1. In the system shown in figure wedge is fixed. All the contact surfaces are frictionless. All the pulleys are light and strings are light and inextensible. Then: [Take \( g = 10 \text{ m/s}^2 \)]

(A) Magnitude of acceleration of each block is \( \frac{5}{6} \text{ m/s}^2 \).

(B) Tension in the string connecting block A and block B is \( \left( \frac{130}{3} \right) \text{N} \).

(C) Tension in the string connecting block B and block C is \( \frac{55}{3} \text{N} \).

(D) Force exerted by string on pulley Q is \( \frac{55}{3} \text{N} \).

1. (ABCD)

Acceleration of the system

\[
a = \frac{(m_c + m_b \sin 30^\circ - m_A)g}{(m_A + m_b + m_c)}
\]

\[
= \frac{\left( 2 + 6 \times \frac{1}{2} - 4 \right)10}{2 + 6 + 4} = \frac{5}{6} \text{ m/s}^2
\]

\[
T_1 = 40 + 4 \times \frac{5}{6} = \left( \frac{130}{3} \right) \text{N}
\]

\[
T_2 = 20 - 2 \times \frac{5}{6} = \left( \frac{55}{3} \right) \text{N}
\]
2. A wedge of mass 2m is kept on a rough horizontal floor and is always stationary. A block of mass m is kept on the smooth surface of wedge and is held stationary by a stopper. The incline plane of the wedge makes an angle \( \theta \) with horizontal.

(A) When the stopper is removed, the normal reaction the floor exerts on the wedge is 
\[ N = mg \left( 2 + \cos^2 \theta \right) \]

(B) When the stopper is removed, the normal reaction the floor exerts on the wedge is 
\[ N = mg \left( 2 + \sin \theta \cos \theta \right) \]

(C) Whether stopper is removed or not, the normal reaction the floor exerts on the wedge is 
\[ N = 3mg \]

(D) When the stopper is removed, the frictional force between the wedge and the floor is 
\[ f = mg \cos \theta \sin \theta \]

2. (AD)

When stopper removed
\[ a = g \sin \theta \]
\[ N = mg \cos \theta \]
\[ N' = \text{Normal between wedge and ground} \]
\[ N' = N \cos \theta + 2mg \]
\[ N' = mg \left[ 2 + \cos^2 \theta \right] \]

Friction 
\[ f = N \sin \theta = mg \cos \theta \sin \theta \]
3. A block of mass 10kg is placed on a rough horizontal surface and is acted upon by a variable force \( F \) horizontally. The coefficient of friction between block and surface is \( \mu = 0.5 \). The force \( F \) starting from a value of zero is increased linearly to 100 N in 4s and then abruptly decreased to 40 N which is then continued for 3 sec. and then force is removed. \([g = 10 \text{ m/s}^2]\)

(A) The maximum velocity reached by the block is 5 m/s
(B) Total time of motion of block is 5.4 sec.
(C) The block reaches its maximum speed, 2 seconds after the start of the motion of the block.
(D) Friction on block will be 25 N at time, 1s after the force begins to act

\[v = 5 \text{ m/s at } t = 4\text{s} \quad \text{(maximum velocity)}\]

At \( t = 2\text{sec} \).
\( F = 50\text{N} \) so motion of block starts at \( t = 4\text{s} \)
\( J = P_f - P_i \)
\[\frac{1}{2}(100+50)\times 2 - 50\times 2 = 10v - 0\]
\( v = 5 \text{ m/s} \) at \( t = 4\text{s} \)

At \( t = 7 \)
\(-10\times 3 = 10v - 50 \quad v = 2 \text{ m/s}\)

After that
\(-50\times (t - 7) = 0 - 10\times 2\)
\( t = 7.4\text{s} \)

Time of motion \( = 7.4 - 2 = 5.4\text{s} \)
At \( t = 1 \)
\( F = 25 \)
So \( f = 25 \) at \( \Sigma F = 0 \)

4. Three blocks A, B and C having masses 2 kg, 2 kg and 4 kg respectively hang from two ideal pulleys as shown in figure. Initially all the three blocks rest on a horizontal floor and the pulleys are held such that the strings just remain taut. At instant \( t = 0 \), a force \( F = 40t \) newton starts acting on pulley \( P \) in upward direction then: \([g = 10 \text{ m/s}^2]\)

(A) Blocks A and B loose contact at the same instant.
(B) All the blocks loose contact at same instant
(C) A looses contact at \( t = 2 \text{ sec.} \)
(D) C never lose the contact

\[F = 40t\]
Two blocks, of masses $M$ and $2M$, are connected to a light spring of spring constant $K$ that has one end fixed, as shown in figure. The horizontal surface and the pulley are frictionless. The blocks are released from rest when the spring is non deformed. The string is light.

(A) Maximum extension in the spring is \( \frac{4Mg}{K} \).

(B) Maximum kinetic energy of the system is \( \frac{2M^2g^2}{K} \).

(C) Maximum energy stored in the spring is four times that of maximum kinetic energy of the system.

(D) When kinetic energy of the system is maximum, energy stored in the spring is \( \frac{4M^2g^2}{K} \).

5. (ABC)

Maximum extension will be at the moment when both masses stop momentarily after going down. Applying W–E theorem from starting to that instant.

\[
k_f - k_i = W_{gr} + W_{sp} + W_{ten}\\
0 - 0 = 2Mg \cdot x + \left( -\frac{1}{2}Kx^2 \right) + 0\\
x = \frac{4Mg}{K}
\]

System will have maximum KE when net force on the system becomes zero. Therefore

\(2Mg = T\) and \(T = kx \Rightarrow x = \frac{2Mg}{K}\)

Hence KE will be maximum when $2M$ mass has gone down by \( \frac{2Mg}{K} \).

