2023	12	18	TS-C2	SEAT NUMBER				

IIT INSPIRE
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XI & XII Science (CBSE/state)
IIT- JEE (Mains + Advance)
NEET, MH-CET , NDA
Mo. No. 9595445177/9021445177

Branches : Chhatrapati Sq., Mangalmurti Sq.

(4 Pages)

calculator is not allowed.
5. All symbols having their usual meanings unless otherwise stated.
6. For each MCQ, correct answer must be written along with its alphabet.
7. Evaluation of each MCQ would be done for the first attempt only.

Physical Constants:
(1) $\pi=3.142$ (2) $g=10\,m/s^2$ (3) $h=6.63\times10^{-34}\,J.s$ (4) $c=3\times10^{8}\,m/s$
(5) $e=1.6\times10^{-19}\,C$ (6) $\varepsilon_0=8.85\times10^{-12}\,C^2/N.m^2$ (7) $\mu_0=4\pi\times10^{7}\,T.m/A$,
(8) $\sigma=5.7\times10^{-8}\,W/m^2K^4$

SECTION-A

Q.1 Select and write the correct answers to the following questions: **[10]**

1)The solubility product of sparingly soluble salt AX **is** 5.2×10^{-3} **Its solubility in mol** dm^{-3} **is_____.** **(1)**

Ans:

a) 7.2×10^{-3}

2)Maltose is_____. **(1)**

Ans:

c) disaccharide

3)For the reaction, $H_2+I_2\rightleftharpoons 2HI\,;\Delta H=12.4$ **kcal. The heat of formation of HI,** ΔH_f **=_____.** **(1)**

Ans:

c) 25.9408kJ

4)_____ is radioactive element in group 16 elements. **(1)**

Ans:

c) Polonium

5)Lanthanoids are characterized by gradual filling of _____ orbitals. **(1)**

Ans:

b) 4 f

6)Resorcinol on distillation with zinc dust gives_____. (1)

Ans:

c) benzene

7)Vinegar contains _____. (1)

Ans:

c) acetic acid

8)Isobutylamine is _____ amine. (1)

Ans:

b) 2°

9)Nylone are _____ fibres. (1)

Ans:

b) polyamide

10) NICAD storage cell is made up of _____ electrodes. (1)

Ans:

d) Nickel-cadmium

Q.2 Answer the following questions in one sentence: [8]

(1) State Henry's law (1)

Ans:

Henry's law: It states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution.

Thus,

$S \propto P \vee S = K_H P$

Where, S is the solubility of the gas in mol L^{-1}, P is the pressure of the gas in bar over the solution. K_H, the proportionality constant is called Henry's law constant and its unit is $mol\,L^{-1}$ ¿$^{-1}$¿.

(2) What are the pseudo-first order reaction? Give one example and explain why it is pseudo-first order. (1)

Ans:

1. Certain reaction which are expected to be of higher order follow the first order kinetics. Such reactions are said to be pseudo-first order reactions.
2. **Example:** Consider hydrolysis of methyl acetate.
   $CH_3COOCH_{3(aq)} + H_2O_{(l)} \longrightarrow CH_3COOH_{(aq)} + CH_3OH_{(aq)}$
   The rate law is rate ¿$k'[CH_3COOCH_3][H_2O]$
3. **Explanation:** The reaction was expected to follow the second order kinetics, however, obeys the first order. The reason is that solvent water is present in such large excess that the change in its concentration is negligible compared to initial one its concentration remains constant.
   Thus, $[H_2O] = constant = k''$. The rate law becomes rate ¿$k'[CH_3COOCH_3]$ k"
   ¿$k[CH_3COOCH_3]$
   Where, $k = k' k''$
   The reaction is thus of first order.

(3) What is phase transition? (1)

Ans:

Phase transition is process in which one phase of a substance is converted into another at constant temperature and pressure without change in chemical composition.

(4) What are legends? **(1)**

Ans:

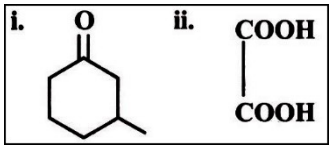
In coordination compound, the species surrounding the central metal atom or ion are called ligands.

