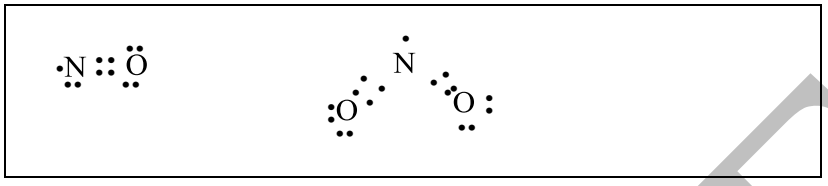
Tentative Solutions

Problem 1 — 17 marks

Oxides of nitrogen

1.1



(1mark)

1.2

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

(0.5 mark)

1.3 i)

600 k moles of N_2

(1 mark)

ii)

ammonia = 3.4%, water = 12.10%

(2 marks)

1.4

ΔG° = 173.37 kJ

(1.5 marks)

1.5

15.45 % will decompose.

(2 marks)

1.6

T = 315.93 K

(2.5 marks)

1.7

α = 0.39 and M_{av} = 66.19

(4 marks)

1.8

pH = 2.38

(2.5 marks)

Problem 2 — 14 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 **(2 marks)**

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

B.

2.4 $V(N_2)$ = 0.094 L **(2 marks)**

C.

2.5 y = 2 Thus acid is dibasic **(1.5 marks)**

D.

2.6 Answer the following questions using the given figure.

a) 7

b) 1.9 and 6.2

c) 3 **(3 marks)**

Problem 3 — 26 marks

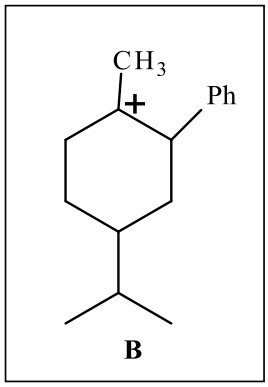
Organic Reaction Intermediates

3.1

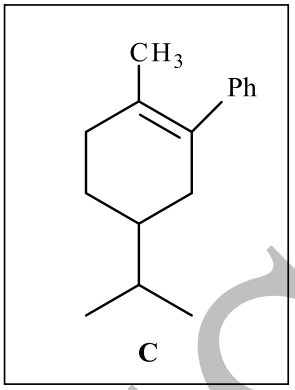
III > I > II

(1 mark)

3.2



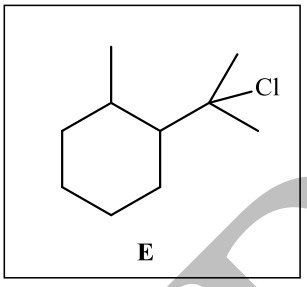
B



C

(2 marks)

3.3



E

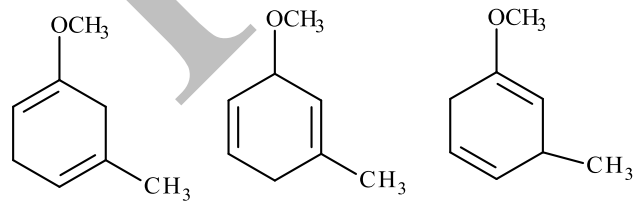
(1 mark)

3.4

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

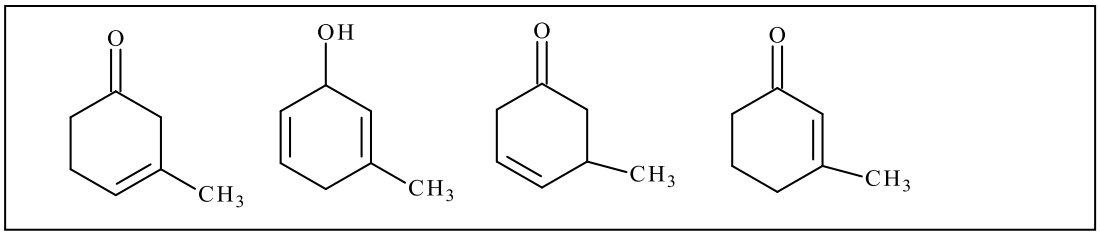
(5 marks)

