Answers & Solutions

Time : 1 hr

for

Max. Marks : 120

International Olympiad Qualifier (Part I) in
CHEMISTRY (IOQC) 2020-21

INSTRUCTIONS TO CANDIDATES

(1) There are 32 objective type questions. Out of 32 questions, 24 questions in **Part A1** and 8 questions in **Part A2**. All questions are compulsory.

(2) In **Part A1** each question has four options out of which only one is correct.

(3) For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer.

(4) In **Part A2** each question has four options out of which any number of option(s) (4,3, 2 or 1) may be correct.

(5) For **Part A2**, each correct answer carries 6 marks if all correct options are marked and no wrong option. No negative marking for this part.

PART-A1

1. Reaction of ammonia with diborane gives an ionic product ($B_2H_6 \cdot 2NH_3$). The hybridization of boron in the cation and anion of this product are respectively

   (a) sp^3 in both

   (b) sp^3 and sp^2

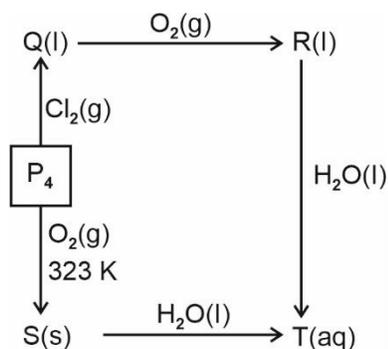   (c) sp^2 and sp^3

   (d) sp^2 in both

Answer (a)

Sol. $B_2H_6 + 2NH_3 \rightarrow \left[(H_3N)_2 BH_2\right]^+ [BH_4]^-$ Ionic Product

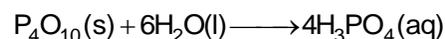Here, hybridization of boron in both $[H_2B(NH_3)_2]^+$ and $[BH_4]^-$ is sp^3
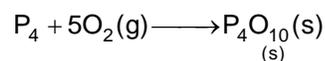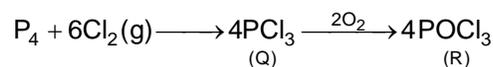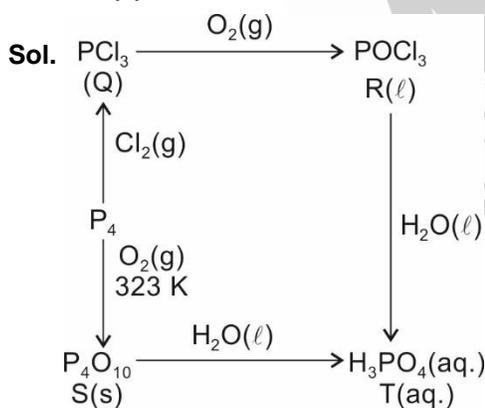
Option (a) is correct.

2. A sequence of reactions of phosphorous (P_4) is given below

   The correct set of products (Q, R, S and T) among the following is

   (a) Q = PCl_3; R = $POCl_3$; S = P_2O_3; T = H_3PO_3

   (b) Q = PCl_5; R = P_2O_5; S = P_4O_6; T = H_3PO_3

   (c) Q = PCl_3; R = $POCl_3$; S = P_4O_{10}; T = H_3PO_4

   (d) Q = PCl_5; R = P_4O_{10}; S = P_4O_{10}; T = H_3PO_4

Answer (c)

Sol.

$$P_4 + 6Cl_2(g) \longrightarrow \underset{(Q)}{4PCl_3} \xrightarrow{2O_2} \underset{(R)}{4POCl_3}$$

$$POCl_3(l) + 3H_2O(l) \longrightarrow \underset{(T)}{H_3PO_4(aq)} + 3HCl$$

$$P_4 + 5O_2(g) \longrightarrow \underset{(s)}{P_4O_{10}(s)}$$

$$P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$$
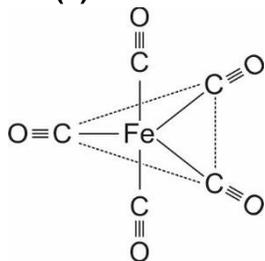
3. In the gaseous state of $Fe(CO)_5$, the 'd' orbital that would participate in hybridization is

   (a) $d_{x^2-y^2}$
   (b) d_{z^2}

   (c) d_{xz}
   (d) any one of the 'd' orbitals

Answer (b)

Sol.

d_{z^2} orbital is involved in hybridisation.

4. Among the following, the correct statement/s about 'p' block elements is/are

   I. The valence shell electronic configuration of all them is ns^2np^{1-6}
   II. Only in p block, metals, nonmetals and metalloids are present
   III. Halogens have the lowest negative electron gain enthalpy in the respective periods
   IV. Noble gases have no tendency to accept an electron and hence they have large negative values of electron gain enthalpy

   (a) I, IV
   (b) II, III
   (c) IV only
   (d) II only

Answer (d)

Sol. • Electronic configuration of He = $1s^2$.

   • Only in *p*-Block, metals, non-metals and metalloids are present.

   • Halogens have the highest negative electron gain enthalpy in the respective periods.

   • Noble gases have large positive values of electron gain enthalpy.

   So only II statement is correct.

5. A chemical reaction is carried out at two different temperatures T_1 and T_2 ($T_2 > T_1$) and also with and without a catalyst.

   The statement that is correct among the following is

   (a) Lowering in the activation energy of the reaction due to catalyst would be higher at T_2 than at T_1

   (b) Lowering in the activation energy of the reaction due to catalyst would be higher at T_1 than at T_2

   (c) The factor by which the rate of the reaction is increased by the catalyst would be lower at T_2 than at T_1

   (d) The factor by which the rate of the reaction is increased by the catalyst would be higher at T_2 than at T_1

Answer (c)

Sol. Reaction is occurring at two different temperatures : T_2 & T_1

   Where $T_2 > T_1$

   Assuming that the activation energy of reaction is temperature independent.

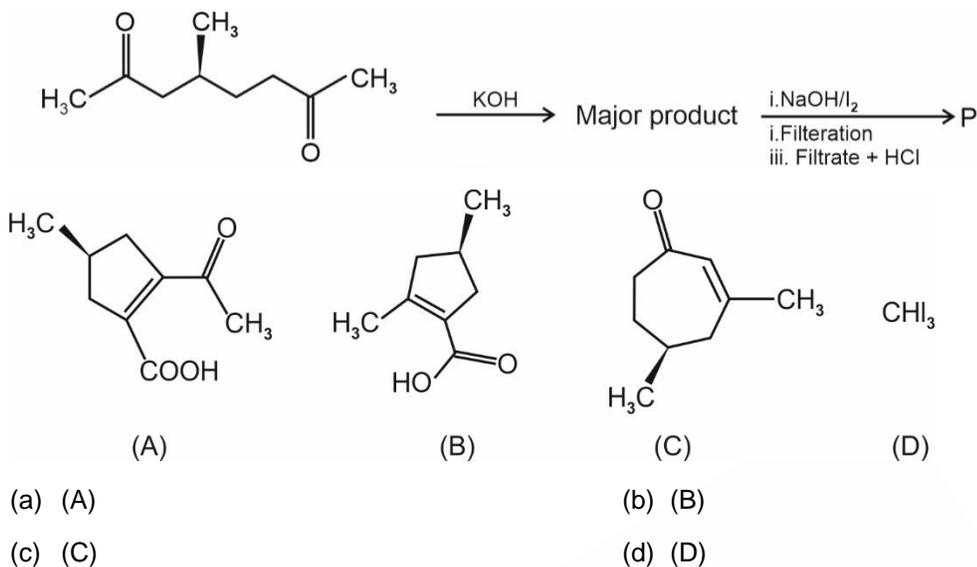   The amount(c) by which the catalyst lowers the activation energy will remain same at T_1 and T_2.

