ONE SHOT

HYDROGEN

#BOUNCEBACK

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BounceBack

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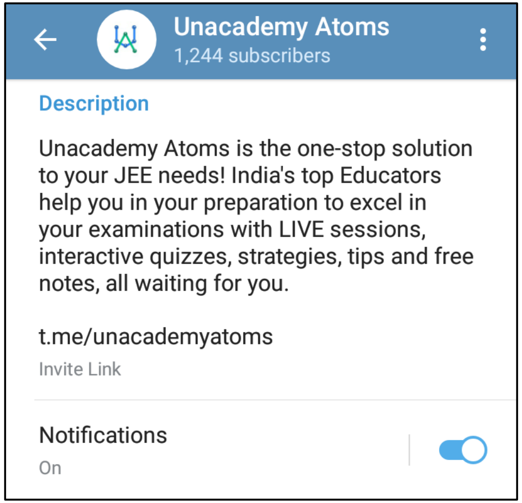

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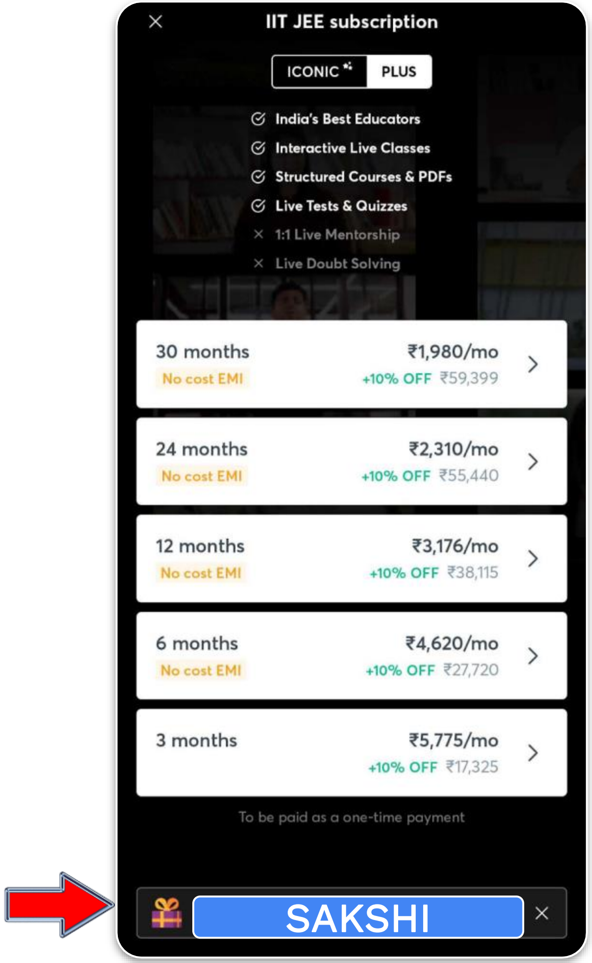
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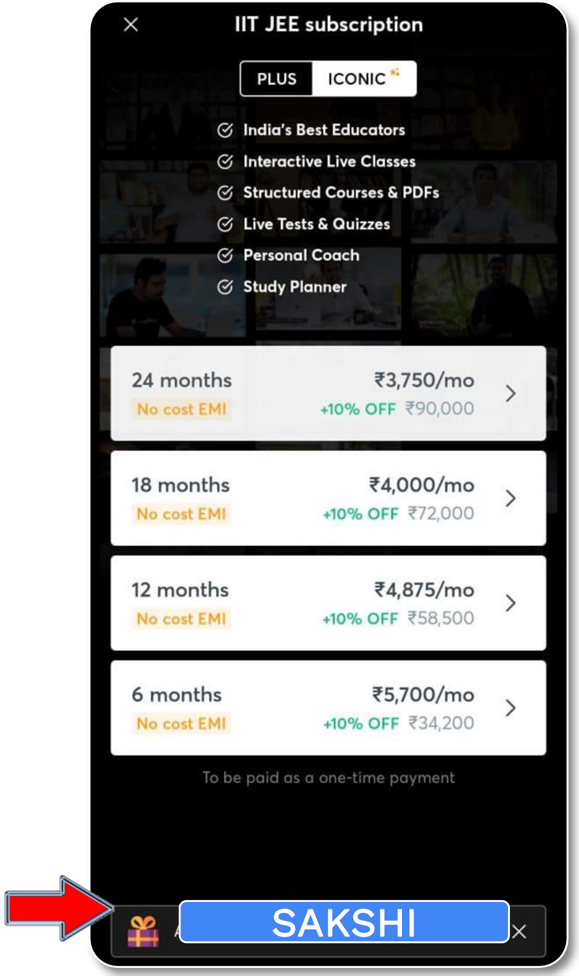
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Introduction

Isotopes of Hydrogen

	Protium	Deuterium	Tritium
	Ordinary hydrogen	Heavy hydrogen	Radioactive
Representation	$^{1}_{1}H$	$^{2}_{1}D$	$^{3}_{1}T$
Neutrons	0	1	2
Occurrence	99.98%	0.16%	10^{-15} %

Hydrogen has three isotopes (A), (B) and (C). If the number of neutron(s) in (A), (B) and (C) respectively, are (x), (y) and (z), the sum of (x), (y) and (z) is :

A. 3

B. 2

C. 4

D. 1

H D T

$n = 0 + 1 + 2 = 3$

[Jan. 08, 2020 (II)]

The total number of isotopes of hydrogen and number of radioactive isotopes among them, respectively, are :

A. 3 and 1

B. 3 and 2

C. 2 and 1

D. 2 and 0

[Jan. 10, 2019 (I)]

Properties of Hydrogen

Bond energy and reactivity

The bond energy of H - H bond is least and hence it is most reactive among the isotopes of hydrogen.