Applying W/E theorem

\[
k_f - 0 = 2Mg \cdot \frac{2Mg}{K} - \frac{1}{2}k \cdot \frac{4M^2g^2}{K^2}\\
k_f = \frac{2M^2g^2}{K}
\]

Maximum energy of spring = \( \frac{1}{2}K \cdot \left( \frac{4Mg}{K} \right)^2 = \frac{8M^2g^2}{K} \)
Therefore maximum spring energy = 4 \times \text{maximum K. E.}

When K. E. is maximum \( x = \frac{2Mg}{K} \)

Spring energy = \( \frac{1}{2}K \times 4 \frac{M^2g^2}{K^2} = \frac{2M^2g^2}{K} \)

i.e. (D) is wrong.

6. A ball of mass 1 kg is thrown up with an initial speed of 4 m/s. A second ball of mass 2 kg is released from rest from some height = 100 m as shown in figure. As long as they are in air.

(A) The centre of mass of two balls comes down with acceleration \( \frac{g}{3} \).

(B) The centre of mass first moves up then comes down.

(C) Acceleration of centre of mass is \( g \) downwards

(D) The centre of mass comes down with constant velocity.

6. (BC)

Initially \( v_{cm} \) is upward. Hence centre of mass will move upward initially.

\[
a_{cm} = \frac{1 \times g + 2 \times g}{1 + 2} = g
\]

7. The string shown in figure is passing over a small smooth pulley rigidly attached to trolley A. The trolley is moving horizontally with constant speed \( V_A \). Speed and magnitude of acceleration of the block B at the instant shown in figure are:

(A) \( V_B = V_A, a_B = 0 \)

(B) \( V_B = \frac{3}{7}V_A \)

(C) \( a_B = \frac{16}{25}V_A^2 \)

(D) \( a_B = \frac{16}{125}V_A^2 \)

7. (D)

\[
(y - 4) + \sqrt{x^2 + (4)^2} = \ell
\]

\[
\frac{dy}{dt} + \frac{x}{\sqrt{x^2 + 16}} \frac{dx}{dt} = 0
\]

\[
\frac{dy}{dt} = -\frac{3}{5}V_A = V_B
\]
\[ \frac{d^2y}{dt^2} = V_A \frac{16}{(x^2 + 16)^{3/2}} \]
\[ a_B = \frac{16}{125} V_A^2 \]

8. Refer to the plot of temperature versus time (figure) showing the changes in the state of ice on heating (not to scale).

(A) The region AB represents ice and water in thermal equilibrium.
(B) At B water starts boiling.
(C) At C all the water gets converted into steam.
(D) CD represents water and steam in equilibrium at boiling point.
Which of the following is/are correct?
8. (AD)

9. A certain amount of an ideal monoatomic gas undergoes a thermodynamic process such that \( VT^2 = \) constant where \( V \) = volume of gas, \( T \) = temperature of gas. Then under process
(A) When heat is supplied to gas its temperature will increase
(B) The coefficient of volume expansion of gas equals \( \frac{2}{T} \)
(C) The molar heat capacity of gas is 2R.
(D) When heat is supplied to the gas its temperature decreases.
9. (BD)
\[ VT^2 = \text{constant}, PV^{3/2} = C \]
\[ C = C_V + \frac{R}{1 - n} = \frac{3R}{2} + \frac{R}{1 - \frac{3}{2}} = -\frac{R}{2} \]
\[ C \text{ is negative no heat is supplied to gas temp. decreases.} \]
\[ VT^2 = C \Rightarrow \frac{\Delta V}{V} + \frac{2\Delta T}{T} = 0 \]
\[ \gamma = \frac{\Delta V}{V\Delta T} = -\frac{2}{T} \]

10. During an experiment, an ideal gas is found to obey a condition \( \frac{p^2}{\rho} = \) constant
\[ \rho = \text{density} \]
P = pressure
The gas is initially at temperature T, pressure P and density \( \rho \), the gas expand such that density changes to \( \frac{\rho}{2} \).

(A) The pressure of gas changes to \( \sqrt{2}P \)
(B) The temperature of gas changes to \( \sqrt{2}T \)
(C) The graph of the above process on P – T diagram is parabola.
(D) The graph of the above process on the P – T diagram is rectangular hyperbola.

10. \( \text{(BD)} \)
\[
\frac{P_1^2}{\rho_1} = \frac{P_2^2}{\rho_2} \Rightarrow \frac{P_2^2}{\rho_2} = \frac{P_1^2}{\rho_1}
\]
\[
\Rightarrow P_2 = \frac{P}{\sqrt{2}} \quad P = \frac{\rho RT}{M}
\]
\[
\frac{P^2}{\rho} = \frac{\rho^2 R^2 T^2}{m \rho} \Rightarrow \rho T^2 \text{ = constant}
\]
\[
\rho T^2 = \frac{\rho}{2} T_2^2
\]
\[
T_2 = \sqrt{2}T
\]

**SECTION-II : (COMPREHENSIONS TYPE)**

This section contains 04 questions. Based on each paragraph, there are **TWO** questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

**Paragraph for Questions No. 11 & 12**

The velocity of a block of mass 2 kg moving along x-axis at any time t is given by \( v = 20 - 10t \) where \( t \) is in seconds and \( v \) is in m/s. At time \( t = 0 \), the block is moving in positive x-direction.

