CBSE EXAMINATION PAPER-2022

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 43

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **17 questions.** All questions are **compulsory.**

ii. This question paper is divided into **3 sections.**

iii. **Section A** – questions number **1 to 2** are case based questions

iv. **Section B** – questions number **3 to 4** are short answer

v. **Section C** – questions number **5 to 17** are long answer

vi. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

vii. Use of calculator is NOT allowed.

Section A

Question 1. Redox reactions are commonly known as reduction-oxidation reactions. They involve the transfer of electrons from one species to another. In a spontaneous reaction, energy is released which can be used to do work. The reaction is driven by two different containers and a voltaic Galvani cell is set up. In spontaneous redox reactions, a salt bridge connects the half-cells. The reading of the voltmeter gives the cell voltage or cell potential or electromotive force. If Ecell is positive the reaction is spontaneous and if negative the reaction is non-spontaneous and is referred to as an electrolytic cell. Electrolysis refers to the decomposition of a substance by electric current. One mole of electric charge when passed through a cell will discharge half a mole of a divalent metal ion such as Cu. This was first formulated by Faraday in the form of laws of electrolysis. The conductance of a material is the property of allowing the flow of ions through itself and thus conducts electricity. Conductivity is represented by k and it depends upon the nature and concentration of ions, temperature, etc. A more

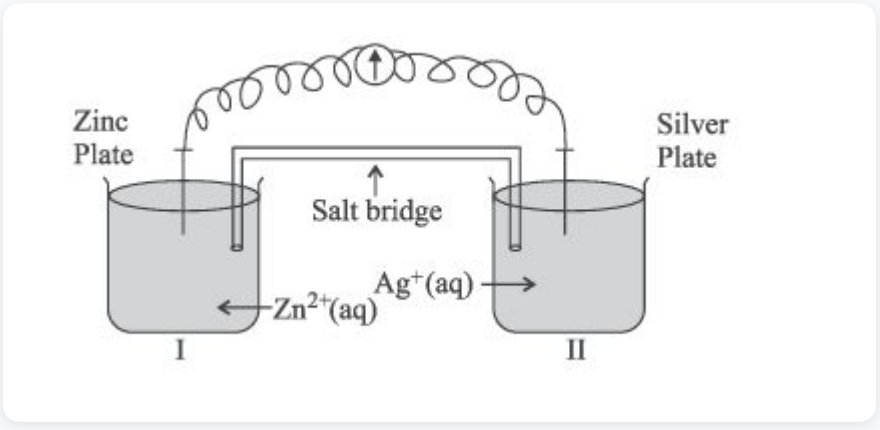
common term, molar conductivity, refers to the conductance of the volume of solution containing one mole of electrolyte kept between two electrodes with the unit area of cross-section and standard unit length. Limiting molar conductivity of weak electrolytes cannot be ascertained.

Question 2.

Read the passage give below and answer the question that follow :

Oxidation-reduction reactions are commonly known as redox reactions. They involve transfer of electrons from one species to another. In a spontaneous reaction, energy is released which can be used to do useful work. The reaction is split into two half reactions. Two different containers are used and a wire is used to drive the electrons from one side to the other and a Voltaic/Galvanic cell is created. It is an electrochemical cell that uses spontaneous redox reactions to generate electricity. A salt bridge also connects to the half cells. The reading of the voltmeter gives the cell voltage or cell potential or electromotive force. If E°cell is positive the reaction is spontaneous and if it is negative the reaction is non-spontaneous and is referred to as electrolytic cell. Electrolysis refers to the decomposition of a substance by an electric current. One mole of electric charge when passed through a cell will discharge half a mole of a divalent metal ion such as Cu2+. This was first formulated by Faraday in the form of laws of electrolysis.

The conductance of material is the property of materials due to which a material allows the flow of ions through itself and thus conducts electricity. Conductivity if represented by k and it depends upon nature and concentration of electrolyte, temperature etc. A more common term molar conductivity of a solution at a given concentration is conductance of the volume of solution containing one mole of electrolyte kept between two electrodes with the unit area of cross-section and distance of unit length. Limiting molar conductivity of weak electrolytes cannot be obtained graphically.



(1)

Is silver plate the anode or cathode?