Bond energy $H_2 < D_2 < T_2$ ✓

Reactivity $H_2 > D_2 > T_2$

$Rxn + H_2 \longrightarrow$

$Rxn + D_2 \longrightarrow$

This difference in the properties of isotopes which arises due to large difference in their atomic masses or molecular masses is called as **isotopic effect**.

$Rxn + T_2 \longrightarrow$

Properties :

(i) Atomic hydrogen is highly **unstable** (half life - 0.3 second).

(ii) It combines readily with non metals : like S, P, As, Sb, Bi, O_2 and halogens forming corresponding hydride, H_2O and hydracids respectively.

SV ① $CuO + 2H \longrightarrow Cu + H_2O$

SV ② $AgCl + H \longrightarrow Ag + HCl$

$CuO + H \longrightarrow$

Methods of Preparation

By action of water with metals.

(a) Active metals like Na, K react at room temperature.

③ $2M + 2H_2O \longrightarrow 2MOH + H_2$

(a) Less active metals like Ca, Zn, Mg, Al liberate hydrogen only on heating

④ $2Al + 3H_2O \longrightarrow Al_2O_3 + 3H_2$

metal cation

anion

Lane's Process :

In this process, **steam** is passed over **hot iron.** Iron decomposes steam with the formation of **magnetic oxide (Fe_3O_4) and hydrogen.** The temperature of iron is maintained between **550 to 800°C**. This reaction is termed **gassing reaction** and time allotted for this reaction is about 10 minutes.

$$\boxed{3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2}$$

red hot भाप

5

By reaction of metals like Zn, Sn, Al with alkalies.

Si

6 $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

7 $Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$

8 $Si + 2NaOH + H_2O \longrightarrow Na_2SiO_3 + 2H_2$

acidic base salt

9 $SnO_2 + NaOH \longrightarrow Na_2SnO_3 + H_2$

Sodium stannate

$SiO_2 + NaOH \longrightarrow Na_2SiO_3 + H_2$

By action of metals with acids.

All active metals which lie above hydrogen in electrochemical series, can displace hydrogen gas from dilute mineral acids.

10 $Fe + 2HCl \rightarrow FeCl_2 + H_2$

11 $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

12 $Zn + \text{dil. } H_2SO_4 \rightarrow ZnSO_4 + H_2$

By electrolysis of water

$$H_2O \xrightarrow{\text{electricity}} \underset{\text{(cathode)}}{H^+} + \underset{\text{(Anode)}}{OH^-}$$

At cathode: $H^+ + e^- \rightarrow 1/2\, H_2 \uparrow$

12.

H^+

$\overline{O}H$

Cathode $\ominus$ $2H^+ + 2e^- \longrightarrow H_2$

$H^+ + e^- \longrightarrow \frac{1}{2} H_2$

$H^+ + e^- \longrightarrow H$

$H + H \longrightarrow H_2$

Preparation of pure H_2

Preparation of pure hydrogen.

14

× **A. The action of pure dil. H_2SO_4 on pure magnesium ribbon.**

$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

A. The electrolysis of a solution of barium hydroxide using nickel

15 **electrodes gives extra pure hydrogen.** 99.98% $Ba(OH)_2$ aq

B. By the action of water on NaH. $+ H - OH$

16 $NaH + H_2O \longrightarrow NaOH + H_2$

× **A. Very pure form of hydrogen is obtained by the action of KOH**

17 **on scrap aluminum**

$$\boxed{2Al + 2KOH + 2H_2O \longrightarrow} 2KAlO_2 + 3H_2\uparrow$$

Industrial Preparation

Bosch process

In this method **water gas is mixed with steam** and passed over heated **catalytic mixture of Fe_2O_3 and Cr_2O_3 at 773 K** when CO_2 and H_2 are obtained. The mixture is compressed to 25 atmospheric pressure and passed into water, CO_2, dissolves while H_2 is set free.

18 $C + H_2O \xrightarrow{\boxed{1270K}} \underset{\text{water gas}}{\boxed{CO + H_2}}$ Water gas

19 $\underset{\text{water gas}}{H_2 + CO} + \underset{\text{steam}}{H_2O} \xrightarrow[Fe_2O_3.Cr_2O_3]{773K} CO_2 + 2H_2$

Watergas shift rxn

20 $\boxed{CO + H_2} \longrightarrow CH_3OH$

Syn gas

synthesis gas

Coal Gasification

Dihydrogen of high purity (> 99.95%) is obtained through:

A. the reaction of Zn with dilute HCl.

B. the electrolysis of acidified water using Pt electrodes.

C. the electrolysis of brine solution.

D. the electrolysis of warm $Ba(OH)_2$ solution using Ni electrodes.

[Sep. 06, 2020 (II)]

The equation that represents the water-gas shift reaction is :

A. $CH_4(g) + H_2O(g) \xrightarrow[Ni]{1270K} CO(g) + 3H_2(g)$

B. $2C(s) + O_2(g) + 4N_2(g) \xrightarrow{1273K} 2CO(g) + 4N_2(g)$

C. $C(s) + H_2O(g) \xrightarrow{1270K} CO(g) + H_2(g)$

D. $CO(g) + H_2O(g) \xrightarrow[Catalyst]{673K} CO_2(g) + H_2(g)$

[Sep. 05, 2020 (I)]

CO, H_2

$\downarrow H_2O$

$CO_2 + H_2$

5g of zinc is treated separately with an excess of
(A) Dilute hydrochloric acid and
(B) Aqueous sodium hydroxide.
The ratio of the volumes of H_2 evolved in these two reactions is :

