

Questions & Solutions

PAPER-1 | SUBJECT : CHEMISTRY

PAPER-1 : INSTRUCTIONS TO CANDIDATES

- Question Paper-1 has three (03) parts: Physics, Chemistry and Mathematics.
- Each part has a total eighteen (18) questions divided into three (03) sections (Section-1, Section-2 and Section-3)
- Total number of questions in Question Paper-1 are Fifty Four (54) and Maximum Marks are One Hundred Ninety Eight (198).

Type of Questions and Marking Schemes

SECTION-1 (Maximum Marks : 18)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONLY ONE** of these four options is the correct answer.
- For each question, choose the correct option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks	:	+3	If ONLY the correct option is chosen ;
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered).
Negative Marks	:	-1	In all other cases.

SECTION-2 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
 - Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
 - For each question, choose the option(s) corresponding to (all) the correct answer(s).
 - Answer to each question will be evaluated according to the following marking scheme.
- | | | | |
|----------------|---|----|---|
| Full Marks | : | +4 | If only (all) the correct option(s) is (are) chosen. |
| Partial Marks | : | +3 | If all the four options are correct but ONLY three options are chosen. |
| Partial Marks | : | +2 | If three or more options are correct but ONLY two options are chosen and both of which are correct. |
| Partial Marks | : | +1 | If two or more options are correct but ONLY one option is chosen and it is a correct option. |
| Zero Marks | : | 0 | If none of the options is chosen (i.e. the question is unanswered). |
| Negative Marks | : | -2 | In all other cases. |

SECTION-3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions. The answer to each question is a **NUMERICAL VALUE**.
 - For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places **truncate/round-off** the value to **TWO** decimal placed.
 - Answer to each question will be evaluated according to the following marking scheme :
- | | | | |
|------------|---|----|---|
| Full Marks | : | +4 | If ONLY the correct numerical value is entered. |
| Zero Marks | : | 0 | In all other cases. |

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CHEMISTRY

SECTION-1 (Maximum Marks : 18)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options **ONLY ONE** of these four options is the correct answer.
- For each question, choose the correct option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme :

Full Marks	:	+3 If ONLY the correct option is chosen.
Zero Marks	:	0 If none of the options is chosen (i.e. the question is unanswered).
Negative Marks	:	-1 In all other cases.

खंड 1 (अधिकतम अंक: 18)

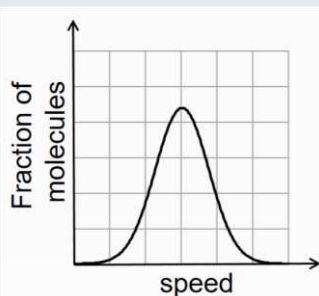
- इस खंड में छः (06) प्रश्न हैं।
- प्रत्येक प्रश्न के लिए सही चार विकल्प दिए गए हैं। इन चार विकल्पों में से **केवल एक** ही विकल्प सही उत्तर है।
- प्रत्येक प्रश्न के लिए दिए हुए विकल्पों में से सही उत्तर से संबंधित विकल्प को चुनिए।
- प्रत्येक प्रश्न के उत्तर का मूल्यांकन निम्न योजना के अनुसार होगा :

पूर्ण अंक : **+3** यदि सिर्फ सही विकल्प ही चुना गया है।

शून्य अंक : **0** यदि कोई भी विकल्प नहीं चुना गया है (अर्थात् प्रश्न अनुत्तरित है)।

ऋण अंक : **-1** अन्य सभी परिस्थितियों में।

1. If the distribution of molecular speeds of a gas is as per the figure shown below, then the ratio of the most probable, the average, and the root mean square speeds, respectively, is



- (A) 1 : 1 : 1
(B) 1 : 1 : 1.224
(C) 1 : 1.128 : 1.224
(D) 1 : 1.128 : 1

Ans. (B)

Sol. Due to symmetrical graph given, the average value of velocities will be at the middle, symmetrical velocity which is also most probable velocity.






While calculating rms speed, we have to take average of square of speeds and its root. In square of speeds, higher speeds will give more contribution so the value will be more than the average value.

