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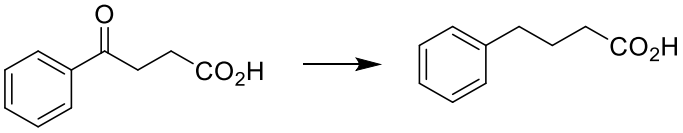
JAM – 2022 – CY

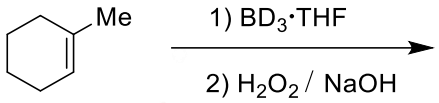
Attempt ALL the questions. Q.1 – Q.10 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

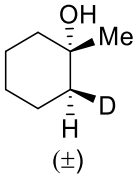
1. The reagent required for the following transformation is

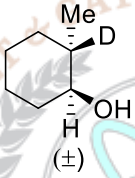


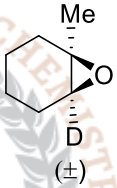
(a) $NaBH_4$ (b) $LiAlH_4$ (c) $H_3B \cdot THF$ (d) $Zn(Hg)/HCl$

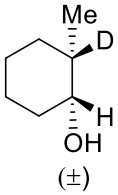
2. The major product formed in the following reaction is



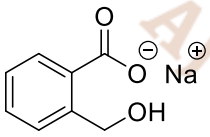
(a)  (±)

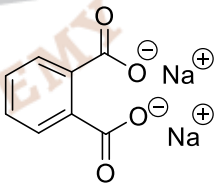
(b)  (±)

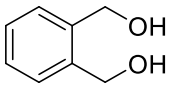
(c)  (±)

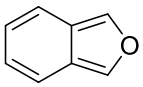
(d)  (±)

3. The major product formed in the following reaction is

(a) 

(b) 

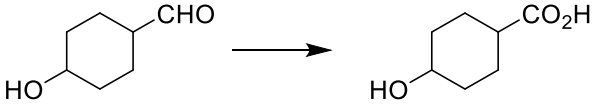
(c) 

(d) 

4. The major product formed in the following reaction $K + O_2 \longrightarrow$ is

(a) K_2O (b) K_2O_2 (c) KO_2 (d) K_2O_3

5. Which one of the following options is best suited for effecting this transformation?



(a) MnO_2 (b) $DMSO, (COCl)_2, Et_3N$ (c) $Al(Oi\text{-}Pr)_3$ (d) Ag_2O/NH_4OH

6. The structure of $[XeF_8]^{2-}$ is

(a) Cubic (b) hexagonal bipyramid (c) square antiprism (d) Octagonal

7. **Among the following, the compound that forms the strongest hydrogen bond is**

(a) HF (b) HCl (c) HBr (d) HI

8. **Among the following, the biomolecule with a direct metal-carbon bond is**

(a) coenzyme B_{12} (b) Nitrogenase (c) Chlorophyll (d) hemoglobin

9. **For the reaction $H_2PO_2^-(aq) + OH^-(aq) \longrightarrow HPO_3^{2-}(aq) + H_2(g)$ the rate expression is $k[H_2PO_2^-][OH^-]^2$. If the concentration of $H_2PO_2^-$ is doubled, the rate is**

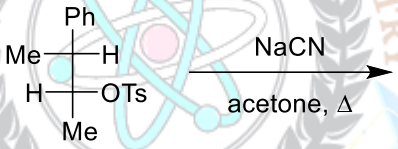
(a) tripled (b) halved (c) doubled (d) unchanged

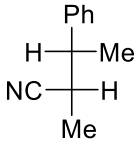
10. **The nature of interaction involved at the gas-solid interface in physisorption is**

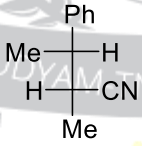
(a) ionic (b) van der Waals (c) hydrogen bonding (d) Covalent

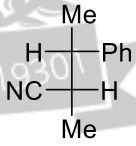
Attempt ALL the questions. Q.11 – Q.30 Multiple Choice Question (MCQ), carry TWO mark each (for each wrong answer: – 2/3).