(5) What is chiral carbon atom? **(1)**

Ans:

The carbon atom in molecule which carries four different groups/atoms is called chiral carbon atom.

(6) Write the IUPAC names of the following structures: **(1)**



Ans:

3-Methylcyclohexanone

1. Ethanedioic acid

(7) Define the terms with examples: Isomerism **(1)**

Ans:

Two or more substances having the same crystal structure are said to be isomorphous.

Examples:

a. NaF and MgO b. $NaNO_3$ and $CaCO_3$

(8) Glucose is also called dextrose. Why? **(1)**

Ans:

Glucose is an optically active compound and has its specific rotation, $[\propto]_D^{20}$ equal to $+52.7^0$. Due to the dextrorotation, glucose is also called dextrose.

SECTION-B

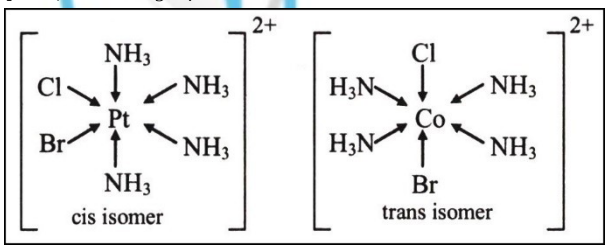
Attempt any eight of the following questions: **[16]**

Q.3 Explain Cis-trans isomerism in MH_4BC type complex?

(2)

Ans:

[Co(NH$NH_3¿_4C1Br¿^{2+¿¿}$



Q.4 A compound made of elements C and D crystallizes in fcc structure. Atoms of C are present at the corners of the cube. Atoms of D are at the centres of faces of the cube. What is the formula of the compound? **(2)**

Ans:

The formula of the given compound is CD_3.

Q.5 Define colligative properties. Give examples. **(2)**

Ans:

The physical properties of solutions that depend on the number of solute particles in solutions and not on their nature are called colligative properties.

These are

1. Vapour pressure lowering
2. Boiling point elevation
3. Freezing point depression
4. Osmotic pressure

Q.6 Distinguish between electrolytic and galvanic calls. **(2)**

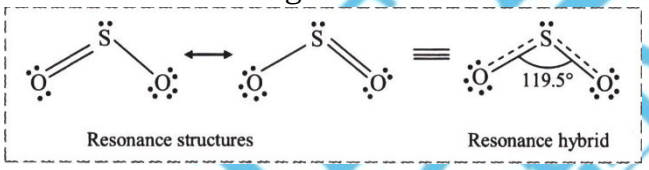
Ans:

No.	Electrolytic cells	Galvanic cells
1	In electrolytic cell, a nonspontaneous reaction, known as electrolysis, is forced to occur by passing a direct current from an external source into the solution.	In galvanic (voltaic) cell a spontaneous chemical reaction produces electricity.
2	In these cells, electrical energy is converted into chemical energy.	In these cells, chemical energy is converted into electrical energy.
3	The anode of electrolytic cell is positive.	The anode of galvanic cell is negative.
4	The cathode of electrolytic cell is negative.	The cathode of galvanic cell is positive.

Q.7 Discuss the structure of sulfur dioxide. Give uses of sulfur dioxide. **(2)**

Ans:

Sulfur dioxide is angular with $O-S-O$ bond angle of 119.5^0.



The $S-O$ double bond arises from $d\pi-p\pi$ bonding. It is a resonance hybrid of two canonical forms.

Uses:

1. In refining of petroleum and sugar.
2. In bleaching wool and silk.
3. As an anti-chlor, disinfectant.
4. As a preservative.
5. In the manufacture of H_2SO_4, $NaHSO_3$.
6. Liquid SO_2 is used as a solvent to dissolve a number of organic and inorganic chemicals.

