MELUHA INTERNATIONAL SCHOOL

HYDERABAD

SR MPC | **JEE MAINS MODEL – UT 1** | **Date: 29-05-2020**

Time: 3 Hours | **Max Marks : 300**

MATHS

SECTION – I

(SINGLE CORRECT ANSWER TYPE)

This section contains 20 multiple choice questions. Each question has 4 options (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** option can be correct.

Marking scheme: +4 for correct answer, 0 if not attempted and -1 if not correct.

01. $f : R \to R$ is a function defined by $f(x) = \dfrac{e^{|x|} - e^{-x}}{e^{x} + e^{-x}}$ then f is

A) a bijection B) an injection only

C) surjection only D)neither injection nor surjection

02. The domain of the function

$f(x) = \sin^{-1}\left(\dfrac{1+x^3}{2x^{3/2}}\right) + \sqrt{\sin(\sin x)} + \log_{(3\{x\}+1)}\left(x^2+1\right)$, where {.} represents fractional part function, is :

A) $x \in \{1\}$ B) $x \in R - \{1,-1\}$ C) $x > 3, x \neq 1$ D) null set

03. Range of $f(x) = [1+\sin x] + [\cos x - 1] + \left[\tan^{-1} x\right] \forall x \in [0, 2\pi]$, is (where $[.]$ denotes the greatest integer function $\left(\tan 1 < \dfrac{\pi}{2}\right)$

A) $\{-1,1,2\}$ B) $\{-1,0,1\}$ C) $\{-1,0,1,2\}$ D) $\{-1,0,2\}$

04. The fundamental period of the function $f(x) = \sin 3x \cos[3x] - \cos 3x \sin[3x]$ (where $[.]$ denotes the greatest integer function) is

A) 2π B) $\dfrac{2\pi}{3}$ C) $\dfrac{1}{3}$ D) $\dfrac{1}{6}$

05. $\lim\limits_{x\to 0} \sin^{-1}\left(\dfrac{\cos^{-1} x + \cos^{-1} x^2}{\pi}\right)$ is equal to

A) does not exist as RHL does not exist B) does not exist but LHL and RHL exist

C) does not exist as LHL does not exist D) $\dfrac{\pi}{2}$

06. $\underset{x\to 0}{Lt} \dfrac{\tan\frac{x}{2} - \tan\frac{x}{3} - \tan\frac{x}{6}}{\sin^2 x\left(e^x - 1\right)}$

A) $\dfrac{1}{6}$ B) $\dfrac{1}{36}$ C) 1 D) $\dfrac{-1}{36}$

07. If $f(2+x) = a + \left[1 - (f(x) - a)^4\right]^{1/4}$ for all $x \in R$, then f(x) is periodic with period

A)1 B)2 C) 4 D) 8

08. Let $f(x)=\begin{cases}\dfrac{\tan^{-1}\left(\dfrac{2-x}{1+2x}\right)-\tan^{-1}(2)}{\tan^{-1}(x)-\tan^{-1}(2x)}, & x>0\\ \dfrac{1-\cos px}{x^2}, & x<0\end{cases}$ and if $f(x)$ is continuous at x=0 then the value of p can be

A) 1 B) $\sqrt{2}$ C) 2 D) $\dfrac{1}{-2}$

09. $\lim\limits_{x\to 0}\dfrac{\sin(\sin x)-\sin x}{ax^5+bx^3+c}=\dfrac{1}{12}$, then

A) a=2 ,b=0 ,c=1 B) $a\in R$,b=2 ,c=0

C) a=2 ,$b\in R$,c=0 D) $a\in R$, b= -2,c=0

10. If g(x) is continuous function at x = a, such that g(a) > 0 and $f'(x)=(g(x))(x^2-ax+a^2)\ \forall\ x\in R$, then f(x) is

A) increasing in the neighbourhood of x = a
B) decreasing in the neighbourhood of x = a
C) constant in the neighbourhood of x = a
D) maximum at x = a

11. $\lim\limits_{x\to 0}\dfrac{f(x)}{x^2}=a$ and $\lim\limits_{x\to 0}\dfrac{f(1-\cos x)}{g(x)\sin^2 x}=b$ (where $b\neq 0$), then $\lim\limits_{x\to 0}\dfrac{g(1-\cos 2x)}{x^4}$ is

A) $\dfrac{4a}{b}$ B) $\dfrac{a}{4b}$ C) $\dfrac{a}{b}$ D) none of these

12. Let $f(x)=\dfrac{|x|\left(3e^{1/|x|}+4\right)}{2-e^{1/|x|}}, x\neq 0$ and $f(0)=0$, then

A) f is not continuous B) f is continuous but not differentiable at $x=0$

C) $f^1(0)$ exist D) $f^1(0^+)=2$

13. Let f(x) = (x + A) (x + B) (x + C) . . . (x + 100) and g(x) = f(x). $f^{11}(x)-\left(f^{11}(x)\right)^2$, then g(x) = 0, has

A) no solution B) exactly one solution
C) exactly two solutions D) minimum three solutions

14. If $f(x)=x\left(\sqrt{x}-\sqrt{x+1}\right)$ then

A) $f(x)$ is continuous at $x=0$ B) $f(x)$ is not continuous at $x=0$

C) $f(x)$ is no where differentiable D) None of the above

15. If $x^y y^x=1$ then $\dfrac{dy}{dx}=$

A) $\dfrac{y(x\log y-y)}{x(y\log x-y)}$ B) $\dfrac{y(x\log y-y)}{x(y\log x+y)}$ C) $\dfrac{y(x\log y+y)}{x(y\log x-y)}$ D) $\dfrac{-y(x\log y+y)}{x(y\log x+x)}$

16. If $y=\sin^{-1}\left(\dfrac{\sqrt{x}-1}{\sqrt{x}+1}\right)+\sec^{-1}\left(\dfrac{\sqrt{x}+1}{\sqrt{x}-1}\right), x>0$ then $\dfrac{dy}{dx}=$

A) 1 B) 0 C) $\frac{\pi}{2}$ D) -1

17. If $f(x)$ is twice differentiable and $f''(0)=a$ then $\underset{x\to 0}{Lt}\frac{2f(x)-3f(2x)+f(4x)}{x^2}$ is equal to

A) $3a$ B) $2a$ C) $5a$ D) $4a$

18. Let y be an implicit function of x defines by $x^{2x}-2x^{x}\cot y-1=0$, then $y'(1)$ is equal to

A) l B) $\ln 2$ C) $-\ln 2$ D) -1

19. If $\ell_1=\underset{x\to 2}{lt}\left(x+|x|\right);\ell_2=\underset{x\to 2}{lt}\left(2x-|x|\right)$ and $\ell_3=\underset{x\to\frac{\pi}{2}}{lt}\frac{\cos x}{x-\pi/2}$ then

A) $\ell_1<\ell_2<\ell_3$ B) $\ell_2<\ell_3<\ell_1$ C) $\ell_3<\ell_2<\ell_1$ D) $\ell_1<\ell_3<\ell_2$

20. $f(x)=\lim_{n\to\infty}\frac{(x-1)^{2n}-1}{(x-1)^{2n}+1}$ is discontinuous at

A) $x=0$ only B) $x=2$ only C) $x=0$ and 2 D) None of these

SECTION-II
(Numerical Value Answer Type)

This section contains 5 questions. The answer to each question is a Numerical value. If the numerical value has more than two decimal places, **round-off the value** of Two decimal places. Answer to each question will be evaluated according to the following marking scheme:
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21. If $\lim_{x\to 0}\left(\left[\frac{\sin^{-1}x}{x}\right]+\left[\frac{2^2\sin^{-1}2x}{x}\right]+\left[\frac{3^2\sin^{-1}3x}{x}\right]+\ldots+\left[\frac{n^2\sin^{-1}nx}{x}\right]\right)=100$, then the value of n, is (where [.] denotes the G.I.F.)

