

Section A

(The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.)

Question 1.

Which of the following solutions will have the highest conductivity at 298 K? [1]

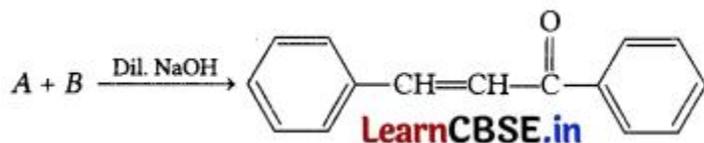
- (a) 0.01 M HCl solution
- (b) 0.1 M HCl solution
- (c) 0.01 M CH₃ COOH solution
- (d) 0.1 M CH₃ COOH solution

Answer:

- (b) 0.1 M HCl solution

0.1 M HCl solution have highest conductivity at 298 K. Conductivity is highest for strong electrolyte. It decreases with dilution.

Question 2.

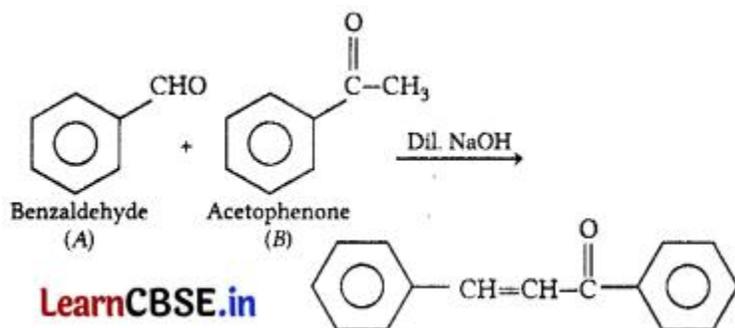


Identify A and B. [1]

- (a) A = 1-phenylethanal, B = Acetophenone
- (b) A = Benzophenone, B = Formaldehyde
- (c) A = Benzaldehyde, B = Acetophenone
- (d) A = Benzophenone, B = Acetophenone

Answer:

- (c) A = Benzaldehyde, B = Acetophenone



This reaction is an example of crossed aldol condensation reaction.

Question 3.

The vitamins which can be stored in our body are [1]

- (a) vitamin A, B, D and E
- (b) vitamin A, C, D and K
- (c) vitamin A, B, C and D
- (d) vitamin A, D, E and K

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Answer:

(d) vitamin A, D, E and K

Fat soluble vitamins can be stored in our body, e.g. Vitamin A, D, E and K.

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Question 4.

What is IUPAC name of the ketone A, which undergoes iodoform reaction to give $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{COONa}$ and yellow precipitate of CHI_3 ? [1]

(a) 3-methylpent-3-en-2-one

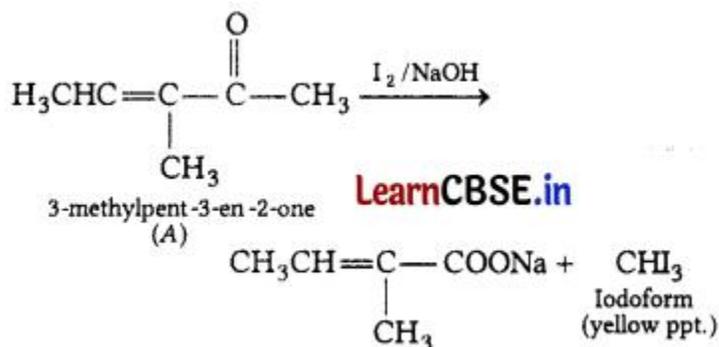
(b) 3-methylbut-2-en- one

(c) 2, 3-dimethylethanone

(d) 3-methylpent-4-one

Answer:

(a) 3-methylpent-3-en-2-one



Question 5.

Which of the following is not correct?

(a) In haloarenes, the electron pairs on halogen atom are in conjugation with π -electrons of the ring.

(b) The carbon-magnesium bond is covalent and non-polar in nature.

(c) During $\text{S}_{\text{N}}1$ reaction, the carbocation formed in the slow step being sp^2 -hybridised is planar.

(d) Out of $\text{CH}_2=\text{CH}-\text{Cl}$ and $\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$, $\text{C}_6\text{H}_5\text{CH}_2\text{Cl}$ is more reactive towards $\text{S}_{\text{N}}1$ reaction. [1]

Answer:

(b) The carbon-magnesium bond is covalent and non-polar in nature.

Statement (b) is incorrect as carbon magnesium bond is polar in nature.

Question 6.

Match the properties with the elements of 3d- series [1]

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(i) lowest enthalpy of atomisation	(p) Sc
(ii) shows maximum number of oxidation states	(q) Mn
(iii) transition metal that does not form coloured compounds	(r) Zn
	(s) Ti

- (a) (i) (r), (ii) (q), (iii) (p)
(b) (i) (r), (ii) (s), (iii) (p)
(c) (i) (p), (ii) (q), (iii) (r)
(d) (i) (s), (ii) (r), (iii) (p)

Answer:

- (a) (i) (r), (ii) (q), (iii) (p)

The correct match is (i)-(r), (ii)-q, (iii)-p.

(i) The lowest enthalpy of atomisation is of Zn. As it has no unpaired electrons in 3s or 4s-orbital.