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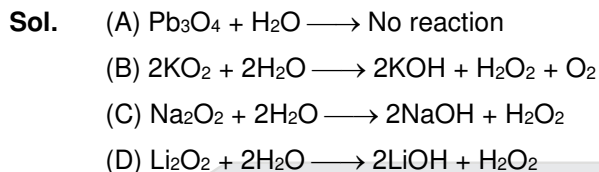
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2. Which of the following liberates O₂ upon hydrolysis?
 (A) Pb₃O₄ (B) KO₂ (C) Na₂O₂ (D) Li₂O₂

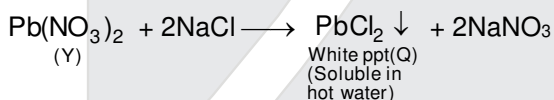
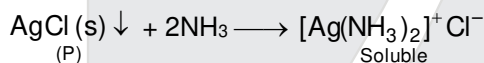
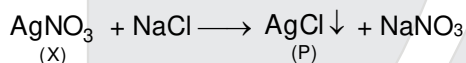
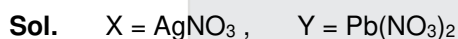
Ans. (B)



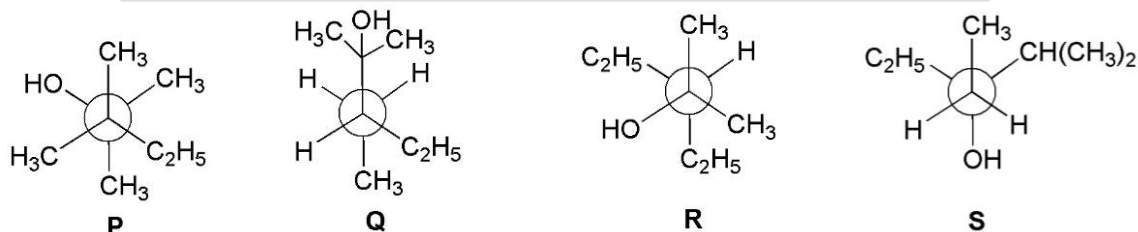
3. A colorless aqueous solution contains nitrates of two metals, X and Y. When it was added to an aqueous solution of NaCl, a white precipitate was formed. This precipitate was found to be partly soluble in hot water to give a residue P and a solution Q. The residue P was soluble in aq. NH₃ and also in excess sodium thiosulfate. The hot solution Q gave a yellow precipitate with KI. The metals X and Y, respectively, are :

- (A) Ag and Pb (B) Ag and Cd (C) Cd and Pb (D) Cd and Zn

Ans. (A)



4. Newman projections P, Q, R and S are shown below:



Which one of the following options represents identical molecules?

- (A) P and Q (B) Q and S (C) Q and R (D) R and S

Ans. (C)