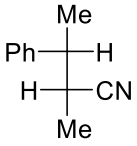
11. **The major product formed in the following reaction is**



(a) 

(b) 

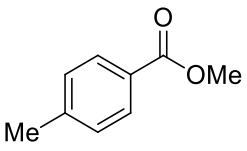
(c) 

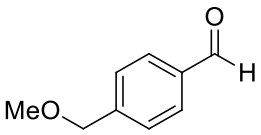
(d) 

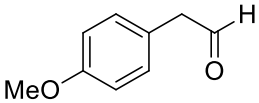
12. **An organic compound having molecular formula $C_9H_{10}O_2$ exhibits the following spectral characteristics. The most probable structure of the compound is**

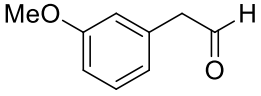
^{1}H NMR : 9.72 (t, 1H), 7.1 (d, 2H), 6.7 (d, 2H), 3.8 (s, 3H), 3.6 (d, 2H)

IR : ~1720 cm^{-1}

(a) 

(b) 

(c) 

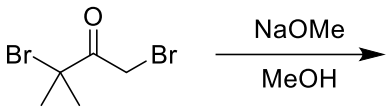
(d) 

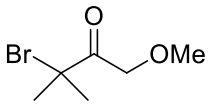
13. **The major product formed in the reaction of (2S,3R)-2-chloro-3-phenylbutane with NaOEt in EtOH is**

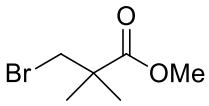
(a) (E)-2-phenyl-but-2-ene (b) (Z)-2-phenyl-but-2-ene

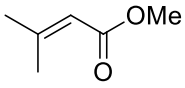
(c) 3-phenyl-but-1-ene (d) (2R,3R)-2-ethoxy-3-phenylbutane

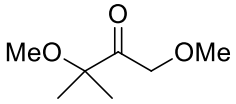
14. The major product formed in the following reaction is



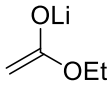
(a) 

(b) 

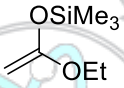
(c) 

(d) 

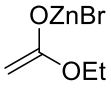
15. The reactivity of the enol derivatives towards benzaldehyde follows the order



I



II



III

(a) I > II > III (b) III > II > I (c) II > I > III (d) I > III > II

16. All possible lattice types are observed in the

(a) cubic crystal system (b) monoclinic crystal system

(c) tetragonal crystal system (d) orthorhombic crystal system

17. The structure types of $B_{10}H_{10}^{2-}$ and $B_{10}H_{14}$ respectively, are

(a) closo and nido (b) nido and arachno (c) nido and closo (d) closo and arachno

18. The ground state and the maximum number of spin-allowed electronic transitions possible in a Co^{2+} tetrahedral complex, respectively, are

(a) $^4A_2$ and 3 (b) $^4T_1$ and 2 (c) $^4A_2$ and 2 (d) $^4T_1$ and 3

19. The correct statement about the geometries of BH_2^+ and NH_2^+ based on valence shell electron pair repulsion (VSEPR) theory is

(a) both BH_2^+ and NH_2^+ are trigonal planar

(b) BH_2^+ is linear and NH_2^+ is trigonal planar

(c) BH_2^+ is trigonal planar and NH_2^+ is linear

(d) both BH_2^+ and NH_2^+ are linear

20. The order of increasing CO stretching frequencies in the following is

$[Co(CO)_4]^-, [Cu(CO)_4]^+, [Fe(CO)_4]^{2-}$ and $[Ni(CO)_4]$

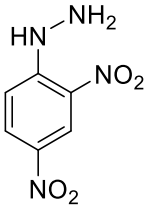
(a) $[Cu(CO)_4]^+ < [Ni(CO)_4] < [Co(CO)_4]^- < [Fe(CO)_4]^{2-}$

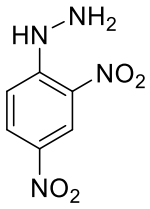
(b) $[Fe(CO)_4]^{2-} < [Co(CO)_4]^- < [Ni(CO)_4] < [Cu(CO)_4]^+$

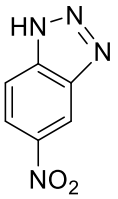
(c) $[Co(CO)_4]^-$ < $[Fe(CO)_4]^{2-}$ < $[Cu(CO)_4]^+$ < $[Ni(CO)_4]$