(ii) In 3d-series the maximum oxidation state is shown by Mn as it has 5 unpaired of electron in 3d-orbital.

(iii) In the ground state of Sc, it has one electron in the 3d-subshell, but in its common oxidation state it has no electron in 3d-subshell. Hence, it does not form coloured compound.

Question 7.

Which of the following statement is true?

- (a) Molecularity of reaction can be zero or a fraction.
(b) Molecularity has no meaning for complex reactions.
(c) Molecularity of a reaction is an experimental quantity.
(d) Reactions with the molecularity three are very rare but are fast. [1]

Answer:

- (b) Molecularity has no meaning for complex reactions.

Molecularity is a theoretical concept. It is applicable to elementary reaction. For complex reaction, it has no meaning.

Question 8.

In which of the following solvents, the $C_4H_9NH_3^+X^-$ is soluble. [1]

- (a) ether
(b) acetone
(c) water
(d) bromine water

Answer:
(c) water

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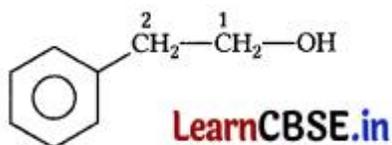
Question 9.

Which of the following observation is shown by 2-phenyl ethanol with Lucas reagent? [1]

- (a) Turbidity will be observed within five minutes.
- (b) No turbidity will be observed.
- (c) Turbidity will be observed immediately.
- (d) Turbidity will be observed at room temperature but will disappear after five minutes.

Answer:

- (b) No turbidity will be observed.



2-phenyl ethanol

The 2-phenyl ethanol is a primary alcohol, and primary alcohols do not produce turbidity at room temperature.

Question 10.

If the initial concentration of substance A is 1.5 M and after 120 seconds the concentration of substance A is 0.75 M, the rate constant for the reaction if it follows zero order kinetics is [1]

- (a) $0.00625 \text{ mol L}^{-1} \text{ s}^{-1}$
- (b) 0.00625 s^{-1}
- (c) $0.00578 \text{ mol L}^{-1} \text{ s}^{-1}$
- (d) 0.00578 s^{-1}

Answer:

- (a) $0.00625 \text{ mol L}^{-1} \text{ s}^{-1}$

Initial concentration of A = 1.5 M

Final concentration of A = 0.75 M, Time = 120 s

For zero order reaction, $k = \frac{[R_0] - [R]_t}{t} = \frac{1.50 - 0.75}{120}$

$= \frac{0.75}{120} = 0.00625 \text{ mol L}^{-1} \text{ s}^{-1}$

Question 11.

Anisole undergoes bromination with bromine in ethanoic acid even in the absence of iron (III) bromide catalyst [1]

- (a) due to the activation of benzene ring by the methoxy group
- (b) due to the de-activation of benzene ring by the methoxy group
- (c) due to the increase in electron density at ortho and para-positions
- (d) due to the formation of stable carbocation

Answer:

- (a) due to the activation of benzene ring by the methoxy group

The given reaction occurs because of the activation of benzene ring by the methoxy group.

Question 12.

The trend of which property is represented by the following graph? [1]



- (a) Ionisation enthalpy
- (b) Atomic radii
- (c) Enthalpy of atomisation
- (d) Melting point

Answer:

- (b) Atomic radii

The given graph is for atomic radii. Atomic radii decrease with increase in atomic number. However, at the end of the series, size of elements increases due to the increases in the magnitude of repulsive forces between electrons.

Question 13.

Given below are two statements labelled as Assertion (A) and Reason (R). [1]

Assertion (A) Alcohols react both as nucleophiles and electrophiles.

Reason (R) The bond between C—O is broken when alcohols react as nucleophiles.

Select the most appropriate answer from the options given below.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer:

- (c) A is true but R is false.

(A) is true but (R) is false. The correct (R) is : The bond between C—O is broken when alcohol reacts as electrophiles.

Question 14.

Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) Strong oxidising agents oxidise toluene and its derivatives to benzoic acids.

Reason (R) It is possible to stop the oxidation of toluene at the aldehyde stage with suitable reagents.

Select the most appropriate answer from the options given below. [1]

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer:

- (b) Both A and R are true but R is not the correct explanation of A.

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Question 15.

Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) Enzymes are very specific for a particular reaction and for a particular substrate.

Reason (R) Enzymes are biocatalysts. Select the most appropriate answer from the options given below. [1]

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer:

- (b) Both A and R are true but R is not the correct explanation of A.

Both (A) and (R) are true but (R) is not the correct explanation of (A). Each enzyme contains an active site which has specific shape and size.

Question 16.

Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) During electrolysis of aqueous copper sulphate solution using copper electrodes hydrogen gas is released at the cathode.

Reason (R) The electrode potential of Cu^{2+}/Cu is greater than that of H^+/H_2 . [1]

Select the most appropriate answer from the options given below.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer:

- (d) A is false but R is true.

(A) is false but (R) is true. As during electrolysis of aqueous copper sulphate solution using copper electrode, copper is deposited at cathode.

Section B

(This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.)

Question 17.

