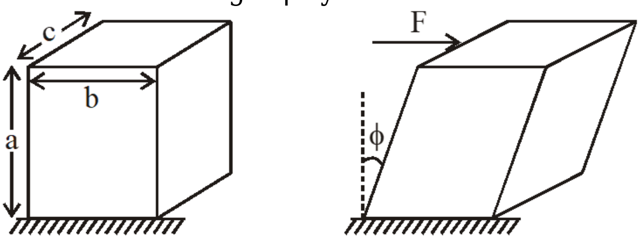
PART-1 : PHYSICS

SECTION-I

1) A cuboidal block of sides a, b and c is fixed on ground. The top is pushed by a horizontal force F as shown. The angle ϕ by which the block deforms is : (η is modulus of rigidity)



(A) $\frac{F}{ab\eta}$

(B) $\frac{F}{ac\eta}$

(C) $\frac{F}{bc\eta}$

(D) $\frac{F}{\sqrt{b^2+c^2}\,\eta}$

2) A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower ends. The weight stretches the wire by 1 mm. Then the elastic energy stored in the wire is-

(A) 0.2 J

(B) 10 J

(C) 20 J

(D) 0.1 J

3) The length of a metal wire is ℓ_1 when the tension in it is T_1 and is ℓ_2 when the tension is T_2. The natural length of the wire is

(A) $\frac{\ell_1+\ell_2}{2}$

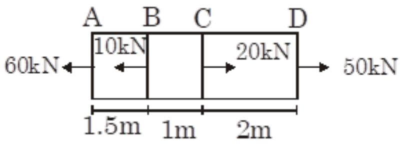
(B) $\sqrt{\ell_1\,\ell_2}$

(C) $\frac{\ell_1 T_2-\ell_2 T_1}{T_2-T_1}$

(D) $\frac{\ell_1 T_2+\ell_2 T_1}{T_2+T_1}$

4) A Steel rod of cross-sectional area $1 m^2$ is acted upon by forces as shown in the Fig. Determine the

total elongation of the bar. Take ($Y = 2.0 \times 10^{11} N/m^2$)



(A) 1.3 μm
(B) 1.7 μm
(C) 0.9 μm
(D) 1.2 μm

5) A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area a floats on the surface of the liquid, covering entire cross section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$, is :

(A) $\frac{Ka}{3mg}$
(B) $\frac{mg}{3Ka}$
(C) $\frac{mg}{Ka}$
(D) $\frac{Ka}{mg}$

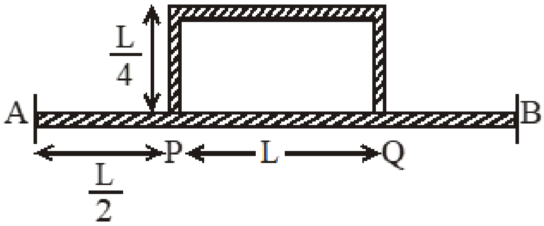
6) The power radiated by a black body is P and it radiates maximum energy around the wavelength λ_0. If the temperature of the black body is now changed so that it radiates maximum energy around wavelength $3/4\lambda_0$, the power radiated by it will increase by a factor of :-

(A) 4/3
(B) 16/9
(C) 64/27
(D) 256/81

7) A copper ball of mass 100 gm is at a temperature T. It is dropped in a copper calorimeter of mass 100gm, filled with 170 gm of water at room temperature. Subsequently, the temperature of the system is found to be 75°C. T is given by :
(Given : room temperature = 30° C, specific heat of copper = 0.1 cal/gm°C)

(A) 1250°C
(B) 825°C
(C) 800°C
(D) 885°C

8) Temperature difference of 120°C is maintained between two ends of a uniform rod AB of length 2L. Another bent rod PQ, of same cross-section as AB and length, is connected across AB (See figure). In steady state, temperature difference between P and Q will be close to :



(A) 60°C

(B) 75°C

(C) 35°C

(D) 45°C

9) 2 kg ice at – 20°C is mixed with 5 kg water at 20°C. Then final amount of water in the mixture would be; Given specific heat of ice = 0.5cal/g°C, specific heat of water = 1 cal/g°C, Latent heat of fusion of ice = 80 cal/g.

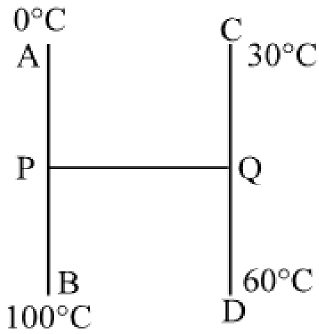
(A) 6 kg

(B) 5 kg

(C) 4 kg

(D) 2 kg

10) Three identical rods AB, CD and PQ are joined as shown. P and Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at 0°C, 100°C, 30°C and 60°C respectively. The direction of heat flow in PQ is



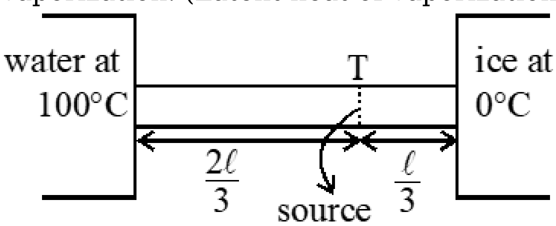
(A) from P to Q

(B) from Q to P

(C) heat does not flow in PQ

(D) data not sufficient

11) The rod connecting two reservoir and connected to a source is as shown in diagram. The rod is in steady state. Find the temperature of source, so that rate of melting of ice is 16 times that rate of vaporization. (Latent heat of vaporization is 540 Cal/gm and latent heat of fusion is 80 Cal/gm)



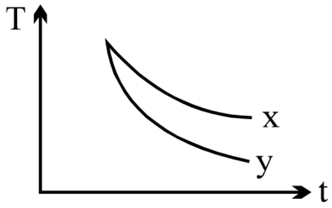
(A) 540°C

(B) 580°C

(C) 640°C

(D) 740°C

12) If emissivity of bodies X and Y are e_x and e_y and absorptive power are A_x and A_y then



(A) $e_y > e_x$; $A_y > A_x$

(B) $e_y < e_x$; $A_y < A_x$

(C) $e_y > e_x$; $A_y < A_x$

(D) $e_y = e_x$; $A_y = A_x$

13) A container X has volume double that of container Y and both are connected by a thin tube. Both contains same ideal gas. The temperature of X is 200K and that of Y is 400K. If mass of gas in X is m then in Y it will be :-

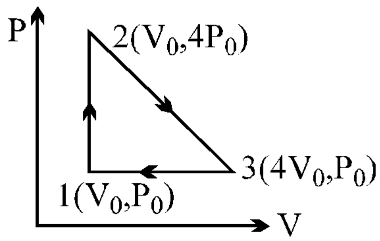
(A) m/8

(B) m/6

(C) m/4

(D) m/2

14) One mole of an ideal diatomic gas is taken through the cycle as shown in the figure.
$1 \rightarrow 2$: isochoric process
$2 \rightarrow 3$: straight line on P-V diagram
$3 \rightarrow 1$: isobaric process
The average molecular speed of the gas in the states 1, 2 and 3 are in the ratio



(A) 1 : 2 : 2

(B) $1 : \sqrt{2} : \sqrt{2}$

(C) 1 : 1 : 1

(D) 1 : 2 : 4

15) Two monoatomic ideal gas at temperature T_1 and T_2 are mixed. There is no loss of energy. If the masses of molecules of the two gases are m_1 and m_2 and number of their molecules are n1 and n2 respectively. The temperature of the mixture will be :

(A) $\dfrac{T_1+T_2}{n_1+n_2}$

(B) $\dfrac{T_1}{n_1}+\dfrac{T_2}{n_2}$

(C) $\dfrac{n_2T_1+n_1T_2}{n_1+n_2}$

(D) $\dfrac{n_1T_1+n_2T_2}{n_1+n_2}$

16) An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then

(A) $P_3 > P_1$, $W > 0$

(B) $P_3 < P_1$, $W < 0$

(C) $P_3 > P_1$, $W < 0$

(D) $P_3 = P_1$, $W = 0$

17) One mole of an ideal gas at temperature T_1 expends according to the law $\dfrac{P}{V^2}$ = a (constant). The work done by the gas till temperature of gas becomes T_2 is :

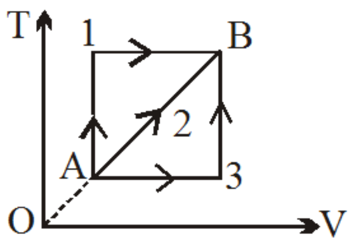
(A) $\frac{1}{2}R(T_2 - T_1)$

(B) $\frac{1}{3}R(T_2 - T_1)$

(C) $\frac{1}{4}R(T_2 - T_1)$

(D) $\frac{1}{5}R(T_2 - T_1)$

18) A given mass of a gas expands from a state A to the state B by three paths 1, 2 and 3 as shown in T-V indicator diagram. If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths, then



(A) $W_1 > W_2 > W_3$

(B) $W_1 < W_2 < W_3$

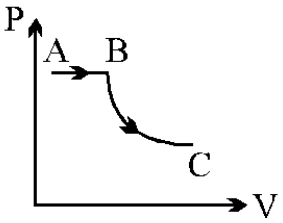
(C) $W_1 = W_2 = W_3$

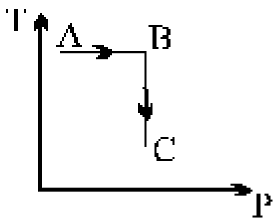
(D) $W_1 < W_2$, $W_1 > W_3$

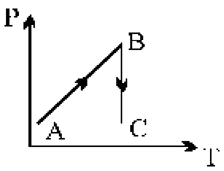
19) During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P/C_V for the gas is-

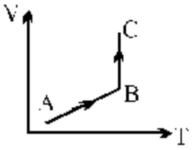
(A) 4/3
(B) 2
(C) 5/3
(D) 3/2

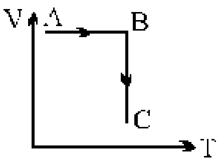
20) A process is shown in the diagram. Which of the following curves may represent the same process ?



