\ldots (1)$$

For 2nd partition

$$P_2 V_2 = n_2 R T_2 \ \ldots\ldots. (2)$$

When the partition is removed

$$PV = nRT \ \ldots\ldots.. (3)$$

Where P is equilibrium pressure, V is final volume, T is equilibrium temperature.

$$V = V_1 + V_2 \ \ldots\ldots (4)$$ 2

$$n = n_1 + n_2 \ \ldots. (5)$$

Lets assume, $T_1 < T_2$

$\therefore$ (*Heat lost by molecules in compartment 2*)
= (*Heat gained by the molecules of compartment 1*)

$$\therefore C_V(T_2 - T) = C_V(T - T_1)$$

$$\therefore T = \frac{T_2 + T_1}{2} \ \ldots\ldots\ldots (6)$$

Putting eqn (6) in (3) we get

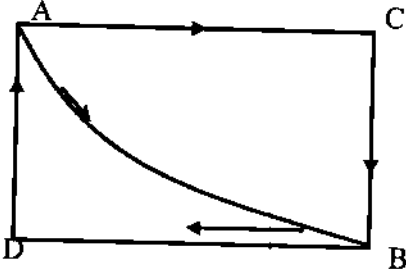$$P = \frac{R(T_1 + T_2)}{2(V_1 + V_2)}$$

Q5   **Attempt any four**

(i) diagram

    explanation   **2**

                           3

(ii) $Y = 2\eta(1+\sigma)$ and $Y = 3K(1-2\sigma)$ use these equations and show   **5**
the result

(iii) Ramsden's eyepiece:
Ray diagram showing images.   **2**
Working $F = \frac{1}{4}f$ **2**
Uses = spectrometer, telescope   **1**

(iv) Methods of reducing spherical aberration   **1**
Stops   **each**
Plano convex
Cross convex lens $R_1 : R_2$ m = 1:6
$d = f_1 - f_2$
high R.I of material

(v) The zeroth law of thermodynamics states that if two bodies A and   **2**
B are each separately in thermal equilibrium with a third body C,
then A and B are also in thermal equilibrium with each other.

Explanation:
We consider two systems A and B insulated from each other but in   **3**
good thermal contact with third body C. System A and B will
attain thermal equilibrium with third system C. Now if the
insulation is removed and system A and B are brought in thermal
contact, we find that there is no further change. This means that
system A and B are also in thermal equilibrium with each other.

(vi)

                                          1

A system can be taken from state A to B by many ways as shown   **4**
in figure.
Let $A \equiv (P_1, V_1)$ and $B \equiv (P_2, V_2)$
$$W = \int P dV$$
i.e. area under the curve.
We can see from the above figure that, the area under the curve is
different for different paths.