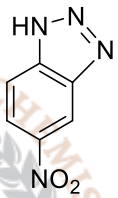
(d) $[Ni(CO)_4]$ < $[Cu(CO)_4]^+$ < $[Co(CO)_4]^-$ < $[Fe(CO)_4]^{2-}$

21. The reaction of 2, 4-dinitrofluorobenzene with hydrazine produces a yellow orange solid X used for the identification of an organic functional group G. X and G, respectively, are

(a)  and carboxylic acid

(b)  and aldehyde

(c)  and aldehyde

(d)  and carboxylic acid

22. The stability of adducts $H_3B \cdot PF_3$, $H_3B \cdot NMe_3$, $H_3B \cdot CO$, $H_3B \cdot OMe_2$ follows the order

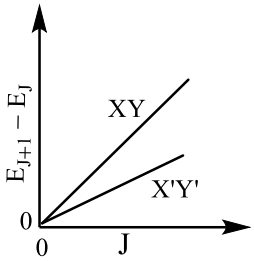
(a) $H_3B \cdot OMe_2$ < $H_3B \cdot CO$ < $H_3B \cdot PF_3$ < $H_3B \cdot NMe_3$

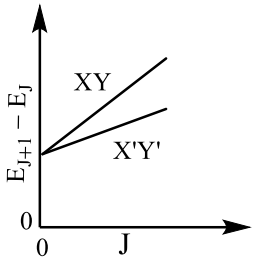
(b) $H_3B \cdot PF_3$ < $H_3B \cdot CO$ < $H_3B \cdot NMe_3$ < $H_3B \cdot OMe_2$

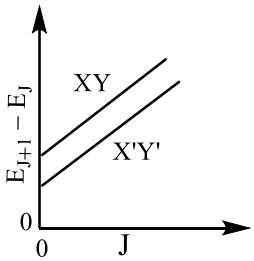
(c) $H_3B \cdot CO$ < $H_3B \cdot PF_3$ < $H_3B \cdot NMe_3$ < $H_3B \cdot OMe_2$

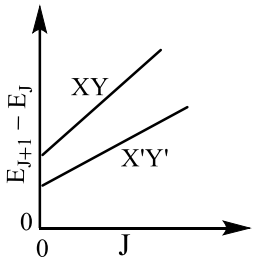
(d) $H_3B \cdot PF_3$ < $H_3B \cdot CO$ < $H_3B \cdot OMe_2$ < $H_3B \cdot NMe_3$

23. The spacing between successive rotational energy levels of a diatomic molecule XY and its heavier isotopic analogue X'Y' varies with the rotational quantum number, J, as

(a) 

(b) 

(c) 

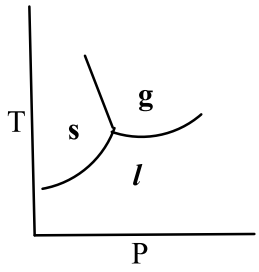
(d) 

24. **The ratio of $2p \rightarrow 1s$ transition energy in He^+ to that in the H atom is closest to**

(a) 1 (b) 2 (c) 4 (d) 8

25. **The phase diagram of water is best represented by**

(a)



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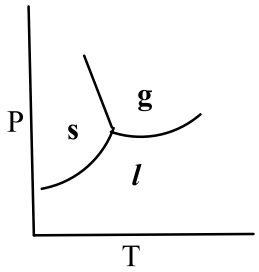

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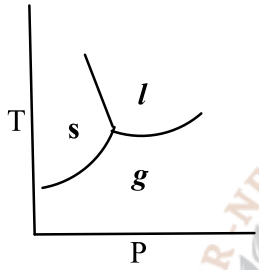
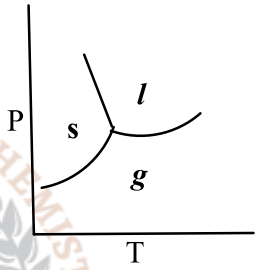


(d)



26. **Capillary W contains water and capillary M contains mercury. The contact angles between the capillary wall and the edge of the meniscus at the air-liquid interface in W and M are θ_W and θ_M, respectively. The contact angles satisfy the conditions**

(a) $\theta_W > 90^\circ$ and $\theta_M > 90^\circ$ (b) $\theta_W > 90^\circ$ and $\theta_M < 90^\circ$