22. If $f(x)=(x-1)^4(x-2)^3(x-3)^2$ then the value of $f'''(1)+f''(2)+f'(3)$ is

23. Let $P(x)=a_0+a_1x+a_2x^2+.....+a_nx^n$. If $|P(x)|\le|e^{x-1}-1|,\forall x\ge 0$, then the maximum value of $|a_1+2a_2+3a_3+.....+na_n|$ is

24. The number of points at which the function $f(x)=|x-0.5|+|x-1|+\tan x$ does not have a derivative in the interval $(0,2)$ is

25. $f(x)=[\sin x]+[\cos x], x\in(0,2\pi)$, where $[\bullet]$ denotes the greatest integer function. The total number of points where $f(x)$ is non-differentiable is equal to

PHYSICS

SECTION – I
(SINGLE CORRECT ANSWER TYPE)

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26. E, m, p and G denote energy, mass, angular momentum and gravitational constant. Then $\frac{Ep^2}{m^5G^2}$ has the dimensions of

A) Length B) Mass C) Angle D) Time

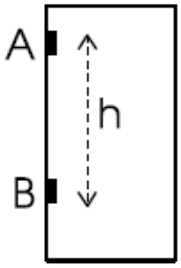
27. In a vernier calipers, n divisions on the mainscale have the same length as (n + A) divisions on the vernier scale. One mainscale division is 'a' units. The least count of the Vernier calipers is

A) $\frac{a}{n+1}$ units B) $\frac{a}{n-1}$ units C) $\frac{n+1}{a}$ units D) $\frac{n-1}{a}$ units

28. A boat capable of a speed v in still water wants to cross a river of width d. The speed of the water current increases linearly from zero at either bank to a maximum of u at the middle of the river. When the boat is rowed at right angles to the bank, its downstream drift is

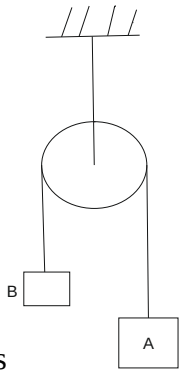
A) $\frac{2\,ud}{v}$ B) $\frac{ud}{v}$ C) $\frac{vd}{u}$ D) $\frac{ud}{2v}$

29. A uniform door of 500 N weight and width 0.5h is fixed with the help of hinges A and B. If the lower hinge supports the entire weight of the door, the magnitude of the total force exerted on the door at the lower hinge is



A) 510.8 N B) 515.4 N C) 520.2 N D) 526.6 N

30. Two bodies of masses m and 2m are connected by a light inextensible string passing over a smooth pulley and released. After 4 sec a mass m is suddenly added to the ascending body. (It has a zero velocity just before the perfectly inelastic collision with the ascending block.



The resulting speed after adding a mass m is

A) $\frac{3}{4}g\ ms^{-1}$ B) 1 g ms^{-1} C) $\frac{5}{4}g$ ms^{-1} D) $\frac{5}{6}g$ ms^{-1}

31. A sphere of mass 3 kg hits a smooth horizontal floor with a speed 20 m/s at an angle of 30^0 to the line of impact. The coefficient of restitution is $\frac{1}{3}$.The impulse given to the ball by the floor is

A) $40\sqrt{3}\ kgms^{-1}$ B) $36\sqrt{3}\ kgms^{-1}$ C) $40\sqrt{2}\ ms^{-1}$ D) $40\sqrt{3}\ ms^{-1}$

32. In the experiment to find focal length of a convex lens by U-V method ,choose the correct statement regarding index correction:

A) It is greater for the object pin B) It is greater for the image pin .
C) It is same for the object and image pin
D) It may be different for the object and image pins

33. The escape velocity for an atmospheric particle 2000 km above the earth's surface is (Radius of the earth $= 6.4 \text{ x } 10^6$ m and g = $10\,ms^{-2}$, g is the acceleration due to gravity at earth's surface)

A) 9.68 kms^{-1} B) 9.78 kms^{-1} C) 9.88 kms^{-1} D) 9.98 kms^{-1}

34. Four identical hollow cylindrical columns of steel, support a big structure of mass 60,000 kg. The inner and outer radii of each column are 40 cm and 50 cm respectively. When the load

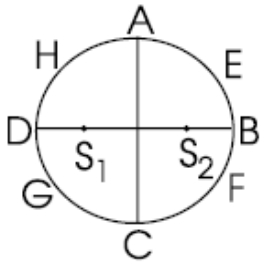
distribution is uniform, the compressional strain on each column is (Young's modulus of steel is 2×10^{11} pa)

A) 2.65×10^{-6} B) 2.45×10^{-6} C) 2.45×10^{-4} D) 2.65×10^{-4}

35. A particle is performing simple harmonic motion along x-axis with amplitude 6 cm and time period 1.8 sec. The minimum time taken by the particle t_0 move from x = 3cm to x = + 6 cm and back again is given by (Mean position of SHM is the origin of coordinate system)

A) 0.5 s B) 0.6 s C) 0.7 s D) 0.8 s

36. Two source of sound S_1 and S_2 each emitting waves of wavelength λ are kept symmetrically on either side of the centre O of a circle ABCD such that $S_1O = S_2O = 2 \quad \lambda$. When the detector is moved along the circumference of the circle, the number of maxima recorded by the detector in one revolution is



A) 24 B) 8 C) 12 D) 6

37. A reversible heat engine converts one fourth of heat input into work. When the temperature of the sink is reduced by 200° C, its efficiency is doubled. The temperature of the source is

A)800 K B)750 K C)700 K D)650 K

38. In the following truth table where A and B are inputs and Y the output

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

The output Y is

A) $A\,\overline{B}$ B) $\overline{A}\,B$ C) $\overline{A} + \overline{B}$ D) AB

39. Two masses of 1 kg each carry equal charges Q and are suspended by light strings of length 1m from a point. The strings are hung at 30° inclination to the vertical. The value of charge Q when the charges are in equilibrium is

(A)22.35 μ C B)25.33 μ C C)27.52 μ C D)29.45 μ C

40. A magnetic material of coercivity 2×10^3 A/m is placed inside a solenoid of length 25 cm having 250 turns, the current strength that should be flown through the solenoid to demagnetise the material completely is

A)1.4 A B)1.6 A C)1.8 A D)2.0 A

41. A long cylindrical conductor of crosssectional area A is made of a material whose resistivity depends only on the distance r from the axis of the conductor as $\rho = \frac{\alpha}{r^2}$ where α is a constant. The resistance per unit length of such a conductor is (Assuming current to flow parallel to the axis of the conductor)

A) $\frac{2\pi A^2}{\alpha}$ B) $\frac{2\pi\alpha}{A^2}$ C) $\frac{\pi\alpha^2}{A}$ D) $\frac{\pi A^2}{\alpha}$

42. A photosensitive material would emit electrons when excited by photons beyond a threshold energy. To cross the threshold one should increase

