# JAM – 2016 – Chemistry

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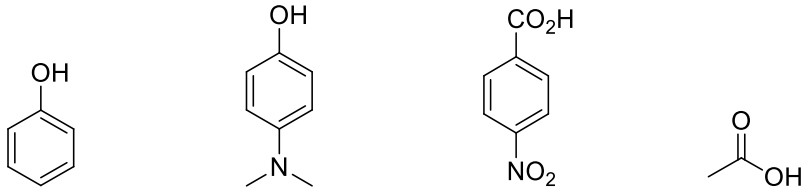
# JAM – 2016 – CY

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

**1. The correct order of pKa for the following compounds is**

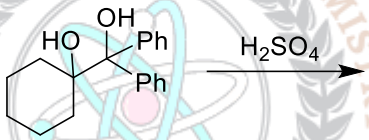


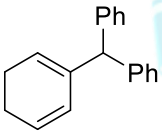

I II III IV

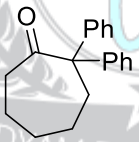
(a) II > I > III > IV (b) II > I > IV > III

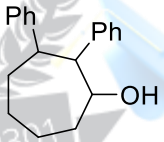
(c) III > IV > I > II (d) IV > II > I > III

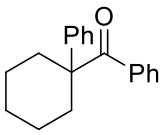
**2. The major product formed in the following reaction is**



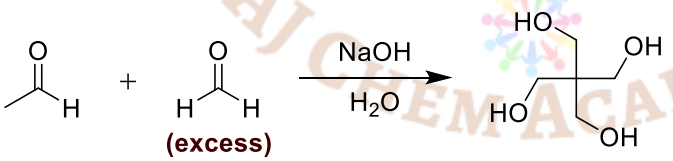

(a) 


(b) 


(c) 


(d) 


**3. The mechanism of the following transformation involves**




(a) Aldol reaction and Cannizzaro reaction

(b) Aldol reaction and Claisen-Schmidt reaction

(c) Knoevenagel condensation and Cannizzaro reaction

(d) Stobbe condensation and Cannizzaro reaction

**4. The most basic amino acid among the following is**

(a) tyrosine (b) methionine (c) arginine (d) glutamine

**5. The crystal field stabilization energy (CFSE) in $[Mn(H_2O)_6]^{2+}$ is**

(a) $0\ \Delta_o$ (b) $2.0\ \Delta_o - 2P$ (c) $0.4\ \Delta_o - 2P$ (d) $2.0\ \Delta_o$

**6. Indicator used in redox titration is**

(a) Eriochrome black T (b) Methyl orange (c) Phenolphthalein (d) Methylene blue

**7.** **Among the following, the compound that has the lowest degree of ionic character is**

(a) NaCl (b) $MgCl_2$ (c) $AlCl_3$ (d) $CaCl_2$

**8.** **The correct order of entropy for various states of $CO_2$ is**

(a) $CO_2(s) > CO_2(\ell) > CO_2(g)$ (b) $CO_2(\ell) > CO_2(s) > CO_2(g)$

(c) $CO_2(g) > CO_2(\ell) > CO_2(s)$ (d) $CO_2(g) > CO_2(s) > CO_2(\ell)$

**9.** **The coordination numbers of $Cs^+$ and $Cl^-$ ions in the CsCl structure, respectively, are**

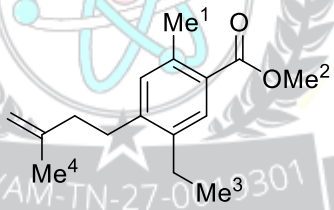
(a) 4, 4 (b) 4, 8 (c) 6, 6 (d) 8, 8

**10.** **Determinant of a square matrix is always**

(a) a square matrix (b) a column matrix (c) a row matrix (d) a number

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

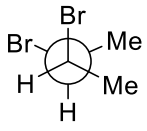
**11.** **The correct order of $^1$H-NMR chemical shift (δ) values for the labeled methyl groups in the following compound is**