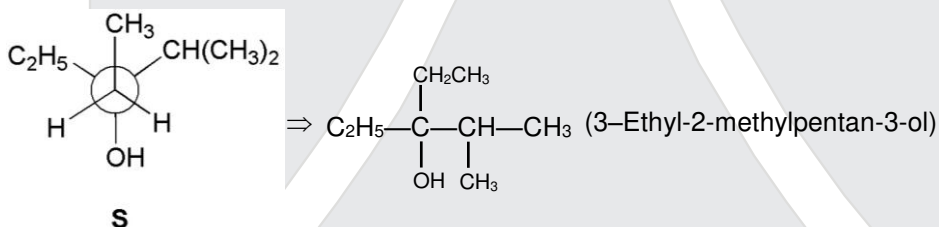
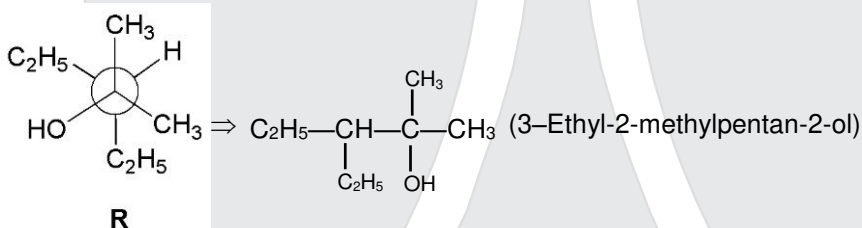
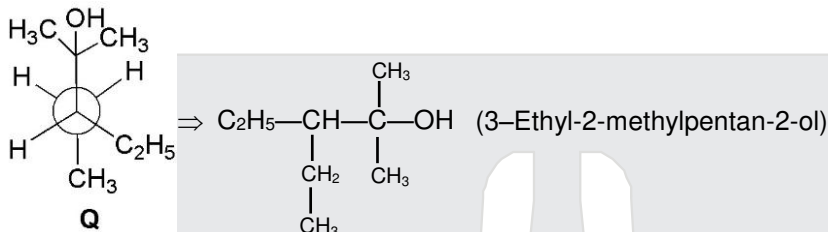
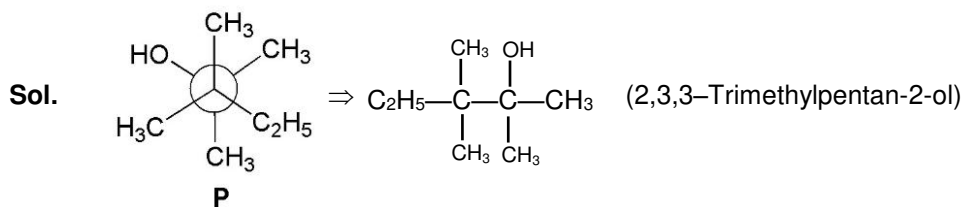
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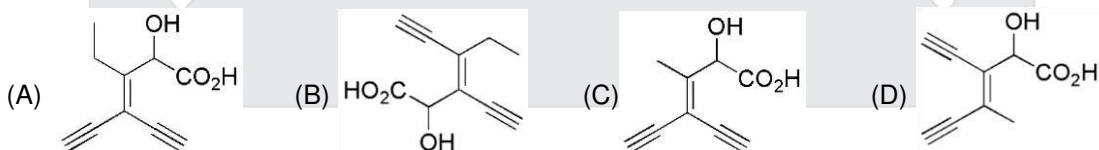
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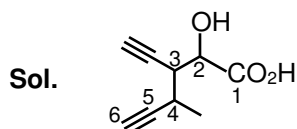
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5. Which one of the following structures has the IUPAC name 3-ethynyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid?



Ans. (D)








3-ethynyl-2-hydroxy-4-methylhex-3-en-5-ynoic acid

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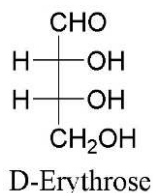
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6. The Fischer projection of D-erythrose is shown below.

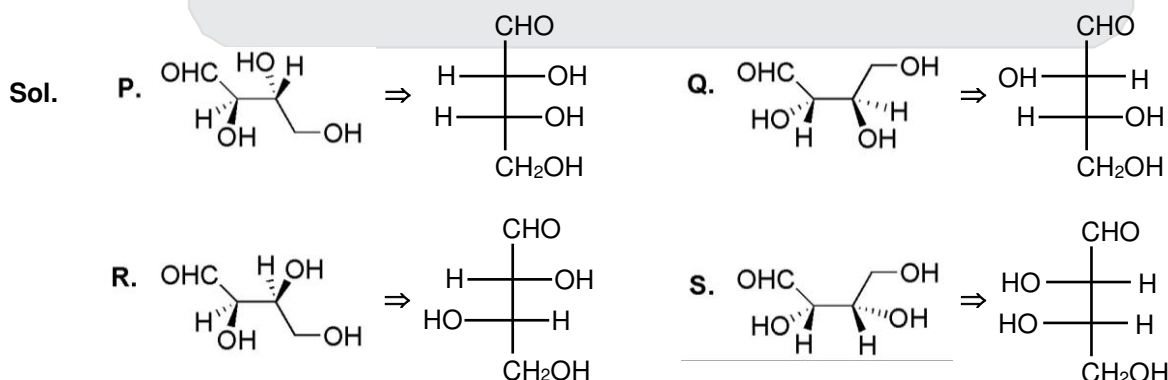


D-Erythrose and its isomers are listed as **P, Q, R,** and **S** in **Column-I**. Choose the correct relationship of **P, Q, R,** and **S** with D-erythrose from **Column II**.

Column-I	Column-II
<p>P. </p>	1. Diastereomer
<p>Q. </p>	2. Identical
<p>R. </p>	3. Enantiomer
<p>S. </p>	

(A) P → 2, Q → 3, R → 2, S → 2 (B) P → 3, Q → 1, R → 1, S → 2
(C) P → 2, Q → 1, R → 1, S → 3 (D) P → 2, Q → 3, R → 3, S → 1

Ans. (C)



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SECTION-2 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options. **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
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Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option.
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered).
Negative Marks : -1 In all other cases.