A) intensity of light B)frequency of light

C)wavelength of light D)voltage applied to the light source

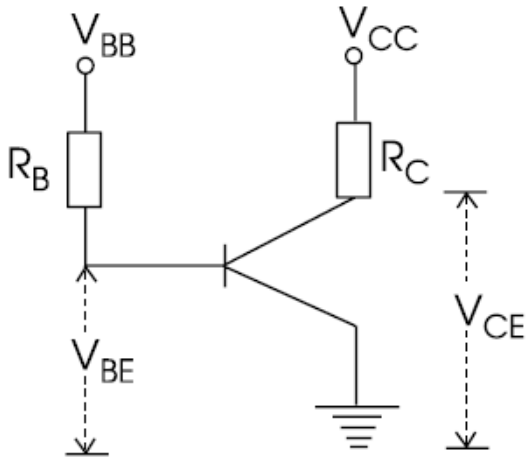
43. On introducing a thin mica sheet of thickness 2×10^{-6} m and refractive index 1.5 infront of one of the slits in standard YDSE setup. Central bright maxima shifts by n fringes. Wavelength of the light used is $5000\,\text{Å}$, then n is:

A) 1 B) 2 C) 5 D) 10

44. A hydrogen atom emits a photon of wavelength $1027^0 A$. Its angular momentum changes by

A) $\frac{h}{\pi}$ B) $\frac{h}{2\pi}$ C) $\frac{3h}{2\pi}$ D) $\frac{2h}{\pi}$

45. In the given circuit $V_{CE} = 30\ V$, $V_{BB} = 20\ V$, $R_B = 1M\Omega$ $R_C = 10\ K\Omega$. Neglecting V_{BE} and taking β = 50, the values of I_C and I_E are respectively



A) 1 mA, 1.02 mA B) 2 mA, 2.02 mA C)10 mA, 1 mA D)2 mA, 0.99 mA

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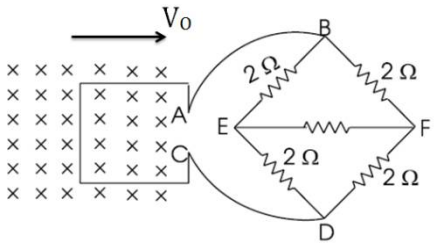
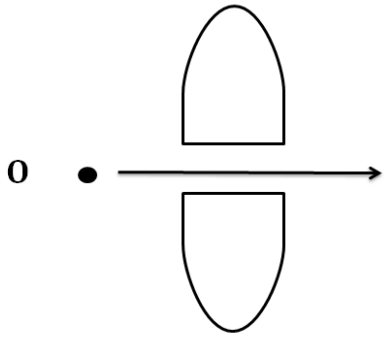
46. A square metal wire loop of side 20 cm and total resistance $1\,\Omega$ is moved with a constant velocity V_0 in a uniform magnetic field of induction $B = 4\ \text{Wb/m}^2$, The magnetic field lines are perpendicular to the plane of the loop and directed inwards. The loop is connected to a network of resistors each of value $2\,\Omega$. The resistance of lead wires AB and CD are negligible. To get a current of 20 mA in the loop, the speed of the loop is (in cm/sec)



47. A point object is placed in front of a convex lens (of focal length 0.2 m) at a distance of 0.3 m. The lens is cut into two halves each part is displaced by 0.0005 m symmetrically as shown. Distance between the two images that are formed is (in m)



48. The walls of a closed cubical box of edge 50 cm are made of a material of thickness 1 mm and coefficient of thermal conductivity 4 x 10^{-4} cal/s/cm/^{0}C.The interior of the box is maintained at 100^0C above the outside temperature by a heater placed inside the box and connected across 400V d.c. The resistance of the heater is nearly:

49. In nuclear reaction, energy released per fission is 200 MeV. When uranium 235 is used as nuclear fuel in a reactor having a power level of 1 MW, the amount of fuel needed in 30 days will be:

50. A radioactive material has an initial mass of 16 g. After 120 days it reduces to 0.5 g, Half-life of the radioactive element is

CHEMISTRY

SECTION – I
(SINGLE CORRECT ANSWER TYPE)

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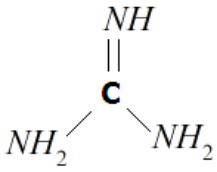
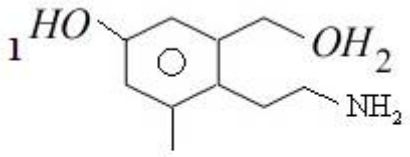
51. Least basic among the following compounds is

A) $Ph-NH_2$ B) NH_3 C) NH_2-NH_2 D) 

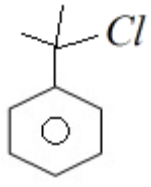
52. Most acidic proton among the following labeled hydrogen H $_{1\text{ to }4}$ is

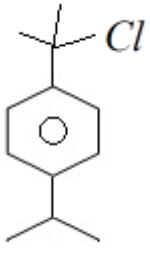


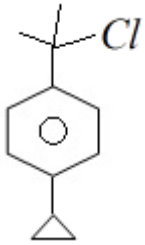
$C \equiv CH_4$

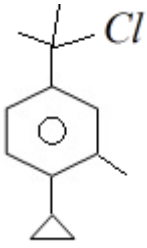
A) H_1 B) H_2 C) H_3 D) H_4

53. Solvolysis occurs most readily in

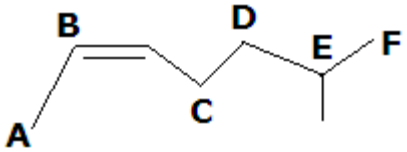
A) 

B) 

C) 

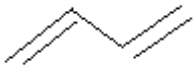
D) 

54. Most reactive position towards radical substitution in



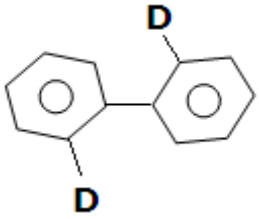
A) A B) F C) B D) D

55. Which of the following molecules have least HOMO – LUMO energy gap

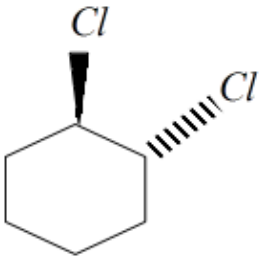
A) $CH_2 = CH_2$ B) 

C)  D) All the three have equal values

56. The optically active molecule among the following is



A) B) $CHD = C = CH_2$

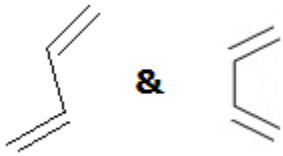


C) D) None of the three 1, 2 & 3 are optically active

57. Which of the following solvent has highest dielectric constant

A) DMSO B) DMF C) water D) acetic acid

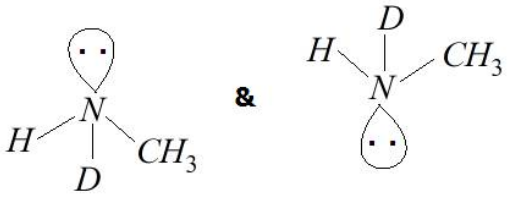
58. Identify the diastereomers among the following pairs



A) Trans-2-butene and cis-2-butene B)

C) Both 1 & 2 D) None of 1 & 2

59. Identify the pairs which can be resolved



A) 