   Using $k = Ae^{-Ea/RT}$ and $k_c = Ae^{-(E_a - c)/RT}$

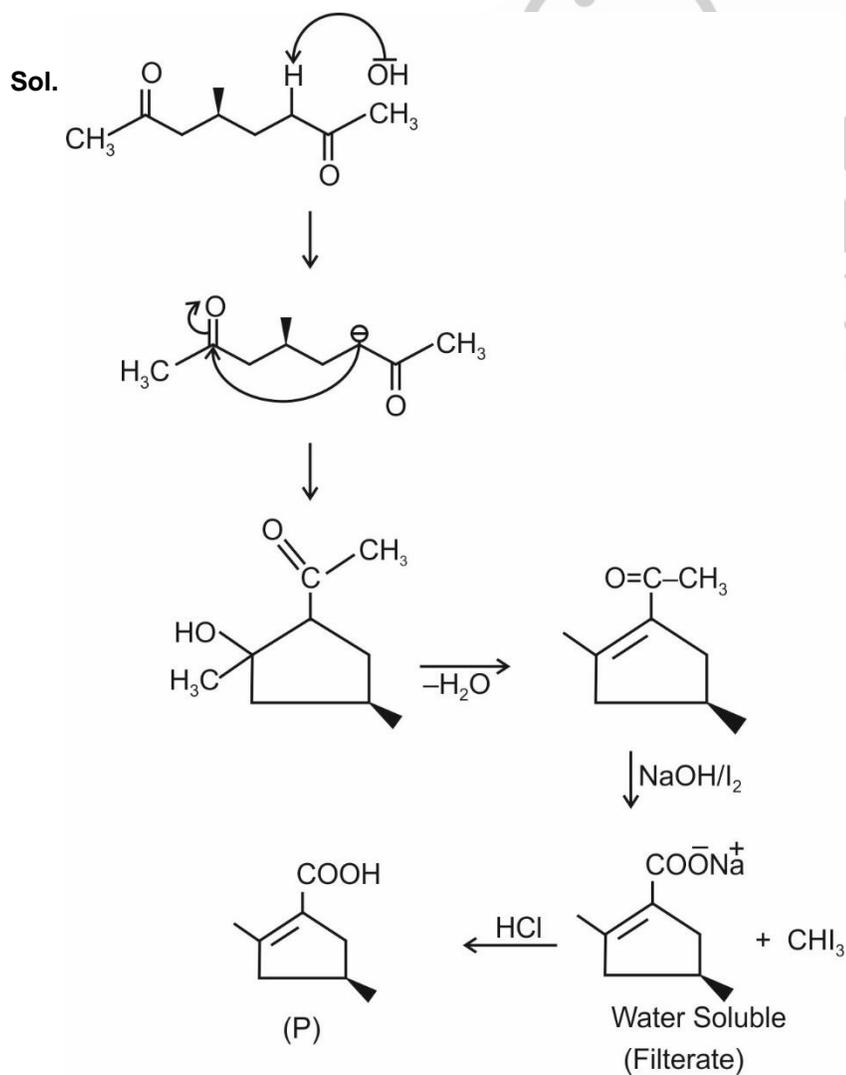 $$\ln \frac{k_c}{k} = \frac{c}{RT}$$

   $\therefore$ At lower temperature the factor $\left(\dfrac{k_c}{k} \right)$ will be higher.

   $\therefore$ Factor by which the rate of reaction is increased by the catalyst would be lower at T_2 than at T_1.

6. The product 'P' in the following sequence of reactions is

(a) (A) (b) (B)

(c) (C) (d) (D)

Answer (b)

Sol.

7. Among the following maximum number of resonance structures is possible for

   (a) PO_4^{-3} (b) SO_4^{-2}

   (c) CO_3^{-2} (d) MnO_4^-

Answer (b)

Sol. Resonating structures of PO_4^{3-} are :
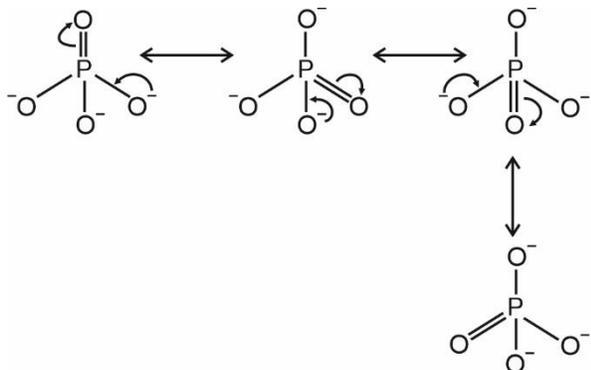
Resonating structures of SO_4^{2-} are :
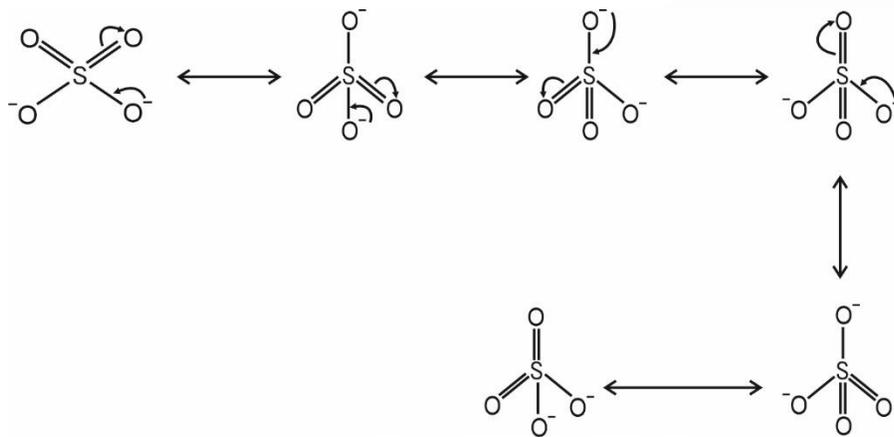
Resonating structures CO_3^{2-} are :