Q.8 Zinc is not considered as transition element. Why? **(2)**

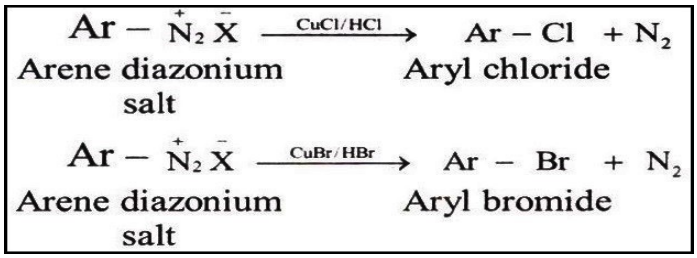
Ans:

Since zinc has completely filled $(n-1)d$ orbital in the ground state $(3d^{10}4s^2)$ and $(3d^{10})$ in its common oxidation state +2, it is not regarded as transition element.

Q.9 What is Sandmeyer's reaction? **(2)**

Ans:

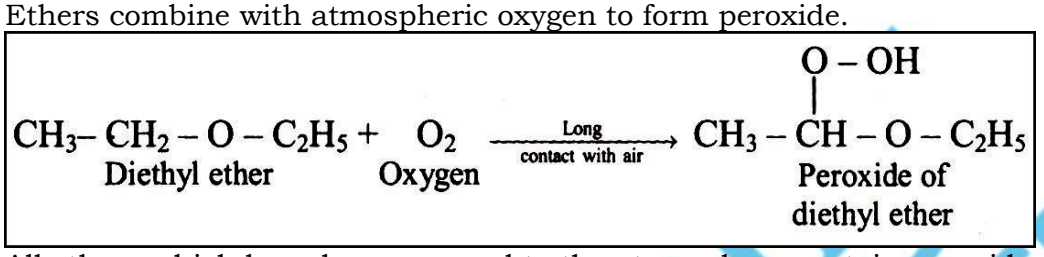
Aryl halides are most commonly prepared by replacement of nitrogen of diazonium salt using copper (I) salts. This reaction is known as Sandmeyer's reaction.



Q.10 What happens when ether are exposed to atmospheric oxygen? **(2)**

Ans:

1. Ethers combine with atmospheric oxygen to form peroxide.



2. All ethers which have been exposed to the atmosphere contain peroxide.
3. This is very undesirable reaction. Peroxides are hazardous because they decompose violently at high temperature.

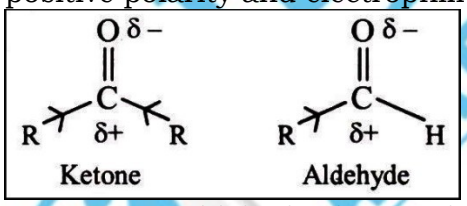
Q.11 Aldehydes are more reactive towards nucleophilic addition reactions than ketones. Explain. **(2)**

Ans:

Reactivity of aldehydes and ketones is due to the polarity of carbonyl group which results in electrophilicity of carbon. In general, aldehydes are more reactive than ketones toward nucleophilic attack. This can be well explained in terms of both the electronic effects and steric effect.

1. **Influence of Electronic Effects:**

a. Alkyl groups have electron donating inductive effect (+I). A ketone has two electron donating alkyl groups bonded to carbonyl carbon which are responsible for decreasing its positive polarity and electrophilicity.



b. In contrast, aldehydes have only one electron donating group bonded to carbonyl carbon. This makes aldehydes more electrophilic than ketones.

2. **Steric Effects:**

a. Two bulky alkyl groups in ketone come in the way of incoming nucleophile. This is called steric hindrance to nucleophilic attack.

b. On the other hand, nucleophile can easily attack the carbonyl carbon in aldehyde because it has one alkyl group and is less crowded or sterically less hindered. Hence aldehyde are more easily attacked by nucleophiles.

