Frozen Solutions

Problem 1   **17 marks**

Oxides of nitrogen

1.1

(1mark)

1.2

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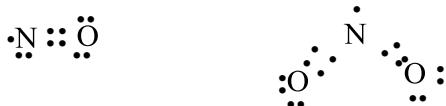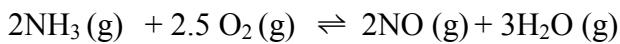
(0.5 mark)

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

$\Delta G° = 173.37$ kJ/mol

(1.5 marks)

1.5

16.57% will decompose.

(2 marks)

1.6

$T = 318$ to 320K is accepted

(2.5 marks)

1.7

$\alpha = 0.39$ 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
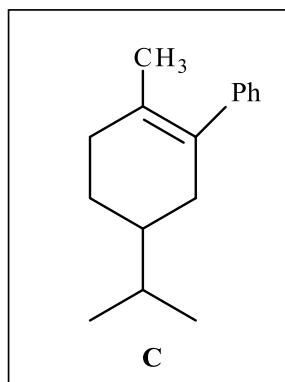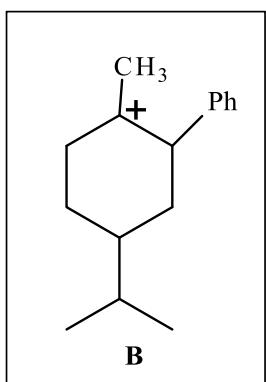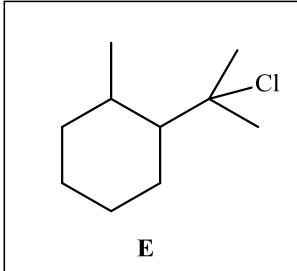
i)	**3,7**	iv)	**6**
ii)	**1,4**	v)	**8 and 5**
iii)	**2, 5,6,8**	vi)	**5**

(5 marks)

3.5
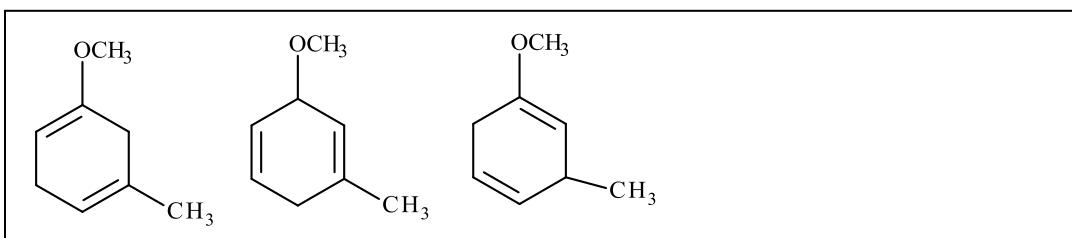
(1.5 marks)

3.6
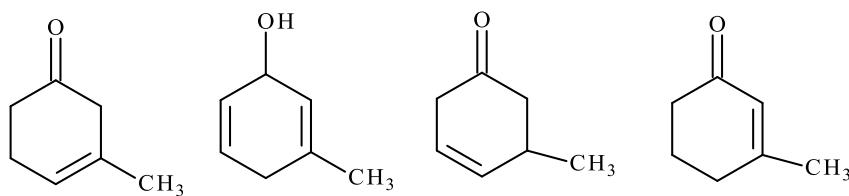
(2.5 marks)

3.7

(2 marks)

3.9

K

L

M

N   **(4.5 marks)**

3.10   i)

enol

enolate
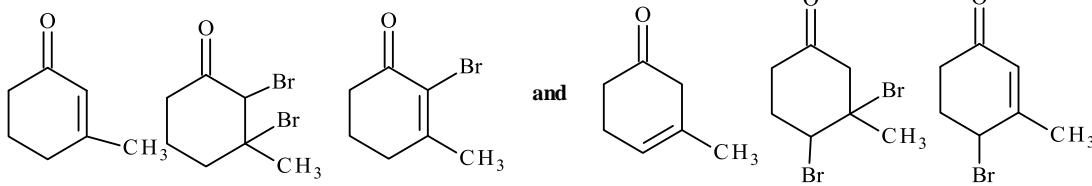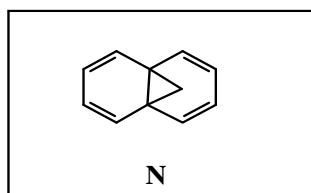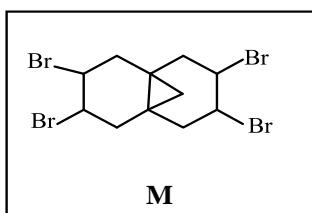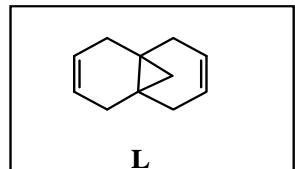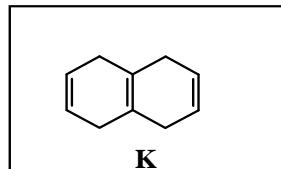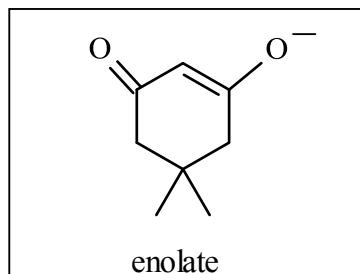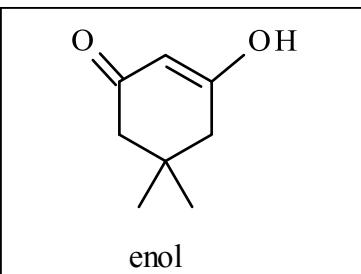
(1 mark)

