Frozen Solutions

Problem 1 — 17 marks

Metallurgy

1.1 $4\ Au + 8\ KCN + O_2 + 2\ H_2O \rightarrow 4\ K[Au(CN)_2] + 4\ KOH$

1.2 1454.3 g of KCN or 1.45 kg of KCN

1.3 2.38×10^{16}

1.4 $Au(CN)_2]^{-1} = 0.00847$

$Ag\ (CN)_2]^{-1} = 0.09153$

1.5 Reduction: $3[NO_3]^{-1}\ (aq) + 6\ H^+\ (aq) + 3e^- \rightarrow 3NO_2(g) + 3H_2O(l)$

Oxidation: $Au(s) \rightarrow Au^{3+}(aq) + 3e^-$

$Au^{3+}\ (aq) + 4Cl^{-1}\ (aq) \rightarrow AuCl_4^{-1}(aq)$

1.6

i)	c) $\Delta G^0 = \Delta H^0 - T\Delta S^0$	X
ii)	c) the standard entropy change of the above reaction is zero.	X
iii)	b) the standard entropy change of the above reaction is negative	X
iv)	a) 750°C	X
v)	a) $C(s) + ½\ O_2(g) \rightarrow CO(g)$	X
vi)	a) below 2200°C	X

1.7 $C(s) + 3/2\ O_2(g) = 3/2\ CO_2(g)$ **or** $2Al_2O_3\ (s) + 3C\ (s) = 4Al(s) + 3CO_2(s)$

1.8 4.1433 % of sodium fluoride should be added.

1.9 **i)** The energy consumed will be = 5.07×10^9 J.

