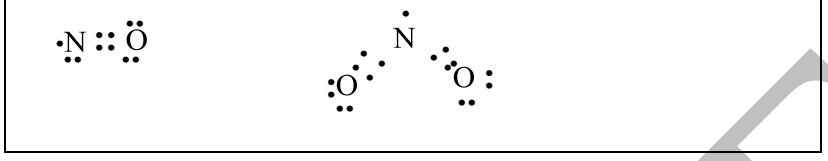
Frozen Solutions

Problem 1 — 17 marks

Oxides of nitrogen

1.1



(1mark)

1.2 $2NH_3\,(g) + 2.5\,O_2\,(g) \rightleftharpoons 2NO\,(g) + 3H_2O\,(g)$

(0.5 mark)

1.3 i) 150 k moles of O_2
600 k moles of N_2

(1 mark)

ii) ammonia = 3.46%, water = 12.10%

(2 marks)

1.4 ΔG° = 173.37 kJ/mol

(1.5 marks)

1.5 16.57% will decompose

(2 marks)

1.6 T = 318 to 320 K is accepted

(2.5 marks)

1.7 α = 0.39 and M_{av} = 66.19

(4 marks)

1.8 pH = 2.31 to 2.38 is accepted

(2.5 marks)

Problem 2 — 12.5 marks

Acid Base chemistry

A.

2.1 a) Molarity = 0.875 M **(1 mark)**

b) pH= 2.41 **(1 mark)**

2.2 a) pH = 3.87 **(1.5 marks)**

b) pH = 8.32 - 8.82 **(2 marks)**

2.3 moles of salt required = 0.128
moles of acid required = 0.0719 **(2 marks)**

B.

2.4 $V(N_2)$ = 0.180 L **(2 marks)**

C.

2.5 This subpart carrying weightage of 1.5 marks has been deleted.

D.

2.6 Answer the following questions using the given figure.

a) 7 or 7.1

b) 1.7-1.9 and 6.1-6.3

c) 3 **(3 marks)**

Problem 3 — 26 marks

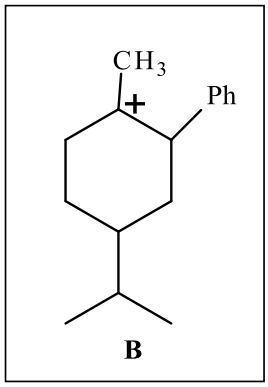
Organic Reaction Intermediates

3.1

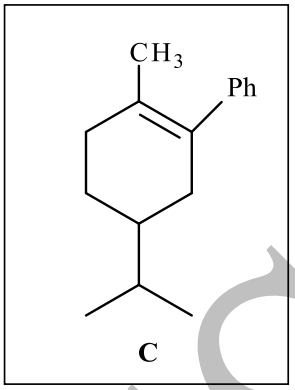
III > I > II

(1 mark)

3.2



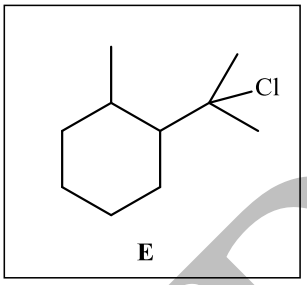
B



C

(2 marks)

3.3



E

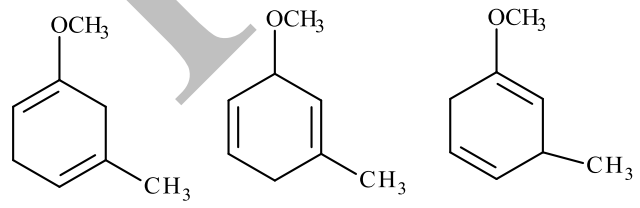
(1 mark)

3.4

i)	**3,7**	iv)	**6**
ii)	**1,4**	v)	**8 and 5**
iii)	**2, 5,6,8**	vi)	**5**

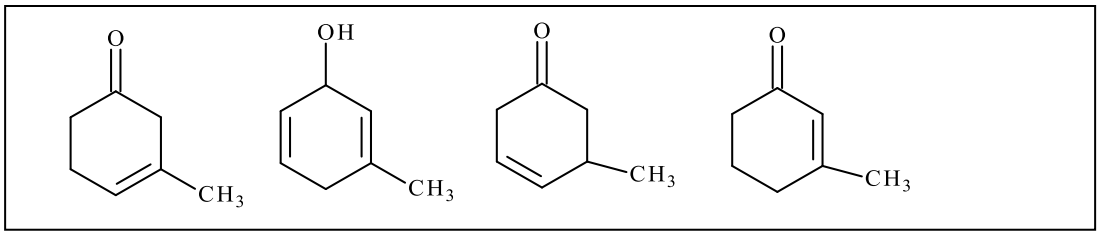
(5 marks)