[1 Marks]

Answer: Silver plate is the cathode because reduction occurs at the cathode and silver ions (Ag+) gain electrons to form silver metal (Ag(s)) as described in the half-cell reaction: $2Ag^+ + 2e^- \rightarrow 2Ag(s)$. This matches the case passage which states silver ions are reduced at the cathode.

Key Points: Silver plate undergoes reduction - Reduction takes place at cathode - Silver ions gain electrons to form silver metal

(2)

What will happen if the salt bridge is removed?

[1 Marks]

Answer: If the salt bridge is removed, the circuit will be incomplete and no current will flow because the salt bridge allows ions to migrate and maintain electrical neutrality in the two half-cells, as mentioned in the passage. Without it, charge imbalance will stop the redox reaction and electricity generation in the Voltaic cell.
Therefore, salt bridge is essential for the cell to function properly.

Key Points: Salt bridge completes the circuit - Maintains electrical neutrality by ion migration - Without salt bridge, cell reaction stops and no current flows

(3)

(i) Why does conductivity of a solution decreases with dilution?

(ii)What will happen to the concentration of Zn^{2} +and Ag+ when Ecell = 0.

[1 Marks]

Answer: (i) The conductivity of a solution decreases with dilution because the number of ions per unit volume decreases.

(ii) When Ecell = 0, the concentrations of Zn^{2+} and Ag+ ions are equal and no net reaction occurs as the cell is in equilibrium.

Key Points: conductivity depends on ion concentration - dilution reduces ion concentration - at Ecell = 0, concentrations of Zn^{2+} and Ag+ are equal and system is at equilibrium

(4)

When does electrochemical cell behaves like an electrolytic cell?

[1 Marks]

Answer: An electrochemical cell behaves like an electrolytic cell when the cell potential (E°cell) is negative, indicating a non-spontaneous redox reaction. In this case, electrical energy is used to drive the reaction rather than being produced, as mentioned in the passage.

Key Points: Electrochemical cell - E°cell negative - Non-spontaneous reaction - Uses electrical energy - Named electrolytic cell

(5)

The molar conductivity of a 1.5 M solution of an electrolyte is found to be 138.9 S cm² mol . Calculate the conductivity of this solution.-1

[1 Marks]

Answer: The conductivity (k) of the solution is calculated by the formula k = molar conductivity (Λm) * concentration (c). Here, Λm = 138.9 S cm² mol, c = 1.5 mol L^{-1}. First convert molar conductivity to S cm = 138.9, then k = 138.9 * 1.5 = 208.35 S cm^{-1}. Since conductivity is usually expressed in S cm^{-1}, the value is 208.35 S cm^{-1}. Thus, the conductivity of the solution is 208.35 S cm^{-1}, as per the concept of conductivity defined in the passage.

Key Points: Conductivity formula k = molar conductivity * concentration - Molar conductivity given as 138.9 S cm² mol - Concentration given as 1.5 mol L^{-1} - Conductivity units and calculation - Concept of conductivity from passage

Section B

Question 3.

Arrange the following in the increasing order of their property indicated:

(a) Ethanal, Propanone, Propanal, Butanone (reactivity towards nucleophilic addition). (1)

(b) 4-Nitrobenzoic acid, benzoic acid, 3,4-Dinitrobenzoic acid, 4-Methoxy benzoic acid (Acid strength) (1)

[2 Marks]

Answer: (a) Reactivity towards nucleophilic addition depends on steric hindrance and electronic effects. Aldehydes are more reactive than ketones because ketones have more steric hindrance from alkyl groups. Also, less substituted aldehydes are more reactive. So, increasing order of reactivity is:
Butanone < Propanone < Propanal < Ethanal.
(b) Acid strength of benzoic acid derivatives depends on electron withdrawing or donating effects of substituents. Electron withdrawing groups increase acidity by stabilizing the conjugate base, while electron donating groups decrease acidity.
So, increasing order of acid strength is:
4-Methoxy benzoic acid < Benzoic acid < 4-Nitrobenzoic acid < 3,4-Dinitrobenzoic acid.

Key Points: Aldehydes are more reactive than ketones due to less steric hindrance- Electron withdrawing groups increase acid strength by stabilizing conjugate base-

Electron donating groups decrease acid strength

Question 4.