ii) g of CO_2 per hour = 7.02×10^4g

Problem 2 — 15 Marks

Energy storage devises

A. Hydrogen storage as metal hydrides

2.1

Li_2NH	LiH	and	$LiNH_2$
A	**B**		**C**

2.2 The maximum volume = 1280 L

2.3

$LiH + HCl \rightarrow LiCl + H_2\uparrow$

LiH = 1.048 g

2.4 $p = 119.85 \times 10^{-4}\,Pa = 11.9\,bar$

2.5 $\Delta H^{\circ} = -36.1\,kJ\,mol^{-1}$

2.6

(a) $C_{12}H_{22}O_{11}(aq) + 13H_2O \rightarrow 12\,CO_2(g) + 48H^+ + 48e^-$

$VO^{2+}(aq) + 2\,H^+(aq) + e \rightarrow V^{3+}(aq) + H_2O(l)$

(b) $VO^{2+}(aq) \rightarrow VO_2^+(aq) + 2H^+(aq) + e^-$

$O_2(g) + 4H^+(g) + 4e^- \rightarrow 2H_2O(l)$

2.7 V(air) = 0.041L

2.8 Y = – 0.27 V X = 0.36 V

2.9

$[VO^{2+}] = 1.996$

$[VO_2^+] = [V^{3+}] = 4 \times 10^{-3}$

2.10 Efficiency = 0.54

Problem 3 — 25 marks

ALKALOIDS

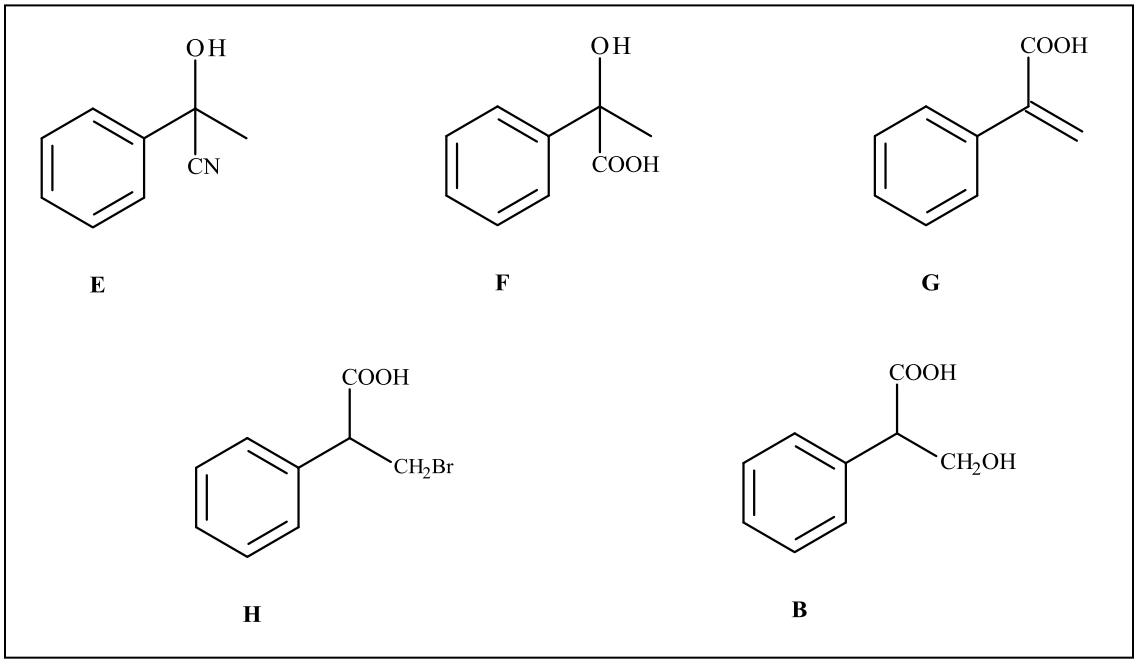
3.1 **a)** B has a hydroxyl group [X]

c) B has a carboxyl group [X]

d) B is an aromatic compound [X]

3.2 **a)** [X] **b)** [X]

3.3



3.4 **a)** [X] **b)** [X] **d)** [X]

3.5 **b)** [X] **d)** [X]

3.6 **a)** **a)** [3] **b)** [2] **or** **a)** [4] **b)** [3]

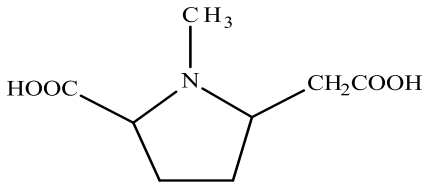
b)

a	b	c	d	e
X	X	X	X	X

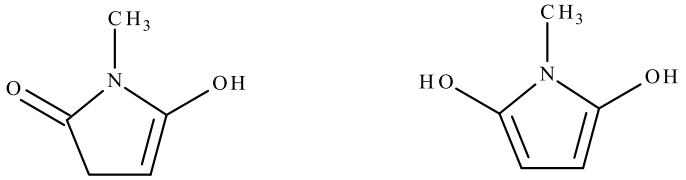
3.7 **187**

3.8 $C_8H_{13}NO_4$

3.9

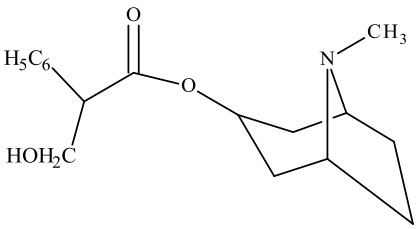


3.10

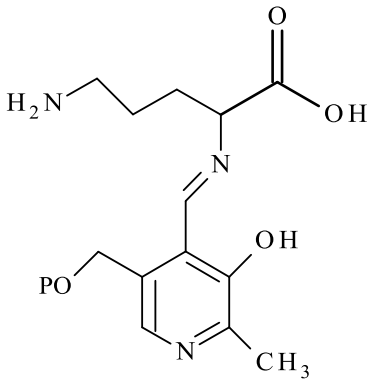


3.11 **b)** X

3.12

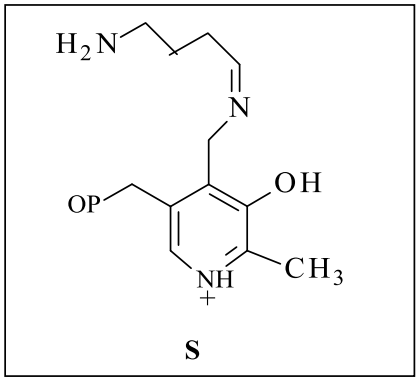


3.13



Q

3.14



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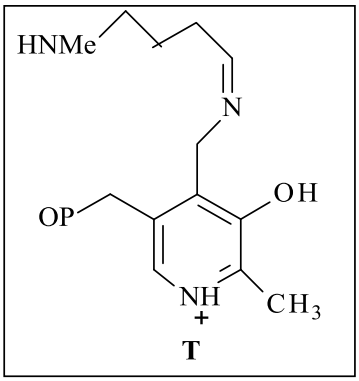