(a) Radioactive decay follows first order kinetics. The initial amount of two radioactive elements X and Y is 1 g each. What will be the ratio of X and Y after two days if their half-lives are 12 h and 16 h respectively? [2]

Answer:

Given : Half-life of X = 12 hr

Half-life of Y = 16 hr

Time = 2 days = 48 hours

For first order reaction,

Half-life of X after 2 days = $48/12 = 4$

Amount of X left after 4 half lives = $\frac{1}{16}$ of initial

value half-life of Y after 2 days = $48/16 = 3$.

Amount of Y left after 3 half lives = $\frac{1}{8}$ of initial value.

Ratio of X : Y = 1 : 2

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(b) The hypothetical reaction $P + Q \rightarrow R$ is half order w.r.t 'P' and zero order w.r.t 'Q'. What is the unit of rate constant for this reaction?

Answer:

For the reaction, $P + Q \rightarrow R$

$$\text{Rate} = k[P]^{1/2}[Q]^0 = k[P]^{1/2}$$

General formula for determination of unit is $\text{mol}^{1-n}\text{L}^{n-1}\text{s}^{-1}$.

So, for 1/2 order reaction, unit is $\text{mol}^{1/2}\text{L}^{-1/2}\text{s}^{-1}$.

Question 18.

A 5% solution of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ (molecular weight = 322) is isotonic with 2% solution of non-electrolytic, non-volatile substance X. Find out the molecular weight of X. [2]

Answer:

Molecular mass of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} = 322$

For isotonic solution osmotic pressure is same.

$$\therefore \pi_1(\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}) = \pi_2 (\text{non-electrolyte})$$

$$\Rightarrow iC_1RT = C_2RT$$

For $\text{Na}_2\text{SO}_4 - 10\text{H}_2\text{O}$,

$$i = 3$$

$$\Rightarrow 3 \times 5322 = 2M$$

$$\Rightarrow M = 2 \times 3223 \times 5$$

[where, M = molecular weight of non-electrolyte] = 42.9 g

Thus, the molecular weight of non electrolyte is 42.9g.

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Question 19.

(a) Arrange the isomeric dichlorobenzene in the increasing order of their boiling point and melting points. [2]

Answer:

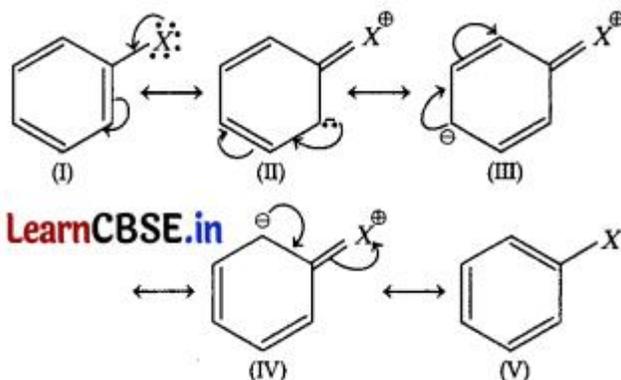
m-dichlorobenzene < o-dichlorobenzene < p-dichlorobenzene.

The p-isomer have high melting point as compared to o- and m-isomer. This is due to the symmetry of p-isomer compared to m-and o-isomers.

(b) Explain why the electrophilic substitution reactions in haloarenes occur slowly and require more drastic conditions as compared to those in benzene?

Answer:

The resonance structure of haloarenes are



The electron density in haloarenes increases more at o- and p-positions than at m-positions. Hence, electrophilic reactions occur at o- and p-position. The halogen atom has the tendency to withdraw electrons due to which electron density on benzene ring decreases (—I-effect) and the

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ring gets deactivate.

Hence, electrophilic substitution in haloarenes occurs at a slow rate.

Question 20.

(a) Out of p-tolualdehyde and p-nitrobenzaldehyde, which one is more reactive towards nucleophilic addition reactions, why? [2]

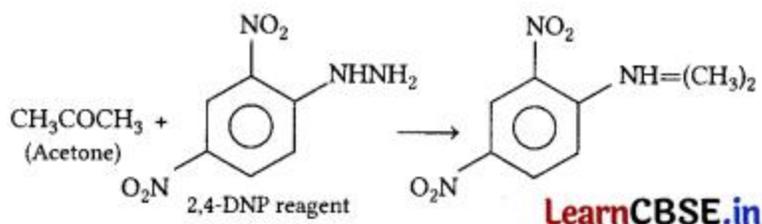
Answer:

p-nitrobenzaldehyde is more reactive towards the nucleophilic addition reaction than p-tolualdehyde as $-\text{NO}_2$ group is electron withdrawing in nature. Presence of nitro group decreases electron density.

Hence, facilitates the attack of nucleophile. Presence of $-\text{CH}_3$ leads to +I-effect as CH_3 is electron donating group.

(b) Write the structure of the product formed when acetone reacts with 2,4-DNP reagent.