(A) 

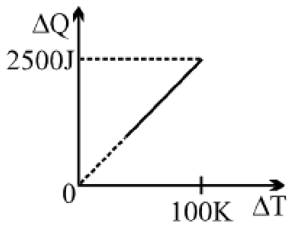
(B) 

(C) 

(D) 

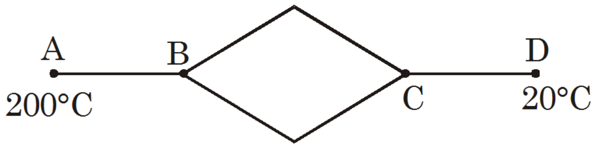
SECTION-II

1) One mole of a gas mixture is heated under constant pressure, and heat required ΔQ is plotted against temperature difference acquired. Find the value of γ for mixture.



2) An aluminium container of mass 100 gm contains 200 gm of ice at – 20°C. Heat is added to the system at the rate of 100 cal/s. Find the temperature of the system after 4 minutes. (Specific heat of ice = 0.5 and L = 80 cal/gm, specific heat of Al = 0.2 cal/gm-°C)

3) Six identical conducting rods are joined as shown in figure. Points A and D are maintained at temperature 200°C and 20°C respectively. The temperature (in °C) of junction 'B' will be :-



4) A gas heater raises temperature of 1kg of water by 30°C in 10min. How long (in minute) will it take the same heater to raise 3kg of oil through the same temperature rise if the specific heat of water is twice that of oil? (assuming that there is no heat loss)

5) The elastic potential energy stored in a steel wire of length 20 *m* stretched through 2 *cm* is 80 *J*. The cross sectional area of the wire is__________ mm^2. (Given, $y = 2.0 \times 10^{11} Nm^{-2}$)

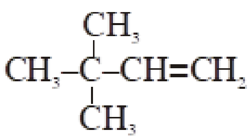
PART-2 : CHEMISTRY

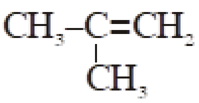
SECTION-I

1) Which of the following molecule has longest C=C bond length ?

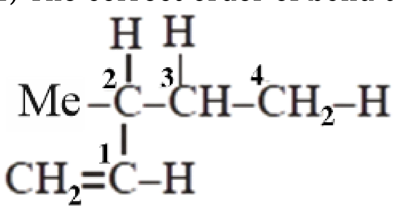
(A) $CH_2=C=CH_2$

(B) $CH_3-CH=CH_2$

(C) 

(D) 

2) The correct order of bond dissociation energy (provided bond undergoes homolytic cleavage):



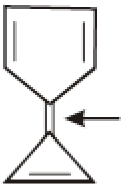
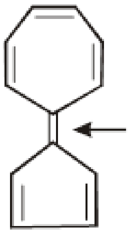
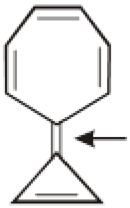
(A) C^2–H > C^3– H > C^4 –H > C^1 – H

(B) C^2–H > C^3– H > C^1 –H > C^4 – H

(C) C^1–H > C^4– H > C^2 –H > C^3 – H

(D) C^1–H > C^4– H > C^3 –H > C^2 – H

3) Compare carbon-carbon bond rotation across I, II, III.

(I)  (II)  (III) 

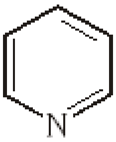
(A) I > II > III

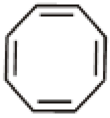
(B) I > III > II

(C) II > I > III

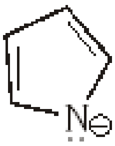
(D) II > III > I

4) Which species is not aromatic ?

(A) 

(B) 

(C) 

(D) 

5) Consider the following statements:

(I) $CH_3O\overset{\oplus}{C}H_2$ is more stable than $CH_3\overset{\oplus}{C}H_2$

(II) $Me_2\overset{\oplus}{C}H$ is more stable than $CH_3CH_2\overset{\oplus}{C}H_2$

(III) $CH_2=CH-\overset{\oplus}{C}H_2$ is more stable than $CH_3CH_2\overset{\oplus}{C}H_2$

(IV) $CH_2=\overset{\oplus}{C}H$ is more stable than $CH_3\overset{\oplus}{C}H_2$

Of these statements:

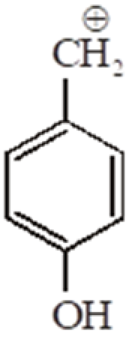
(A) I and II are correct

(B) III and IV are correct

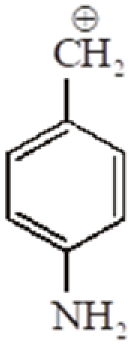
(C) I, II and III are correct

(D) II, III and IV are correct

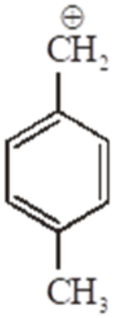
6) Correct order of carbocation stability is :



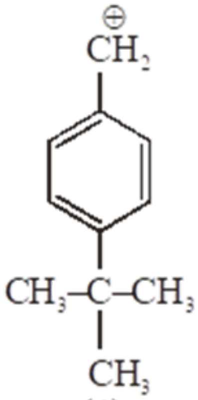
(1)



(2)



(3)



(4)

(A) 2 > 1 > 4 > 3

(B) 1 > 2 > 4 > 3

(C) 3 > 4 > 2 > 1

(D) 2 > 1 > 3 > 4

7) Most stable carbanion is :-

(A) $HC\equiv C^{\ominus}$

(B) $C_6H_5^{\ominus}$

(C) $(CH_3)_3C-CH_2^{\ominus}$

(D) $(CH_3)_2C=CH^{\ominus}$

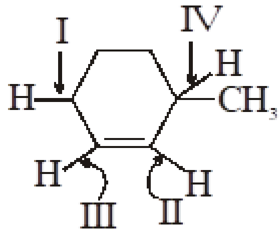
8) $CH_2 = CH - CH = CH - CH_3$
(I)
is more stable than
$CH_3 - CH = C = CH - CH_3$ because
(II)

(A) there is resonance in I but not in II

(B) there is tautomerism in I but not in II

(C) there is hyperconjugation in I but not in II

(D) II has more cononical structures than I.

9) Which of the following C-H bonds participate in hyperconjugation ? 

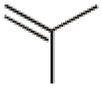
(A) I and II

(B) I and IV

(C) I and III

(D) III and IV

10) Rank the following alkenes in decreasing order of heat of combustion values :

(I)  (II) 

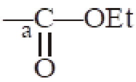
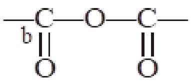
(III)  (IV) 

(A) II > III > IV > I

(B) II > IV > III > I

(C) I > III > IV > II

(D) I > IV > III > II

11) Statement-I :  

bond length a < b

Because

Statement-II : More is the double bond character less is the bond length.