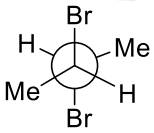


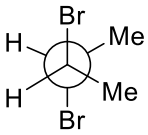

(a) $Me^1 < Me^2 < Me^3 < Me^4$ (b) $Me^3 < Me^4 < Me^1 < Me^2$

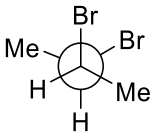
(c) $Me^3 < Me^1 < Me^4 < Me^2$ (d) $Me^2 < Me^4 < Me^3 < Me^1$

**12.** **Among the following, the most stable conformation of meso-2,3-dibromobutane is**

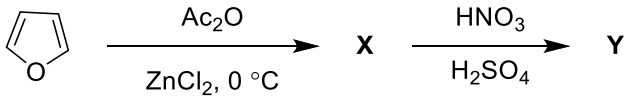
(a) 

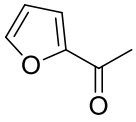

(b) 

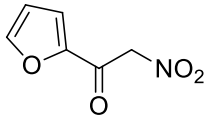

(c) 

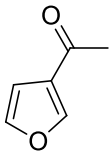
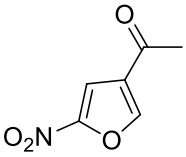

(d) 

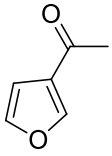
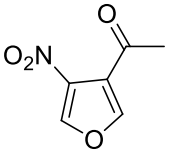

**13.** **The major products X and Y in the following reaction sequence are**

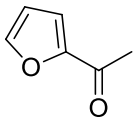
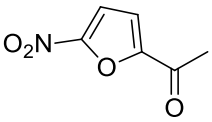



(a) X = 

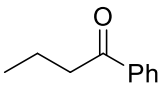
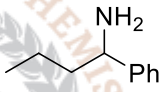
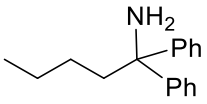
; Y = 

(b) X =  ; Y = 

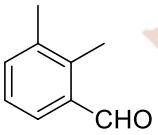
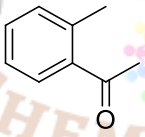
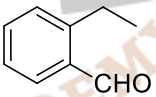
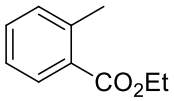
(c) X =  ; Y = 

(d) X =  ; Y = 

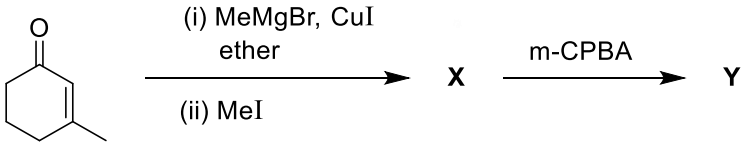
**14. The major product formed in the reaction of butanenitrile with phenylmagnesium-bromide followed by acidification is**

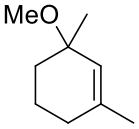
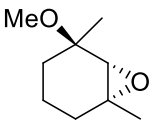
(a)  (b)  (c)  (d) 

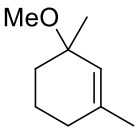
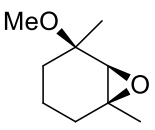
**15. An organic compound on reaction with 2, 4-dinitrophenylhydrazine (2, 4-DNP) gives a yellow precipitate. It also gives silver mirror on reaction with ammoniacal $AgNO_3$. It gives an alcohol and sodium salt of a carboxylic acid on reaction with concentrated NaOH. It yields benzene-1, 2-dicarboxylic acid on heating with alkaline $KMnO_4$. The structure of the compound among the following is**

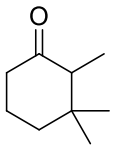
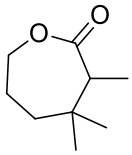
(a)  (b)  (c)  (d) 

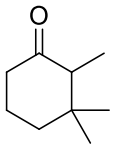
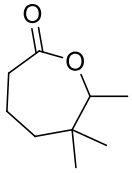
**16. The major products X and Y in the following reaction sequence are**