Resonating structures of MnO_4^- are :

Maximum number of resonating structures is possible for SO_4^{2-}

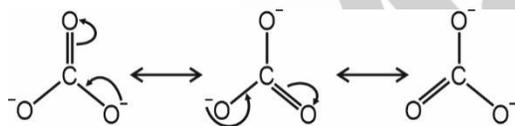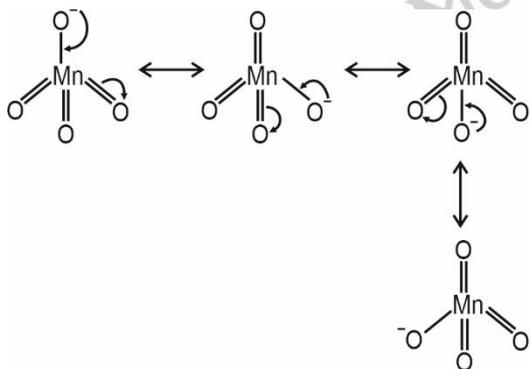8. A mixture of sodium (Na) and potassium (K) metals weighing 32 g was reacted with water and the solution obtained could be neutralized with 517.3 mL of 1.0 M H_2SO_4 (aq).

   The mass of sodium that was present in the mixture is

   (a) 20 g

   (b) 16 g

   (c) 10 g

   (d) 12 g

Answer (d)

Sol. Assume mass of Na in mixture = x g

And mass of K in mixture = (32 – x) g
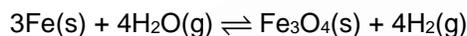
Using law of equivalence.

Total equivalent of acid = Total equivalent of bases

$$\Rightarrow \frac{517.3}{1000} \times 1 \times 2 = \frac{x}{23} \times 1 + \frac{32 - x}{39}$$

$$\Rightarrow 1.0346 = \frac{39x + 32 \times 23 - 23x}{23 \times 39}$$

$$\Rightarrow x = 12 \text{ g}$$

9. The mass ratio of steam and hydrogen is found to be 1:1.5 at equilibrium in the following reaction

   $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

   The value of the equilibrium constant (K_c) of the above reaction is

   (a) 3.0×10^{-5}

   (b) 3.3×10^{4}

   (c) 3.3×10^{6}

   (d) 1.3×10^{3}

Answer (b)

Sol. $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

$$\because \left(\frac{m_{H_2O}}{m_{H_2}}\right)_{eq} = \frac{1}{1.5}$$

$$\Rightarrow \left(\frac{n_{H_2O}}{n_{H_2}}\right)_{eq} : \frac{1 \times 2}{18 \times 1.5} = \frac{1}{13.5}$$

$$K_c = \frac{\left(n_{H_2} / V\right)^4}{\left(n_{H_2O} / V\right)^4} = \left(\frac{n_{H_2}}{n_{H_2O}}\right)^4$$

$$= (13.5)^4$$

$$\boxed{K_c \approx 3.3 \times 10^4}$$

10. Two students did a set of experiments on ketones 'X' and 'Y' independently and obtained the following result.

Reaction/Experiment	X	Y
Optical rotation	Yes	Yes
Optical rotation after treatment with a base	Zero	Yes
NH$_2$NH$_2$, KOH, Heat	Formation of an optically inactive hydrocarbon C$_6$H$_{12}$	Formation of an optically inactive hydrocarbon C$_6$H$_{12}$

The ketones '**X**' and '**Y**' are respectively

(a) 2-ethylcyclobutanone and 3-ethylcyclobutanone

(b) 2-methylcyclopentanone and 3-methylcyclopentanone

(c) 3-methylcyclopentanone and 2-methylcyclopentanone

(d) 3-methyl-4-penten-2-one and 4-methyl-1-penten-3-one

Answer (b)

Sol.

(2-Methylcy-clopentanone)
(x)
Optically active

$^-$OH → (Racemization) Loss of optical activity

NH$_2$–NH$_2$, KOH, Δ

C$_6$H$_{12}$ Optically inactive

(3-Methylcy-clopentanone)
(y)
Optically active

$^-$OH → No loss of optical activity

NH$_2$–NH$_2$, KOH, Δ

C$_6$H$_{12}$ Optically inactive

11. Glycine ($C_2H_5O_2N$) is the simplest of amino acids. Molecular formula of the linear oligomer synthesized by linking ten glycine molecules together via a condensation reaction would be

(a) $C_{20}H_{32}O_{11}N_{10}$

(b) $C_{20}H_{68}O_{29}N_{10}$

(c) $C_{20}H_{40}O_{10}N_{10}$

(d) $C_{20}H_{50}O_{20}N_{10}$

Answer (a)

Sol. $10H_2N-\underset{\text{Glycine}}{CH_2}-COOH\longrightarrow$ Oligomer of 10 Glycine units $+ 9H_2O$

Formula of oligomer would be $= 10 \times (C_2H_5O_2N) - 9H_2O$

$= C_{20}H_{32}O_{11}N_{10}$

12. If Ni^{2+} is replaced by Pt^{2+} in the complex ion $[NiCl_2Br_2]^{2-}$, which of the following would change?

I. Magnetic moment

II. Geometry

III. Geometrical isomerism

IV. Optical isomerism

(a) I, II, III

(b) II, III

(c) I, II

(d) II, III, IV

Answer (a)

Sol. $[NiCl_2Br_2]^{2-}$

* geometry = Tetrahedral

* magnetic moment $= \sqrt{2(2+2)} = \sqrt{8}$ B.M

$[PtCl_2Br_2]^{2-}$

* geometry – square planar

* magnetic moment = 0 B.M.

* shows geometrical isomerism

cis   trans

Both the complex ions do not show optical isomerism.

13. An inorganic compound '**X**' of an alkali metal on heating gives a reddish-brown gas '**Y**' and a binary solid '**Z**'. This solid is less soluble in water and its solution is basic. '**X**' does not give a positive silver nitrate test. '**X**' can be identified as

(a) KIO_3

(b) $LiNO_3$

(c) $NaNO_3$

(d) KNO_2

Answer (b)

Sol. Compound (X) is $LiNO_3$ as it gives reddish brown gas NO_2 (Y) on heating and a binary solid Li_2O (Z).

$$2LiNO_3(s)\xrightarrow{\Delta}Li_2O(s)+2\underset{\text{Brown}}{NO_2}(g)+\frac{1}{2}O_2(g)$$

Li_2O reacts with water to give LiOH which is soluble in water and the solution is basic
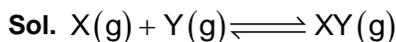
$$Li_2O(s)+H_2O(\ell)+\underset{\text{Basic}}{LiOH}(aq)$$

14. The qualitative plots given represent the yield of the product, [XY], at equilibrium in the reaction $X(g) + Y(g) \rightleftharpoons XY(g)$, as a function of temperature, at total pressures P_1 and P_2. The reaction is
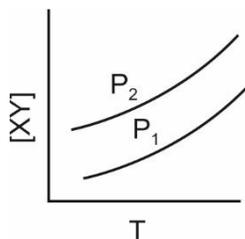
(a) endothermic and $P_1 < P_2$

(b) endothermic and $P_2 < P_1$

(c) exothermic and $P_1 > P_2$

(d) exothermic and $P_2 > P_1$

Answer (a)

Sol. $X(g) + Y(g) \rightleftharpoons XY(g)$

From given graph & Le-Chatelier's principle :

At any pressure P_1 or P_2, on increasing temperature [XY] is increasing.

