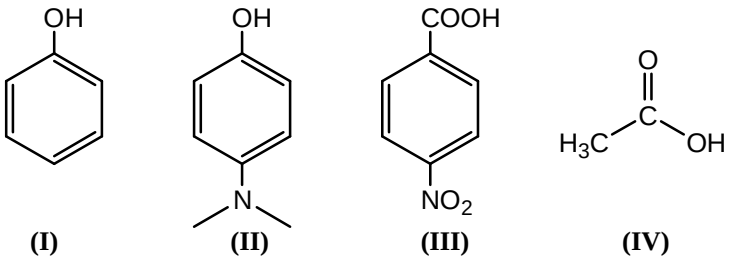
Section-A

Multiple Choice Questions (MCQ)

Q.1 – Q.10 carry ONE mark each.

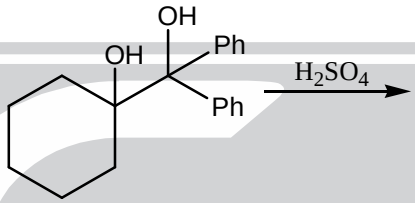
1. The correct order of pKa for the following compounds is

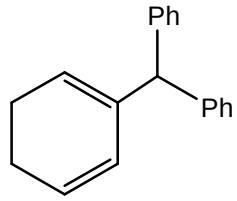


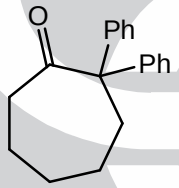
(I) **(II)** **(III)** **(IV)**

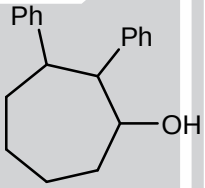
(A) II > I > III > IV (B) II > I > IV > III (C) III > IV > I > II (D) IV > II > I > III

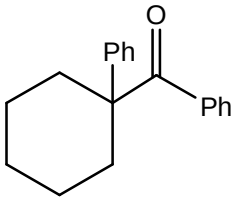
2. The major product formed in the following reaction is



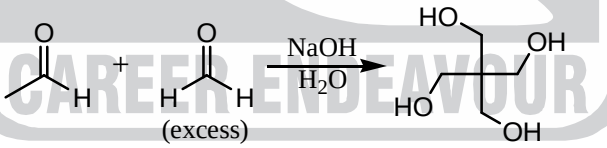
(A) 

(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) $0\ \Delta_0$ (B) $2.0\ \Delta_0 - 2P$ (C) $0.4\ \Delta_0 - 2P$ (D) $2.0\ \Delta_0$

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) $CaCl_2$

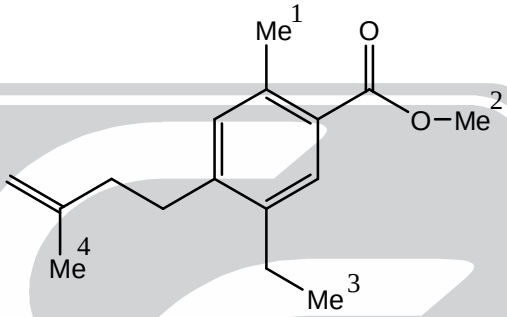
8. The correct order of entropy for various states of CO_2 is
(A) $CO_2(s) > CO_2(l) > CO_2(g)$ (B) $CO_2(l) > CO_2(s) > CO_2(g)$
(C) $CO_2(g) > CO_2(l) > CO_2(s)$ (D) $CO_2(g) > CO_2(s) > CO_2(l)$

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

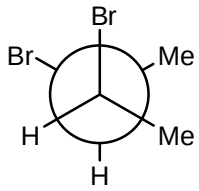
Q.11 – Q.30 carry TWO marks each.

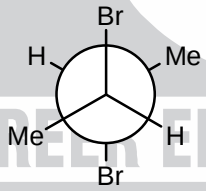
11. The correct order of ^1H NMR chemical shift (δ) values for the labeled methyl groups in the following compound is

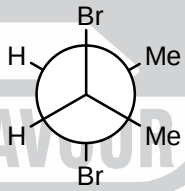


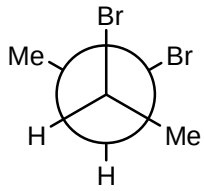
(A) $Me^1 < Me^2 < Me^3 < Me^4$ (B) $Me^3 < Me^4 < Me^1 < Me^2$
(C) $Me^3 < Me^1 < Me^4 < Me^2$ (D) $Me^2 < Me^4 < Me^3 < Me^1$

