INCHO 2003

Problem 1 14 marks

Chemical Kinetics

1.1

$$[ES] = \frac{k_1[E][S]}{k_{-1} + k_2}$$

1.2

$$\therefore [ES] = \frac{k_1[E]_0[S]}{k_{-1} + k_2 + k_1[S]}$$

1.3

where $K_m = \frac{k_{-1} + k_2}{k_1}$

K_m has unit of concentration.

1.4

$v = k_2[E]_0\,[S]$ when $[S] << K_m$

(first order in S)

$v = k_2[E]_0$ when $[S] >> K_m$

(zero order in S)

1.5

$E \approx 52 kJmol^{-1}$

.

1.6

ES

exothermic

ES $\longrightarrow$ E + S

E_2

Problem 2 17 marks

Ionic Equilibrium and Electrochemistry

A.

2.1 V = 30 mL

2.2 $pK_a = 6.1$

2.3 pH = 9.4

B.

2.4 $E^0 = 0.76$ V

C.

2.5 $K_{eq} = 6.0 \times 10^{-7}$ M

$E^0_{cell} = -0.367$ V

2.6 $E^0_{cell} = 2\,E^0_{Cu^{2+}/Cu} - 2E^0_{Cu^{+}/Cu}$

Or, $E^0_{Cu^{+}/Cu} = (E^0_{Cu^{2+}/Cu} - \frac{1}{2}\,E^0_{cell})$

$E^0_{Cu^{+}/Cu} = 0.521$ V

2.7 Since E^0_{cell} for the above cell is –0.367 V, E^0 for the cell corresponding to the reverse reaction

$2Cu^{+} \longrightarrow Cu + Cu^{2+}$ is + 0.367 V and is positive.

Hence this reaction is spontaneous and therefore Cu^{+} does not exist in aqueous solution. This can also be predicted from the equilibrium constant of the above reaction (1).

Problem 3 17 marks

Metallurgy and Chemistry of Iron

3.1

As temperature rises FeO will be reduced first.

Minimum Temperature for reduction of FeO = 750 °C

Minimum Temperature for reduction of SiO_2 = 1500 °C

$2FeO + C \rightarrow 2Fe + CO_2$ and $FeO + C \rightarrow Fe + CO$

$SiO_2 + 2C \rightarrow Si + 2\ CO$

3.2

$C + O_2 \rightarrow CO_2$

3.3

$CO_2 + C \rightarrow 2CO$

3.4

$2\ Fe_2O_3 + CO \longrightarrow 2\ Fe_3O_4 + CO_2$

$Fe_3O_4 + CO \longrightarrow 3\ FeO + CO_2$

$FeO + CO \longrightarrow Fe + CO_2$

3.5

$CaCO_3 \rightarrow CaO + CO_2$

3.6

a) $SiO_2 + CaO \rightarrow CaSiO_3$

b) No, Iron oxide being much less acidic than SiO_2 will not react with calcium oxide, which is basic.

3.7 $FeO + SiO_2 \rightarrow FeSiO_3$

3.8 To feed the charge, and to prevent escape of the volatile matter.

3.9

Test tube	**Reagent added**	**Observations**	**Balanced chemical equation/s**
1	NaOH	Reddish brown precipitate	$Fe^{3+}(aq) + 3\ OH^{-}(aq) \rightarrow Fe(OH)_3\ (s) \downarrow$
2	KSCN (under acidic condition)	Blood red colour	$Fe(H_2O)_6^{3+}(aq) + SCN(aq) \rightarrow Fe(H_2O)_5\,(SCN)^{2+}(aq) + H_2O(l)$
3	$K_4[Fe(CN)_6]$	Blue colour precipitate	$3Fe(CN)_6^{4-} + 4Fe^{3+} \rightleftharpoons Fe_4[Fe(CN)_6]_3\ (s)$