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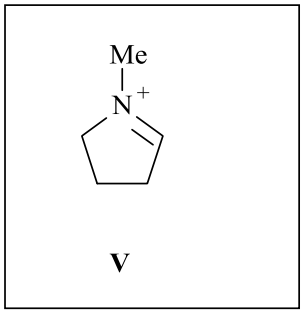

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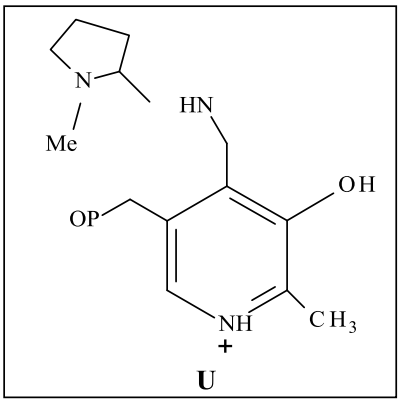
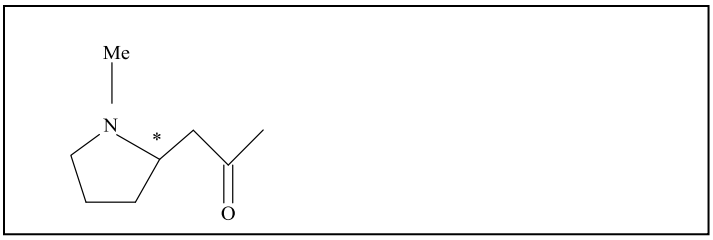


U

3.15



Problem 4 — 15 marks

Applications of Transition Metal Complexes

4.1 $[Co(H_2O)_6]^{2+}$

4.2 $[Co(H_2O)_6]^{2+} \xrightarrow{\Delta} [Co(H_2O)_4]^{2+} + 2H_2O$

4.3 $Hg[Co(SCN)_4]$

4.4 Yes [X]

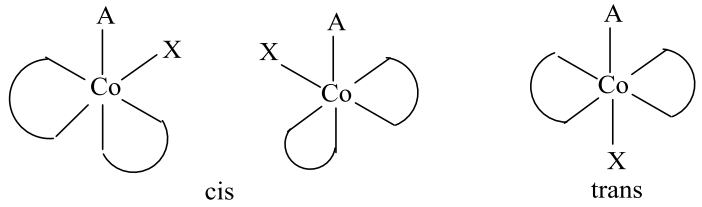
4.5
The CFSE of Co (III) in octahedral sites = 592.90 kJ mol^{-1}
The CFSE of Co (III) in tetrahedral sites = 65.8 kJ mol^{-1}
The CFSE of Co (II) in octahedral sites = 87.58 kJ mol^{-1}
The CFSE of Co (II) in tetrahedral sites = 58.40 kJ mol^{-1}

4.6
The difference of CFSE for Co(III) in octahedral and tetrahedral site is = 527.10 kJ mol^{-1}
The difference of CFSE for Co(II) in octahedral and tetrahedral site is = 29.18 kJ mol^{-1}

4.7 A normal spinel [X]

4.8 3 [X]

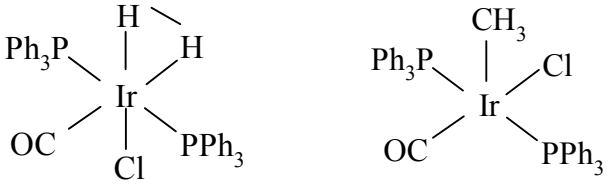
4.9



4.10 only trans product [X]

4.11 Mixture of cis and trans product [X]

4.12 i)



ii) a) [+3] b) [+3]

