
2008

Question: 1 – 30

Question: 1

a. What is the coordination number of each type of ions in a rock-salt type crystal structure? [1]

Answer:

Rock salt type crystal structure has 6:6 coordination number of each type of ion. In NaCl, coordination of no. of Na^+ = 6 and coordination no. of Cl^- = 6.

Question: 2

Define the term 'order of reaction' for chemical reactions. [1]

Answer:

The order of a reaction is equal to the sum of the powers (exponents) to which the various concentration terms are raised in the rate of law expression of the reaction.

Question: 3

What causes Brownian movement in a colloidal solution? [1]

Answer:

The molecules of dispersion medium due to their kinetic motion strike against the colloidal particles (dispersed phase) from all sides with different forces causing them to move.

Question: 4

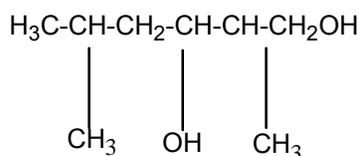
In which one of the two structures, NO_2^+ and NO_2^- , the bond angle has a higher value? [1]

Answer:

The bond angle of NO_2^+ is higher than NO_2^- .

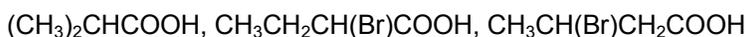
Question: 5 ()**

Write the IUPAC name of the following compound? [1]



Question: 6

Arrange the following compounds in an increasing order of their acid strengths: [1]



Answer:

We know that +I –effect while –I-effect increases the acid strength of carboxylic acids. the overall acid strength increases in the order.

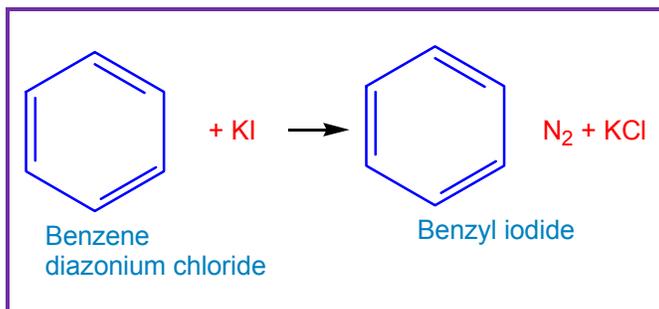


Question: 7

Write a chemical reaction in which the iodide ion replaces the diazonium group in a diazonium salt. [1]

Answer:

The replacement of the diazonium group by iodine is done by treating a diazonium salt with potassium iodide.



Question: 8

Name a substance that can be used as an antiseptic as well as a disinfectant. [1]

Answer:

Phenol, 0.2% solution of phenol acts as antiseptic where as 1% solution acts as disinfectant.

Question: 9

Explain as to why haloarenes are much less reactive than haloalkanes towards nucleophilic substitution reactions. [2]

Answer:

Haloarenes are much less reactive than haloalkanes towards nucleophilic substitution reactions due to the following reasons:

- i. Resonance effect
- ii. Difference in hybridization of carbon atom in C-X bond
- iii. Instability of phenyl cation

OR

Which compound in each of the following pairs will react faster in S_N2 reaction with -OH⁻? Why? [2]

- i. CH₃Br or CH₃I
- ii. (CH₃)₃CCl

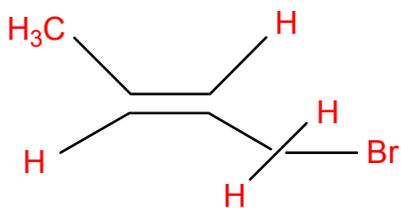
Answer:

Since I⁻ ion is a better leaving group than Br⁻ ion, therefore CH₃I reacts faster than CH₃Br in S_N2 reaction with OH⁻ ion.