(a) X =  ; Y = 

(b) X =  ; Y = 

(c) X =  ; Y = 

(d) X =  ; Y = 

**17. The TRUE statement about $[Cu(H_2O)_6]^{2+}$ is**

(a) All Cu-O bond lengths are equal

(b) One Cu-O bond length is shorter than the remaining five

(c) Three Cu-O bond lengths are shorter than the remaining three

(d) Four Cu-O bond lengths are shorter than the remaining two

**18. The complexes $[Pt(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$, respectively, are**

(a) paramagnetic, paramagnetic (b) diamagnetic, diamagnetic

(c) paramagnetic, diamagnetic (d) diamagnetic, paramagnetic

**19. The value of 'x' in $[Cu(CO)_x]^+$ such that it obeys the 18-electron rule is**

(a) 6 (b) 5 (c) 4 (d) 3

**20. The correct order of $\nu_{NO}$ $(cm^{-1})$ in the following compounds is**

| $NO^+$ | NO | $[NiCp(NO)]$ | $[Cr(Cp)_2(NO)_4]$ |
|---|---|---|---|
| I | II | III | IV |

(a) I > II > III > IV (b) IV > III > I > II

(c) I > IV > II > III (d) III > II > IV > I

**21. The red color of ruby is due to**

(a) d-d transition of $Cr^{3+}$ ion in $Cr_2O_3$ lattice

(b) d-d transition of $Cr^{3+}$ ion in $Al_2O_3$ lattice.

(c) ligand to metal charge transfer transition

(d) metal to metal charge transfer transition

**22. The final products in the reaction of $BF_3$ with water are**

(a) $B(OH)_3$ and $OF_2$ (b) $H_3BO_3$ and $HBF_4$ (c) $B_2O_3$ and $HBF_4$ (d) $B_2H_6$ and HF

**23. The correct order of bond angles in $BF_3$, $NH_3$, $NF_3$ and $PH_3$ is**

(a) $BF_3$ > $NH_3$ > $NF_3$ > $PH_3$

(b) $PH_3$ > $BF_3$ > $NF_3$ > $NH_3$

(c) $BF_3 > PH_3 > NH_3 > NF_3$

(d) $NH_3 > NF_3 > BF_3 > PH_3$

**24.** **The maximum of a function $Ae^{-ax^2}$ $(A > 0; a > 0)$ is at $x =$**

(a) 0 (b) $+\infty$ (c) $-\infty$ (d) $1/\sqrt{a}$

**25.** **At 298K, 0.1 mol of ammonium acetate and 0.14 mol of acetic acid are dissolved in 1 L of water. The pH of the resulting solution is [Given: a $pK_a$ of acetic acid is 4.75]**

(a) 4.9 (b) 4.6 (c) 4.3 (d) 2.3

**26.** **An electrochemical cell consists of two half-cell reactions**

$$AgCl(s) + e^- \longrightarrow Ag(s) + Cl^-(aq)$$

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$$

**The mass of copper (in grams) dissolved on passing 0.5A current for 1 hour is [Given: atomic mass of Cu is 63.6; F = 96500 C $mol^{-1}$]**

(a) 0.88 (b) 1.18 (c) 0.29 (d) 0.59

**27.** **For a zero-order reaction, the half-life depends on the initial concentration $[C_0]$ of the reactant as**

(a) $[C_0]$ (b) $[C_0]^0$ (c) $[C_0]^{-1}$ (d) $[C_0]^{1/2}$

**28.** **The effective nuclear charge of helium atom is 1.7. The first ionization energy of helium atom in eV is**

(a) 13.6 (b) 23.1 (c) 39.3 (d) 27.2

**29.** **The relationship between the van der Waals coefficient (b) of $N_2$ and $O_2$ is**

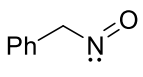
(a) $b_{N_2} = b_{O_2} = 0$ (b) $b_{N_2} = b_{O_2} \neq 0$ (c) $b_{N_2} > b_{O_2}$ (d) $b_{N_2} < b_{O_2}$

**30.** **From the kinetic theory of gases, the ratio of most probable speed ($C_{mp}$) to root mean square speed ($C_{rms}$) is**

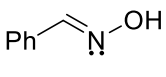
(a) $\sqrt{3}$ (b) $\sqrt{2}/\sqrt{3}$ (c) $\sqrt{3}/\sqrt{2}$ (d) $3/\sqrt{2}$