Answer:



Or

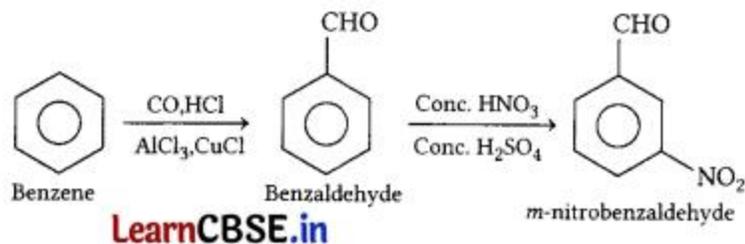
Convert the following. [2]

(a) Benzene to m-nitrobenzaldehyde

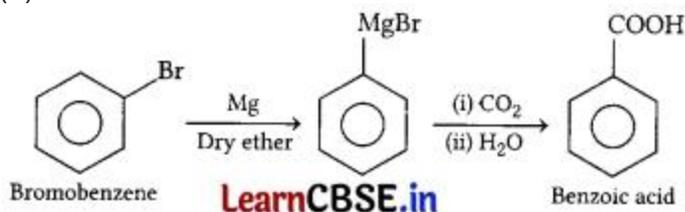
(b) Bromobenzene to benzoic acid

Answer:

(a) Benzene to m-nitrobenzaldehyde



(b) Bromobenzene to benzoic acid



Question 21.

(a) DNA fingerprinting is used to determine paternity of an individual. Which property of DNA helps in the procedure?

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(b) What structural change will occur when a native protein is subjected to change in pH? [2]

Answer:

(a) A sequence of bases on DNA is unique for a person and is the genetic material which is transferred to the individual from the parent. This helps in the determination of paternity.

(b) When a native protein is subjected to change in pH, the denaturation of secondary and tertiary structure of protein takes place. Whereas the primary structure remains intact.

Section C

(This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.)

Question 22.

(a) Write the formula for the following coordination compound.

Bis(ethane-1,2-diamine)dihydroxidochromium (III) chloride

(b) Does ionisation isomer for the following compound exist? Justify your answer. $\text{Hg}[\text{Co}(\text{SCN})_4]$

(c) Is the central metal atom in coordination complexes a Lewis acid or a Lewis base? Explain.

[3]

Answer:

(a) $[\text{Cr}(\text{en})_2(\text{OH})_2] \text{Cl}$

or $[\text{Cr}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2(\text{OH})_2]\text{Cl}$

(b) In the given compound ionisation isomers are not possible. This is because ionisation isomers are possible by exchange of ligand with counter ion only and not by exchange of central metal ion.

(c) The central metal in coordination complexes acts as an electron pair acceptor. Thus, it behaves as Lewis acid.

Question 23.

(a) Can we construct an electrochemical cell with two half-cells composed of ZnSO_4 solution and zinc electrodes? Explain your answer.

(b) Calculate the λ_m° for Cl^- ion from the data given below.

$$\lambda_m^\circ(\text{MgCl}_2) = 258.6 \text{ S cm}^2 \text{ mol}^{-1} \text{ and}$$

$$\lambda_m^\circ(\text{Mg}^{2+}) = 106 \text{ S cm}^2 \text{ mol}^{-1}$$

(c) The cell constant of a conductivity cell is 0.146 cm^{-1} . What is the conductivity of 0.01 M solution of an electrolyte at 298 K , if the resistance of the cell is 1000 ohm ? [3]

Answer:

(a) Yes, we can construct an electrochemical cell the concentration of ZnSO_4 in the two half-cells is different, the electrode potential will be different making the cell possible.

(b) Given, $\Lambda_m^\circ(\text{MgCl}_2) = 258.6 \text{ S cm}^2 \text{ mol}^{-1}$

$$\Lambda_m^\circ(\text{Mg}^{2+}) = 106 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\Lambda_m^\circ(\text{MgCl}_2) = \lambda_m^\circ(\text{Mg}^{2+}) + 2\lambda_m^\circ(\text{Cl}^-)$$

$$258.6 = 106 + 2\lambda_m^\circ(\text{Cl}^-) \text{ LearnCBSE.in}$$

$$\lambda_m^\circ(\text{Cl}^-) = 76.3 \text{ S cm}^2 \text{ mol}^{-1}$$

(c) Given, cell constant, $G^* = 0.146 \text{ cm}^{-1}$

Resistivity, $R = 1000 \text{ ohm}$

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Also, $G^* = k \times R$

$$k = G^*R = 0.1461000 = 146 \times 10^{-4} \text{ S cm}^{-1}$$

Question 24.

Write the name of the reaction, structure and IUPAC name of the product formed when

(a) phenol reacts with CHCl_3 in the presence of NaOH followed by hydrolysis.

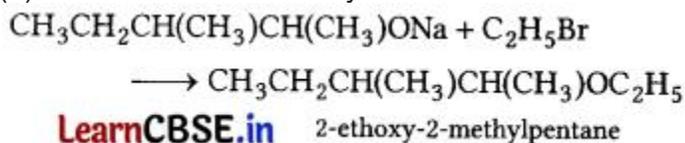
(b) $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{ONa}$ reacts with $\text{C}_2\text{H}_5\text{Br}$. [3]

Answer:

(a) Phenol reacts with CHCl_3 in the presence of NaOH followed by hydrolysis form 2-hydroxy benzaldehyde. This reaction is known as Reimer-Tiemann.



(b) Alkoxide reacts with alkyl halide to form ether. This reaction is called Williamson's synthesis.



Question 25.