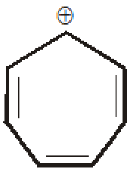
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the corret explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

12) The most stable and the least stable carbocation among

(I)  (II) $CH_2=CH-\overset{+}{C}H_2$

(III) $C_6H_5-\overset{+}{C}H_2$ (IV) $CH_3-\overset{+}{C}H-CH_3$

are respectively :

(A) II, I

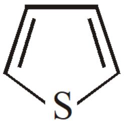
(B) III, IV

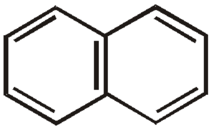
(C) I, II

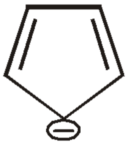
(D) I, IV

13) The non aromatic compound among the following is :-

(A) 

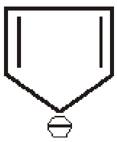
(B) 

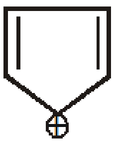
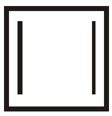
(C) 

(D) 

14) Which of the following compounds are antiaromatic :-

(I)  (II) 

(III)  (IV) 

(V)  (VI) 

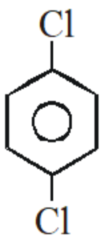
(A) (III) and (VI)

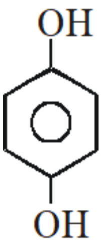
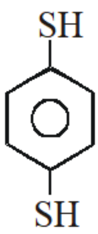
(B) (II) and (V)

(C) (I) and (V)

(D) (V) and (VI)

15) For which of the following molecule significant $\mu \neq 0$

(1)  (2) 

(3)  (4) 

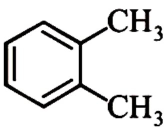
(A) Only (3)

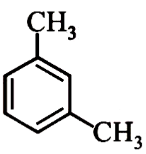
(B) (3) and (4)

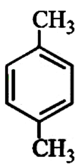
(C) Only (1)

(D) (1) and (2)

16) Ring nitration of dimethyl benzene results in the formation of only one nitro dimethyl benzene. The dimethyl benzene is :

(A) 

(B) 

(C) 

(D) None of these

17) For the electrophilic substitution reaction involving nitration, which of the following sequence regarding the rate of reaction is true?

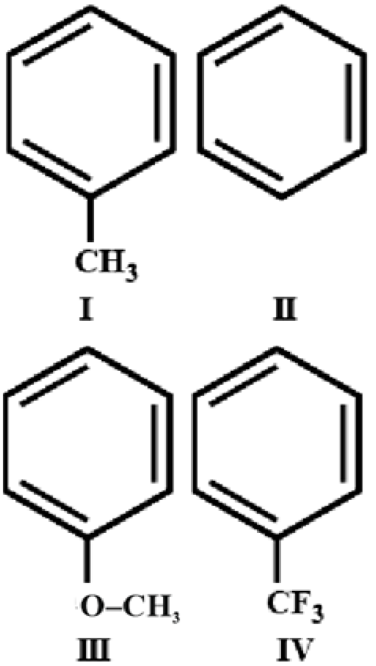
(A) $k_{C_6H_6} > k_{C_6D_6} > k_{C_6T_6}$

(B) $k_{C_6H_6} < k_{C_6D_6} < k_{C_6T_6}$

(C) $k_{C_6H_6} = k_{C_6D_6} = k_{C_6T_6}$

(D) $k_{C_6H_6} > k_{C_6D_6} < k_{C_6T_6}$

18) Among the following compounds, the decreasing order of reactivity towards electrophilic



substitution is

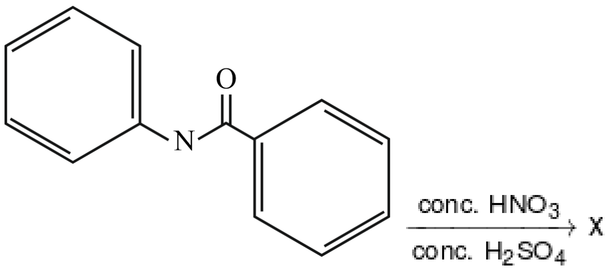
(A) III > I > II > IV

(B) IV > I > II > III

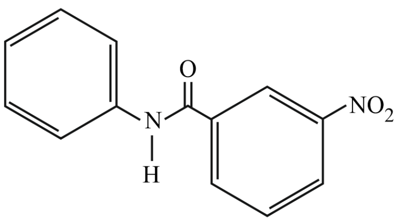
(C) I > II > III > IV

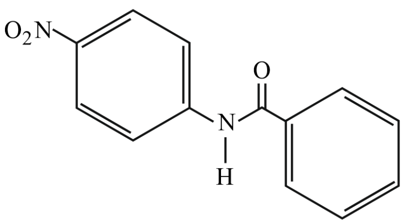
(D) II > I > III > IV

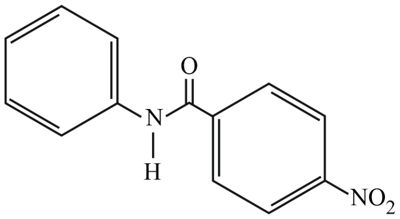
19) In the following reaction

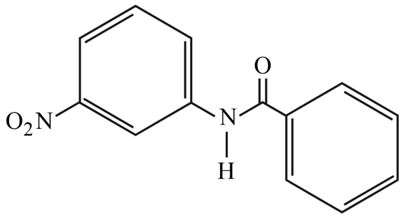


the structure of the major product 'X' is

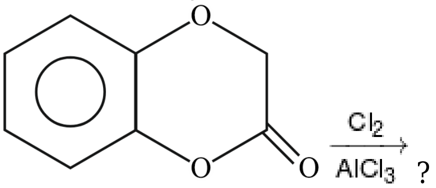
(A) 

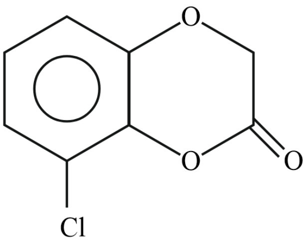
(B) 

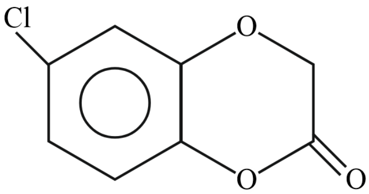
(C) 

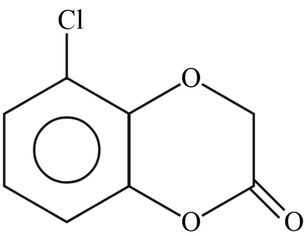
(D) 

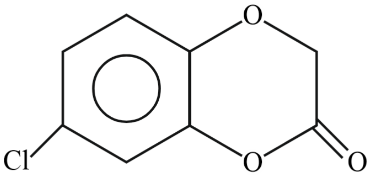
20) Predict major product in the following reaction,



(A) 

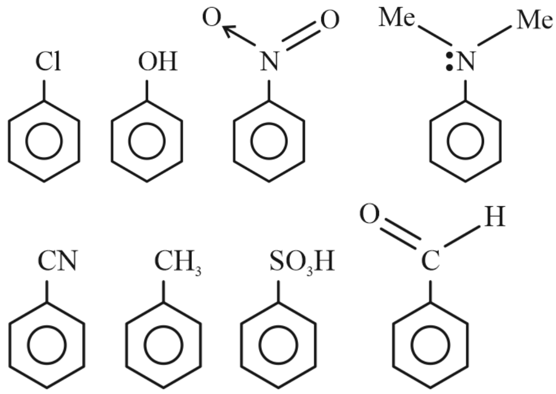
(B) 

(C) 

(D) 

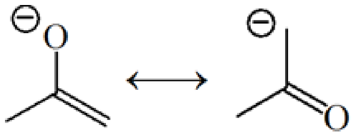
SECTION-II

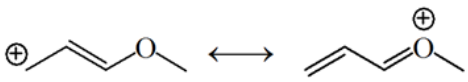
1) Number of compounds which can show higher rate of electrophilic substitution than benzene.

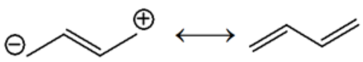


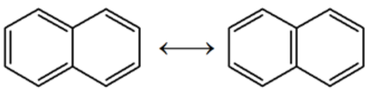
2) Total number of pairs of resonating structure in which second is more stable than first.

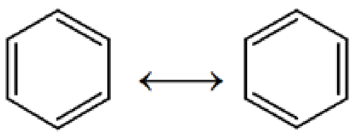
(a) $CH_3-\overset{\oplus}{C}=O \longleftrightarrow CH_3-C\equiv\overset{\oplus}{O}$

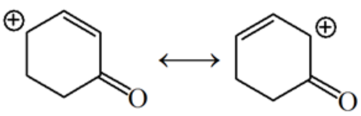
(b) 

(c) 

(d) 

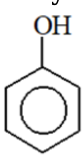
(e) 

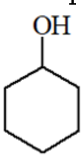
(f) 

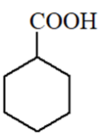
(g) 

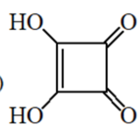
3)

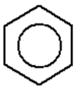
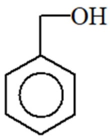
Identify total number of compounds soluble in aq. NaOH

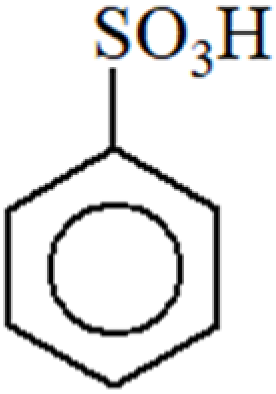
(1) 

(2) 

(3) 

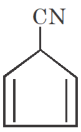
(4) 

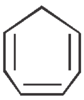
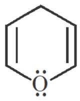
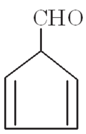
(5)  (6) 