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

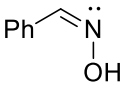
**31.** **The correct statement(s) about the following species is(are)**




I




II

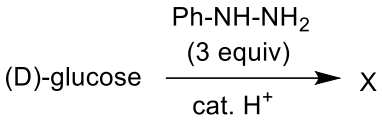



III

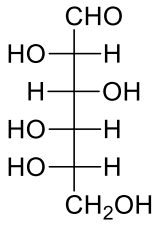
(a) I and II are resonance structures (b) II and III are resonance structures

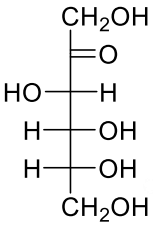
(c) II and III are diastereomers (d) III is a tautomer of I

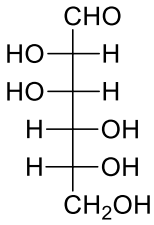
**32. Consider the following reaction:**

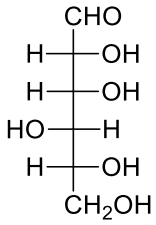



**Among the following, the compound(s) whose osazone derivatives(s) will have the same melting point as that of X is(are)**

(a) 


(b) 


(c) 


(d) 


**33. The appropriate reagents required for carrying out the following transformation are**


(a) (i) = $PCC, CH_2Cl_2$
(ii) = $Ph_3P{=}CHCO_2Et$
(iii) = aq. NaOH, Δ, then acidify

(b) (i) = $CrO_3, H_2SO_4$, aq. acetone
(ii) = $Ac_2O, NaOAc$

(c) (i) = $MnO_2$
(ii) = $CH_2(CO_2H)_2$
(iii) = piperidine, pyridine

(d) (i) = $PCC, CH_2Cl_2$
(ii) = $BrCH_2CO_2C(CH_3)_3, Zn$
(iii) = $H_3O^+, \Delta$

**34. The appropriate reagents required for carrying out the following transformation are**


(a) (i) = succinic anhydride, $AlCl_3$
(ii) = Zn/Hg, HCl
(iii) = polyphosphoric acid

(b) (i) = maleic anhydride, $AlCl_3$
(ii) = $H_2N{-}NH_2, KOH$
(iii) = $H_2SO_4$

(c) (i) = succinic anhydride, $FeCl_3$
(ii) = $LiAlH_4$
(iii) = $H_2SO_4$

(d) (i) = phthalic anhydride, $BF_3$
(ii) = $HS(CH_2)_2SH, H^+$
(iii) = Raney Ni
(iv) = polyphosphoric acid

**35. The protein(s) that belong to the class of blue copper proteins is(are)**

(a) ceruloplasmin (b) superoxide dismutase (c) hemocyanin (d) azurin

**36. The ion(s) that exhibit only charge transfer bands in the absorption spectra (UV-visible region) is/are**

(a) $[Cr(C_2O_4)_3]^{3-}$ (b) $[CrO_4]^{2-}$ (c) $[ReO_4]^{-}$ (d) $[NiO_2]^{2-}$

**37. The type(s) of interaction(s) that hold layers of graphite together is (are)**

(a) **π-π** stacking (b) van der Waals (c) hydrogen bonding (d) Coulombic

**38. TRUE statement(s) about Langmuir isotherm is(are)**

(a) valid for monolayer coverage

(b) all adsorption sites are equivalent

(c) there is dynamic equilibrium between free gas and adsorbed gas

(d) adsorption probability is independent of occupancy at the neighboring sites

**39. The $3p_z$ orbital has**

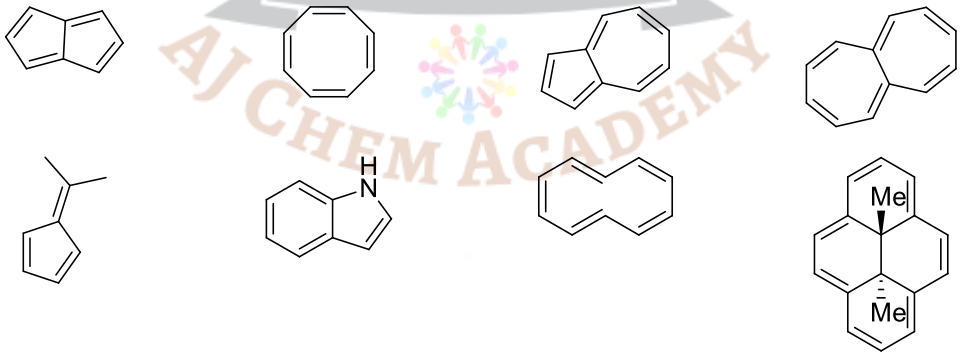
(a) one radial node (b) two radial nodes (c) one angular node (d) two angular nodes

