Time: 2:30 PM to 3:30 PM
Question Paper Code: 31

Student's Roll No:														

Write the question paper code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.

Instructions to Candidates:
1. Use of mobile phone, smart watch, and iPad during examination is STRICTLY **PROHIBITED**
2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **fourteen-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in Indian Olympiad Qualifier in Chemistry 2020 – 21 (Part I).
6. Question paper has two parts. In part A1 (Q. No.1 to 24) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

Q.No.12   ⓐ ⬤ ⓒ ⓓ

In part A2 (Q. No. 25 to 32) each question has four alternatives out of which any number of alternative(s) (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternative(s) and fill the appropriate bubble(s), as shown

Q.No.30   ⓐ ⬤ ⓒ ⬤

7. For **Part A1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer.
   In **Part A2,** you get 6 marks if all the correct alternatives are marked and no incorrect. No negative marks in this part.
8. Rough work should be done only in the space provided. There are **12** printed pages in this paper.
9. Use of **non - programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper & candidate's copy of OMR for your reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.

OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.

Instructions to Candidates (Continued) :
You may read the following instructions after submitting the answer sheet.

12. **Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on www.iaptexam.in on the specified format till February 12, 2021.**

13. **The answers/solutions to this question paper will be available on the website: www.iapt.org.in by February 13, 2021.**

14. **CERTIFICATES and AWARDS:**
    Following certificates are awarded by IAPT / ACT to students, successful in the Indian Olympiad Qualifier in Chemistry 2020 – 21 (Part I).
    (i)   "CENTRE TOP 10 %"
    (ii) "STATE TOP 1 %"
    (iii) "NATIONAL TOP 1 %"
    (iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC – 2021 at HBCSE Mumbai.

15. All these certificates (except gold medal) will be downloadable from IAPT website: www.iapt.org.in after March 15, 2021.

16. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: www.iapt.org.in by **Feb 25, 2021. See the Minimum Admissible Score Clause** on the Student's brochure on the web.

17. List of students eligible for evaluation of IOQC 2020-21 (Part II) shall be displayed on www.iapt.org.in by March 1, 2021.

Useful constants

Charge of electron, $e = 1.602 \times 10^{-19} C$

Mass of electron, $m_e = 9.1 \times 10^{-31} kg$

Planck's constant, $h = 6.626 \times 10^{-34} J s$

Speed of light, $c = 3.0 \times 10^8 ms^{-1}$

Avogadro constant, $N_A = 6.022 \times 10^{23} mol^{-1}$

Molar gas constant, $R = 0.082 L atm mol^{-1} K^{-1}$
$$= 8.314 J mol^{-1} K^{-1}$$

Question Paper Code: 31

Attempt All The Thirty two Questions
A – 1
ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION

1. Reaction of ammonia with diborane gives an ionic product ($B_2H_6.2NH_3$).
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

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

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

4. Among the following, the *correct* statement/s about 'p' block elements is/are
I. The valence shell electronic configuration of all of them is $ns^2 np^{1-6}$
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

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

6. The product 'P' in the following sequence of reactions is
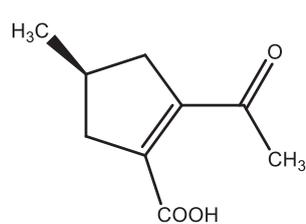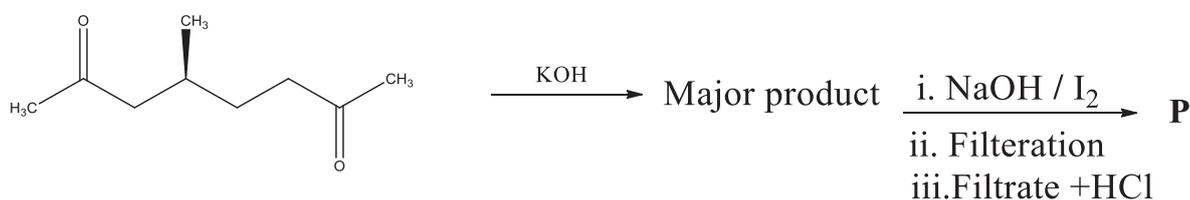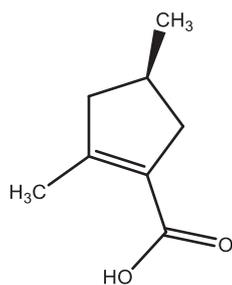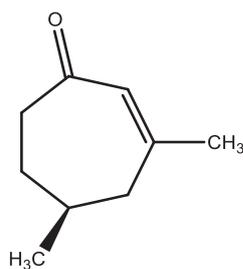
(A)	(B)	(C)	(D)
(a) (A)	(b) (B)	(c) (C)	(d) (D)

