CBSE Delhi 2015

Chemistry (Theory)

Time: 3 Hrs **Max. Marks: 70**

General Instructions:

(a) *All questions are compulsory.*
(b) *Question numbers 1 to 5 are very short answer questions and carry 1 mark each.*
(c) *Question numbers 6 to 10 are short answer questions and carry 2 marks each.*
(d) *Question numbers 11 to 22 are also short answer questions and carry 3 marks each.*
(e) *Question numbers 23 is long answer question and carry 4 marks each.*
(f) *Question numbers 24 to 26 are long answer questions and carry 5 marks each.*
(g) *Use Log Tables, if necessary. Use of calculators is not allowed.*

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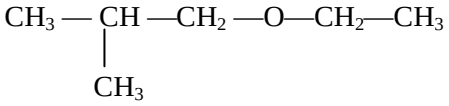
1. A delta is formed at the meeting point of sea water and river water. Why?
Solution:
Sea water contains lots of electrolytes and river water is a colloidal solution of clay. When they meet, electrolytes coagulate the colloidal solution of clay resulting in the formation of delta.

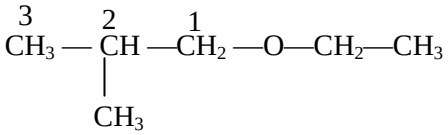
2. What is the formula of a compound in which the element Y forms ccp lattice and atoms of X occupy $2/3^{rd}$ of tetrahedral voids?
Solution:
Let the number of atoms in ccp arrangement be *N*
Contribution of Y = *N*
Contribution of X = 2/3(2*N*) = 4/3*N*
Thus, the ratio is X: Y = 4/3:1
Hence, the formula of compound is X_4Y_3

3. Write the formulae of any two oxoacids of sulphur.
Solution:
The formulae of two oxoacids of Sulphur are: Sulphurous acid (H_2SO_3) and sulphuric acid (H_2SO_4)

4. Write the IUPAC name of the gives compound:



Solution:
The IUPAC name of the given compound is



1-ethoxy-2-methyl propane

5. Which would undergo S_N1 reaction faster in the following pair:

$CH_3 — CH_2 — CH_2 — Br$ and $CH_3 — \underset{\displaystyle Br}{\underset{|}{CH}} — CH_3$

Solution:
S_N1 mechanism is favored by the use of substrates that can form relatively stable carbocation. Thus, CH_3 — CH(Br) —CH_3 will undergo S_N1 faster due to the formation of stable secondary carbocation than that of $CH_3 — CH_2 — CH_2 — Br$ which will form unstable primary carbocation.

6. Write the reagents required in the following reactions:

(i) $CH_2 = CH - CH_2OH \xrightarrow{?} CH_2 = CH - CHO$

(ii) $CH_3 - COOH \xrightarrow{?} CH_3 - CONH_2$

Solution:
(i) PCC, when dissolved in CH_2Cl_2, will oxidize a primary alcohol to an aldehyde and stop at that stage

$$CH_2 = CH - CH_2OH \xrightarrow[CH_2Cl_2]{PCC} CH_2 = CH - CHO$$

(ii) $CH_3 - COOH \xrightarrow{NH_3/PCC} CH_3 - CONH_2$

OR

Arrange the following compounds in increasing order of their property as indicated:
(i) CH_3COCH_3, $C_6H_5COCH_3$, CH_3CHO (reactivity towards nucleophilic addition reaction)
(ii) Cl–CH_2COOH, F–CH_2–COOH, CH_3–COOH (acidic character)

Solution:
(i) Aldehydes are more reactive in nucleophilic additions than ketones. Both steric and electronic factors favor aldehydes. With one group being the small hydrogen atom, the central carbon of the tetrahedral product formed from an aldehyde is less crowded and the product is more stable. Among CH_3COCH_3 and $C_6H_5COCH_3$, first compound is more reactive than second due to less steric. Thus, the reactivity order is

$$C_6H_5COCH_3 < CH_3COCH_3 < CH_3CHO$$

(ii) The carboxylic acids having electron-withdrawing groups are stronger than unsubstituted acids. Fluorine being highly electronegative produces an increase in the strength of fluoroethanoic acid as compared to chloroethanoic acid. Thus, order of acidic character is

$$CH_3COOH < ClCH_2COOH < FCH_2COOH$$

7. (i) On mixing X and liquid Y, volume of the resulting solution decreases. What type of deviation from Raoult's law is shown by the resulting solution? What change in temperature would you observe after mixing liquids X and Y?
(ii) What happens when we place the blood cell in water (hypotonic solution)? Give reason.