ii)   a)
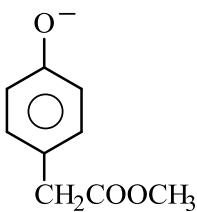
b)
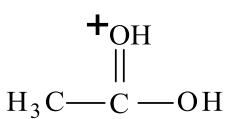
(1 mark)

3.11
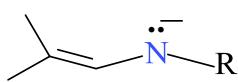
(1 mark)

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

3.13
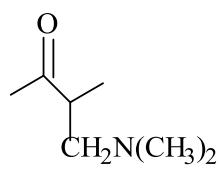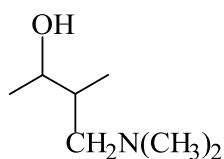
P   Q
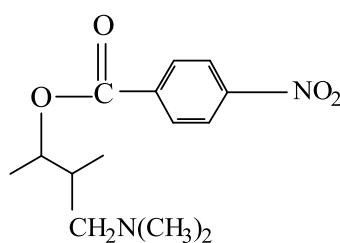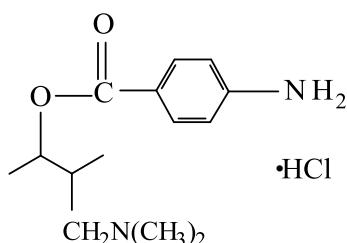
R   S

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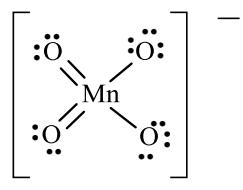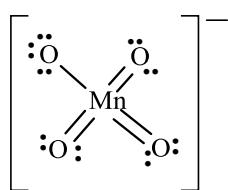
Manganate is paramagnetic, B.M = $\sqrt{[n(n+2)]}$ =1.73 B.M $\rightarrow MnO_4^{2-}$ (n=1)

(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)

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:

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

At Anode:

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

Overall

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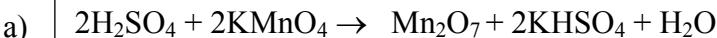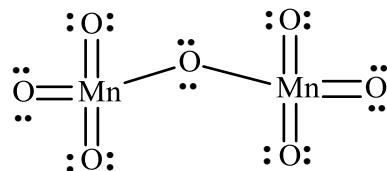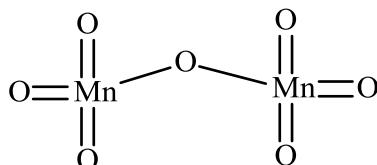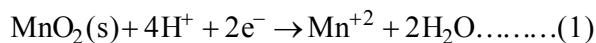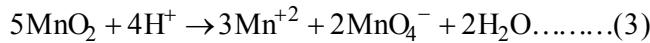
(1.5 marks)

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

$0.425\,g$ 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
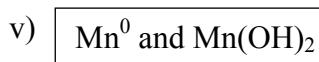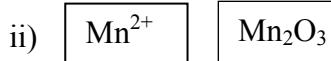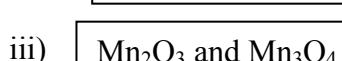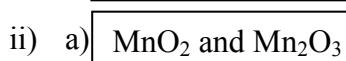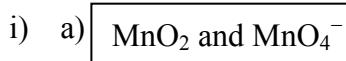
(5 marks)

Problem 5   21 marks

Natural Nitrogen Compounds

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

(1.5 marks)

5.2

N(CH₃)₃

2R, 4S, 5R
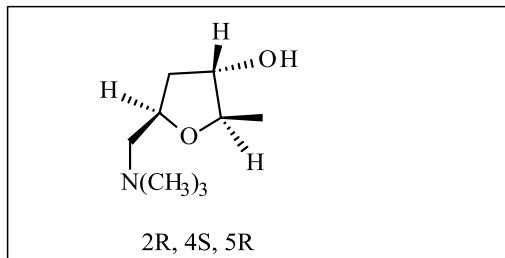
(2 marks)

