SECTION A (40 MARKS)

*Answer **ALL** questions*

Question 1

a) **For each question, there are four alternatives A, B, C and D. Choose the correct alternative and circle it. DO NOT circle more than ONE alternative. If there are more than ONE circled alternatives, NO score shall be awarded.** **[25]**

i. The expression for concentration unit, normality is given as,

$$\text{Normality} = \frac{\text{Mass of solute in grams}}{\text{X} \times \text{ Volume of solution in litres}}.$$

'X' in the expression represents

A equivalent weight of solute.
B equivalent weight of solvent.
C number of gram-equivalent of solute.
D number of gram-equivalent of solvent.

ii. The carbonyl compounds P, Q, R and S are tested using different reagents. The observations are recorded as follows.

Reagent	P	Q	R	S
Fehling's solution	Red ppt.	Red ppt.	No reaction	No reaction
Tollen's reagent	Silver mirror	Silver mirror	Silver mirror	No reaction

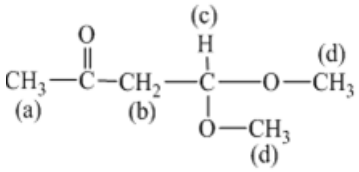
Identify the compound 'R'.

A acetone
B acetaldehyde
C formaldehyde
D benzaldehyde

iii. Carboxylic acids are widely used in laundries. One of the acids used to remove ink stains from clothes is

A acetic acid.
B oxalic acid.
C formic acid.
D benzoic acid.

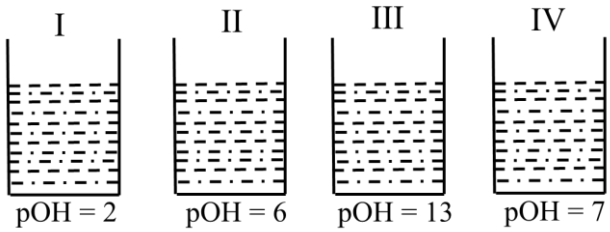
iv. An organic compound as shown below is analysed using HNMR spectroscopy.



Which set of hydrogen in the molecule would give triplet signal in the spectrum?

A hydrogen (a)
B hydrogen (b)
C hydrogen (c)
D hydrogen (d)

v. The given figure shows four juices of different fruits, each of which has the labelling of its pOH value.



Which fruit juice would you recommend to someone who is suffering from acute stomach acidity?

A juice I
B juice II
C juice III
D juice IV

vi. Tetraammineaquaiodocobalt (III) sulphate is a coloured coordination complex. The formula of the compound is

A $[Co(NH_3)_4(H_2O)I]SO_4$.
B $[Co(NH_3)_4(H_2O)I](SO_4)_2$.
C $[Co(NH_3)_4(H_2O)I]_2(SO_4)_3$.
D $[Co(NH_3)_4(H_2O)I]_2(SO_4)_5$.

vii. The standard reduction potentials of certain metals are given in the table below.

Metal	E^0 (V)
K	–1.240
L	– 0.340
M	–0.024
N	–0.244

The appropriate container to store an aqueous solution of $NiCl_2$, given that

$E^0_{Ni^{2+}/Ni} = -0.240V$ is

A K.
B L.
C M.
D N.

viii. The given figure shows a plot of rates of reaction of dil. HCl with different physical forms of zinc metal.

Which plots in the graph represent reactions of zinc powder and a solid zinc piece with dilute HCl respectively?

A plot R and Q
B plot R and P
C plot Q and P
D plot P and R

ix. An organic compound with the formula R- NH_2 acts as

A a base by donating a proton.
B an acid by donating a proton.
C a base by donating pair of electrons.
D an acid by donating pair of electrons.

x. $_{83}Bi^{209}$ (Group 15) decays to form a new element 'Z' by emitting one alpha particle and one beta particle from its nucleus. The element 'Z' belongs to group

A 13.
B 14.
C 15.
D 16.

xi. Organic compounds possessing fragrant smell are used in the preparation of perfumes. Such compounds belong to the family of

A acyl halides.
B alkyl alkanoates.
C aliphatic amines.
D carboxylic acids.

xii. The N_2O molecule on heating decomposes as follows:

$$2N_2O(g) \xrightarrow{Pt} 2N_2(g) + O_2(g)$$

If the rate of this reaction is 'R', then the rate of disappearance of N_2O will be

A $\frac{R}{2}$.