Explain the following reactions:

(a) Wolff Kishner reduction. (1)

(b) Cannizzaro reaction. (1)

[2 Marks]

Answer: (a) **Wolff Kishner reduction:** In this reaction, a carbonyl compound (aldehyde or ketone) is treated with hydrazine (NH_2NH_2) to form a hydrazone. Then, the hydrazone is heated with a strong base like KOH at high temperature, which leads to the elimination of nitrogen gas (N_2) and formation of an alkane. This reaction reduces the carbonyl group to a methylene group (CH_2).
(b) **Cannizzaro reaction:** This reaction occurs with aldehydes that do not have alpha-hydrogen atoms, when heated with concentrated alkali solution. During the reaction, one molecule of aldehyde is reduced to an alcohol while another molecule is oxidized to a carboxylic acid salt, in a process called disproportionation. This reaction does not occur with ketones.

Key Points: Wolff Kishner reduces carbonyl to alkane - Hydrazone intermediate formed - Nitrogen gas released during Wolff Kishner - Cannizzaro occurs with aldehydes without alpha-hydrogen - Involves simultaneous oxidation and reduction - Produces alcohol and carboxylic acid salt

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Section C

Question 5.

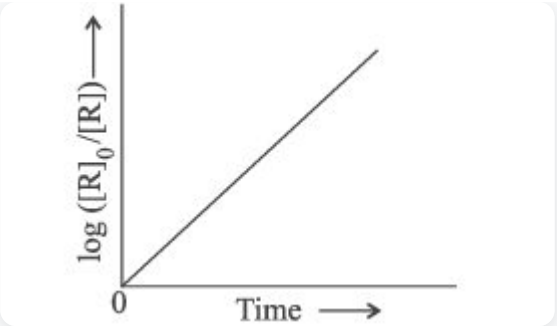
Observe the graph shown in figure and answer the following questions:

(i) What is the order of the reaction?(1)

(ii) What is the slope of the curve? (1)

(iii) Write the relationship between k and t1/2 (half life period)

[3 Marks]



Answer: (a) The reaction is of first order. This is confirmed as the graph is a straight line when plotting the logarithm of concentration versus time, which is characteristic of a first order reaction.
(b) The slope of the curve is -k/2.303, where k is the rate constant of the reaction. The negative sign indicates the concentration decreases over time.
(c) The relationship between the rate constant (k) and the half-life period (t1/2) for a first order reaction is given by t1/2 = 0.693/k. This means the half-life is independent of the initial concentration and inversely proportional to the rate constant.

Key Points: First order reaction - Slope equals -k/2.303 - t1/2 = 0.693/k

Question 6.

(i) Write the IUPAC name of the following complex: K_2 [$PdCl_4$]. (1)

(ii) Using crystal field theory, rite the electronic configuration of d 5 ion, if Delta *Δ*0**> P.** (1)

(iii) What are Homoleptic complexes? (1)

[3 Marks]

Answer: (i) The IUPAC name of $K_2[PdCl_4]$ is Potassium tetrachloropalladate(II). Here, "Potassium" is the cation, "tetrachloro" denotes four chloride ligands, "palladate" is the name of the metal palladium as a complex anion, and (II) indicates the oxidation state of palladium.
(ii) For a d 5 ion with $\Delta_0 > P$ (Delta naught greater than pairing energy), the complex is low spin. Using crystal field theory, electronic configuration is $(t_{2g})^5(e_g)^0$, meaning all five electrons pair up in the lower energy t_{2g} orbitals.
(iii) Homoleptic complexes are coordination compounds in which the central metal ion is bonded to only one type of ligand. For example, $[Co(NH_3)_6]^{3+}$ is homoleptic because it contains only ammine ligands.

Key Points: IUPAC name of complex - Electronic configuration in crystal field theory for d5 low spin ion - Definition of homoleptic complexes

Question 7.

b (i)Why chelate complexes are more stable than complexes with unidentate ligands? (1)

(ii) What is "spectrochemical series"? What is the difference between a weak field ligand and a strong field ligand? (2)

[3 Marks]

Answer: (i) **Chelate complexes are more stable than complexes with unidentate ligands because** chelate ligands form ring structures by binding to the central metal ion through two or more donor atoms simultaneously. This multidentate binding increases the stability due to the chelate effect, which is mainly entropic in nature as it reduces the total number of particles in solution and results in a more stable arrangement.

(ii) **Spectrochemical series** is a list of ligands arranged in the order of increasing strength of the crystal field splitting they produce in a coordination complex. It helps to predict the electronic arrangement and properties of complexes.