Solution:
(i) The mixture shows negative deviation. Heat is evolved in the negative deviation, hence temperature decreases.
(ii) If red blood cells are placed in a solution that is hypotonic with the fluids inside the cell, the cell swells with the inflowing liquid and eventually burst, releasing haemoglobin and other proteins.

8. (i) Write down the IUPAC name of the following complex:

$$\left[Co(NH_3)_5Cl\right]^{2+}$$

(ii) Write the formula for the following complex:

Potassium tetrachloridonickelate(II)

Solution:

(i) The IUPAC name of the complex is pentaamminechlorocobalt(I)ion

(ii) The formula of the complex is $K_2[NiCl_4]$

9. Calculate the time to deposit 1.27 g of copper at cathode when a current of 2 A was passed through the solution of $CuSO_4$.

(Molar mass of Cu = 63.5 g mol^{-1}, 1 F = 96500 C mol^{-1})

Solution:

$$Cu^{2+} + 2e^- \rightarrow Cu$$

63.5 g will require 2 × 96500 C of electricity

1.27 g will require $\frac{2 \times 96500 \times 1.2}{63.5} = 3860$ C

$$Q = It$$
$$3860 = 2 \times t$$
$$t = 1930 \text{ s}$$

10. Write one similarity and one difference between the chemistry of lanthanoids and that of actinoids.

Solution:

Similarity

- Both are inner transition elements or *f* block elements.

Difference

- In case of lanthanoids, most of the ions are colourless while in case of actinoids, most of their ions are coloured.

11. How can the following conversions are carried out:

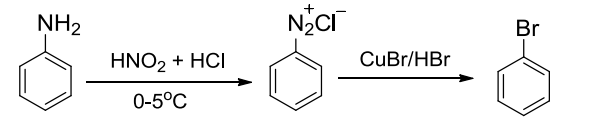
(i) Aniline to bromobenzene

(ii) Chlorobenzene to 2–chloroacetophenone

(iii) Chloroethane to butane

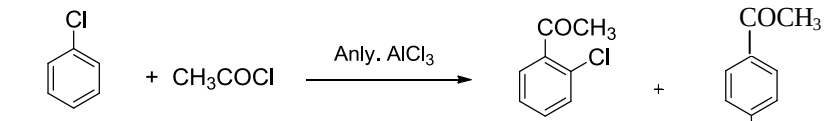
Solution:

(i)



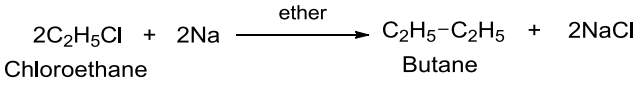
Aniline Bromobenzene

(ii)



Chlorobenze 2-chloro acetophenone

(iii)

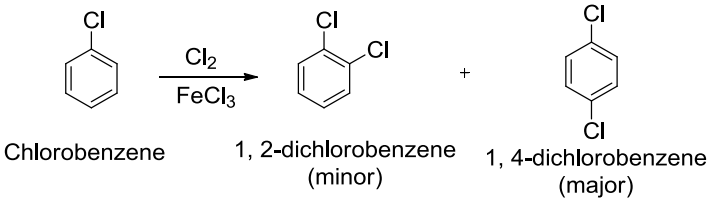


OR

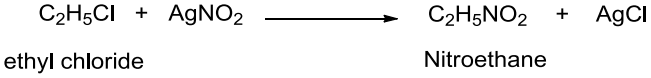
What happens when
(i) chlorobenzene is treated with $Cl_2/FeCl_3$
(ii) ethyl chloride is treated with $AgNO_2$
(iii) 2–bromopentane is treated with alcoholic KOH?
Write the chemical equations in support of your answer.