B $\frac{2}{R}$.

C R.

D 2R.

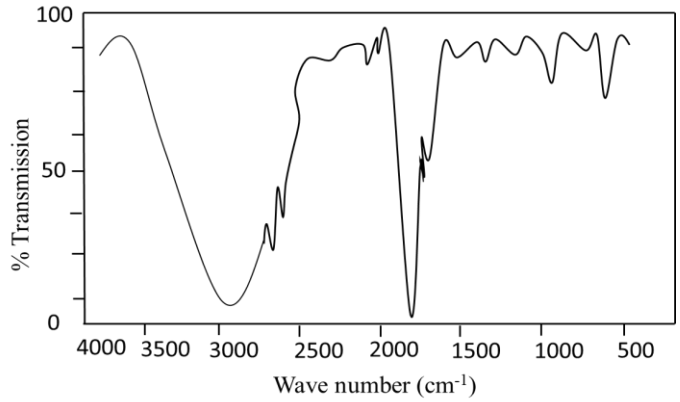
xiii. Glycine is an optically inactive molecule. Which one of the following properties explains its optical inactivity?

A lacks chiral centre
B possesses chiral centre
C is an asymmetric molecule
D forms non-super imposable mirror images

xiv. A student treated toluene with CrO_2Cl_2 in presence of CCl_4. The content was further hydrolysed in water. The final product that the student would obtain from the reaction is

A benzoic acid.
B benzaldehyde.
C benzyl alcohol.
D sodium benzoate.

xv. The figure below shows the IR spectrum of certain groups of organic compounds present in a plant extract. Which group of organic compounds is present in the plant extract?



A alcohol
B ketone
C aldehyde
D carboxylic acid

xvi. Two compounds, HCN and CH_3COOH have ionization constant (K) values of 7×10^{-10} and 1.8×10^{-5} respectively. If equal moles of the compounds are used in preparing equal volume of their aqueous solution at a certain temperature, then

A both will remain unionised.
B both will ionize to the same extent.
C HCN will ionize to a greater extent than CH_3COOH.
D CH_3COOH will ionize to a greater extent than HCN.

xvii. Karma prepares an acidic buffer solution to be used in the laboratory for research works. Which one of the following pairs of chemical substances is most appropriate for the buffer?

A HCl + NaCl
B NH_3 + NH_4Cl
C HCOOH + Na_2CO_3
D H_3PO_4 + NaH_2PO_4

xviii. The pH of human skin lies between 5 and 6. Research on different brands of bathing soap available in the market was carried out and the data collected are given in the table.

Brand	pH
P	3.8
Q	10.2
R	5.7
S	12.0

Which brand would be suitable for our skin?

A P
B Q
C R
D S

xix. One of the important components of a galvanic cell is the salt bridge. Which of the following best describes its function in the galvanic cell?

A Generates electrons that flow in the circuit.
B Facilitates interactions between the solutions of half cells.
C Maintains constant electrical charge of the solutions in the half cells.
D Maintains the constant concentrations of the solutions in the half cells.

xx. The charge on a complex ion of the complex $[Cr(NH_3)_5\ Cl_2]\ Cl$ is

A +3.
B –3.
C +1.
D –1.

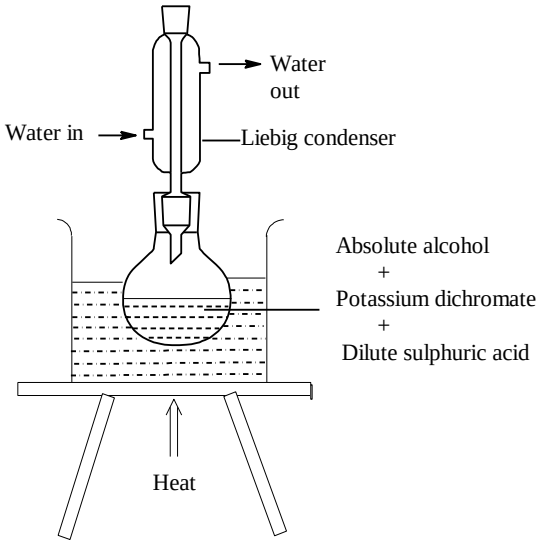
xxi. A team of students formulated four types of coolant for a car as per the information given in the table.