3.5



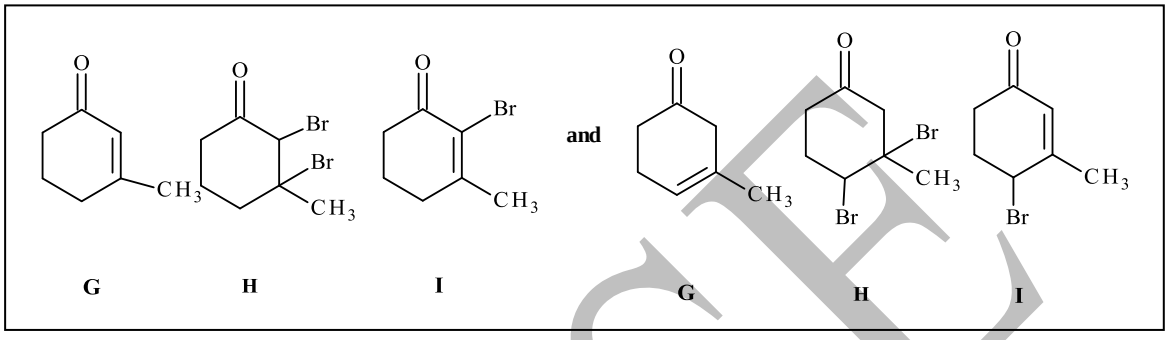
(1.5 marks)

3.6



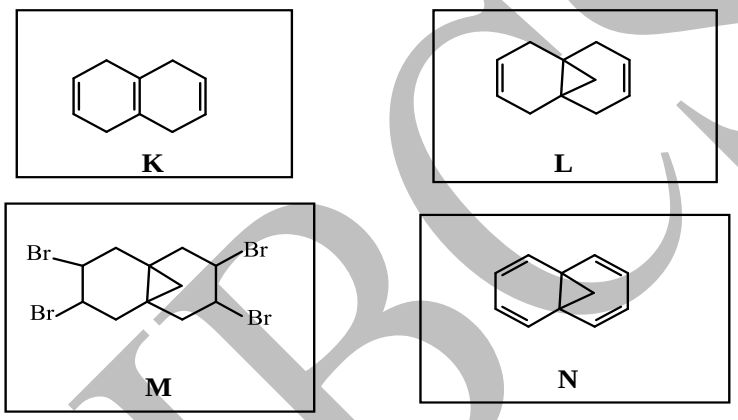
(2.5 marks)

3.7



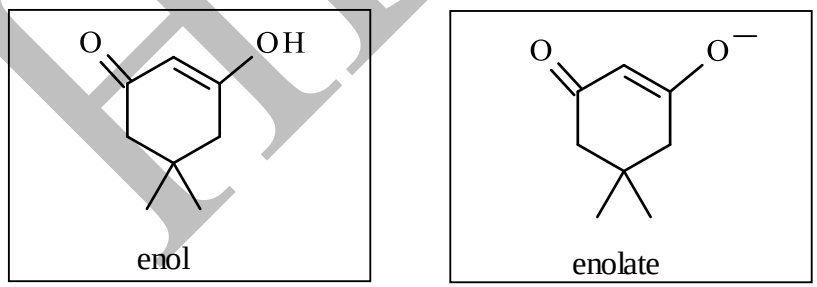
(2 marks)

3.9



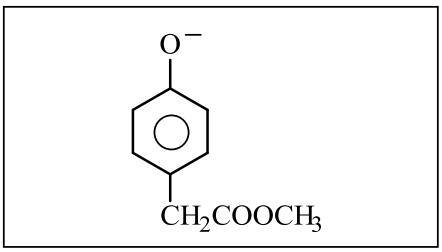
(4.5 marks)

3.10 i)

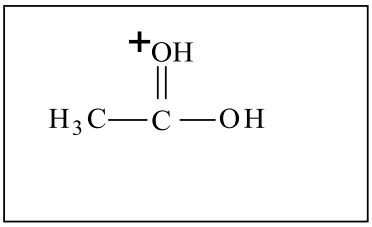


(1 mark)

ii) a)