A. 1 : 2

B. 1 : 1

C. 1 : 4

D. 2 : 1

$$\underset{5g}{Zn} + \underset{\text{excess}}{2HCl} \longrightarrow ZnCl_2 + H_2$$

$$\underset{5g}{Zn} + \underset{\text{excess}}{2NaOH} \longrightarrow Na_2ZnO_2 + H_2$$

1 1

[Jan. 09, 2020 (II)]

The metal that gives hydrogen gas upon treatment with both acid as well as base is :

A. magnesium

B. mercury

C. zinc

D. iron

[April 12, 2019 (I)]

The synonym for water gas when used in the production of methanol is :

A. Natural gas

B. Fuel gas

C. Laughing gas

D. Syn gas

[April. 10, 2019 (I)]

Physical Properties

Physical Properties :

1. Hydrogen is **colourless, odourless and tasteless gas.** $\boxed{CO_2 + H_2}$ H_2O
2. It is **sparingly soluble** in water.
3. It is **adsorbed** (occluded) by certain metals like Fe, Au, Pt and Pd. Palladium in the powdered state can occlude nearly 1000 times its own volume of hydrogen.

hydrogenation

Chemical Properties

Chemical Properties :

H_2

1. **Reactions of hydrogen are slow at room temperature but rapid at high temperatures.**
2. It is neutral towards litmus.
3. It is combustible and burns in air or oxygen with nearly **invisible pale blue flame.**

ही

$$2H_2 + O_2 \rightarrow \boxed{2H_2O}$$

1. **Reducing property.** When hydrogen is passed over heated metallic oxides, the latter are reduced to the respective metal.

$$CuO + H_2 \longrightarrow Cu + H_2O$$

3. **Reaction with metals and non - metals.** It combines with strongly electropositive metals (active metals) like Li, Na and Ca to form corresponding hydrides.

22 $$2\overset{0}{Na} + \overset{0}{H_2} \longrightarrow 2\overset{+1}{Na}\overset{-1}{H}$$

It combines with N, C, O, halogens, S, etc. Under suitable conditions form NH_3, CH_4, H_2O, HX and H_2S respectively.

4. **Reaction with unsaturated compounds.** Hydrogen adds on the Double and triple bond in the presence of finely divided Ni to form saturated compounds.

23 $$\underset{\text{Ethylene}}{CH_2=CH_2} + H_2 \xrightarrow{Ni} \underset{\text{Ethane}}{CH_3-CH_3}$$

Hydrides

Ionic or Saline Hydrides :

Ionic hydrides or salt - like hydrides.

- The compounds of Hydrogen with more electropositive metals like alkali metals and alkaline earth metals are ionic hydrides.
- They are formed by transfer of electron from metal to hydrogen.

$$Na + H_2 \longrightarrow \overset{+}{Na}\overset{-}{H}$$

$$\underset{0}{Ca} + \underset{0}{H_2} \longrightarrow Ca^{2+} H^{-}$$

$$CaH_2$$

Ionic or Saline Hydrides :

a. They are crystalline solids.

b. They have high melting and boiling points.

c. They conduct electricity in molten state

d. They react with water and release hydrogen gas and thus act as powerful reducing agents.

$$NaH + H_2O \longrightarrow NaOH + H_2$$

$\overset{+}{Na}\overset{-}{H} \quad \overset{+}{H}\overset{-}{OH}$

Ionic or Saline Hydrides :

a. They are crystalline solids.

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$NaH + H_2O \longrightarrow NaOH + H_2$

The thermal stability decreases with increasing size of cations.

Thus LiH > NaH > KH > RbH > CsH > CaH_2 >> SrH_2 > BaH_2

Covalent or Molecular Hydrides :

The compounds of hydrogen with more electronegative elements or ‘p’ Block elements are **covalent or Molecular hydrides.**

$Na^{+}H^{-}$ — Na^{+} — H^{-}

For example : HCl, H_2O, CH_4, PH_3 etc. NH_3

H_2O .. H_2O

a. They are generally soft, with less melting and boiling points.

b. They are poor conductors of electricity

c. They release hydrogen on decomposition and thus act as reducing agents.

Q4

d. Some of them react with water and release hydrogen gas.

$$B_2H_6 + 6H_2O \longrightarrow 2B(OH)_3 + 6H_2 \uparrow$$

P-block elements

Interstitial hydrides or Metallic Hydrides :

The hydrogen atoms occupy the interstitial spaces of transition elements and hence they are interstitial hydrides. They are **nonstoichiometric** in nature.

solid state

Na^+H^-

NaH is an example of :

A. Electron - rich hydride

B. Metallic hydride

C. Saline hydride

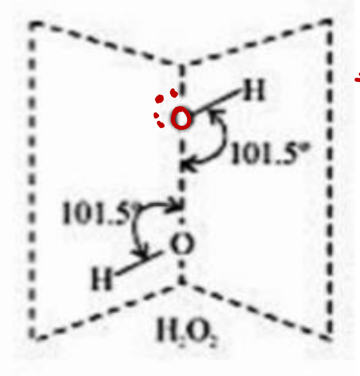
D. Molecular hydride

[Jan. 11, 2019 (I)]

Hydrogen Peroxide

Structure :

The H_2O_2 molecules is not planar but described as open book structure. The O-O-H bond angle is found to be nearly 101.5. The O-O single bond distance in H_2O_2 is 1.48 A.



