

QUESTION BANK

CHP -4101

SECTION -1

A) Multiple choice question

- 1) In a cyclic process-
 - a) Work done is zero.
 - b) Work done by the system is equal to the quantity of heat given to the system.
 - c) Work done does not depend upon quantity of heat given to the system.
 - d) The internal energy of the system increases.
- 2) For a thermodynamic system, work done in a process depends upon
 - a) The path
 - b) State of the system
 - c) External pressure
 - d) Nature of the system
- 3) In a reversible process entropy of the system
 - a) Remains constant
 - b) Increases
 - c) Decreases
 - d) Sometime increases or decreases
- 4) the first law of thermodynamics is related to
 - a) Internal energy
 - b) Enthalpy
 - c) Entropy
 - d) Gibbs free energy
- 5) Third law of thermodynamics implies that
 - a) $T=0\text{K}$ cannot be attained by infinite number of processes
 - b) T cannot be negative
 - c) Even at $T=0\text{K}$, there is non-zero entropy
 - d) None of the above
- 6) The combined form of first and second law of thermodynamics is given by
 - a) $TdS = dU + PdV$
 - b) $dQ = TdS + PdV$
 - c) $dU = TdS + dQ$
 - d) $TdS = dU - PdV$
- 7) If W is work done by a system against
 - a) Work done on the system by surrounding
 - b) Work done by system on its surrounding
 - c) Work done is zero
 - d) None of the above

- 8) Which of the following is fully fluorinated polymer?
a) Polyethylene b) Teflon c) PVC d) Polystyrene
- 9) General gas equation is
a) $PV = mRT$ b) $PV = nRT$ c) $PV^n = C$ d) $C_p - C_v = R$
- 10) Carnot cycle consist of
a) Two constant volume and two reversible adiabatic processes
b) Two isothermal and two adiabatic processes
c) Two constant pressure and two reversible adiabatic processes
d) One constant volume, one constant pressure and two reversible adiabatic processes
- 11) The efficiency of Carnot cycle may be increased by
a) Increasing highest temperature
b) Decreasing the highest temperature
c) Increasing the lowest temperature
d) Decreasing the lowest temperature

B) One sentence answer

- 1) What is a state function?
- 2) What is a path function?
- 3) Enlist colligative properties.
- 4) Write a equation of Vant Hoff's factor.
- 5) State Raoult's law and write the equation.
- 6) Define heat and work.
- 7) Write down Schrödinger equation for particle in one dimensional box.
- 8) Write down photoelectric effect.
- 9) Define polymer and enlist it's types.
- 10) State second law of thermodynamics.
- 11) State third law of thermodynamics.
- 12) Define entropy and enthalpy.
- 13) Write down combined form of first and third law of thermodynamics.
- 14) State phase rule.
- 15) Draw a vapour-pressure phase diagram.
- 16) What is mean by the triple point of water?
- 17) How number average molecular weight of polymer is calculated?
- 18) Define partial molar volume.
- 19) Define osmosis and osmotic pressure
- 20) Write a mathematical form of first law of thermodynamics.
- 21) Draw diagram of Carnot cycle.
- 22) Enlist the steps of polymerisation chain reaction.
- 23) Define monomer and polymer.

- 24) Define rate and rate laws.
- 25) What is mean by pseudo-first order reactions. Give example.
- 26) Write a equation of efficiency of Carnot engine.

C) Short notes

- 1) Write a short note on black body radiation.
- 2) Write a short note on photoelectric effect and work function.
- 3) Write a short note on Gibbs function.
- 4) Write a note on depression in freezing point.
- 5) Write a note on elevation in boiling point
- 6) Write down Heisenberg uncertainty principle.
- 7) Write a note on Gibbs energy of mixing.
- 8) Write a note on exact and inexact differentials.
- 9) Write a note on Eigen value and Eigen function.
- 10) Write a note on Carnot cycle.

D) Short answer question.

- 1) Derive Schrödinger equation for particle in 1-D bore.
- 2) Enlist postulates of quantum mechanics.
- 3) Calculate stabilization energy of ethylene & Butadiene.
- 4) Write a short note on Helmholtz & Gibbs function.
- 5) Write a note on Gibbs energy of mixing.
- 6) Explain why entropy of adiabatic process is zero.
- 7) Define vapour pressure of liquids. How does it vary with temperature?
- 8) Define Helmholtz free energy. Show that it is state function.
- 9) Derive equation for Gibbs Helmholtz equation.
- 10) Derive Gibbs- Duhem equation.
- 11) Calculate the maximum work that can be done by reversible heat engine operating between.

E) Long answer questions

- 1) Write in brief addition & condensation polymerisation.
- 2) Derive Clausius -Clapyron equation.
- 3) Calculate the linear momentum of photons of wavelength 750 nm. What speed does an electron need to travel to have the same linear momentum?
- 4) Calculate the work done for a perfect gas which expands from its initial volume to final volume at 300 K temperature.
- 5) Explain the terms black body radiation ultraviolet catastrophe & Rayleigh-Jeans law.

- 6) Give Eigen function & Eigen value equation for particle in 1-D box.
- 7) Derive the Vant- Hoff reaction isotherm. Give its applications.
- 8) The energy required for the ionisation of certain atom is 3.44×10^{-18} . The absorption of a photon of unknown wavelength ionises the atom & ejects an electron with velocity $1.03 \times 10^6 \text{ ms}^{-1}$. Calculate the wavelength of incident radiation.
- 9) For a reaction, $\Delta G = -91.63 \text{ KJ}$ at 25°C & 1 Pascal pressure, find out the temperature coefficient at 25°C , if the heat of reaction is $105.06 \text{ KJ deg}^{-1}$.
- 10) Boiling point of H_2O is 100°C under what pressure will water boil at 102°C . Heat of vaporization of H_2O is 2259 Jg^{-1} .
- 11) Calculate the entropy change of a sample of perfect gas when it expands isothermally from a volume V_i to volume V_f .
- 12) Enthalpy change accompanying the formation of 1 mole $\text{NH}_3(\text{g})$ from its elements at 298 K is -46.1 KJ . Estimate change in internal energy and calculate Δn_g .
- 13) A polymer has the following molar mass distribution, calculate number average molar mass of the polymer-

Number of molecules	Molar mass(g/mol)
50	5000
75	6000

Section II

A) Multiple choice questions

- 1) Which statistics will apply to deuterons and alpha particles?
a) Bose-Einstein b) Fermi –Dirac c) Maxwell – Boltzmann d) All of the above
- 2) The total accessible states of N non interacting particles of spin 1/2 is
a) 2^N b) N^2 c) N d) $2^{N/2}$
- 3) Choose the correct statement
a) The half life of first order reaction is independent of the initial concentration.
b) Order is always equal to molecularity of reaction.
c) The rate constant of reaction decreases with temperature.
d) The unit of second order rate constant are $\text{mole dm}^{-3} \text{ s}^{-1}$
- 4) The rate constant $k = 1.2 \times 10^3 \text{ mole}^{-1} \text{ LS}^{-1}$ and $E_a = 2 \times 10^2 \text{ KJmole}^{-1}$ when $T \rightarrow \infty$
a) $A = 2 \times 10^2 \text{ KJmole}^{-1}$
b) $A = 1.2 \times 10^3 \text{ L mole}^{-1} \text{ S}^{-1}$
c) $A = 1.2 \times 10^2 \text{ L mole}^{-1} \text{ S}^{-1}$
d) $A = 2.4 \times 10^3 \text{ KJmole}^{-1}$
- 5) Unit of first order rate constant is ...
a) Time^{-1} b) $\text{L mol}^{-1} \text{ S}^{-1}$ c) L mol^{-1} d) none of the above
- 6) The half life period of a first order reaction is 6.93 min. The time required for the completion of 99% of the chemical reaction will be ...
a) 230.3 min b) 23.03 min c) 46.06 min d) 460.6 min
- 7) The frequency factor A in Arrhenius equation is directly related to ...
a) Entropy change in the chemical reaction
b) The free energy change in the reaction
c) The energy of activation
d) All of the above
- 8) Which of the following does not influence the rate of reaction?
a) Nature of the reactant
b) concentration of the reactants
c) Temperature
d) Molecularity of the reaction
- 9) The number of ways of distributing 20 identical objects into the boxes, with the arrangement 1, 0, 3, 5, 10, 1
a) 9.11×10^8 b) 9.31×10^8 c) 8.31×10^8 d) 9.5×10^8
- 10) The steady state approximation is applied only for...
a) Reactant b) Product c) Intermediate d) All of the above

B) One sentence answer

- 1) Define weight of configuration and configuration.
- 2) Write down rule of undetermined multiplier.

- 3) Write down the Boltzmann distribution law.
- 4) Define ensemble and enlist its types.
- 5) Define order and molecularity.
- 6) Write down steady state approximation.
- 7) Write down Arrhenius equation and enlist terms involved in it.
- 8) Write down equation of third order rate constant and give its unit.
- 9) What are unimolecular and bimolecular reactions and write its examples.
- 10) Define quantum yield for photochemical reactions.
- 11) Define steric factor P.
- 12) Write equation of Michaels-Menten catalysis constant K_M .

C) Write short notes

- 1) State law of photochemical equivalence.
- 2) Write a note on consecutive reactions.
- 3) Write down the difference between order and molecularity.
- 4) Define partition function and obtain an expression for rotational partition function.
- 5) Write a short note on factors affecting on rate of chemical reaction.
- 6) Explain in short –Explosion.
- 7) Write a short note on flash photolysis.
- 8) Write a short note on radiolysis of water.
- 9) Write in short vibrational partition function.
- 10) Explain in detail translational partition function.
- 11) Describe in short uniform ladder system for molecular energy levels.
- 12) Explain in short temperature dependence of chemical reactions.
- 13) Explain reactions approaching equilibrium.
- 14) Derive equation first order rate constant.

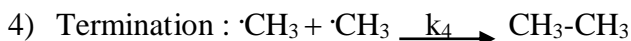
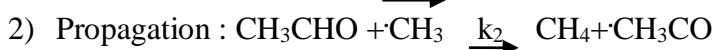
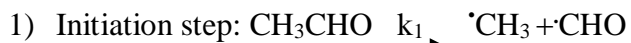
D) Short answer questions

- 1) Calculate translational partition function for hydrogen molecule in a 100 cc vessel at 25°C. Find out the thermal wavelength.
- 2) Plot Lineweaver-Burk plots for competitive inhibition.
- 3) Write down the difference between Maxwell-Boltzmann distribution and Fermi-Dirac distribution.
- 4) Explain in detail activated complex theory.
- 5) Explain in detail transition state theory.
- 6) Explain in detail steady state approximation with example.
- 7) State the law of photochemical equivalence and define the term Einstein.
- 8) Plot Lineweaver-Burk plots for competitive, uncompetitive and non-competitive inhibition.

- 9) Explain the terms initiation, propagation and termination. Discuss with suitable examples of the phenomenon of the chain reactions.
- 10) In a reaction a decrease in reactant concentration 30% in 30 min and 40% in 40 min calculate order of reaction and rate constant.
- 11) Derive the equation for second order velocity constant and show $t_{1/2} = 1/ak$
- 12) Calculate molecular translational partition function for N_2 at 298K in 24.7 L container.
- 13) Calculate the residual entropy for CO.

E) Long answer questions.