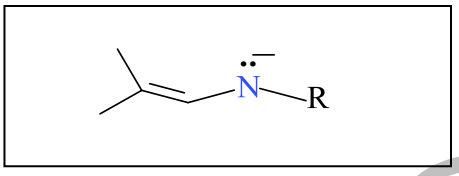


b)



(1 mark)

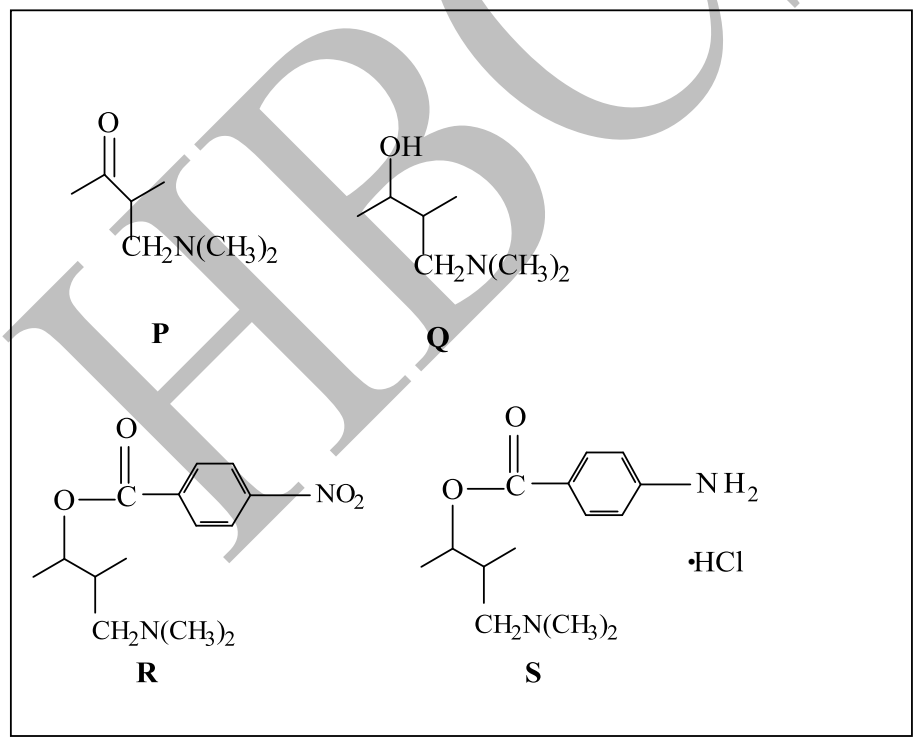
3.11



(1 mark)

3.12 iii) An aldehyde and a primary amine X **(1 mark)**

3.13



(2.5 marks)

Problem 4 — 24 marks

Chemistry of Potassium Permanganate

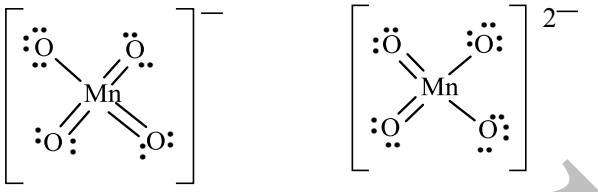
4.1

$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O$

or equivalent molecular equation

(1mark)

4.2



MnO_4^- **MnO_4^{2-}**

Manganate is paramagnetic, B.M = $\sqrt{[n(n+2)]}$ =1.73 B.M $\rightarrow MnO_4^{2-}$ (n=1)

(2.5 marks)

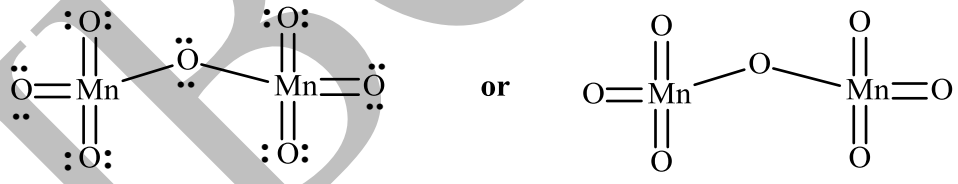
4.3 a)

$2H_2SO_4 + 2KMnO_4 \rightarrow Mn_2O_7 + 2KHSO_4 + H_2O$

$H_2SO_4 + 2KMnO_4 \rightarrow Mn_2O_7 + K_2SO_4 + H_2O$

(1mark)

b)



or

Mn_2O_7

(1 mark)

4.5

$2\ Mn_2O_7 \rightarrow 4MnO_2(s) + 3O_2(g)$

(0.5 mark)

4.6 i)

At cathode:

$MnO_2(s) + 4H^+ + 2e^- \rightarrow Mn^{+2} + 2H_2O$ ……(1)

At Anode:

$MnO_2(s) + 2H_2O \rightarrow MnO_4^- + 4H^+ + 3e^-$ ……(2)

Overall

$5MnO_2 + 4H^+ \rightarrow 3Mn^{+2} + 2MnO_4^- + 2H_2O$ ……(3)

(1.5 marks)

ii) $E_{cathode} = 1.230\,V$

$E_{anode} = -1.693\,V$

$E_{overall} = -0.463\,V$

(3 marks)

iii) $K = 1.09 \times 10^{-47}$

(1mark)

4.7 0.425gof sampleof 6%$H_2O_2$was weighed. **(3 marks)**

4.8 i) E°

ii) Mn^{2+} Mn_2O_3

iii) MnO_4^{3-}

iv) Mn and MnO_2 Mn^{3+} and H_3MnO_4

v) Mn^0 and $Mn(OH)_2$

vi) MnO_2

(4.5 marks)

4.9 i) a) MnO_2 and MnO_4^- b) $Mn(OH)_2$ and Mn

ii) a) MnO_2 and Mn_2O_3 b) Mn^{2+}

iii) Mn_2O_3 and Mn_3O_4

(5 marks)

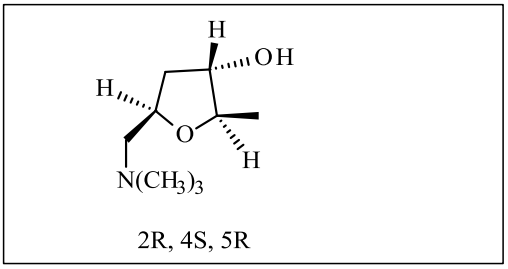
Problem 5 21 marks

Natural Nitrogen Compounds

5.1 **a.** III **b.** II **c.** III

(1.5 marks)

5.2



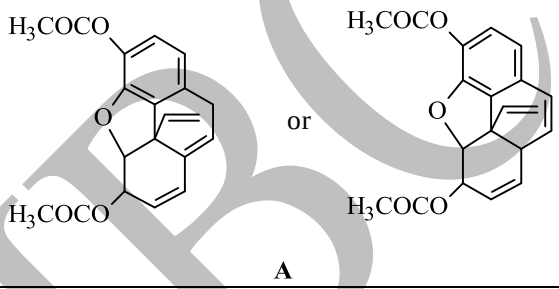
2R, 4S, 5R

(2 marks)

5.3 d) 6 X **(1 mark)**

5.4 b) 2 X **(1 mark)**

5.5

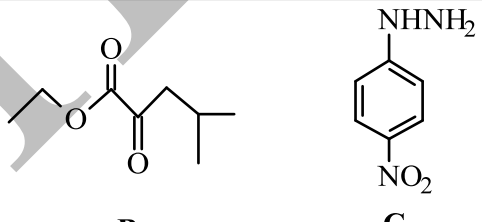


A

(2 marks)

5.6 b) 3 X **(1 mark)**

5.7

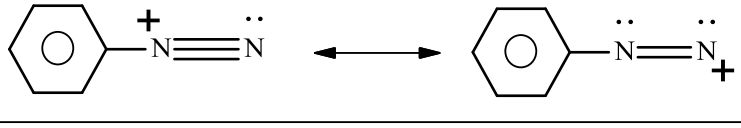


B

C

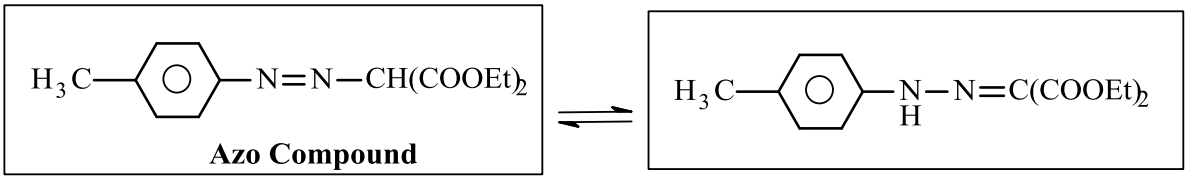
(1.5 marks)

5.8



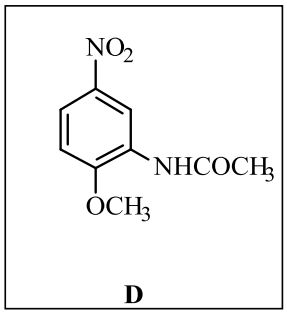
(1 mark)