~~109°28'~~

~~107~~

$\boxed{104.5°}$

Preparation of Hydrogen Peroxide

Methods of preparation

(25) 1. $\boxed{\text{Merck's Method}}$: Na_2O_2 is gradually added to 20% ice cold H_2SO_4 ×

$$Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$$

(26) 1. **By the action of CO_2 on an ice cold paste of BaO_2**

$$BaO_2 + H_2O + CO_2 \longrightarrow BaCO_3\downarrow + H_2O_2$$

(27) 1. **By the action of phosphoric acid on BaO_2**

$$3BaO_2 + 2H_3PO_4 \longrightarrow Ba_3(PO_4)_2\downarrow 3H_2O_2$$

$Ba^{2+} O_2^{2-}$

O^{2-} oxide

$\bar{\bar{O}}-\bar{\bar{O}}$ O_2^{2-} Peroxide

O_2^- superoxide

Na_2O_2 $2Na^+$ O_2^{2-}

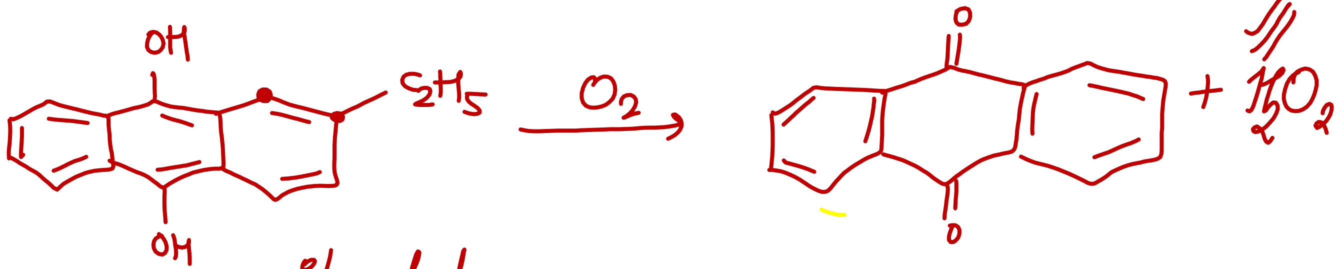
$Na^+ O_2^{2-}$

Na_2O_2

Auto oxidation of 2 - Ethylanthraquinol :

Air is bubbled in 10% solution of 2 - Ethylanthraquinol in benzene 2 - Ethylanthraquionone obtained is reduced back to 2 - Ethylanthraquinol. The solution is concentrated by reduced pressure distillation to get 20% H_2O_2.

Q/28



10% solution

Strength of Hydrogen Peroxide

$\% \frac{m}{m}$

$\% \frac{m}{v}$

$\% \frac{v}{v}$

M

m

N

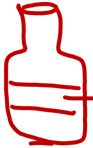
Strength of hydrogen peroxide solution :

ok

A. **Percentage strength** : It expresses the **amount of H_2O_2 by weight present in 100 ml of the solution.** For example, a **30% aqueous solution (w/v) of H_2O_2** means 30 g of hydrogen peroxide is present in 100 ml of the solution.

10V 10volume H_2O_2 1ml $H_2O_2 \xrightarrow{\Delta} H_2O + O_2$

B. **Volume strength** : The **volume (in ml) of oxygen liberated at N. T. P. by the decomposition of 1 ml of the at sample of hydrogen peroxide.**



$\boxed{30\%\ H_2O_2}$ — 100ml solution $H_2O_2 = 30g$

The volume strength of 8.9 M H_2O_2 solution calculated at 273 K and 1 atm is _ . (R = 0.0821 L atm K^{-1} mol $^{-1}$) (rounded off to the nearest integer)

H_2O_2

8.9M

273K

1 atm

R = 0.0821 l atm K^{-1} mol^{-1}

[Sep. 03, 2020 (I)]

$$M = \frac{V.S}{11.2}$$

$8.9 \times 11.2 = V.S$

$\boxed{100}$ ✓

The strengths of 5.6 volume hydrogen peroxide (of density 1 g/mL in terms of mass percentage and molarity (M), respectively, are :
(Take molar mass of hydrogen peroxide as 34 g/ mol)

A. ~~1.7 and 0.5~~

B. 0.85 and 0.25

C. 1.7 and 0.25

D. 0.85 and 0.5

[Sep. 03, 2020 (II)]

H_2O_2
$d = 1 g/mL$
$VS = 5.6 V$

$M = ?$

$\% \frac{m}{m}$

$M = \frac{VS.}{11.2} = \frac{5.6}{11.2} = 0.5 M.$

$\% \frac{m}{m} = \frac{m_{solute}}{m_{solution}} \times 100$

$\left(\frac{34 \times 0.5}{1000 g} \times 100 \right)$

$M = 0.5 M$

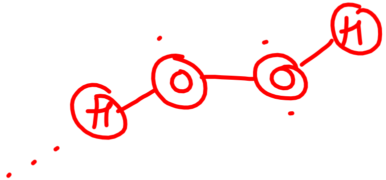
0.5 moles of H_2O_2 in 1 l solution

1000 mL solution
1000 g

Properties of Hydrogen Peroxide

Physical Properties :

1. Pure hydrogen peroxide is a thick syrupy liquid with **pale blue** colour.
2. It has a **bitter taste.**
3. Hydrogen peroxide is **more dense** (1.44g/cm³) and **more viscous** than water. This is due to the reason that the molecules of H_2O_2 are even more highly associated through H - Bonds than H_2O molecules.



Chemical Properties :

livedaily me/atoms

1. **Decomposition :** Pure hydrogen peroxide is an unstable liquid and decomposes into water and oxygen on long standing or heating.

$$2H_2O_2 \longrightarrow 2H_2O + O_2 ; \Delta H = -196.0 \text{ kJ}$$

1ml

O–O vs

$$\overset{-1}{H_2O_2} \longrightarrow \overset{-2}{H_2O} + \overset{0}{O_2}$$

It is an example of **auto - oxidation and auto - reduction.**

The decomposition is further accelerated by the presence of certain metal ions (e.g Fe²), metal powders (Co,Au,Ag,Pt etc.), and metal oxides (e.g. MnO_2). Even carbon, rough surfaces and light also catalyse its decomposition.