11. The work done by net force on the block starting from \( t = 0 \) till it covers a distance of 25 meter will be:
   (A) +200 J \hspace{1cm} (B) -200 J \hspace{1cm} (C) +300 J \hspace{1cm} (D) -300 J

11. \( \text{(D)} \)

   The velocity of particle is zero when \( v = (20 - 10t) = 0 \).

   That is at \( t = 2 \) sec. \( v = 0 \).

   \[
   \text{a=10m/s, u=20m/s, t=0}
   \]

   From \( t = 0 \) to \( t = 2 \) distance travelled is

   \[
   S_1 = \frac{(20)^2}{2 \times 10} = 20 \text{ m}.
   \]

   Next 5 meter will be covered in \( 5 = \frac{1}{2} \times 10 \times t^2 \) or \( t = 1 \)s
The particle covers 25 metres distance in 3 sec.

K. E. at \( t = 0 \) is \( K_i = \frac{1}{2} m u^2 = \frac{1}{2} \times (20)^2 = 400 \text{J} \)

KE at \( t = 3 \) is

\[
K_f = \frac{1}{2} m v^2 = \frac{1}{2} \times (10)^2 = 100 \text{J}
\]

Therefore work done by block from \( t = 0 \) to \( t = 3 \) is

\[
\Delta W = K_f - K_i = 100 - 400 = -300 \text{J}
\]

12. The power due to net force on block at \( t = 3 \) sec. is:
   (A) 100 watts                    (B) 200 watts                    (C) 300 watts                    (D) 400 watts
   (B)
   At \( t = 3 \) sec. force on particle is \( F = ma = 2 \times 10 \) towards –ve x–direction
   At \( t = 3 \) sec. The velocity of particles is \( v = 10 \text{ m/s} \) towards –ve x–direction
   \( P = FV = 200 \text{ watts} \).

**Paragraph for Questions No. 13 & 14**

One mole of helium gas follows cycle 1→2→3→1 shown in the diagram. During process 3→1, the internal energy \((U)\) of the gas depends on its volume \((V)\) as \( U = bV^2 \), where \( b \) is a positive constant. If gas releases the amount of heat \( Q_1 \) during process 3→1 and gas absorbs the amount of heat \( Q_2 \) during process 1→2→3.

13. The value of ratio of volume of gas in state \( (V_3) \) to that of gas in state \( (V_1) \) is:
   (A) \( \frac{1}{2} \)                    (B) \( \frac{2}{1} \)                    (C) \( \frac{1}{3} \)                    (D) None of these
   (B)

14. The value of \( \frac{Q_1}{Q_2} \) is:
   (A) \( \frac{8}{9} \)                    (B) \( \frac{9}{8} \)                    (C) \( \frac{12}{13} \)                    (D) None of these
   (C)

\[
U_i = nCvT = \frac{3R}{2} T \Rightarrow T_i = \frac{2U_0}{3R}
\]
Process $3-1 \Rightarrow U = bV^2$

$$\Rightarrow \frac{2bV^2}{3R} \Rightarrow \frac{PV_1}{R} = \frac{2bV^2}{3R} \Rightarrow p_1 = \frac{2bV}{3}$$

When temperature becomes four times, the volume becomes double.

$$\Delta U_{11} = U_0 - 4U_0 = -3U_0$$

$$\left[ \frac{1}{2} \times 3P_0 \times V_0 \right] \Rightarrow \frac{3R}{2} \times \frac{P_0 V_0}{R} = \frac{-3R}{2} \times 2U_0 = \frac{-3R}{2} \times 3R = -U_0$$

$$Q_{31} = -4U_0 = -Q_1$$

Process 1–2 ⇒ Isochoric process

$$Q_{12} = \Delta U_{12} = nCV (T_2 - T_1) = 1 \times \frac{3R}{2} \left( \frac{2P_0 V_0}{R} - \frac{P_0 V_0}{R} \right)$$

$$= \frac{3R}{2} \times \frac{P_0 V_0}{2} = \frac{3R T_0}{2} = U_0$$

$$Q_{12} = U_0$$

Process 2–3 ⇒ Isobaric process

$$W_{23} = 2P_0 V_0 = 2 \times RT_0 = 2R \times \frac{2U_0}{3R} = \frac{4U_0}{3}$$

$$U_{23} = nCV (T_3 - T_2) = 1 \times \frac{3R}{2}$$

$$\left[ \frac{4P_0 V_0}{R} - \frac{2P_0 V_0}{R} \right] = 3P_0 V_0 = 3RT_0 = 2U_0$$

$$Q_{23} = \frac{10U_0}{3}$$

$$Q_2 = Q_{12} + Q_{23} = \frac{13U_0}{3}$$

**SECTION-III : (INTEGER ANSWER TYPE)**

This section contains **06** questions. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, 0.33, 30.27)
15. A force \( F = 20 \text{N} \) is applied to a block (at rest) as shown in figure. After the block has moved a distance of 8 m to the right, the direction of horizontal component of the force \( F \) is reversed. Find the distance travelled before block stops after the horizontal component of \( F \) is reversed. \( (g = 10 \text{m/s}^2) \sin 37^\circ = \frac{3}{5} \).