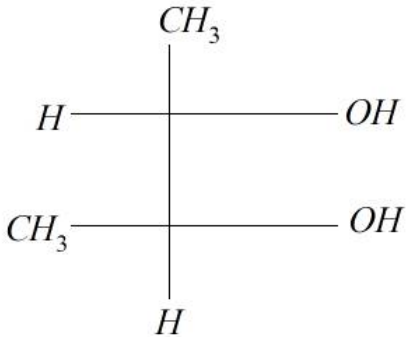
B)

C) D) None of 1 & 2

60. Which of the following is not an isomer of but – 1 – yne?

A) But – 2 – yne B) Buta – 1,3 – diene C) But – 2 – ene D)Methyl cyclopropene

61. Correct configuration of the following carbons (numbering is done from the top C in given fischer projection) is

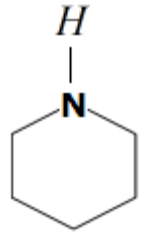


A) 2S, 3S B) 2S, 3R C) 2R, 3S D) 2R, 3R

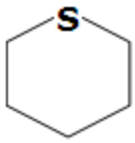
62. Identify the ortho-para directing group among the following

A) $-NH_2$ B) $-C_6H_5$ C) Both D) None

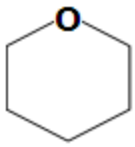
63. Which of the following is strongest base



A)



B)



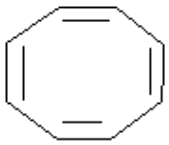
C) D) pyridine

64. Which of the following reactions involve a carbene intermediate?

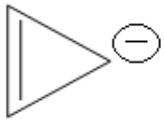
A) reimer-tiemann reaction B) carbylamine test

C) both D) none

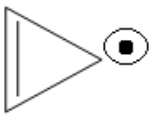
65. Identify the aromatic species among the following



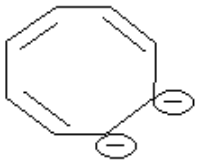
A)



B)



C)



D)

66. Formal charge on the nitrogen atom in nitrobenzene is

A) +1 B) –1 C) 0 D) +2

67. Which of the following reactions have considerable tendency to proceed to right .

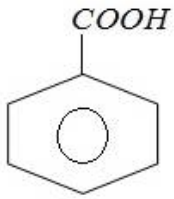
A) $CH_3MgBr + CH_3-C\equiv CH \rightarrow CH_4 + \overset{\ominus}{C}H_2-C\equiv CH$

B) $NaOH + C_2H_5OH \rightarrow C_2H_5ONa + H_2O$

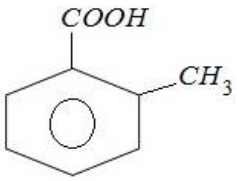
C) Both

D) None of 1 & 2

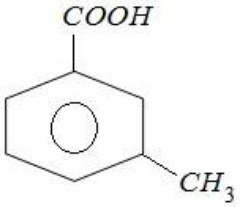
68. Most acidic among the following is



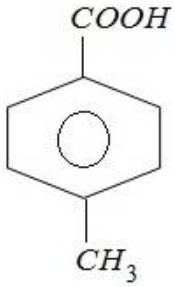
A)



B)

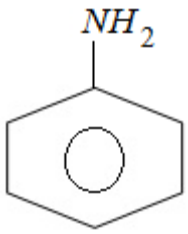


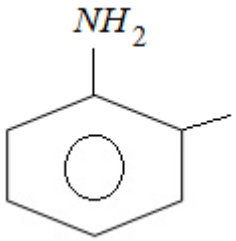
C)

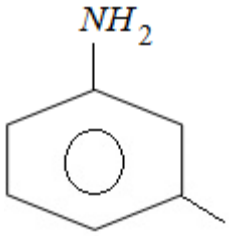


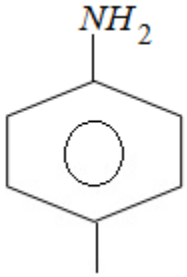
D)

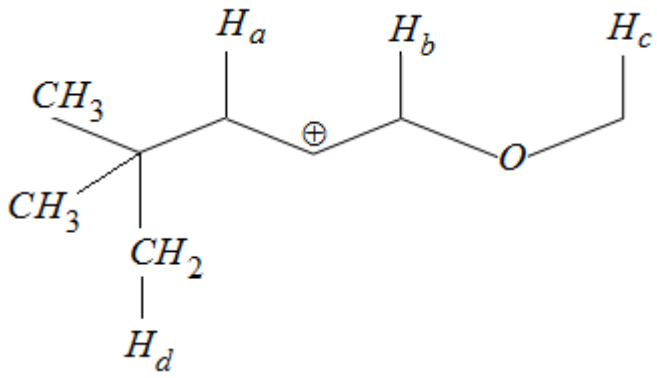
69. Least basic among the following is

A) 

B) 

C) 

D) 

70. 

Which of the following hydride has maximum tendency to migrate?

A) H_a B) H_b C) H_c D) H_d

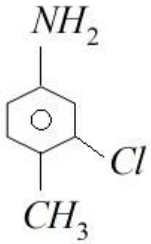
SECTION-II
(Numerical Value Answer Type)

This section contains 5 questions. The answer to each question is a Numerical value. If the numerical value has more than two decimal places, **round-off the value** of Two decimal places. Answer to each question will be evaluated according to the following marking scheme:
Marking scheme: +4 for correct answer, 0 in all other cases.

71. The number of cyclic isomers (structural) with the formula C_3H_6O is

72. The total number of internal mirror planes in CH_4 molecule is / are

73. The position number (In IUPAC name) of '*Cl*' in the following compound is



74. The number of optically active isomers for $CH_3-CH(OH)-CH(OH)-CH_2Cl$

75. The number of sp^2 hybridized atoms in 

is

MELUHA INTERNATIONAL SCHOOL

HYDERABAD

SR MPC | **JEE MAINS MODEL – UT 1** | **Date: 29-05-2020**

Time: 3 Hours | **Max Marks : 300**

KEY SHEET

MATHS

1) **D**	2) **D**	3) **C**	4) **C**	5) **D**	6) **B**	7) **C**	8) **B**	9) **D**	10) **A**
11) **C**	12) **B**	13) **A**	14) **A**	15) **D**	16) **B**	17) **A**	18) **D**	19) **C**	20) **C**
21) **4**	22) **0**	23) **1**	24) **3**	25) **3**					

PHYSICS

26) **C**	27) **A**	28) **D**	29) **B**	30) **B**	31) **A**	32) **D**	33) **C**	34) **A**	35) **B**
36) **B**	37) **A**	38) **C**	39) **B**	40) **D**	41) **B**	42) **B**	43) **B**	44) **A**	45) **A**
46) **7.5**	47) **0.003**	48) **6.36**	49) **32**	50) **24**					

CHEMISTRY

51) **A**	52) **A**	53) **D**	54) **A**	55) **C**	56) **C**	57) **C**	58) **A**	59) **C**	60) **C**
61) **A**	62) **C**	63) **A**	64) **C**	65) **D**	66) **A**	67) **D**	68) **B**	69) **B**	70) **B**
71) **3**	72) **2**	73) **3**	74) **4**	75) **4**					

HINTS & SOLUTIONS

MATHS

01. Clearly f(x)=0 for all $x \le 0$ and f(x)>0 for all x>0
Neither one-one nor onto

02. $f(x) = \sin^{-1}\left(\frac{1+x^3}{2x^{3/2}}\right) + \sqrt{\sin(\sin x)} + \log_{(3\{x\}+1)}(x^2+1)$