∴ The reaction is endothermic:

On increasing pressure the reaction will more in forward direction, hence increasing in [XY].

∴ The reaction is endothermic & $P_2 > P_1$

15. When 6.8 g of $AgNO_3$ completely reacts with H_3PO_2, metallic silver produced(g) and H_3PO_2 consumed (mole) are respectively.

(a) 4.32 and 0.1
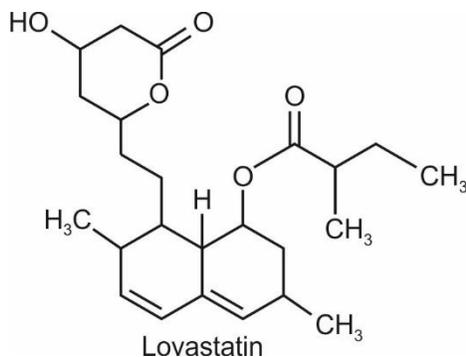
(b) 1.08 and 0.01

(c) 4.32 and 0.01

(d) 2.16 and 0.01

Answer (c)

Sol. $4AgNO_3 + H_3PO_2 \longrightarrow 4Ag + H_3PO_4 + 4HNO_3 + 2H_2O$
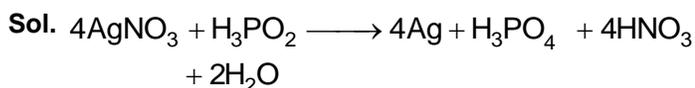
∴ Amount of Ag produced = $\dfrac{6.8}{170} \times 108 = 4.32$ g   [Using POAC]

Moles of H_3PO_2 consumed = $\dfrac{6.8}{170} \times \dfrac{1}{4} = 0.01$ moles   [Using reaction stoichiometry]

16. Lovastatin, a drug used to reduce the risk of cardio vascular diseases has the following structure

Lovastatin

The number of stereogenic centers present in lovastatin is

(a) 8

(b) 3

(c) 4

(d) 6

Answer (a)

Sol. C – atom bonded with four different groups or atoms can be called as stereogenic centre. There are 8 stereogenic centres in Lovastatin.

17. Among the following sets, the one in which all the molecules are non polar is

(a) XeF_4, XeO_3, XeO_4

(b) XeF_2, XeO_4, $XeOF_4$

(c) XeF_2, XeF_4, XeO_4

(d) XeF_2, XeO_3, $XeOF_4$

Answer (c)

Sol. From the structures of XeF_2, XeF_4 and XeO_4, it is clear that each molecule has polar bonds but the resultant of the bond moments cancels out in each case. Therefore, all these molecules are non-polar.

XeF_2 ($\mu = 0$) XeF_4 ($\mu = 0$) XeO_4 ($\mu = 0$)

[Hybridisation]: sp^3d sp^3d^2 sp^3
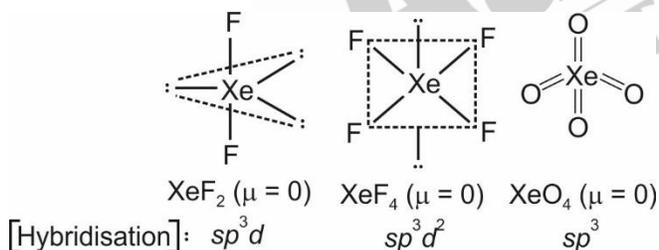
18. Gas phase reactions (i) and (ii) are of first and second order respectively

$2N_2O_5 \rightarrow 4NO_2 + O_2$ … (i)

$2NO + O_2 \rightarrow 2NO_2$ … (ii)
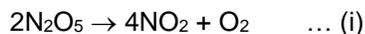
Under certain conditions, the rate constants (k_1, k_2) of (i) and (ii) respectively, have the same numerical value, when the concentrations of the reactants are expressed in mol/dm^3.

If the concentrations are expressed in mol/mL, the correct relationship between k_1 and k_2 is

(a) $k_2 \times 10^{-3} = k_1$

(b) $k_2 \times 10^3 = k_1$

(c) $k_1 = k_2$

(d) $k_1 \times 10^6 = k_2$

Answer (a)

Sol. $2N_2O_5 \rightarrow 4NO_2 + O_2$ … (i)

$2NO + O_2 \rightarrow NO_2$ …(ii)

When conc. is in mol/dm^3 (mol/L), then

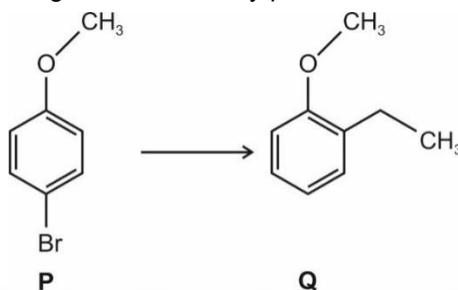$$\underset{(\text{Unit of } k_1 = s^{-1})}{k_1} = \underset{(\text{Unit of } k_2 = L\,mol^{-1}s^{-1})}{k_2}$$ (Numerical value)

On expressing conc. in mol/mL,

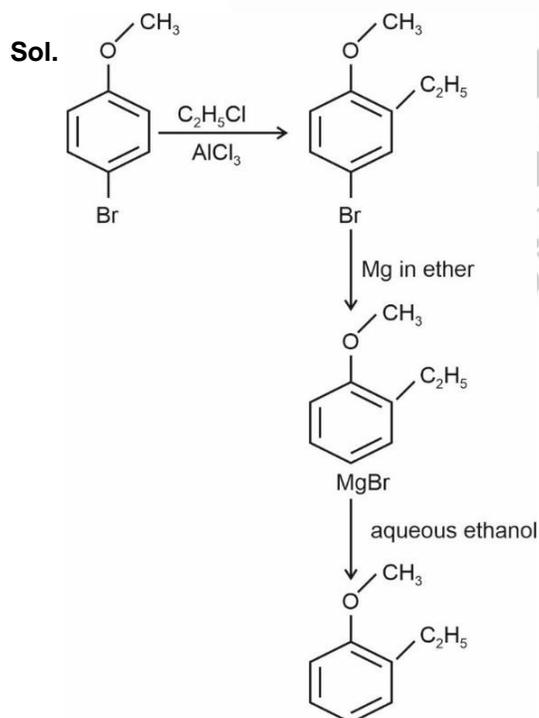No change in numerical value of k_1

While new numerical value of $k_2 = 1000 \times$ old value $= 1000\,k_1$

$$\boxed{10^{-3}\,k_2 = k_1}$$

19. The correct sequence of reactions to get '**Q**' as the only product from '**P**' is

(a) (i) H_2 and Pt catalyst (ii) C_2H_5Cl and $AlCl_3$

(b) (i) Mg in ether (ii) aqueous alcohol (iii) C_2H_5Cl and $AlCl_3$

(c) (i) Mg in ether (ii) C_2H_5Cl and $AlCl_3$

(d) (i) C_2H_5Cl and $AlCl_3$ (ii) Mg in ether (iii) aqueous alcohol

Answer (d)

Sol.