- 1) Derive the equation for Lindeman mechanism for unimolecular reactions.
- 2) Derive the equation for Michaelis - Menten catalysis.
- 3) What are diffusion controlled reactions and derive the equations for it.
- 4) What will be the initial rate of reaction if its rate constant is 10^{-3} min^{-1} and the concentration of the reactant will be converted into product in 200 min.
- 5) The enzymatic conversion of substrate at 25°C has a Michaelis constant 0.035. The rate of reaction is $1.2 \times 10^{-3} \text{ Ms}^{-1}$, when the substrate concentration is 0.11M. What is the rate constant of the enzymolysis of the initial concentration of the enzyme is considered constant.
- 6) Derive the equation for Rotational partition function.
- 7) Define residual entropy and calculate residual entropy for CO_2 molecule.
- 8) Prove that order of pyrolysis reaction of acetaldehyde is $3/2$,



Prove that $d[\text{CH}_4]/dt = k[\text{CH}_3\text{CHO}]^{3/2}$ for reaction,



- 9) What is the rate constant for the recombination of Iodine atoms in hexane at 298 K, when the viscosity of the solvent is 0.326 CP.
- 10) Estimate the steric factor for the reaction $\text{H}_2 + \text{C}_2\text{H}_4 \rightarrow \text{C}_2\text{H}_6$ at 628K , given that the pre-exponential factor is $1.24 \times 10^6 \text{ L mol}^{-1} \text{ s}^{-1}$.
- 11) Derive equation of Arrhenius complex theory for energy of activation.
- 12) Half life of ^{14}C is 5760 years and 15.3 decay per minutes . Find out each of wood that decay 2.4 events per minute of ^{14}C .

QUESTION BANK

CHP -4102

Section I

A] Multiple choice questions.

- 1) Square pyramidal MX_4 molecule belongs to C_{4v} point group and symmetry elements are E, $2C_4$, C_2 , $2\sigma_v$, $2\sigma_d$ the trace for the reducible representation is-
 - a) 5 1 1 1 3
 - b) 5 1 1 1 1
 - c) 1 1 1 1 1
 - d) 4 1 1 1 3
- 2) The point group of $[M(CO)_3L_3]$ is-
 - a) C_{2v}
 - b) C_{3v}
 - c) Oh
 - d) D_{3h}
- 3) Point group of Cyclohexane is -
 - a) Chair form is D_{3d}
 - b) Boat form is C_{3v}
 - c) Both chair and boat form is C_{2v}
 - d) Boat form is D_{3d}
- 4) In which of the following pairs both the molecules will give pure rotational spectra-
 - a) CH_4 and $CHCl_3$
 - b) CH_2Cl_2 and CCl_4
 - c) CH_2Cl_2 and $CHCl_3$
 - d) CH_4 and CCl_4
- 5) The character table for C_{2v} point group is given below. In cis butadiene molecule the vibrational modes belonging to A_2 irreducible representation are IR inactive. The remaining are-

C_{2v}	E	C_2	σ_v	σ'_v	
A_1	1	1	1	1	Z, x^2, y^2, z
A_2	1	1	-1	-1	R_z, xy
B_1	1	-1	1	-1	X, R_y, xz

B ₂	1	-1	-1	1	Y, R _x , yz

- a) $7A_1 + 5B_1 + 8B_2$
b) $9A_1 + 4B_1 + 7B_2$
c) $7A_1 + 3B_1 + 7B_2$
d) $9A_1 + 3B_1 + 8B_2$
- 6) SF₄ is consistent with the point group symmetry-
a) C_{3v}
b) C_{4v}
c) T_d
d) C_{2v}
- 7) The point group of NOCl is-
a) C₃
b) C_{3v}
c) D₃
d) C_{2v}
- 8) Which of the following is not the point group of ferrocene –
a) D_{5h}
b) D_{5d}
c) C_{4v}
d) None of the above
- 9) The order of C_{3v} point group is-
a) 3
b) 6
c) 9
d) 12
- 10) Which of the following is non abelian group-
a) C_{2v}
b) C_{3v}
c) C_{4v}
d) None of the above

B] Short answer questions

- 1) Define improper axis of rotation.
- 2) Enlist all the symmetry elements of H₂O molecule.
- 3) What is the difference between symmetry and symmetry operation?
- 4) Give the definition of symmetry elements.
- 5) What is inversion centre? Give example.

- 6) Explain equivalent atoms with suitable example.
- 7) What are the conditions for mathematical group?
- 8) Define abelian group.
- 9) What is mean by order of a group?
- 10) What is matrix? Give the matrix representation of C_2^z .

C] Short answer questions

- 1) Write down the associative operation of S_3 axis.
- 2) How do you distinguish between C_{nv} and C_{nh} point group?
- 3) Using molecular geometry give the product $\sigma_v^1 \times \sigma_v^2$ operation in NH_3 molecule?
- 4) Find out the product $\sigma_v(xz) \times \sigma_v(xy)$ symmetry operations by matrix multiplication method.
- 5) Identify and draw different types of planes present in CO_3^{2-} ion.
- 6) What are the symmetry criterion for a molecule to possess permanent dipole?
- 7) Classify cisplatin in the appropriate point group. Justify your answer.
- 8) When n is odd, $S_n^{2n} = E$, prove this.
- 9) How will you distinguish between Cis and trans isomer of 1,2-dichloroethylene using plane of symmetry?
- 10) Mention the symmetry elements, order and classes of D_{4h} point group.
- 11) Identify and draw the different types of planes in NO_3^- ion.
- 12) Give the equation of direct product.
- 13) What is point group of $[Co(en)_3]^{2+}$?
- 14) What are the point group symmetry for cyclopropane and benzene?
- 15) Find improper axis of rotation in following molecules?
 - i) CCl_4
 - ii) C_2H_4 (eclipsed)

D] Long answer type questions

- 1) What are the conditions of mathematical group? Show C_{2v} forms a mathematical group.
- 2) Sketch and describe all the S_4 operations in trans- $[Co(NH_3)_4Cl_2]$
- 3) For PF_5 molecule find out reducible representation for which sigma bonds form the basis and find out which of the orbitals from the P atom will be offered for sigma bonding?

D _{3h}	E	2C ₃	3C ₂	σ _h	2S ₃	3σ _v		
A ₁ '	1	1	1	1	1	1	R _z (x, y)	X ² +Y ² , z ²
A ₂ '	1	1	-1	1	1	-1		(x ² -y ² , xy)
E'	2	-1	0	2	-1	0		
A ₁ ''	1	1	1	-1	-1	-1	Z (R _x , R _y)	
A ₂ ''	1	1	-1	-1	-1	1		
E''	2	-1	0	-2	1	0		(xz, yz)

- 4) Define abelian group. Explain an abelian group with example.
- 5) Using great orthogonality theorem derive the character table for D₂ point group.
- 6) Find the normalized SALC using projection operator of E_u irreducible representation on σ₁ of the [PtCl₄]²⁻ / [Cu(NH₃)₄]²⁺ complex ion.

D _{4h}	E	2C ₄	C ₂	2C ₂ '	2C ₂ ''	I	2S ₄	σ _h	2σ _v	2σ _d
E _u	2	0	-2	0	0	-2	0	2	0	0

- 7) Prove that C_{3v} point group is Non-Abelian point group.
- 8) Derive the transformation matrix for the axis of rotation and mention the matrix for C₂^z rotation.
- 9) Find out the normalized SALC using projection operator of A_g irreducible representation on σ₁ orbital of the B₂H₆ molecule which belongs to D_{2h} point group.

D _{2h}	E	C ₂ ^z	C ₂ ^y	C ₂ ^x	I	σ(xy)	σ(xz)	σ(yz)
A _g	1	1	1	1	1	1	1	1

- 10) Derive the character table for H₂O₂trans molecule.
- 11) Sketch and describe all the symmetry elements in [Ni(CN)₅]³⁻ complex.
- 12) Explain all symmetry elements and classify it into appropriate point group :
Eclipsed ferrocene.
- 13) Give the matrices for σ^{xy} and C₂^z and find out the product of them. Give the matrix representation for improper axis of rotation.
- 14) Write short note on symmetry elements and symmetry operations.
- 15) Give point group of Allene and describe symmetry elements, symmetry operations of it.
- 16) Write short note on great orthogonality theorem and its consequences and derive the character table for C_{2h} using great orthogonality theorem.
- 17) Give the point group for following molecules.
 - i) H₂O₂ (cis)
 - ii) [TiCl₄]²⁻
 - iii) ferrocene (staggered)

- iv) $C_2H_4Cl_2$
- iv) HCl
- v) $XeOF_4$
- vi) $C_2H_2Cl_2$
- vii) B_2H_6
- viii) CH_4
- ix) Cyclooctatetraene
- x) SF_5Cl
- xi) 1,2- Dichlorobenzene

- 18) Prove that all irreducible representations of abelian groups must be one dimensional
- 19) Write the matrices describing the effect on a point (x,y,z) of reflections vertical planes which lie halfway between the xz and yz planes by matrix methods determine hat operations result when each of these reflections is followed by reflection in the xy plane.
- 20) The character table of the irreducible representation A_1 in C_{3v} point group is given below.

	E	$2C_3$	$3\sigma_v$
A_1	1	1	1

Identify one irreducible representation orthogonal to A_1 among the following

	E	$2C_3$	$3\sigma_v$
T_1	1	-1	1
T_2	2	-1	0
T_3	2	0	1
T_4	1	-1	-1

- 21) Give the point group for H_3BO_3 molecule and give its symmetry elements, classes, order
- 22) Construct the character table for C_{3v} point group with proper explanation.

Section II

A) Objective questions

- 1) Borax is used in preparing-
- a) soda glass
 - b) pyrex glass
 - c) opal glass
 - d) Portland cement

- 2) Hydrogen will not reduce –
- Heated cupric oxide
 - Heated ferric oxide
 - Heated stannic oxide
 - Heated aluminium oxide
- 3) The ratio of ortho hydrogen:para hydrogen-
- Decrease with increase of temperature
 - Increase with increase of temperature
 - Is independent of temperature
 - at highest at 100°C and then decreases
- 4) Alkali metal in liquid ammonia are blue in colour because –
- They contain alkali metal cations
 - the free electron is trapped in solvent cages
 - an ion pair is formed
 - An amide ion is formed
- 5) The Si-O-Si bond angle in $\text{Me}_3\text{Si-O-SiMe}_3$ is –
- $\sim 120^{\circ}$
 - $\sim 180^{\circ}$
 - $\sim 90^{\circ}$
 - $\sim 109^{\circ}$
- 6) Which of the following an arachnaborane
- $[\text{B}_6\text{H}_6]^{2-}$
 - $[\text{B}_5\text{H}_9]$
 - $[\text{B}_2\text{H}_6]$
 - $[\text{B}_6\text{H}_{12}]$
- 7) C_{60} has –
- 14 pentagons and 18 hexagons
 - 12 pentagons and 20 hexagons
 - 10 pentagons and 20 hexagons
 - 12 pentagons and 18 hexagons
- 8) Inorganic graphite is –
- $\text{B}_3\text{N}_3\text{H}_6$
 - B_3N_3
 - SiC

d) P_4S_3

9) White phosphorous belongs to the –

- a) closo system
- b) Nido system
- c) Arachno system
- d) Hypo system

10) Which of the following alkali metal cations forms the most stable cryptate[2 2 2]-