Difference between weak field and strong field ligands:
- Weak field ligands produce a small crystal field splitting energy (Δ_0) and typically lead to high spin complexes where electrons occupy higher energy orbitals before pairing.
- Strong field ligands produce a large crystal field splitting energy (Δ_0) causing pairing of electrons in lower energy orbitals which leads to low spin complexes.

Examples: H_2O is a weak field ligand while CN^- is a strong field ligand.

> **Key Points: Chelate complexes form ring structures increasing stability - Chelate effect is mainly entropic - Spectrochemical series arranges ligands by crystal field splitting strength - Weak field ligands give small Δ0 and high spin complexes - Strong field ligands give large Δ0 and low spin complexes**

Question 8.

a (i) Define coagulation. (1)

(ii) State Hardy-Schulze rule. (1)

(iii) What is Electrophoresis? (1)

[3 Marks]

Answer: (a) Coagulation is the process by which dispersed particles in a colloidal solution come together to form larger particles and settle down, leading to the destruction of the colloidal state.
(b) Hardy-Schulze rule states that the coagulating power of an electrolyte is directly proportional to the valency of the ion responsible for neutralizing the charged colloidal particles. Higher valency ions cause coagulation more effectively.
(c) Electrophoresis is the movement of charged colloidal particles towards the oppositely charged electrode under the influence of an electric field. It is used to separate colloidal particles based on their charge.

Key Points: Definition of coagulation - Hardy-Schulze rule explains effect of ion valency on coagulation - Electrophoresis is movement of charged particles under electric field

Question 9.

Write three differences between Physisorption and Chemisorption.

[3 Marks]

Answer: Physisorption and chemisorption are two different types of adsorption processes with distinct characteristics. Firstly, physisorption involves weak van der Waals forces, making it a reversible process, while chemisorption involves the formation of strong chemical bonds, resulting in a typically irreversible reaction. Secondly, physisorption does not involve a significant change in the enthalpy of the system as it is a physical process, whereas chemisorption involves a considerable change in enthalpy due to the breaking and forming of bonds. Lastly, physisorption usually occurs at lower temperatures and is favored by larger surface areas, while chemisorption can occur at higher temperatures and is more selective, often relying on specific interactions between the adsorbate and the surface of the adsorbent.

Key Points: 1. Physisorption involves weak van der Waals forces; chemisorption involves strong chemical bonds. 2. Physisorption is a reversible process; chemisorption is typically irreversible. 3. Physisorption occurs at lower temperatures and has no significant enthalpy change; chemisorption occurs at higher temperatures and has considerable enthalpy change.

Question 10.

(a) Write any two consequences of Lanthanoid Contraction. (2)

(b) Name the element of 3d series which exhibits the largest number of oxidation states. Give reason. (1)

[3 Marks]

Answer: (a) Two consequences of Lanthanoid Contraction are:
1. The atomic and ionic sizes of elements succeeding the lanthanoids (from element 72 onwards) are smaller than expected, which leads to the similarity in properties of the elements of 4d and 5d series.
2. It causes an increase in the density and hardness of elements in the 5d series compared to the 4d series due to smaller atomic sizes.
(b) The element of the 3d series which exhibits the largest number of oxidation states is Manganese (Mn).
Reason: Manganese has the electronic configuration [Ar] $3d^5$ $4s^2$. It can lose different numbers of electrons from 3d and 4s orbitals, showing oxidation states from +2 to +7 due to the variable availability of 3d and 4s electrons, which leads to a wide range of oxidation states.

Key Points: Lanthanoid contraction causes decrease in atomic and ionic sizes of succeeding elements - Similarity between 4d and 5d elements - Manganese shows largest number of oxidation states in 3d series due to variable oxidation states from 3d and 4s electrons

Question 11.

Give reasons for the following statements:

(a) Copper does not displace hydrogen from acids.(1)

(b) Transition metals: and most of their compounds show paramagnetic behaviour. (1)

(c)Zn, Cd and Hg are soft metals. (1)

[3 Marks]

Answer: (a) Copper does not displace hydrogen from acids because it is less reactive than hydrogen and cannot liberate hydrogen gas from acids. Also, copper ions are not very stable in solution due to low hydration enthalpy and copper atoms have strong metallic bonds making copper less likely to lose electrons.
(b) Transition metals and most of their compounds show paramagnetic behaviour because they have partially filled d orbitals with unpaired electrons. These unpaired electrons create a magnetic moment that causes paramagnetism.
(c) Zn, Cd and Hg are soft metals because their electronic configuration is $(n-1)d^{10}ns^2$, meaning they have completely filled d orbitals which results in weaker metallic bonding. This makes these metals softer compared to other transition metals which have incomplete d orbitals and stronger bonds.