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^-

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

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

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

Reaction /Experiment	X	Y
Optical rotation	Yes	Yes
Optical rotation after treatment with a base	Zero	Yes
NH_2NH_2, KOH, Heat	Formation of an optically inactive hydrocarbon C_6H_{12}	Formation of an optically inactive hydrocarbon C_6H_{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

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

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

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

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 $P_2 > P_1$

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

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

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, $XeOF_4$

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) $k_1 \times 10^6 = k_2$

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

P   **Q**
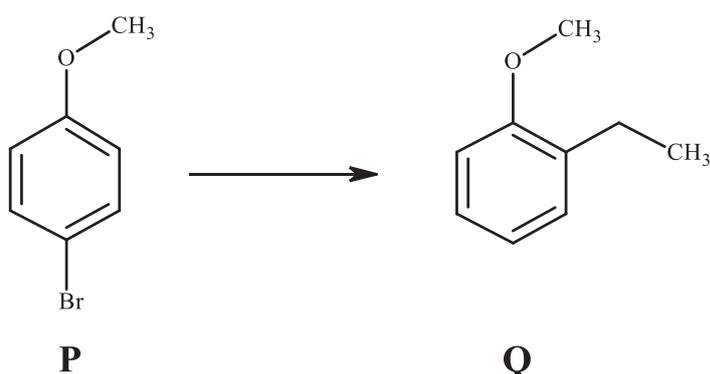
(a) (i) H_2 & Pt catalyst (ii) C_2H_5Cl & $AlCl_3$

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

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

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

20. The Galvanic cell can be represented as $Zn / Zn^{2+}(0.1M) // Cu^{2+}(0.1M)/Cu$.
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 -0.763V and 0.337V respectively)

(a) $Zn / Zn^{2+}(0.1M) // Cu^{2+}(0.01M)/Cu$ (b) $Zn / Zn^{2+}(1M) // Cu^{2+}(0.01M)/Cu$

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

21. The correct match of the molecules in column I and reactions in column II is
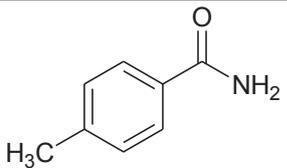
Column I	Column II
i) 4-methylbenzamide (H_3C–C$_6$H$_4$–CONH$_2$)	(L) Coloration with $FeCl_3$
ii) 4-aminoacetophenone (H_2N–C$_6$H$_4$–COCH$_3$)	(M) Effervescence with $NaHCO_3$
iii) 4-(methylamino)benzaldehyde (H_3C–NH–C$_6$H$_4$–CHO)	(N) Yellow precipitate with NaOH and I_2
iv) 4-hydroxybenzaldimine (HO–C$_6$H$_4$–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
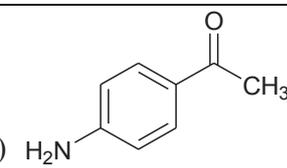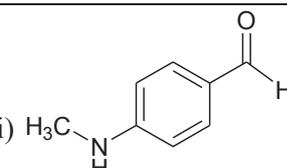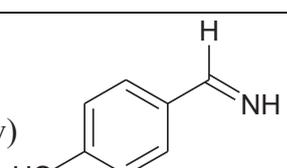
(a) i)-N   ii)-L   iii)-O   iv)-M
(b) i)-O   ii)-N   iii)-L   iv)- P
(c) i)-P   ii)-O   iii)-L   iv)-M
(d) i)-P   ii)-N   iii)-O   iv)-L

22. While doing titration, a student recorded a burette reading of 10.0 mL for the neutralization of 10.0 mL $NaHC_2O_4$ (aq) with 0.1 M NaOH (aq). In a separate experiment, 10.0 mL of this $NaHC_2O_4$ (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

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
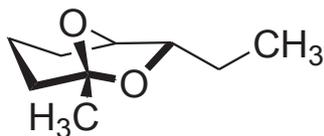
Brevicomin

(a) 7,8-dihydroxynonan-3-one   (b) 6,7-dihydroxynonan-3-one

(c) 7,8-dihydroxynonan-2-one   (d) 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_3I followed by heating with AgOH