**40. The diatomic molecule(s) that has (have) two π-type bonds is(are)**

(a) $B_2$ (b) $C_2$ (c) $N_2$ (d) $O_2$

**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 molecules that are aromatic is _____**




**42. The number of all possible isomers for the molecular formula $C_6H_{14}$ is _____.**

**43. Hydrolysis of 15.45 g of benzonitrile produced 10.98 g of benzoic acid. The percentage yield of acid formed is _____.**

**44. Acetic acid content in commercial vinegar was analyzed by titrating against 1.5 M NaOH solution. A 20 mL vinegar sample required 18 mL of titrant to give endpoint. The concentration of acetic acid in the vinegar (in mol $L^{-1}$) is _____.**

**45. The bond order of $Be_2$ molecule is _____.**

**46. The number of P-H bonds in hypophosphorus acid is _____.**

47. The isotope $^{214}_{84}Po$ undergoes one alpha and one beta particle emission sequentially to form an isotope "X". The number of neutrons in "X" is _____.

48. In a diffraction experiment with X-rays of wavelength $1.54$ Å, a diffraction line corresponding to $2\theta = 20.8°$ is observed. The inter-planar separation in Å is _____.

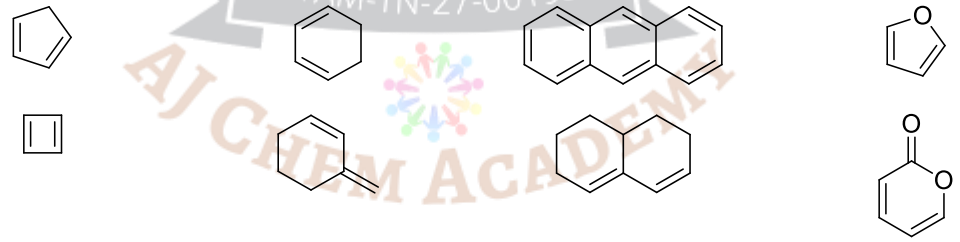
49. The potential energy of interaction between two ions in an ionic compound is given by $U = 1389.4 \left[\frac{Z_1 Z_2}{r/Å}\right]$ kJ mol$^{-1}$. Assuming that $CaCl_2$ is linear molecule of length $5.6$ Å, the potential energy for $CaCl_2$ molecule in kJ mol$^{-1}$ is _____.

50. The enthalpy of formation for $CH_4(g)$, C(g) and H(g) are $-75,717$ and $218$ kJ mol$^{-1}$, respectively. The enthalpy of the C–H bond in kJ mol$^{-1}$ is_____

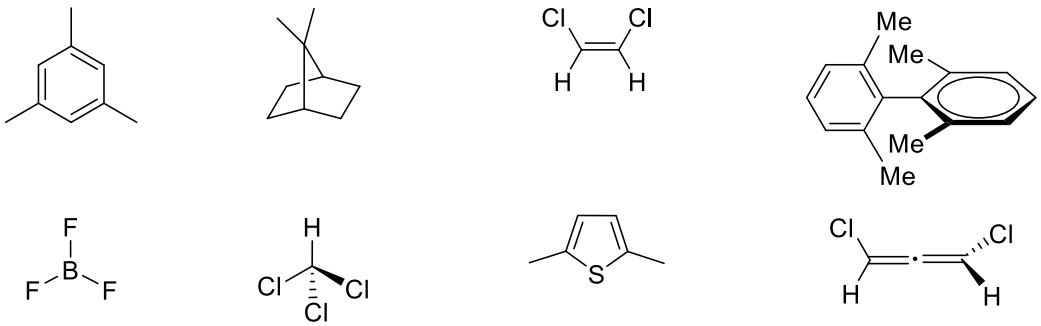
**Attempt ALL the questions. Q.51 – Q.60 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).**

51. Specific rotation of the (R)-enantiomer of a chiral compound is 48. The specific rotation of a sample of this compound which contains 25 % of (S)-enantiomer is ___.