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

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

5.5
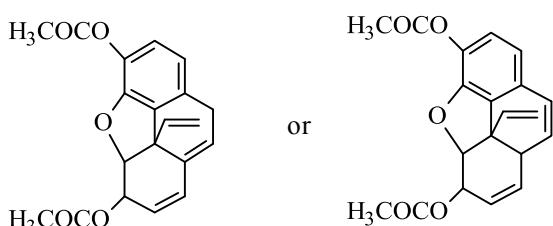
A

(2 marks)

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

5.7

B   **C**
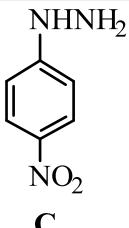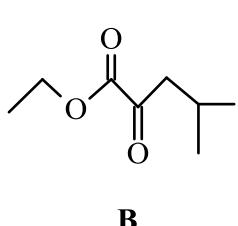
(1.5 marks)

5.8
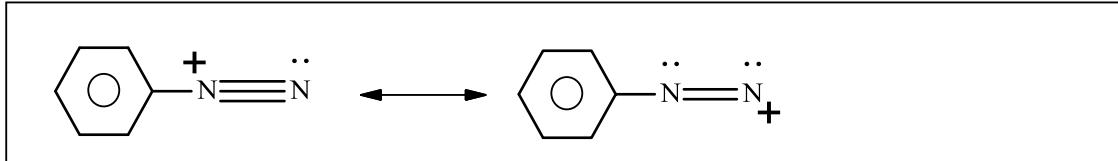
(1 mark)

5.9
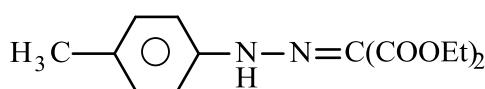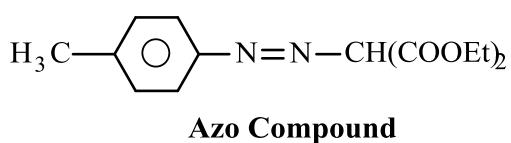
(1 mark)

5.10
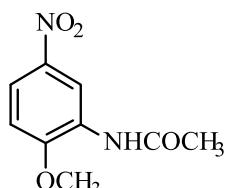
D

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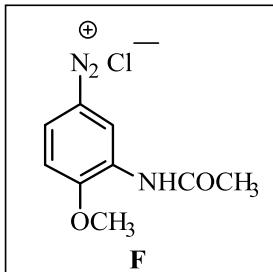
F
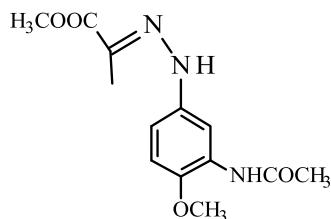
G $(C_{13}H_{17}N_3O_4)$

G does not give precipitate with , -DNP
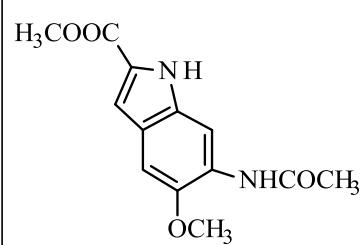
H $(C_{13}H_{14}N_2O_4)$
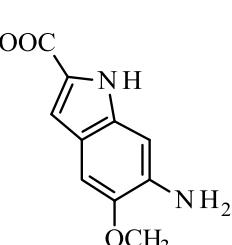
I $(C_{10}H_{10}N_2O_3)$

(4.5 marks)

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

5.12
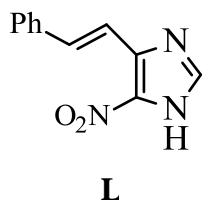
L
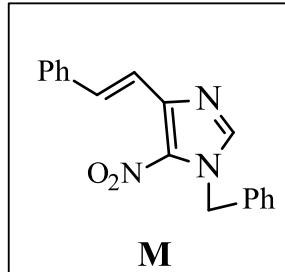
M
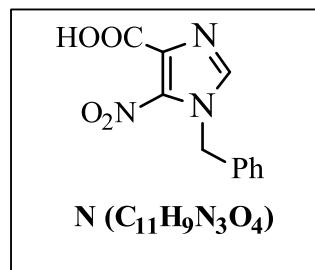
N $(C_{11}H_9N_3O_4)$
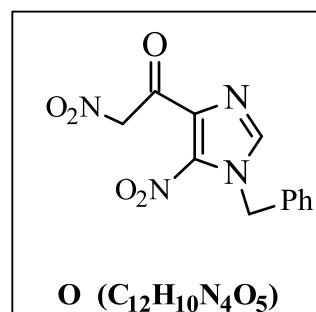
O $(C_{12}H_{10}N_4O_5)$

(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

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

$C_1 = 5.825 \times 10^{-5}\,\text{M}$
$C_2 = 1.56 \times 10^{-5}\,\text{M}$

                                                                                (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.