20. The Galvanic cell can be represented as Zn/Zn^{2+} (0.1 M) // Cu^{2+} (0.1 M)/Cu. Among the following, the cell that can produce an EMF more than that of the Galvanic cell is

(E^0 of Zn^{2+}/Zn and Cu^{2+}/Cu are –0.763 V and 0.337 V respectively)

(a) Zn/Zn^{2+} (0.1 M) // Cu^{2+}(0.01 M)/Cu

(b) Zn/Zn^{2+} (1 M) // Cu^{2+} (0.01 M)/Cu

(c) Zn/Zn^{2+} (0.01 M) // Cu^{2+} (1 M)/Cu

(d) Zn/Zn^{2+} (0.01 M) // Cu^{2+} (0.01 M)/Cu

Answer (c)

Sol. For given galvanic cell

$$E_{cell} = E_{cell}^{\circ} - \frac{RT}{2F} \ln \frac{\left[Zn^{2+} \right]}{\left[Cu^{2+} \right]}$$

$$= \left(0.337 - (-0.763) \right) - \frac{2.303 RT}{2F} \log \frac{0.1}{0.1}$$

$$= 1.1 \text{ V}$$
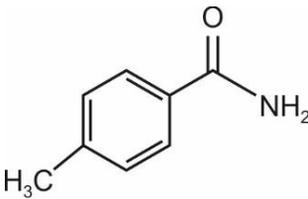
Now,

$$E_{cell} = 1.1 - \frac{0.059}{2} \log \frac{\left[Zn^{2+} \right]}{\left[Cu^{2+} \right]}$$
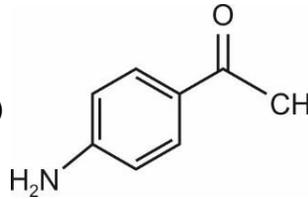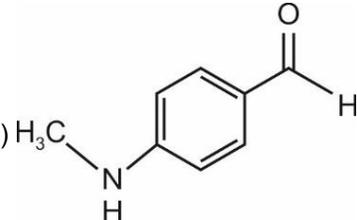
$$= 1.1 + \frac{0.059}{2} \log \frac{\left[Cu^{2+} \right]}{\left[Zn^{2+} \right]}$$

$\frac{\left[Cu^{2+} \right]}{\left[Zn^{2+} \right]}$ have maximum value when

Cu^{2+} = 1 M and Zn^{2+} = 0.01 M

∴ Option (c) is correct

21. The correct match of the molecules in column I and reactions in column II is

Column I	Column II
(i) 4-methylbenzamide (H$_3$C on ring, C(=O)NH$_2$)	(L) Coloration with FeCl$_3$
(ii) 4-aminoacetophenone (H$_2$N on ring, C(=O)CH$_3$)	(M) Effervescence with NaHCO$_3$
(iii) H$_3$C–NH– on ring, CHO (4-(methylamino)benzaldehyde)	(N) Yellow precipitate with NaOH and I$_2$
(iv) 4-hydroxybenzaldimine (HO on ring, CH=NH)	(O) Yellow oil with NaNO$_2$, HCl at 0°C
	(P) Heating with NaOH gives out a gas that turns moist turmeric paper brown
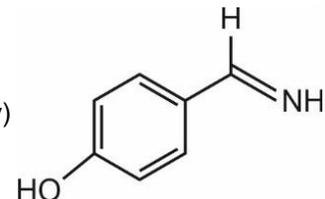
(a) (i)-N (ii)-L (iii)-O (iv)-M

(b) (i)-O (ii)-N (iii)-L (iv)-P

(c) (i)-P (ii)-O (iii)-L (iv)-M

(d) (i)-P (ii)-N (iii)-O (iv)-L

Answer (d)

Sol.

(i) 4-methylbenzamide $\xrightarrow[\Delta]{^-OH}$ 4-methylbenzoate (COO$^-$) + NH$_3$
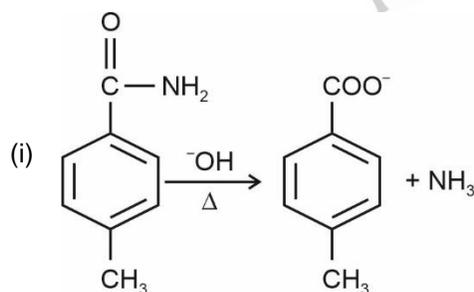
NH$_3$ is a basic gas that turns moist turmeric paper brown.

So, (i) → P

(ii)

CHI$_3$ yellow precipitate

So, (ii) → N

(iii)

So, (iii) → O

(iv)

will give coloration with FeCl$_3$
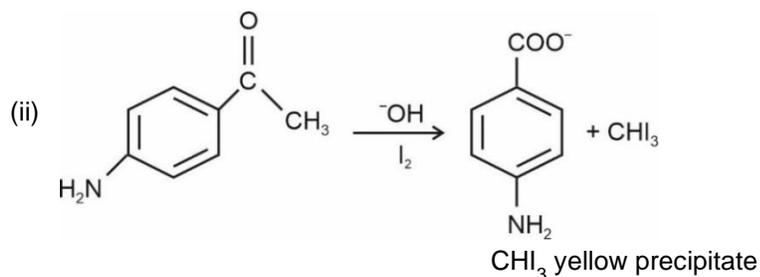
So, (iv) → L

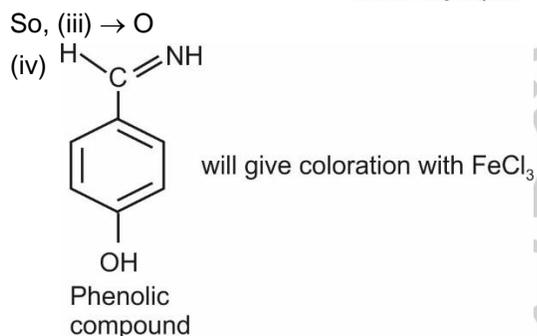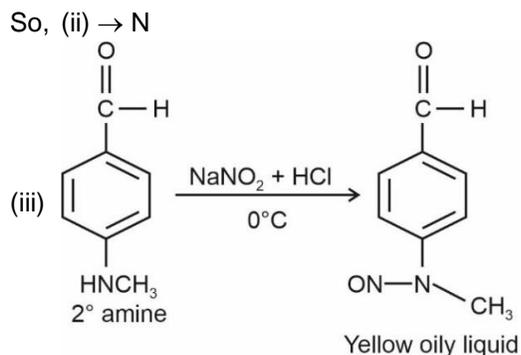22. While doing titration, a student recorded a burette reading of 10.0 mL for the neutralization of 10.0 mL NaHC$_2$O$_4$ (aq) with 0.1 M NaOH (aq). In a separate experiment, 10.0 mL of this NaHC$_2$O$_4$ (aq) solution could be completely oxidized by 10.0 mL of KMnO$_4$ in an acidic medium.