Question: 10

a. State the IUPAC name of the following compound: [2]





Answer:
1- Bromobut -2-ene

b. Complete the chemical reaction: $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{HBr} \xrightarrow{\text{peroxide}} \dots\dots\dots$

Answer:
 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{HBr} \xrightarrow{\text{peroxide}} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
 But -1-ene (Anti-Mark addition) 1-Bromobutane

Question: 11

State Henry's law correlating the pressure of a gas and its solubility in a solvent and mention two applications for the law. [2]

Answer:
It states that at constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

Applications:

- a. in the production of carbonated beverages
- b. in the deep sea diving
- c. in the function of lungs

Question: 12

A first order decomposition reaction takes 40 minutes for 30% decomposition. Calculate its $t_{1/2}$ value. [2]

Answer:
Here $t = 40$ min. $t/12 = ?$
Let $a = 100 \therefore 30\%$ of $100 = 30$

Using this formula.

$$t = \frac{2.303}{K} \log \frac{a}{a-x} \Rightarrow 40 = \frac{2.302}{K} = \log \frac{100}{100-30}$$

$$40 = \frac{2.303}{K} \log \frac{100}{70} \Rightarrow 40 \frac{2.303}{K} (\log 10 - \log 7)$$

$$40 = \frac{2.303}{K} (1 - 0.8451) \Rightarrow 40 = \frac{2.303}{K} \times 0.1549 \Rightarrow$$

$$K = \frac{2.303 \times 0.1549}{40} \Rightarrow \frac{0.357}{40} = 0.0089 \text{ min}$$

$$t_{1/2} = \frac{0.693}{K} = \frac{0.693}{0.0089} = 77.86 \text{ min}$$



Question: 13

What is meant by the 'rate constant, k ' of a reaction? If the concentration in mol L^{-1} units and time in seconds, what would be the units for k (i) for a zero order reaction and (ii) for a first order reaction? [2]

Answer:

Rate constant k : The rate constant k is equal to the rate of reaction when the concentration of the reactant is unity.

It depends upon the order of reaction as well as temperature.

Units for K :

- For zero order reaction : $\text{mol L}^{-1} \text{s}^{-1}$
- For a first order reaction: s^{-1}

Question: 14

Define the following terms in relation to proteins: [2]

- Peptide linkage

Answer:

Proteins are condensation polymers of α -amino acids in which the same or different α -amino acids are connected by peptide bonds.

Chemically, a peptide bond is an amide linkage formed between $-\text{COOH}$ group of one α -amino acids and NH_2 group of the other α -amino acids by loss of a molecule of water.

- Denaturation

Answer:

The complex three-dimensional structure of proteins gets disrupted by changing the pH, temperature or by adding some salt. This disruption of the native structure of protein is called denaturation of protein.

Question: 15

List the reactions of glucose which cannot be explained by its open chain structure. [2]

Answer:

Limitation of the open chain structure: Although the open chain structure of D – (+) glucose explains most of its reactions yet it fails to explain the following facts.

- D(+) – glucose does not undergo certain reactions of aldehydes. For example, glucose does not form NaHSO_3 addition product, aldehyde – ammonia 2 and 4-DNP derivative and does not respond to Schiff's reagent test.
- Glucose reacts with NH_2OH to form an oxime but glucose penta-acetate does not.

Question: 16

Assign a reason for each of the following statements. [2]



i. Ammonia is a stronger base than phosphine.

Answer:

Due to the presence of lone pair of electrons on the central atom both NH_3 and PH_3 are Lewis Bases. When NH_3 or PH_3 accepts a proton, an additional N-H or P-H bond is formed.

ii. Sulphur in vapour state exhibits a paramagnetic behaviour.

Answer:

In vapor state sulphur partly exists as S_2 molecule which has two unpaired electrons in the antibonding π^* orbitals like O_2 and, hence exhibits its paramagnetism.

Question: 17 ()**

Draw the structures of the following molecules:

- i. SF_4
- ii. XeF_4

Question: 18

What are biodegradable and non-biodegradable detergents? Give one example of each class.

[2]

Answer:

Biodegradable detergents:

Detergents having straight hydrocarbon chains are easily decomposed by micro-organisms and are called biodegradable detergents.

Example: Sodium lauryl sulphate

Non-biodegradable detergents:

The detergents containing branched hydrocarbon chains are not easily degraded (or decomposed) by the micro-organisms and are called non-biodegradable detergents.

Example: Sodium 4-(1, 3, 5, 7 – tetramethyl) benzene sulphonate.

Question: 19

What is a semiconductor? Describe the two main types of semiconductors and explain mechanisms for their conduction.