Solution	Solvent	Non-volatile and Non-electrolyte Solute	Molecular Mass of Solute	Mass of Solute Taken (g)
I	Water	A	60	92
II	Water	B	342	92
III	Water	C	180	92
IV	Water	D	46	92

Which solution is the most effective coolant?

A solution I
B solution II
C solution III
D solution IV

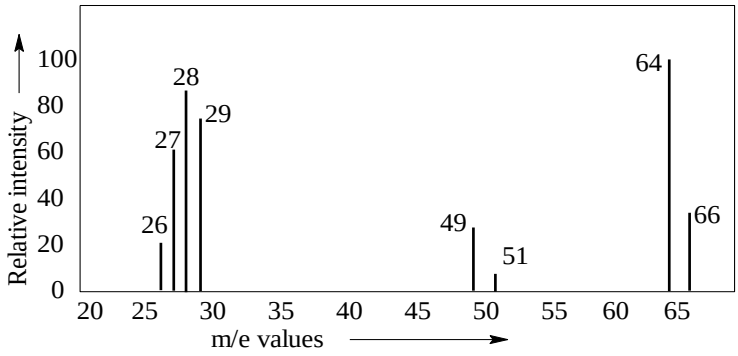
xxii. An experimental set-up for the preparation of ethanoic acid is shown in figure below.



The mixture of dilute sulphuric acid and potassium dichromate act as

A a reducing agent.
B an oxidising agent.
C a dehydrating agent.
D a hydrolysing agent.

xxiii. The following mass spectrum is obtained on analysis of an unknown organic compound.



The unknown organic compound is

A ethyl iodide.
B ethyl fluoride.
C ethyl chloride.
D ethyl bromide.

xxiv. $_{11}Na^{24}$ is a radioisotope of sodium. Which of the following particle is likely to be emitted by it in order to become a stable isotope?

A alpha particle
B beta particle
C positron particle
D neutron particle

xxv. The rate of reaction for a certain reaction is found to be equal to its rate constant, when 1.0 $molL^{-1}$ of reactant 'A' was taken. Which of the following graph(s) can appropriately represent this reaction?

A (I) only
B (II) only
C (III) only
D (I) and (III)

b) Match each item of Column A with the most appropriate item of Column B. Rewrite the correct pairs by writing the alphabet against the number in the spaces provided. **[5]**

Column A		Column B	
i.	Dissolution of sugar in water	a.	daughter ions
ii.	Dissociation of weak electrolyte in water	b.	effective collision
iii.	Generation of electric current in a galvanic cell	c.	buffer action
iv.	Attainment of threshold energy by reactant	d.	vapour pressure lowering
v.	Addition of excess of NH_3 to $CuSO_4$ solution	e.	disintegration
vi.	IR irradiation of organic molecule	f.	molecular vibration
vii.	Linking of same ligand with metal through two sites	g.	ionic equilibrium
viii.	Irradiation of NH_3 molecule with energetic electrons	h.	chelation
ix.	Conversion of $^{226}_{88}Ba$ to $^{218}_{84}Po$	i.	precipitation
x.	Addition of HCl to CH_3COONH_4 solution	j.	redox reaction
		k.	addition reaction
		l.	complex reaction

Column A	Column B	
i.		
ii.		
iii.		
iv.		
v.		
vi.		
vii.		
viii.		
ix.		
x.		