You are given four organic compounds A, B, C and D. The compounds A, B and C form an orange-red precipitate with 2, 4-DNP reagent. Compounds A and B reduce Tollen's reagent while compounds C and D do not. Both B and C give a yellow precipitate when heated with iodine in the presence of NaOH . Compound D gives brisk effervescence with sodium bicarbonate solution. Identify A, B, C and D given the number of carbon atoms in three of these carbon compounds is three while one has two carbon atoms. Give an explanation for your answer. [3]

Answer:

According to the question, A, B and C, contain carbonyl group as they form an orange-red precipitate with 2,4-DNP reagent.

A and B reduces Tollen's reagent, thus they are aldehydes.

C is a ketone as it contains carbonyl group but does not give positive Tollen's test. As C gives positive iodoform test, thus it is a methyl ketone.

B gives positive iodoform test, thus it is an aldehyde.

D is a carboxylic acid, as it gives brisk effervescence with bicarbonate solution.

Since, the number of carbons in the compounds A, B, C and D is either three or two, therefore B is CH_3CHO as this is the only aldehyde which gives a positive iodoform test.

The remaining compounds A, C, and D have three carbons.

A = $\text{CH}_3\text{CH}_2\text{CHO}$; C = CH_3COCH_3 ; D = $\text{CH}_3\text{CH}_2\text{COOH}$ (3)

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Question 26.

When sucrose is hydrolysed the optical rotation values are measured using a polarimeter and are given in the following table. [3]

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S.no.	Time (hours)	Specific rotation
1.	0	+ 66.5°
2.	∞	- 39.9° LearnCBSE.in

- (a) Account for the two specific rotation values.
 (b) What is the specific name given to sucrose based on the above observation?
 (c) One of the products formed during the hydrolysis of sucrose is a glucose, that reacts with hydroxylamine to give compound A. Identify compound A.

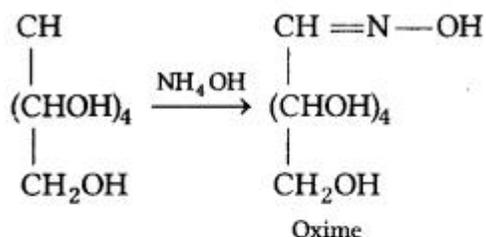
Answer:

(a) Sucrose is dextrorotatory but after hydrolysis, gives dextrorotatory glucose and laevorotatory fructose.

Since, the laevorotation of fructose (-92.4°) is more than dextrorotation of glucose (+52.5°), the mixture is laevorotatory.

(b) The hydrolysis of sucrose brings about a change in the sign of rotation from dextro (+) to laevo (-) and the product is named as invert sugar.

(c)



The product A is $\text{CH} = \text{N} - \text{OH}$.



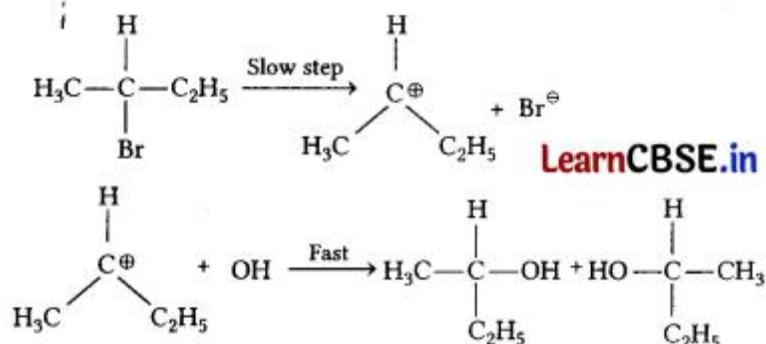
Question 27.

An organic compound A with the molecular formula (+) $\text{C}_4\text{H}_9\text{Br}$ undergoes hydrolysis to form (+) $\text{C}_4\text{H}_9\text{OH}$. Give the structure of A and write the mechanism of the reaction. [3]

Answer:

The structure of A is $\text{C}_2\text{H}_5\text{CH}(\text{Br})\text{CH}_3$.

Mechanism



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Question 28.

The rate constants of a reaction at 200K and 500K are 0.02 s^{-1} and 0.20 s^{-1} respectively.

Calculate the value of E_a .

(Given : $2.303 R = 19.15 \text{ JK}^{-1}\text{mol}^{-1}$) [3]

Answer:

$$\text{Rate constants, } k_1 = 0.02 \text{ s}^{-1}; k_2 = 0.20 \text{ s}^{-1}$$

$$T_1 = 200 \text{ K}; T_2 = 500 \text{ K}$$

We know that,

$$\log \left(\frac{k_2}{k_1} \right) = \frac{E_a}{2.303R} \left[\frac{1}{T_1} - \frac{1}{T_2} \right] \text{ LearnCBSE.in}$$

$$\log \frac{0.20}{0.02} = \frac{E_a}{2.303R} \left[\frac{1}{200} - \frac{1}{500} \right]$$

$$\log 10 = \frac{E_a}{1915} \left(\frac{300}{200 \times 500} \right)$$

$$E_a = \frac{1915 \times 200 \times 500}{300} = 6383 \text{ J/mol}$$

Section D

(The following questions are case-based questions. Each question has an internal choice and carries 4(1+1+2) marks each. Read the passage carefully and answer the questions that follow.)