Q.12 Explain carbylamine's reaction suitable examples. **(2)**

Ans:

1. Aliphatic or aromatic primary amines on heating with chloroform give foul (offensive) smelling products called alkyl/aryl isocyanides or carbylamines.
2. This reaction is a test for primary amines. Secondary and tertiary amines do not give this test.

$$R-NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} R-NC + 3KCl + 3H_2O$$

1° Amine — Alkyl isocyanide

Q.13 What is extensive property and intensive property? Give example. (2)

Ans:

1. **Extensive Property:**
   A property which depends on the amount of matter present in a system is called an extensive property.
   Examples: Mass, volume, internal energy, heat capacity, number of moles.
2. **Intensive Property:**
   A property which is independent of the amount of matter in a system is called intensive property.
   Examples: Pressure, temperature, surface tension, viscosity, melting point, boiling point, specific heat.

Q.14 Give reasons: Hydrolysis of sucrose is called inversion. (2)

Ans:

1. Sucrose $\left(C_{12}H_{22}O_{11}\right)$ is dextrorotatory $\left(+66.5^0\right)$. On hydrolysis with dilute acid or an enzyme called invertase sucrose gives equimolar mixture of D-(+) glucose and D-(-) fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\Delta]{H^+} \underset{\text{D-(+)-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-(−)-Fructose}}{C_6H_{12}O_6}$$

2. Since the laevoratotion of fructose $\left(-92.4^0\right)$ is larger than the dextrorotation of glucose $\left(+52.7^0\right)$, the hydrolysis product has net laevorotation.
   Hence, hydrolysis of sucrose is also called inversion of sucrose.

SECTION-C

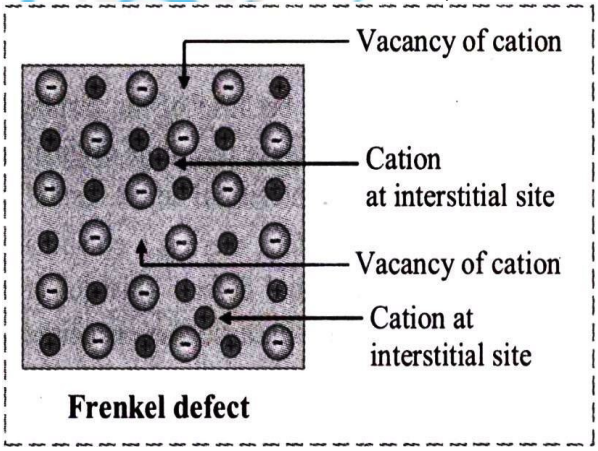
Attempt any eight of the following questions: [24]

Q.15 Explain with diagram, Frenkel defect? What are the conditions for its formation? What is its effect on density and electrical neutrality of the crystal? (3)

Ans:

1. **Frenkel defect:**

a. Frenkel defect arises when an ion of an ionic compound is missing from its regular lattice site and occupies interstitial position between lattice points. The cations are usually smaller than anions. Therefore, the cations occupy interstitial sites.



b. The smaller cation is displaced from its normal site to an interstitial space. It, therefore, creates a vacancy defect at its original position and interstitial defect at its new location in the same crystal. Frenkel vacancy defect and interstitial defect.

c. This defect is found in ionic crystals like ZnS, AgCl, AgBr, Agl and CaF_2.

2. **Conditions for the formation of Frenkel defect:**

a. Frenkel defect occurs in ionic compounds with large difference between sizes of cation and anion.

b. The ions of ionic compounds must be having low coordination number.

3. **Consequences of Frenkel defect:**

a. As no ions are missing from the crystal lattice as a whole, the density of solid and its chemical properties remain unchanged.

b. The crystal as a whole remains electrically neutral because the equal numbers of cations and anions are present.

Q.16 How molar mass of a solute is determined by osmotic pressure measurement? (3)

Ans:

1. For very dilute solutions, the osmotic pressure follows the equation,

$$\pi = \frac{n_2 RT}{V}$$

2. If the mass of solute in V litres of solution is W_2 and its molar mass is M_2, then $n_2 = \frac{W_2}{M_2}$.

Substituting the value of n_2 in equation (1), we get

$$\pi = \frac{W_2}{M_2}\frac{RT}{V}$$

$$\therefore M_2 = \frac{W_2 RT}{\pi V}$$

This formula can be used for the calculation of molar mass of a nonionic solute (i.e., nonelectrolyte), by osmotic pressure measurement.