[2]

Answer:

The solids which have intermediate conductivities generally between 10^{-6} to $10^4 \Omega^{-1} \text{m}^{-1}$ are called semiconductors. For example - germanium and silicon. The two main types of semiconductors are as follows:

n-type semiconductor:

When a silicon crystal is doped with atoms of group-15 elements, such as P, As, Sb or Bi; then only four of the five valence electrons of each impurity atom participate in forming covalent bonds and the fifth electron is almost free to conduct electricity. Silicon that has been doped with a group-15 element is called n-type semiconductor.

p-type semiconductor:

When a silicon crystal is doped with atoms of group-13 elements such as B, Al, Ga or In; each impurity atom forms only three covalent bonds with the host atoms.



The place where the fourth electron is missing is called a hole which moves through the crystal like a positive charge and hence increases its conductivity. Silicon that has been doped with group-13 element is called p-type semiconductor.

Question: 20

Calculate the temperature at which a solution containing 54g of glucose, ($C_6H_{12}O_6$) in 250g of water will freeze. [2]

Answer:

Molecular mass of glucose,
 $MB = 72 + 12 + 96 = 180$

$$\Delta T_f = \frac{K_f \times W_B \times 100}{M_B \times W_A} = \frac{1.86 \times 54 \times 1000}{180 \times 250} = \frac{100440}{45000} = 2.23$$

Question: 21

What are lyophilic and lyophobic solutions? Give one example of each type. Which one of these two types of solutions are easily coagulated and why? [2]

Answer:

Lyophilic sols

The colloids in which the particles of the dispersed phase have a strong affinity for the dispersion medium are called lyophilic sols. These colloidal solutions, even if precipitated, change back to the colloidal form simply by adding dispersion medium. So lyophilic sols are reversible in nature e.g. glue, starch, rubber.

Lyophobic sols

The colloids in which particles of the dispersed phase have no or very little affinity for dispersion medium are called lyophobic sols. These are colloidal form on simply adding dispersion medium e.g. As_2S_3 sol.

Hydrophobic sols get easily coagulated on the addition of small amount of electrolytes or by heating or even shaking as they are not stable.

Question: 22

State briefly the principles which serve as basis for the following operations in metallurgy: [3]

i. Froth floatation process

Answer:

See topics on 'Gravitational (flotation methods)'.

ii. Zone refining

Answer:

See topics on 'zone refinement'.

iii. Refining by liquation



Answer:

See topics on 'liquation'.

Question: 23

[3]

Write chemical equations for the following processes:

i. reacts with a hot concentrated solution of sodium hydroxide

Answer:



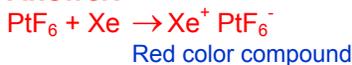
ii. Orthophosphorous acid is heated

Answer:



iii. PtF₆ and xenon are mixed together

Answer:



OR

Complete the following chemical equations:

[3]

i. $\text{Ca}_3\text{P}_2(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow$

Answer:



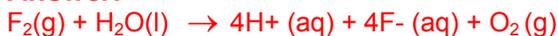
ii. $\text{Cu}^{2+}(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow$

Answer:



iii. $\text{F}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow$

Answer:



Question: 24

[3]

a. What is a ligand? Give an example of a bidentate ligand.

Answer:

See topics on 'ligands'. Example of a bidentate ligand: $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ (ethylenediamine)

b. Explain as to how the two complexes of nickel, $[\text{Ni}(\text{CN})_4]^{2-}$ and $\text{Ni}(\text{CN})_4$, have different structures but do not differ in their magnetic behaviour. (Ni = 28)



Answer:

$[\text{Ni}(\text{CN})_4]^{2-}$ is a square planar complex which is diamagnetic as no unpaired electron is present.

$[\text{Ni}(\text{CO})_4]$ is a tetrahedral complex which is diamagnetic due to absence of unpaired electrons.

Question: 25

[3]

Name the reagents which are used in the following conversions:

- i. A primary alcohol to an aldehyde

Answer:

Pyridinium chlorochromate (PCC) a complex of chromium trioxide with pyridine and HCl.



- ii. Butan-2-one to butan-2-ol (**)
iii. Phenol to 2,4,6-tribromophenol

Answer:

Ni / H_2 or LiAlH_4 or NaBH_4

Question: 26

Account for the following observations:

[3]

- i. pK_b for aniline is more than that for methylamine.

Answer:

In aniline, the lone pair of electrons on the N-atom are delocalized over the benzene ring. As a result, electron density on the nitrogen decreases. In contrast, in CH_3NH_2 + I-effect of CH_3 increases the electron density on the N-atom.