खंड 2 (अधिकतम अंक: 24)

- इस खंड में छः (06) प्रश्न हैं।
- प्रत्येक प्रश्न के लिए चार विकल्प दिए गए हैं। इन चार विकल्पों में से एक या एक से अधिक विकल्प सही हैं(हैं)।
- प्रत्येक प्रश्न के लिए, दिए हुए विकल्पों में से सही उत्तर (उत्तरों) से संबंधित विकल्प (विकल्पों) को चुनिए।
- प्रत्येक प्रश्न के उत्तर का मूल्यांकन निम्न योजना के अनुसार होगा :
 पूर्ण अंक : +4 यदि केवल (सारे) सही विकल्प (विकल्पों) को चुना गया है।
 आंशिक अंक : +3 यदि चारों विकल्प सही हैं परन्तु केवल तीन विकल्पों को चुना गया है।
 आंशिक अंक : +2 यदि तीन या तीन से अधिक विकल्प सही हैं परन्तु केवल दो विकल्पों को चुना गया है और दोनों चुने हुए विकल्प सही विकल्प हैं।
 आंशिक अंक : +1 यदि दो या दो से अधिक विकल्प सही हैं परन्तु केवल एक विकल्प को चुना गया है और चुना हुआ विकल्प सही विकल्प है।
 शून्य अंक : 0 यदि किसी भी विकल्प को नहीं चुना गया है (अर्थात् प्रश्न अनुत्तरित है)।
 ऋण अंक : -1 अन्य सभी परिस्थितियों में।

7. In thermodynamics, the $P - V$ work done is given by

$$w = - \int dV P_{\text{ext}}$$

For a system undergoing a particular process, the work done is,

$$w = - \int dV \left(\frac{RT}{V-b} - \frac{a}{V^2} \right)$$

This equation is applicable to a

- (A) system that satisfies the van der Waals equation of state.
- (B) process that is reversible and isothermal.
- (C) process that is reversible and adiabatic.
- (D) process that is irreversible and at constant pressure.

Ans. (A, B, C)

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Sol. $W = - \int P_{\text{ext}} dv$

From van der waal equation of state for one mole gas

$$\left(p + \frac{a}{v^2} \right) (v - b) = RT$$

$$p = \left(\frac{RT}{v-b} - \frac{a}{v^2} \right)$$

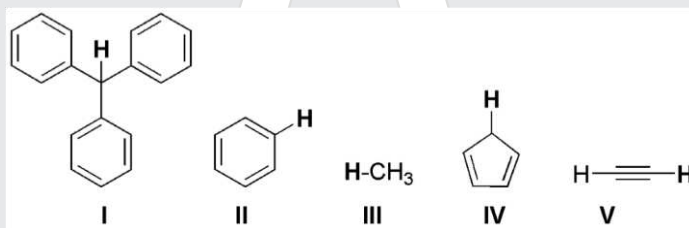
For reversible process

$$p_{\text{ext}} = p_{\text{gas}}$$

$$W = - \int \left(\frac{RT}{v-b} - \frac{a}{v^2} \right) dv$$

process is only not applicable for irreversible process.

8. With respect to the compounds I-V, choose the correct statement(s).



- (A) The acidity of compound I is due to delocalization in the conjugate base.
 (B) The conjugate base of compound IV is aromatic.
 (C) Compound II becomes more acidic, when it has a $-\text{NO}_2$ substituent.
 (D) The acidity of compounds follows the order $\text{I} > \text{IV} > \text{V} > \text{II} > \text{III}$.

Ans. (ABC)

Sol. (A) is stabilised by conjugation

Conjugate base of (I)

(B) Conjugate base of is which is an aromatic anion

(C) $-\text{NO}_2$ group is an electron withdrawing group it increases acidic strength of any compound to which it is added.