Q.17 A weak monobasic acid is 0.05% dissociated in 0.02 M solution. Calculate dissociation constant of the acid. (3)

Ans:

Dissociation constant of acid (K_a) is 5×10^{-9}.

Q.18 At constant pressure, show that $\Delta H = \Delta U + P\Delta V$ (3)

Ans:

1. Change in enthalpy, ΔH, is a state function given by

$$\Delta H = H_2 - H_1$$

Where, H_1 and H_2 are the enthalpies of initial and final states, respectively.

2. Now, $H = U + PV$. Therefore, $H_1 = U_1 + P_1V_1$ and $H_2 = U_2 + P_2V_2$

Hence,

$$\Delta H = H_2 - H_1 = U_2 + P_2V_2 - U_1 + P_1V_1$$
$$¿ (U_2 - U_1) + (P_2V_2 - P_1V_1)$$
$$¿ \Delta U + \Delta(PV)$$

3. At constant pressure, $P_1 = P_2 = P$

Therefore, $\Delta H = \Delta U + P\Delta V$

Q.19 Construct a galvanic cell from the electrodes $Co^{3+¿|Co¿}$ and $Mn^{2+¿|Mn¿}$.

$E^0_{Co} = 1.82V$, $E^0_{Mn} = -1.18V$. Calculate E^0_{cell} (3)

Ans:

The standard cell potential is 3.00 V.

Q.20 Obtain the relationship between the rate constant and half-life of a first order reaction. **(3)**

Ans:

1. The integrated rate law for the first order reaction is $k=\frac{2.303}{t}\log_{10}\frac{A_0}{A_t}$

Where, $[A]_0$ is the initial concentration of reactant at $t=0$. It falls to $[A]_t$ at time t after the start of the reaction T.

2. The time required for $[A]_0$ to become $\frac{[A]_0}{2}$ is denoted as $t_{1/2}$ or $[A]_t=\frac{[A]_0}{2}$ at $t=t_{1/2}$

Putting this condition in the integrated rate law we write

$$k=\frac{2.303}{t_{1/2}}\log_{10}\frac{[A]_t}{[A]_0/2}=\frac{2.303}{t_{1/2}}\log_{10}2$$

Substituting value of $\log_{10}2$,

$$k=\frac{2.303}{t_{1/2}}\times 0.3010$$

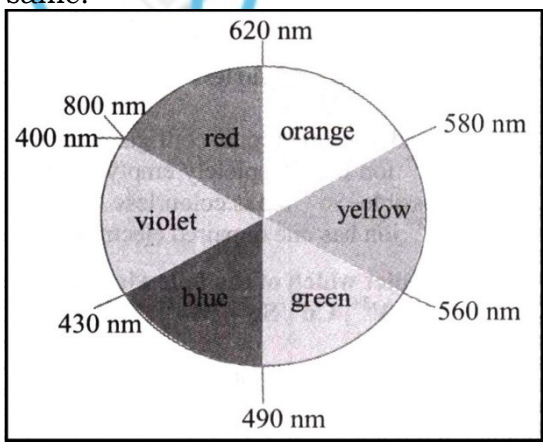
Q.21 Distinguish between rhombic sulfur and monoclinic sulfur. **(3)**

	Rhombic sulfur (α-sulfur)		Monoclinic sulfur (β- sulfur)
i.	It is pale yellow coloured solid.	i.	It is bright yellow solid
ii.	It forms orthorhombic crystals	ii.	It forms needle shaped monoclinic crystals
iii.	Its melting point is 385.8 K.	iii.	Its melting point is 393 K.
iv.	Its density is 2.06 g/cm^3.	iv.	Its density is 1.98 g/cm^3.
v.	It is insoluble in water and soluble in CS_2.	v.	Soluble in CS_2
vi.	It is stable below 369 K and transforms to β-sulfur above this temperature.	vi.	It is stable above 369 K and transforms into α-sulfur below this temperature.
vii.	It is prepared by evaporation of rolls sulfur in CS_2.	vii.	It is prepared from rhombic sulfur.