3.5



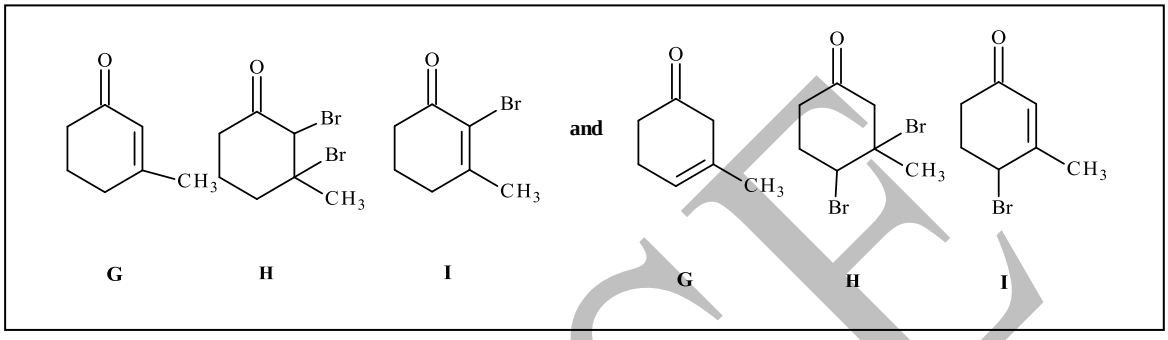
(1.5 marks)

3.6



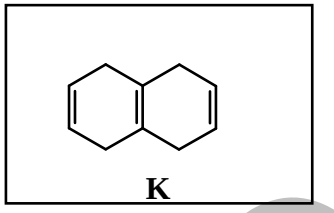
(2.5 marks)

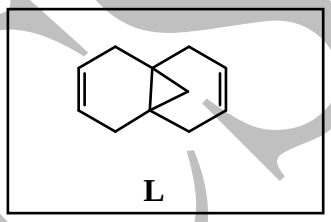
3.7

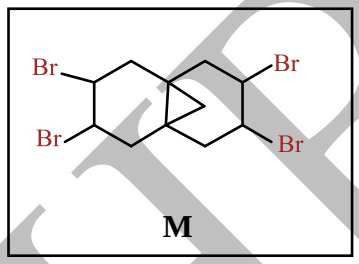


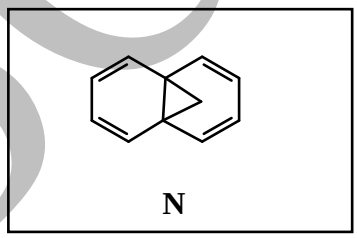
(2 marks)

3.9



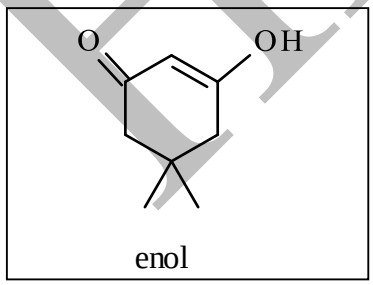


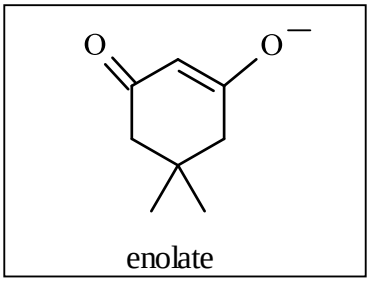




(4.5 marks)

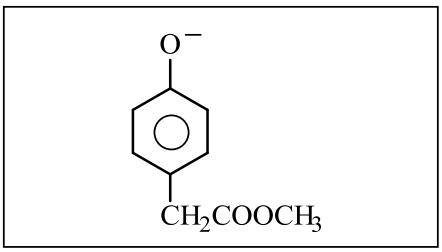
3.10 i)



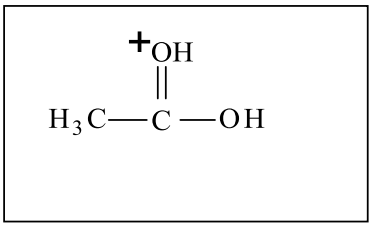


(1 mark)

ii) a)

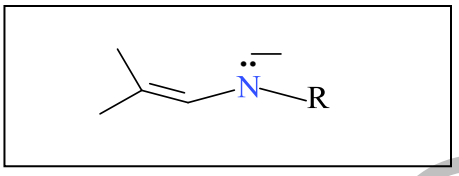


b)



(1 mark)