15. \((6.22)\)

16. A block of mass 3 kg moving with a speed 1 ms\(^{-1}\) collides with a spring of spring constant 100 N/m as shown. Portion AB of the surface is smooth while BC is rough. The minimum value of coefficient of friction for which block will not bounce back once the spring is compressed is \( \frac{1}{n} \). Find the value of \( n \). \( [g = 10 \text{m/s}^2] \)

16. \((3.00)\)

By work energy theorem
\[
\frac{1}{2}mu^2 = \mu mgx + \frac{1}{2}kx^2 \quad \text{……….. (1)}
\]
For block not to bounce back
\[
\mu mg \geq kx \quad \text{…………… (2)} \quad v = 1 \text{m/s}
\]
On solving.
\[
\mu \geq \frac{1}{3}
\]
\[
\mu_{\text{min}} = \frac{1}{3} \quad ; \quad n = 3
\]

17. Two particles A and B move on coplanar concentric circles of radii 1 m and 2 m with angular velocities 1 rad/s and 0.5 rad/s (in the same sense) respectively. \( (\text{For } 0 \leq \theta \leq \pi \text{ radian}) \) At \( \theta = \frac{(n-3)\pi}{2} \text{ radian, relative angular velocity between B and A is zero. Find the value of } n. \)
17. \( (3.00) \)
Here, \( v_A = r_1 \omega_1 \) and \( v_B = r_2 \omega_2 \)
The relative angular velocity of \( B \) with respect to \( A \) is
\[
\omega_{\text{rel}} = \frac{r_2 \omega_2 \cos \alpha + r_1 \omega_1 \cos \beta}{AB}
\]
\[
\omega_{\text{rel}} = \frac{r_2 \omega_2 \cos \alpha + r_1 \omega_1 \cos \beta}{d}
\]
\[
r_2 \omega_2 \left( \frac{r_2^2 + d^2 - r_1^2}{2r_2 d} \right) + r_1 \omega_1 \left( \frac{r_1^2 + d^2 - r_2^2}{2r_1 d} \right)
\]
\[
= \frac{d}{d}
\]
\[
\therefore \omega_{\text{rel}} = \left( \frac{\omega_1 + \omega_2}{2} \right) + \left( \frac{\omega_2 - \omega_1}{2} \right) \left( \frac{r_2^2 - r_1^2}{r_1^2 + r_2^2 - 2r_1 r_2 \cos \theta} \right)
\]
But, \( \omega_{\text{rel}} = 0 \)
\[
\cos \theta = 1
\]
\[
\theta = 0^\circ
\]

18. A particle starts from origin and moves along a path whose equation is \( y = 2x^{3/2} \). The distance travelled by particle when it reaches at \( x = 7 \) m is \( \frac{1022}{3n} \) m. Find the value of \( n \).

18. \( (9.00) \)
\[
\therefore y = 2x^{3/2} \quad \text{or} \quad \frac{dy}{dx} = 2 \times \frac{3}{2} x^{1/2} = 3x^{1/2}
\]
\[
\therefore ds = \sqrt{(dx)^2 + (dy)^2} \quad \text{or} \quad ds = \sqrt{9x + 1} \ dx
\]
Or \( s = \int_0^x \sqrt{1 + 9x} \ dx \)
Put \( 1 + 9x = z \) or \( 9 = \frac{dz}{dx} \)
\[
\therefore s = \int_{z=0}^z \left( \frac{1}{9} \right) \ dz
\]
\[
= \frac{1}{9} \int_{z=0}^{z=27} \left( \frac{1}{3} \right) \ dz
\]
\[
= \frac{2}{27} \left[ (1 + 9x)^{3/2} - 1 \right]_{0}^{7}
\]
\[
= \frac{2}{27} \left[ (1 + 9 \times 7)^{3/2} - 1 \right]
\]
\[
= \frac{2}{27} \times 511 = \frac{1022}{27} \ m
\]

19. The situation shown in the figure, all strings and pulleys are ideal. If tension in the string connecting blocks A and C is \( 8x \) Newton. Find the value of \( x \). \( [g = 10 \text{ m/s}^2] \)
19. (5.00)
Equation of motion for block C is
\[ m_c g - T = m_c a_c \]
Or \[ 180 - T = 18a_c \] .............. (i)
\[ T - 45 = 9a_A \] .............. (ii)
And \[ 2T - 45 = 9a_B = 9 \left( \frac{a_c - a_A}{2} \right) \] .............. (iii)
From (i), (ii) & (iii)
\[ T = 40 \]
Comparing with the given value, we have \( x = 5 \).

20. (4.00)
A particle starts from rest at the origin and moves along the positive branch of curve \( y^2 = 4x^3 \), so that the distance \( s \) measured from origin along the curve varies with time \( t \) according to \( s = 2t^3 \), where \( x, y \) and \( s \) are in metre and \( t \) is in second. The tangential acceleration in m/s\(^2\) at \( t = 1s \) is 3\( n \). Find the value of \( n \).

Here, \( s = 2t^3 \)
\[ v = \frac{ds}{dt} = 6t^2 \]
\[ a_t = \frac{dv}{dt} = 12t = 12 \text{ m/s}^2 \text{ at } t = 1s \]
\[ 3n = 12 \]
\[ n = 4 \]
PART (B) : CHEMISTRY

SECTION-I : (MULTIPLE CORRECT ANSWER(S) TYPE)

This section contains **10 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE** than one is/are correct.