- a) Li^+
- b) Na^+
- c) K^+
- d) Rb^+

B) Answer in one sentence

- 1) Give the account of the hydrides of boron
- 2) Among the following elements the one that acts as a major component in semiconductor is – a) carbon b) silicon c) gallium d) arsenic
- 3) Draw the structures $[B_5H_9]$, $[B_4H_9]$, N_2O_5 , P_4O_{10}
- 4) Define electron deficient compounds
- 5) Define electron rich compounds

C) Short Answer Questions

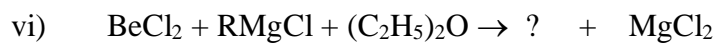
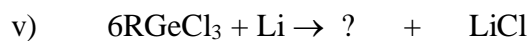
- 1) What are the metallic hydrides ? Mention their properties.
- 2) Explain the alkali metal solution in ammonia used as a good reducing agent ?
- 3) Diborane is best soft lewis acid. Explain
- 4) Explain any two reactions of $COCl_2$.
- 5) What are nitrides of boron ?
- 6) What are the electron rich compound?
- 7) Explain the Oxoanions of nitrogen.
- 8) Draw the structure of B_5H_9
- 9) Explain the Nitrogen Oxyacids.
- 10) Draw the structure of Diborane.
- 11) Difference between Diamond and Graphite.
- 12) Give the classification of electron deficient and electron rich hydrides
- 13) Give an account of Borazine

D) Shorts Notes

- 1) Write a short note on Interhalogen Compound
- 2) Short Note on aluminosilicate
- 3) Pseudohalogens
- 4) Give an account of Borazole
- 5) Short note on Intercalation compounds
- 6) Short note on Carbon Nanotubes
- 7) Applications of carbon Nanotubes
- 8) Write a note on π - acidity.
- 9) Applications of Crown Ether
- 10) Write a note on Coordination compounds of alkali metals?
- 11) Short notes on zeolits
- 12) How many types of bonds are involved in the bonding of boranes? Give the structural features of B_4H_{10} , B_5H_9 , B_5H_{11} , B_6H_{10} , $B_{10}H_{14}$ what is the STYX number write the STYX number of above boranes
- 13) Give the structure of Diborane and write a short note on it.

E) Long Answer Questions

- 1) Give an account reactions of BX_3
- 2) Write a note on solutions of alkali metals in liquid ammonia.
- 3) Give an account of Oxyanions of Nitrogens.
- 4) Short note on Fullerene.
- 5) Give the reactions of – 1) $COCl_2$ 2) CO_2 3) PCl_5 4) CH_3X 5) C_2H_5Br
- 6) What is Grignard Reagent? How it is prepared Properly? Uses of it.
- 7) Synthesis and properties of Saline Carbides.
- 8) Define Interhalogen Compounds? Give their classification. Explain preparation, bonding and structure of XY_5 type of Interhalogen compound.
- 9) What are the silicons ? How they are prepared? Give two important properties and uses of silicons?
- 10) Discuss structural aspects of different types of Silicate.
- 11) Write down the classification and synthesis of structure of Organometallic compounds of Li, Mg, Br.
- 12) Explain with one example each of Closo, Nido, Arachno Carborane. Explain Wade's rule.
- 13) Distinguish between Geminal and Vicinal dihalides.
- 14) Explain Allotropes of carbon
- 15) Complete the following reactions
 - i) $XeF_2 + NO \rightarrow$
 - ii) $RLi + R'CHO \rightarrow$
 - iii) $Be(CH_3)_2 + CH_3OH \rightarrow$
 - iv) $B_3N_3H_3Cl_3 + NaBH_4 \rightarrow ? + NaCl + BH_3$

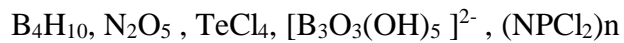


16) Draw the structure of following- XeF_2 , XeF_4 , XeOF_4 , XeO_2F_2 , XeO_3 , $[\text{XeO}_6]^{4-}$, XeO_4

17) Draw the structure of following –



18) Draw the structure of following –



Question Bank

CHO-4103

Basic organic chemistry

A. Multiple choice questions:

1. The hybridization of the central carbon in $\text{CH}_3\text{C}\equiv\text{N}$ and the bond angle CCN are

- a. sp^2 , 180° .
- b. sp , 180° .
- c. sp^2 , 120° .
- d. sp^3 , 109° .

2. Which of the following statements about sp hybridized carbon is FALSE?

- a. It is divalent.
- b. It forms bonds that are linear.
- c. It has two p orbitals.
- d. It always forms triple bonds to carbon.

3. Which molecule has the largest dipole moment?

- a. HCl
- b. CCl_4
- c. H_2S
- d. CO_2

4. What are the hybridizations of carbons 1 and 2 respectively in the **Cyclopentene**?

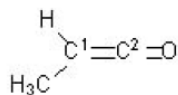
- a. sp^3 and sp^2
- b. sp^2 and sp^3
- c. sp^3 and sp
- d. sp^2 and sp^2

5. What are the hybridizations of atoms 1 and 2 respectively in the **Pyridine**?

- a. sp^3 and sp^2

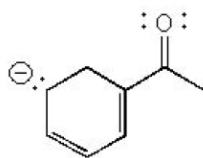
- b. sp^2 and sp^3
- c. sp^3 and sp
- d. sp^2 and sp^2

6. What are the hybridizations of atoms 1 and 2 respectively in the following structure?



- a. sp^3 and sp^2
- b. sp^2 and sp^3
- c. sp^3 and sp
- d. sp^2 and sp^2

7. How many **total resonance structures** can be drawn for the following anion (include those without separation of charge)?



- a. 1
- b. 2
- c. 3
- d. 4

8. How many **resonance structures** can be drawn for the following molecule?

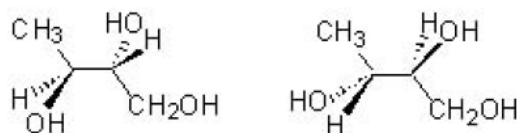


- a. 1
- b. 4
- c. 3
- d. 2

9. The correct geometry around oxygen in CH_3OCH_3 is

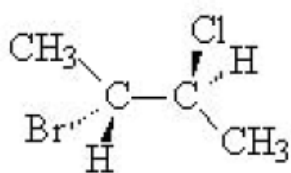
- a. linear.
- b. bent.
- c. tetrahedral.
- d. trigonal planar

10. Determine the relationship between the two molecules shown.



- a. constitutional isomers
- b. enantiomers
- c. diastereomers
- d. identical molecules

11. What is the correct name for this molecule?

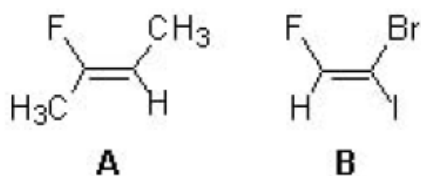


- a. (2*R*,3*R*)-2-bromo-3-chlorobutane
- b. (2*S*,3*R*)-2-bromo-3-chlorobutane
- c. (2*S*,3*S*)-2-bromo-3-chlorobutane
- d. (2*R*,3*S*)-2-bromo-3-chlorobutane

12. Which of the following physical properties differ for each of a pair of enantiomers?

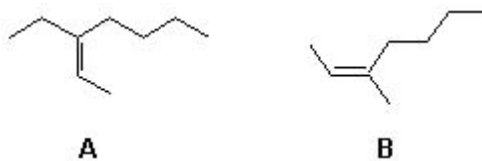
- a. solubility in ethanol
- b. direction of rotation of plane-polarized light
- c. boiling point and melting point
- d. index of refraction

13. Determine the double bond stereochemistry (*E* or *Z*) for the following molecules.



- a. **A:** *E*; **B:** *E*
- b. **A:** *Z*; **B:** *Z*
- c. **A:** *E*; **B:** *Z*
- d. **A:** *Z*; **B:** *E*

14. Determine the double bond stereochemistry (*E* or *Z*) for the following molecules.



- a. **A:** *E*; **B:** *E*
- b. **A:** *Z*; **B:** *Z*
- c. **A:** *E*; **B:** *Z*
- d. **A:** *Z*; **B:** *E*

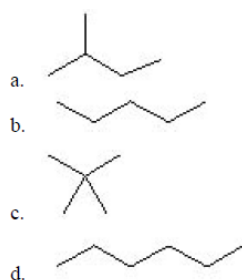
15. Which of the following cycloalkanes has the MOST strain energy?

- a. cyclobutane
- b. cyclopentane
- c. cyclohexane
- d. cycloheptane

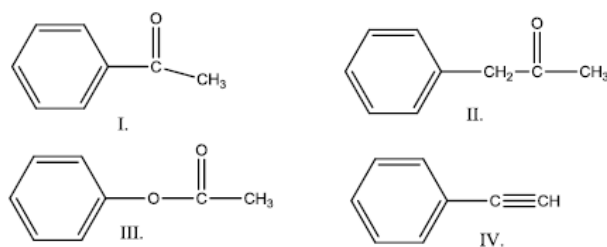
16. Which compound has the highest melting point?

- a. decane
- b. 2,2,3,3-tetramethylbutane
- c. 2,2,3-trimethylpentane
- d. 4-methylnonane

17. Which of the following alkanes will have the lowest boiling point?

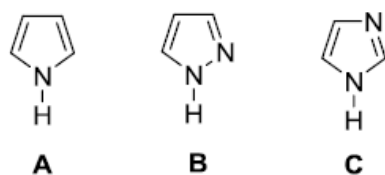


18. Circle the letter which correctly ranks the following compounds from fastest to slowest as they react in an EAS reaction with HNO_3 and H_2SO_4 . (If $a > b$, a is faster than b)



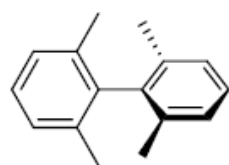
- a) $\text{I} > \text{II} > \text{III} > \text{IV}$
 b) $\text{IV} > \text{III} > \text{II} > \text{I}$
 c) $\text{III} > \text{IV} > \text{II} > \text{I}$
 d) $\text{III} > \text{II} > \text{I} > \text{IV}$

19. The correct basicity order for the following heterocycles is:



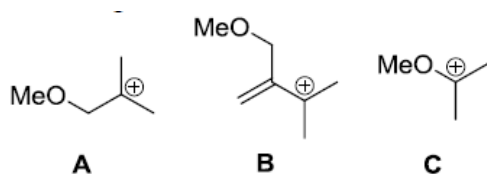
1. $\text{A} > \text{C} > \text{B}$ 2. $\text{C} > \text{A} > \text{B}$
 3. $\text{C} > \text{B} > \text{A}$ 4. $\text{B} > \text{A} > \text{C}$

20. The number of signals observed in the proton decoupled ^{13}C NMR of the following compound is,



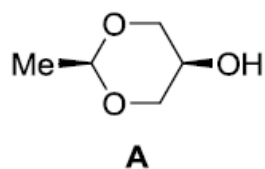
1. five 2. six
 3. ten 4. thirteen

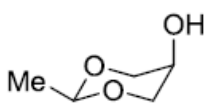
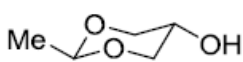
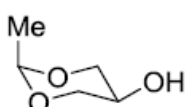
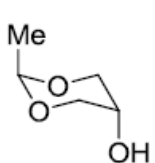
21. The correct order of stability of following cation is,



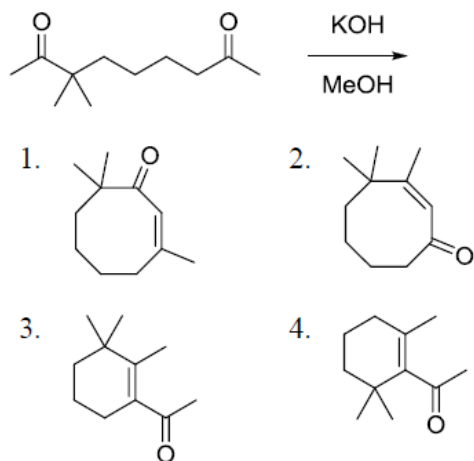
1. **A > C > B**
2. **B > C > A**
3. **C > A > B**
4. **C > B > A**

22. Among the structures given below, the one that corresponds to the most stable conformation of compound A is,

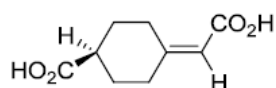


1. 
2. 
3. 
4. 

