CHEMISTRY GRADE 12 MODEL PAPER
RUBRICS- (SECTION B)

Q2 (Part-i): Write reactions of water with (a) Na, (b) Mg, (c) Al, (d) Si. [1+1+1+1 = 04]

Possible Answer
1. Sodium (Na): $2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$ (vigorous, exothermic with cold water).
2. Magnesium (Mg): Slow with cold water → $Mg(OH)_2 + H_2\uparrow$;
3. Aluminium (Al): $2Al+3H_2O \rightarrow Al_2O_3+3H_2\uparrow$
4. Silicon (Si):$Si+2H_2O \rightarrow SiO + 2H_2 \uparrow$.

Rubric (1 mark each)
- Sodium: Correct balanced eqn + note of vigour (1). Partial: products correct but unbalanced (0.5). Wrong/steam only (0).
- Magnesium: Any one valid reaction with condition (1). Partial: incomplete (0.5). Incorrect (0).
- Aluminium: Correct balanced eqn (1). Partial: (0.5). Incorrect (0).
- Silicon: Correct balanced eqn (1). Partial: (0.5). Incorrect (0).

Q2 (Part-ii): What is atomic radius? Discuss its various types. [1+1+1+1 = 04]

Possible Answer
Atomic radius: The distance between the nucleus and the outer most shell of electrons of an atom or an ion is generally named as atomic radious or ionic radius respectively.

Types: covalent radius:It is defined as “one half of the distance between the nuclei of two identical atoms bonded together by a single covalent bond”.

metallic radius : This term is used for radius of metallic atoms e.g.Na,Mg, and Al. It is half of the total distance between nuclei of two adjacent atoms in the metallic cluster.

Van der waal’s radius: It is defined as “one half of the distance between the nuclei of two non bonded and identical neighbouring atoms of two adjacent molecules in the soled state”.

Rubric (1 mark each)
- Definition: Correct Definition(1) Partial incomplete (0.5). Wrong (0).
- Covalent radius: Correct definition (1). Partial/incomplete (0.5). Wrong (0).
- Metallic radius: : Correct definition(1). Partial/incomplete (0.5). Wrong (0).
- Covalent radius: Correct definition (1). Partial/incomplete (0.5). Wrong (0).
- Van der Waals: : Correct definition (1). Partial/incomplete (0.5). Wrong (0).

Q2 (Part-iii): How does Be differ from other members of its group? [1+1+1+1 = 04]

Possible Answer (any four)
Beryllium is the lightest of all the Group – IIA metals.

- Beryllium has higher melting and boiling point compared to other elements in Group – IIA.

- Beryllium, unlike other Group – IIA metals, is not easily affected by dry air.

- Beryllium does not react with water or steam at red heat.

- The oxide of beryllium, BeO, is amphoteric whereas other oxides of Group – IIA metals are strong bases.

- Oxides, nitrides, chlorides, etc. of Group – IIA elements are ionic, while those of beryllium are covalent.

- Salts of beryllium do not impart any colour during flame test unlike its other family members.

- Beryllium oxide is insoluble in water, unlike oxide of other members of its family.

- Beryllium does not liberate hydrogen from acids as observed in other Group – IIA metals.

Rubric (1 mark each)
- Each clear, correct difference = 1. Partial/vague statement = 0.5. Wrong/repetition = 0.

Q2 (Part-iv): Define homologous series. Give characteristics. [1+1+1+1 = 04]

Possible Answer
Homologous series: A series of organic compounds in which all members possess similar structural features and similar chemical characteristics, but each member is different from the next member by a methylene (–CH_2–) group is called a homologous series.

Characteristics:

- As mentioned, each class of organic compounds has its own homologous series having general formula.

- All the members of homologous series have similar chemical properties and same general methods of preparation, similar structural features and same functional group.

- The physical properties like melting point, boiling points, densities etc, increase down the series due to increase in their molecular masses

Rubric (1 mark each)
- Definition: (1)
- Characteristics : Each characteristics (1)

Q2 (Part-v): Mechanism of free-radical substitution in alkanes. [1+1+1+1 = 04]

Possible Answer
Occurs under UV/heat with halogens. Example: methane chlorination. Initiation: $Cl_2 \rightarrow 2Cl\bullet$. Propagation: $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$; $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$. Termination: radicals combine (e.g., $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$). Multiple substitutions (CH_2Cl_2, $CHCl_3$, CCl_4). Bromination is more selective.

Rubric (1 mark each)
- Conditions: UV/heat + halogen.
- Initiation: correct cleavage of Cl_2.
- Propagation: both steps.
- Termination/products/selectivity.

Q2 (Part-vi): Define metamerism and tautomerism with examples. [1+1+1+1 = 04]