What would be the molarity of KMnO$_4$ used by this student?

(a) 0.02 M   (b) 0.04 M

(c) 0.1 M   (d) 0.2 M

Answer (b)

Sol. In case of neutralisation

Valency factor of NaHC$_2$O$_4$ = 1

$\therefore \ 10 \times 1 \times M_{NaHC_2O_4} = 10 \times 0.1 \times 1$

$M_{NaHC_2O_4} = 0.1\,M$

In case of titration with KMnO$_4$

VF of NaHC$_2$O$_4$ = 2

$\therefore$ Equivalent of NaHC$_2$O$_4$ = Equivalent of KMnO$_4$

$0.1 \times 2 \times 10 = 10 \times M_{KMnO_4} \times 5$

$M_{KMnO_4} = \dfrac{0.1 \times 2 \times 10}{10 \times 5}$

= 0.04 M

23. Pheromones are chemicals that animals produce for social response. The structure of brevicomin, a pheromone, is shown below. The open chain ketodiol that would form brevicomin is
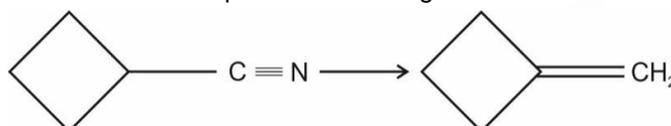

(a) 7, 8-dihydroxynonan-3-one

(b) 6, 7-dihydroxynonan-3-one

(c) 7, 8-dihydroxynonan-2-one

(d) 6, 7-dihydroxynonan-2-one

Answer (d)

Sol.

Brevicomin

$\Rightarrow$ This is a cyclic **ketal** and open chain structure of same is

and IUPAC name is 6, 7-dihydroxynonan-2-one

24. The best reagents and conditions to accomplish the following conversion is

(a) (i) LiAlH$_4$ in ether, (ii) 3 moles of CH$_3$I followed by heating with AgOH

(b) (i) LiAlH$_4$ in ether, (ii) P$_2$O$_5$ and heat

(c) (i) 20% H$_2$SO$_4$ and heat, (ii) P$_2$O$_5$ and heat

(d) H$_2$ and Lindlar catalyst

Answer (a)

Sol.
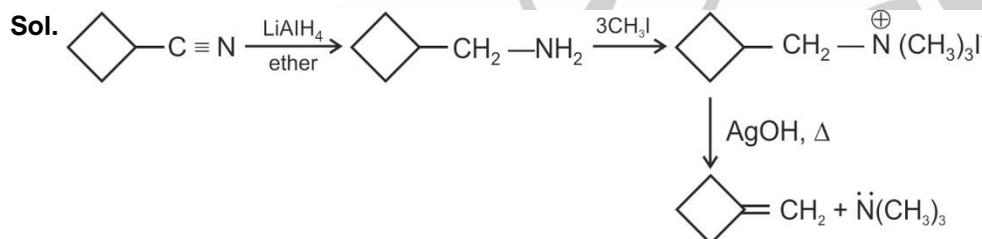
PART-A2

25. The correct statement/s among the following is/are

(a) Intermolecular forces in n-heptane are stronger than those in 2-methylheptane

(b) Boiling point of 2, 2-dimethylpentane is higher than that of 2, 2-dimethylbutane

(c) Both hydrogen bonding and van der Waals forces exist between molecules of 2-methylbutan-2-ol

(d) In 2, 2-dimethylbutane, 1º, 2º and 3º types of carbon atoms are present

Answer (b, c)

Sol. • Boiling point of n-heptane is 98.42°C whereas boiling point of 2-methylheptane is 116°C. This indicates 2-methylheptane has stronger intermolecular forces than n-heptane. Also 2-methylheptane has higher molar mass.

• 2, 2-dimethylpentane has higher molar mas than 2, 2-dimethylbutane, so earlier should have higher boiling point.

• 2-methylbutan-2-ol has –OH group hence it can form hydrogen bonds and van der Waals forces also exist.

• 2, 2-dimethylbutane is
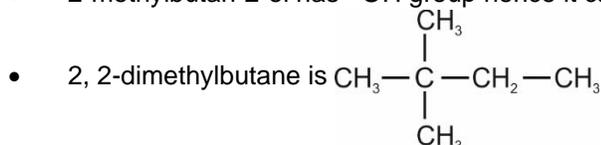
26. Which of the following aqueous solution/s will have a pH value between 4.0 and 5.0 at 25ºC?

    (a) 0.01 M solution of benzoic acid ($K_a = 6.6 \times 10^{-5}$ at 25ºC)

    (b) 0.02 mol benzoic acid and 0.05 mol sodium benzoate dissolved in appropriate amount of water to make a solution of 1 L

    (c) A mixture of 999 mL water and 1 mL 0.2 M HCl

    (d) 499 mL of 0.01 M NaOH and 501 mL of 0.01 M HCl mixed together

Answer (b, d)

Sol. (a) $\alpha = \sqrt{\dfrac{K_a}{C}} = \sqrt{\dfrac{6.6 \times 10^{-5}}{10^{-2}}} = 0.081$

$[H^+] = 0.01 \times 0.081$

$= 8.1 \times 10^{-4}$

$pH = 4 - 0.9 = 3.1$

(b) $pH = pK_a + \log\dfrac{0.05}{0.02}$

$= (5 - 0.82) + \log 2.5 = 4.58$

(c) V = 1000 mL

Millimoles of HCl = 0.2 × 1

$\left[H^+\right] = \dfrac{0.2}{1000} = 2 \times 10^{-4}$

$pH = 4 - \log 2 = 3.7$

(d) $V_T = 499 + 501 = 1000$ mL

Millimoles of NaOH(initial) = 4.99 $pH = 5 - \log 2 = 4.7$

Millimoles of HCl (initial) = 5.01

$$\underset{\substack{4.99 \\ -}}{NaOH} + \underset{\substack{5.01 \\ 0.02}}{HCl} \longrightarrow \underset{-}{NaCl} + H_2O$$
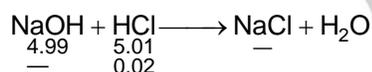
27. The energy required to remove an electron from a gaseous species 'X' to form 'X⁺' is known as first ionization energy (IE) of X. The energy required to remove an electron from a gaseous species 'X⁺' to form 'X⁺⁺' is called the second IE of X. Similarly, the energy required to remove an electron from a gaseous species X⁻ to form X is called the IE of X⁻.