c) Fill in the blanks by writing suitable word/words. **[5]**

xxvi.	Alcohols are formed when aldehydes are reduced in presence of a suitable reagent_____ with catalyst_____.	
xxvii.	In the IR spectrum of an organic compound, the region with _____wave length is called fingerprint region and that with_____ wave length is called functional group region.	
xxviii.	The basic strength of primary amine is_____ than that of secondary amine due to greater _____ effect in secondary amine.	
xxix.	The IUPAC name of NH_2-CH_2-CH_2- COOH is _____and that of NH_2CH_2COOH is _____.	
xxx.	For the reaction with rate law, rate = k[A]½[B], the order is _____.	
xxxi.	0.5 m glucose ($C_6H_{12}O_6$) solution contains _____ g of solute per kg of solvent.	

d) State true/false for the following statements in the boxes provided. [5]

i.	The IUPAC name of CH_3CH_2COOH is ethanoic acid.		
ii.	Propanamide on heating with bromine and potassium hydroxide solution yields ethanamine.		
iii.	The solvent flows from hypertonic solution to hypotonic solution during osmosis.		
iv.	Electrode potential is developed when zinc electrode is dipped in a solution of sulphate ions.		
v.	All carboxylic acids are soluble in water but not in ether.		
vi.	Acetamide should be kept in a tightly closed container as it is deliquescent in nature.		
vii.	Biodiesel can be prepared from both vegetable oil and animal fat.		
viii.	Acetyl chloride has a higher boiling point compared to acetic acid due to absence of intermolecular hydrogen bonding.		
ix.	Fluorine ($E^0_{F_2/2F^-}$ =2.87V) is a weaker reducing agent than Chlorine ($E^0_{Cl_2/2Cl^-}$ =1.36V) .		
x.	MRI- a medical diagnostic technique is based on the same principle as that of a HNMR spectroscopy.		

SECTION B (60 MARKS)

*Attempt **ANY SIX** questions*

Question 2

a) Mention **TWO** common physical properties in the following carbonyl compounds. **[1]**

Acetone, formaldehyde and acetaldehyde

b) Various radioisotopes of elements are used for different purposes. What are your views on the use of such radioisotopes? **[2]**

c) For the study of kinetics of a reaction, $2A + B \rightarrow$ product, the following data was recorded.

Sl.no	**[A] mol L^{-1}**	**[B] molL^{-1}**	**Initial Rate (mol$L^{-1}min^{-1}$)**
1	0.28	0.28	9.4×10^{-4}
2	0.56	0.28	37.6×10^{-4}
3	0.28	0.56	9.4×10^{-4}

i. Determine the overall order of the reaction. **[1½]**

ii. Derive the unit for rate constant of this reaction. **[1]**

iii. Plot a graph to represent variation of rate of reaction with respect to [B]. **[½]**

d) The table below shows three recipes for preparing sugar candies.

Recipe	**Ratio of sugar to water (mass/mass)**	**Nature of sugar crystals**	**Boiling point of solution**	**Colour of candy**	**Texture of candy**
A	2:1	Granules	102.3°C	Pale yellow	hard
B	4:1	Granules	104.8°C	Dark brown	hard
C	2:1	Powder	102.3°C	Pale yellow	Creamy and smooth

i. What is the effect of size of sugar crystals on the boiling point of sugar solution? **[½]**

ii. What is the other purpose of adding sugar besides the sweetness? **[½]**

iii. Which colligative property is used here? Give **ONE** application of this colligative property in daily life. **[1]**

e) The table below shows a list of complex ions and their corresponding colours.

	Complex ions	**Colour**
A	$[Ti(H_2O)_6]^{3+}$	violet
B	$[Co(H_2O)_6]^{2+}$	red
C	$[Ni(H_2O)_6]^{2+}$	blue green
D	$[Ni(NH_3)_6]^{2+}$	blue

What conclusion can you draw from the information given in the table? **[2]**

Question 3

a) Name the chemical reaction that takes place during fuming of acetyl chloride in moist air. **[1]**

b) A galvanic cell is represented as follows.
$Fe(s)/Fe^{2+}(aq)$ // $H^{+}(aq)/ H_2(g)$

i. Write the cell reaction. **[½]**

ii. Write the Nernst equation for the determination of emf of the cell. **[½]**

iii. Couple each of the electrodes given in the table below with iron electrode ($E^{0}_{Fe^{2+}/Fe}$ = -0.44V) and calculate their emf at standard conditions. Which electrode coupled with iron generates the most appropriate cell emf to run the wall clock in your classroom? **[2]**