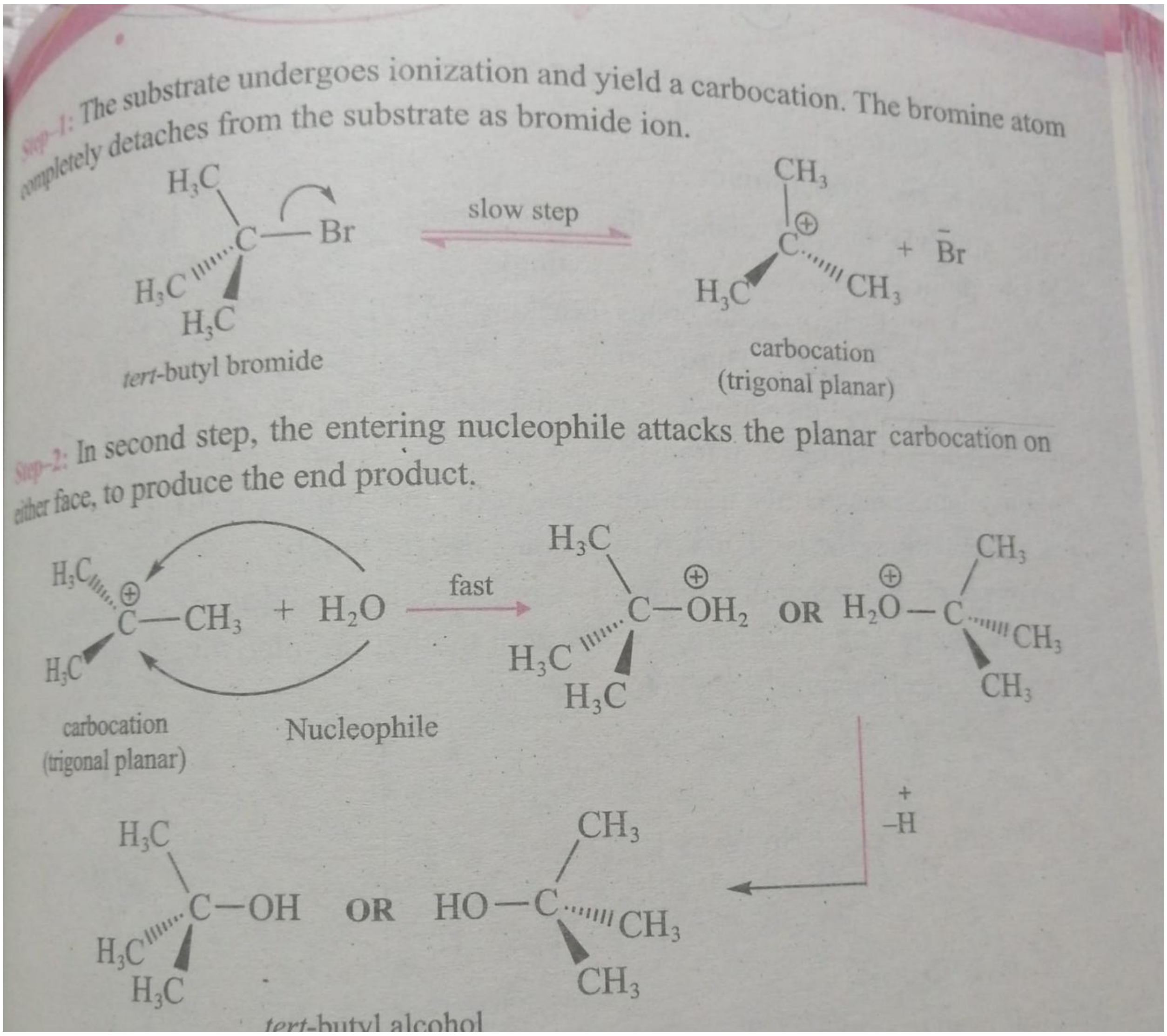
Possible Answer
Metamerism: functional isomerism where compounds have same formula and group but different alkyl groups around polyvalent atom (O, N, S).

Example: methyl n-propyl ether (CH_3 O-CH_2-CH_2-CH_3) vs diethyl ether.(CH_3-CH_2-O-CH_2-CH_3)
Tautomerism: dynamic equilibrium between isomers differing by position of proton and double bond. Example: keto–enol tautomerism of acetone ($CH_3–CO–CH_3 \rightleftharpoons CH_2=C(OH)–CH_3$).

Rubric (1 mark each)
- Metamerism definition.
- Metamerism example.
- Tautomerism definition.
- Tautomerism example.

Q2 (Part-vii): Describe SN1 and SN2 mechanisms. [2+2 = 04]

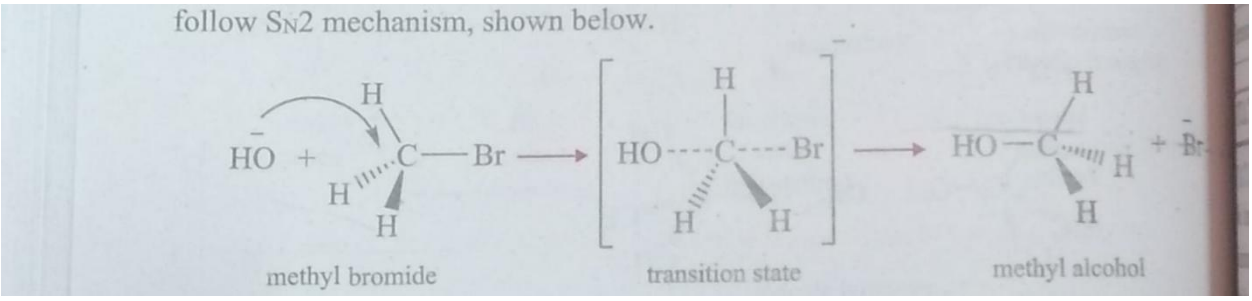
Possible Answer
SN1: Two-step via carbocation, rate = k[RX]. Favoured by tertiary halides in polar protic solvents. Nucleophile attacks planar carbocation → racemization. Rearrangements possible.



Step-1: The substrate undergoes ionization and yield a carbocation. The bromine atom completely detaches from the substrate as bromide ion.

Step-2: In second step, the entering nucleophile attacks the planar carbocation on either face, to produce the end product.

SN2: One-step backside attack, rate = k[RX][Nu⁻]. Favoured by primary halides in polar aprotic solvents with strong nucleophiles. Leads to inversion of configuration (Walden inversion).



follow SN2 mechanism, shown below.

Rubric (2 marks each)

- SN1: Stepwise carbocation, rate law, substrate order, solvent, stereochemistry. Partial = 1.
- SN2: One-step backside, rate law, order, inversion. Partial = 1.