Oxidising character :

Hydrogen peroxide acts as an oxidising agent both in acidic as well as in alkaline medium.

In acidic medium : $H_2O_2 + 2H^+ + 2e^- \longrightarrow 2H_2O$

In basic medium : $H_2O_2 + OH^- + 2e^- \rightarrow 3\ OH^-$

29 H_2O_2 OA acidic $H_2O_2 \longrightarrow H_2O$

30 Basic $H_2O_2 \longrightarrow \bar{O}H$

It oxidises acidified ferrous sulphate to ferric sulphate :

$$H_2O_2 \rightarrow H_2O + [O]$$

$$2FeSO_4 + H_2SO_4 + [O] \rightarrow Fe_2(SO_4)_3 + H_2O$$

$\rightarrow \gamma$

31 $2FeSO_4 + H_2SO_4 + H_2O_2 \rightarrow Fe_2(SO_4)_3 + 2H_2O$

+2 acidic

$FeSO_4 + H_2SO_4 + H_2O_2 \longrightarrow Fe^{3+} + H_2O$

Fe^{2+}

$Fe_2(SO_4)_3$

It liberates iodine form acidified potassium iodide solution :

$$H_2O_2 \rightarrow H_2O + [O]$$

$$2KI + H_2SO_4 + [O] \rightarrow K_2SO_4 + I_2 + H_2O$$

32 $$2KI + H_2SO_4 + H_2O_2 \rightarrow K_2SO_4 + 2H_2O + I_2$$

$$K\overset{-1}{I} + \underbrace{H_2SO_4}_{\text{acidic}} + \underbrace{H_2O_2}_{\text{OA}} \longrightarrow I_2 + H_2O$$

Reducing character :

In presence of strong oxidising agents, hydrogen peroxide behaves as a reducing agent both in acidic as well as alkaline medium. In all these reactions, molecular oxygen is always produced by the combination of H_2O_2 with the oxygen atom released by the strong oxidising agent :

$$H_2O_2 + [O] \rightarrow H_2O + O_2$$

33 Acidic medium $H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$

34 Alkaline medium $H_2O_2 + 2OH^- \rightarrow 2H_2O + O_2 + 2e^-$

H_2O_2 RA

acidic. $H_2O_2 \longrightarrow O_2$

Basic. $H_2O_2 \longrightarrow O_2 + H_2O$

It reduces acidified potassium permanganate solution. As a result of this reaction, the pink color of $KMnO_4$ disappears.

$$KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$H_2O_2 + [O] \rightarrow H_2O + O_2] \times 5$$
$$2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$$

35

$$H^+ + H_2O_2 + K\overset{+7}{Mn}O_4 \longrightarrow O_2 + Mn^{2+}$$

Bleaching Action :

The bleaching action of hydrogen peroxide is due to the nascent oxygen which it liberates on decomposition.

36 $H_2O_2 \longrightarrow H_2O + [O]$

The nascent oxygen combines with colouring matter which, in turn, gets oxidised. It is used for the bleaching of delicate materials like ivory, feather, silk, wool etc.

Colouring matter + [O] $\longrightarrow$ Colourless matter.

Hydrogen peroxide, in the pure state, is :

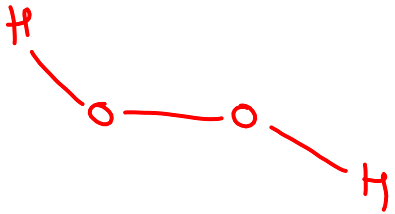
A. non - planar and almost colorless

B. Linear and blue in color

C. Linear and almost colorless

D. Planar and blue in color

[Sep. 05, 2020 (II)]



The chemical nature of hydrogen peroxide is :

A. Oxidising agent in acidic medium, but not in basic medium.

B. Reducing agent in basic medium, but not in acidic medium.

C. Oxidising and reducing agent in acidic medium, but not in basic medium.

D. Oxidising and reducing agent in both acidic and basic medium.

[Jan. 10, 2019 (I)]

Hard and Soft Water

Hard water & Soft water :

$C_{17}H_{35}COO^-Na^+$ — Ca^{2+} — $\boxed{(C_{17}H_{35}COO)_2Ca}$ (↓)

A water is said to be a soft water if it produces sufficient lather with the soap

Water is hard if it forms an insoluble scum before it forms a lather with soap.

The hardness of natural water is generally caused by presence of the **bicarbonates and sulphates** of calcium and magnesium.

Soap
Sod/pot salt of long chain fatty acids

(37) $2C_{17}H_{35}COONa + CaCl_2 \longrightarrow (C_{17}H_{35}COO)_2Ca\downarrow + 2NaCl$

Sodium stearate (Sodium soap) — (Hardness) — Calcium stearate (insoluble)

(38) $2C_{17}H_{35}COONa + MgSO_4 \longrightarrow (C_{17}h_{35}COO)_2Mg\downarrow + Na_2SO_4$

Magnesium stearate

Temporary hardness :

This is due to the presence of **bicarbonates of calcium and magnesium.**
Temporary hardness in water is easily removed by boiling, as the bicarbonates decompose readily and the insoluble carbonates are precipitated.

(29) $Ca(HCO_3)_2 \xrightarrow[\Delta]{Boil} \underset{(Insoluble)}{CaCO_3} + H_2O + CO_2$ (↓)

(40) $Mg(HCO_3)_2 \xrightarrow[\Delta]{Boil} \underset{(Insoluble)}{MgCO_3} + H_2O + CO_2$ (↓)

$Mg(OH)_2$

$Ca^{2+}(HCO_3^-) \xrightarrow{\Delta} \boxed{CaCO_3}$ (↓)

Ca^{2+} free + soap

Clark's method

Temporary hardness can also be removed by Clark's process which involves the addition of slaked lime $[Ca(OH)_2]$.