52. Among the following, the number of compounds, which can participate as 'diene' component in a Diels-Alder reaction is _____.




53. Among the following, the number of molecules that possess $C_2$ axis of symmetry is_____.




54. Effective nuclear charge for 3d electron in vanadium (atomic number = 23) according to Slater's rule is _____.

55. The total number of isomers possible for the molecule $[Co(NH_3)_4Cl(NO_2)]^+$ is___.

56. The bond angle in $PBr_3$ is 101°. The percent 's' character of the central atom is ___.

57. $Cu(s) + 4H^+(aq) + 2NO_3^-(aq) \longrightarrow 2NO_2(g) + Cu^{2+}(aq) + 2H_2O(\ell)$

In the above reaction at 1 atm and 298K, if 6.36 g of copper is used. Assuming ideal gas behaviour, the volume of $NO_2$ produced in liters is _____.

[Given: atomic mass of Cu is 63.6; $R = 0.0821$ L atm $K^{-1}$ $mol^{-1}$]

58. The $\Delta H^0$ for the reaction $CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g)$ at 400 K in kJ $mol^{-1}$ is ____.

Given at 298K:

| | $\Delta H_f^0$ kJ $mol^{-1}$ | $C_p^0$ J $mol^{-1}K^{-1}$ |
|---|---|---|
| $O_2$ | 0 | 29.4 |
| CO | −110 | 29.1 |
| $CO_2$ | −394 | 37.1 |

59. The rate constants for a reaction at 300 and 350K are 8 and 160 L $mol^{-1}s^{-1}$, respectively. The activation energy of the reaction in kJ $mol^{-1}$ is _____.

[Given: $R = 8.314$ J $K^{-1}mol^{-1}$].

60. A 10 L flask containing 10.8 g of $N_2O_5$ is heated to 373K, which leads to its decomposition according to the equation $2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$. If the final pressure in the flask is 0.5 atm, then the partial pressure of $O_2(g)$ in atm is _____.

[Given: $R = 0.0821$ L atm $K^{-1}mol^{-1}$]

## Answer Key

| q.no | Ans | | q.no | Ans | | q.no | Ans |
|---|---|---|---|---|---|---|---|
| 1. | b | | 21. | b | | 41. | 3.0 to 3.0 |
| 2. | b | | 22. | b | | 42. | 5.0 to 5.0 |
| 3. | a | | 23. | a | | 43. | 60.0 to 60.0 |
| 4. | c | | 24. | a | | 44. | 1.3 to 1.4 |
| 5. | a | | 25. | b | | 45. | 0.0 to 0.0 |
| 6. | d | | 26. | d | | 46. | 2.0 to 2.0 |
| 7. | c | | 27. | a | | 47. | 127.0 to 127.0 |
| 8. | c | | 28. | c | | 48. | 4.2 to 4.3 |
| 9. | d | | 29. | c | | 49. | −1738 to −1734 |
| 10. | d | | 30. | b | | 50. | −417.0 to −415.0 |
| 11. | b | | 31. | c & d | | 51. | 24.0 to 24.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12. | b | | 32. | a & b & c | | 52. | 6.0 to 6.0 |
| 13. | d | | 33. | a & c & d | | 53. | 7.0 to 7.0 |
| 14. | a | | 34. | a | | 54. | 4.2 to 4.4 |
| 15. | c | | 35. | a & d | | 55. | 4.0 to 4.0 |
| 16. | d | | 36. | b & c | | 56. | *** |
| 17. | d | | 37. | a & b | | 57. | 4.8 to 5.0 |
| 18. | d | | 38. | a & b & c & d | | 58. | −284.70 to −284.65 |
| 19. | c | | 39. | a & c | | 59. | 52.0 to 53.0 |
| 20. | ** | | 40. | B & c | | 60. | 0.06 to 0.07 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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) |