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

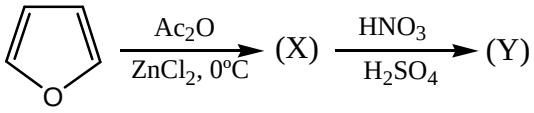
(A) 

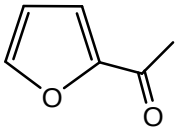
(B) 

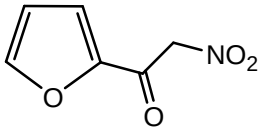
(C) 

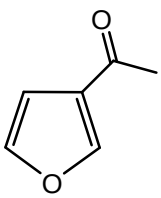
(D) 

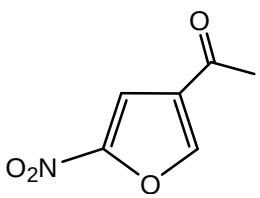
13. The major products X and Y in the following reaction sequence are

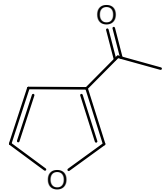
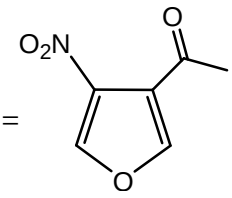


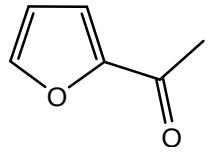
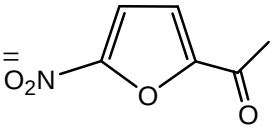
(A) X = 

Y = 

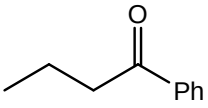
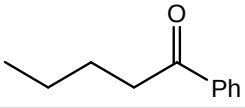
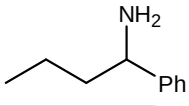
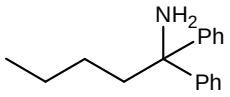
(B) X = 

Y = 

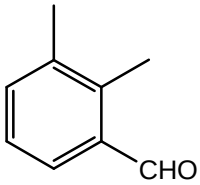
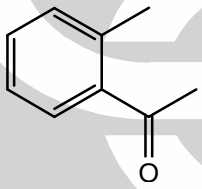
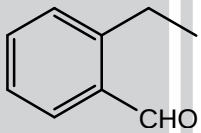
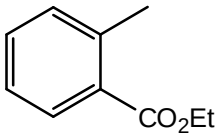
(C) X =  Y = 

(D) X =  Y = 

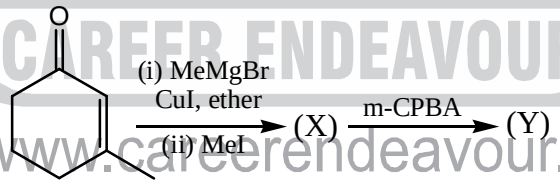
14. The major product formed in the reaction of butanenitrile with phenylmagnesium bromide followed by acidification is

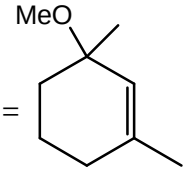
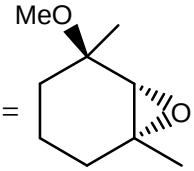
(A)  (B)  (C)  (D) 

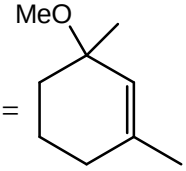
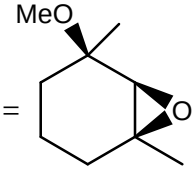
15. An organic compound on reaction with 2, 4-dinitrophenylhydrazine (2, 4-DNP) gives a yellow precipitate. It also gives silver mirror on reaction with ammonical $AgNO_3$. It gives an alcohol and sodium salt of a carboxylic acid on reaction with concentrated NaOH. It yields benzene-1, 2-dicarboxylic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

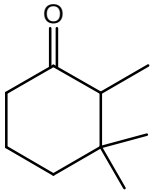
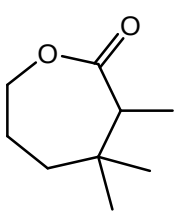
(A)  (B)  (C)  (D) 

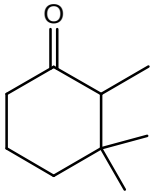
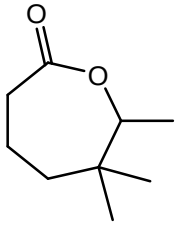
16. The major products X and Y in the following reaction sequence are