21. A mixture of H₂ and O₂ having total volume 55 mL is sparked in an Eudiometry tube and contraction of 45 mL is observed after cooling. What can be composition of reaction mixture?
   (A) 30 ml H₂ and 25 ml O₂  (B) 10 ml H₂ and 45 ml O₂  
   (C) 40 ml H₂ and 15 ml O₂  (D) 35 ml H₂ and 20 ml O₂

21. (AC)
   Use options, H₂ + \( \frac{1}{2} \) O₂ \( \rightarrow \) H₂O

22. For the wave function
   \[ \Psi = \frac{\sqrt{2}}{81 \sqrt{\pi a_0^{3/2}}} \left[ 6 - \frac{r}{a_0} \right] e^{-r/3a_0} \sin \theta \cdot \cos \phi \]
   Identify the orbital.
   (A) 3pₓ  (B) 3pᵧ  (C) 3pₓ  (D) 6pₓ, 6pᵧ, or 6pₓ

22. (A)
   \[ x = r \cos \theta \]
   \[ y = r \sin \theta \sin \phi \]
   \[ z = r \sin \theta \cos \phi \]

23. Which of the following statement(s) are **incorrect**?
   (A) Combustion of methane in an adiabatic rigid container will cause no change in temperature of the system.
   (B) It is possible to have both adiabatic reversible and adiabatic irreversible processes between two states.
   (C) For a reaction involving only ideal gases, occurring at constant temperature there will be no change in internal energy.
   (D) P-V work is always non-zero when there is change in volume.

23. (ABCD)
   Combustion of hydrocarbon is always an exothermic process, so if the process is occurring in an adiabatic rigid container temperature must increase.
   \[ \Rightarrow 2\text{CH}_3\text{COOH} \rightarrow (\text{CH}_3\text{COOH})_2 \]
Entropy decreases as number of moles decreases.

⇒ In adiabatic process, between any two states there can be only one path.

\[ R \to P \quad \text{at constant } T \]

\[ \Delta U = (U)_P - (U)_R \neq 0 \]

⇒ In case of the free expansion \( P_{ext} = 0 \)

\[ w = 0 \text{ even if there is change in volume.} \]

24. Which of the following order is/are correct?

(A) \( \text{CH}_4 > \text{CH}_3\text{F} > \text{CH}_2\text{F}_2 > \text{CHF}_3 \) : 'C–H' bond length

(B) \( \text{CH}_3\text{F} < \text{CH}_2\text{F}_2 < \text{CHF}_3 \) : 'C–F' bond length

(C) \( \text{SeF}_4 < \text{SeF}_3\text{Cl} < \text{SeF}_2\text{Cl}_2 \) : equatorial bond angle

(D) \( \text{N}_2\text{O}_4 > \text{NO}_2 > \text{NO}_2^- \) : O–N–O bond angle

24. (ACD)

25. If \( \text{IF}_x^n \), types species are planar and nonpolar, then which of the following match is correct

(Where \( x \) is number of F atoms and \( n \) is charge on species)

(A) \( x = 2 \) and \( n = +1 \)

(B) \( x = 3 \) and \( n = 0 \)

(C) \( x = 2 \) and \( n = -1 \)

(D) \( x = 5 \) and \( n = 0 \)

25. (C)

26. Which of the following statements are correct?

(A) The second IE of boron is greater than carbon.

(B) First IE of S is greater than first IE of P.

(C) The second IE of Mg is greater than that of P.

(D) Size of Al and Ga are almost same.

26. (AD)

27. The ionization potential and electron affinity of an element are 15.0 eV and 4.6 eV respectively. The electronegativity of the element in the Pauling’s scale is –

(A) 4 \hspace{1cm} (B) 3.5 \hspace{1cm} (C) 3.0 \hspace{1cm} (D) 2.8

27. (B)

28. Select option with correct IUPAC names.

(A) \( \text{COOH} \)

(B) \( \text{2-hexyne} \)

(C) \( \text{propane nitrile} \)

(D) \( \text{2-methoxy propane} \)

28. (BD)
29. Select **correct** statement.

(A) It is homocyclic compound
(B) It is having –COOH as the principal functional group
(C) It is having isocyanide as one of the functional group
(D) It is having ethyl at 2nd position

29. (AB)

30. Which of the following carbocation is more stable from $\text{CH}_3 - \text{CH}_2$?

(A) $\text{CH}_3 - \text{CH-CH}_3$

(B) $\text{(CH}_3)_3 \text{C}$

(C) $\text{NO}_2 - \text{CH}_2 - \text{CH}_2$

(D) $\text{CH}_3 - \text{CH-CH}_2 \text{H}_3$

30. (ABD)
SECTION-II : (COMPREHENSIONS TYPE)

This section contains 04 questions. Based on each paragraph, there are TWO questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONLY ONE is correct.

Paragraph for Questions No. 31 & 32

Predict the sign of \( q, w, \Delta U \) and \( \Delta H \) for given processes.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Process</th>
<th>Sign of ( q )</th>
<th>Sign of ( w )</th>
<th>Sign of ( \Delta U )</th>
<th>Sign of ( \Delta H )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Melting of solid benzene at 1 atm and normal melting point.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Melting of ice at 1 atm and 0°C.</td>
<td></td>
<td></td>
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<tr>
<td>3.</td>
<td>Adiabatic expansion of one mole of ideal gas.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.</td>
<td>Adiabatic expansion of ideal gas into vacuum.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Isothermal expansion of an ideal gas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Heating of perfect gas at constant ( P ).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Cooling of perfect gas at constant volume.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

31. Find number of processes for which at least one of \( q, w, \Delta U, \Delta H \) are zero.
   (A) 4         (B) 5         (C) 6         (D) 7
   31. (A)