Q.22 Explain in detail: Most of the transition metal compounds are remarkably coloured. **(3)**

Ans:

1. A substance appears coloured if it absorbs a portion of visible light. The colour depends upon the wavelength of absorption in the visible region of electromagnetic radiation.
2. The ionic and covalent compounds formed by the transition elements are coloured. Transition elements contain unpaired electrons in their d orbitals. When the atoms are free or isolated, the five d orbitals are degenerate; or have the same energy.
3. In complexes, the metal ion is surrounded by solvent molecules or ligands. The surrounding molecules affect the energy of d orbitals and their energies are no longer the same.



4. As the principal quantum number of 'd' orbitals is the same, the amount of energy required for transition of electron from one d orbital to another is quite small.

5. The small energy required for this transition is available by absorption of radiation having certain wavelength from the visible region. Remaining light is transmitted and the observed colour of the compound corresponds to the complimentary colour of light absorbed. That means, if red light is absorbed then the transmitted light contains excess of other colours in the spectrum, in particular blue, so the compound appears blue.
6. The ions having no unpaired electrons are colorless for example Cu^{+} $(3d^{10})$; Ti^{4+} $(3d^{0})$.
7. Colour of the transition metal ion depends upon ligand and geometry of the complex formed by metal ion.
   Eg: When cobalt chloride is dissolved in water, it forms a pink solution of the complex $\left[Co\left(H_2O\right)_6\right]^{2+}$ which has octahedral geometry. But when this solution is treated with concentrated hydrochloric acid, it turns deep blue. This change is due to the formation of another complex $\left[Co\,Cl_4\right]^{2-}$ which has a tetrahedral structure.
   $\left[Co\left(H_2O\right)_6\right]^{2+}+4Cl^{-} \rightarrow \left[CoCl_4\right]^{2-}+6H_2O$
8. Thus, the colour of a transition metal ion relates to
   a. Presence of unpaired d electrons
   b. d-d transitions
   c. Nature of ligands attached to the metal ion
   d. Geometry of the complex formed by the metal ion

Q.23 State and explain: Effective atomic number (EAN) rule **(3)**

Ans:

1. EAN equals total number of electrons around the central metal ion in the complex.
2. EAN rule states that *"a metal ion continues to accept electrons pairs till it attains the electronic configuration of the next noble gas".*
3. If the EAN is equal to 18 (Ar), 36 (Kr), 54 (Xe) or 86 (Rn) then the EAN rule is obeyed.
4. EAN can be calculated with the following. Formula:
   EAN = Number of electrons of metal ion + total number of electrons donated by ligands
   = Atomic number of metal (Z) – Number of electrons lost by metal to form the ion (X) + Number of electrons donated by ligands (Y).
   $= Z-X+Y$

Eg: Consider, $\left[Co\left(NH_3\right)_6\right]^{3+}$

Oxidation state of Cobalt is +3, six ligands donate 12 electrons.

$Z=27, X=3, Y=12$

EAN of $Co^{3+} = Z-X+Y$

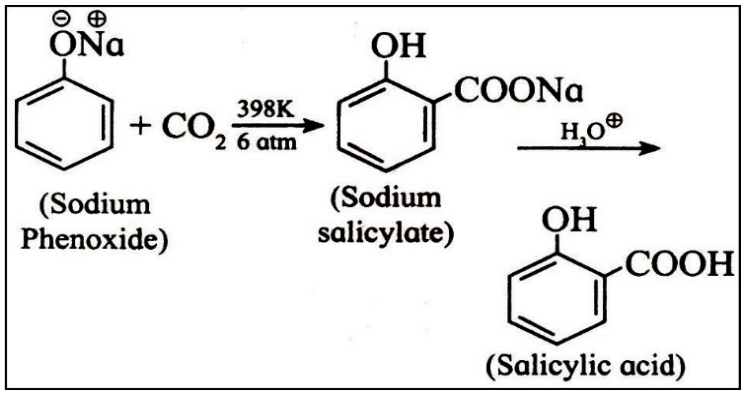
$= 27-3+12$

$= 36$

Q.24 Explain: Kolbe reaction **(3)**

Ans:

The treatment of sodium phenoxide with carbondioxide at 398 K under pressure of 6 atm followed by acid- hydrolysis, salicylic acid (o-hydroxybenzoic acid) is formed. This reaction is known as Kolbe's reaction.