23. The major product formed in the following reaction is,



24. The following molecule has:



1. plane of symmetry
2. *R* configuration
3. *S* configuration
4. centre of symmetry

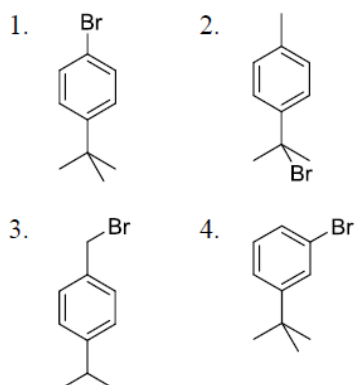
25. Correct match of the following compounds in Column P with the IR stretching frequencies (cm^{-1}) in column Q is:

	Column P		Column Q
I		A	1865
II		B	1770
III		C	1745

1. I - B; II - C; III - A
2. I - C; II - A; III - B
3. I - C; II - B; III - A
4. I - A; II - C; III - B

26. The organic compound that displays following data is;

^1H NMR (400 MHz): δ 7.38 (d), 7.25 (d), 1.29 (s) ppm



27. Choose the INCORRECT statement for the phosphomolybdate anion, $[\text{PMo}_{12}\text{O}_{40}]^{3-}$:

1. It has a Keggin structure.
2. Phosphorus is in +5 oxidation state.
3. It is extremely basic.
4. It forms crystalline precipitates with $[\text{R}_4\text{N}]^+$ (R = bulky alkyl or aryl group)

28. The number of optically active stereoisomers possible for $\text{CH}_3\text{-CH(OH)-CH(OH)-CH}_3$ is:

- | | |
|--------|----------|
| 1. two | 2. four |
| 3. six | 4. eight |

29. Which of the following alcohol would undergoes dehydration the fastest?

- a. 2-phenyl-2-butanol
- b. 2-methyl-2-butanol
- c. 2-butanol
- d. 1-butanol

30. Which of the following is NOT stereospecific reaction.

- a. epoxidation of cyclohexene with m-CPBA
- b. elimination of HBr from 2-bromo-2-methylpropane by sodium ethoxide
- c. dehydration of 1-methylcyclohexanol by heating with H_2SO_4 .
- d. reaction of 2-bromobutane with NaOH.

31. Reaction of a secondary alkyl halide with a weak base would likely result in

- a. $\text{S}_{\text{N}}1$ reaction
- b. $\text{S}_{\text{N}}2$ reaction
- c. $\text{E}1$ Reaction
- d. mixture of $\text{S}_{\text{N}}1$ and $\text{E}1$
- e. $\text{E}2$ elimination
- f. mixture of $\text{S}_{\text{N}}2$ and $\text{E}2$

32. Which of the following is the stronger acid?

- a. ethanol
- b. ethanethiol
- c. acetylene
- d. butane

33. Which of the following would be the most soluble in water?

- a. diethyl ether
- b. methanol
- c. 1-butanol
- d. dimethylsulfide

34. Which of the following would undergo $\text{S}_{\text{N}}2$ reaction the fastest?

- a. $\text{CH}_3\text{I} + \text{HO}^- \text{Na}^+$
- c. $\text{CH}_3\text{I} + \text{HS}^- \text{Na}^+$
- b. $\text{CH}_3\text{CH}_2\text{I} + \text{HO}^- \text{Na}^+$
- d. $(\text{CH}_3)_2\text{CHI} + \text{HO}^- \text{Na}^+$
- e. $(\text{CH}_3)_2\text{CHI} + \text{HS}^- \text{Na}^+$

B. Write a short notes on the following.

- 1. Inductive effect affecting basicity
- 2. Prochiral relationship
- 3. Benzenoid compounds
- 4. S_{Ni} mechanism
- 5. Non-classical carbocation
- 6. Crown ether
- 7. Proton sponge

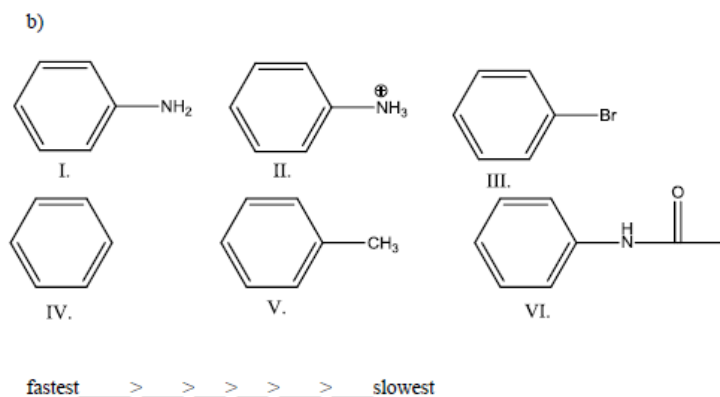
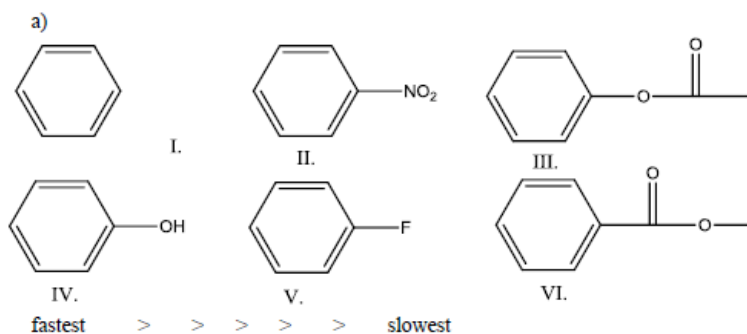
8. Ambident nucleophile
9. Tautomerism
10. Stability of carbanion
11. Chloromethylation of aromatic compounds
12. Hyper conjugation.
13. Carbocation
14. Carboanion
15. Aromatic nucleophilic substitution
16. Carbene
17. Nitrene
18. Aromatic electrophilic substitution
19. NGP

C. Answer in one sentence.

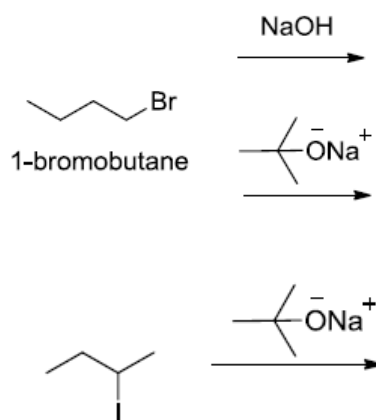
- 1) Describe regioselectivity in ambident nucleophile.
- 2) Write any one reaction involving SET mechanism.
- 3) Explain hydrolysis of 2-bromopropionic acid.
- 4) What is SN^2 reaction.
- 5) Explain Benzyne intermediate.
- 6) Formic acid is stronger than acetic Acid, Explain.
- 7) Aniline is less basic than cyclohexyl amine, Explain.
- 8) 2,4,6 trinitro phenol is known as Picric acid, Explain.
- 9) Explain the factors affecting strengths of organic Acids and Bases.
- 10) N,N Dimethyl 2, 6 dimethyl aniline is more basic than Aniline, Explain.
- 11) Write a short note on H-bonding.
- 12) Write general structure of carbocation.
- 13) Write general structure of carbene
- 14) Write general structure of nitrene
- 15) Write stability order of carboanion
- 16) Write any method for formation of carbocation
- 17) Write any method for formation of carboanion
- 18) Write any method for formation of carbene
- 19) Write any method for formation of Nitrene
- 20) Write any rearrangement involving carbocation
- 21) Write any rearrangement involving carbene
- 22) Write any rearrangement involving Nitrene

D. Short answer question.

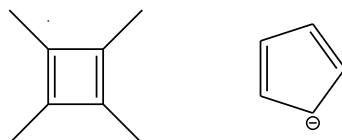
1. Rank the following compounds from fastest to slowest as they react in an EAS with $\text{Br}_2/\text{FeBr}_3$ and justify your answer.



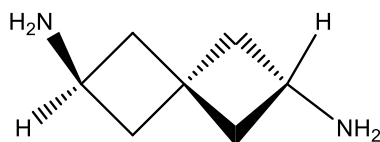
2. Predict the products.



3. Comment on the aromaticity of the following compound.



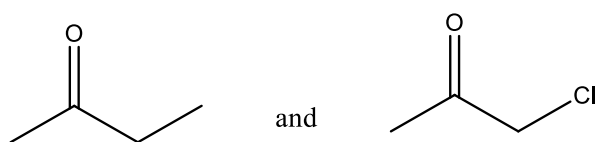
4. Comment on the optical activity of the following with justification.



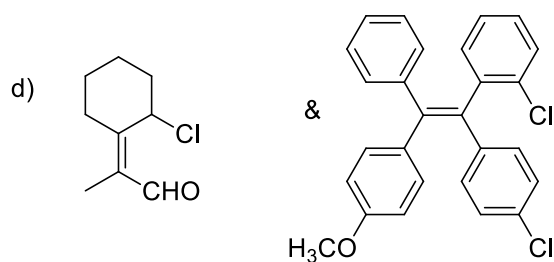
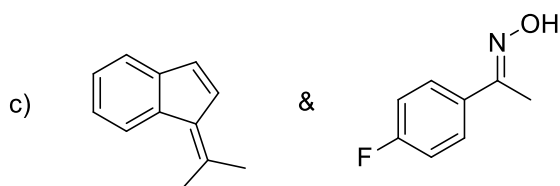
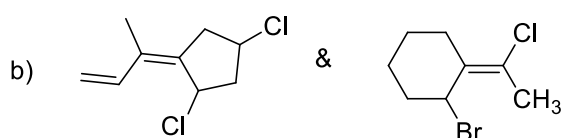
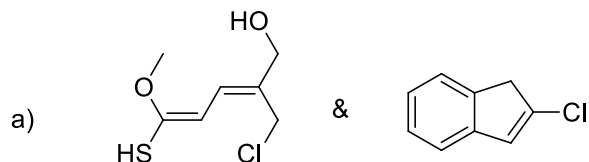
5. Assign Re and Si face labels to the following compounds.