Solution:

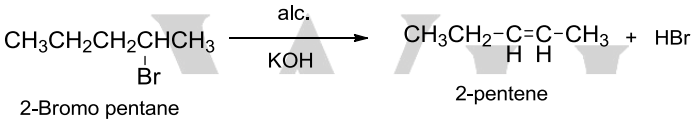
(i)



(ii)



(iii)



12. Examine the given defective crystal:

X^+	Y^-	X^+	Y^-	X^+
Y^-	O	Y^-	X^+	Y^-
X^+	Y^-	X^+	O	X^+
Y^-	X^+	Y^-	X^+	Y^-

Answer the following questions:
(i) Is the above defect stoichiometric or non-stoichiometric?
(ii) Write the term used for this type of defect. Give an example of the compound which shows this type of defect.
(iii) How does this defect affect the density of the crystal?

Solution:

(i) The above defect is stoichiometric.
(ii) When a pair of one cation and one anion of equal valence is missing from an ionic crystal, the condition of charge neutrality is still maintained. The pair of vacant sites, thus formed, is called Schottky defect. Thus, this is a Schottky defect. NaCl shows this type of defect.
(iii) Since the number of particles per unit area is reduced, the density of the solid decreases as a result of this defect.

13. Conductivity of 2.5×10^{-4} M methanoic acid is 5.25×10^{-5} S cm^{-1}. Calculate its molar conductivity and degree of dissociation.

Solution:

$$\Lambda_m = k \times \frac{1000}{C}$$

$$= 5.25 \times 10^{-5} \times \frac{1000}{2.5 \times 10^{-4}}$$

$$= 210 \text{ Scm}^2\text{mol}^{-1}$$

$$\Lambda_m^o(CH_3COOH) = \Lambda_o(H^+) + \Lambda_o(CH_3COO^-)$$

$$= 349.5 + 50.5$$

$$= 400 \text{ Scm}^2\text{mol}^{-1}\alpha$$

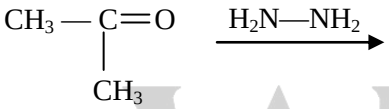
Degree of dissociation is given by

$$\alpha = \frac{\Lambda_m}{\Lambda_m^o}$$

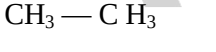
$$= \frac{210}{400}$$

$$= 0.525$$

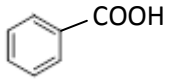
14. Predict the products of the following reactions:



(i)



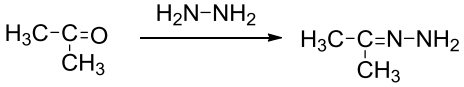
(ii)



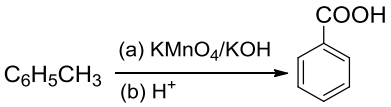
(iii)

Solution:

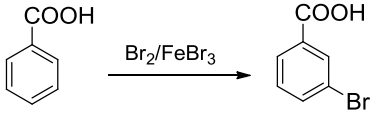
(i) Hydrazine form C = N derivatives of aldehydes and ketones.



(ii) Primary and secondary alkyl groups (but not tertiary groups) directly attached to a benzene ring are oxidized by acidic $KMnO_4$ to a $-CO_2H$ group



(iii) Aromatic carboxylic acids undergo electrophilic substitution reactions with $Br_2/FeBr_3$ in which the carboxyl group is meta-directing and deactivating.



15.

(a) Accont for the following:

(i) Cu^+ is unstable in an aqueous solution.

(ii) Transition metals form complex compounds.

(b) Complete the following equation:

$$Cr_2O_7^{2-} + 8H^+ + 3NO_2^- \rightarrow$$

Solution:

(a) (i) Second ionization enthalpy of Cu is large but enthalpy of hydration for Cu^{2+} is much more negative than Cu^+

$$2Cu^+ \rightarrow Cu^{2+} + Cu$$

(ii) Transition metals form complexes due to their small size and availability of vacant *d*-orbitals so as to accept lone pairs donated by ligands.