(c) $\theta_W < 90^\circ$ and $\theta_M > 90^\circ$ (d) $\theta_W < 90^\circ$ and $\theta_M < 90^\circ$

27. **The Maxwell-Boltzmann distribution $f(v_x)$ of one-dimensional velocities v_x at temperature T is_____ [Given: k_B is the Boltzmann constant and A is a normalization constant such that $\int_{-\infty}^{\infty} f(v_x)dv_x = 1$]**

(a) $A \exp(-mv_x^2/2k_BT)$ (b) $A \exp(-mv_x^2/k_BT)$

(c) $Av_x^2 \exp(-mv_x^2/2k_BT)$ (d) $Av_x^2 \exp(-mv_x^2/k_BT)$

28. **The potential for a particle in a one-dimensional box is given as: $V(x) = 0$ for $0 \leq x \leq L$, and $V(x) = \infty$ elsewhere. The locations of the internal nodes of the eigenfunctions $\Psi_n(x), n \geq 2$, are [Given: m is an integer such that $0 < m < n$]**

(a) $x = \frac{m+\frac{1}{2}}{n} L$ (b) $x = \frac{m}{n} L$ (c) $x = \frac{m}{n+1} L$ (d) $x = \frac{m+1}{n+1} L$

29. **The number of CO stretching bands in the infrared spectrum of $Fe(CO)_5$ is**

(a) 1 (b) 2 (c) 3 (d) 4

30. **The standard Gibbs free energy change for the reaction**

$H_2O(g) \longrightarrow H_2(g) + \frac{1}{2}O_2(g)$ at 2500 K is $+118$ kJ mol^{-1}. The equilibrium constant

for the reaction is **[Given: R = 8.314 JK^{-1} mol^{-1}]**

(a) 0.994 (b) 1.006 (c) 3.42×10^{-3} (d) 292.12

Attempt ALL the questions. Q.31 – Q.40 Multiple Select Question (MSQ), carry TWO mark each (no negative marks).

31. Among the following, the reaction(s) that favour(s) the formation of the products at 25 ℃ is/are

(a) 

(b) 

(c) 

(d) 

32. Among the following, the correct statement(s) is/are:

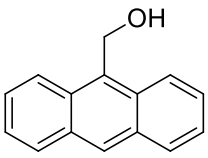
(a) The first pK_a of malonic acid is lower than the pK_a of acetic acid while its second pK_a is higher than the pK_a of acetic acid.

(b) The first pK_a of malonic acid is higher than the pK_a of acetic acid while its second pK_a is lower than the pK_a of acetic acid.

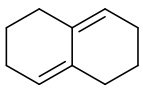
(c) Both the first and the second pK_as of malonic acid are lower than the pK_a of acetic acid.

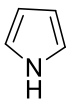
(d) Both the first and the second pK_as of malonic acid are higher than the pK_a of acetic acid.

33. The compound(s) that participate(s) in Diels-Alder reaction with maleic anhydride is/are

(a) 

(b) 

(c) 

(d) 

34. Among the following, the suitable route(s) for the conversion of benzaldehyde to acetophenone is/are

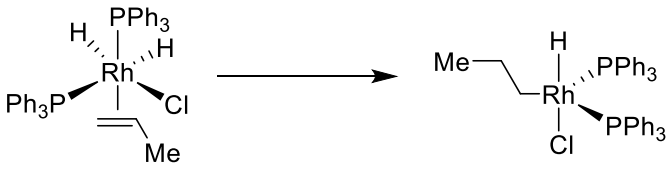
(a) CH_3COCl, anhydrous $AlCl_3$

(b) (i) $HS(CH_2)_3SH, F_3B \cdot OEt_2$; (ii) n-BuLi; (iii) MeI; (iv) $HgCl_2$, $CdCO_3$, H_2O

(c) $NaNH_2$, MeI

(d) (i) MeMgBr; (ii) aq. acid; (iii) pyridinium chlorochromate (PCC)

35. The reaction involve(s)



(a) migratory insertion (b) change in electron count of Rh from 18 to 16

(c) oxidative addition (d) change in electron count of Rh from 16 to 18

36. The reason(s) for the lower stability of Si_2H_6 compared to C_2H_6 is/are

(a) silicon is more electronegative than hydrogen

(b) Si−Si bond is weaker than C−C bond

(c) Si−H bond is weaker than C−H bond

(d) the presence of low-lying d-orbitals in silicon

37. For an N-atom nonlinear polyatomic gas, the constant volume molar heat capacity $C_{v,m}$ has the expected value of $3(N-1)R$, based on the principle of equipartition of energy. The correct statement(s) about the measured value of $C_{v,m}$ is/are

(a) The measured $C_{v,m}$ is independent of temperature.