(7) 

4)

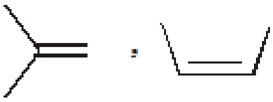
How many compounds can give aromatic ion after deprotonation :

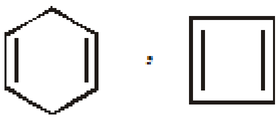
(a)  (b)  (c) 

(d)  (e)  (f) 

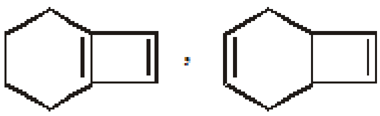
5)

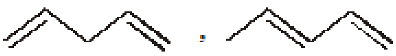
Number of pairs in which 1st compound has more heat of hydrogenation than 2nd are :

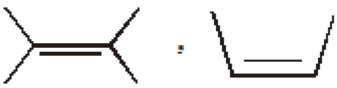
(a) 

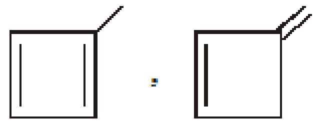
(b) 

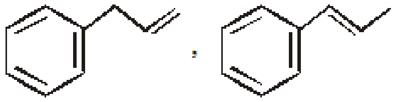
(c) 

(d) 

(e) 

(f) 

(g) 

(h) 

PART-3 : MATHEMATICS

SECTION-I

1) In the expansion of $\left(x-\frac{1}{x}\right)^6$, the term independent of x is

(A) –20
(B) 20
(C) 30
(D) –30

2) In the expansion of $\left(1+x+x^3+x^4\right)^{10}$ the coefficient of x^4 is

(A) ${}^{40}C_4$
(B) ${}^{10}C_4$
(C) 210
(D) 310

3) The remainder when 2^{2003} is divided by 17 is

(A) 1
(B) 2
(C) 8
(D) none of these

4) The greatest term in the expansion of $\sqrt{3}\left(1+\frac{1}{\sqrt{3}}\right)^{20}$ is

(A) $\frac{25840}{9}$
(B) $\frac{24840}{9}$
(C) $\frac{26840}{9}$
(D) None of these

5) Coefficient of x^{11} in the expansion of $\left(1+x^2\right)^4\left(1+x^3\right)^7\left(1+x^4\right)^{12}$ is

(A) 1051
(B) 1106
(C) 1113
(D) 1120

6) Number of rational terms in the expansion of $\left(1+\sqrt{2}+\sqrt{5}\right)^6$ is

(A) 7
(B) 10
(C) 6
(D) 8

7) The sum of the series
$2.{}^{20}C_0 + 5.{}^{20}C_1 + 8.{}^{20}C_2 + 11.{}^{20}C_3 + \ldots + 62.{}^{20}C_{20}$
is equal to

(A) 2^{24}
(B) 2^{25}
(C) 2^{26}
(D) 2^{23}

8) Let $(5+2\sqrt{6})^n = p + f$ where n, p∈N and $0 < f < 1$ then the value of $f^2 - f + pf - p$ is

(A) a natural number
(B) a negative integer
(C) a prime number
(D) an irrational number

9) If α and β be the coefficients of x^4 and x^2 respectively in the expansion of $\left(x+\sqrt{x^2-1}\right)^6+\left(x-\sqrt{x^2-1}\right)^6$, then

(A) $\alpha + \beta = 60$
(B) $\alpha + \beta = -30$
(C) $\alpha - \beta = -132$
(D) $\alpha - \beta = 60$

10) Let [x] denote greatest integer less than or equal to x.

If for $n \in \mathbb{N}$, $(1-x+x^3)^n = \sum_{j=0}^{3n} a_j x^j$, then $\sum_{j=0}^{\left[\frac{3n}{2}\right]} a_{2j} + 4\sum_{j=0}^{\left[\frac{3n-1}{2}\right]} a_{2j+1}$ is equal to

(A) 2

(B) 2^{n-1}

(C) 1

(D) n

11) In the expansion of $\left(\frac{x}{\cos\theta} + \frac{1}{x\sin\theta}\right)^{16}$, if ℓ_1 is the least value of the term independent of x when $\frac{\pi}{8} \leqslant \theta \leqslant \frac{\pi}{4}$ and ℓ_2 is the least value of the term independent of x when $\frac{\pi}{16} \leqslant \theta \leqslant \frac{\pi}{8}$, then the ratio of ℓ_2 to ℓ_1 is equal to

(A) 1 : 8

(B) 1 : 16

(C) 8 : 1

(D) 16 : 1

12) If one end of a focal chord of the parabola, $y^2 = 16x$ is at (1, 4), then the length of this focal chord is

(A) 25

(B) 24

(C) 20

(D) 22

13) A point P moves such that slope of one tangent drawn from it to parabola $y^2 = 16x$ is four times the slope of other tangent. Length of latus rectum of conic represented by locus of P will be

(A) 25

(B) 30

(C) 35

(D) 50

14) Equation of circle drawn with focus of parabola $(x-1)^2 = 8y$ as centre and touching the parabola at its vertex is

(A) $x^2 + y^2 - 2x - 4y + 1 = 0$

(B) $2x^2 + 2y^2 - 2x - 4y + 3 = 0$

(C) $x^2 + y^2 - 2x - 4y = 0$

(D) $x^2 + y^2 - 2x - 2y + 1 = 0$

15) Let P be the point (1, 0) and point Q varies on the curve $y^2 = 8x$. The locus of mid point of PQ is

(A) $x^2 + 4y + 2 = 0$
(B) $x^2 - 4y + 2 = 0$
(C) $y^2 - 4x + 2 = 0$
(D) $y^2 + 4x + 2 = 0$

16) The equation of common tangent of the parabola $y^2 = 8x$ and the circle $x^2 + y^2 = 2$ is

(A) $y = x + 1$
(B) $x + y + 1 = 0$
(C) $x + y + 2 = 0$
(D) $y = x - 2$

17) Minimum distance between the curves
$y^2 = 4x$ and $x^2 + y^2 - 12x + 31 = 0$ is

(A) $\sqrt{5}$
(B) $\sqrt{21}$
(C) $\sqrt{28} - \sqrt{5}$
(D) $\sqrt{21} - \sqrt{5}$

18) If $\left(3m_i^2, -6m_i\right)$ where i = 1, 2, 3 represents the feet of the normals to the parabola $y^2 = 12x$ from (1, 2), then $\sum_{i=1}^{3} \frac{1}{m_i}$ is

(A) $\frac{-5}{2}$
(B) $\frac{3}{2}$
(C) 6
(D) -3

19) If the reflection of the parabola $y^2 = 4(x - 1)$ in the line $x + y = 2$ is the curve $Ax + By = x^2$, then the value of (A + B) is

(A) 0
(B) 1
(C) 2
(D) 3

20)

Coefficient of x^{65} in expansion of $\prod_{i=0}^{10} (i + x)^{i+1}$ is

(A) 650

(B) 325

(C) 440

(D) 66

SECTION-II

1) $\left(1+x+x^2\right)^{3n+1} = a_0 + a_1 x + \ldots + a_{6n+2}x^{6n+2}$
then
$\sum_{r=0}^{20}\left(a_{3r} - \frac{a_{3r+1}+a_{3r+2}}{2}\right)$ equals___

2) If $\sum_{k=0}^{100}\left(\frac{k}{k+1}\right){}^{100}C_k = \frac{a\left(2^{100}\right)+b}{c}$
where $a, b, c \in N$,
then find the least value of $\frac{(a+b+c)}{670}$.

3) Normal PO, PA and PB ('O' being the origin) are drawn to $y^2 = 4x$ from P(h, 0). If $\angle AOB = \pi/2$, then area of quadrilateral OAPB (in square units) is equal to

4) A focal chord to $y^2 = 16x$ is a tangent to $(x - 6)^2 + y^2 = 2$, then the number of possible integral value(s) of slope of this chord is

5) If the co-ordinate of the vertex of the parabola whose parametric equation is $x = t^2 - t + 1$ and $y = t^2 + t + 1$, $t \in R$ is (a, b), then (2a + 4b) equals

ANSWER KEYS

PART-1 : PHYSICS

SECTION-I

Q.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A.	**C**	**D**	**C**	**A**	**B**	**D**	**D**	**D**	**A**	**A**	**C**	**A**	**C**	**A**	**D**	**C**	**B**	**A**	**D**	**C**

SECTION-II

Q.	21	22	23	24	25
A.	**1.5**	**25.45**	**140.00**	**15.00**	**40.00**

PART-2 : CHEMISTRY

SECTION-I

Q.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
A.	**D**	**D**	**C**	**B**	**C**	**D**	**A**	**A**	**B**	**D**	**D**	**D**	**A**	**D**	**B**	**C**	**C**	**A**	**B**	**D**