Q2 (Part-viii): Explain sulphur analogues (thiols). [1+1+1+1 = 04]

Possible Answer

Thiols (mercaptans) are sulphur analogues of alcohols (–OH replaced by –SH). General formula: R–SH (e.g., CH_3–SH). Functional group: –SH (thiol). Properties: lower boiling points than alcohols, strong unpleasant odour, less soluble in water, more acidic than alcohols, readily oxidized to disulphides (R–S–S–R).

Rubric (1 mark each)
- Definition.
- General formula.
- Functional group.
- Properties (any two).

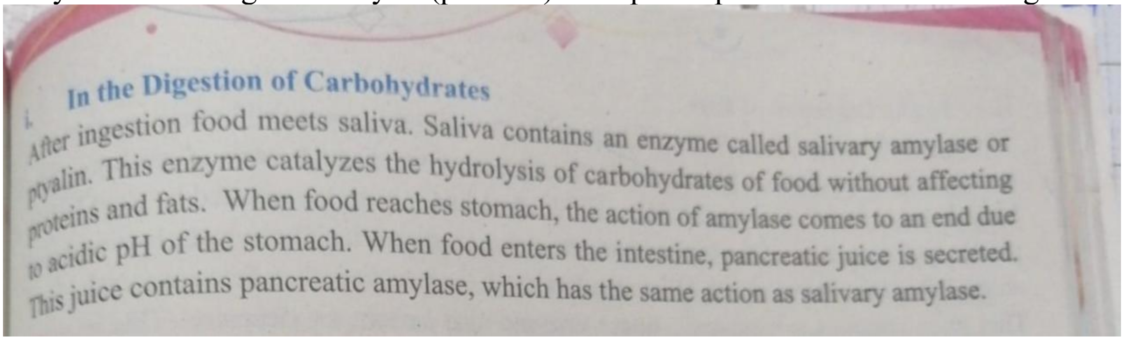
Q2 (Part-ix): Isomerism in carboxylic acids with examples. [2+2 = 04]

Possible Answer
1. Chain isomerism: same formula but different carbon chain. Example: Butanoic acid vs 2-methylpropanoic acid.
2. Position/functional isomerism: same formula but different group positions. Example: 2-hydroxypropanoic acid vs 3-hydroxypropanoic acid.

Rubric (2 marks each)
- Chain isomerism: definition + valid pair.
- Positional/functional: definition + valid pair.

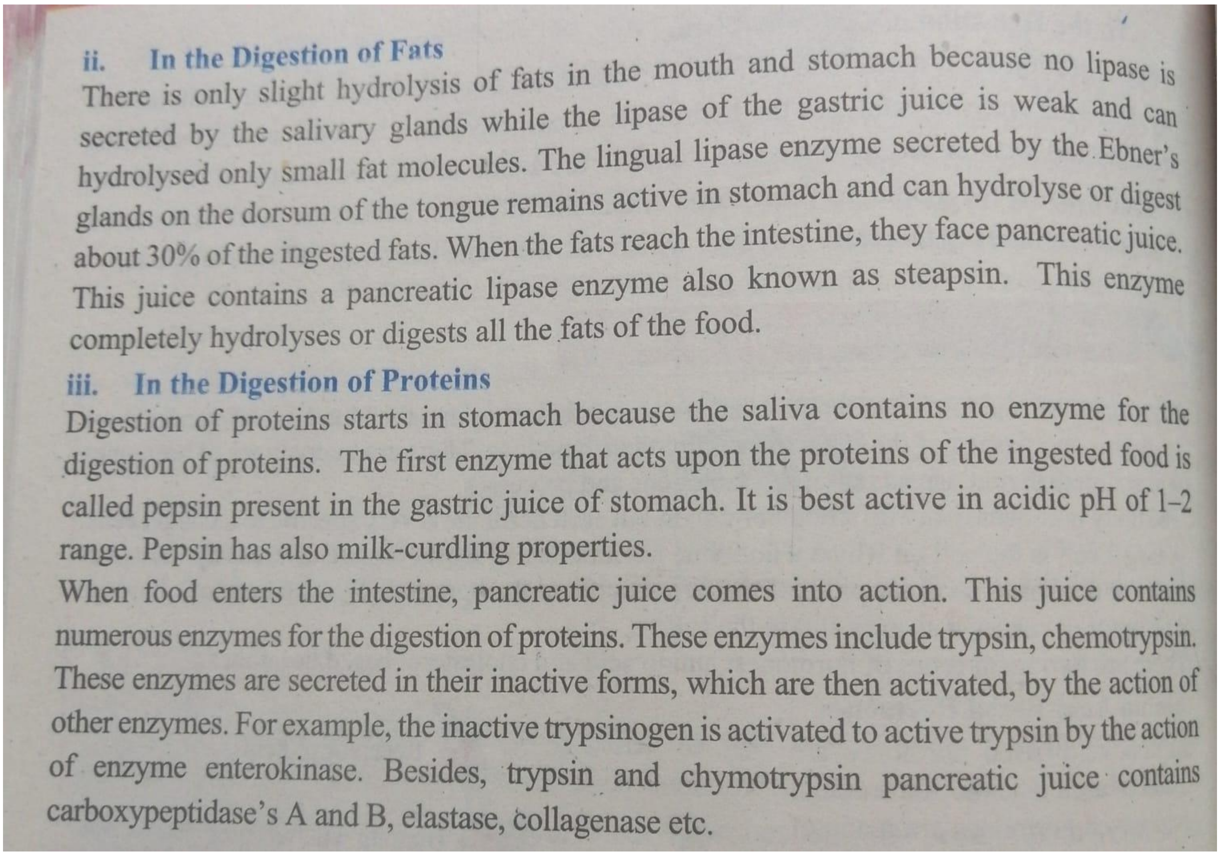
Q2 (Part-x): What are enzymes? Role in digestion of fats, carbohydrates, and proteins. [1+1+1+1 = 04]

Possible Answer
Enzymes are biological catalysts (proteins) that speed up reactions without being consumed.