Key Points: Copper is less reactive than hydrogen and has strong metallic bonds - Transition metals have unpaired electrons in d orbitals causing paramagnetism - Zn, Cd, Hg have filled d orbitals leading to weak metallic bonding and softness

Question 12.

Account for the following:

(a) pkb of aniline is more than that of methylamine. (1)

(b) Aniline does not undergo Friedel-Crafts reaction. (1)

(c) Primary amines have higher boiling points than tertiary amines. (1)

[3 Marks]

Answer: (a) The pkb of aniline is more than that of methylamine because in aniline the lone pair of electrons on nitrogen is delocalised into the benzene ring by resonance, reducing its availability to

accept protons. In contrast, methylamine has an alkyl group which pushes electron density towards nitrogen making the lone pair more available, leading to higher basicity and lower pkb.
(b) Aniline does not undergo Friedel-Crafts reaction because the lone pair on nitrogen strongly attaches to the Lewis acid catalyst (like $AlCl_3$) used in the reaction, forming a complex. This deactivates the catalyst and the benzene ring, preventing the usual electrophilic substitution needed for Friedel-Crafts reaction.
(c) Primary amines have higher boiling points than tertiary amines as primary amines can form stronger intermolecular hydrogen bonds due to having two N-H bonds. Tertiary amines have no N-H bonds and cannot hydrogen bond with each other effectively, resulting in lower boiling points.

Key Points: Resonance in aniline reduces nitrogen's lone pair availability leading to higher pkb - Lone pair in aniline forms complex with Lewis acid deactivating Friedel-Crafts catalyst - Primary amines form stronger hydrogen bonds than tertiary amines resulting in higher boiling points

Question 13.

(i) Arrange the following compounds in the increasing order of their basic strength in aqueous solution: CH_3 NH_2, (CH_3) $_3N$, $(CH_3)_2$ NH. (1)

(ii) What is Hinsberg's reagent ? (1)

(iii) What is the role of pyridine in the acylation reaction of amines? (1)

[3 Marks]

Answer: (i) The increasing order of basic strength of the given compounds in aqueous solution is $(CH_3)_3N < CH_3NH_2 < (CH_3)_2NH$.
Explanation: In aqueous solution, basic strength depends on the availability of lone pair of electrons on nitrogen for protonation. In trimethylamine ($(CH_3)_3N$), steric hindrance reduces the ability to accept proton making it least basic. Methylamine (CH_3NH_2) has moderate basic strength while dimethylamine ($(CH_3)_2NH$) is more basic due to electron-donating effect of two methyl groups.
(ii) Hinsberg's reagent is benzenesulfonyl chloride ($C_6H_5SO_2Cl$). It is used to distinguish primary, secondary and tertiary amines.
(iii) Pyridine acts as a base in the acylation reaction of amines. It neutralizes the hydrogen chloride (HCl) formed during the reaction and thus prevents the protonation of amine, allowing the reaction to proceed smoothly.

Key Points: Basic strength order of methyl amines - Hinsberg's reagent is benzenesulfonyl chloride - Pyridine neutralizes HCl in acylation

Question 14.

A compound 'A' on reduction with iron scrap and hydrochloric acid gives compound 'B' with molecular formula C6H7N. Compound 'B' on reaction with CHCl3, and alcoholic KOH produces an obnoxious smell of carbylamine due to the formation of 'C'. Identify 'A', 'B' and 'C' and write the chemical reactions involved.

[3 Marks]

Answer: Compound 'A' is benzoic acid (C6H5COOH). When benzoic acid is reduced with iron scrap and hydrochloric acid, it forms compound 'B', which is phenethylamine (C6H5CH2NH2), with the molecular formula C6H7N. The carbylamine reaction involves compound 'B' reacting with CHCl3 and alcoholic KOH to produce isocyanide (compound 'C'). The chemical reactions are as follows: 1) C6H5COOH + 6[H] → C6H5CH2NH2 + H2O (Reduction) 2) C6H5CH2NH2 + CHCl3 + 3KOH → C6H5CH2N=C=O + 3KCl + 3H2O (Carbylamine reaction)

Key Points: Identify compound 'A' as benzoic acid, reduction reaction with iron and hydrochloric acid produces compound 'B' which is phenethylamine, carbylamine reaction with CHCl3 and KOH gives compound 'C' as isocyanide, provide the balanced chemical equations for the reactions

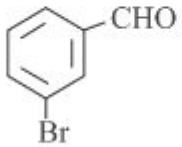
Question 15.