Ca^{2+}

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 + 2H_2O$$

It is essential to add only the calculated amount of $Ca(OH)_2$ because excess will cause artificial hardness.

CaO Quick lime

$\downarrow H_2O$ slaking

$Ca(OH)_2$ slaked lime

Permanent Hardness :

Permanent hardness is introduced when water passes over rocks containing the **sulphates or chlorides of both of calcium and magnesium.**

This type of hardness cannot be removed by boiling or by the addition of slaked lime.

The substances used to remove that hardness of water are known as water softeners.

Washing Soda :

It removes both the temporary and permanent hardness by converting soluble calcium and magnesium compounds into insoluble carbonates.

42 $CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$

43 $CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$

Permanent

44 $Ca(HCO_3)_2 + Na_2CO_3 = \underset{\text{(Insoluble)}}{CaCO_3} + \underset{\text{(Soluble)}}{2NaHCO_3}$

Ca^{2+}, Mg^{2+}

Permutit : Zeolites.

Cation exchanger

Permutit is the technical name given to certain **hydrated silicates of aluminium and sodium.** The sodium ions of permutit are exchanged with calcium and magnesium ions when hard water is passed through it.

(3) $Na_2Al_2Si_2O_8 . xH_2O + Ca^{2+} \longrightarrow CaAl_2Si_2O_8.xH_2O + 2Na^+$

or $MgAl_2Si_2O_8.xH_2O$ or

Pure.

These ions can be re-exchanged by treating it with brine (NaCl) solution.

(4b) $CaAl_2Si_2O_8. xH_2O + 2NaCl \longrightarrow Na_2Al_2Si_2O_8.xH_2O + CaCl_2$

This method is useful for the removal of both temporary and permanent hardness of water.

Calgon :

It is a complex salt of metaphosphoric acid, **sodium hexametaphosphate** $(NaPO_3)_6$, is known as calgon. It is represented as $\mathbf{Na_2[Na_4(PO_3)_6]}$.

48

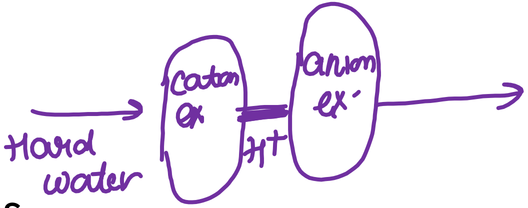
$$2CaSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Ca_2(PO_3)_6] + 2Na_2SO_4$$

$$2MgSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Mg_2(PO_3)_6] + 2Na_2SO_4$$

48

$Na_2[Na_4(PO_3)_6]$

Ion exchange resins :



- These resins are synthetic substances.
- The cation exchanger consists of granular insoluble organic acid resin having giant molecules with $-SO_3H$ or $-COOH$ groups
- The anion exchanger contains giant organic molecules with basic groups derived from amines.
- Ion exchange resins remove all soluble minerals from water.
- The hard water is first passed through a bed of cation exchanger, which removes the cations like Na^+, Mg^{2+}, Ca^{2+} and others by exchanging with H^+ ions.

$R-H + Ca^{2+}$

$\downarrow$

$2H^+ + \boxed{R_2Ca}$

49

$$2RH + Ca^{2+} \longrightarrow (R)_2Ca + 2H^+$$

Cation exchanger

Insoluble organic acid

RH / R-SO_3H / RCOOH

Ion exchange resins :

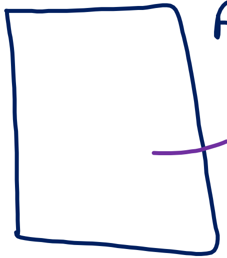
- The water coming from cation exchanger is acidic on account of free H^+ ions.
- This water is then passed through another bed containing anion exchanger
- This exchanger removes anions like Cl^-, $SO^{2}{}_4^-$, NO^-_3 by exchanging with OH^- ions.

50 $R - NH_4OH + Cl^- \rightarrow R- NH_4Cl + OH^-$

$R-N\overset{+}{H_3}\overline{OH} + \overline{Cl} \rightarrow R\overset{+}{NH_3}Cl^- + \overline{OH}$

The OH^- ions neutralise the H^+ions

51 $H^+ OH = H_2O$



Anion exchanger

$R-N\overset{+}{H_3}\overline{OH}$

The one that is NOT suitable for the removal of permanent hardness of water is :

[Sep. 05, 2020 (II)]

A. Clark's method

B. Ion - exchange method

C. Calgon's method

D. Treatment with sodium carbonate

The temporary hardness of water is due to :

A. Na_2SO_4

B. $NaCl$

C. $Ca(HCO_3)_2$

D. $CaCl_2$

[Jan. 9, 2019 (II)]

The temporary hardness of a water sample is due to compound X. Boiling this sample converts X to compound Y. X and Y, respectively, are:

[April. 12, 2019 (II)]

A. $Mg(HCO_3)_2$ and $Mg(OH)_2$

B. $Ca(HCO_3)_2$ and ~~$Ca(OH)_2$~~ $CaCO_3$

C. $Mg(HCO_3)_2$ and $MgCO_3$

D. $Ca(HCO_3)_2$ and CaO

Qual

$\boxed{K_{sp}}$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} Mg(OH)_2 (\downarrow)$$

$$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 (\downarrow)$$

In comparison to the zeolite process for the removal of permanent hardness, the synthetic resins method is :

[Jan. 07, 2020 (I)]