(b) The complete equation is as follows:

$$Cr_2O_7^{2-} + 8H^+ + 3NO_2^- \rightarrow 2Cr^{3+} + 3NO_3^- + 4H_2O$$

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

(i) Terylene

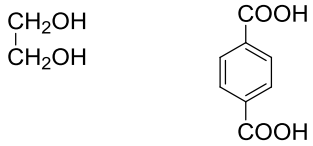
(ii) Buna-S

(iii) Neoprene

Solution:

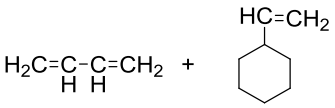
(i) The monomers of terylene are Ethylene glycol and terephthalic acid

Ethylene glycol + Terephthalic acid



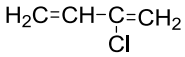
(ii) The monomers of Buna-S are 1, 3 Butadiene and Styrene.

Monomer ⟶ 1, 3 Butadiene + Styrene



(iii) The monomer of neoprene is chloroprene.

Monomer ⟶ Chloroprene



17. A solution is prepared by dissolving 10 g of non-volatile solute in 200 g of water. It has a vapor pressure of 31.84 mm Hg at 308 K. calculate the molar mass of the solute.
(Vapor pressure of pure water at 308 K = 32 mm Hg)

Solution:

Given data

p_1^o = 32mm Hg

p_1 = 31.84 mm Hg

M_1 = 18g/mol

W_1 = 200g

W_2 = 10g

Using the colligative property, relative lowering in vapor pressure

$$\frac{p_1^o - p_1}{p_1^o} = \frac{W_2 \times M_1}{M_2 \times W_1}$$

$$\frac{32 - 31.84}{31.84} = \frac{10 \times 18}{M_2 \times 200}$$

$$M_2 = 179.1 \text{ g / mol}$$

18.
(i) Name the method of refining to obtain silicon of high purity?
(ii) What is the role of SiO_2 in the extraction of copper?
(iii) What is the role of depressants in froth floatation process?
Solution:
(i) Silicon is refined by Zone refining.
(ii) SiO_2 is used to remove FeO as slag.

$$FeO + SiO_2 \rightarrow FeSiO_3$$

(iii) Depressants are used to prevent one type of sulphide ore particles forming froth with air bubbles for example; NaCN is used to separate PbS from ZnS ore.

19. Write any three differences between Physisorption and Chemisorption.
Solution:

Physisorption	Chemisorption
(1) It is not specific in nature.	(1) It is highly specific in nature.
(2) It is reversible in nature.	(2) It is irreversible in nature.
(3) Its enthalpy of adsorption is low (20-40 kJ/mol).	(3) Its enthalpy of adsorption is very high (80-240 kJ/mol)

20. Give reasons for the following:
(i) Phenol is more acidic than methanol.
(ii) The C–O–H bond angle in alcohols is slightly less than the tetrahedral angle $(109°28')$
(iii) $(CH_3)_3C–O–CH_3$ on reaction with HI gives $(CH_3)_3C–I$ and $CH_3–OH$ as the main products and not $(CH_3)_3C–OH$ and $CH_3–I$
Solution:
(i) Phenol is more acidic than methanol because phenoxide ion is resonance stabilized while there is no such stabilization in ethoxide ion.
(ii) The C–O–H bond angle in alcohols is slightly less than the tetrahedral angle due to the repulsion between the lone pair (of oxygen atom) and the bond pairs.
(iii) Heating dialkyl ethers with strong acid HI causes them to undergo reactions in which carbon-oxygen bond breaks. In case of one of the alkyl groups is tertiary, the reaction proceeds through S_N^1 mechanism and the product formed is determined by the stability of the carbocation formed. Since tertiary carbocation is more stable, tertiary alkyl halides are formed.

21.
(i) Which of the following is a polysaccharide?
Starch, maltose, fructose, glucose

(ii) Write one difference between α–helix and β–pleated sheet structures of protein.
(iii) Write the name of the disease caused by the deficiency of vitamin B_{12}.

Solution:

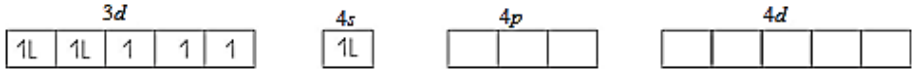
(i) Polysaccharide consists of monosaccharides joined together by glycosidic linkages. Starch (a polymer of α) is a polysaccharide. While fructose and glucose are monosaccharides and maltose is disaccharide.
(ii) In α-helix structure, the polypeptide chain coils up into a spiral structure while in β-pleated structure, the polypeptide chains lie side by side in a zig zag manner with alternate *R* groups on the same side.
(iii) Pernicious anaemia is caused by the deficiency of vitamin B_{12}.