Electrode	**E⁰ (V)**
K	0.1
L	1.1
M	-3.5

[2]

c) Why is consuming liquid vegetable oil preferred over solid fat? Support your answer with **TWO** reasons.

d) Distinguish between the following pairs of organic compounds using the most appropriate analytical technique.

i. **[1]**

CH_3COCH_3	$C(CH_3)OH$

ii. **[1]**

CH_3COCH_3	CH_3COOCH_3

[2]

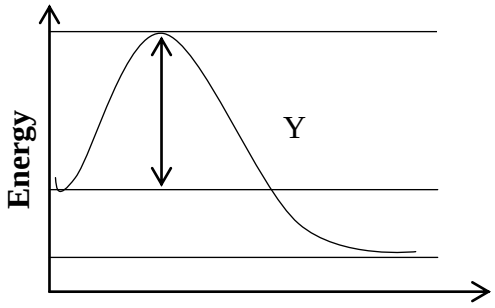
e) The table below shows a list of chemical species.

Sl. No.	**Chemical Species**
1	NH_3
2	HS^-
3	H_2O

Write at least **TWO** acid- base reactions by combining any two species and identify conjugate acid – base pairs in each case.

Question 4

a) The figure below shows the reaction pathway of a particular reaction.



Progress of the reaction

i. What does 'Y' in the figure indicate? **[½]**

ii. Write the definition of 'Y' in relation to a chemical reaction. **[½]**

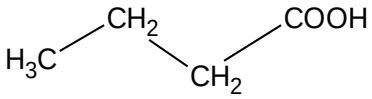
b) Answer the following questions based on the given coordination compound.
$K[Co(CN)_3(CO)_2(H_2O)]$

i. Identify the neutral ligand(s). **[1]**

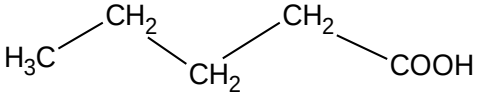
ii. Calculate the oxidation number of central metal. **[1]**

iii. Name the metals which are part of coordination compounds found naturally in plants and animals. **[1]**

c) The structures for two carboxylic acids are given below.



Acid I



Acid II

i. Which carboxylic acid has a higher melting point? Explain your answer. **[2]**

ii. Write a chemical equation for the reaction of Acid I with ethanol in the presence of concentrated sulphuric acid. **[1]**

d) The table represents an example of data collection for a type of colligative property.

Trial	**Mass of solvent (g)**	**Mass of unknown solute (g)**	**Vapour pressure of pure solvent at 25°C (atm)**	**Vapour pressure of solution (atm)**
I	9.01	0.41	0.198	0.190
II	9.00	0.40	0.198	0.191
III	9.02	0.41	0.198	0.190

Calculate the molecular mass of the unknown solute using the average values of trials I, II and III. **[3]**

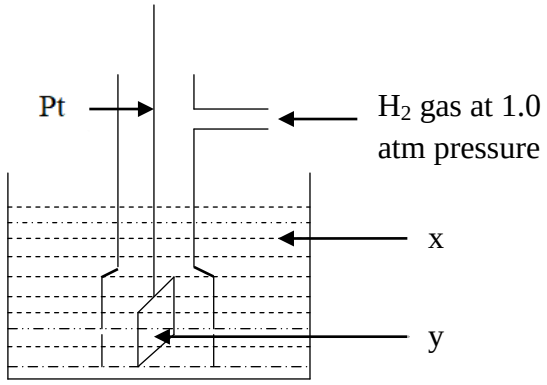
Question 5

a) Students prepared aniline in the laboratory according to the equation as follows:

$$X+6[H] \xrightarrow[\Delta]{Sn/HCl} C_6H_5\text{-}NH_2 + 2H_2O$$ **[1]**

What is compound 'X' in the above reaction?

b) The figure shows the construction of Standard Hydrogen Electrode.