A. Less efficient as it exchanges only anions

B. more efficient as it can exchange both cations as well as anions.

C. Less efficient as the resins cannot be regenerated

D. More efficient as it can exchange only cations

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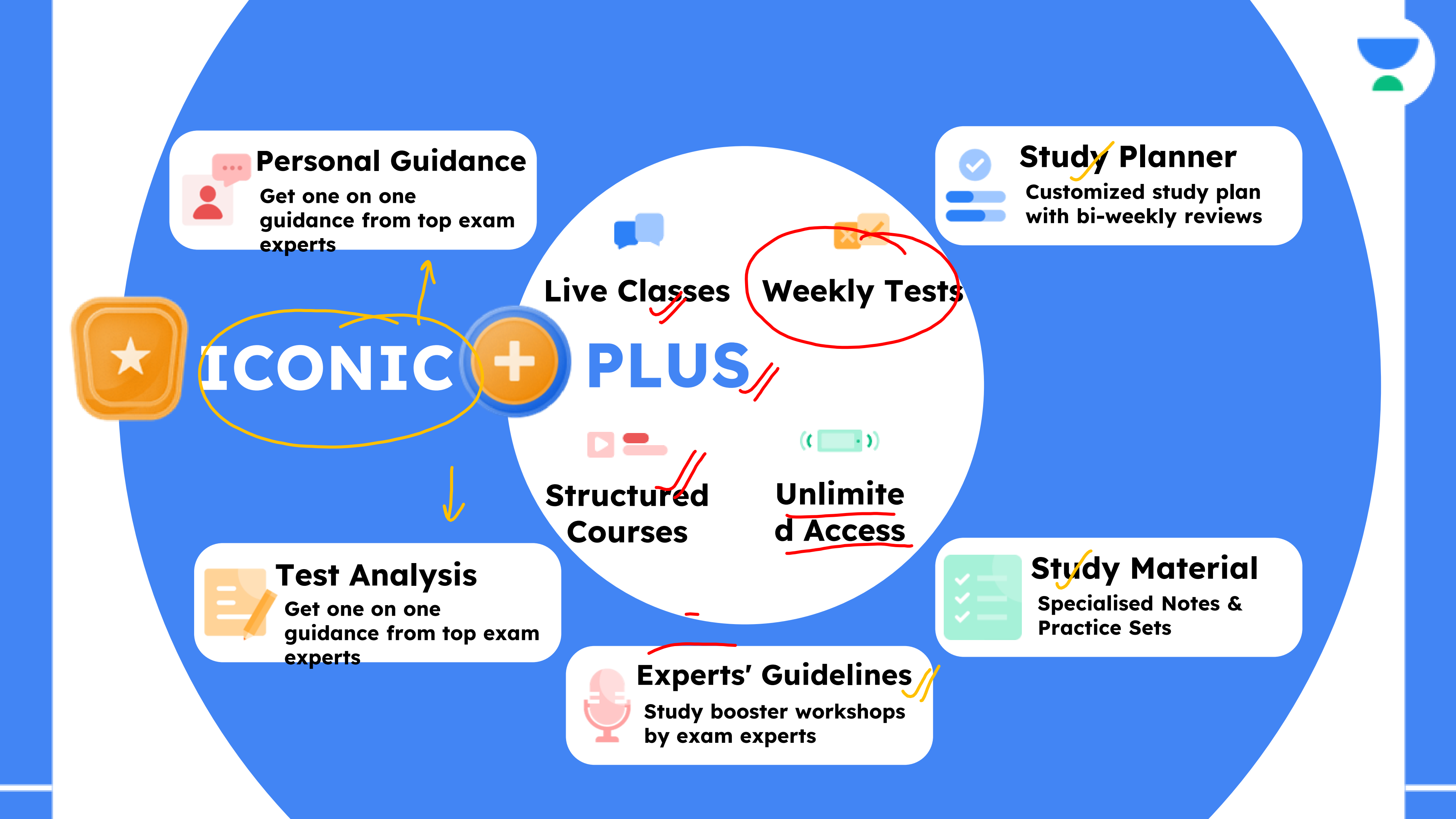