Problem 5 — 18 marks

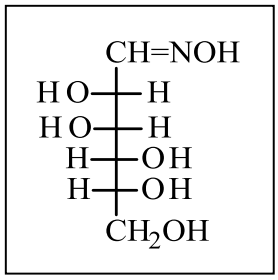
Chemistry of Carbohydrates

5.1 **A** L **B** L **C** D

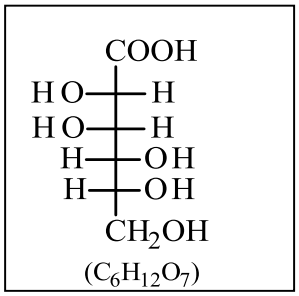
5.2 a) Diastereomer X b) Enantiomer X c) Identical X

5.3 **a)**

i)



ii)



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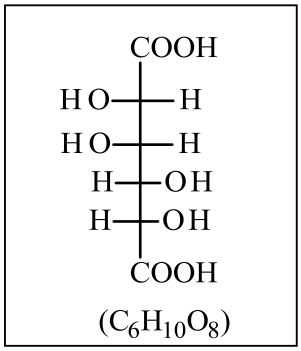

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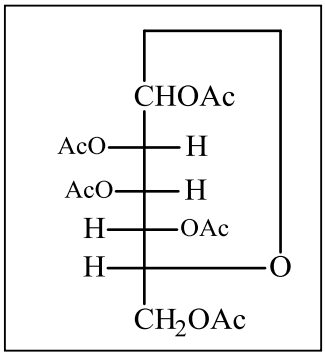

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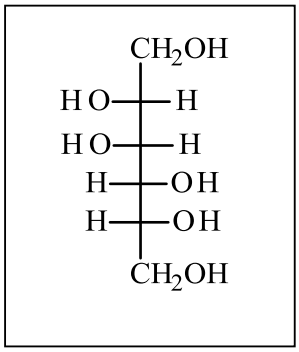
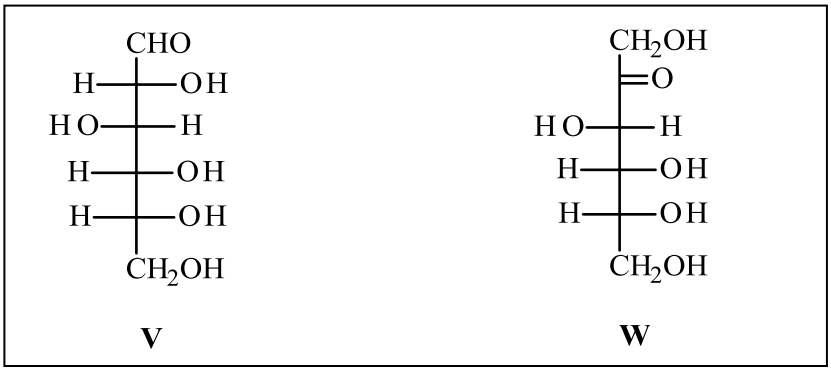


b)



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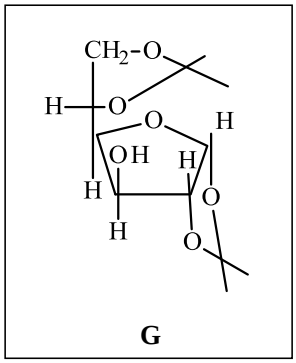

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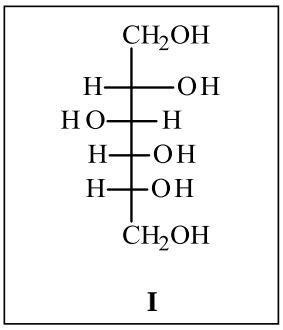
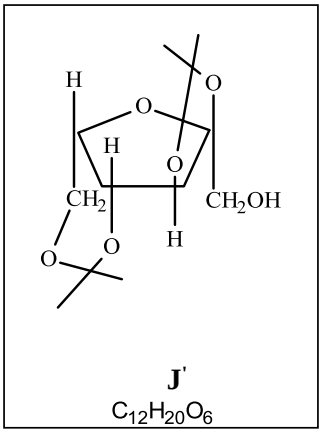