    Identify the correct statement/s from the following

    (a) The second IE of the He atom is four times that of the (first) IE of the H atom.

    (b) The first IEs of F, Ne and Na atoms follow the order IE(Na) < IE(Ne) < IE(F)

    (c) The second IE of the H⁻ ion is much less than the (first) IE of the H atom.

    (d) The IEs of Li, Na and K atoms follow the order IE(K) < IE(Na) < IE (Li)

Answer (a, d)

Sol. First IE of H-atom = $\dfrac{13.6 \times Z^2}{n^2} = 13.6$ eV

Second IE of He$^+$ ion = $\dfrac{13.6(2)^2}{(1)^2} = 4 \times 13.6$ eV

∴ IE$_2$ of He$^+$ ion = 4 × IE$_1$ of H-atom.

The first IE of F, Ne and Na follows the order IE(Na) < IE(F) < IE(Ne)

Second IE of H$^-$ ion is same as the first IE of H-atom.

$$H^-(g) \xrightarrow[(IE_1)]{-e^-} H(g) \xrightarrow[(IE_2)]{-e^-} H^+(g)$$
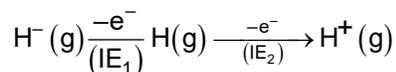
The first IE of alkali metals decreases down the group.

IE$_1$(K) < IE$_1$(Na) < IE$_1$(Li)

28. The product/s formed in the following reaction is/are

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

(a) (A)   (b) (B)

(c) (C)   (d) (D)

Answer (a, b, d)

Sol.

as this C is planar Br$^-$ can attack from both sides of the plane

29. Which of the following option/s is/are correct?

    (a) C_2 is paramagnetic

    (b) He_2^+ has the same energy as that of two isolated He atoms

    (c) S_2 is paramagnetic and S_2^{2-} is diamagnetic

    (d) N_2^+ and N_2^- have the same bond order

Answer (c, d)

Sol. $C_2 : \sigma_{1s^2} \sigma_{1s^2}^* \sigma_{2s^2} \sigma_{2s^2}^* \begin{matrix} \pi_{2p_x^2} \\ \pi_{2p_y^2} \end{matrix}$

i.e. C_2 is diamagnetic.

$He_2^+ : \sigma_{1s^2} \sigma_{1s^1}^*$

i.e., He_2^+ has two electrons in bonding molecular orbital and only one electron in antibonding molecular orbital (i.e., bond order = 0.5)

∴ He_2^+ will not have the same energy as that of two isolated He atoms.

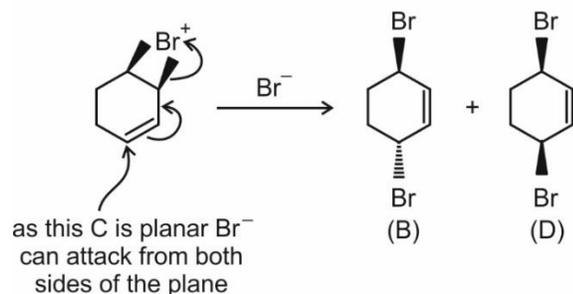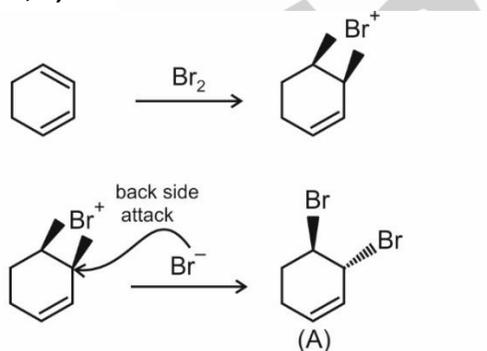$O_2 : \sigma_{1s^2} \sigma_{1s^2}^* \sigma_{2s^2} \sigma_{2s^2}^* \sigma_{2p_z^2} \begin{matrix} \pi_{2p_x^2} & \pi_{2p_x^1}^* \\ \pi_{2p_y^2} & \pi_{2p_y^1}^* \end{matrix}$

Similar outer E.C. will be for S_2 (belong to same group in periodic table)

∴ S_2 is paramagnetic and S_2^{2-} will be diamagnetic.

$N_2^+ : \sigma_{1s^2} \sigma_{1s^2}^* \sigma_{2s^2} \sigma_{2s^2}^* \begin{matrix} \pi_{2p_x^2} \\ \pi_{2p_y^2} \end{matrix} \sigma_{2p_z^1}$

   B.O. $= \dfrac{9-4}{2} = 2.5$

$N_2^- : \sigma_{1s^2} \sigma_{1s^2}^* \sigma_{2s^2} \sigma_{2s^2}^* \begin{matrix} \pi_{2p_x^2} \\ \pi_{2p_y^2} \end{matrix} \sigma_{2p_z^2} \pi_{2p_x^1}^*$

   B.O. $= \dfrac{10-5}{2} = 2.5$

30. Nitromethane undergoes an aldol type reaction with a racemic mixture of 2-methylcyclohexanone in presence of aqueous NaOH in two steps (I, II) to give the product 'P'. The statement/s NOT correct among the following is/are

I $\overset{\ominus}{OH}$ + $H-CH_2-NO_2$ $\rightleftharpoons$ H_2O + $\overset{\ominus}{CH_2}NO_2$
                        Nitromethane   pKa 14.0   Carbanion
                        pKa 10.2

II   + $\overset{\ominus}{CH_2}NO_2$ ⟶ Product 'P'

    (a) The equilibrium in step I will be more towards the right as water is a stronger acid than nitromethane

    (b) The carbanion formed in reaction I can be stabilized due to resonance

    (c) The product formed will be a mixture of four stereoisomers in the form of two pairs of enantiomers