Domain : $3\{x\}+1 \neq 1 \text{ or } 0 \Rightarrow x \notin I$

And $-1 \le \frac{1+x^3}{2x^{3/2}} \le 1$

$-2x^{3/2} \le 1+x^3 \le 2x^{3/2}$

$1+x^3+2x^{3/2} \ge 0$

$\left(1+x^{3/2}\right)^2 \ge 0 \Rightarrow x \in R$

$1+x^3-2x^{3/2} \le 0$ or $\left(1-x^{3/2}\right)^2 \le 0$ or $1-x^{3/2}=0$ or x = 1

Hence domain $x \in \phi$

03. $f(x) = [\sin x] + [\cos x] + \left[\tan^{-1} x\right]$,

We get,

$$f(x) = \begin{cases} 1, & x = 0 \\ 0, & 0 < x < \tan 1 \\ 1, & \tan 1 \le x < \frac{\pi}{2} \\ 2, & x = \frac{\pi}{2} \\ 0, & \frac{\pi}{2} < x < \pi \\ -1, & \pi \le x < \frac{3\pi}{2} \\ 0, & \frac{3\pi}{2} \le x^2 < 2\pi \\ 2, & x = 2\pi \end{cases}$$

Thus range of $f(x) = (-1, 0, 1, 2)$

04. f(x) = sin 3{x}, where {.} is a fractional part function

05. $\lim\limits_{x \to 0^-} \left(\dfrac{\cos^{-1} x + \cos^{-1} x^2}{\pi} \right) = 1^+ \qquad \left(\because x^2 < |x| \right)$

$$\Rightarrow \lim_{x \to 0} \sin^{-1} \left(\frac{\cos^{-1} x + \cos^{-1} x^2}{\pi} \right)$$

Does not definedL.H.L.

06. $\dfrac{x}{2} - \dfrac{x}{3} - \dfrac{x}{6} = 0$

$$\lim_{x \to 0} \frac{\tan \frac{x}{2} - \tan \frac{x}{3} \tan \frac{x}{6}}{x^3} = \frac{1}{36}$$

07. $f(2 + x) - a = \{1 - [f(x) - a]^4\}^{1/4}$

$\Rightarrow [f(2 + x) - a]^4 = 1 - [f(x) - a]^4$

$[f(2 + x) - a]^4 + [f(x) - a]^4 = 1$ …(i)

(i) is true for all x

Replace x by (x + 2) in (i)

$[f(x + 4) - a]^4 + [f(x + 2) - a]^4 = 1$ …(ii)

(i) and (ii) gives, $f(x) - a]^4 = [f(x + 4) - a]^4$

$\Rightarrow f(x + 4) - a = f(x) - a$

$\Rightarrow f(x + 4) = f(x)$

08. $L.L = \lim\limits_{x \to 0} \dfrac{1 - \cos px}{x^2} = \dfrac{p^2}{2}$

$$R.L = \lim_{x \to 0} \frac{\tan^{-1}(2) - \tan^{-1} x - \tan^{-1}(2)}{\tan^{-1}(x) - \tan^{-1}(2x)} = \lim_{x \to 0} \frac{-1}{1 - \frac{\tan^{-1}(2x)}{\tan^{-1} x}} = \frac{-1}{1-2} = 1$$

$$\therefore \frac{p^2}{2} = 1 \Rightarrow p = \sqrt{2}, -\sqrt{2}$$

09. $\lim\limits_{x\to 0}\dfrac{\sin(\sin x)-\sin x}{ax^5+bx^3+c}=\dfrac{1}{12}$ (Given)

Suppose c is not zero, then the limit on the L.H.S=0

C=0

Now $\lim\limits_{x\to 0}\dfrac{\sin(\sin x)-\sin x}{ax^5+bx^3}$

$=\lim\limits_{x\to 0}\dfrac{2\sin\left(\dfrac{\sin x-x}{2}\right)\cos\left(\dfrac{\sin x+x}{2}\right)}{ax^5+bx^3}$

$=\lim\limits_{x\to 0}\dfrac{2\sin\left(\dfrac{\sin x-x}{2}\right)}{\left(\dfrac{\sin x-x}{2}\right)}.\dfrac{\sin x-x}{2}.\dfrac{\cos\left(\dfrac{\sin x+x}{2}\right)}{ax^5+bx^3}$

$=\lim\limits_{x\to 0}\left(\dfrac{\sin x-x}{ax^5+bx^3}\right)$

Because the other terms tend to 1 as $x\to 0$

$=\lim\limits_{x\to 0}\dfrac{\cos x-1}{5ax^4+3bx^2}$ by L Hospital Rule

$\lim\limits_{x\to 0}\dfrac{-\sin x}{20ax^3+6bx}=\lim\limits_{x\to 0}\dfrac{-\sin x}{x}.\dfrac{1}{20ax^2+6b}$

$-\dfrac{1}{6b}$ for all $a\in R=\dfrac{1}{12}\Rightarrow b=-2$

$a\in R$,b=-2,c=0

10. $f'(a)>0$

$\Rightarrow$f is increasing in the neighbourhood of $x=a$

11. $\lim\limits_{x\to 0}\dfrac{f(1-\cos x)}{(1-\cos x)^2}\cdot\dfrac{(1-\cos x)^2}{g(x)\sin^2 x}=b$

$\Rightarrow\ \lim\limits_{x\to 0}a\cdot\left(\dfrac{(1-\cos x)}{x^2}\right)^2\cdot\dfrac{x^4}{g(x)\cdot\sin^2 x}=b$

$\Rightarrow\ \dfrac{a}{4}\cdot\dfrac{1}{\lim\limits_{x\to 0}\dfrac{g(x)}{x^2}}=b$

$\Rightarrow\ \lim\limits_{x\to 0}\dfrac{g(x)}{x^2}=\dfrac{a}{4b}$

$\Rightarrow\ \lim\limits_{x\to 0}\dfrac{g(1-\cos x)}{(1-\cos x)^2}\cdot\dfrac{(1-\cos x)^2}{x^4}=\dfrac{a}{4b}\times 4=\dfrac{a}{b}$

12. LH limit = 0

RH limit = 0

$f'(0^+)=-3,\ f'(0^-)=2$

13. $\ell nf(x)=\ell n(x+1)+\ell n(x+2)+\ldots\ell n(x+100)$

$\therefore$ Differentiating

$$\frac{f'(x)}{f(x)}=\frac{1}{x+1}+\frac{1}{x+2}+\ldots+\frac{1}{x+100}$$

Again differentiating

$$\frac{f(x)f''(x)-f'(x)^2}{f(x)^2}=\frac{-1}{(x+1)^2}-\frac{1}{(x+2)^2}\cdots\frac{-1}{(x+100)^2}<0$$

$\therefore\ f(x)f''(x)-f'(x)^2<0$

$\therefore\ g(x)<0$

$\therefore\ g(x)=0$ has no solution.