(b) (i) $LiAlH_4$ in ether; (ii) P_2O_5 and heat

(c) (i) 20 % H_2SO_4 & heat, (ii) P_2O_5 and heat

(d) H_2 and Lindlar catalyst

A2
ANY NUMBER OF OPTIONS, 4, 3, 2 or 1 MAY BE CORRECT
MARKS WILL BE AWARDED ONLY IF ALL CORRECT OPTIONS ARE BUBBLED AND NO WRONG OPTION

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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, $1°$, $2°$ and $3°$ types of carbon atoms are present

26. Which of the following aqueous solution/s will have a pH value between 4.0 and 5.0 at 25 ºC?
(a) 0.01 M solution of benzoic acid (K_a= 6.6 x 10^{-5} at 25 ºC)
(b) 0.02 mol benzoic acid and 0.05 mol sodium benzoate dissolved in appropriate
  amount of water to make a solution of 1L
(c) A mixture of 999 mL water and 1mL 0.2 M HCl
(d) 499 mL of 0.01M NaOH and 501 mL of 0.01 M HCl mixed together

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)

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

(a) (A)   (b) (B)   (c) (C)   (d) (D)
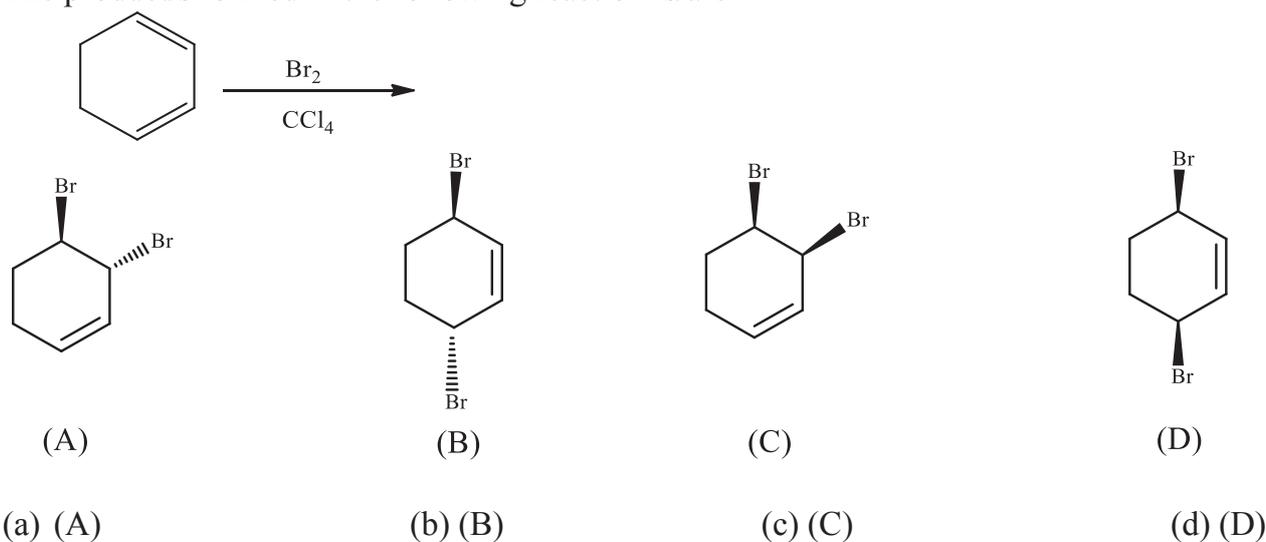
29. Which of the following option/s is /are correct?

(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

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 $\overset{\ominus}{OH}$ + $H\text{-}CH_2\text{-}NO_2$ $\rightleftharpoons$ H_2O + $\overset{\ominus}{C}H_2NO_2$

                Nitromethane   pKa 14.0   Carbanion

                pKa 10.2

II   [2-methylcyclohexanone structure]   + $\overset{\ominus}{C}H_2NO_2$ $\longrightarrow$ **product 'P'**
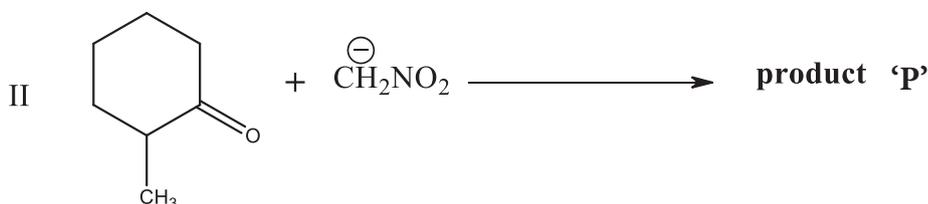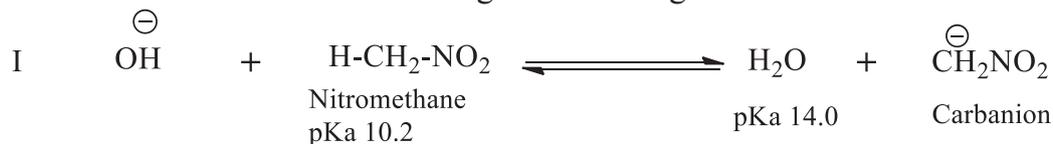
(a) The equilibrium in step I will be more towards the right as water is a stronger acid than nitromethane