22.

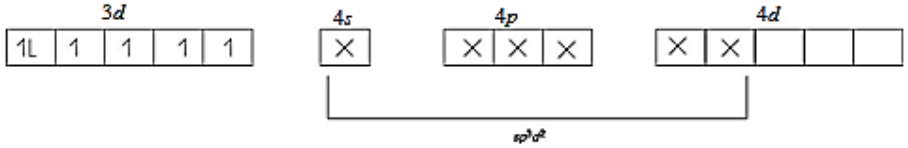
(i) What type of isomerism is shown by the complex $[Cr(H_2O)_6]Cl_3$?
(ii) On the basis of crystal field theory, write the electronic configuration for d^4 ion if $\Delta_0 > P$.
(iii) Write the hybridization and shape of $[CoF_6]^{3-}$. (Atomic number of Co = 27)

Solution:

(i) Hydrate isomerism is shown by the complex $[Cr(H_2O)_6]Cl_3$. The hydrate isomers of the compound are: $[Cr(H_2O)_5Cl]H_2O{\cdot}Cl_2$, $[Cr(H_2O)_4Cl_2)]\ Cl{\cdot}2H_2O$, $[Cr(H_2O)_3Cl_3)]{\cdot}3H_2O$
(ii) $\Delta_o > P$ in case of strong field ligands so, the configuration is $t_{2g}^4\ e_g^0$.
(iii) In this complex cobalt is in oxidation state +3. On formation of Co(III), the electronic configuration changes from $3d^7 4s^2$ (in ground state) to $3d^7 4s^0$ as shown.
Co atom (27) = $3d^7 4s^2$,



Co (III) = $3d^6$



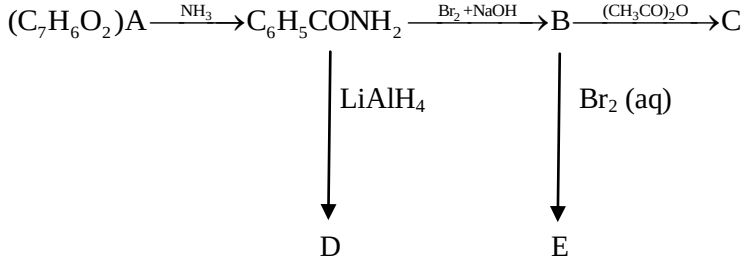
F^- is a weak field ligand therefore, 3*d* electrons do not show any tendency to pair up. Therefore, 4*s*, three 4*p* and two 4*d* orbitals hybridize to form six equivalent sp^3d^2 orbitals.

23. Seeing the growing cases of diabetes and depression among young children, Mr. Chopra, the principal of one reputed school organized a seminar in which he invited parents and principals. They all resolved this issue by strictly banning junk food in school
ls and introducing healthy snacks and drinks like soup, lassi, milk, etc. in school canteens. They also decided to make compulsory half an hour of daily physical activities for the students in the morning assembly. After six months, Mr. Chopra conducted the health survey in most of the schools and discovered a tremendous improvement in the health of the students.
After reading the above passage, answer the following questions:
(i) What are the values (at least two) displayed by Mr. Chopra?
(ii) As a student, how can you spread awareness about this issue?
(iii) Why should antidepressant drugs not be taken without consulting a doctor?
(iv) Give two examples of artificial sweeteners.