(D) The acidic strength order on the basis of pK_a data is $\text{IV} > \text{V} > \text{I} > \text{II} > \text{III}$

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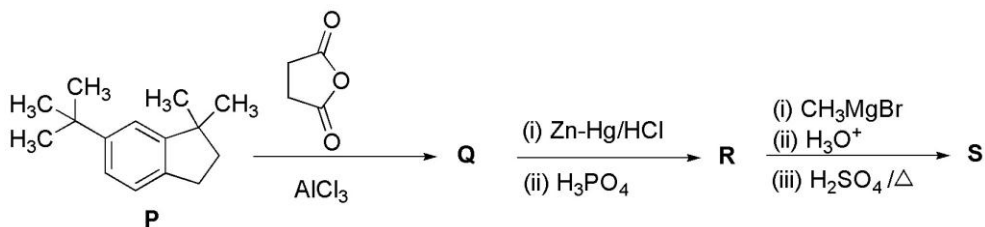
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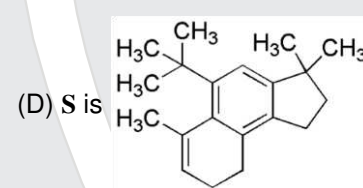
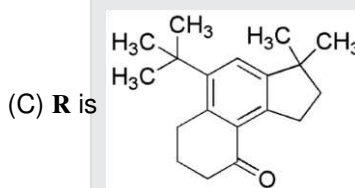
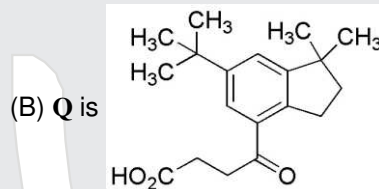
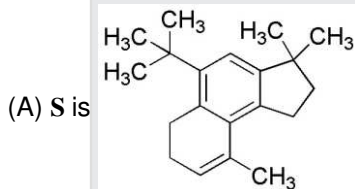
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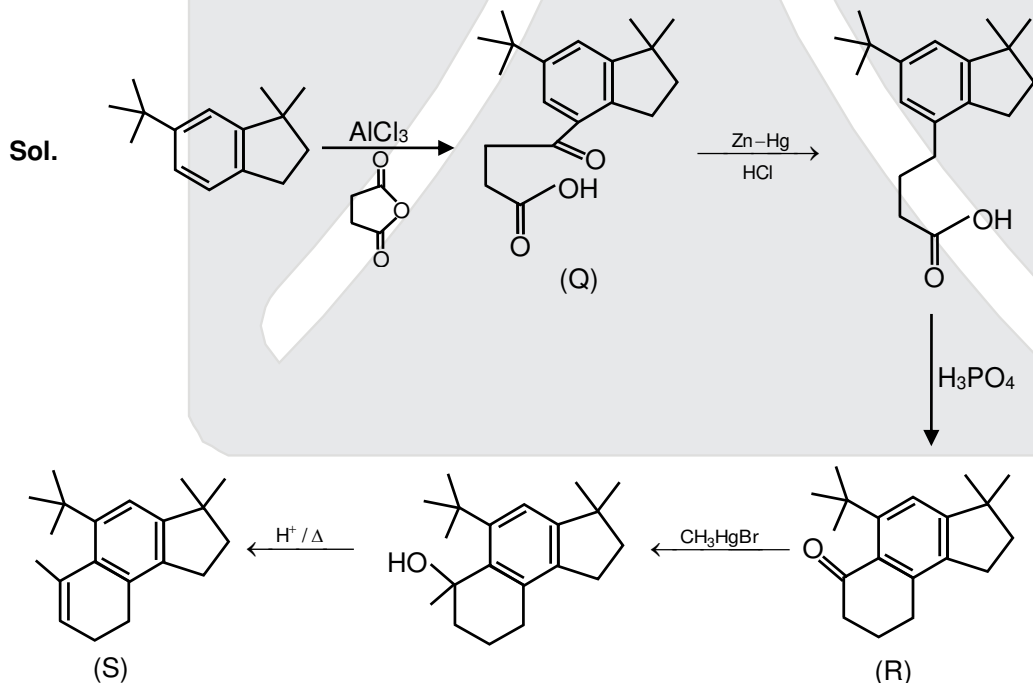
9. In the reaction scheme shown below, Q, R, and S are the major products.



The correct structure of



Ans. (BD)



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10. Choose the correct statement(s) among the following:
- (A) $[\text{FeCl}_4]^-$ has tetrahedral geometry.
 (B) $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$ has 2 geometrical isomers.
 (C) $[\text{FeCl}_4]^-$ has higher spin-only magnetic moment than $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$.
 (D) The cobalt ion in $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$ has sp^3d^2 hybridization.