Therefore, aniline is a weaker base than methylamine and hence its pK_b values are higher than that of methylamine.

- ii. Methylamine solution in water reacts with ferric chloride solution to give a precipitate of ferric hydroxide

Answer:

Methylamine being more basic than water, accepts a proton from water liberating OH^- ions. These OH^- ions combine with Fe^{3+} ions present in H_2O to form brown ppt. of hydrated ferric oxide.



- iii. Aniline does not undergo Friedel-Crafts reaction.

Answer:

Aniline being a Lewis base reacts with Lewis acid AlCl_3 to form a salt.



Question: 27 ()**

[3]

Write the names and structures of the monomers of the following polymers:

- i. Buna-S
- ii. Neoprene
- iii. Nylon-6

Question: 28 ()**

[5]

Conductivity of 0.00241 M acetic acid solution is $7.896 \times 10^{-5} \text{ S cm}^{-1}$. Calculate its molar conductivity in this solution. If Λ_m^0 for acetic acid be $390.5 \text{ S cm}^2 \text{ mol}^{-1}$, what would be its dissociation constant?

Answer:

Conductivity of acetic acid, $K = 7.896 \times 10^{-5} \text{ cm}^{-1}$, Λ_m^0 for acetic acid = $390.5 \text{ S cm}^2 \text{ mol}^{-1}$.

$$\begin{aligned} \text{Molar conductivity, } \Lambda_m^0 &= \frac{K \times 1000}{\text{Molarity}} \\ &= \frac{7.896 \times 10^{-5} \times 1000}{0.00241} = \frac{789600 \times 1000 \times 10^{-5}}{241} \\ &= 32.76 \text{ S cm}^2 \text{ mol}^{-1} \end{aligned}$$

$$\text{Degree of dissociation, } \alpha = \frac{\Lambda_m^c}{\Lambda_m^0} = \frac{32.76}{390.5} = 8.4 \times 10^{-2}$$

$$\begin{aligned} \text{Dissociation constant of acetic acid, } K_a &= \frac{C\alpha^2}{1-\alpha} \\ &= \frac{(0.00241) \times (8.4 \times 10^{-2})^2}{1-0.084} = 1.86 \times 10^{-5} \end{aligned}$$

OR

Three electrolytic cells A, B and C containing solutions of zinc sulphate, silver nitrate and copper sulphate, respectively are connected in series. A steady current of 1.5 ampere was passed through them until 1.45 g of silver were deposited at the cathode of cell B.

How long did the current flow? What mass of copper and what mass of zinc were deposited in the concerned cells? (Atomic masses of Ag = 108, Zn = 65.4, Cu = 63.5) [5]

Answer:

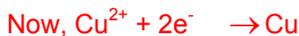


\therefore 108 g of A is deposited by 1 F = 96500C

\therefore 1.45 g of A is deposited by 1 F = $\frac{96500}{108} \times 1.45 = 1295.6 \text{ C}$

$\therefore Q = It$

$$\therefore t = \frac{Q}{I} = \frac{1295.6}{1.5} = 863.75 \text{ sec}$$



\therefore Copper, Cu deposited $\frac{63.5}{2 \times 96500} \times 1259.6 = 0.426 \text{g}$



$$\frac{65.4}{2 \times 96500} \times 1295.6 = \frac{84732.24}{193000} = 0.439 \text{g}$$

Question: 29

Assign reasons for the following:

[5]

- i. The enthalpies of atomization of transition elements are high.

Answer:

The transition elements exhibit high enthalpies of atomization because they have large number of unpaired electrons in their atoms. Due to it they have stronger interatomic interaction and hence stronger bonding between atoms.

- ii. The transition metals and many of their compounds act as good catalyst.

Answer:

Many transition metals and their compounds act as catalysts. The catalytic activity is due to their ability to exhibit multiple oxidation states.

For example V_2O_5 in contact process and finely divided iron in Haber process.

- iii. From element to element the actinoid contraction is greater than the lanthanoid contraction

Answer:

The actinide contraction is similar to lanthanide contraction; this contraction is due to poor shielding by 5 f electrons in the actinides than that by 4f electrons in the lanthanides.

- iv. The E^0 value for the $\text{Mn}^{3+} / \text{Mn}^{2+}$ couple is much more positive than that for $\text{Cr}^{3+} / \text{Cr}^{2+}$.