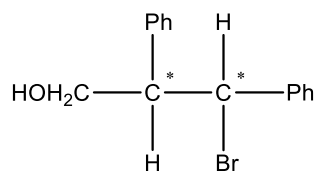
6. Explain which of the following will have higher pKa values



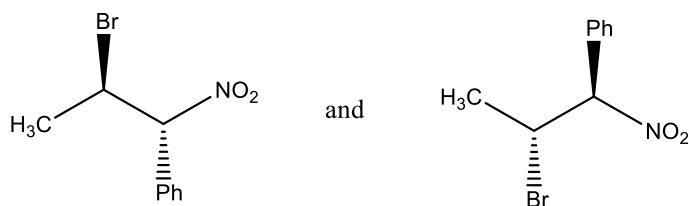
7. Assign E/Z designation to the following.



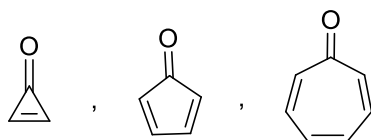
8. Assign R/S label to the chiral carbons and justify.



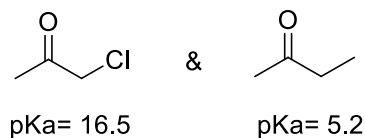
9. What is the stereochemical relationship between the following compounds?



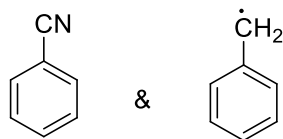
10. Explain stability order of the following.



11. Explain the pK_a values of the following compounds.



12. Draw resonance structures of the following.



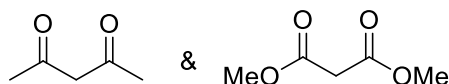
13. Which of the following compound is optically active? Justify your answer.



14. Comment on the stabilities of the following.



15. Discuss the acidity of the following.



16. pK_a value of 4-nitroanisole is less than 3-nitroanisole. Explain.

17. Anti-elimination occurs readily than syn elimination.

18. PhCOCH₂Cl reacts with KI in acetone about 32000 times faster than n-butyl chloride.

19. m-chloroanisole on reaction with sodamide in liquid ammonia gives p-anisidine.

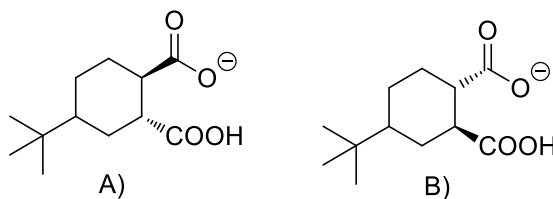
20. Addition of Br₂ to cis-butene is stereospecific. Explain.

21. Cis-4-hydroxy cyclohexane carboxylic acid lactonized on heating but trans does not. Explain.

22. What are Lewis acids? Give uses of Lewis acids in organic synthesis.

23. Electrophilic as well as nucleophilic substitutions of naphthalene occurs at α-position. Explain.

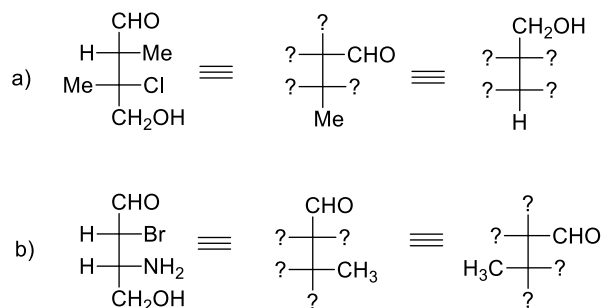
24. Which of the following is more acidic? Why?



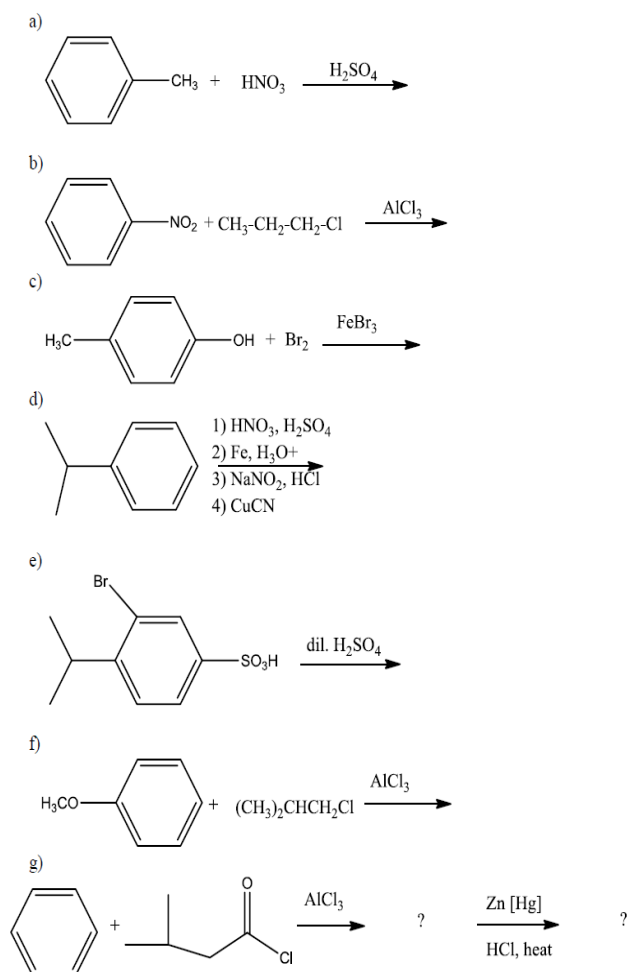
E. Long answer question.

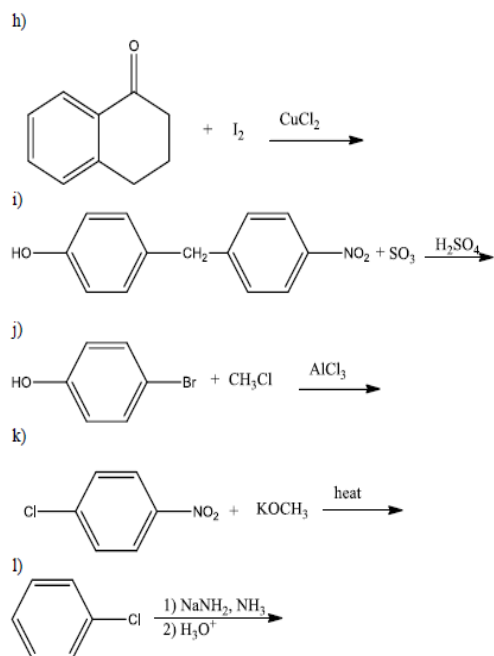
- 1) Explain with suitable examples. Benzenoid and non-benzenoid compounds.
- 2) Comment on the conformational analysis of cyclic compounds.
- 3) Annulenes are aromatic. Why?
- 4) Discuss in brief stereoselective analysis of cyclic compounds.
- 5) Explain diastereomeric relationship.

- 6) Explain structure and stability of carbenes.
 7) Write equivalent structures.

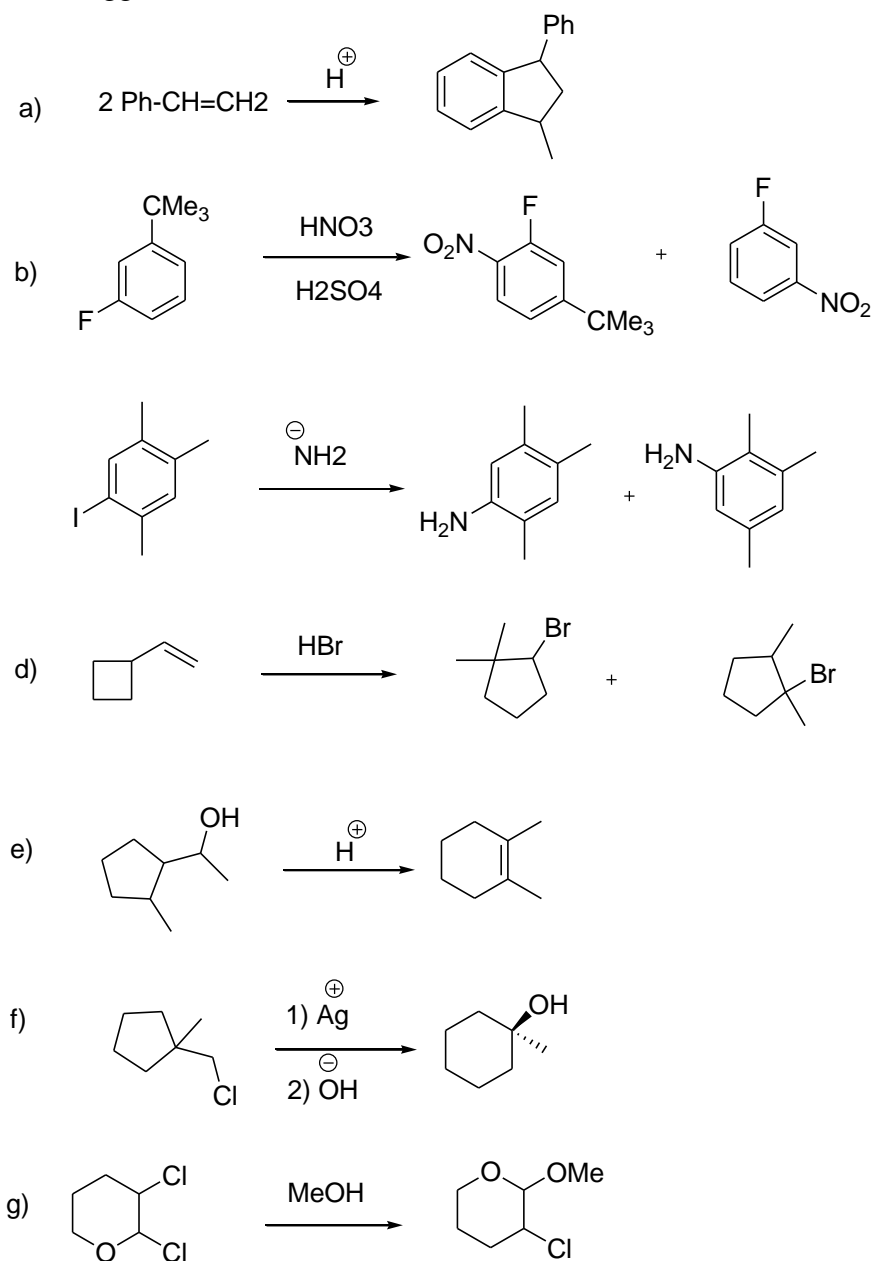


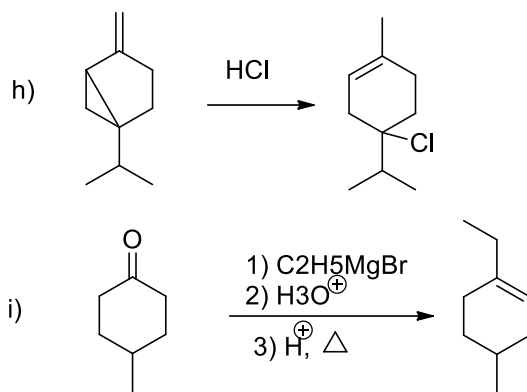
- 8) Explain chemoselectivity in addition reactions.
 9) What is $\text{S}_{\text{N}}\text{i}$ mechanism?
 10) Discuss in brief conjugate addition.
 11) Explain non-classical carbocation with suitable examples.
 12) What is difference between E2 and E1cb mechanism.
 13) Predict the product/products:



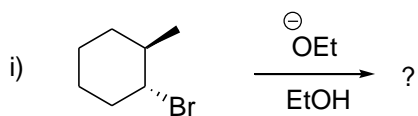
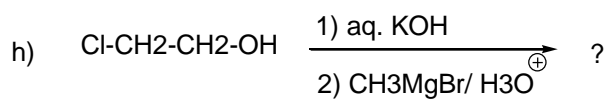
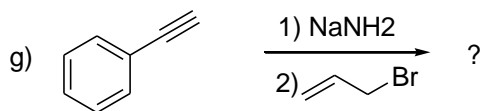
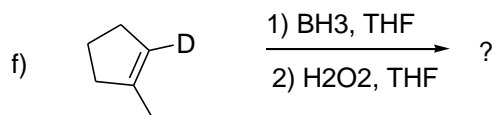
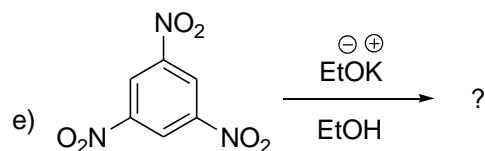
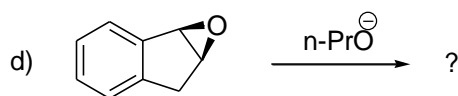
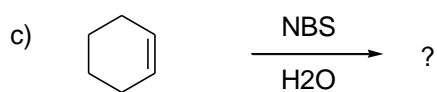
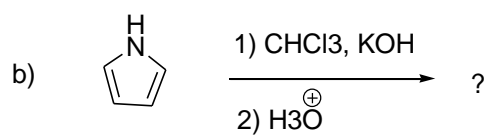
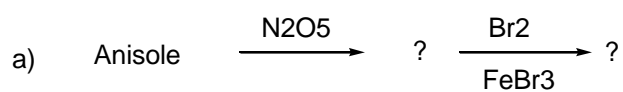


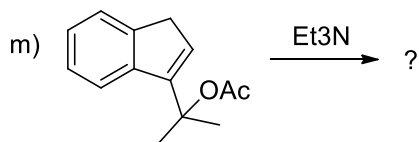
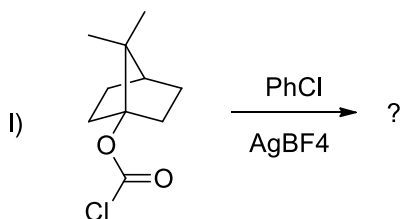
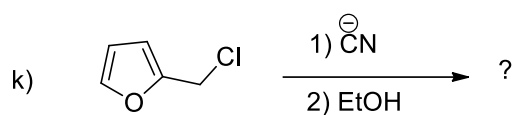
14) Suggest the mechanism.



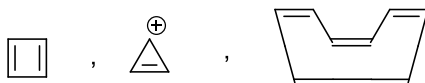


15) Predict the product with mechanism.



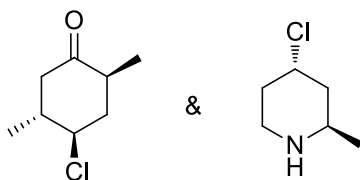


- 16) Identify aromatic, anti-aromatic and non-aromatic compounds.



- 17) Acetamide is neutral but phthalimide is acidic. Explain.

- 18) Assign total number of stereo-isomers of the following.



- 19) Discuss in brief stereoselective reactions.

- 20) Why indene and fluorine are acidic?

- 21) What is concept of anti-aromaticity?

- 22) Cyclohexanone does not exist in planar form. Give reason.

- 23) What is concept of NGP?

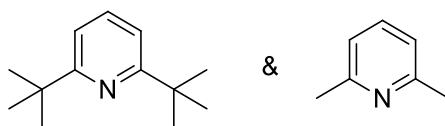
- 24) Discuss the structure and stability of carbene.

- 25) Chlorobenzene resists hydrolysis whereas benzyl chloride undergoes hydrolysis. Explain.

- 26) Comment on the optical activity of biphenyls.

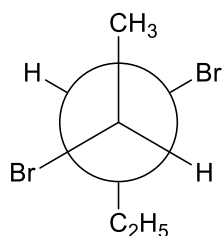
- 27) 3-hydroxy-2-butanone on reduction with sodium borohydride gives meso compound. Explain.

- 28) Comment on the basicity of the following.

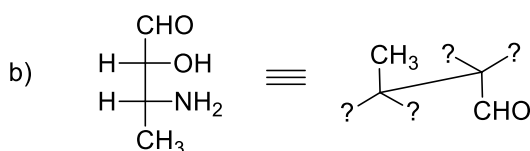
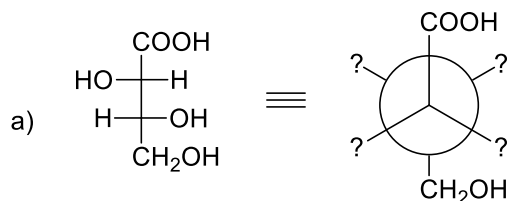


- 29) Describe the stereochemistry of the product formed by the reaction of maleic acid with osmium tetroxide.

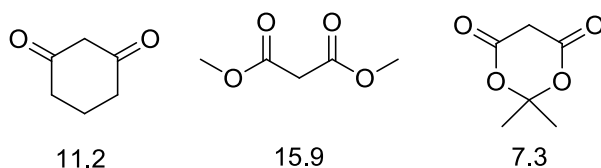
- 30) Make the conversion from Newmann projection into Fischer projection and assign the configuration at each chiral centres.



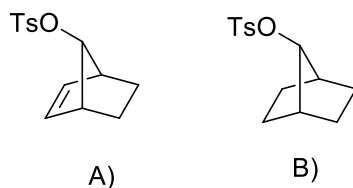
- 31) Convert Fischer projection to Newmann/ Sawhorse projection as shown below.



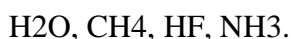
- 32) Explain the pKa values.



- 33) Explain SN1 reaction with suitable examples.
 34) Comment on stability of 3,2 and 1 carbocation.
 35) Explain with suitable examples Si and Re face.
 36) Acetolysis of compound A is 10 times faster than compound B. Why?



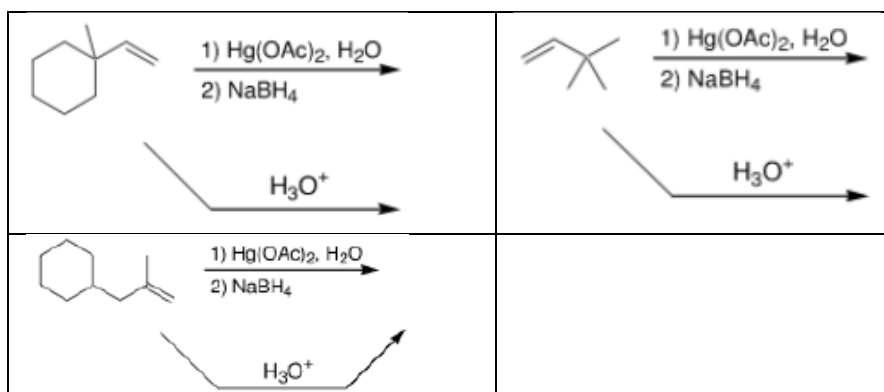
- 37) Explain advantages of Friedel-Craft acylation over F.C. alkylation with a suitable example.
 38) Give a brief account of ortho effect in aromatic nucleophilic substitution reaction.
 39) Nitration of N,N-dimethylaniline gives mainly m-nitro derivative when conc-HNO₃ + conc-H₂SO₄ is used but mainly gives o and p-nitro derivatives in less acidic conditions.
 40) Explain the terms enantiomers and distereomers with suitable examples.
 41) What are characteristics of Hard acids?
 42) Write a short note on nucleophilicity and basicity.
 43) Arrange the following in decreasing order of acid strength and justify.



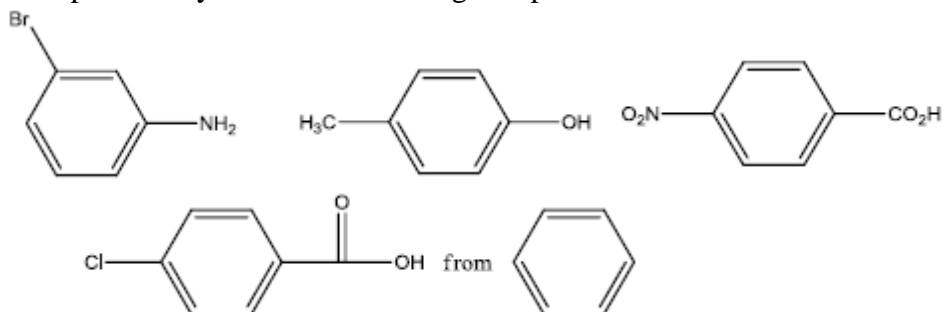
- 44) Explain the effect of leaving group on SN2 reaction suitable examples.
 45) Acetolysis of both 4-methoxy-1-pentyl brosylate and 5-methoxy-2-pentyl brosylate give the same product. Explain.
 46) Elimination of HBr from meso-1,2-dibromo-1,2-diphenyl ethane gives cis-2-

bromostilbene. Explain.

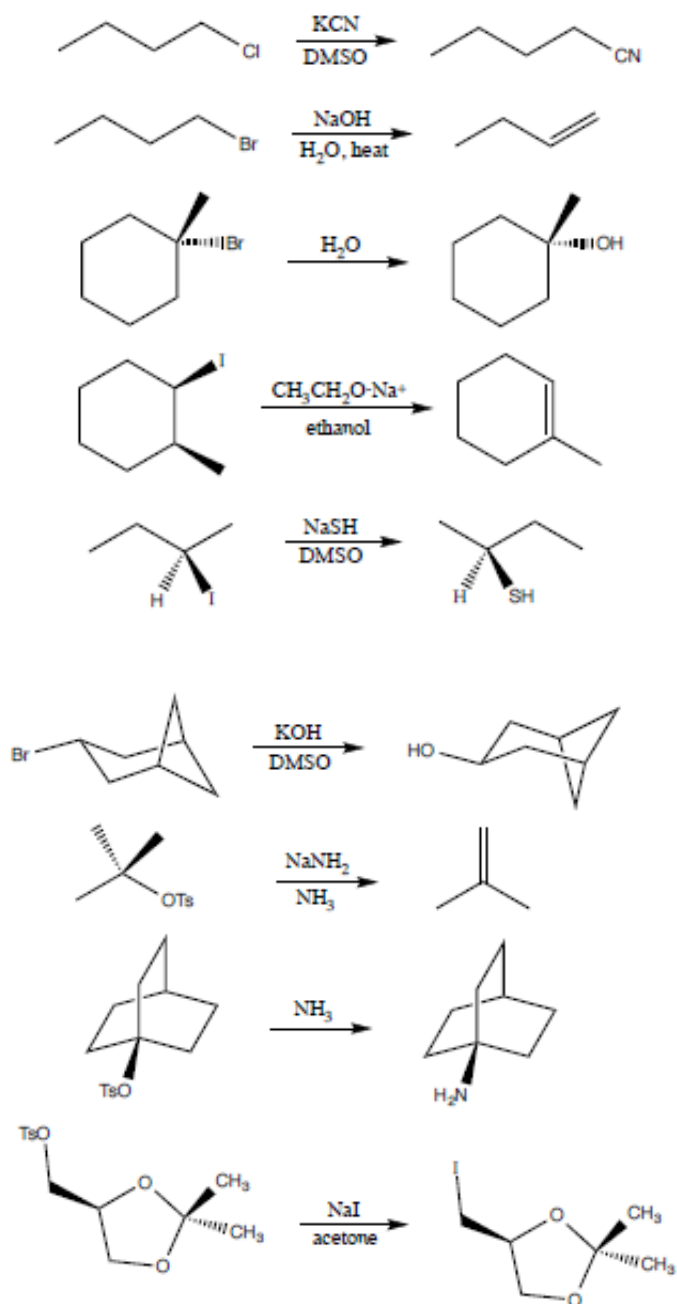
- 47) What is Hoffman elimination reaction? Explain with suitable example.
- 48) Nucleophilic substitution reactions at bridge-head carbons are almost impossible. Explain.
- 49) Addition of HBr to propene in the presence of hydrogen peroxide gives 1-bromopropane. Explain.
- 50) Draw all possible conformational isomers of 1-chloro-3-methyl cyclohexane.
- 51) Differentiate between protic and aprotic solvents.
- 52) Cyclo-octatetraene is not aromatic. Explain.
- 53) Explain IPSO substitution with suitable example. Explain the terms Aromatic, Anti aromatic and Non Aromatic compound, with suitable Example?
- 54) Tropone shows high Dipole moment, Explain ?
- 55) Justify the term homoaromaticity and quaziaromaticity with examples?
- 56) Cyclopentadiene is acidic, Explain?
- 57) Explain the term Prochirality with examples?
- 58) Explain the term Atropisomerism with examples?
- 59) Explain Hard and Soft acid concept with examples?
- 60) Mercury is toxic and used only when necessary for synthesis. In class we learned that the oxymercuration/demercuration scheme could be used to give products of alkene hydration without rearrangements. For each of the following reactions, give the product of each and indicate you would obtain by simple hydration in aqueous acid.