In the Digestion of Carbohydrates

i. After ingestion food meets saliva. Saliva contains an enzyme called salivary amylase or ptyalin. This enzyme catalyzes the hydrolysis of carbohydrates of food without affecting proteins and fats. When food reaches stomach, the action of amylase comes to an end due to acidic pH of the stomach. When food enters the intestine, pancreatic juice is secreted. This juice contains pancreatic amylase, which has the same action as salivary amylase.



ii. In the Digestion of Fats

There is only slight hydrolysis of fats in the mouth and stomach because no lipase is secreted by the salivary glands while the lipase of the gastric juice is weak and can hydrolysed only small fat molecules. The lingual lipase enzyme secreted by the Ebner's glands on the dorsum of the tongue remains active in stomach and can hydrolyse or digest about 30% of the ingested fats. When the fats reach the intestine, they face pancreatic juice. This juice contains a pancreatic lipase enzyme also known as steapsin. This enzyme completely hydrolyses or digests all the fats of the food.

iii. In the Digestion of Proteins

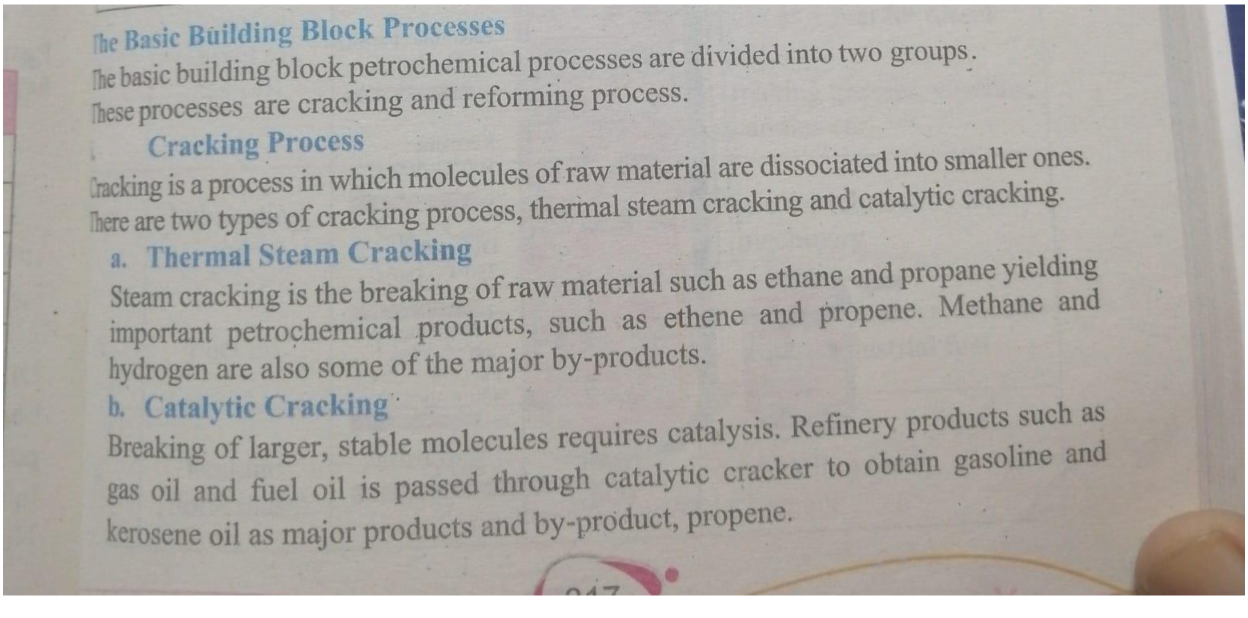
Digestion of proteins starts in stomach because the saliva contains no enzyme for the digestion of proteins. The first enzyme that acts upon the proteins of the ingested food is called pepsin present in the gastric juice of stomach. It is best active in acidic pH of 1–2 range. Pepsin has also milk-curdling properties.

When food enters the intestine, pancreatic juice comes into action. This juice contains numerous enzymes for the digestion of proteins. These enzymes include trypsin, chemotrypsin. These enzymes are secreted in their inactive forms, which are then activated, by the action of other enzymes. For example, the inactive trypsinogen is activated to active trypsin by the action of enzyme enterokinase. Besides, trypsin and chymotrypsin pancreatic juice contains carboxypeptidase's A and B, elastase, collagenase etc.

Rubric (1 mark each)
- Definition.
- Role in fats digestion.
- Role in carbohydrate digestion.
- Role in protein digestion.

Q2 (Part-xi): Basic building-block processes of petrochemical technology. [2+2 = 04]

Possible Answer



The Basic Building Block Processes

The basic building block petrochemical processes are divided into two groups. These processes are cracking and reforming process.