32. Find number of processes for which at least one of \( q, w, \Delta U, \Delta H \) is positive.
   (A) 4         (B) 5         (C) 6         (D) 7
   32. (A)
Four identical vessels contains 1 mole of ideal monoatomic gas at $P_0, V_0, T_0$. Each container is compressed to $\frac{V_0}{2}$ in following ways:

Container 1 → reversibly isothermally
Container 2 → reversibly adiabatically
Container 3 → irreversibly isothermally
Container 4 → irreversibly adiabatically

33. If $T_1, T_2, T_3, T_4$ are the final temperatures in container 1, 2, 3, 4 respectively, then which are correct?

(A) $T_1 > T_2$
(B) $T_2 < T_3$
(C) $T_1 = T_2$
(D) $T_1 = T_3$

34. If $Q_1, Q_2, Q_3, Q_4$ are the heat involved in container 1, 2, 3, 4 respectively then

(A) $Q_1 < Q_2 < Q_3 < Q_4$
(B) $Q_1 > Q_2 > Q_3 > Q_4$
(C) $Q_2 = Q_3 < Q_1 < Q_4$
(D) $Q_2 = Q_4 < Q_1 < Q_3$

35. At 300 K, two gases are filled in two equal sized container as given.

What will be the pressure of A(g) (in cm of Hg)?

35. (81.00)

36. A Carnot engine converts one-fifth of heat given into work. If temperature of sink is reduced by 80°C, efficiency gets doubled. If temperature of source and sink is $T_1$ and $T_2$ respectively then calculate value of $\frac{T_1 - T_2}{10}$.

36. (8.00)
37. The heat of combustion of C(graphite) and CO(g) are –390 kJ/mole and –280 kJ/mole respectively.

\[ \text{CO(g)} + \text{Cl}_2(g) \longrightarrow \text{COCl}_2(g) \quad \Delta H = +208 \text{ kJ} \]

Calculate heat of formation (in kJ/mole) of COCl\(_2\)(g) (in kJ/mole)

37. (98.00)

38. Out of the following total number of molecules that do not have regular geometry are:

- SF\(_4\)
- CCl\(_4\)
- IF\(_5\)
- BrF\(_3\)
- SO\(_2\)
- OF\(_2\)
- SF\(_6\)
- BF\(_3\)

38. (5.00)

39. How many carbon atoms are present in parent carbon chain?

39. (7.00)

40. Find the total number of secondary hydroxyl group in sucrose.

40. (5.00)
PART (C) : MATHEMATICS

SECTION-I : (MULTIPLE CORRECT ANSWER(S) TYPE)

This section contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE or MORE than one is/are correct.

41. The coefficient of $x^{53}$ in the expansion $\sum_{m=0}^{100} C_m (x-3)^{100-m} \cdot 2^m$ is
   (A) $-100 C_{47}$ (B) $100 C_{53}$ (C) $-100 C_{53}$ (D) $-100 C_{100}$

41. (AC)
   We have
   $\sum_{m=0}^{100} C_m (x-3)^{100-m} \cdot 2^m = (x-3 + 2)^{100}
   = (x-1)^{100} = (1-x)^{100}$
   coefficient of $x^{53} = -100 C_{53}$

42. $2^{60}$ when divided by 7 leaves the remainder equal to
   (A) 1 (B) 6 (C) 5 (D) 2

42. (A)
   $2^{60} = (1+7)^{20} = 20 C_0 + 20 C_1 \cdot 7 + 20 C_2 \cdot 7^2 + ............. + 20 C_{20} \cdot 7^{20}
   \therefore$ The remainder $= 20 C_0 = 1$

43. The diagonals of the parallelogram whose sides are $\ell x + my + n = 0$, $\ell x + my + n' = 0$, $mx + \ell y + n = 0$, $mx + \ell y + n' = 0$ cannot be inclined at an angle equal to $(\ell, m, n \in R)$
   (A) $\frac{\pi}{3}$ (B) $\frac{\pi}{2}$ (C) $\tan^{-1}\left( \frac{\ell^2 - m^2}{\ell^2 + m^2} \right)$ (D) $\tan^{-1}\left( \frac{2\ell m}{\ell^2 + m^2} \right)$

43. (ACD)
   Since
   $\frac{n-n'}{\sqrt{\ell^2 + m^2}} = \frac{n-n'}{\sqrt{m^2 + \ell^2}}$

43. (ACD)
   The given parallelogram is a rhombus
   $\therefore$ angle between diagonals is always $\frac{\pi}{2}$

44. The equations of bisectors of two lines $L_1$ and $L_2$ are $2x-16y-5=0$ and $64x+8y+35=0$. If the line $L_1$ passes through the point $(-11, 4)$, then
(A) The equation of acute angle bisector is \(2x - 16y - 5 = 0\)
(B) The equation of acute angle bisector is \(64x + 8y + 35 = 0\)
(C) The equation of obtuse angle bisector is \(2x - 16y - 5 = 0\)
(D) The equation of obtuse angle bisector is \(64x + 8y + 35 = 0\)

44. (AD)
\[
\begin{align*}
P_1 &= \frac{-22 - 64 - 5}{\sqrt{256 + 4}} = \frac{91}{\sqrt{260}} \\
P_2 &= \frac{-11 \times 64 + 32 + 35}{8\sqrt{8^2 + 1}} = \frac{637}{8\sqrt{65}} \\
P_1 < P_2
\end{align*}
\]

