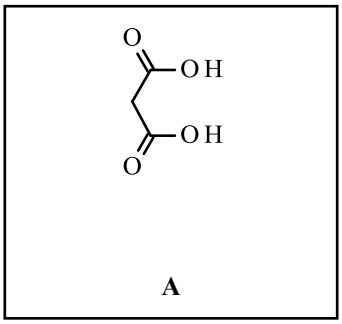
Note: The total marks of INChO-2017 paper are 111.5 (instead of 113). This is because:
(i) Total marks of Problem 2 are 25.
(ii) Total marks of Problem 3 are 22.5.

Common lapses observed in INChO 2017 answerscripts:
1) **In sub-parts requiring detailed calculations, only final answer is written without showing the necessary steps.**
2) **Numerical answers being written without appropriate units.**
3) **In writing structures of molecules, valency of various atoms not being satisfied.**

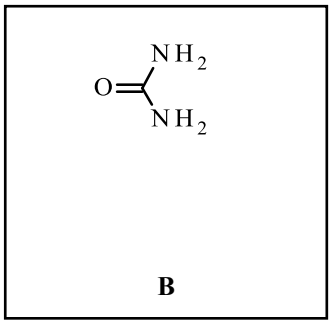
Problem 1 — 17 Marks

Barbiturates in our lives

1.1



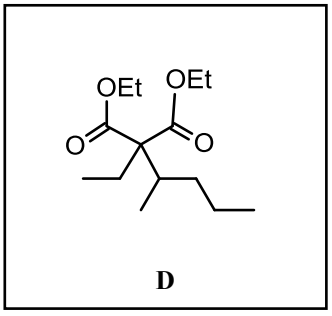
A



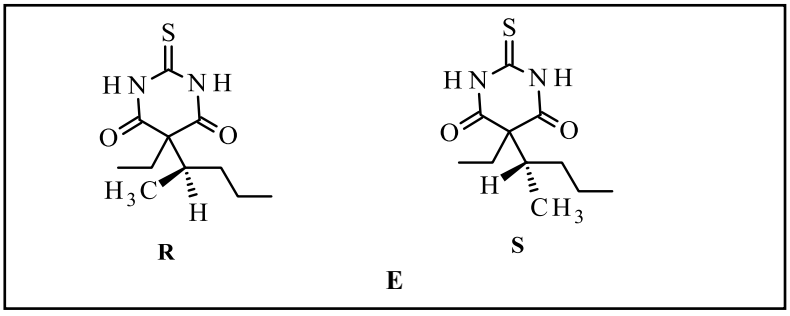
B

(1 mark)

1.2



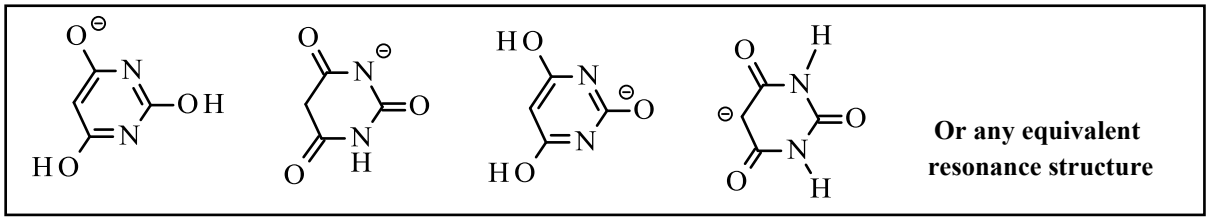
D



R **S** **E**

(2.5 marks)

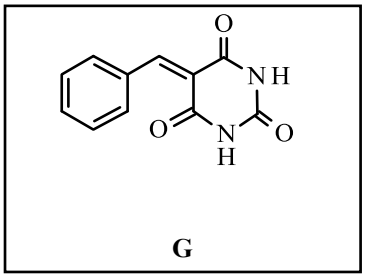
1.3



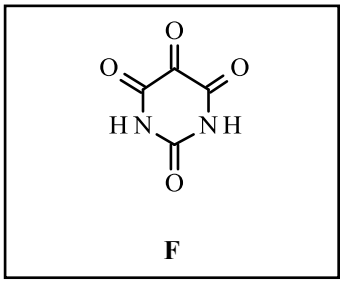
Or any equivalent resonance structure

(2 marks)

1.4



G

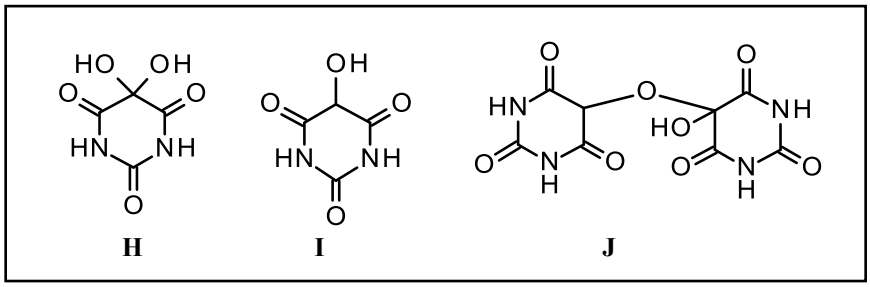


F

(1.5 marks)