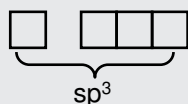
Ans. (AC)

Sol. (A) $[\text{FeCl}_4]^-$

Oxidation number of Fe atom = +3

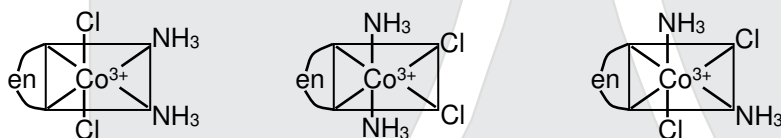
$\text{Fe} \rightarrow 3\text{d}^6 4\text{s}^2$

$\text{Fe}^{3+} \rightarrow 3\text{d}^5 4\text{s}^0 4\text{p}^0$



$\therefore [\text{FeCl}_4]^-$ is having tetrahedral geometry

(B) $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$ have three geometrical isomers.



(C) $[\text{FeCl}_4]^-$ is sp^3 hybridized with 5-unpaired electrons. While $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$ is d^2sp^3 hybridised with zero unpaired electrons.

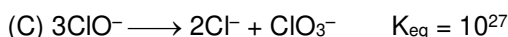
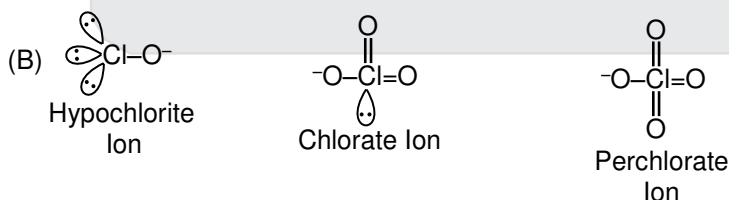
(D) $[\text{Co}(\text{en})(\text{NH}_3)_2\text{Cl}_2]^+$ has d^2sp^3 hybridization.

11. With respect to hypochlorite, chlorate and perchlorate ions, choose the correct statement(s).

- (A) The hypochlorite ion is the strongest conjugate base.
 (B) The molecular shape of only chlorate ion is influenced by the lone pair of electrons of Cl.
 (C) The hypochlorite and chlorate ions disproportionate to give rise to identical set of ions.
 (D) The hypochlorite ion oxidizes the sulfite ion.

Ans. (ABD)

Sol. (A) Since HOCl is weakest oxyacid of chlorine. Therefore ClO^- become strongest conjugate base.

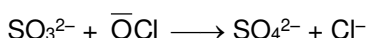


In hot solution rate of disproportionation is fairly rapid.



It is thermodynamically possible but kinetically, it is very slow reaction.

(D) Lower oxyacids are good oxidizing agents.



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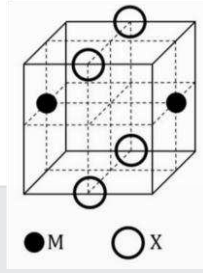
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12. The cubic unit cell contains atoms of two different elements M and X. The atoms of M are located at the corners of the cube and the atoms of X are located at the centers of the edges of the cube. The edge length of the cube is a . The distance between two nearest M atoms is d . The value of d is _____.



दिए गए क्यूबिक इकाई को देखें।

इकाई को देखें।

इकाई को देखें।

इकाई को देखें।

दिए

।

वस

$$M \times \frac{1}{2} + X \times \frac{1}{4} = MX$$

इकाई को देखें।

इकाई को देखें।

इकाई को देखें।

$$d^2 = \left(\frac{a}{\sqrt{2}}\right)^2 + \left(\frac{a}{2}\right)^2$$

$$d^2 = \frac{a^2}{2} + \frac{a^2}{4} = \frac{3a^2}{4}$$

$$\frac{d^2}{a^2} = \frac{3}{4}$$

$$\frac{d}{a} = \frac{\sqrt{3}}{2} = \frac{1.732}{2} = 0.866$$

इकाई को देखें।

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SECTION-3 (Maximum Marks : 18)

- This section contains **SIX (06)** questions. The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme :
Full Marks : +3 If ONLY the correct numerical value is entered.
Zero Marks : 0 In all other cases.