Cracking Process

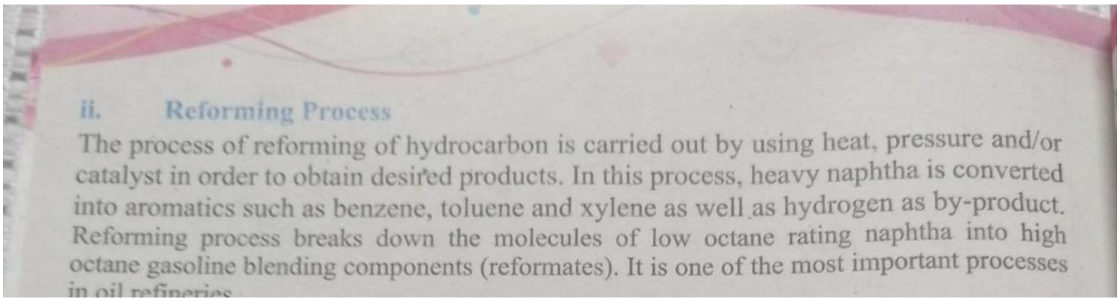
Cracking is a process in which molecules of raw material are dissociated into smaller ones. There are two types of cracking process, thermal steam cracking and catalytic cracking.

a. Thermal Steam Cracking

Steam cracking is the breaking of raw material such as ethane and propane yielding important petrochemical products, such as ethene and propene. Methane and hydrogen are also some of the major by-products.

b. Catalytic Cracking

Breaking of larger, stable molecules requires catalysis. Refinery products such as gas oil and fuel oil is passed through catalytic cracker to obtain gasoline and kerosene oil as major products and by-product, propene.



ii. Reforming Process

The process of reforming of hydrocarbon is carried out by using heat, pressure and/or catalyst in order to obtain desired products. In this process, heavy naphtha is converted into aromatics such as benzene, toluene and xylene as well as hydrogen as by-product. Reforming process breaks down the molecules of low octane rating naphtha into high octane gasoline blending components (reformates). It is one of the most important processes in oil refineries

Rubric (2 marks each)
- First correct process: named + explained.
- Second correct process: named + explained.

Q2 (Part-xii): Molecular vibrations in IR spectroscopy. [2+2 = 04]

Possible Answer
Stretching vibrations: change in bond length. Symmetric (bonds move together) and asymmetric (bonds move in opposite ways). Examples: C–H ~2850–3100 cm^{-1}, O–H ~3200–3600 cm^{-1}.
Bending vibrations: change in bond angle/position. Types: scissoring (~1450 cm^{-1}), rocking (~720 cm^{-1}), wagging (~650–900 cm^{-1}), twisting (~600–800 cm^{-1}).

Rubric (2 marks each)
- Stretching: symmetric + asymmetric explained with example.
- Bending: at least three types described.

Q2 (Part-xiii): Construction and working of a mass spectrometer. [2+2 = 04]

Possible Answer
Construction: ion source (forms ions), accelerating region (gives kinetic energy), analyzer (separates ions by m/z), detector (measures signals).
Working: sample ionized to positive ions, accelerated through potential ($\frac{1}{2}mv^2 = zeV$), ions separated in magnetic/electric field according to m/z, detected as peaks on a mass spectrum to give molecular mass and structural information.

Rubric (2 marks each)
- Construction: at least three components with functions.
- Working: ionization → acceleration → separation (m/z) → detection.

Q3 (a): What are halogens? Give the electronic configuration of F (9), Cl (17), Br (35) and I (53). [1+1+1+1+1 = 05]

Possible Answer

Halogens are the elements of Group 17 in the periodic table. They are non-metals, highly reactive, and occur naturally as diatomic molecules (F_2, Cl_2, Br_2, I_2). They readily form salts when combined with metals, hence the name “halogen” (salt-former). Their electronic configurations are:

- Fluorine (F, Z=9): $1s^2\ 2s^2\ 2p^5$
- Chlorine (Cl, Z=17): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
- Bromine (Br, Z=35): $[Ar]\ 3d^{10}\ 4s^2\ 4p^5$
- Iodine (I, Z=53): $[Kr]\ 4d^{10}\ 5s^2\ 5p^5$

Rubric (1 mark each)

- Definition of halogens (1).
- Correct configuration for each halogen (1 each).

Q3 (b): Write the IUPAC names of the following: (i) $K_4[Fe(CN)_6]$ (ii) $Na_2[NiCl_4]$ (iii) $Pt(NH_3)_2Cl_4$ (iv) $Fe(CO)_5$ [1+1+1+1 = 04]

Possible Answer

(i) $K_4[Fe(CN)_6]$: Potassium hexacyanoferrate(II), a coordination compound where Fe is in +2 oxidation state.
(ii) $Na_2[NiCl_4]$: Sodium tetrachloronickelate(II), a complex salt of Ni^{2+} with four chloride ligands.
(iii) $Pt(NH_3)_2Cl_4$: Diamminetetrachloroplatinum(IV), a platinum complex with two neutral ammonia ligands and four chloride ligands.
(iv) $Fe(CO)_5$: Pentacarbonyl iron(0), a metal carbonyl where Fe is in oxidation state 0.

Rubric (1 mark each)

- Each compound correctly named according to IUPAC rules = 1.
- Partial credit (0.5) for correct ligands but wrong oxidation state or naming error.

Q4 (a): Draw the structural formula of the following: (i) Cyclohexyne (ii) n-Butane (iii) Isobutane (iv) Neopentane (v) Cyclopentane [1+1+1+1+1 = 05]

Possible Answer

- Cyclohexyne: A six-membered carbon ring with a triple bond between two carbons.
- n-Butane: Straight-chain alkane, $CH_3–CH_2–CH_2–CH_3$.
- Isobutane: Branched alkane, $(CH_3)_2CH–CH_3$.
- Neopentane: Highly branched alkane, $C(CH_3)_4$ (tetramethylmethane).
- Cyclopentane: Five-membered carbon ring, fully saturated with single bonds.