Solution:

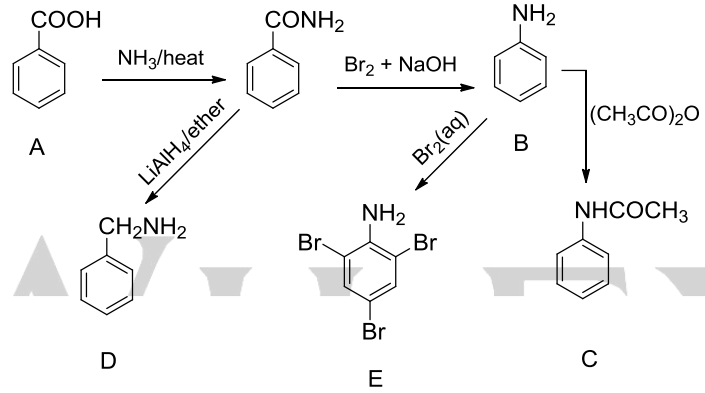
(i) The values displayed by Mr. Chopra are concern about children, use of scientific knowledge.
(ii) As a student I can aware children by explaining the harmful effects caused by eating junk food.
(iii) Anti-depressant drugs should not be taken empty stomach because they can have side effects as the drug can bind to more than one receptor site.
(iv) Saccharin and aspartame are the examples of two artificial sweeteners.

24. An aromatic compound 'A' of molecular formula $C_7H_6O_2$ undergoes a series of reactions as shown below. Write the structures of A, B, C, D and E in the following reactions:



Solution:

The complete reaction is as follows:



OR

(a) Write the structure of main products when benzene diazonium chloride reacts with the following reagents:

(i) $H_3PO_2 + H_2O$

(ii) CuCN/KCN

(iii) H_2O

(b) Arrange the following in the increasing order of their basic character in an aqueous solution:

$C_2H_5NH_2$, $(C_2H_5)_2NH$, $(C_2H_5)_3N$

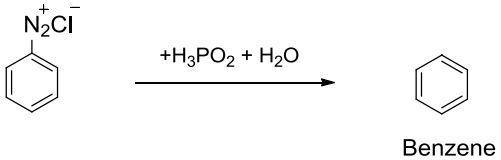
(c) Give a simple chemical test to distinguish between the following pair of compounds:

$C_6H_5–NH_2$ and $C_6H_5–NH–CH_3$

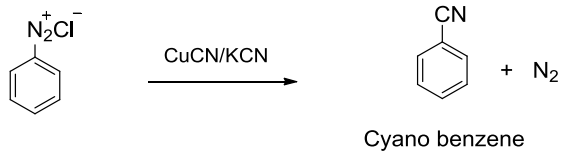
Solution:

(a) Benzene diazonium chloride salts react with hypophosphorous acid, cuprous cyanide and water to give products in which the diazonium group has been replaced by –H, –CN and –OH, respectively. These reactions are known generally as Sandmeyer reactions.

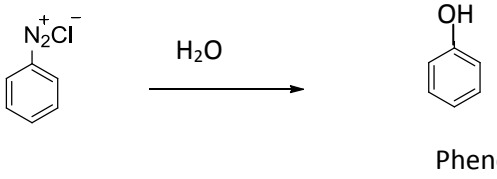
(i)



(ii)



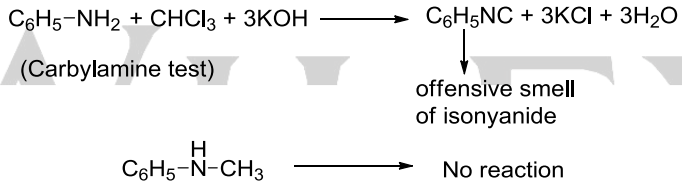
(iii)



(b) In aqueous phase, the substituted ammonium cations get stabilized by +I effect of the alkyl group as well as solvation with water molecules. With a larger size of the ion, solvation and stability of the ion will be lesser. When the stability of the substituted ammonium cation is greater, the corresponding amine as a base is stronger. The basicity order in aliphatic amines is 1° > 2° > 3°.
This is the reverse of basicity order based on inductive effect. Therefore, in aqueous state, inductive effect, solvation effect and steric hindrance of the alkyl group determine the basicity strength. Thus, the correct order is :

$$C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$$

(c) Primary amines when heated with chloroform and ethanolic potassium hydroxide form pungent isocyanides or carbylamines. This reaction is exclusive to primary amines.