14. $f'(0)$ does not exist,

15. given $y\log x+x\log y=0$

$$\Rightarrow\frac{y}{x}+\ln x\frac{dy}{dx}+\frac{x}{y}\frac{dy}{dx}+\log y=0$$

16. given $y=\frac{\pi}{2}$

17. use L'Hospitals rule

18. $x^{2x}-2x^x\cot y-1=0$

$$\Rightarrow\cot y=\frac{x^x-x^{-x}}{2}$$

$$\Rightarrow y=\cot^{-1}\left(\frac{x^x-x^{-x}}{2}\right);\left.\frac{dy}{dx}\right|_{x=1}=-1$$

19. $l_1=4,\ l_2=2;\ l_3=-1$

20. $$\lim_{n\to\infty}\frac{1-\frac{1}{\left[(x-1)^2\right]^n}}{1+\frac{1}{\left[(x-1)^2\right]^n}}$$

$$=\begin{cases}1, & x<0\\ 0, & x=0\\ -1, & 0<x<2\\ 0, & x=2\\ 1, & x>2\end{cases}$$

$f(x)$ is discontinuous at $x=0,2$

21. $\Rightarrow\quad \frac{\sin^{-1}x}{x}>1,$

$\therefore\quad \ell=1^3+2^3+3^3+\ldots+n^3$

$$=\left(\frac{n(n+1)}{2}\right)^2=100\Rightarrow n=4.$$

22. If $(x-1)$ is a factor of $f(x)$ repeated 4 times hence $f'''(1)=0$.

Similarly, $(x-2)$ is a factor of $f(x)$ repeated 3 times hence $f''(2)$ and $(x-3)$ is a factor of $f(x)$ repeated twice hence $f'(3)$ will be zero.

Hence, $f'''(1)+f''(2)+f'(3)=0+0+0=0$.

23. $|P(1)| \le |e^{1-1}-1| = 0 \Rightarrow P(1) = 0, |a_1 + 2a_2 + 3a_3 + ... + na_n| = |P'(1)|$

$= \left|\lim_{h\to 0} \frac{P(1+h)-P(1)}{h}\right| \le \left|\lim_{h\to 0} \frac{e^h - 1}{h}\right| = |1| = 1$

24. $|x-a|$ is not differentiable at $x = a$

Also $\tan x$ is not differentiable if $x = (2k+1)\frac{\pi}{2}, k \in I$

$\therefore$ In the interval $(0,2)$, $f(x)$ is not derivable at $x = \frac{1}{2}, x = 1$ and $x = \frac{\pi}{2}$

25. $[\sin x]$ is non differentiable at $x = \frac{\pi}{2}, \pi, 2\pi$

And $[\cos x]$ is non differentiable at $x = 0, \frac{\pi}{2}, \frac{3\pi}{2}, 2\pi$

$\therefore$ $f(x)$ is non differentiable at $x = \frac{\pi}{2}, 2\pi$

PHYSICS

26. $E = ML^2T^{-2}$ $m = M$; $P = ML^2T^{-2}$ $G = M^{-1}L^3T^{-2}$

$\therefore \quad \frac{Ep^2}{m^5G^2} = \frac{ML^2T^{-2}.\ M^2L^4T^{-2}}{M^5.\ M^{-2}\ L^6T^{-4}}$

= no dimension

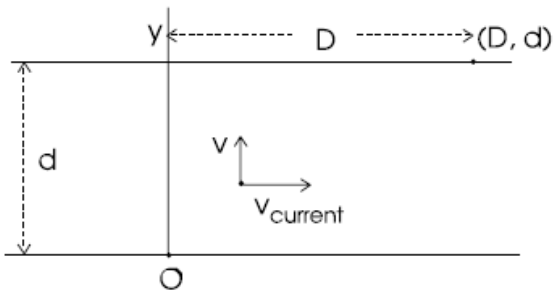
it represents angle which has no dimension

27. Let the length of one vernier scale division be x units. n xa units = (n + A) x units (given)

$\therefore \quad X = \frac{na}{(n+1)}$

Least count of a vernier = 1 m.s.d̃ 1 v.s.d $= a - \frac{na}{(n+1)} = \frac{na + a - na}{n+1} = \frac{a}{(n+1)} units$

28. Let us choose a coordinate system with its origin as the starting point of the boat, the + x-axis points downstream and + y-axis points at right angles to the bank of the river.



x-motion of the boat is due to the water current velocity $V_{current}$ while the y-motion is caused solely by the velocity v of the boat. The above two motions are independent of each other and can be treated separately. Assuming that the boat starts at time t = 0, the y coordinate after a time t is y = vt ... (i)

The speed of water current is a function of y and is given by

$V_{current} = \frac{2uy}{d}$ for $y < \frac{d}{2}$ ……. (ii)

Substituting for y from equation (i)

$$V_{current} = \frac{2u(vt)}{d} \quad (\text{or}) \qquad \frac{dx}{dt} = \frac{2uvt}{d} \qquad \text{.....(iii)}$$

Let the downstream drift of the boat across the river be D.

By symmetry, its value at the middle of the river is $\frac{D}{2}$. The time required to reach the middle of the river is

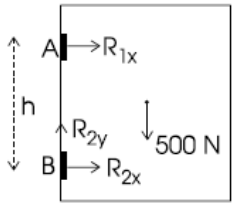
$$t = \frac{\frac{d}{2}}{v} = \frac{d}{2v}$$

Separating the variables in equation (iii) and integrating

$$\int_0^{\frac{D}{2}} dx = \frac{2uv}{d} \int_0^{\frac{d}{2v}} t \; dt$$

$$\frac{D}{2} = \frac{2uv}{d}\left[\left(\frac{\frac{d}{2v}}{2}\right)^2\right] = \frac{ud}{4v} \qquad \therefore \; D = \frac{ud}{2v}$$

29. The FBD given shows all the forces acting on the door. The given condition is $R_{1y} = 0$ (since the lower hinge only supports the entire weight of the door)



For equilibrium,

$$\sum F_X = R_{1X} + R_{2X} = 0$$

i.e., $R_{1X} = -R_{2X}$

$\Sigma F_y = R_{2y} - 500 = 0$

$\therefore R_{2y} = 500$ N

Considering the torque about lower hinge,

$$\Sigma\tau = R_{1x}\, h + 500 \times \frac{h}{4} = 0$$

$\therefore R_{1x}\, h = -125\, h$

$\Rightarrow R_{1x} = -125$ N and

$R_{2x} = +125$ N

Thus R_1 pulls the door to the left.

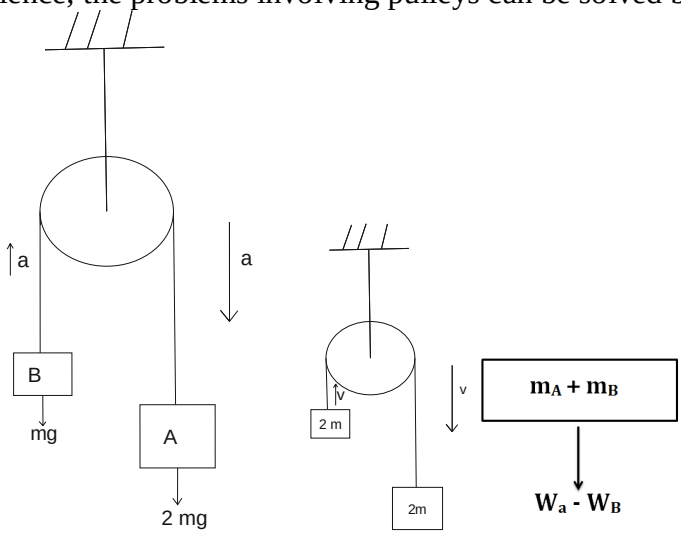
Magnitude of R_2 is

$$\left|\overline{R}_2\right| = \sqrt{R_{2x}^2 + R_{2y}^2}$$

$$= \sqrt{500^2 + 125^2}$$

$= 515.4$ N

30. For convenience, the problems involving pulleys can be solved by including the blocks and pulley in the system.



This simple body has mass $m_A + m_B$ and is acted upon by a single force ($m_A\, g - m_B\, g$)

When $t < 4$ s, the system is accelerated.