SECTION-II

Q.	46	47	48	49	50
A.	**3.00**	**4.00**	**4.00**	**3.00**	**5.00**

PART-3 : MATHEMATICS

SECTION-I

Q.	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
A.	**A**	**D**	**C**	**A**	**C**	**B**	**B**	**B**	**C**	**C**	**D**	**A**	**A**	**A**	**C**	**C**	**A**	**A**	**A**	**C**

SECTION-II

Q.	71	72	73	74	75
A.	**10.00**	**0.30**	**24.00**	**2.00**	**6.00**

PART-1 : PHYSICS

1) Modulus of rigidity $(\eta) = \dfrac{(F/bc)}{\phi}$

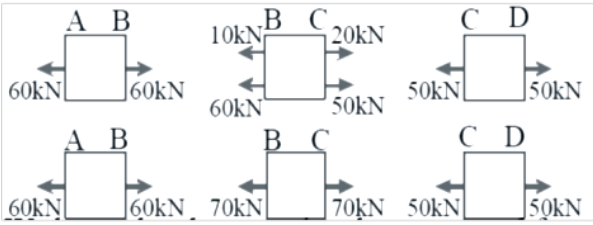
$\Rightarrow \phi = \dfrac{F}{bc\eta}$

2) Elastic energy stored in wire $= \dfrac{1}{2}(mg)x = \dfrac{1}{2}(200)(10^{-3})J = 0.1\ J$

3) $T_1 \propto (\ell_1 - \ell) \,\&\, T_2 \propto (\ell_2 - \ell)$

$\therefore \dfrac{\ell_1 - \ell}{\ell_2 - \ell} = \dfrac{T_1}{T_2} \Rightarrow T_2\ell - T_1\ell = T_2\ell_1 - T_1\ell_2 \Rightarrow \boxed{\ell = \dfrac{T_2\ell_1 - T_1\ell_2}{T_2 - T_1}}$

4) The action of forces on each part of rod is shown in figure



We know that the extension due to external force F is given by

$e = \dfrac{F\ell}{AY}$

$\therefore e_{AB} = \dfrac{(60 \times 10^3) \times 1.5}{1 \times 2 \times 10^{11}} = 4.5 \times 10^{-7} m$

$\therefore e_{BC} = \dfrac{(70 \times 10^3) \times 1}{1 \times 2 \times 10^{11}} = 3.5 \times 10^{-7} m$ and $e_{CD} = \dfrac{(50 \times 10^3) \times 2}{1 \times 2 \times 10^{11}} = 5.0 \times 10^{-7} m$

The total extension $e = e_{AB} + e_{BC} + e_{CD}$

$= 4.5 \times 10^{-7} + 3.5 \times 10^{-7} + 5.0 \times 10^{-7}$

$= 13 \times 10^{-7}\ m = 1.3\ \mu m$

5) [Bulk Modulus $= \dfrac{\text{volumetric stress}}{\text{volumetric strain}}$]

$K = \dfrac{mg}{a\left(\frac{dV}{V}\right)}$

$\dfrac{dV}{V} = \dfrac{mg}{Ka}$ ...(i)

volume of sphere $\rightarrow V = \dfrac{4}{3}\pi R^3$

Fractional change in volume $\dfrac{dV}{V} = \dfrac{3dr}{r}$ ...(ii)

U sing eq. (i) & (2) $\frac{3dr}{r} = \frac{mg}{Ka}$

$\frac{dr}{r} = \frac{mg}{3Ka}$

6) $\lambda_0 T_0 = \frac{3}{4}\lambda_0 T_1 \Rightarrow T_1 = \frac{4}{3}T_0$ ...(i)

$P_0 = \sigma A T_0^4$ ...(ii)

$P_1 = \sigma A T_1^4$ ...(iii)

$P_1 = \sigma A\left(\frac{4}{3}T_0\right)^4$

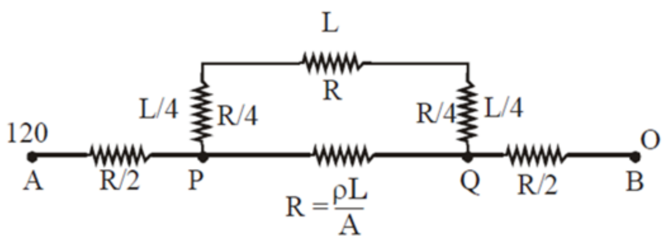
7) Heat given = Heat take

(100) (0.1)(T – 75) = (100)(0.1)(45) + (170)(1)(45)

10(T – 75) = 450 + 7650 = 8100

T – 75 = 810

T = 885°C



8)

$\frac{\Delta T}{R_{eq.}} = I = \frac{(120)\,5}{8R} = \frac{120 \times 5}{8R}$

$\Delta T_{PQ} = \frac{120 \times 5}{8R} \times \frac{3}{5}R = \frac{360}{8} = 45°C$

9)

Heat lost = Heat gain

2kg Ice at –20°C → 2 kg Ice at 0°C

Heat gain = $2 \times 10^3 \times \frac{1}{2} \times 20$ = 20 $Kcal$

5 Kg water a 20°C → 5 Kg water at 0°C

heat loss = 100 $Kcal$

Extra heat loss = 100 – 20 = 80 $Kcal$

Suppose x kg ice is melts upon supplying 80 $Kcal$ heat

80 $Kcal$ = x × 80 cal/gm

x = 1 Kg

Final amount of water = 5 + 1 = 6 kg

10) Both the rods are at steady state and temperature gradient constant and temperature drops linearly with the distance.

Temperature at P = $\frac{T_A + T_B}{2} \Rightarrow 50°C = T_P$

Temperature at $Q = \frac{T_C + T_D}{2} \Rightarrow 45°C = T_Q$

Since temperature at P more than at Q. So heat flow from P to Q.

11) $\left.\frac{dm}{dt}\right|_{Steam} = \frac{1}{16}\left.\frac{dm}{dt}\right|_{ice}$

$\left.\frac{dQ}{dt}\right|_{Steam} = \frac{T-100}{\left(\frac{2\ell}{3Ak}\right)} = \left(\frac{dm}{dt}\right)_{steam} L_V$

$\left.\frac{dQ}{dt}\right|_{Ice} = \frac{T-0}{\left(\frac{\ell}{3Ak}\right)} = 16\left(\frac{dm}{dt}\right)_{steam} L_f$

$\frac{\frac{T-100}{2}}{\frac{T}{1}} = \frac{L_V}{16L_f}$

$\frac{(T-100)}{2T} = \frac{540}{16 \times 80}$; $\frac{T-100}{T} = \frac{540}{640}$; $\frac{T-100}{2T} = \frac{540}{8 \times 80}$.

12) $-\frac{dT}{dt} \propto e$ ....(i)

From graph

$\left[\frac{-dT}{dt}\right]_x > \left[\frac{-dT}{dt}\right]_y$

So, $e_y > e_x$; $A_y > A_x$

13) $P \times 2V_0 = m \times R \times 200$

$P \times V_0 = M_1 R \times 400$

$M_1 \times 400 = m \times 100$

$M_1 = \frac{m}{4}$

14) For point (i)

$P_0V_0 = nRT_1$

For point (ii)

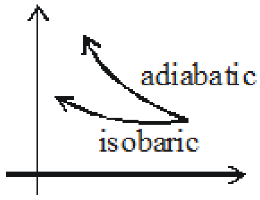
$V_0 \times 4P_0 = nRT_2$

For point (iii)

$4V_0 \times P_0 = nRT_3$

15) $\frac{3n_1}{N_A}\frac{f}{2}RT_1 + \frac{n_2}{N_A}\frac{3}{2}fRT_2$

$= \left(\frac{n_1 + n_2}{N_A}\right)\left(\frac{3f}{2}R\right)T_f$

16) 

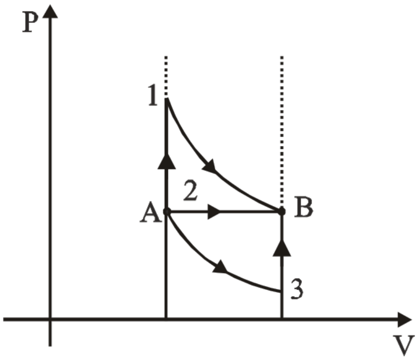
17)

PV^{-2} = constant = $\frac{R(T_2 - T_1)}{1-(-2)}$.