With reference to the figure, answer the following questions.

i. Name the solution 'x' that can produce required ions in the solution. **[½]**

ii. What is the function of part labelled 'y'? **[½]**

iii. Write at least **TWO** disadvantages of using SHE as a reference electrode. **[1]**

c) A chemical compound 'D' can be produced by using two methods as shown below. In both the methods, reactions follow first order kinetics. **[2]**

Method 1	**Method 2**
$2B \rightarrow D$ Rate = 31 x 10^{-2} $molL^{-1}hr^{-1}$ when 5.0 $molL^{-1}$ of B is used.	$C \rightarrow D$ Rate = 15. 4 x 10^{-2} $molL^{-1}hr^{-1}$ when 0.95 $molL^{-1}$of C is used.

Which one of the above methods of reaction is more effective in terms of time in yielding the product 'D'? (Show your detailed working.)

d) **[1]**

i. What causes chemical shift in HNMR spectrum of organic compounds?

ii. Which proton in the ethyl bromide molecule is less shielded? Why? **[1]**

iii. Compare the relative positions of peaks that will be obtained in the HNMR spectrum of ethyl bromide. **[1]**

e) Use any relevant pair of chemicals to prepare a buffer solution which can be used in carrying out certain biochemical reactions. Name the type of buffer solution that you prepared and explain its buffer action. **[2]**

Question 6

a) A mixture of baking soda and vinegar is used in households for cleaning purposes. What do you observe when the two substances are mixed in a test tube? **[1]**

b) Ugyen carried out acid – base titration to investigate the effectiveness of two samples of antacids available in the local market. The data were recorded in the tables below. The volumes and weights used in preparing solutions of each of the samples are same.

Sample 1 – $Mg(OH)_2$		
Sl. No.	**Volume of 0.1M HCl used (mL)**	**Volume of base used (mL)**
1	25	14.5
2	25	14.5
3	25	14.3

Sample 2 – $Al(OH)_3$		
Sl. No.	**Volume of 0.1M HCl used (mL)**	**Volume of base used (mL)**
1	25	10.9
2	25	10.7
3	25	10.9

i. Write the balanced chemical equations for the neutralization reaction between each of the base and the acid. **[1]**

ii. With the help of relevant mathematical calculations, compare the effectiveness of the samples of antacid. **[2]**

c) Some of the metals have the tendency to react with dilute acids and liberate hydrogen gas.

i. In such reactions, are the metals reduced or oxidized? **[½]**

ii. Arrange the following metals in increasing order of their tendency to liberate hydrogen gas from dilute acids. **[1]**

Cr, $E^0_{Cr^{3+}/Cr} = -0.71V$

Pb, $E^0_{Pb^{2+}/Pb} = -0.13V$

Mn, $E^0_{Mn^{2+}/Mn} = -1.05V$

Pt , $E^0_{Pt^{2+}/Pt} = 1.20V$

iii. Write the balanced equation for the reaction between the second most reactive metal with any dilute acid. **[½]**

d) Explain the amphoteric nature of amino acids with the help of equations. **[2]**

e) The leakages in the underground water pipes are located without digging the whole network of pipes by using radioactive radiations. Which radioactive radiation would be the most appropriate for this task and why? **[2]**

Question 7

a) Name the cathode and the anode used in the Daniel cell. **[1]**

b) Complexes of $_{27}Co^{+2}$ are coloured while that of $_{48}Cd^{+2}$ are colourless though both are transition metals. Explain. **[1]**

c) Transesterification reaction can be acid-catalysed as well as base-catalysed. Which one do you prefer? Support your answer with **TWO** reasons. **[2]**

d) The shelf life of fruits can be increased by preserving them in salt or sugar solution.

i. Name the phenomenon that occurs when fruits are placed in a concentrated salt solution. **[½]**

ii. What change is observed in fruits due to this phenomenon? **[½]**

iii. How do you think, these solutions prevent the growth of microorganisms in the food? **[1]**

e)

$$C_2H_5OH \xrightarrow{K_2Cr_2O_7/H_2SO_4} X \xrightarrow{Ag_2O} CH_3COOH \xrightarrow{PCl_5} Y$$

Identify compounds 'X' and 'Y' in the above chain reaction. **[2]**

f) **[1½]**

i. Which one of the following compounds is most reactive towards nucleophile. Give a reason.