(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 $\left[Pt(CN)_4\right]^{2-}$ and $\left[NiCl_4\right]^{2-}$, respectively, are
(A) paramagnetic, paramagnetic
(B) diamagnetic, diamagnetic
(C) paramagnetic, diamagnetic
(D) diamagnetic, paramagnetic

19. The value of 'x' in $\left[Cu(CO)_x\right]^{+}$ such that it obeys the 18 electron rule is
(A) 6 (B) 5 (C) 4 (D) 3

20. The correct order of $\nu_{NO}\left(cm^{-1}\right)$ in the following compounds is
(A) $NO^+ > NO > [NiCp(NO)] > [Cr(Cp)_2(NO)_4]$
(B) $[Cr(Cp)_2(NO)_4] > [NiCp(NO)] > NO^+ > NO$
(C) $NO^+ > [Cr(Cp)_2(NO)_4] > NO > [NiCp(NO)]$
(D) $[NiCp(NO)] > NO > [Cr(Cp)_2(NO)_4] > NO^+$

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) $\frac{1}{\sqrt{a}}$

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 : 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

$$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$$
$$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$$

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 'b' coefficient 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) $b(N_2) < b(O_2)$

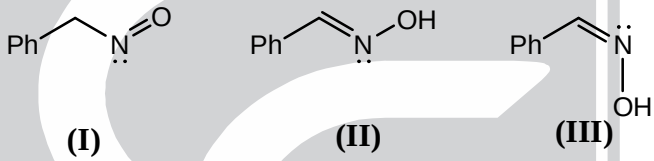
30. From the kinetic theory of gases, the ratio of most probable speed (C_{mp}) to root mean square speed (C_{rms}) is
(A) $\sqrt{3}$ (B) $\sqrt{2}/\sqrt{3}$ (C) $\sqrt{3}/\sqrt{2}$ (D) $3/\sqrt{2}$

Section-B

Multiple Select Questions (MSQ)

Q.31 – Q.40 carry TWO marks each.

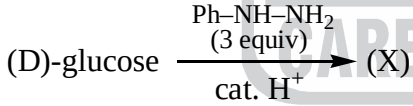
31. The correct statement(s) about the following species is(are)



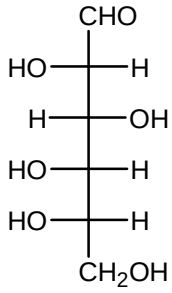
(I) **(II)** **(III)**

(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)


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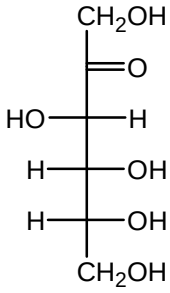
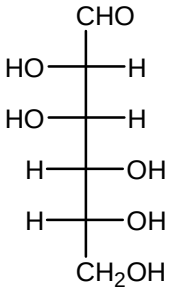
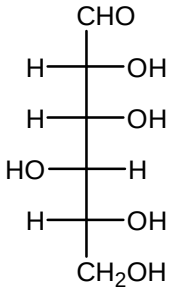
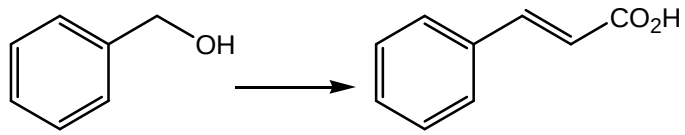


(C)


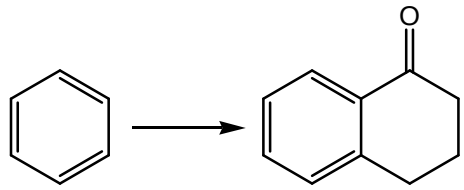
(D)


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, heat, then acidify
(B) (i) CrO_3, H_2SO_4, aq. acetone (ii) Ac_2O, NaOAc
(C) (i) MnO_2; (ii) $CH_2(CO_2H)_2$, piperidine, pyridine
(D) (i) PCC; CH_2Cl_2; (ii) $BrCH_2CO_2C(CH_3)_3$, Zn (iii) H_3O^+, heat

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) $H_2N\text{-}NH_2$, KOH; (iii) H_2SO_4
(C) (i) succinic anhydride, $FeCl_3$; (ii) $LiAlH_4$; (iii) H_2SO_4
(D) (i) phthalic anhyride, $F_3B.OEt_2$; (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) $\left[Cr\left(C_2O_4\right)_3\right]^{3-}$ (B) $\left[CrO_4\right]^{2-}$ (C) $\left[ReO_4\right]^{-}$ (D) $\left[NiO_2\right]^{2-}$