18)

$W_1 = nRT_2 \ell n \left(\frac{V_2}{V_1}\right)$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$= nRT_2 \left(\ell n \left(\frac{T_2}{T_1}\right)\right)$



$W_2 = nR\Delta T = nR(T_2 - T_1) = nRT_2 \left(1 - \frac{T_1}{T_2}\right)$

$W_2 = nRT_1 \ell n \left(\frac{V_2}{V_1}\right)$

19)

PT^{-3} = constant

$P^{1-\gamma}T^{\gamma}$ = constant

$\frac{\gamma}{1-\gamma} = -3$ $\Rightarrow \gamma = 3\gamma - 3$, $\gamma = 3/2$

20) AB → isobaric
BC → May be isothermal

21)

$C_P\Delta T = 2500$

$100 \times 8.31 \times \frac{\gamma}{\gamma - 1} = 2500$

$\frac{\gamma}{\gamma-1} = 3 \Rightarrow \gamma = 3\gamma - 3 \Rightarrow 3 = 2\gamma$

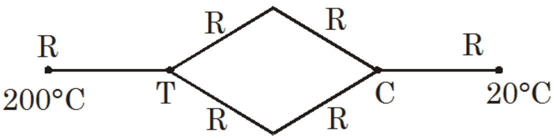
$\gamma = 1.5$

22) $Q = \left(100\frac{cal}{s}\right)(240s) = 24000\text{ cal}$

$Q = m_{al}S_{al}(20) + m_{ice}S_{ice}(20) + m_{ice}L_{ice} + m_{al}S_{al}(T) + m_wS_wT$

$\Rightarrow T = 25.5°C$

23)



$R_{eq} = 3R$

$i = \frac{\Delta T}{R_{eq}} = \frac{180}{3R} = \frac{60}{R} = \frac{200 - T_B}{R}$

$T_B = 200 - 60 = 140°C$

24) P =Power of heater

$= \frac{(1)\times S_W \times 30}{10\text{ min}.\frac{(3)\times S_0 \times 30}{t}} (S_W = 2s_0)$

$t = 15$ min.

25) Energy per unit volume $= \frac{1}{2}\text{Stress} \times \text{Strain}$

Energy $= \frac{1}{2}\text{Stress} \times \text{Strain} \times \text{Volume}$

$80 = \frac{1}{2} \times Y \times \text{Strain}^2\ A \times \ell$

$80 = \frac{1}{2} \times 2 \times 10^{11} \times \frac{\left(2\times 10^{-2}\right)^2}{400} \times A \times 20$

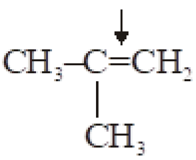
$20 = \frac{10^{+7}}{20} \times A$

$40 \times 10^{-6}\ m^2 = A$

$A = 40\ mm^2$

PART-2 : CHEMISTRY

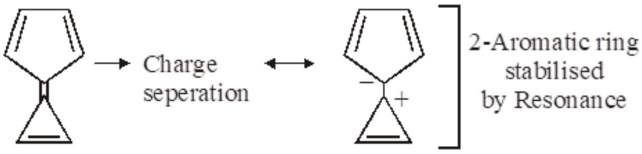
26)



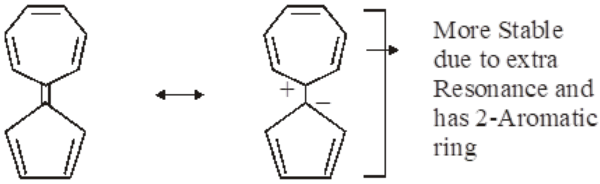
$6H_\alpha$ more hyperconjugation = converted into more single bond, B.L.

27) Bond dissociation energy of bond $\alpha \dfrac{1}{\text{Stability of corresponding free radical}}$.

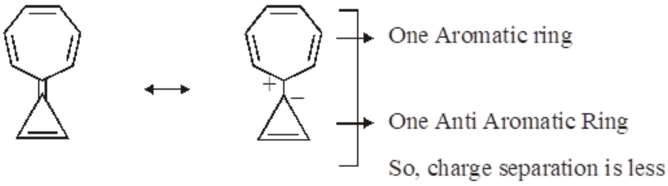
28) (i)



(ii)

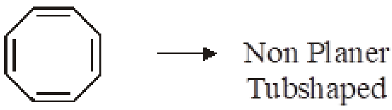


(iii)



So, Bond Rotation Energy ® III > I > II

So, Order of Rotation ® II > I > III

29) 

[Cyclooctatetraene]

$H_3C-\ddot{\underset{..}{O}}-\overset{+}{C}H_2 \longleftrightarrow H_3C-\overset{+}{\underset{..}{O}}=CH_2$

Resonance Stabilized

30) (I) $H_3C-\overset{+}{C}H_2 \longrightarrow$ No Resonance

$Me-\overset{+}{C}(Me)-H$ $\quad H_3C-CH_2-\overset{+}{C}H_2$

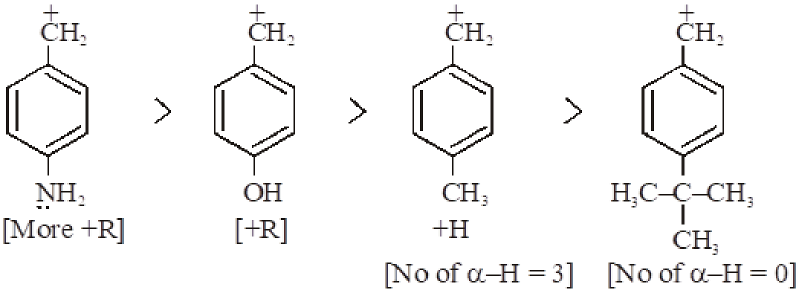
No of α–H = 2

(II) No of α–H = 6

$H_2C=C(H)-\overset{+}{C}H_2 \longleftrightarrow H_2\overset{+}{C}-C(H)=CH_2$

Resonance Stabilised

(III) $H_3C-CH_2-\overset{+}{C}H_2 \longrightarrow$ [No Resonance]

31) 

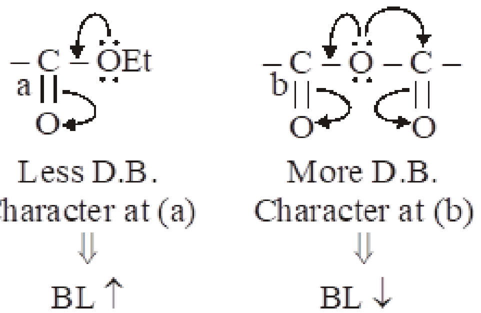
32)

Most stable carbanion is
$H-C\equiv C^-$
–ive charge is at sp hybridized carbon.

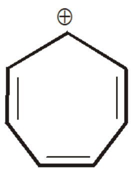
33) there is resonance in I but not in II

34) I and IV are only α–H.

35) HOC ∝ No of Carbon
If no of C is equal
Then HOC ∝ Unstability

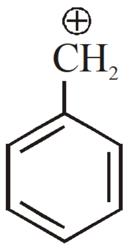


36)
BL $\boxed{a > b}$

37) (I) 
Aromatic
⇓
Most Stable

(II) $CH_2=CH-\overset{+}{C}H_2$
Resonance

(III)



(III)
Resonance
(More)

(IV) $CH_3-\overset{+}{C}H-CH_3$
6 α-H
⇓

Least Stable

Because for stability of CÅ we will see –

(1) Dancing Resonance

(2) Aromaticity

(3) +M

(4) Resonance

(5) +H

Increase stability

(6) +I

(7) Hybridisation

Increase stability

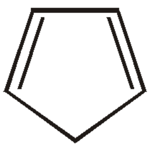
(8) –I

(9) –H

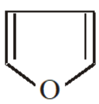
(10) –M

Decrease Stability

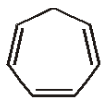
(11) Antiaromatic

38)  Non-aromatic due to non planarity

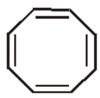
39)

(I) 

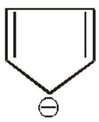
Aromatic

(II) 

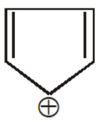
Non-Aromatic

(III) 

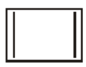
Non Aromatic

(IV) 

Aromatic

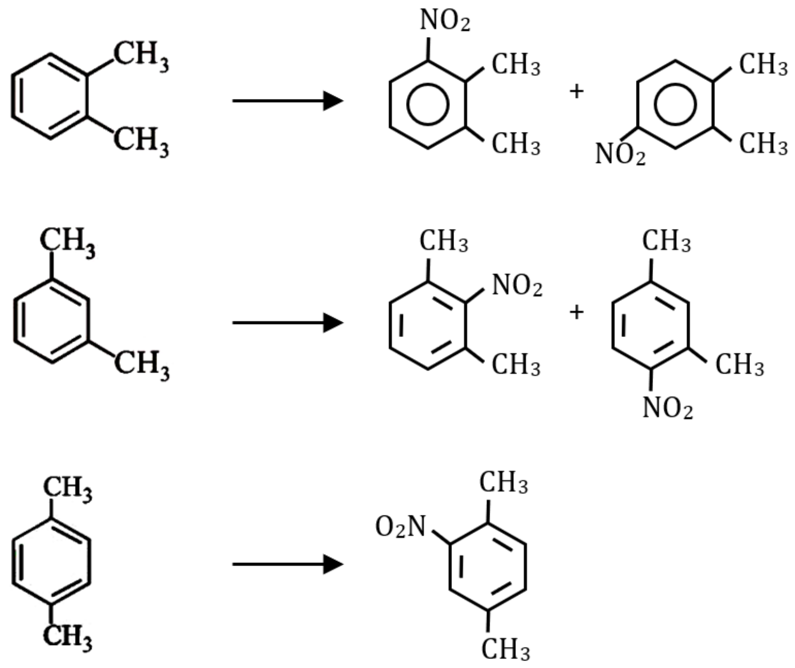
(V) 

Anti Aromatic

(VI) 

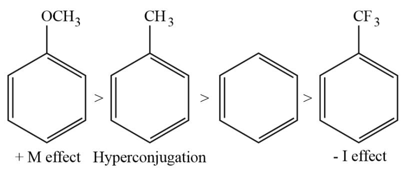
Anti Aromatic

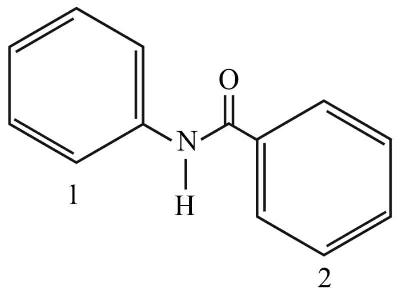
40) – OH & – SH are angular groups, so net dipole is non zero.