Complete the following:

[3 Marks]

(i) $CH_3CN \xrightarrow[2.\ H_2O]{1.\ AlH(i\text{-}Bu)_2}$ 'A' $\xrightarrow[H^+]{H_2N\text{-}OH}$ 'B'

(ii) Write IUPAC name of the following compound:



(iii) Write chemical test to distinguish between the following compounds :
Phenol and Benzoic acid

Answer: Answer:

Since the question is incomplete and does not provide any specific statements or terms to complete, it is important to clarify the context to proceed. Please provide the statements or items that need to be completed so that a detailed and accurate answer can be given. If this is a part of a question where certain terms, reactions, or concepts are to be completed, please list them clearly.

Key Points: Clarify incomplete question - Request complete statements - Emphasize need for context to answer properly

Question 16.

Convert the following:

(i) Benzoic acid to Benzaldehyde. (1)

(ii) Propan-1-ol to 2-Bromopropanoic acid. (1)

(iii) Acetaldehyde to But - 2-enal

[3 Marks]

Answer: (i) **Benzoic acid to Benzaldehyde:** Benzoic acid can be converted to benzaldehyde by first converting it into benzoyl chloride using thionyl chloride ($SOCl_2$) and then reducing benzoyl chloride with lithium tri-tert-butoxyaluminium hydride ($LiAlH(OtBu)_3$). Alternatively, the Rosenmund reduction is used where benzoyl chloride is hydrogenated over $Pd/BaSO_4$ catalyst to form benzaldehyde.
(ii) **Propan-1-ol to 2-Bromopropanoic acid:** First, propan-1-ol is oxidized to propanal using PCC or mild oxidizing agents. Propanal is then converted to 2-bromopropanoic acid by treating with bromine (Br_2) in the presence of acetic acid which brominates the alpha position and then oxidation of the aldehyde to acid using an oxidizing agent like $KMnO_4$ or CrO_3.
(iii) **Acetaldehyde to But-2-enal:** Acetaldehyde undergoes an aldol condensation reaction to form But-2-enal. Two molecules of acetaldehyde react in the presence of dilute NaOH as a base to form 3-hydroxybutanal (aldol product), which upon heating undergoes dehydration to form But-2-enal (cinnamaldehyde).

Key Points: Benzoic acid converted to benzaldehyde via benzoyl chloride and reduction - Propan-1-ol oxidized to propanal then alpha-bromination and oxidation to 2-bromopropanoic acid - Acetaldehyde undergoes aldol condensation to but-2-enal

Question 17.

1. Answer the following questions.

(a) Identify the order of reaction from the following unit for its rate constant $Lmol^{-1} s^{-1}$. (1)

(b) The conversion of molecules A to B follows second order kinetics. If the concentration of A is increased to three times, how will it affect the rate of formation of B?(1)

(c) Write the expression of the integrated rate equation for zero-order reaction. (1)

[3 Marks]

Answer: (a) The unit of the rate constant is given as L mol^{-1} s^{-1}. This unit corresponds to a second-order reaction because for second-order reactions, the unit of rate constant k is mol^{-1} L s^{-1}. Hence, the order of the reaction is 2.

(b) Since the conversion of A to B follows second order kinetics, the rate equation is rate = k $[A]^2$. If the concentration of A is increased to three times, that is [A] becomes 3[A], then the new rate = k $(3[A])^2$ = 9 k $[A]^2$. Thus, the rate of formation of B increases by 9 times.

(c) The integrated rate equation for zero-order reaction is $[A] = [A]_0 - k\,t$, where [A] is the concentration of the reactant at time t, $[A]_0$ is the initial concentration and k is the rate constant. This equation shows that concentration decreases linearly with time in zero-order reactions.

Key Points: Unit L mol-1 s-1 indicates second order - Rate increases by 9 times if concentration of A is tripled in second order reaction - Integrated rate law for zero order is [A] = [A]0 - k t