Answer:

Scandium ($Z = 21$) has incompletely filled 3d orbitals in the ground state. ($3d^1$). Hence, it is considered as a transition element.

OR

- a. What may be the possible oxidation states of the transition metals with the following d electronic configurations in the ground state of their atoms:

$3d^3rs^2$, $3d^54s^2$ and $3d^64s^2$. Indicate relative stability of oxidation states in each case.

Answer:

The most stable oxidation state for $3d^3rs^2 = +5$

The most stable oxidation state for $3d^54s^2 = +7, +2$

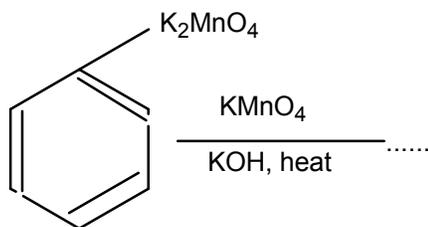
The most stable oxidation state for $3d^64s^2 = +2$

In a transition series, the oxidation states which lead to exactly half-filled or completely filled d-orbitals are more stable. It shows that oxidation states +2 to +7 are most stable.

- b. Write steps involved in the preparation of (i) Na_2CrO_4 from chromate ore and (ii) K_2MnO_4 from pyrolusite ore. (**)

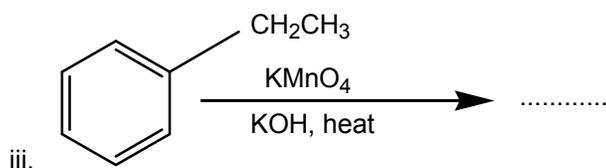
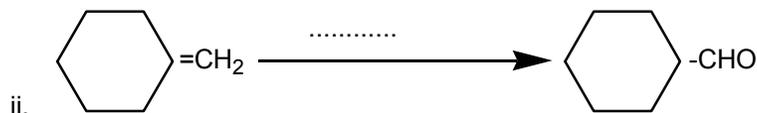
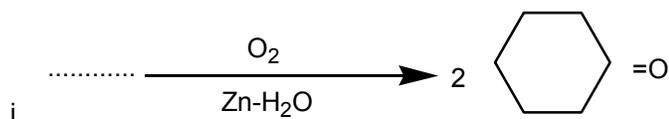
[3, 2]





Question: 30

- a. Complete the following reaction statements by giving the missing starting material, reagent or product as required: [3,2]



- b. Describe the following reactions:

- i. Cannizzaro reaction
- ii. Cross aldol condensation

OR

How would you account for the following: [3,2]

- i. Aldehydes are more reactive than ketones towards nucleophiles.

Answer:

Due to smaller + I effect of one alkyl group in aldehydes as compared to larger +I –effect of two alkyl groups, the magnitude of positive charge on the carbonyl carbon is more in aldehydes than in ketones.

As a result nucleophilic addition reaction occurs more readily in aldehyde than in Ketones.

- ii. The boiling points of aldehydes and ketones are lower than of the corresponding acids.

Answer:

The boiling points of aldehydes and ketones are lower than corresponding acids and alcohols due to absence of intermolecular hydrogen bonding.

- iii. The aldehydes and ketones undergo a number of addition reactions.



Answer:

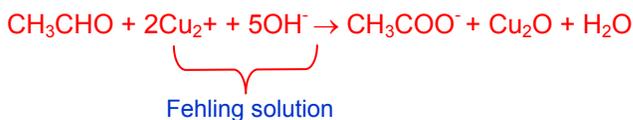
Aldehydes and Ketones undergo a number of addition reactions as both possess the carbonyl functional group which reacts with a number of nucleophiles such as HCN, NaHSO₃, alcohols, ammonia derivatives and Grignard reagents.

Give chemical tests to distinguish between:

- i. Acetaldehyde and benzaldehyde

Answer:

Acetaldehyde and benzaldehyde can be distinguished by Fehling solution. Acetaldehyde gives red colored precipitate with Fehling solution while benzaldehyde does not.



- ii. Propanone and propanol

Answer:

Propanone (CH₃COCH₃) and propanol (CH₃CH₂CH₂OH) can be distinguished by iodoform test. Propanone when warmed with sodium hypoiodite (NaOI) i.e. I₂ in NaOH, it gives yellow precipitation of iodoform while propanol does not respond to iodoform test.



(**) Currently out of syllabus. Answer can be provided up on request