(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

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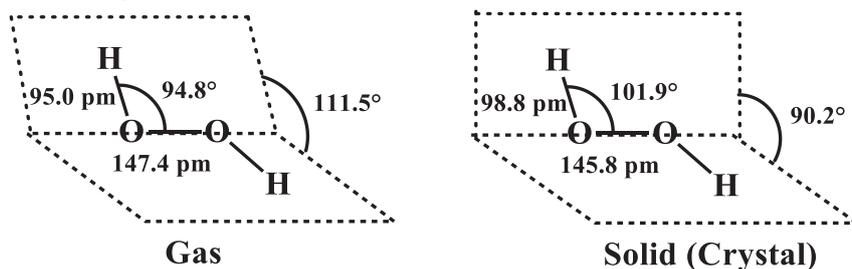
(a) Both O atoms are near enough to cause repulsion between the electron lone pairs thus making the O-O bond susceptible for cleavage

(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

32. Viruses are nonliving complex chemical entities. They undergo inactivation and hence lose the ability to infect a host, with time. Concentration (expressed as 'median tissue culture infectious dose', 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
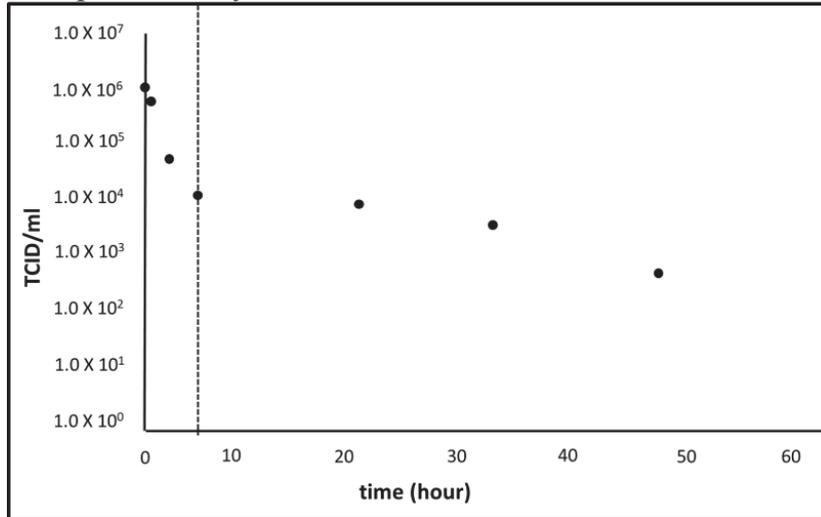
II. Plastic currency note
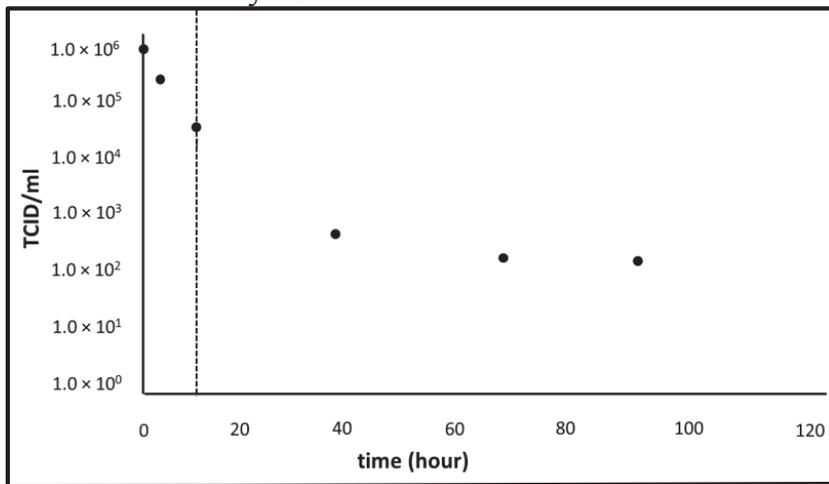
The correct option/s among the following is/are
(a) Inactivation of the virus follows zero order kinetics in 1ˢᵗ zone and first order kinetics in 2ⁿᵈ zone
(b) The rate of inactivation is independent of the surface material
(c) The virus reacts with different chemical entities/substances in 1ˢᵗ zone and 2ⁿᵈ zone
(d) On both the surfaces, at least 95 % of the virus is inactivated within 10 h