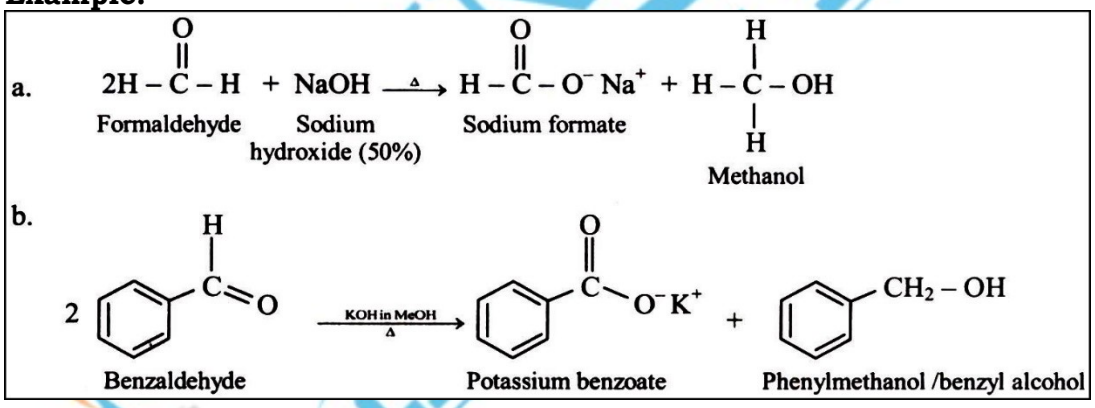


Q.25 Write a note on Cannizzaro reaction. **(3)**

Ans:

1. This reaction is given only by aldehydes having no α – hydrogen atom.
2. Aldehydes undergo self -oxidation and reduction reaction on heating with concentrated alkali.
3. In cannizzaro reaction one molecule of an aldehyde is reduced to alcohol and at the same time second molecule is oxidized to carboxylic acid salt. This is an example of disproportionation reaction.

Example:



Q.26 Weitw a important structural and functional difference between DNA and RNA. **(3)**

Ans:

	DNA	RNA
i.	DNA molecules contain several million nucleotides.	RNA molecules contain a few thousand nucleotides.
ii.	The sugar present in DNA is D-2-deoxyribose.	The sugar present in RNA is D-ribose.
iii.	DNA contains cytosine and thymine as pyrimidine bases.	RNA contains cytosine and uracil as pyrimidine bases.
iv.	DNA has double stranded α-helix structure.	RNA has single stranded α-helix structure.

SECTION-D

Attempt any three of the following question: **[12]**

Q.27 Explain in detail the applications of nanotechnology/nanomaterials in various discipline. **(4)**

Ans:

Nanochemistry has contributed to number of innovative products in various disciplines because of their unique physical, chemical, optical, structural, catalytic properties, etc.

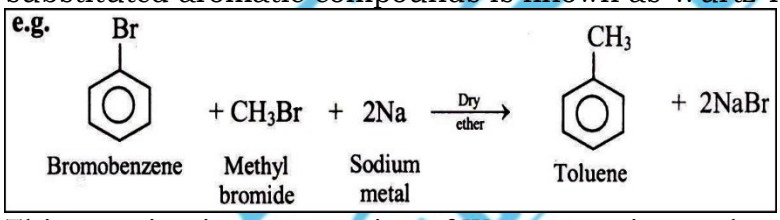
Following are the few applications:

1. Nanoparticles can contribute to stronger, lighter, cleaner and smarter surfaces and systems. They are used in the manufacturing of scratchproof eyeglasses, transport, sunscreen, crack resistant paints and so on.
2. Used in electronic devices. Eg: Magnetoresistive Random Access Memory (MRAM).
3. Nanotechnology plays an important role in water purification techniques.
   a. Water contains waterborne pathogens like viruses, bacteria.
   b. Cost-effective filter materials coated with silver nanoparticles (AgNps) is an alternative technology and can be used in water purification.
   c. Silver nanoparticles act as highly effective antibacterial agent which kills E. coli from water.
4. Self-cleaning materials:
   a. Lotus is an example of self-cleaning. The lotus plant (Nelumbo nucifera) although grows in muddy water, its leaves always appear clean.
   b. The plants' leaves are super-hydrophobic.
   c. Nanostructures on lotus leaves repel water which carries dirt as it rolls off. Lotus effect is the basis of self-cleaning windows.

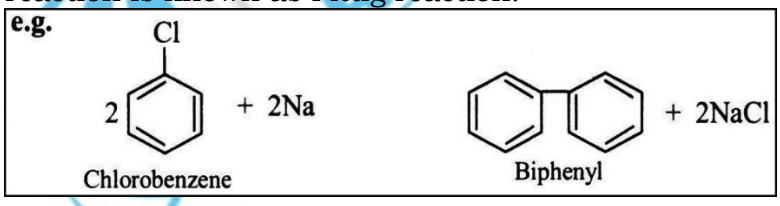
Q.28 Explain Wurtz-Fitting reaction. Also comment on Fitting reaction. **(4)**

Ans:

1. The reaction of aryl halide with alkyl halide and sodium metal in dry ether to give substituted aromatic compounds is known as Wurtz-Fittig reaction.



2. This reaction is an extension of Wurtz reaction and was carried out by Fittig. The reaction allows alkylation of aryl halides.
3. If only aryl halide takes part in the reaction, the product is biphenyl (or diphenyl) and the reaction is known as Fittig reaction.



Q.29 Write a short note on ozone depletion. **(4)**

Ans:

1. Thinning of ozone layer in upper atmosphere is called ozone depletion.
2. The ozone (O_3) layer in the upper atmosphere, absorbs harmful UV radiations from the sun, thus protecting people on the earth.
3. Depletion of ozone layer in the upper atmosphere is caused by nitrogen oxide released from exhausts system of car or supersonic jet aeroplanes.
   $NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$
4. Depletion (thining) of ozone layer can also be caused by chlorofluoro carbons (freons) used in aerosol and refrigerators and their subsequent escape into the atmosphere.

5. The depletion of ozone layer has been most pronounced in polar regions, especially over Antarctica.
6. Ozone depletion is a major environmental problem because it increases the amount of ultraviolet (UV) radiation that reaches earth's surface, thus causing an increase in rate of skin cancer, eye cataracts and genetic as well as immune system damage among people.

Q.30 Show that time required for 99.9% completion of a first order reaction is three times the time required for 90% completion. (4)

Ans:

Therefore, for a first order reaction, the time required for 99.9% completion is 3 times of that required for 90% completion.

Q.31 Europium and ytterbium behave as good reducing agents in +2 oxidation state explain. (4)

Ans:

1. Europium (Eu) and Ytterbium (Yb) show +2 oxidation states.
   Their electronic configurations are given below:
   $Eu = [Xe]4f^7 6s^2 : Eu^{2+} = [Xe]4f^7$
   $Yb = [Xe]4f^{14} 6s^2 : Yb^{2+} = [Xe]4f^{14}$
2. It is clear from the configuration of Eu that Eu^{2+} is favoured by its half-filled f-subshell. But it can be easily converted into stable Eu^{3+} by loss of an electron. Due to this reason, Eu^{2+} is a good reducing agent.
3. Similarly, Yb^{2+} ion is stabilized due to complete filled f-subshell. It can be easily converted into Yb^{3+} by loss of an electron. Due to this reason, Yb^{2+} is a good reducing agent.

"All the Best"

"When you focus on problems,
you get more problems,
When you focus on possibilities,
you have more opportunities."