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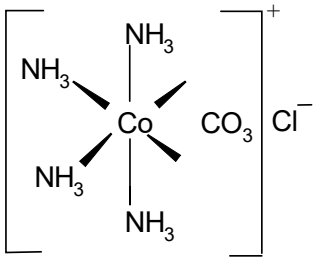
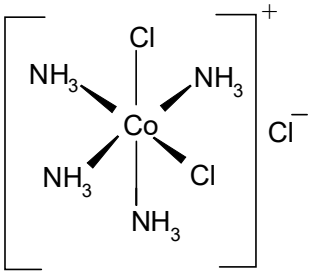
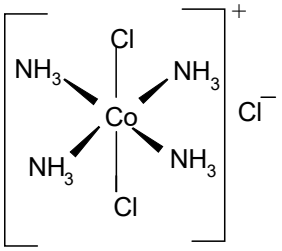
Problem 4 7 marks

Coordination Chemistry

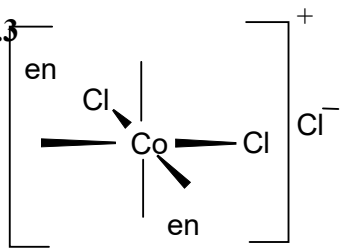
4.1

Compound A	Compound B	Compound C
		
tetraaminecarbonato-cobalt(III) chloride	*cis*-tetraaminedichloro-cobalt(III) chloride	*trans* –tetraamine-dichlorocobalt(III)chloride

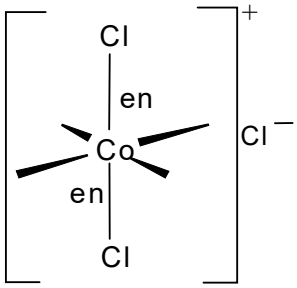
4.2

Geometrical Isomerism (*cis*-*trans*)

4.3



cis-dichlorobis(ethylenediamine)-cobalt(III) chloride



trans-dichlorobis(ethylenediamine)-cobalt(III) chloride

cis isomer will exhibit optical activity

Problem 5 24 marks

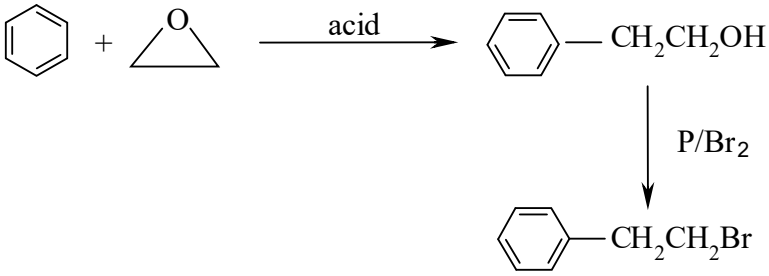
Synthesis of Drug

5.1 (i) True

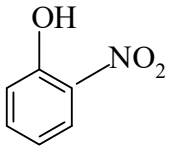
(ii) False

(iii) False

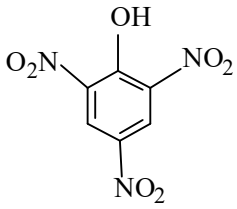
5.2 Suggest a method for the preparation of **(2)** starting from benzene.



5.3

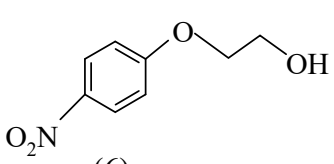


Steam Distillation



\+ Lots of oxidised products

5.4



(6)

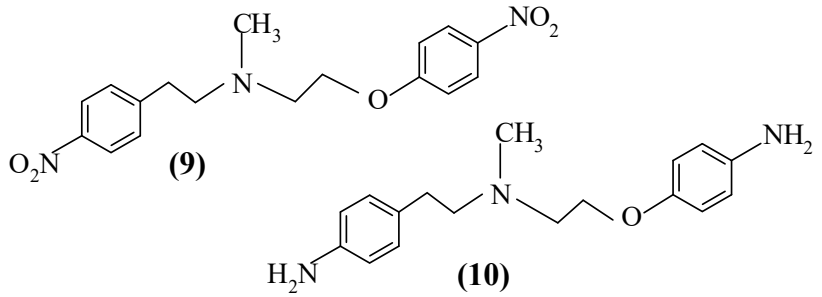
Any base like Pyridine, Na_2CO_3, etc — Reagent A

$SOCl_2$ — Reagent B

5.5

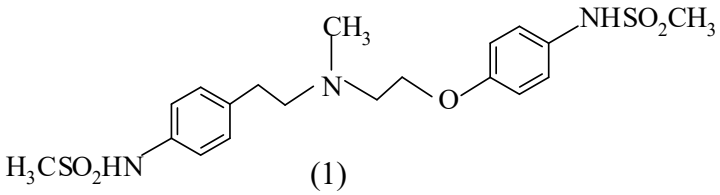
To avoid formation of the tertiary amine.