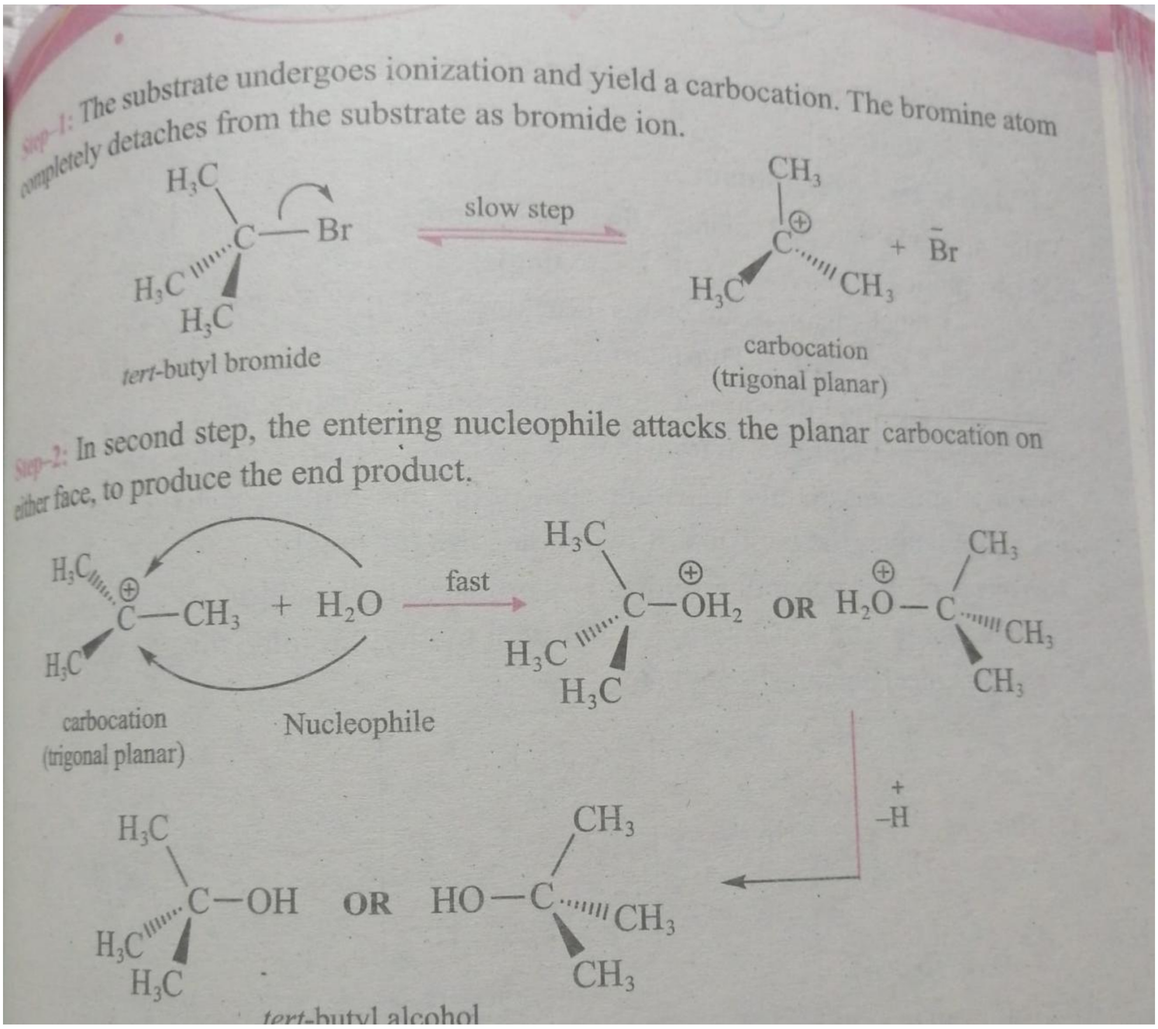
Rubric (1 mark each)

- Each correct and recognisable structure = 1.
- Partial (0.5): incomplete or slightly incorrect but recognisable.

Q4 (b): Explain E1 and E2 mechanism in alkyl halides. [2+2 = 04]

Possible Answer

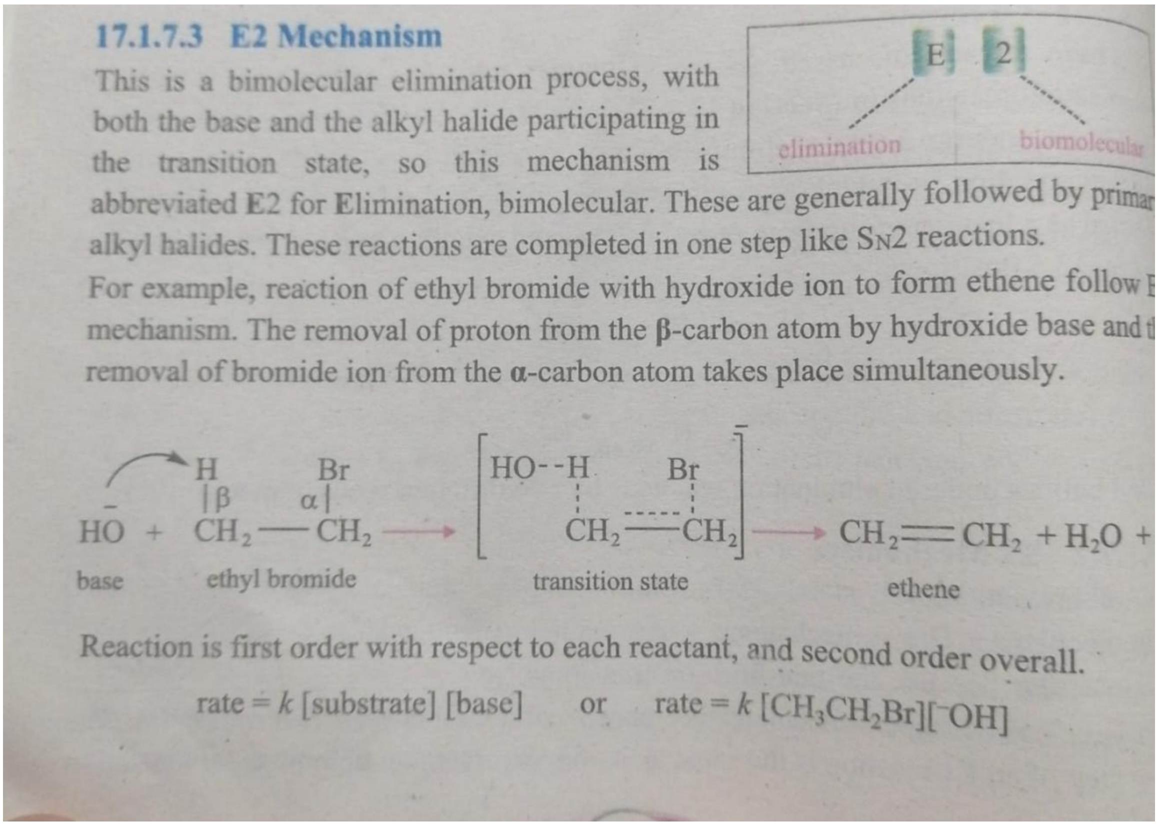
E1 mechanism (Unimolecular elimination): This mechanism proceeds in two steps. First, the alkyl halide ionizes to form a carbocation intermediate. Then a base removes a β-hydrogen to form an alkene. The rate law is first order (rate = k[RX]). E1 is favoured in tertiary halides and polar protic solvents. Carbocation rearrangements may occur.