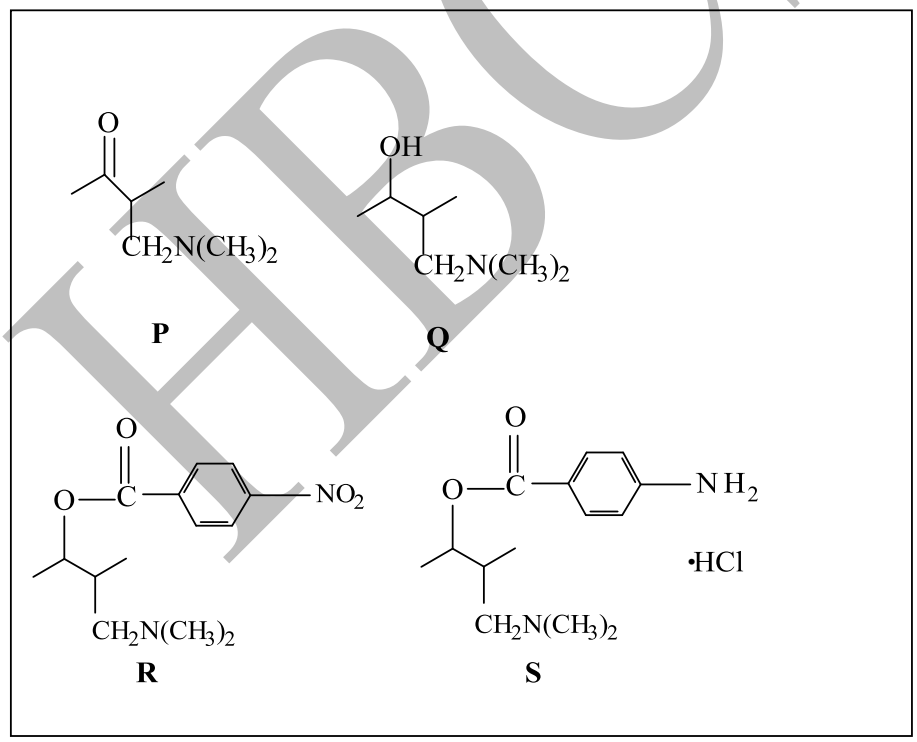
3.11



(1 mark)

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

3.13



(2.5 marks)

Problem 4 — 24 marks

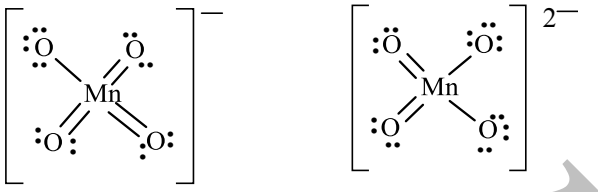
Chemistry of Potassium Permanganate

4.1

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

(1mark)

4.2



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

B.M = $\sqrt{n(n+2)}$ =1.73 B.M → MnO_4^{2-} (n=1)

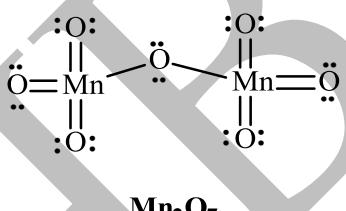
(2.5 marks)

4.3 a)

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

(1mark)

b)



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 0.425g of sample of 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)

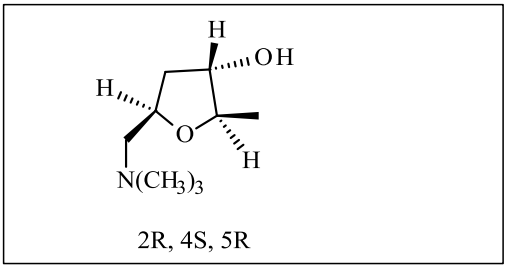
Problem 5 — 21 marks

Natural Nitrogen Compounds

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

(1.5 marks)

5.2



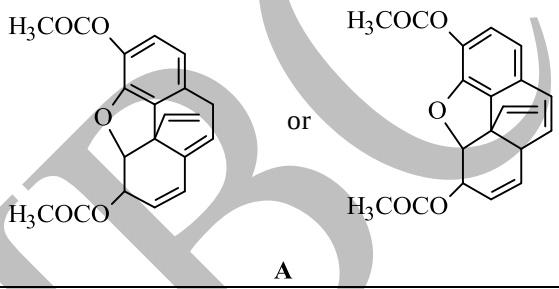
2R, 4S, 5R

(2 marks)

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

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

5.5

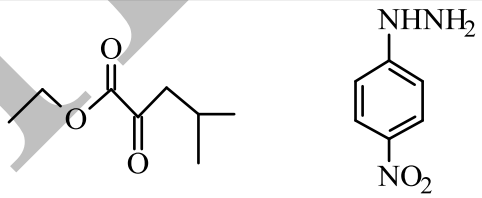


A

(2 marks)

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

5.7

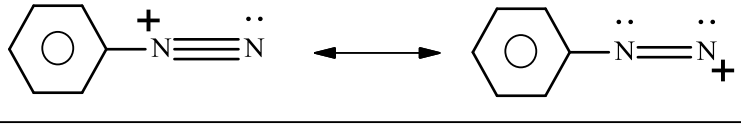


B

C

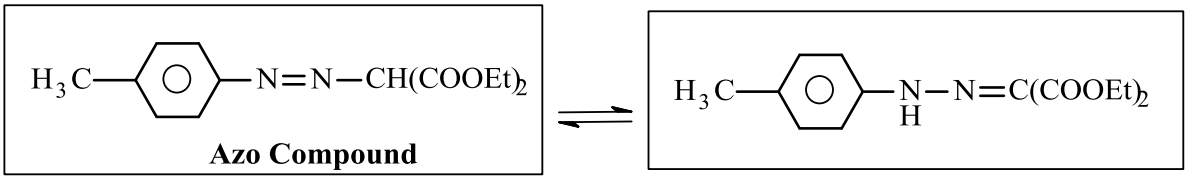
(1.5 marks)