Question 29.

Crystal Field Splitting by Various Ligands

Metal complexes show different colours due to d-d transitions. The complex absorbs light of specific wavelength to promote the electron from t_{2g} to e_g level. The colour of the complex is due to the transmitted light, which is complementary of the colour absorbed. The wave number of light absorbed by different complexes of Cr ion are given below.

Complex	Wave number of light absorbed (cm^{-1})	Energy of light absorbed (kJ/mol)
$[\text{CrA}_6]^{3-}$	13640	163
$[\text{CrB}_6]^{3+}$	17830	213
$[\text{CrC}_6]^{3+}$	21680	259
$[\text{CrD}_6]^{3-}$	26280	314

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Answer the following questions. [4]

(a) Out of the ligands A, B, C and D which ligand causes maximum crystal field splitting? Why?

Answer:

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Energy is directly proportional to the wave number. Maximum energy of light is required for an electron to jump from t_{2g} to e_g in case of $[\text{CrD}_6]^{3-}$.

Or

Which of the two, A or D will be a weak field ligand? Why?

(b) Which of the complexes will be violet in colour? $[\text{CrA}_6]^{3-}$ or $[\text{CrB}_6]^{3+}$ and why?

(Given: If 560 – 570 nm of light is absorbed, the colour of the complex observed is violet.)

(c) If the ligands attached to Cr^{3+} ion in the complexes given in the table above are water, cyanide ion, chloride ion, and ammonia (not in this order).

Identify the ligand, write the formula and IUPAC name of the following.

(i) $[\text{CrA}_6]^{3-}$

(ii) $[\text{CrC}_6]^{3+}$

Answer:

A weak field ligand causes the splitting of energy orbital (i.e. t_{2g} and e_g) with minimum extent. Hence, A is a weak field ligand on the energy required is minimum.

(b) For $[\text{CrB}_6]^{3+}$, wavelength of light absorbed

$$= \frac{1}{\text{wave number}} = \frac{1}{117830} = 560 \text{ nm}$$

For $[\text{CrA}_6]^{3-}$, wavelength of light absorbed

$$= \frac{1}{113640} = 733 \text{ nm.}$$

Thus, E_0 $[\text{CrB}_6]^{3+}$ complex is violet in colour.

(c) A = Cl^- (weak field ligand), B = H_2O , C = NH_3 , D = CN^- (strong field ligand)

(i) $[\text{CrCl}_6]^{3-}$ = Hexachloridochromate (III) ion

(ii) $[\text{Cr}(\text{NH}_3)_6]^{3+}$ = Hexaamminechromium (III) ion

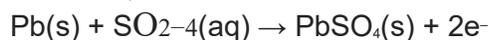
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Question 30.

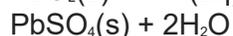
The lead-acid battery represents the oldest rechargeable battery technology. Lead acid batteries can be found in a wide variety of applications including small-scale power storage such as UPS systems, ignition power sources for automobiles, along with large, grid-scale power systems.

The spongy lead act as the anode and lead dioxide as the cathode. Aqueous sulphuric acid is used as an electrolyte. The half-reactions during discharging of lead storage cells are

At anode,



At cathode,



There is no safe way of disposal and these batteries end – up in landfills. Lead and sulphuric acid are extremely hazardous and pollute soil, water as well as air. Irrespective of the environmental challenges it poses, lead-acid batteries have remained an important source of energy.

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Designing green and sustainable battery systems as alternatives to conventional means remains relevant. Fuel cells are seen as the future source of energy. Hydrogen is considered a green fuel. Problem with fuel cells at present is the storage of hydrogen. Currently, ammonia and methanol are being used as a source of hydrogen for fuel cell. These are obtained industrially, so add to the environmental issues.

If the problem of storage of hydrogen is overcome, is it still a "greenfuel"? Despite being the most abundant element in the Universe, hydrogen does not exist on its own, so needs to be extracted from the water using electrolysis or separated from carbon fossil fuels. Both of these processes require a significant amount of energy which is currently more than that gained from the hydrogen itself. In addition, this extraction typically requires the use of fossil fuels.

More research is being conducted in this field to solve these problems. Despite the problem of no good means to extract hydrogen, it is a uniquely abundant and renewable source of energy, perfect for our future zero-carbon needs.

Answer the following questions. [4]

- (a) How many coulombs have been transferred from anode to cathode in order to consume one mole of sulphuric acid during the discharging of lead storage cell?
- (b) How much work can be extracted by using lead storage cell if each cell delivers about 2.0 V of voltage? ($1 F = 96500 C$)
- (c) Do you agree with the statement—"Hydrogen is a green fuel." Give your comments for and against this statement and justify your views.

Answer:

- (a) As, 2 Faradays (or 2 mol) have been transferred from anode to cathode to consume 2 moles of H_2SO_4 .

Therefore, 1 mole of H_2SO_4 required 1 Faraday of electricity or 96500 coulombs.

- (b) Given , $E^\circ = 2V$, $n = 2$, $F = 96500$

$$W_{\max} = -nFE^\circ = -2 \times 96500 \times 2 = -386000 J$$

Then, 386000 J of work can be extracted using lead storage cell when the cell is in use.

- (c) Both Yes and No should be accepted as correct answer.