37. The type(s) of interaction(s) that hold layers of graphite together is(are)
(A) $\pi-\pi$ 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

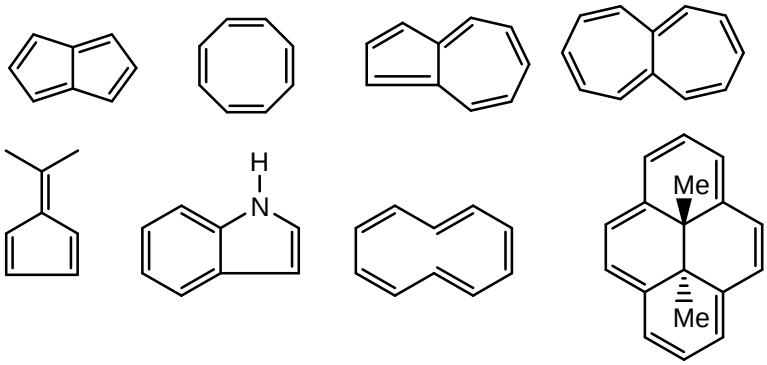
40. The diatomic molecule(s) that has (have) two π-type bonds is(are)
(A) B_2 (B) C_2 (C) N_2 (D) O_2

Section-C

Numerical Answer Type (NAT)

Q.41 – Q.50 carry ONE mark each.

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 15.45g 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 $^{217}_{84}Po$ 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 1.54Å, a diffraction line corresponding to $2\theta = 20.8^{o}$ is observed. The inter-planar separation in Å is _____

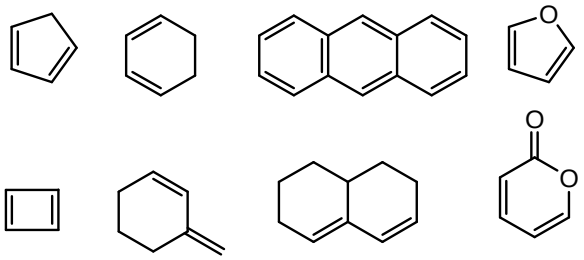
49. The potential energy of interaction between two ions in an ionic compound is given by $U = 1389.4\left[\frac{Z_1Z_2}{r/Å}\right]$ kJ mol^{-1}. Assuming that $CaCl_2$ is linear molecule of length 5.6Å, the potential energy for $CaCl_2$ molecule in kJ mol^{-1} is _____

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 ._____

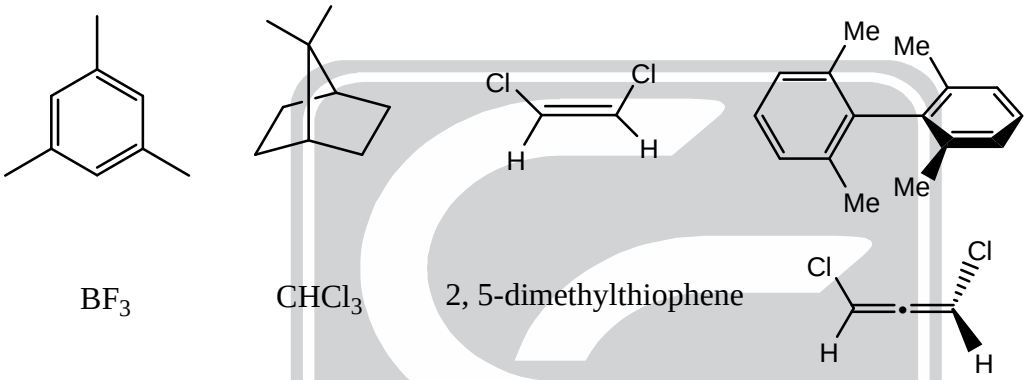
Q.51 – Q.60 carry TWO marks each.

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 participates 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 _____



BF_3 $CHCl_3$ 2, 5-dimethylthiophene

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 $\left[\mathrm{Co(NH_3)_4Cl(NO_2)}\right]^+$ is _____

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

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

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 ΔH^0 for the reaction $\mathrm{CO(g) + ½O_2(g) \rightarrow CO_2(g)}$ at 400K in kJ mol^{-1} is _____

Given at 298K :

	ΔH_f^0	C_p^0
	kJ mol^{-1}	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 350 K 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 JK^{-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 $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$. 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}]

***** END OF THE QUESTION PAPER *****