(b) The measured $C_{v,m}$ is dependent on temperature.

(c) The measured $C_{v,m}$ is typically lower than the expected value.

(d) The measured $C_{v,m}$ is typically higher than the expected value.

38. Zinc containing enzyme(s) is/are

(a) carboxypeptidase (b) hydrogenase (c) carbonic anhydrase (d) Urease

39. The conversion of ICl to ICl^+ involve(s)

(a) the removal of an electron from a π^* molecular orbital of ICl

(b) an increase in the bond order from 1 in ICl to 1.5 in ICl^+

(c) the formation of a paramagnetic species

(d) the removal of an electron from a molecular orbital localized predominantly on Cl

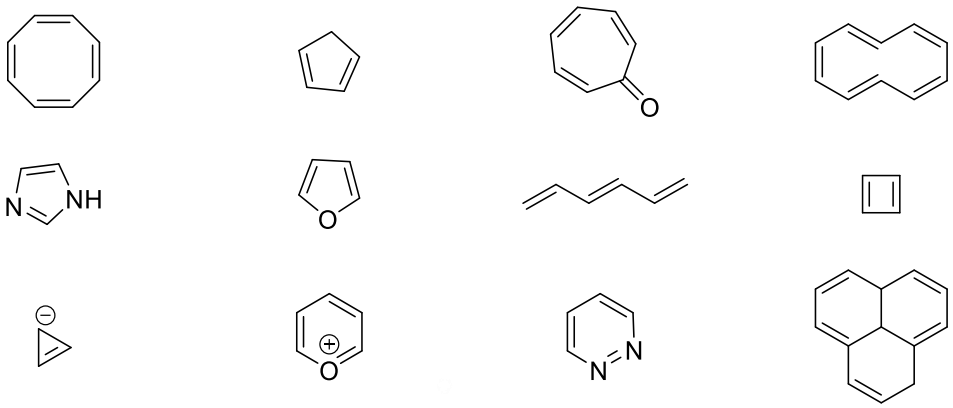
40. The common point defect(s) in a solid is/are

(a) Wadsley defect (b) Schottky defect (c) Suzuki defect (d) Frenkel defect

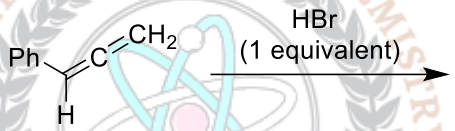
Attempt ALL the questions. Q.41 – Q.50 Numerical Answer Type

(NAT), carry ONE mark each (no negative marks).

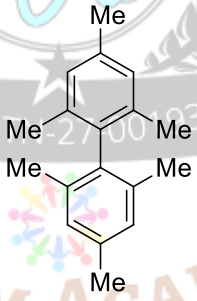
41. **Among the following the number of aromatic compounds is _____.**



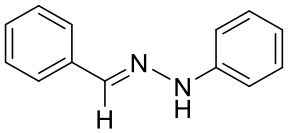
42. **The number of stereoisomers possible for the major product formed in the reaction is_____.**



43. **The number of signals observed in the ^{1}H-NMR spectrum of the compound is_____**



44. **The reaction of 122 g of benzaldehyde with 108 g of phenylhydrazine gave 157 g of the product. The yield of the product is _____%. (round off to the nearest integer)**



45. **The B−B bond order in B_2 is_____.**

46. **The number of unpaired electrons in $[Co(H_2O)_6]^{2+}$ is_____.**

47. **The number of significant figures in 5.0820×10^2 is_____.**

48. **The d spacing for the first-order X-ray ($\lambda = 1.54$ Å) diffraction event of metallic iron (*fcc*) at $2\theta = 20.2^\circ$ is_____Å. (round off to three decimal places)**

49. **The volume fraction for an element in an *fcc* lattice is_____. (round off to two**

decimal places)

50. A steady current of 1.25 A is passed through an electrochemical cell for 1.5 h using a 12 V battery. The total charge, Q, drawn during this process is_____Coulombs. (round off to the nearest integer)

Attempt ALL the questions. Q.51 – Q.60 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

51. The specific rotation of optically pure (R)-1-phenylethylamine is +40 (neat, 20 °C). A synthetic sample of the same compound is shown to contain 4 : 1 mixture of (S)- and (R)-enantiomers. The specific rotation of the neat sample at 20 °C is_____.