5.6



(9)

(10)

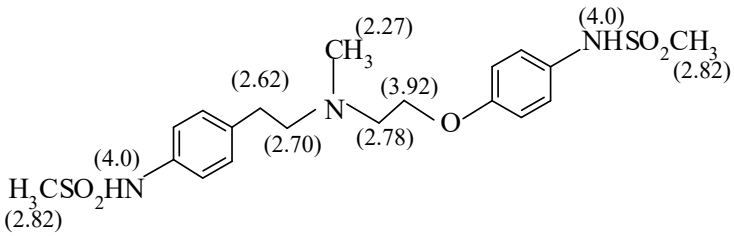


(1)

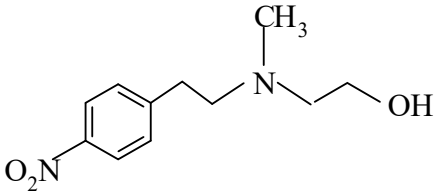
5.7

1) Oxidation of CHO by HNO_3.
2) Reduction of NO_2 on the aromatic ring.
3) *o*-isomer may be formed.

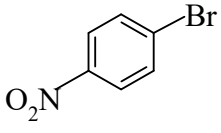
5.8



5.9



(11)



D

Difficult aromatic nucleophilic reaction.

Problem 6 — 11 marks

Structure Elucidation

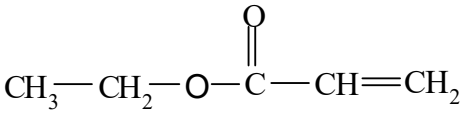
6.1 a)

Two double bond equivalents

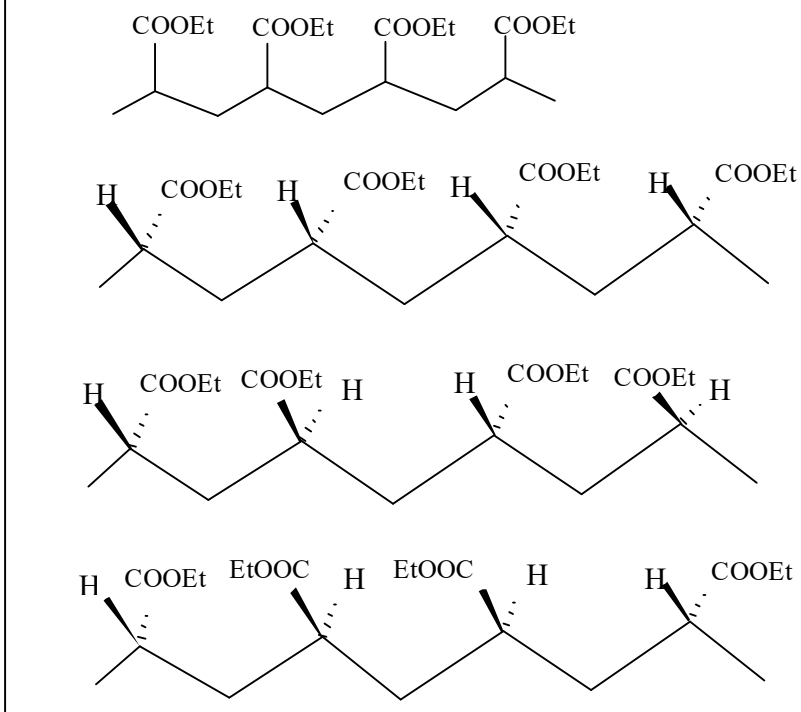
b)