Hydrogen is a green fuel. On combustion it emits water vapour and leaves no residue in the air. However, at present there is no green method to obtain hydrogen. It is obtained by electrolysis of water which use electricity obtained from fossil fuels.

Or

Imagine you are a member of an agency funding scientific research. Which of the following projects will you fund and why?

- (a) Safe recycling of lead batteries
- (b) Extraction of hydrogen [4]

Answer:

- (a) Safe recycling of lead batteries.

Lead batteries are widely used batteries but their disposal is an issue because currently, these

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are being thrown into landfills and no safe method of disposal or recycling exists. Research on this project will lead to reducing the pollution and health hazards.

(b) Fuel cell is a clean source of energy but the current problem is obtaining/extraction of hydrogen. Research on this project will reduce the pollution problem and find a sustainable solution.

Section E

(The following questions are long answer type and carry 5 marks each. All questions have an internal choice.)

Question 31.

Attempt any five of the following. [5]

(a) Which of the following ions will have a magnetic moment value of 1.73 BM?

Sc^{3+} , Ti^{3+} , Ti^{2+} , Cu^{2+} , Zn^{2+}

(b) In order to protect iron from corrosion, which one will you prefer as a sacrificial electrode, Ni or Zn? Why?

(Given : Standard electrode potentials of Ni, Fe and Zn are -0.25 V, -0.44 V and -0.76 V respectively.)

(c) The second ionisation enthalpies of chromium and manganese are 1592 and 1509 kJ/mol respectively. Explain the lower value of Mn.

(d) Give two similarities in the properties of Sc and Zn.

(e) What is actinoid contraction? What causes actinoid contraction?

(f) What is the oxidation state of chromium in chromate ion and dichromate ion?

(g) Write the ionic equation for reaction of KI with acidified KMnO_4 .

Answer:

(a) Among the given option, Ti^{3+} and Cu^{2+} have 1 unpaired of electron. Thus , their magnetic moment is 1.73 or $3-\sqrt{3}$.

(b) Zinc can be used as sacrificial metals as, it is more reactive than iron and lose its electrons in preference to iron. This prevent iron from losing its electrons and becoming oxidised.

(c) Electronic configuration of $\text{Mn}^{2+} = 3d^5 4s^1$

Electronic configuration of $\text{Cr}^{2+} = 3d^4$

As Cr^{2+} has stable half-filled electronic configuration thus, it requires more ionisation energy to remove electron from stable configuration whereas, Mn^{2+} has 1 electron in 4s¹ which can easily be removed. Thus, its ionisation energy is less.

(d) Sc in its common +3 oxidation state has no electron in 3d-orbital and Zn has no unpaired electron in its 3d-orbital in either its atomic state or ionic state. Thus, both Sc and Zn form colourless compound and are diamagnetic.

(e) The radii of trivalent and quadrivalent ions of actinoids contract slightly with increasing atomic number. This contraction is known as actinoid contraction. This results from poor shielding experienced by 5f-electrons.

(f) The oxidation state in chromate ion [$\text{Cr}_2\text{O}_4^{2-}$] and dichromate ion [$\text{Cr}_2\text{O}_7^{2-}$] is +3 and +6 respectively.

(g) $2\text{MnO}_4^- + 10\text{I}^- + 6\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{I}_2$

Question 32.

(a) What is the effect of temperature on the solubility of glucose in water? [5]

(b) Ibrahim collected 100 mL each of fresh water and ocean water. He observed that one sample labelled P froze at 0°C while the other Q at -1.3°C. Ibrahim forgot which of the two, P or Q was ocean water. Help him identify which container contains ocean water, giving rationalisation for

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your answer.

(c) Calculate van't Hoff factor for an aqueous solution of $K_3[Fe(CN)_6]$ if the degree of dissociation (α) is 0.852. What will be the boiling point of this solution if its concentration is 1 molal? ($K_b = 0.52 \text{ K kg/mol}$)

Answer:

(a) The solubility of glucose in water, increases with increase in temperature.

(b) Q is ocean water because due to the presence of salts it freezes at lower temperature (depression in freezing point).

(c) Degree of dissociation of $K_3[Fe(CN)_6] = 0.852$

$$K_b = 0.52 \text{ K kg / mol}$$

$K_3[Fe(CN)_6]$ gives 4 ions in aqueous solution

$$i = 1 + (n - 1)\alpha$$

$$= 1 + (4 - 1) \times 0.852 = 3.556$$

$$\Delta T_b = iK_b m = 3.556 \times 0.52 \times 1 = 1.85^\circ\text{C}$$

$$\Delta T_b = 1.85^\circ\text{C}$$

$$T_b = 100 + 1.85^\circ\text{C} = 101.85^\circ\text{C}$$

Or

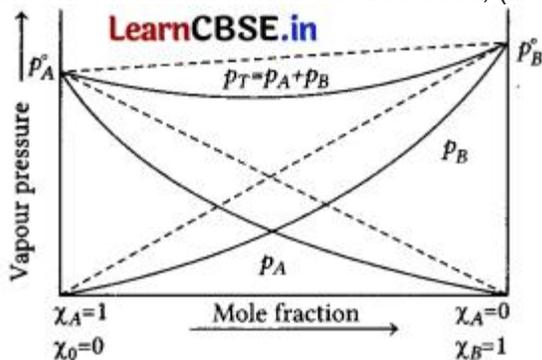
(a) What type of deviation from Raoult's law is expected when phenol and aniline are mixed with each other? What change in the net volume of the mixture is expected? Graphically represent the deviation.