$M_A = 2\, m_B = m$, the equation of motion is $mg = 3ma$

The speed at $t = 4$ s is

$$V = 0 + at = \frac{4g}{3} ms^{-1}$$

The addition of mass at $t = 4$ s is equivalent to a collision between the system and a body of mass m which is at rest.

By conservation of momentum, the new speed is $3mv + 0 = 4mv'$

$$\therefore\ v' = \frac{3}{4}v = \frac{3}{4}\ \text{x}\ 1\ g\ ms^{-1}$$

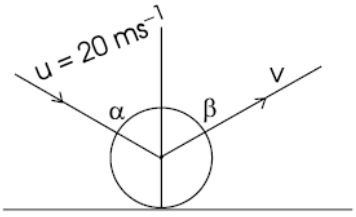
The addition of mass at t = 4 s is equivalent to a collision between the system and a body of mass m which is at rest. By conservation of momentum, the new speed is

$$3mv + 0 = 4mv'$$

$$\therefore v' = \frac{3}{4}v = \frac{3}{4}\ \text{x}\ \frac{4g}{3} = 1g\ ms^{-1}$$

31. The floor is smooth. Hence the velocity component of the sphere parallel to the floor does not change during collision (i.e.,)

$$v\sin\beta = u\ \sin\alpha \qquad \text{.....(i)}$$



In the perpendicular direction, taken positive upwards, the velocity component changes as

$$e = \frac{velocity\ of\ separation}{velocity\ of\ approach}$$

$$= \frac{0 - v\ \cos\beta}{-\ u\ \cos\alpha - 0} = \frac{v\ \cos\beta}{u\ \cos\alpha}$$

$$\therefore v\cos\beta = e\ u\cos\alpha$$

Squaring (A), (2) and adding,

$$v^{2(\sin^2\beta + \cos^2\beta)}$$

$$= (u\ \sin\ \alpha)^2 + (u\cos\ \alpha)^2$$

$$v = u\sqrt{\sin^2\alpha + e^2\cos^2\alpha}\ = = 20\sqrt{\left(\frac{1}{2}\right)^2 + \left(\frac{1}{3}\right)^2\left(\frac{\sqrt{3}}{2}\right)^2}$$

33.

Escape velocity $v_e = \sqrt{2gR}$

At a height h above the Earth's surface, $v_e = \sqrt{2g_h\,(R + h)}$ and

$$g_h = \frac{gR^2}{(R + h)^2}$$

$$\therefore\ v_e = \sqrt{\frac{2gR^2}{(R+h)^2}(R+h)}$$

$$= \sqrt{\frac{2gR^2}{(R+h)}}$$

$$= \sqrt{\frac{2 \times 10 \times (6.4 \times 10^6)^2}{(6.4 + 2)\ 10^6}}$$

$$= \sqrt{\frac{2 \times 10 \times 6.4^2 \times 10^{12}}{8.4 \times 10^6}}$$

$$= \sqrt{\frac{20 \times 40.96}{8.4}} = 9.88\ \text{km/s}$$

34. Total mass supported by the columns = 60,000 kg Total weight supported = 60,000 x 10 N

Compressional force on each column, $F = \frac{60,000 \times 10}{4} = 1,50,000\ N$

Cross-sectional area of each column, $a = \pi (r_2^2 - r_1^2)$

$= \frac{22}{7} (0.5^2 - 0.4^2)$

$= \frac{22}{7} (0.9 \times 0.1) = \frac{1.98}{7}$

$a = 0.283\ m^2$

Young's modulus,

$$Y = \frac{\frac{F}{a}}{\text{Compressional strain}}$$

$\therefore$ compressional strain

$$= \frac{F}{aY}$$

$$= \frac{1,50,000}{0.283 \times 2 \times 10^{11}}$$

$$= \frac{150 \times 10^{-5}}{566}$$

$$= 0.265 \times 10^{-5}$$

$$= 2.65 \times 10^{-6}$$

35. When the particle is at x = 3, the displacement is y = 6 -3 = 3 cm Let t be the time taken by the particle to move from x = 4 cm to 2 cm

Then $y = a \cos \omega t$

$= a \cos \frac{2\pi t}{T}$

$= a \cos \frac{2\pi t}{1.8}$

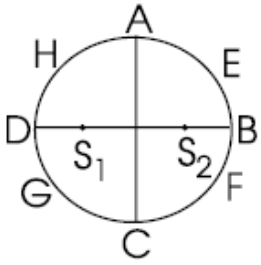
$\therefore \cos \frac{2\pi t}{1.8} = \frac{y}{6} = \frac{3}{6} = \frac{1}{2} = \cos \frac{\pi}{3}$

$\therefore \frac{2t}{1.8} = \frac{1}{3}$

$t = \frac{1.8}{6} = 0.3\ s$

Time taken to move from x = + 3 cm to + 6 cm and back again = 2 t = 2 x0.3 s = 0.6 sec.

36. For the point A, the path difference is zero and for the point B, it is 2λ.n between A and B there will be a point E where the path difference is λ



Hence at the points A, E and B there will be maximum sound due to S_1 and S_2

In a circular path, it will be easier to locate points like F, C, G, D and H so that the total number of maxima amounts to 8.

37.

$$\eta = \frac{T_1 - T_2}{T_1} = \frac{1}{4} \text{ and}$$

$$\frac{T_1 - (T_2 - 200)}{T_1} = \frac{1}{2}$$

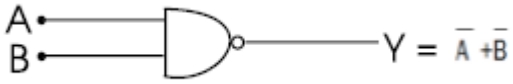
$$\frac{T_1 - T_2}{T_1} + \frac{200}{T_1} = \frac{1}{2}$$

$$\text{(i.e.,)}\ \frac{1}{4} + \frac{200}{T_1} = \frac{1}{2}$$

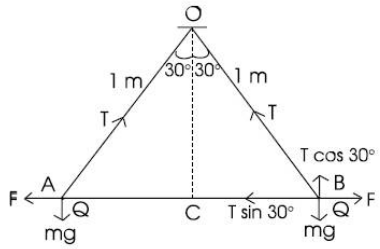
$$\Rightarrow T_1 = 800\ K$$

.

38.