$CH_3CH_2COOC_2H_5$, CH_3CH_2COCl, $CH_3CH_2CONH_2$, CH_3CH_2COOH.

ii. Mention **ONE** unique characteristic of the compound chosen in (i). **[½]**

Question 8

a) The energy changes involved during decomposition and the formation of one mole of water molecules are shown below.

$H_2O + 68.4\ kcal \rightarrow H_2 + ½O_2$

$½O_2 + H_2 \rightarrow H_2O + 68.4\ kcal.$

i. Which law of thermodynamics explains these energy changes? **[½]**

ii. State the law. **[½]**

b) **[1]**

i. Under what conditions, the ΔE and ΔH referred to as heat energies exchanged between system and the surrounding?

ii. In which two of the following processes, $\Delta H = \Delta E$? **[1]**

I. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

II. $C(s) + O_2(g) \rightarrow CO_2(g)$

III. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

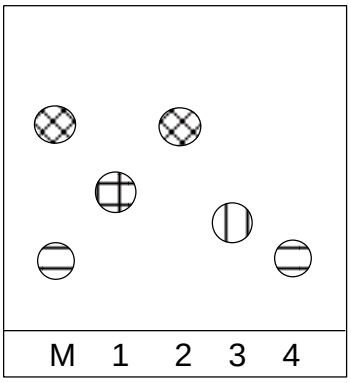
IV. $H_2O(g) + C(s) \rightarrow CO(g) + H_2(g)$

c) Acetone undergoes nucleophilic addition reaction in presence of HCN.

i. Show the reaction mechanism. **[1½]**

ii. Name the product formed. **[½]**

d) A mixture of amino acids (M) was tested against four known amino acids (1 to 4) using thin layer chromatography technique. The following chromatogram was obtained after the analysis.



i. Which amino acids are present in mixture 'M'? **[1]**

ii. What is the drawback of this technique? **[1]**

e) Design an experiment to check the acidic stength of formic acid, oxalic acid and acetic acid. Draw a diagram and write the procedure. **[2]**

f) The molecular structure given below is that of an amino acid.

i. Identify any **ONE** chiral centre in the molecule. **[½]**

ii. Draw its mirror image. **[½]**

Question 9

a) **[2½]**

i. A chemistry student performed an experiment to investigate the enthalpy change of the following reaction at 20ºC in an isolated system.

$CO + ½O_2 \rightarrow CO_2$

Given that; $\Delta S = -0.094 kJ\ mol^{-1}K^{-1}$

$\Delta G = -257.2\ kJ\ mol^{-1}$.

With the help of mathematical calculations, predict whether the temperature of the system will increase or decrease.

ii. Does the entropy change of the reaction favour the reaction to be spontaneous? **[½]**

b) All those reactions with positive values of ΔH and ΔS are non-spontaneous. Justify. **[1]**

c) What is the cause of spin – spin coupling in the molecule in HNMR spectroscopy? **[1]**

d) In high performance liquid chromatography (HPLC), the components of a given sample are separated based on their relative affinities towards stationary phase and mobile phase. Mention the nature of substance used as mobile phase and the stationary phase in HPLC. **[1]**

e) The list of reagents and the reactants are given in the table as follows.

Reagents	**Reactants**
Na and C_2H_5OH Na and alkali Na and base	$CH_3C \equiv N$ $HC \equiv N$ $NaC \equiv N$

i. From the table, pick the most appropriate reactant and the reagent to complete the reaction. **[1]**

.....$+4[H] \longrightarrow C_2H_5NH_2$

ii. Give the IUPAC name of the product. **[1]**

f) What colour change will you observe if a few drops of phenolphthalein are added to the following solutions?

i. HNO_3 solution **[½]**

ii. KOH solution **[½]**

g) The basic strength of amines depends on the number of electron-donating group attached to nitrogen atom. Tertiary amine is less basic than secondary amine though it has three electron-donating alkyl groups attached to nitrogen. Explain. **[1]**