45. A(1, 3) and C(7, 5) are two opposite vertices of a square \(ABCD\). The equation of side through A is
(A) \(x + 2y - 7 = 0\)  
(B) \(2x + y - 5 = 0\)  
(C) \(x - 2y + 5 = 0\)  
(D) \(2x - y + 1 = 0\)

45. (AD)
Slope of \(AD\) and \(AB\) be
\[
\begin{align*}
s &= \tan(45^\circ + \theta) \quad \text{and} \quad t = \tan(45^\circ - \theta)
\end{align*}
\]
Where \(\tan \theta = \frac{5 - 3}{7 - 1} = \frac{1}{3}\); Slopes are \(2, -\frac{1}{2}\)
\[
\therefore \quad \text{Equation are} \quad y - 3 = 2(x - 1) \quad \text{and} \quad y - 3 = -\frac{1}{2}(x - 1)
\]
\[
x + 2y - 7 = 0 \quad \text{and} \quad 2x - y + 1 = 0
\]

46. The equation \(x^2 (\log_2 x)^2 + \log_3 x^2 + 5 = \sqrt{2}\) has
(A) at least one real solution  
(B) exactly three solutions  
(C) exactly one irrational solution  
(D) exactly one rational solution

46. (ABC)
\[
\begin{align*}
\left(\frac{3}{4} (\log_2 x)^2 + \log_2 x - \frac{5}{4}\right) \log_2 x &= \log_2 \sqrt{2} \\
\Rightarrow \quad \log_2 x &= y \\
\left(\frac{3}{4} y^2 + y - \frac{5}{4}\right) y &= \frac{1}{2} \\
\Rightarrow \quad \frac{3}{4} y^3 + y^2 - \frac{5}{4} y - \frac{1}{2} &= 0 \\
\Rightarrow \quad 3y^3 + 4y^2 - 5y - 2 &= 0 \\
\Rightarrow \quad y = 1 \quad \text{and} \quad 3y^2 + 7y + 2 &= 0 \\
y = 1 \quad \text{and} \quad y &= -\frac{1}{3} \quad \text{and} \quad y = -2
\end{align*}
\]
47. The equation \( \log_{x+1} (x-0.5) = \log_{x-0.5} (x+1) \) has
(A) no real solution    (B) no prime solution
(C) an irrational solution (D) no composite solution

Let \( \log_{x+1} (x-0.5) = t \)
\[ t = \frac{1}{t} \]
\[ t^2 = 1 \]
\[ \log_{x+1} (x-0.5) = \pm 1 \]
\[ \log_{x+1} (x-0.5) = 1 \text{ or } \log_{x+1} (x-0.5) = -1 \]
\[ x - 0.5 = x + 1 \text{ or } (x - 0.5) = \frac{1}{x + 1} \]
\[ -0.5 = 1 \text{ or } 2x^2 + x - 3 = 0 \]
\[ \text{no solution or } x = 1 \text{ or } x = -\frac{3}{2} \Rightarrow x = 1 \text{ is only solution}. \]

48. If \( \cos (A-B) = \frac{3}{5} \) and \( \tan A \tan B = 2 \), then
(A) \( \cos A \cos B = \frac{1}{5} \)    (B) \( \sin A \sin B = \frac{2}{5} \)    (C) \( \cos (A + B) = -\frac{1}{5} \) (D) \( \tan^2 (A + B) = 26 \)

48. (ABC)
\[ \tan A \tan B = 2 \Rightarrow \sin A \sin B = 2 \cos A \cos B \]
\( \cos (A-B) = \frac{3}{5} \Rightarrow \cos A \cos B + \sin A \sin B = \frac{3}{5} \)
\( \cos A \cos B = \frac{1}{5}, \sin A \sin B = \frac{2}{5} \)
\( \cos (A + B) = \frac{1}{5} - \frac{2}{5} = -\frac{1}{5} \)
\( \tan^2 (A + B) = \sec^2 (A + B) - 1 \)
\[ = 25 - 1 = 24 \]

49. The number of solutions of the equation \( |5 \tan 20 \tan 0 - 12 \tan 0| + |3 \sin^2 0 - \sin 20| = 0 \) in \( [0, 2\pi] \) is :
(A) 2    (B) 3    (C) 5    (D) 6

49. (C)

50. The equation of a line passing through the point of intersection of the lines, \( x - 2y = 3 \) and \( x + 3y = 8 \) having equal intercept on the co-ordinate axes is :
(A) \( x + y = 6 \)    (B) \( x - 5y = 0 \)    (C) \( 5x - y = 0 \) (D) \( x + y = 5 \)

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50.  (AB)

**SECTION-II : (COMPREHENSIONS TYPE)**

This section contains **04** questions. Based on each paragraph, there are **TWO** questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

**Paragraph for Questions No. 51 & 52**

Consider a $\triangle ABC$ whose sides $BC$, $CA$ and $AB$ are represented by the straight lines $x - 2y + 5 = 0$, $x + y + 2 = 0$ and $8x - y - 20 = 0$ respectively.