39. As shown in the **Figure**, the light strings hung at 30□to the vertical. Hence the angle between the strings is 60□. OA = OB = AB = 1 m



$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q^2}{\ell^2} = \frac{9 \times 10^9 \times Q^2}{1^2}$$

$$= 9 \times 10^9\ Q^2\ N$$

The tension T in the string may be splitted up into two components vertically and horizontally. For equilibrium,

$$T \sin 30^\circ = F = 9 \times 10^9 Q^2 \text{ and}$$
$$T \cos 30^\circ = mg = 1 \times 10 = 10 \text{ N}$$

$$\frac{T \sin 30^\circ}{T \cos 30^\circ} = \tan 30^\circ = \frac{9 \times 10^9 Q^2}{10}$$

$$\therefore Q^2 = \frac{\tan 30^\circ}{9 \times 10^8} = \frac{1}{\sqrt{3} \times 9 \times 10^8}$$

$$Q = 25.33 \ \mu C$$

40. Coercivity of the given magnetic material, H = 2 x10^3 A/m Length of the solenoid = 25 cm = 0.25 m Total number of turns in the solenoid = 250

$$H = \frac{B}{\mu_0} = \frac{\mu_0 NI}{\mu_0 \ell} = \frac{NI}{\ell}$$

$$\therefore I = \frac{H\ell}{N} = \frac{2 \times 10^3 \times 0.25}{250} = 2 \text{ A}$$

41. Let us consider a cylindrical conductor of length 1 m and radius a. Let the conductor be made up of a large number of thin ring shaped conductors each of length 1 m. Let us consider one such element of the conductor of radius r and thickness dr. The resistance of the conductor

$$dR = \frac{P \times 1}{2\pi r \, dr}$$

$$\therefore \frac{1}{dR} = \frac{2\pi r \, dr}{P}; \ P = \frac{\alpha}{r^2} \text{ given}$$

$$\therefore \frac{1}{dR} = \frac{2\pi r \, dr}{\frac{\alpha}{r^2}} = \frac{2\pi}{\alpha} r^3 \, dr$$

All ring shaped conductors are in parallel. Hence reciprocal of net resistance

$$\frac{1}{R} = \varepsilon \frac{1}{dR} = \int_0^a \frac{2\pi}{\alpha} r^3 \, dr$$

$$= \frac{2\pi}{\alpha} \int_0^a r^3 \, dr$$

$$\frac{1}{R} = \frac{2\pi}{\alpha} \left[\frac{r^4}{4} \right]_0^a = \frac{2\pi}{\alpha} \cdot \frac{a^4}{4}$$

$$\therefore R = \frac{2\alpha}{\pi a^4}$$

But $A = \pi a^2 \Rightarrow a^2 = \frac{A}{\pi}$

$$\therefore R = \frac{2\alpha}{\pi} \cdot \frac{1}{\left(\frac{A}{\pi}\right)^2} = \frac{2\pi\alpha}{A^2}$$

42. For a given metal, maximum kinetic energy of photoelectrons varies linearly with the frequency of incident radiation.

43.

$d \sin\theta = n\lambda$ 1 inch = 2.54 cm

$$d = \frac{2.54}{15{,}000} = 169.3 \times 10^{-6} \text{ cm and}$$

$\lambda = 5890$ Å

$= 5890 \times 10^{-10}$ m

$$\therefore n = \frac{d \sin\theta}{\lambda} = \frac{169.3 \times 10^{-8} \times 1}{5890 \times 10^{-10}}$$

$$= 2.87$$

Since n is an integer, only first and second order spectra i.e., 2 orders of spectrum can only be seen.

44.

The energy of the photon emitted

$$E = \frac{12430}{1027} = 12.1 \text{ eV}$$

This corresponds to transition from $n = 3$ with $E_3 = -1.5$ eV to $n_f = 1$ with $E_1 = -13.6$ eV

Hence $\Delta L = 3\left(\frac{h}{2\pi}\right) - 1\left(\frac{h}{2\pi}\right) = \frac{h}{\pi}$

45.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{20 - 0}{1 \times 10^6} = 20\ \mu A$$

$$I_C = \beta I_B = 50 \times 20 = 1000\ \mu A = 1\ mA$$

$$I_E = I_B + I_C$$

$$= 1\ mA + 20\ \mu A$$

$$= 1 + 0.02 = 1.02\ mA$$

46. The network of resistors in a balanced Wheatstone's network. Hence the resistance EF is ineffective. The equivalent resistance R'of the network is

$$\frac{1}{R'} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2} \text{ or } R' = 2\ \Omega$$

The resistance of the square loop is 1 Ω

∴effective resistance of the circuit R = 2 + 1 = 3 Ω

The emf induced in the loop $e = B v_0 \ell$

$$\text{Current in the loop } i = \frac{e}{R} = \frac{B v_0 \ell}{R}$$

∴ speed of the loop v_0

$$= \frac{iR}{B\ell}$$

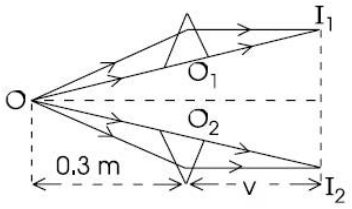
$i = 2\ mA = 2 \times 10^{-3}\ A$; $\ell = 0.2\ m$

$B = 4\ Wb/m^2$

Speed of the loop

$$= v_0 = \frac{2 \times 3}{4 \times 0.2} = 7.5\ cm/s$$

47. The rays through the optic centres O_1 and O_2 will pass undeviated and form the images I_1 and I_2 due to upper and lower halves of the lenses respectively.



$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{0.2} - \frac{1}{0.3} = \frac{1}{0.6}$$

$v = 0.6$ m

Triangles OO_1O_2 and OI_1I_2 are similar

$$\frac{O_1O_2}{|u|} = \frac{I_1I_2}{|v|+|u|}$$

$$\text{(i.e.,)}\ \frac{0.001}{0.3} = \frac{I_1I_2}{0.3 + 0.6}$$

Distance between images

$$= I_1I_2 = \frac{0.001 \times 0.9}{0.3} = 0.003 \text{ m}$$

48. The rate of heat transmitted through the walls of the closed cubical box,

$$H = \frac{q}{t}$$

$$= \frac{kA\,(\theta_2 - \theta_1)}{d}$$

$$= \frac{4 \times 10^{-4} \times 6 \times 50 \times 50 \times 100}{0.1}$$

$$= 6000 \text{ cal/s}$$

To maintain constant temperature difference between outside and inside the box, this heat escaped must be produced by the electric current in the heater. Let R be the resistance of the coil.
The heat produced per second is

$$H = \frac{Q}{t} = \frac{V^2}{R} J = \frac{V^2}{JR} \text{ cal} = \frac{V^2}{4.2\,R} \text{ cal}$$

$$\therefore \frac{V^2}{4.2\,R} = 6000 \Rightarrow R = \frac{400 \times 400}{4.2 \times 6000}$$

$$= 6.35\ \Omega$$

49. Energy produced by the reactor in 1 day = 10^6 x 86400 J. Energy released per fission = 200 x 10^6 x 1.6 x 10^{-19} J. No. of fissions required (i.e.,) no. of 235U atoms fissioned in a month

$$= \frac{10^6 \times 86{,}400 \times 30}{200 \times 10^6 \times 1.6 \times 10^{-19}}$$

Mass of ^{235}U having the requisite no. of atoms

$$= \left(\frac{235}{6.02 \times 10^{26}}\right)$$

$$\left(\frac{10^6 \times 86400 \times 30}{200 \times 10^6 \times 1.6 \times 10^{-19}}\right)$$

$$\left[\because \text{no. of atoms in 1 kg of } ^{235}U = \frac{6.02 \times 10^{26}}{235}\right]$$

$$= \frac{235 \times 864 \times 3 \times 10^9}{6.02 \times 3.2 \times 10^{15}}$$

$$= 32 \text{ g}$$

50. Using the relation $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{32}\right)$

$\Rightarrow n = 5$

$n = \frac{t}{T}$ and $t = 120$ days

$\therefore T = \frac{120}{5} = 24$ days

CHEMISTRY

53. solvolysis is related to stability of carbocation
54. allylic radical
55. increasing conjugation decreases the gap
62. phenyl group is ortho-para directing

58 and 59 ortho effect