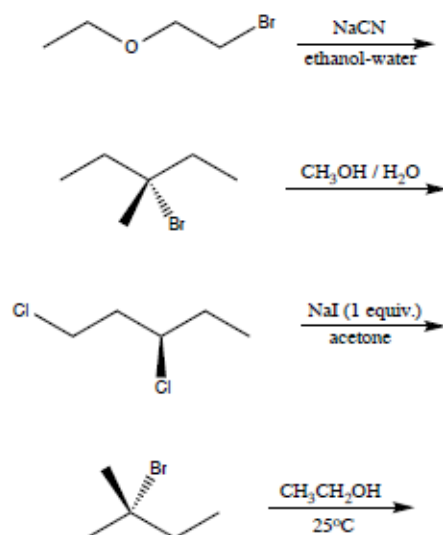
- 61) Propose the synthesis of following compound from benzene



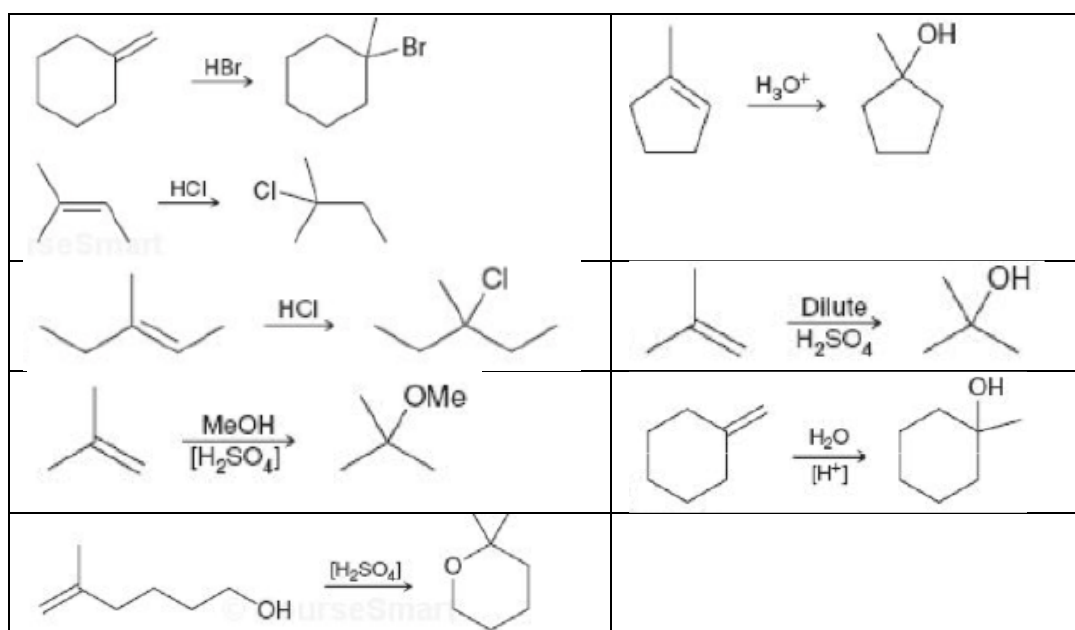
- 62) Describe the following chemical reactions as S_N1 , S_N2 , E_1 , E_2 . Draw a curved arrow mechanism for each reaction.



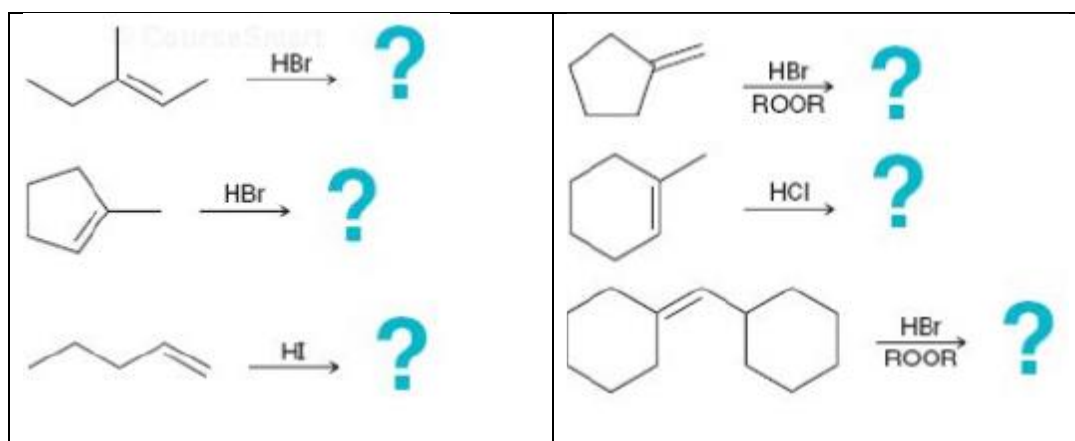
- 63) For each of the chemical substitution reaction below identify the major products and whether the reaction is likely an $\text{S}_{\text{N}}1$ or $\text{S}_{\text{N}}2$.



64) Propose the mechanism of the following:

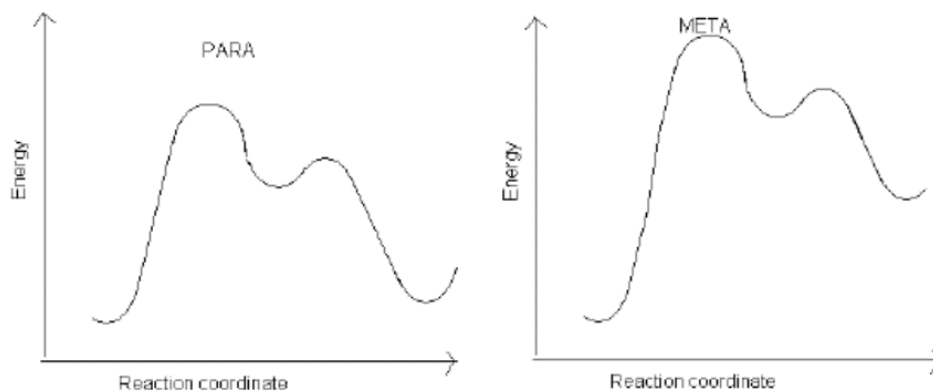


65) Complete the following examples of hydroboration/oxidation. Indicate proper stereochemistry.

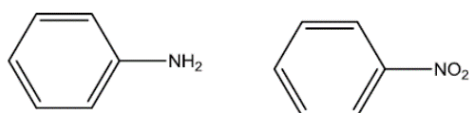


 	? ? ?
? ? ?	? ? ?
? ? ?	

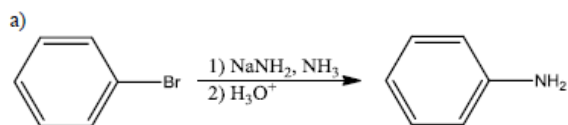
66. Below are two reaction energy coordinates for a para and meta chlorination of an aromatic structure.



67. Which one of the following two materials could be responsible? Explain why?



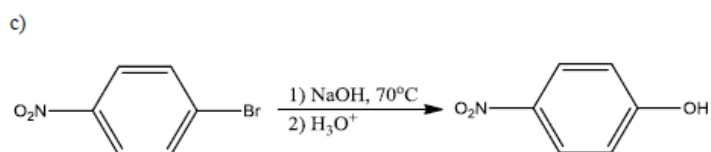
68. Under each reaction, circle the correct operating mechanism:



EAS, S_NAr , or Elimination-Addition

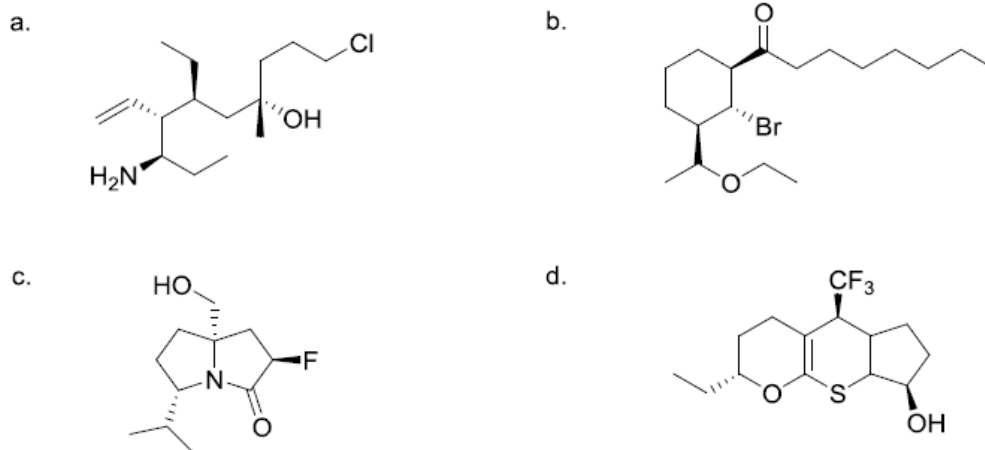


EAS, S_NAr , or Elimination-Addition

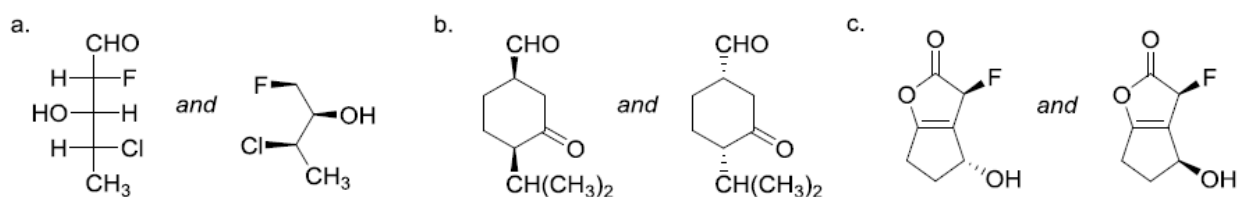


EAS, S_NAr , or Elimination-Addition

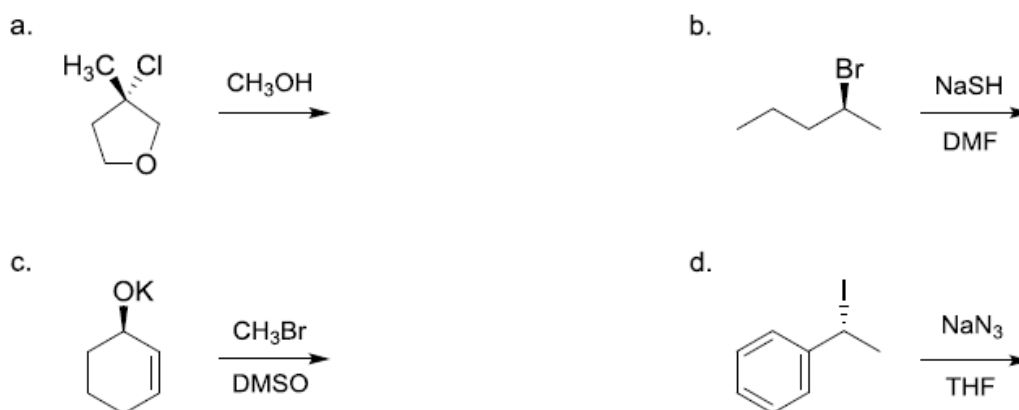
69. Identify any chiral carbons in the following molecules and using the Cahn- Ingold- Prelog rules, label their configuration as either *R* or *S*.



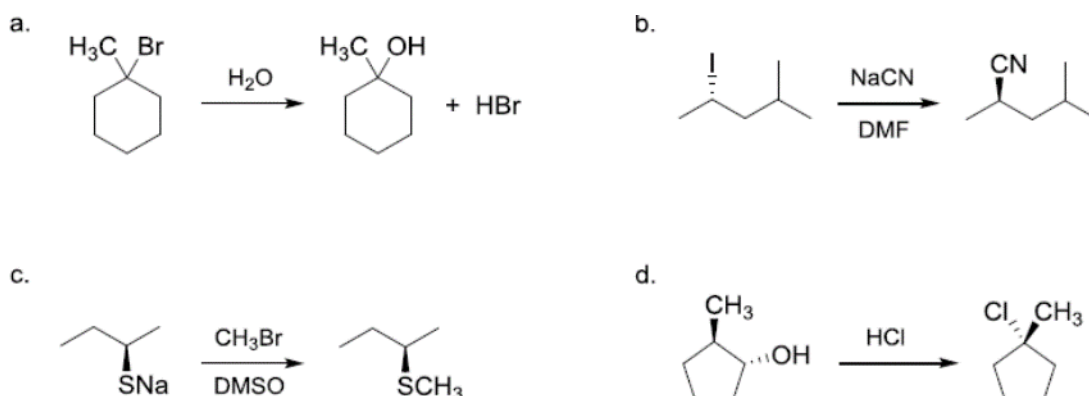
70. Within each of the following pairs of molecules, identify the relationship between them as being either enantiomers, diastereomers or identical.



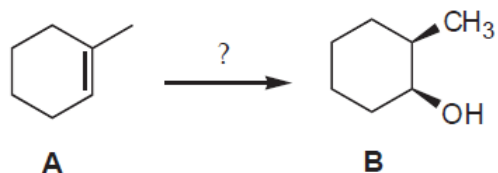
71. Provide the products expected to be formed under each of the following sets of conditions.



72. Draw detailed mechanism for the following reactions that use “curved arrows” to show the breaking and forming of bonds and identify the mechanism that is operating.

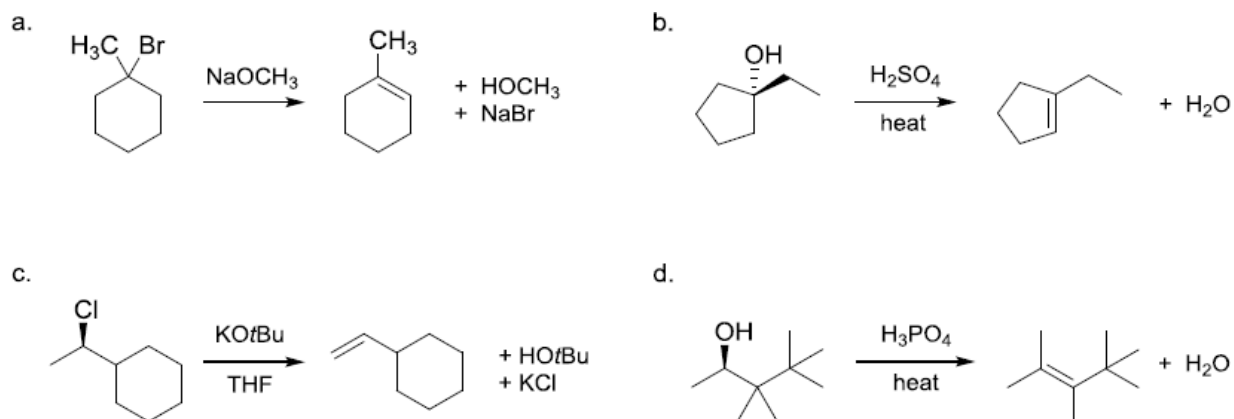


73. Can you make B from A by hydroboration-oxidation?

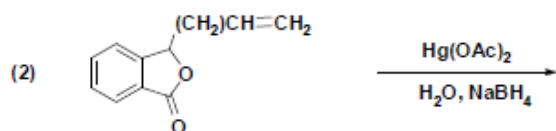
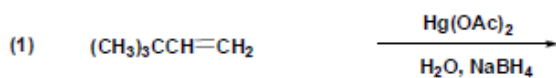


Notice that the methyl and the alcohol group are *cis* to each other.

74. Draw the detailed mechanism for the following reactions that use “curved arrows” to show the breaking and forming of bonds and identify the mechanism that is operating.



75. Show the addition reaction of following.



Question Bank

CHA-4104

Section I

Que.1) Objective questions

1. CSSO Stands for.....
2. MSDS Stands for.....
3. ICSC Stands for.....
4. TLV Stands for.....
5. ACGIH Stands for.....
6. TWA Stands for.....
7. LCSS Stands for.....
8. OEL Stands for.....
9. HSE Stands for.....
10. COSHH Stands for.....
11. ILO Stands for.....
12. UEL Stands for.....
13.may be the part of building safety equipments.
14.Extinguisher are effective against the burning paper and trash.
15.have adverse effect on the structure or function of central or peripheral nervous system.
16.are the substances that cause the chromosomal damage.
17. Radiofrequency and microwave frequency is used in

Q.2) Answer in one sentence.

1. Explain the flammable, Explosive and Reactive Chemicals.
2. Define Biohazard.
3. What is the use of CO₂ Fire extinguishers.
4. For which purpose Met-L-X Fire extinguishers is used.
5. Write down the use of Respirators.
6. Write the use of safety shields.
7. Enlist the routes of exposure for toxic chemicals.
8. Enlist the different types of fire extinguishers.
9. Define acute toxicants.
10. What is mean by irritants.
11. Enlist the corrosive substances.
12. Define asphyxiants.
13. Enlist the different types of neurotoxins..

14. Define carcinogens.
15. Explain the flammability characteristics.
16. Write down the example of oxygen oxidants.
17. Enlist the ignition sources.
18. Define the Exothermic reaction.
19. Define Green chemistry.
20. Explain the steps for receiving the chemicals in the laboratory.

Q.3) Short Note on

1. Write a note on safety shower and eye wash unit.
2. Write a note on effect of neurotoxins.
3. Write a note on effect of Reproductive and developmental toxins.

Q.4) Long answer questions

1. Write down the ten steps to established safety and security in management system.
2. Explain the different types of fire extinguishers.
3. Explain the different routes of exposure for toxic chemicals.
4. Explain the irritants, corrosive, allergens and sensitizers.
5. Explain in detail reactive hazards and explosive hazards.
6. Explain the different types of physical hazards.
7. Write a note on principal of green chemistry.
8. Explain the guideline for storage of chemicals.
9. Discuss the need of safety and security in laboratory.

Section II

Q.1) Objective Questions

1. GLP stands for.....
2. GMP stands for.....
3. TDR stands for.....
4. OECD stands for.....
5. SOP stands for.....
6. COC stands for.....
7. ----- Gloves are suitable for incidental contact with chemicals.
8. Liquids that have flash point ----- that has the potential to cause the fire.

Q.2) Answer in one sentence

1. Define Waste and who is responsible for waste.
2. Enlist the properties of Hazardous waste.
3. Draw the symbol for i) Explosive ii) oxidizer iii) Flammable iv) Corrosivity v) Reactivity vi) Irritant
4. Define Flash Point.
5. Enlist the fundamental principles of working with chemicals.
6. Explain in detail careful planning for working with chemicals.
7. Explain different types of safety gloves.
8. Why the labeling of waste container is necessary?
9. What is Corrosivity?
10. Discuss the general procedure for working with electrical equipment.

Q.3) Short Note

1. Write a note on working with biohazardous material.
2. Write a note on Cryogenic liquids.
3. Write a note on GLP.
4. Explain in short GMP.
5. Write a note on Incineration.
6. Write a note on Spill containment.
7. Write a note on Handling of flammable gases.
8. Write a note on reduction of exposure of chemicals.
9. Spill clean up
10. Reduction of multihazardous waste
11. Disposal of non hazardous waste
12. Write a note on specific chemical hazards of selected gases.
13. Write a note on transfer, transport and shipments of chemicals.

Q. 4) Short answer questions.

1. Explain the guidelines for containers and equipment use to store the chemical.
2. Explain the guidelines for storage of cold chemical.
3. Explain the guidelines for flammable and combustible liquids.
4. Give the precautions for storing the carcinogen, reproductive , toxins and chemicals.

Q.5) Long answer Questions.

1. Explain different steps for managing waste.
2. Write a note on Disposal options.
3. Write a note on general procedures for working with hazardous chemicals.

4. Explain in detail Working with substances of high toxicity.
5. Discuss the working with flammable chemicals.
6. Discuss the working with highly reactive and toxic chemicals.
7. Explain the working with Electrically powered equipment.
8. Explain in detail the working with compressed gases.
9. Explain the working with high and low pressure and temperature.
10. What are the different types personal protective equipments.
11. Discuss the drug development process.
12. Explain in detail GLP and its applications.
13. Give the fundamental points of GLP.
14. Write a note on Rules for conduct of studies.
15. Explain the standard operating procedure.
16. Explain in detail the overview of SOP system.
17. Discuss in detail the protocol amendments.
18. Write a note on Approval of protocol.
19. Explain the general guidelines for storing highly reactive substances.