(round off to the nearest integer)

52. The number of β particles emitted in the nuclear reaction $^{238}_{92}U \longrightarrow {}^{206}_{82}Pb$ is_____.

53. Iron is extracted from its ore via the reaction $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$.
The volume of CO (at STP) required to produce 1 kg of iron is_____ liters.
(round off to the nearest integer)

[Given: Atomic wt. of Fe = 56 ; assume STP to be 0 ℃ and 1 atm]

54. Total degeneracy (number of microstates) for a Ti^{3+} ion in spherical symmetry is_____.

55. A galvanic electrochemical cell made of Zn^{2+}/Zn and Cu^{2+}/Cu half-cells produces 1.10 V at 25 ℃. The ratio of $[Zn^{2+}]$ to $[Cu^{2+}]$ is maintained at 1.0. The ΔG° for the reaction when 1.0 mol of Zn gets dissolved is _____kJ. (round off to the nearest integer) [Given: Faraday's constant = 96485 C mol^{-1}]

56. At constant volume, 1.0 kJ of heat is transferred to 2 moles of an ideal gas at 1 atm and 298 K. The final temperature of the ideal gas is _____K. (round off to one decimal place) [Given: R = 8.314 J K^{-1} mol^{-1}]

57. Two close lying bands in a UV spectrum occur at 274 nm and 269 nm. The magnitude of the energy gap between the two bands is_____ cm^{-1}.

(round off to the nearest integer)

58. The pH of an aqueous buffer prepared using CH_3COOH and $CH_3COO^-Na^+$ is 4.80. The quantity $\frac{[CH_3COO^-] - [CH_3COOH]}{[CH_3COOH]}$ is____. (round off to three decimal places)

[Given: pK_a of CH_3COOH in water is 4.75]

59. At constant temperature, 6.40 g of a substance dissolved in 78 g of benzene decreases the vapor pressure of benzene from 0.125 atm to 0.119 atm. The molar

mass of the substance is _____g mol^{-1}. (round off to one decimal place)

[Given: Mol. wt. of benzene = 78 g mol^{-1}]

60. For a van der Waals gas, the critical temperature is 150 K and the critical pressure is 5×10^6 Pa. The volume occupied by each gas molecule is _____$Å^3$. (round off to two decimal places)

[Given : $R = 8.314$ J $mol^{-1}K^{-1}$; $N_A = 6.023 \times 10^{23}$]

Answer Key

Q.No	Ans		Q.No	Ans		Q.No	Ans
1.	d		21.	b		41.	5 to 5
2.	b		22.	d		42.	2 to 2
3.	a		23.	d		43.	3 to 3
4.	c		24.	c		44.	80 to 80
5.	d		25.	d		45.	1 to 1
6.	c		26.	c		46.	3 to 3
7.	a		27.	a		47.	5 to 5
8.	a		28.	b		48.	4.390 to 4.400
9.	c		29.	b		49.	0.73 to 0.75
10.	b		30.	c		50.	6750 to 6750
11.	c		31.	a, b		51.	–24 to –24
12.	c		32.	a		52.	6 to 6
13.	b		33.	a, b		53.	599 to 602
14.	c		34.	b, d		54.	10 to 10
15.	d		35.	a, b		55.	–212 to – 212
16.	d		36.	b, c, d		56.	338.0 to 338.2
17.	a		37.	b, c		57.	670 to 685
18.	a		38.	a, c		58.	0.121 to 0.123
19.	b		39.	a, b, c		59.	126.0 to 128.0
20.	b		40.	b, d		60.	***

Q. 1 – 10	1 Mark (MCQ)					Q. 41 – 50	1 Mark (NAT)
Q. 11 – 30	2 Mark (MCQ)		Q. 31 – 40	2 Mark (MSQ)		Q. 51 – 60	2 Mark (NAT)