Step-1: The substrate undergoes ionization and yield a carbocation. The bromine atom completely detaches from the substrate as bromide ion.

Step-2: In second step, the entering nucleophile attacks the planar carbocation on either face, to produce the end product.

E2 mechanism (Bimolecular elimination): This is a single-step, concerted process. The base abstracts a β-hydrogen while the leaving group departs at the same time, forming an alkene. It follows second-order kinetics (rate = k[RX][Base]). It requires a strong base and anti-periplanar geometry. Favoured by primary or secondary halides with strong bases.



17.1.7.3 E2 Mechanism

This is a bimolecular elimination process, with both the base and the alkyl halide participating in the transition state, so this mechanism is abbreviated E2 for Elimination, bimolecular. These are generally followed by primar alkyl halides. These reactions are completed in one step like S_N2 reactions.

For example, reaction of ethyl bromide with hydroxide ion to form ethene follow E mechanism. The removal of proton from the β-carbon atom by hydroxide base and t removal of bromide ion from the α-carbon atom takes place simultaneously.

$$\underset{\text{base}}{\overset{-}{HO}} + \underset{\text{ethyl bromide}}{\overset{\overset{H}{|\beta}}{CH_2} - \overset{\overset{Br}{\alpha|}}{CH_2}} \longrightarrow \underset{\text{transition state}}{\left[\overset{\overset{HO\text{- -}H}{\vdots}}{CH_2} \overset{\text{- - - - -}}{=\!=} \overset{\overset{Br}{\vdots}}{CH_2} \right]^{-}} \longrightarrow \underset{\text{ethene}}{CH_2 = CH_2} + H_2O +$$

Reaction is first order with respect to each reactant, and second order overall.

rate = k [substrate] [base] or rate = k $[CH_3CH_2Br][^{-}OH]$

Rubric (2 marks each)

- E1: Must describe two steps, carbocation, rate law, solvent/substrate preference.
- E2: Must describe concerted one-step, rate law, strong base, geometry.

Q5 (a): Differentiate between the structure of Alcohols and Phenol. [2.5+2.5 = 05]

Possible Answer

Alcohols: Contain the –OH functional group attached to an aliphatic (sp^3-hybridized) carbon. Example: ethanol ($CH_3–CH_2–OH$). They are generally neutral in behaviour and less acidic.

Phenols: Contain the –OH group directly attached to an aromatic benzene ring (sp^2-hybridized carbon). Example: phenol ($C_6H_5–OH$). They are more acidic because the phenoxide ion formed is resonance-stabilized.

Rubric (2.5 marks each)

- Alcohol: Must describe structure, hybridization, example.
- Phenol: Must describe aromatic attachment, acidic property, example.

Q5 (b): Describe chain isomerism and position isomerism in aldehydes and ketones with one example each. [1+1+1+1 = 04]

Possible Answer

Chain isomerism: Aldehydes or ketones with same molecular formula but different carbon skeleton. Example: Butanal ($CH_3–CH_2–CH_2–CHO$) and 2-methylpropanal ($(CH_3)_2CH–CHO$).

Position isomerism: Same molecular formula but carbonyl group at different positions. Example: 2-pentanone ($CH_3–CO–CH_2–CH_2–CH_3$) and 3-pentanone ($CH_3–CH_2–CO–CH_2–CH_3$).

Rubric (1 mark each)
- Chain isomerism definition (1).
- Example of chain isomer (1).
- Position isomerism definition (1).
- Example of position isomer (1).