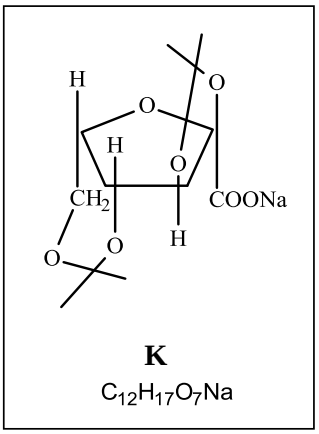
I

5.6 C5 X

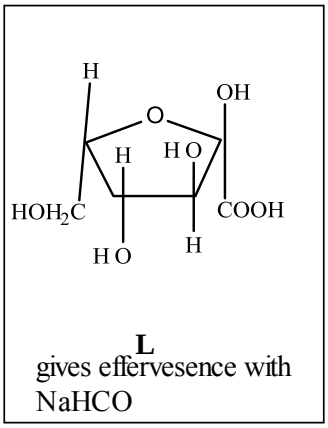
5.7



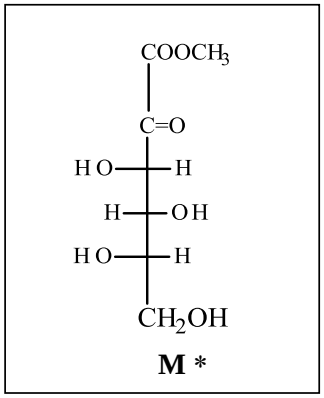
J'
$C_{12}H_{20}O_6$



K
$C_{12}H_{17}O_7Na$

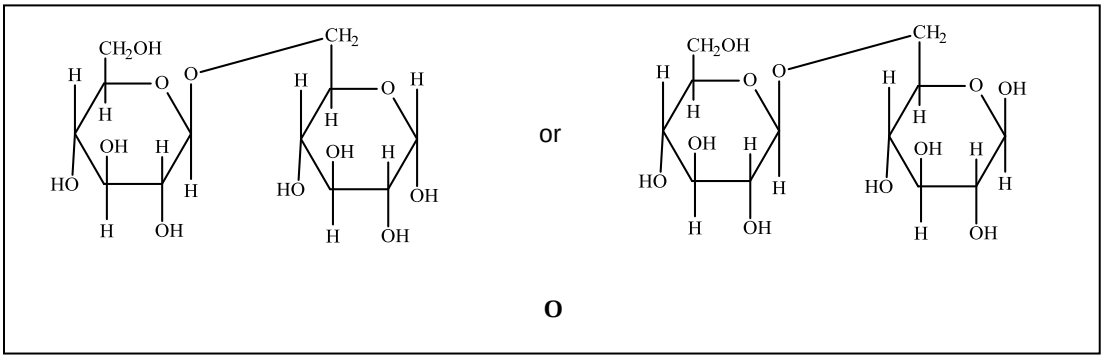


L
gives effervesence with NaHCO



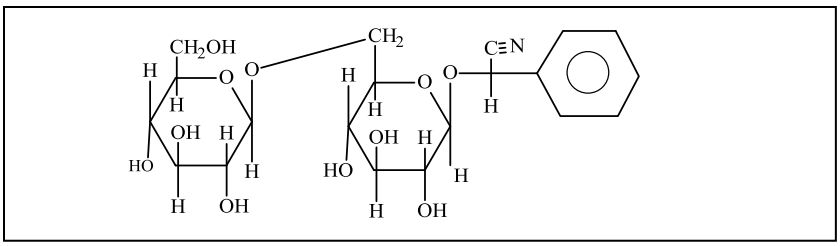
M *

5.8



O

5.9



Problem 6 — 8 marks

Chemical equilibria in quantitative analysis

6.1

(i) pH = 5.15

(ii) At pH = 12.0,
$[H^+] = 10^{-12}$ M, $[HS^-] = 0.05$; $[H_2S] = 5\times10^{-5}$, $[S^{2-}] = 6.5\times10^{-4}$, $[OH^-] = 10^{-2}$

(iii) Mass of NaOH added = 2.452g

6.2

pH range = 2.7 to 3.85

6.3

% of AsO_4^{3-} in 10g of the pesticide sample = 0.405%