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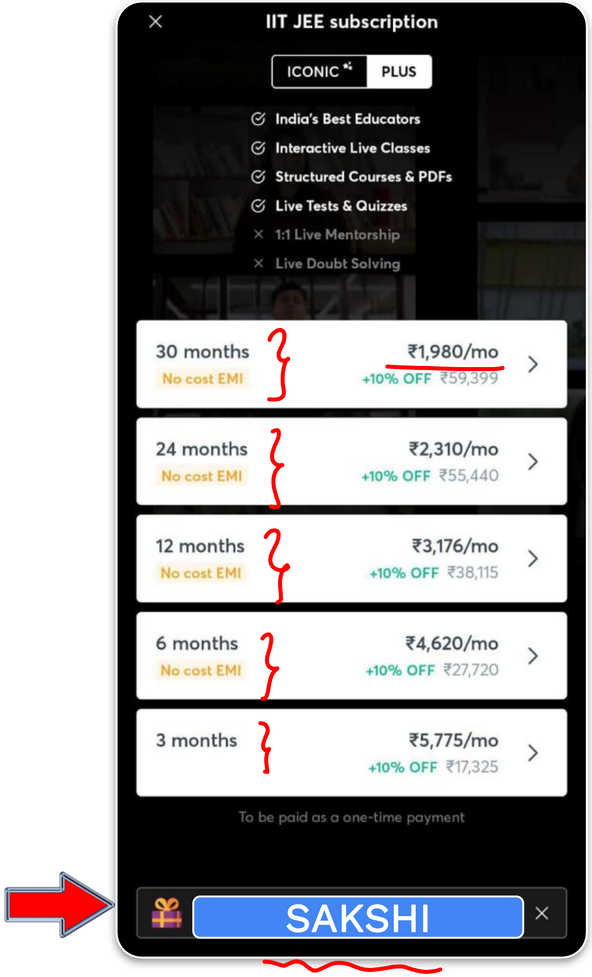
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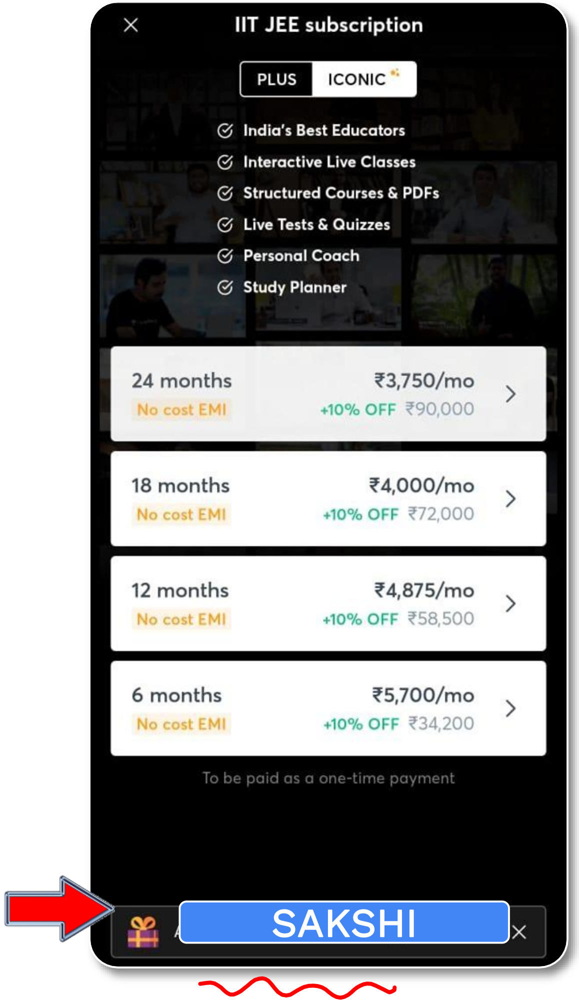
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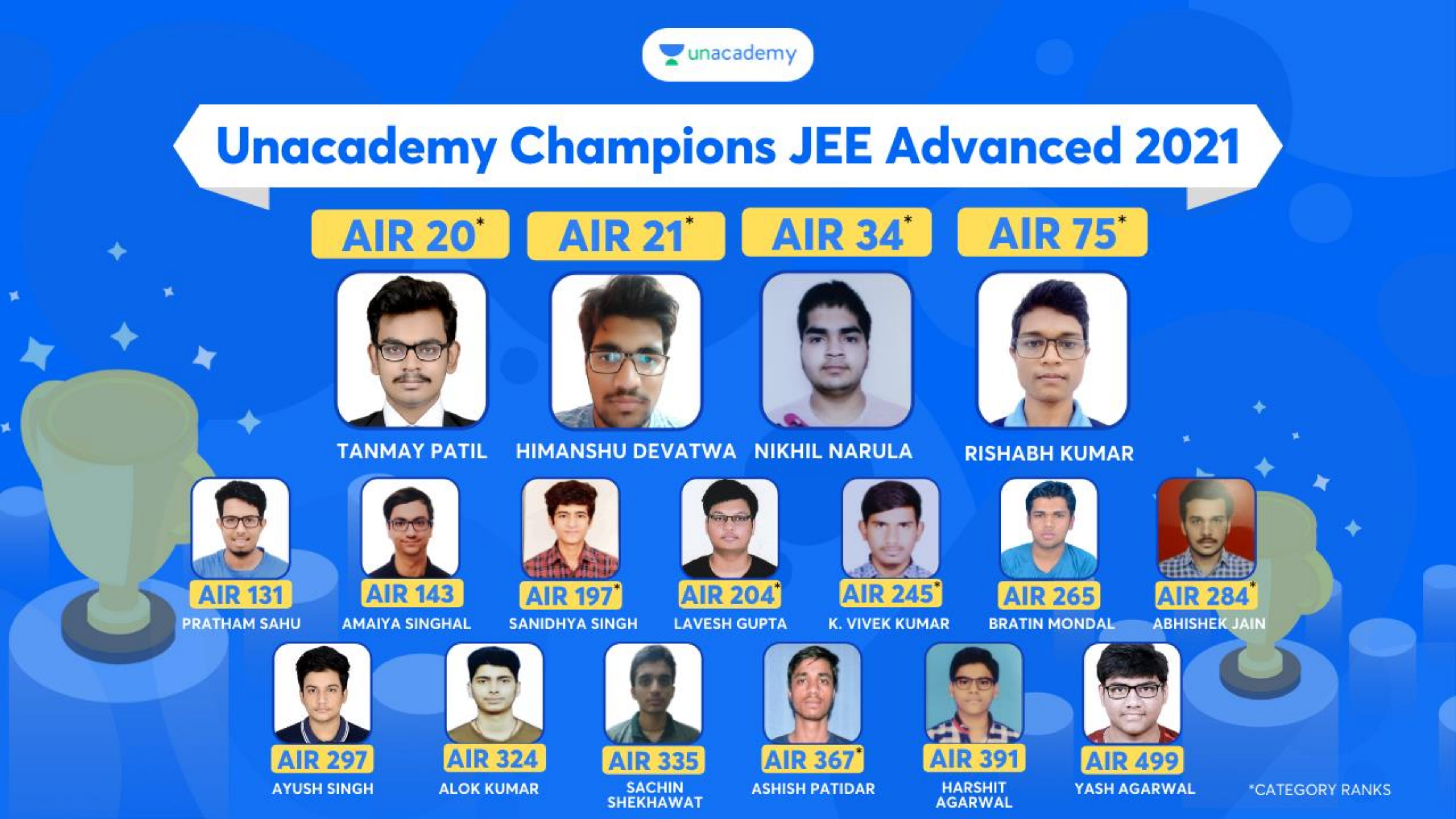
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