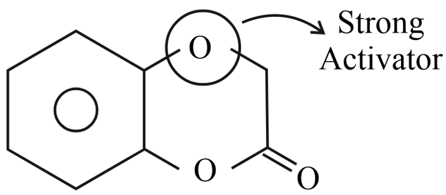
41) 

42)

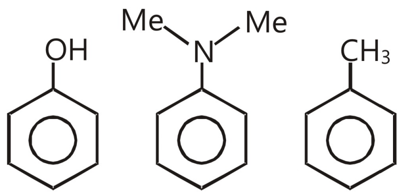
Nitration reaction does not shows primary kinetic isotopic effect

43) 

44) 

45) 

46) Electron releasing group such as –OH, – $N(Me)_2$, – CH_3 are present on the benzene ring they increases the electron density on benzene ring and activate the ring toward electrophilic aromatic substitution reaction.

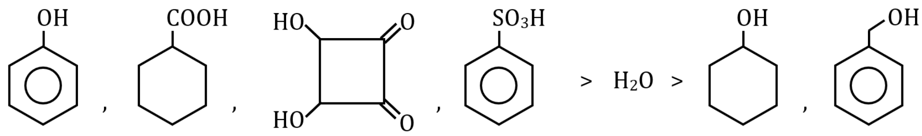


47)

a, c, d, e

48)

Those compound which are more acidic than H_2O are soluble in aq. NaOH.

So. 

49)

a,c,f

50)

(c) , (d) , (e) , (g) , (h)

PART-3 : MATHEMATICS

51)

In the expansion of $\left(x-\frac{1}{x}\right)^6$, the general term is ${}^6C_r x^{6-r}\left(-\frac{1}{x}\right)^r = {}^6C_r(-1)^r x^{6-2r}$

For term independent of x, $6-2r=0 \Rightarrow r=3$

$\Rightarrow$ Term independent of $x = {}^6C_3(-1)^3 = -20$

52) $(1+x+x^3+x^4)^{10} = (1+x)^{10}(1+x^3)^{10}$

$= (1+{}^{10}C_1.x+{}^{10}C_2.x^2+....)(1+{}^{10}C_1.x^3+{}^{10}C_2.x^6+....)$

 Coefficient of $x^4 = {}^{10}C_1.\,{}^{10}C_1. + {}^{10}C_4. = 310.$

53) $2^{2003} = 8.(16)^{500}$

$= 8(17-1)^{500}$

 Remainder = 8

54)

Let $(r+1)^{th}$ term be the greatest term. Then

$$T_{r+1} = \sqrt{3}.{}^{20}C_r\left(\frac{1}{\sqrt{3}}\right)^r \text{and} T_r = \sqrt{3}.{}^{20}C_{r-1}\left(\frac{1}{\sqrt{3}}\right)^{r-1}$$

$$\text{Now} \frac{T_{r+1}}{T_r} = \frac{20-r+1}{r}\left(\frac{1}{\sqrt{3}}\right)$$

$$\therefore T_{r+1} \geqslant T_r \Rightarrow 20-r+1 \geqslant \sqrt{3}r$$

$$\Rightarrow 21 \geqslant r(\sqrt{3}+1) \Rightarrow r \leqslant \frac{21}{\sqrt{3}+1} \Rightarrow r \leqslant 7.686 \Rightarrow r = 7$$

Hence the greatest term is

$$T_8 = \sqrt{3}{}^{20}C_7\left(\frac{1}{\sqrt{3}}\right)^7 = \frac{25840}{9}$$

55) Coefficient of $x^{11} \text{in} \left(1+x^2\right)^4\left(1+x^3\right)^7\left(1+x^4\right)^{12}$

$= {}^4C_0.{}^7C_1.{}^{12}C_2 + {}^4C_1.{}^7C_3.{}^{12}C_0 + {}^4C_2.{}^7C_1.{}^{12}C_1 + {}^4C_4.{}^7C_1.{}^{12}C_0$

$= 462 + 140 + 504 + 7 = 1113$

56) General term is

$$= \frac{6!}{r_1!r_2!r_3!}(1)^{r_1}(\sqrt{2})^{r_2}(\sqrt{5})^{r_3} = \frac{6!}{r_1!r_2!r_3!}(2)^{\frac{r_2}{2}}(5)^{\frac{r_3}{2}} \text{where} r_1 + r_2 + r_3 = 6$$

r_1	r_2	r_3
2	4	0
4	2	0
0	4	2
2	2	2
4	0	2
0	2	4
2	0	4
0	0	6
0	6	0
6	0	0

10 terms are possible

57) $2.{}^{20}C_0 + 5.{}^{20}C_1 + 8.{}^{20}C_2 + 11.{}^{20}C_3 + \ldots + 62.{}^{20}C_{20}$

$$= \sum_{r=0}^{20}(3r+2)\ {}^{20}C_r$$

$$= 3\sum_{r=0}^{20} r.{}^{20}C_r + 2\sum_{r=0}^{20} {}^{20}C_r$$

$= 3\sum_{r=0}^{20} r\left(\frac{20}{r}\right) {}^{19}C_{r-1} + 2.2^{20}$

$= 60.2^{19} + 2.2^{20} = 2^{25}$

58) $p + f = \left(5 + 2\sqrt{6}\right)^n = {}^nC_0(5)^n + {}^nC_1(5)^{n-1}2\sqrt{6} + \ldots\ldots\ldots + {}^nC_n$ ....(1)

Consider $0 < \left(5 - 2\sqrt{6}\right) < 1$

.... (2)

Add (1) and (2)

$P + f + F = 2\left[{}^nC_0(5)^n + {}^nC_2(5)^{n-2}\left(2\sqrt{6}\right)^2\ldots\ldots\ldots\right]$

= 2[integer]

p + f + F = even integer

Hence f + F = 1

Now

(p + f)F =

p – pf + f – f2 = 1

OR f2 – f + pf – p = –1

Thus a negative integer

59) $2[{}^6C_0.x^6 + {}^6C_2x^4(x^2 - 1) + {}^6C_4x^2(x^2 - 1)^2 + {}^6C_6(x^2 - 1)^3]$

a = – 96 & b = 36

 a – b = –132

(3) Option

60) $(1 - x + x^3)^n = \sum_{j=0}^{3n} a_j x^j$

$\left(1 - x + x^3\right)^n = a_0 + a_1x + a_2x^2\ldots\ldots + a_{3n}x^{3n}$

$\sum_{j=0}^{\left[\frac{3n}{2}\right]} a_{2j}$ = Sum of $a_0 + a_2 + a_4\ldots\ldots\ldots$

$\sum_{j=0}^{\left[\frac{3n-1}{2}\right]} a_{2j} + 1$ = Sum of $a_1 + a_3 + a_5\ldots\ldots\ldots$

put x = 1

$1 = a_0 + a_1 + a_2 + a_3\ldots\ldots\ldots + a_{3n}$ ....(A)

Put x = -1

$1 = a_0 - a_1 + a_2 - a_3\ldots\ldots\ldots + (-1)^{3n}a_{3n}$ ....(B)

Solving (A) and (B)

$a_0 + a_2 + a_4\ldots\ldots = 1$

$a_1 + a_3 + a_5\ldots\ldots\ldots = 0$

$$\sum_{j=0}^{\left[\frac{3n}{2}\right]} a_{2j} + 4\sum_{j=0}^{\left[\frac{3n-1}{2}\right]} a_{2j+1} = 1$$

61) $T_{r+1} = {}^{16}C_r\left(\frac{x}{\cos\theta}\right)^{16-r}\left(\frac{1}{x\sin\theta}\right)^r$