Ester carbonyl group

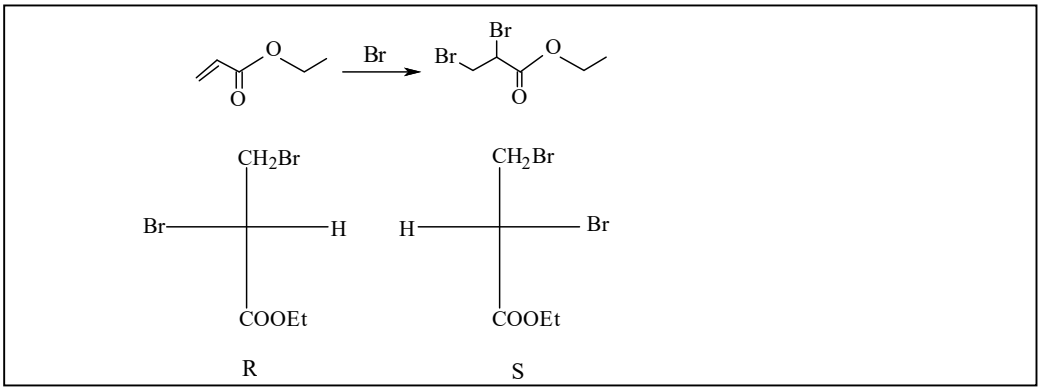
c)



6.2



6.3

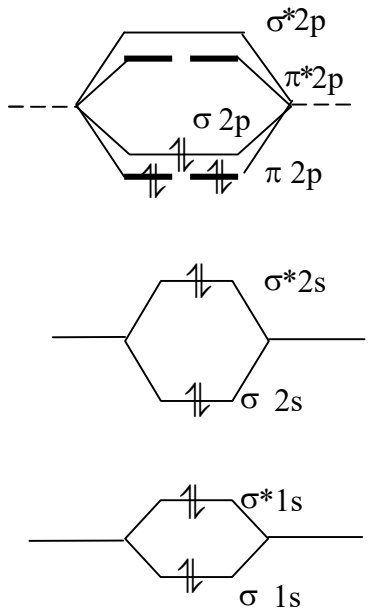


Problem 7 12 marks

Molecular Spectroscopy

A.

7.1



39.6	σ, σ^* (1s)
3.8	σ (2s)
1.8	σ^* (2s)
1.6	π (2p)
1.5	σ (2p)

N_2 : Bond order = ½ (10 – 4) = 3.

N_2^+ : 2.5 ; N_2^- : = 2.5

7.2

$\therefore Z_{eff} = 0.78$

B.

7.3

$l = 3$ m

Problem 8 18 marks

Nucleic Acids

A.

8.1

The nucleic acids in **I, II** and **III** are DNA, since they all contain thymine, instead of uracil.

The direction of each strands is: $5^{/} \rightarrow 3^{/}$.

8.2

a) UV 

b)

A	→	**II**
B	→	**I**
C	→	**III**

No. of hydrogen bonds in **III > I > II.** Higher the no of hydrogen bonds more is the stability.

For these reasons, the least stable nucleic acid **II** unstacks first, followed by **I**, and **III**.

c) Complete unstacking of double helical structure.

All the above nucleic acids have same length (15 base pairs).

d) Once the unfolding of double strand begins more number of bases are exposed to the radiation. This leads to sudden rise in relative absorbance for each nucleic acid.

Carbohydrates and Fats

B.

8.3

a) Glucose is assimilated into the blood and is transported to each part of the body. Finally oxidation of glucose releases energy for the body to utilize and helps to recover.

b) Lactose needs to be digested before conversion to glucose. Lactose (12%) present in the milk will yield less amount of glucose on hydrolysis compared to amount of glucose in the glucose solution. Therefore, the energy obtained will be less hence recovery will be slower.

c) Calculate the energy content in (kJ) of a solution prepared by mixing 10 grams of a commercial health drink powder in 150 mL of water.

$$\text{Carbohydrate content} = 10 \times \frac{38.2}{100} = 3.82$$

$$\text{Fats content} = 10 \times \frac{21.5}{100} = 2.15$$

$$\text{Energy/150mL drink} = \frac{\{(3.82 \times 16.8 + (2.15 \times 43.62)\}\ \text{kJ}}{150\ \text{mL}}$$

$$= = \frac{157.959\ \text{kJ}}{150\ \text{mL}}$$