25. For the hydrolysis of methyl acetate in aqueous solution, the following results were obtained:

t/s	0	10	20
$[CH_3COOCH_3]$/mol L^{-1}	0.10	0.05	0.025

(a) Show that it follows pseudo first order reaction, as the concentration of water remains constant.
(b) Calculate the average rate of reaction between the time intervals 10 to 20 seconds. (Given: log 2 = 0.3010, log 4 = 0.6021)

Solution:
(a) For a first order reaction,

$$k = \frac{2.303}{t\left(\log \frac{R_o}{R}\right)}$$

$$k_1 = \frac{2.303}{10\left(\log \frac{0.10}{0.05}\right)} = 0.0693\ s^{-1}$$

$$k_2 = \frac{2.303}{20\left(\log \frac{0.10}{0.025}\right)} = 0.0693\ s^{-1}$$

It can be seen that $k = k[H_2O]$ is constant i.e 0.0692 s^{-1}

So, we can say it is a pseudo first order reaction.

(b) Average rate = $\frac{0.025-0.05}{20-10} = 0.0025\ \text{molL}^{-1}$

OR

(a) For a reaction A+ B → P, the rate is given by

$$\text{Rate} = k\,[\text{A}]\,[\text{B}]^2$$

(i) How is the rate of reaction affected if the concentration of B is doubled?

(ii) What is the overall order of reaction if A is present in large excess?

(b) A first order reaction takes 30 minutes for 50% completion. Calculate the time required for 90% completion of this reaction.

Solution:

(a)

(i) Rate = $k[\text{A}][\text{B}]^2$

If concentration of B is doubled the rate gets 4 times

Rate = $k[\text{A}][2\text{B}]^2$

Rate = $4k[\text{A}][\text{B}]^2$

(ii) If A is present in excess, then the rate will only depend on the concentration of B. So, the overall order will be 2.

$$\text{Rate} = k[\text{B}]^2$$

(b) Using the equation, $k = \frac{0.693}{t_{1/2}}$ we get, $k = \frac{0.693}{30}$

$$t(90\%) = \frac{2.303}{k\left(\log \frac{R_0}{R}\right)}$$

$$t(90\%) = \frac{2.303}{\frac{0.693}{30}\left(\log \frac{100}{100-90}\right)} = 99.7\,\text{min}$$

26.

(a) Account for the following:

(i) Acidic character increases from HF to HI.

(ii) There is a large difference between the melting point and boiling points of oxygen and sulphur.

(iii) Nitrogen does not form pentahalide.

(b) Draw the structures of the following:

(i) ClF_3

(ii) XeF_4

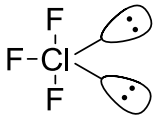
Solution:

(a) (i) The acidic character increases from HF to HI. It is because the stability of halides decreases from HF to HI as the bond dissociation decreases.

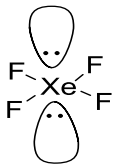
(ii) The large difference between the melting points of oxygen and sulphur can be explained on the basis of their atomicity: oxygen exists as diatomic molecule while sulphur exists as a polyatomic molecule (S_8)

(iii) Nitrogen does not form pentahalide due to non-availability of *d* orbitals.

(b) (i) The shape of ClF_3 is distorted trigonal bipyramid (T-shape).



(ii) The shape of XeF_4 is square planar.



OR

(i) Which allotrope of phosphorus is reactive and why?
(ii) How are the supersonic jet aeroplanes responsible for the depletion of ozone layer?
(iii) F_2 has lower bond dissociation enthalpy than Cl_2 Why?
(iv) Which noble gas is used in filling balloons for meteorological observations?
(v) Complete the following equation:

$$XeF_2 + PF_5 \rightarrow$$

Solution:
(i) White phosphorous is most reactive because of angular strain in P_4 molecule where the angles are only 60^o. It readily catches fire in air to give dense white fumes of P_4O_{10}.
(ii) Nitrogen oxides emitted by supersonic jet planes combines very rapidly with ozone and thus deplete it

$$NO + O_3 \rightarrow NO_2 + O_2$$

(iii) F_2 has lower bond enthalpy than Cl_2 because fluorine atoms are small, the F – F distance is also small, and hence internuclear repulsion is appreciable. The large electron-electron repulsions between the lone pairs of electrons on the two fluorine atoms weaken the bond.
(iv) Helium gas is used in filling balloons for meteorological observations.
(v) The complete equation is:

$$XeF_2 + PF_5 \rightarrow [XeF^+]\,[PF_6^-]$$