$= {}^{16}C_r(x)^{16-2r} \times \frac{1}{(\cos\theta)^{16-r}(\sin\theta)^r}$

For independent of x; $16 - 2r = 0 \Rightarrow r = 8$

$\Rightarrow T_9 = {}^{16}C_8\frac{1}{\cos^8\theta\sin^8\theta}$

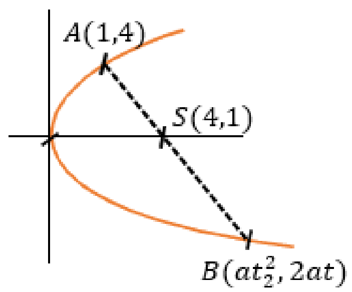
$= {}^{16}C_8\frac{2^8}{(\sin 2\theta)^8}$

for $\theta \in \left[\frac{\pi}{8}, \frac{\pi}{4}\right]$ ℓ_1 is least for $\theta_1 = \frac{\pi}{4}$

for $\theta \in \left[\frac{\pi}{16}, \frac{\pi}{8}\right]$ ℓ_2 is least for $\theta_2 = \frac{\pi}{8}$

$\frac{\ell_2}{\ell_1} = \frac{(\sin 2\theta_1)^8}{(\sin 2\theta_2)^8} = \left(\sqrt{2}\right)^8 = \frac{16}{1}$

62)



$y^2 = 4ax = 16x \Rightarrow a = 4$

$A(1, 4) \Rightarrow 2.4.t_1=4 \Rightarrow t_1 = \frac{1}{2}$

 length of focal chord $= a\left(t + \frac{1}{t}\right)^2$

$= 4\left(\frac{1}{2} + 2\right)^2 = 4.\frac{25}{4} = 25$

63) Let P(h,k)

Equation of tangent : $y = mx + \frac{4}{m}$

$\Rightarrow k = mh + \frac{4}{m} \Rightarrow m^2 h - km + 4 = 0 \begin{cases} m_1 \\ 4m_1 \end{cases}$

$5m_1 = \frac{k}{h}; 4m_1^2 = \frac{4}{h} \Rightarrow 4\left(\frac{k}{5h}\right)^2 = \frac{4}{h}$

$\Rightarrow k^2 = 25h$

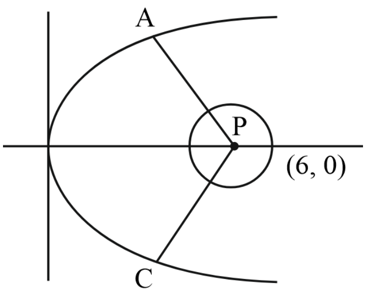
$\Rightarrow y^2 = 25x \Rightarrow L_{LR} = 25$

64) Vertex (1, 0), focus (1, 2)
Equation is $(x-1)^2 + (y - 2)^2 = 4$

65) P = (1, 0), Q = (h, k) such that $k^2 = 8h$
Let (α, β) be the midpoint of PQ;
$\alpha = \frac{h+1}{2}, \ \beta = \frac{k+0}{2}; \ 2\alpha - 1 = h, \ 2\beta = k$
$(2\beta)^2 = 8(2\alpha - 1) \Rightarrow \beta^2 = 4\alpha - 2$
$\Rightarrow y^2 - 4x + 2 = 0$

66) Any tangent of $y^2 = 8x$ is $y = mx + \frac{2}{m}$ ..(1)
Also the tangent of circle so r = distance from center to tangent
$\Rightarrow \sqrt{2} = \frac{\left|0 - 0 - \frac{2}{m}\right|}{\sqrt{1+m^2}}$
$\Rightarrow 2 + 2m^2 = \frac{4}{m^2}$
$\Rightarrow m = \pm 1$, put in (1)
$y = \pm x \pm 2$

67) Centre and radius of the given circle is P(6,0) and $\sqrt{5}$ respectively.
Equation of normal for $y^2 = 4x$ at $(t^2, 2t)$ is
$y = -tx + 2t + t^3$, it must pass through (6,0) in order that it gives minimum distance between the two curves.
$\therefore 0 = t^3 - 4t \Rightarrow t = 0$ or $t = \pm 2$



$\therefore$ A(4,4) and C (4, -4)
$PA = PC = \sqrt{20} = 2\sqrt{5}$
$\therefore$ required minimum distance $= 2\sqrt{5} - \sqrt{5} = \sqrt{5}$.

68) Equation of normal of slope m to the parabola $y^2 = 12x$ is given by:
$y = mx - 6m - 3m^3$
It passes through (1, 2), so
$2 = m - 6m - 3m^3$

$$3m^3+5m+2=0 \quad \begin{matrix} m_1 \\ m_2 \\ m_3 \end{matrix}$$

$$\sum m_1 = 0,\ \sum m_1m_2 = \frac{5}{3},\ m_1m_2m_3 = \frac{-2}{3}$$

Now, $\displaystyle\sum_{i=1}^{3}\frac{1}{m_i} = \frac{\sum m_1m_2}{m_1m_2m_3} = \frac{\frac{5}{3}}{\frac{-2}{3}}$

$= \dfrac{-5}{2}$

69) Let a variable point on the parabola be
$(1 + t^2, 2t)$ and its reflection in the given line be (h,k)

□ $h - (1 + t)^2 = k - 2t = \dfrac{-2\left(1+t^2+2t-2\right)}{2}$

□ $h - (1 + t^2) = -1 - t^2 - 2t + 2 \Rightarrow h = 2(1 - t)$ and $k = -(t^2 - 1)$

□ $\dfrac{k}{h} = \dfrac{-(t-1)(t+1)}{2(1-t)}$ □ $t+1 = \dfrac{2k}{h}$

and $t = \dfrac{2k}{h} - 1$

and $1 - t = 2 - \dfrac{2k}{h} = \dfrac{h}{2}$

□ $2h - 2k = \dfrac{h^2}{2}$

□ $4x - 4y = x^2$

□ $A + B = 0$.

70) $\displaystyle\prod_{i=0}^{10}(i+x)^{i+1} = x(1 + x)^2(2 + x)^3 \ldots\ldots (10 + x)^{11}$

$= x^{66} + (1.2 + 2.3 + 3.4 + \ldots\ldots + 10.11)x^{65} + \ldots..$

$\Rightarrow$ coefficient

$x^{65} = \displaystyle\sum_{n=1}^{10} n(n+1) = \sum_{n=1}^{10} n^2 + \sum_{n=1}^{10} n = 385+55 = 440$

71) Put $x=1,w,w^2$ and add

72) Let $S = \displaystyle\sum_{k=0}^{100}\left(\frac{k}{k+1}\right){}^{100}C_k$

$= \displaystyle\sum_{k=0}^{100}\frac{((k+1)-1)}{(k+1)}{}^{100}C_k = \left(\sum_{k=0}^{100}{}^{100}C_k\right) - \sum_{k=0}^{100}\frac{{}^{100}C_k}{k+1}$

$= 2^{100} - \dfrac{1}{101}\displaystyle\sum_{k=0}^{100}\left(\frac{101}{k+1}{}^{100}C_k\right)$

$= 2^{100} - \frac{1}{101}\sum_{k=0}^{100} {}^{101}C_{k+1}$

$2^{100} - \left(\frac{2^{101}-1}{101}\right) = \frac{(101)\,2^{100} - 2^{101} + 1}{101} = \frac{99\left(2^{100}\right)+1}{101}$

$= \frac{a\left(2^{100}\right)+b}{c}$ (Given)

So, $a = 99$, $b = 1$, $c = 101$

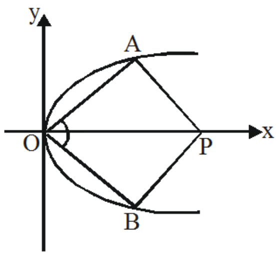
Hence, $(a+b+c)_{least} = 99 + 1 + 101 = 201.$

73) Let $A \equiv \left(t^2, 2t\right), B \equiv \left(t^2, -2t\right)$

$m_{OA} = \frac{2}{t},\ m_{OB} = -\frac{2}{t}$

$\Rightarrow \quad t^2 = 4$

$\Rightarrow \quad t = 2$



Equation of normal AP is

$y = -2x + 4 + 8$

$\Rightarrow \quad P \equiv (6, 0)$

Thus area of quadrilateral

OAPB $= \frac{1}{2}$ (OP)(AB)

$= \frac{1}{2} .6.8 = 24$ sq. units.

74) Focus (4, 0)

focal chord $\Rightarrow y = m(x - 4)$ is a tangent of the circle $(x - 6)^2 + y^2 = 2$

$\therefore \left|\frac{6m - 0 - 4m}{\sqrt{1+m^2}}\right| = \sqrt{2}$

$\Rightarrow 4m^2 = 2 + 2m^2$

$\Rightarrow m^2 = 1 \Rightarrow m = \pm 1$

75)

$x + y = 2(t^2 + 1)$

$y - x = 2t$

$\left(\frac{x+y}{2} - 1\right) = \left(\frac{y-x}{2}\right)^2$

$\left(\frac{x+y-2}{2}\right) = \frac{(x-y)^2}{4}$

$(x - y)^2 = 2(x + y - 4)$

axis : $x - y = 0$
Tangent at vertex : $x + y = 2$
Vertex $\equiv (1, 1)$