IUPAC Periodic Table of the Elements

Key:
atomic number
Symbol
name
conventional atomic weight
standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen 1.008 [1.0078, 1.0082]																	2 **He** helium 4.0026
3 **Li** lithium 6.94 [6.938, 6.997]	4 **Be** beryllium 9.0122											5 **B** boron 10.81 [10.806, 10.821]	6 **C** carbon 12.011 [12.009, 12.012]	7 **N** nitrogen 14.007 [14.006, 14.008]	8 **O** oxygen 15.999 [15.999, 16.000]	9 **F** fluorine 18.998	10 **Ne** neon 20.180
11 **Na** sodium 22.990	12 **Mg** magnesium 24.305 [24.304, 24.307]											13 **Al** aluminium 26.982	14 **Si** silicon 28.085 [28.084, 28.086]	15 **P** phosphorus 30.974	16 **S** sulfur 32.06 [32.059, 32.076]	17 **Cl** chlorine 35.45 [35.446, 35.457]	18 **Ar** argon 39.95 [39.792, 39.963]
19 **K** potassium 39.098	20 **Ca** calcium 40.078(4)	21 **Sc** scandium 44.956	22 **Ti** titanium 47.867	23 **V** vanadium 50.942	24 **Cr** chromium 51.996	25 **Mn** manganese 54.938	26 **Fe** iron 55.845(2)	27 **Co** cobalt 58.933	28 **Ni** nickel 58.693	29 **Cu** copper 63.546(3)	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.723	32 **Ge** germanium 72.630(8)	33 **As** arsenic 74.922	34 **Se** selenium 78.971(8)	35 **Br** bromine 79.904 [79.901, 79.907]	36 **Kr** krypton 83.798(2)
37 **Rb** rubidium 85.468	38 **Sr** strontium 87.62	39 **Y** yttrium 88.906	40 **Zr** zirconium 91.224(2)	41 **Nb** niobium 92.906	42 **Mo** molybdenum 95.95	43 **Tc** technetium	44 **Ru** ruthenium 101.07(2)	45 **Rh** rhodium 102.91	46 **Pd** palladium 106.42	47 **Ag** silver 107.87	48 **Cd** cadmium 112.41	49 **In** indium 114.82	50 **Sn** tin 118.71	51 **Sb** antimony 121.76	52 **Te** tellurium 127.60(3)	53 **I** iodine 126.90	54 **Xe** xenon 131.29
55 **Cs** caesium 132.91	56 **Ba** barium 137.33	57-71 lanthanoids	72 **Hf** hafnium 178.49(2)	73 **Ta** tantalum 180.95	74 **W** tungsten 183.84	75 **Re** rhenium 186.21	76 **Os** osmium 190.23(3)	77 **Ir** iridium 192.22	78 **Pt** platinum 195.08	79 **Au** gold 196.97	80 **Hg** mercury 200.59	81 **Tl** thallium 204.38 [204.38, 204.39]	82 **Pb** lead 207.2	83 **Bi** bismuth 208.98	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium	113 **Nh** nihonium	114 **Fl** flerovium	115 **Mc** moscovium	116 **Lv** livermorium	117 **Ts** tennessine	118 **Og** oganesson

57 **La** lanthanum 138.91	58 **Ce** cerium 140.12	59 **Pr** praseodymium 140.91	60 **Nd** neodymium 144.24	61 **Pm** promethium	62 **Sm** samarium 150.36(2)	63 **Eu** europium 151.96	64 **Gd** gadolinium 157.25(3)	65 **Tb** terbium 158.93	66 **Dy** dysprosium 162.50	67 **Ho** holmium 164.93	68 **Er** erbium 167.26	69 **Tm** thulium 168.93	70 **Yb** ytterbium 173.05	71 **Lu** lutetium 174.97
89 **Ac** actinium	90 **Th** thorium 232.04	91 **Pa** protactinium 231.04	92 **U** uranium 238.03	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

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For notes and updates to this table, see www.iupac.org. This version is dated 1 December 2018.