51.  The area of $\triangle ABC$ equals :

(A) $\frac{41}{2}$  (B) $\frac{43}{2}$  (C) $\frac{45}{2}$  (D) $\frac{47}{2}$

52.  The orthocentre of the $\triangle ABC$ is :

(A) $(-3, 1)$  (B) $\left(-\frac{1}{3}, \frac{2}{3}\right)$  (C) $(-2, 4)$  (D) $\left(-\frac{2}{3}, \frac{4}{3}\right)$

**Solution for Que. No. 51 & 52**

\[\begin{vmatrix}
2 & -4 & 1 \\
3 & 4 & 1 \\
-3 & 1 & 1 \\
\end{vmatrix} = \frac{45}{2}
\]

51.  (C)

52.  (B)

The equation of altitude through angular point $A$ to side $BC$ is :

\[2x + y = 0 \quad \ldots (1)\]

And the equation of altitude through angular point $C$ to side $AB$ is :

\[x + 8y - 5 = 0 \quad \ldots (2)\]

\[\therefore \quad \text{On solving eqns. (1) and (2), we get} \]

\[x = -\frac{1}{3}, \quad y = \frac{2}{3}\]

Hence orthocentre of $\triangle ABC$ is $\left(-\frac{1}{3}, \frac{2}{3}\right)$
Paragraph for Questions No. 53 & 54

Let $\alpha, \beta$ are the roots of $375x^2 - 25x - 2 = 0$ and $y = \sum_{r=1}^{10} (t - r)^2$, where $t \in R$.

53. Sum of the 30 A.M’s inserted between $\alpha$ and $\beta$ is:
   (A) 4  (B) 3  (C) 2  (D) 1

53. (D)

$$A_1 + A_2 + \ldots + A_{30} = 30A = 30\left(\frac{\alpha + \beta}{2}\right) = 1$$

54. The value of $t$ for which $y$ will be minimum is:
   (A) $\frac{11}{2}$  (B) $\frac{10}{2}$  (C) $\frac{1}{10}$  (D) 10

54. (A)

$$y = \sum_{r=1}^{10} (t^2 - 2rt + r^2) = \sum_{r=1}^{10} t^2 - 2t \sum_{r=1}^{10} r + \sum_{r=1}^{10} r^2$$

$$= 10t^2 - 2\left(\frac{10}{2}\right)(11)t + \sum r^2 = 10t^2 - 110t + \sum r^2$$

$y$ is minimum at $t = -\frac{b}{2a} = -\frac{110}{20} = \frac{11}{2}$

SECTION-III : (INTEGER ANSWER TYPE)

This section contains 06 questions. The answer to each question is a NUMERICAL VALUE. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 6.25, 7.00, 0.33, 30.27)

55. Find the area of triangle formed by line $3x + 4y + 12 = 0$, with co-ordinate axis is

55. (6.00)

$$\Delta = \frac{1}{2} \times 4 \times 3 = 6$$

56. The sum of the areas of $n$ squares is $n^2$. If the areas of the squares form an A.P. What is the length of the side of the 25th square?

56. (7.00)

$$S_n = n^2$$

$$T_n = S_n - S_{n-1} = n^2 - (n-1)^2$$

$$T_n = 2n - 1 \text{ put } n = 25$$

$$T_{25} = 50 - 1 = 49$$

Side of 25th square = $\sqrt{T_{25}} = \sqrt{49} = 7$
57. A ray of light emanating from the point \(A(3, 10)\), incident at \(M(1, 4)\), reflects from a line passing through the point \(M\). After reflection passes through the point \(B(4, 3)\). If the equation of the line is \(ax + by - 12 = 0\), then find the perpendicular distance of the point \((a, b)\) from the line \(3x + 4y + 20 = 0\).

57. (8.00)
Equation of \(AM\) is \(3x - y + 1 = 0\), Equation of \(BM\) is \(x + 3y - 13 = 0\)

\[\therefore\] Angle bisectors are \(x - 2y + 7 = 0\) and \(2x + y - 6 = 0\)

Since \(6 + 10 - 6 = 10 > 0\) and \(8 + 3 - 6 = 5 > 0\)

\[\therefore\] \(A\) and \(B\) lie on the same side of \(2x + y - 6 = 0\)

\[\therefore\] The required line is \(2x + y - 6 = 0\)

Perpendicular distance of (4, 2) from the line \(3x + 4y + 20 = 0\) is 8

58. Find the circum radius of the triangle whose vertices are \((-2, -3), (-1, 0), (7, -6)\).

58. (5.00)
Slope of \(AB\) = \(\frac{0 + 3}{-1 + 2} = 3\)
Slope of \(AC\) = \(\frac{-6 + 3}{7 + 2} = \frac{-3}{9} = \frac{-1}{3}\)

\[\Rightarrow AB \perp AC \Rightarrow \angle A \text{ is } 90^\circ\]

\[BC = \sqrt{64 + 36} = 10\]

\[\Rightarrow \text{Circumradius } = \frac{10}{2} = 5\]

59. If the ratio in which \(y - x + 2 = 0\) divides internally the line segment joining \((3, -1)\) and \((8, 9)\) is \(\lambda : 3\), then find the value of \(\lambda\).

59. (2.00)
Ratio = \(\frac{-[1 - 3 + 2]}{9 - 8 + 2} = \frac{2}{3}\)

\[\Rightarrow \lambda : 3 \text{ is } 2 : 3\]

\[\Rightarrow \lambda = 2\]

60. From the fixed point \(A(-6, 8)\), line is drawn to cut the \(x\)-axis at \(B\). If the locus of the mid-point of \(AB\), as \(B\) varies, is \(y = k\), then find the value of \(k\).

60. (4.00)
Let point \(B\) is \((\lambda, 0)\)

\[\Rightarrow \text{midpoint of } AB \text{ is } \left(\frac{\lambda - 6}{2}, 4\right)\]

\[\Rightarrow \text{Locus of mid-point of } AB \text{ is } y = 4\]

\[\Rightarrow k = 4\]