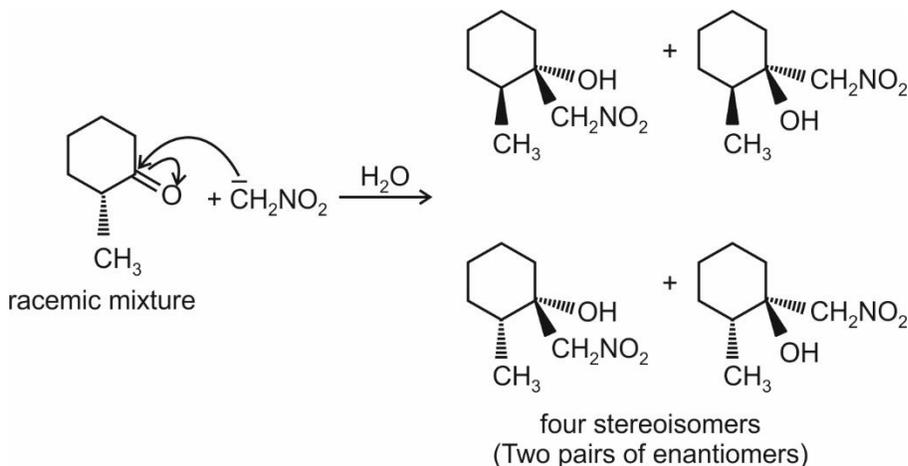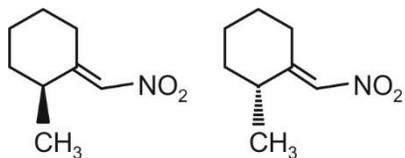   (d) The mixture of products formed can be readily dehydrated to give a single product

Answer (a, d)

Sol. Nitromethane has lower pka than water, means water is weaker acid, option (a) is incorrect.

racemic mixture

four stereoisomers
(Two pairs of enantiomers)

Two dehydration products are formed from the mixture.

31. The structures of hydrogen peroxide (H_2O_2) in the solid and gaseous states are given below. H_2O_2(l) is slightly more viscous than H_2O(l). The correct option/s among the following is/are

**Gas**   **Solid (Crystal)**
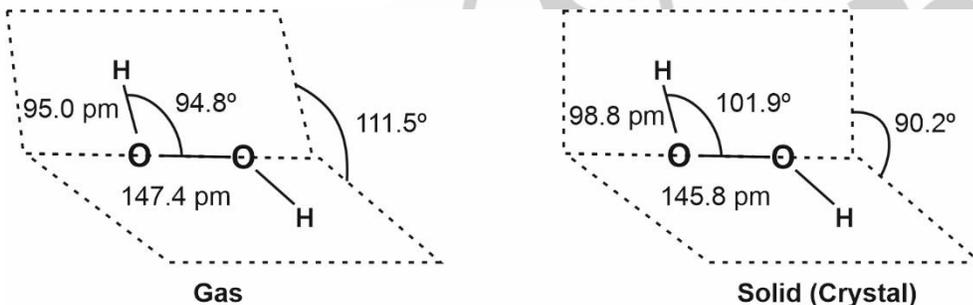
(a) Both O atoms are near enough to cause repulsion between the electron lone pairs thus making the O-O bond susceptible for cleavage

(b) The strong intermolecular H-bonding along with restricted rotation present in the liquid state of H_2O_2 make it more viscous than H_2O (l)

(c) The molecule gets twisted to minimize the repulsion between the lone pair and bond pair of electrons

(d) The difference in the dihedral angles in the solid and gaseous states is a consequence of hydrogen bonding between the molecules

Answer (a, b, c, d)

Sol. The structures of H_2O_2 in the gaseous state as well as in the solid state as given imply that the two lone pair of electrons on each O-atom bonded through a single covalent bond repel each other thereby decreasing the bond strength of O-O bond. Extensive intermolecular H-bonding coupled with restricted rotation along O-O bond due to repulsion between the OH groups results in higher viscosity than H_2O(l). The molecule acquires twisted shape to minimise repulsion between the lone pair and bond pair. In the solid state the extent of H-bonding increases which cause increase in O-H bond length and decrease in dihedral angle as well as O-O bond length.

32. Viruses are non-living complex chemical entities. They undergo inactivation and hence lose the ability to infect a host, with time. Concentration (expressed as 'median tissue culture infectious' TCID/ml, a unit used in expressing virus concentrations) vs. time plots of a corona virus on the surfaces of a paper currency note and a plastic currency note are shown below. Both these plots have two separate regions (shown by vertical lines in the plots), indicating two time zones.

I. Paper currency note
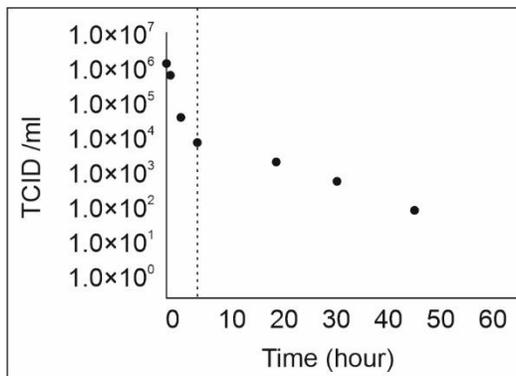
II. Plastic currency note
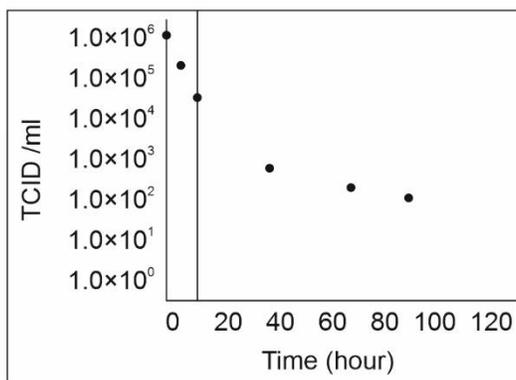
The correct option/s among the following is/are

(a) Inactivation of the virus follows zero order kinetics in 1st zone and first order kinetics in 2nd zone

(b) The rate of inactivation is independent of the surface material

(c) The virus reacts with different chemical entities/substances in 1st zone and 2nd zone

(d) On both the surfaces, at least 95% of the virus is inactivated within 10 h

Answer (c, d)

Sol. From the plot of TCID/ml vs time(hr) of corona virus on the surface of paper currency note, it appears the inactivation of the virus follows first order kinetics in the first zone and zero order kinetics in the second zone. On the other hand a similar plot on the surface of plastic currency note, it appears the inactivation of virus follows zero order kinetics in the first zone (up to 10 hrs) and first order kinetics in the second zone. The rate of inactivation is not same in both the cases. Therefore, it depends on the surface material. The rate of inactivation of the virus in 1st zone is different from 2nd zone. It suggests that virus reacts with different chemical substances in the two zones.

Case-I : Paper currency note

$[A]_0$ = Initial virus concentration = 1×10^6

At t = 10 hrs, $[A]_t$ = virus conc. at time t = 1×10^4

Average inactivation of the virus at 10 hrs = $\left(\dfrac{10^6 - 10^4}{10^6} \right)100 = 99\%$

Case-II : Plastic currency note

$$[A]_0 = 1 \times 10^6$$

At t = 5 hrs, $[A]_t = 4 \times 10^4$

Average inactivation of the virus at 5 hrs = $\left(\dfrac{10^6 - 4 \times 10^4}{10^6} \right)100 = 96\%$

❑   ❑   ❑