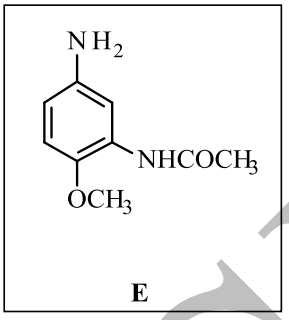
5.9

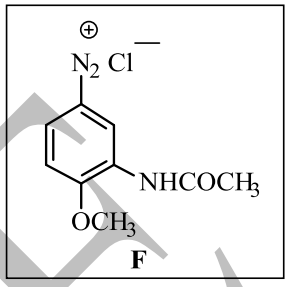


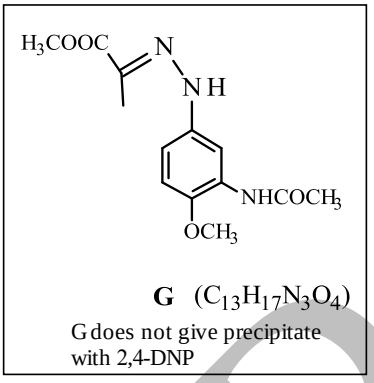
(1 mark)

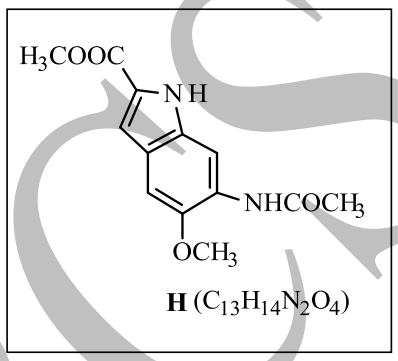
5.10

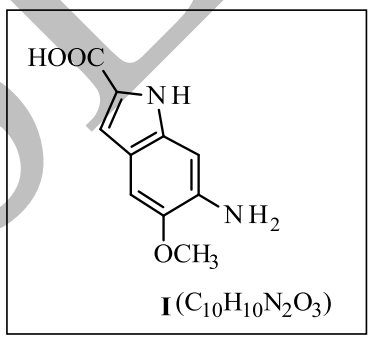










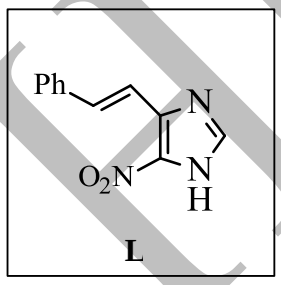


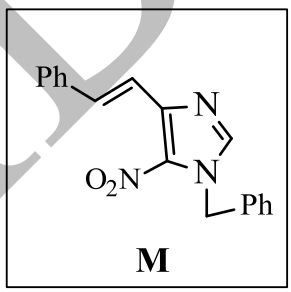
(4.5 marks)

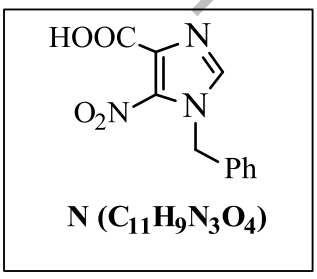
5.11 **C**

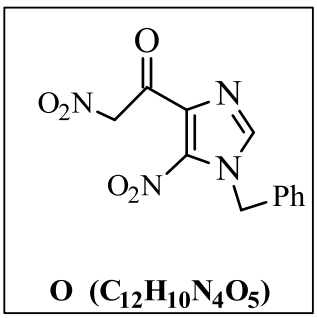
(0.5 mark)

5.12









(4 marks)

Problem 6 — 12 marks

Beer-Lambert Law

A.

6.1 L absorbs at $X_M = 0$ M absorbs at $X_M = 1$ **(1 mark)**

6.2 $\varepsilon_M = 1.33\ \varepsilon_L$ **(2 marks)**

6.3 For $X_M = 0.1$: % transmittance between 50% or 44.6%

For $X_L = 0.2$: % transmittance between 25.1% or (21.6-21.9) % **(1.5 marks)**

6.4 The composition of the complex is ML_3 **(2 marks)**

B.

6.5 $C_1 = 5.825 \times 10^{-5}\ M$

$C_2 = 1.56 \times 10^{-5}\ M$ **(1.5 marks)**

6.6 $K_f = 1.764 \times 10^{9}$ **(4 marks)**

**** Please note that due to deletion of subpart 2.5, the final marks of the paper is now 112.5 instead of 114 marks.**