खंड 3 (अधिकतम अंक: 18)

- इस खंड में छः (06) प्रश्न हैं। प्रत्येक प्रश्न का उत्तर एक संख्यात्मक मान (**NUMERICAL VALUE**) है।
- प्रत्येक प्रश्न के उत्तर के सही संख्यात्मक मान को माउज (mouse) और ऑन-स्क्रीन (on-screen) वर्चुअल नुमेरिक कीपेड (virtaul numeric keypad) के प्रयोग से उत्तर के लिए चिन्हित स्थान पर दर्ज करें। यदि संख्यात्मक मान में दो से अधिक दशमलव स्थान है, तो संख्यात्मक मान को दशमलव के दो स्थानों तक **ट्रंकेट/राउंड ऑफ (truncate/round-off)** करें।
- प्रत्येक प्रश्न के उत्तर का मूल्यांकन निम्न योजना के अनुसार होगा :-
 पूर्ण अंक : +3 यदि दर्ज किया गया संख्यात्मक मान (**Numerical value**) ही सही उत्तर है।
 शून्य अंक : 0 अन्य सभी परिस्थितियों में।

13. 5.00 mL of 0.10 M oxalic acid solution taken in a conical flask is titrated against NaOH from a burette using phenolphthalein indicator. The volume of NaOH required for the appearance of permanent faint pink color is tabulated below for five experiments. What is the concentration, in molarity, of the NaOH solution?

Exp. No.	Vol. of NaOH (mL)
1	12.5
2	10.5
3	9.0
4	9.0
5	9.0

Ans. (0.11)

Sol. True data for NaOH used volume = 9 ml

Milli equivalent of $H_2C_2O_4$ = Milli equivalent of NaOH

$$5 \times 0.1 \times 2 = 9 \times x \times 1$$

$$x = \frac{1}{9} = 0.11 \text{ M}$$

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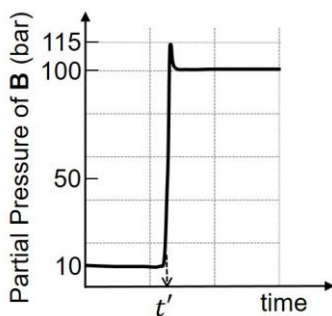
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14. Consider the reaction $A \rightleftharpoons B$ at 1000 K. At time t' , the temperature of the system was increased to 2000 K and the system was allowed to reach equilibrium. Throughout this experiment the partial pressure of A was maintained at 1 bar. Given below is the plot of the partial pressure of B with time. What is the ratio of the standard Gibbs energy of the reaction at 1000 K to that at 2000 K?



Ans. (0.25)

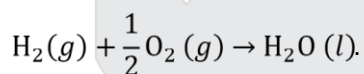
Sol. Use $\Delta G^\circ = -RT \ln K_P$ at equilibrium

$$\Delta G_1^\circ = -RT_1 \ln K_{P1} \quad \dots\dots(1)$$

$$\Delta G_2^\circ = -RT_2 \ln K_{P2} \quad \dots\dots(2)$$

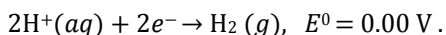
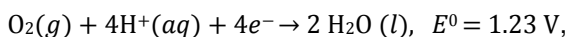
$$\begin{aligned} \frac{\Delta G_1^\circ}{\Delta G_2^\circ} &= \frac{T_1}{T_2} \times \frac{\ln K_{P1}}{\ln K_{P2}} \\ &= \frac{1000}{2000} \times \frac{\ln(10)}{\ln(100)} \\ &= \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = 0.25 \end{aligned}$$

15. Consider a 70% efficient hydrogen-oxygen fuel cell working under standard conditions at 1 bar and 298 K. Its cell reaction is



The work derived from the cell on the consumption of 1.0×10^{-3} mol of $H_2(g)$ is used to compress 1.00 mol of a monoatomic ideal gas in a thermally insulated container. What is the change in the temperature (in K) of the ideal gas?

The standard reduction potentials for the two half-cells are given below.



Use $F = 96500 \text{ C mol}^{-1}$, $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$.