(b) The vapour pressure of pure water at a certain temperature is 23.80 mm Hg.

If 1 mole of a non- volatile non- electrolytic solute is dissolved in 100g water, calculate the resultant vapour pressure of the solution. [5]

Answer:

(a) The negative deviation is expected when phenol and aniline are mixed with each other. The net volume of the mixture will decrease, ($\Delta V = 0$) due to stronger intermolecular interactions.



p, χ diagram for solutions showing negative deviation from Raoult's law

(b) Vapour pressure of pure water = 23.80 mmHg

Amount of non-volatile electrolyte solute = 1 mol

Amount of water = 100 g

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We know, relative lowering of vapour pressure

$$\Rightarrow \frac{(p^\circ - p)}{p^\circ} = x_2 = \frac{n_2}{n_1} \text{ and } n_2 = 0.1$$

$$n_1 = 100 / 18 = 5.55$$

$$\therefore x_2 = \frac{n_2}{n_2 + n_1} = \frac{0.1}{5.65} = 0.018$$

$$p^\circ = 23.8 \text{ mmHg} \quad \text{LearnCBSE.in}$$

Relative lowering of vapour pressure

$$= \frac{23.8 - p}{23.8} = 0.018$$

$$23.80 - p = 0.428$$

$$p = 23.8 - 0.428 = 23.37 \text{ mmHg}$$

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Question 33.

An organic compound with molecular formula $C_7H_7NO_2$ exists in three isomeric forms, the isomer 'A' has the highest melting point of the three. 'A' on reduction gives compound 'B' with molecular formula C_7H_9N . 'B' on treatment with $NaNO_2/HCl$ at $0-5^\circ C$ to form compound 'C'. On treating C with H_3PO_2 , it gets converted to D with formula C_7H_8 , which on further reaction with CrO_2Cl_2 followed by hydrolysis forms 'E' C_7H_6O . Write the structure of compounds A to E. Write the chemical equations involved. [5]

Answer:

Compound having molecular formula $C_7H_7NO_2$ is

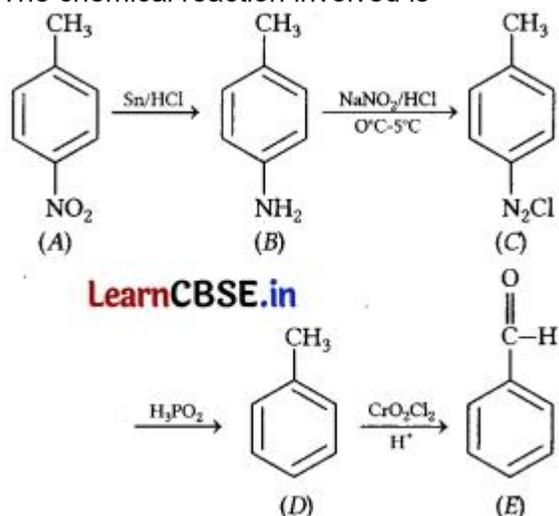


forms).

Among these 3 forms, (A) p-methylnitrobenzene has highest melting point due to greater symmetry, which on reaction with Sn/HCl is reduced to C_7H_9N , i.e. (p-methylbenzenamine) (B). (B) on treatment with $NaNO_2/HCl$ forms diazonium salt of p-methylbenzene (C). On treating (C) with hypophosphorus acid forms toluene (D). D on oxidation forms benzaldehyde (E).

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The chemical reaction involved is



Or

(a) Account for the following. [5]

- (i) N-ethylbenzenesulphonyl amide is soluble in alkali.
- (ii) Reduction of nitrobenzene using Fe and HCl is preferred over Sn and HCl.

Answer:

(i) The hydrogen attached to nitrogen in N-ethylbenzene sulphonylamide is strongly acidic in nature due to the presence of strong electron withdrawing group, i.e. sulphonyl group. Hence, it is soluble in alkali.

(ii) Reduction of nitrobenzene using Fe and HCl is preferred because FeCl_2 formed during the reaction get hydrolysed to release HCl.

Thus, only a small amount of HCl is required to initiate the reaction.

(b) Arrange the following in

- (i) decreasing order of pK_b values $\text{C}_6\text{H}_5\text{NH}_2$, $\text{C}_6\text{H}_5\text{NHCH}_3$, $\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2$, CH_3NH_2 , NH_3
- (ii) increasing order of solubility in water $\text{C}_2\text{H}_5\text{Cl}$, $\text{C}_2\text{H}_5\text{NH}_2$, $\text{C}_2\text{H}_5\text{OH}$
- (iii) decreasing boiling point CH_3COOH , $\text{C}_2\text{H}_5\text{OH}$, CH_3NH_2 , CH_3OCH_3

Answer:

(i) Higher the pK_b value, weaker is the base.

Decreasing order of pK_b value is



(ii) Increasing order of solubility in water.



(iii) Decreasing boiling point order is