5.8



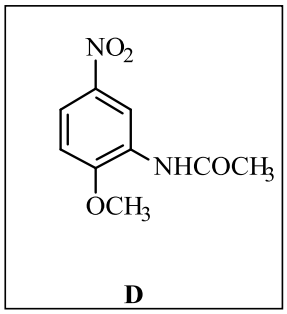
(1 mark)

5.9

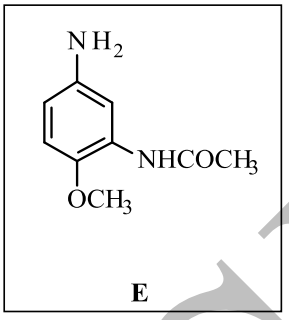


(1 mark)

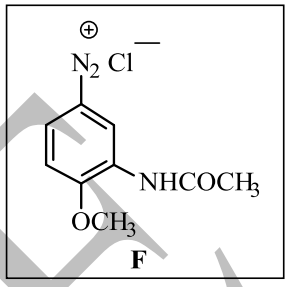
5.10



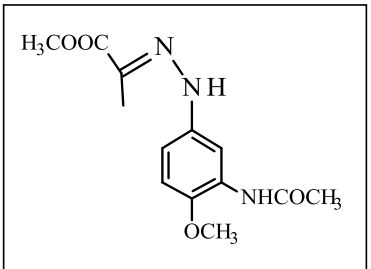
D



E

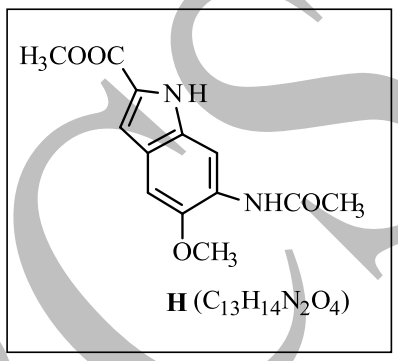


F

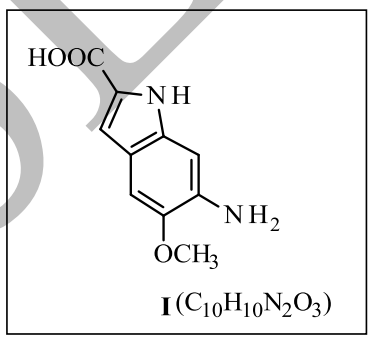


G ($C_{13}H_{17}N_3O_4$)

G does not give precipitate with 2,4-DNP



H ($C_{13}H_{14}N_2O_4$)

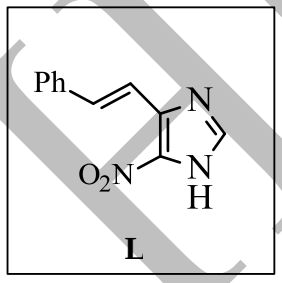


I ($C_{10}H_{10}N_2O_3$)

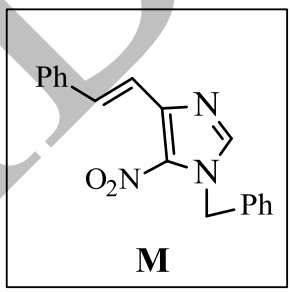
(4.5 marks)

5.11 **C** **(0.5 mark)**

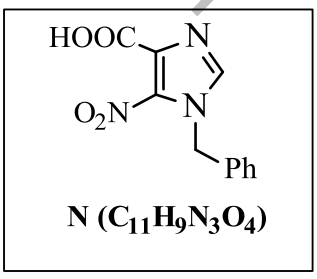
5.12



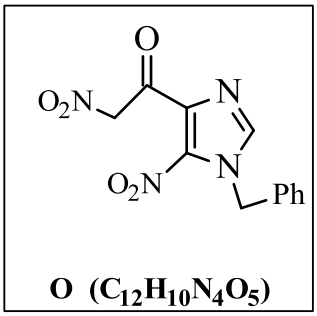
L



M



N ($C_{11}H_9N_3O_4$)



O ($C_{12}H_{10}N_4O_5$)

(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 What percentage of the incident light is transmitted through solutions when (i) $X_M = 0.1$ and when (ii) $X_L = 0.2$?

For $X_M = 0.1$: 50% has been transmitted

For $X_L = 0.2$: 25.1% has been transmitted

(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)