Ans. (13.32)

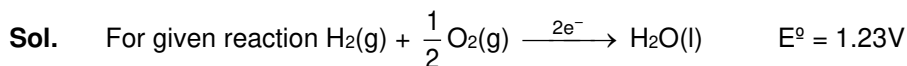
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$$\Delta G^\circ = -nFE^\circ_{\text{cell}} = [-2 \times 96500 \times 1.23] \times 1 \times 10^{-3} \times 0.7 = -166.173 \text{ J}$$

$$W = 166.173 \text{ J}$$

$$W = \frac{nR\Delta T}{\gamma - 1}$$

$$166.173 = \frac{1 \times 8.314 \times \Delta T}{\left(\frac{5}{3} - 1\right)} = \frac{8.314 \times 3}{2} \Delta T$$

$$\Delta T = \frac{166.173 \times 2}{8.314 \times 3} = 13.32$$

16. Aluminium reacts with sulfuric acid to form aluminium sulfate and hydrogen. What is the volume of hydrogen gas in liters (L) produced at 300 K and 1.0 atm pressure, when 5.4 g of aluminium and 50.0 mL of 5.0 M sulfuric acid are combined for the reaction?

(Use molar mass of aluminium as 27.0 g mol^{-1} , $R = 0.082 \text{ atm L mol}^{-1} \text{ K}^{-1}$)

Ans. (06.15)



$$\frac{5.4}{27} \qquad \frac{50 \times 5}{1000}$$

= 0.2 mole = 0.25 mole

(Limiting reagent)

∴ 0.25 mole H_2 is formed

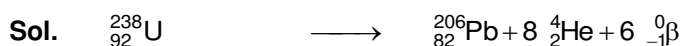
$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{0.25 \times 0.082 \times 300}{1 \text{ atm}}$$

$$= 6.15 \text{ litre}$$

17. $^{238}_{92}\text{U}$ is known to undergo radioactive decay to form $^{206}_{82}\text{Pb}$ by emitting alpha and beta particles. A rock initially contained $68 \times 10^{-6} \text{ g}$ of $^{238}_{92}\text{U}$. If the number of alpha particles that it would emit during its radioactive decay of $^{238}_{92}\text{U}$ to $^{206}_{82}\text{Pb}$ in three half-lives is $Z \times 10^{18}$, then what is the value of Z ?

Ans. (1.2)



$$0.286 \times 10^{-6} \text{ mole}$$

$$[0.286 \times 10^{-6} \times N_a]$$

$$= 0.286 \times 6.02 \times 10^{17}$$

$$= 1.72 \times 10^{17}$$

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After 3 Half lives

$$N = \frac{N_0}{(2)^3} = \frac{1.72 \times 10^{17}}{8}$$

$$= 0.215 \times 10^{17}$$

So, no. of molecule of uranium decayed

$$= [1.72 - 0.215] \times 10^{17}$$

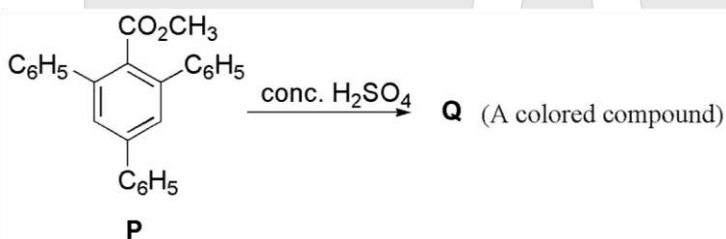
$$= 1.5 \times 10^{17}$$

So No. of α particle produced = $8 \times 1.5 \times 10^{17}$

$$= 12 \times 10^{17}$$

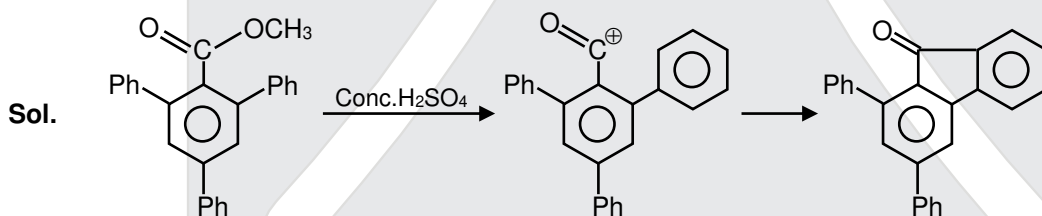
$$= 1.2 \times 10^{18}$$

18. In the following reaction, compound Q is obtained from compound P via an ionic intermediate.



What is the degree of unsaturation of Q?

Ans. (18)



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(SC: AIR-4, 8 & 10 | ST: AIR-9)

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