Q6 (a): What is meant by atmosphere? Describe the chemistry of Troposphere. [1+3 = 04]

Possible Answer
Atmosphere: The layer of gases surrounding the earth. Major components are N_2 (78%), O_2 (21%), CO_2 (~0.03%), noble gases, and trace gases.
Troposphere:

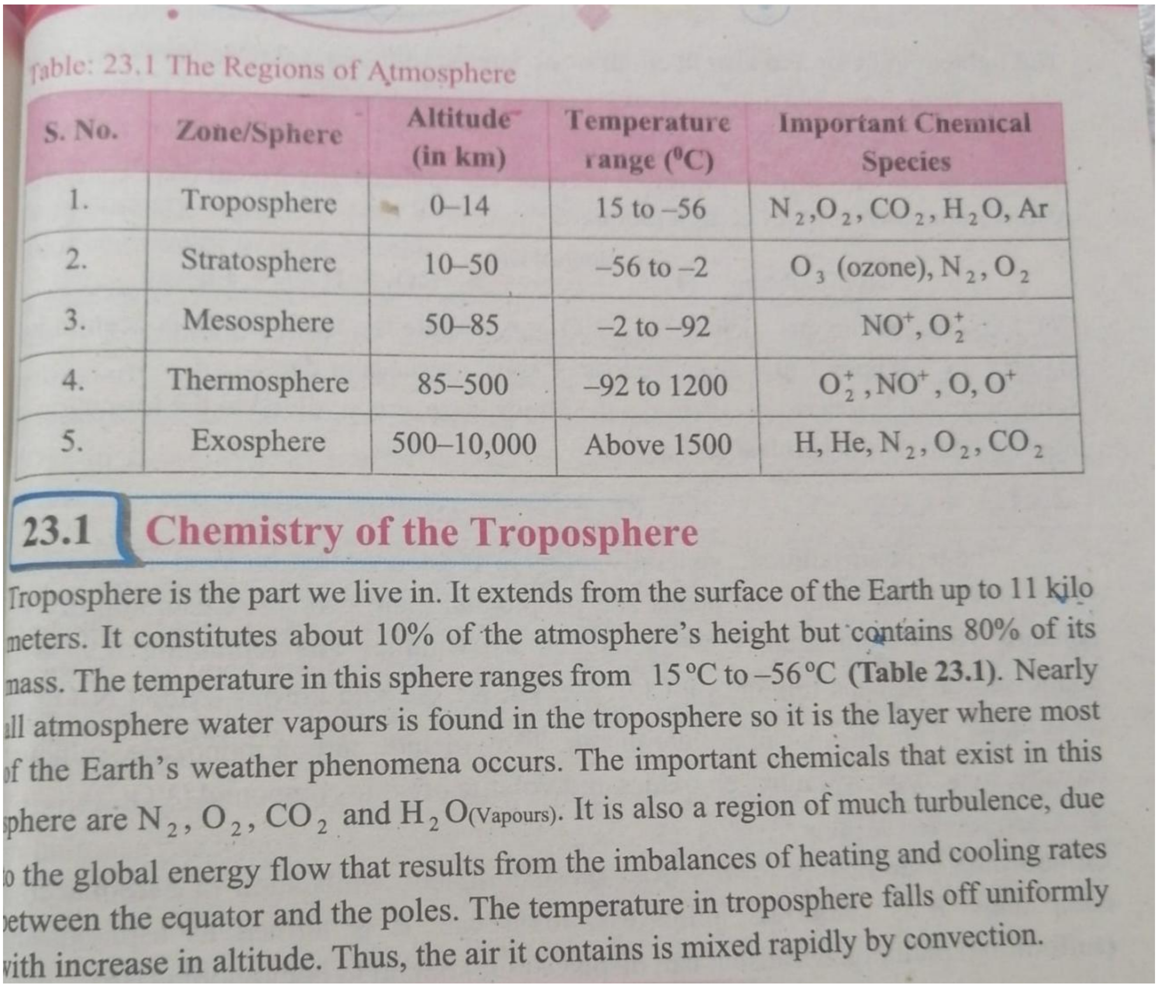


Table: 23.1 The Regions of Atmosphere

S. No.	Zone/Sphere	Altitude (in km)	Temperature range (°C)	Important Chemical Species
1.	Troposphere	0–14	15 to –56	N_2, O_2, CO_2, H_2O, Ar
2.	Stratosphere	10–50	–56 to –2	O_3 (ozone), N_2, O_2
3.	Mesosphere	50–85	–2 to –92	NO^+, O_2^+
4.	Thermosphere	85–500	–92 to 1200	O_2^+, NO^+, O, O^+
5.	Exosphere	500–10,000	Above 1500	H, He, N_2, O_2, CO_2

23.1 Chemistry of the Troposphere

Troposphere is the part we live in. It extends from the surface of the Earth up to 11 kilo neters. It constitutes about 10% of the atmosphere's height but contains 80% of its nass. The temperature in this sphere ranges from 15 °C to –56 °C (**Table 23.1**). Nearly ll atmosphere water vapours is found in the troposphere so it is the layer where most f the Earth's weather phenomena occurs. The important chemicals that exist in this phere are N_2, O_2, CO_2 and H_2O(Vapours). It is also a region of much turbulence, due o the global energy flow that results from the imbalances of heating and cooling rates etween the equator and the poles. The temperature in troposphere falls off uniformly vith increase in altitude. Thus, the air it contains is mixed rapidly by convection.

Rubric (1+3 = 4)
- Atmosphere defined (1).
- Troposphere: composition, processes, importance (3).

Q6 (b): What is Spectroscopy? Write down the applications of U.V.-Visible Spectroscopy. [1+4 = 05]

Possible Answer
Spectroscopy: The science of studying the interaction of electromagnetic radiation with matter to obtain structural or compositional information.

Applications of UV-Vis spectroscopy:

1. Determination of conjugated double bonds and extent of conjugation.
2. Study of transition metal complexes and their colours (due to d–d transitions).
3. Quantitative determination of concentrations using Beer-Lambert's law.
4. Detection of impurities in organic and inorganic samples.
5. Study of reaction kinetics and mechanisms by monitoring absorbance changes.

Rubric (1+4 = 5)

- Definition of spectroscopy (1).
- Four correct applications of UV-Vis spectroscopy (4).
- Partial credit (0.5–1) for incomplete or vague examples.