1.5 a) < 4.01 [ ] b) > 4.01 [X] c) = 4.01 [ ] **(0.5 mark)**

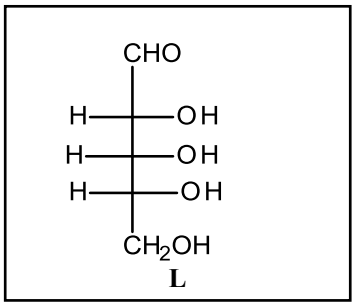
1.6



H **I** **J**

(2 marks)

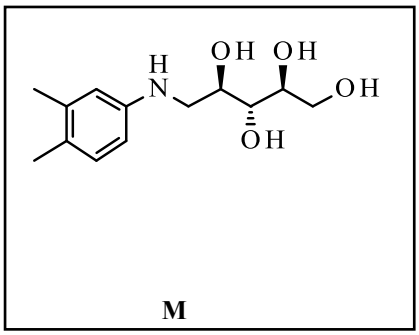
1.7



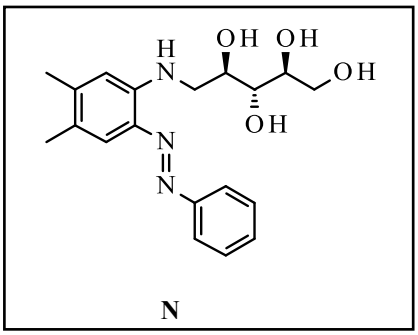
L

(2 marks)

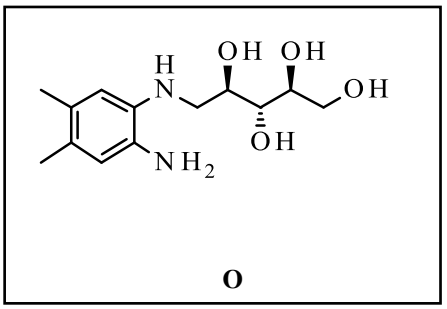
1.8 a)



M



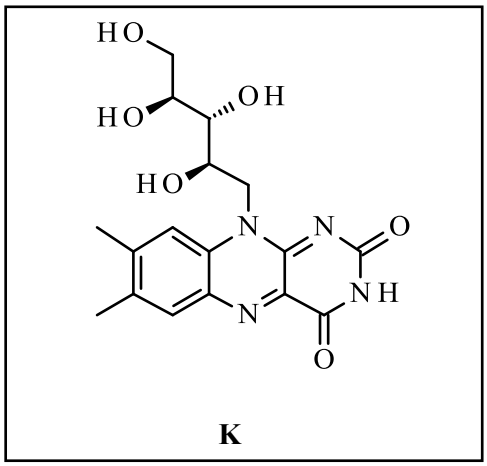
N



O

(2.5 marks)

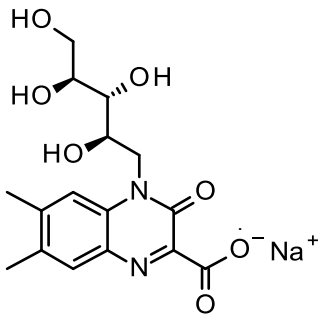
b)



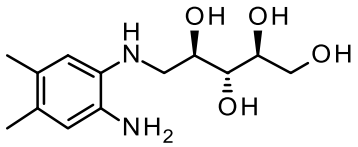
K

(2 marks)

1.9



P



Q

(1 mark)

Problem No. 2 **25 Marks**

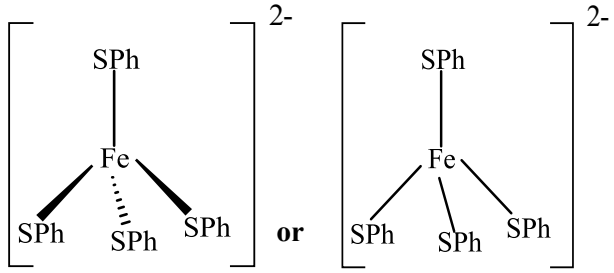
Chemistry of Iron

[The total marks for this question are 25 marks instead of 26 marks – This is due to deletion of subpart 2.9.]

Part A: Iron Sulphur proteins

2.1

Structure of $[Fe(SPh)_4]^{2-}$



Geometry: Tetrahedral

Calculation for magnetic moment:

d^6 system

4 unpaired electrons, 4.89 BM

(2 marks)

2.2

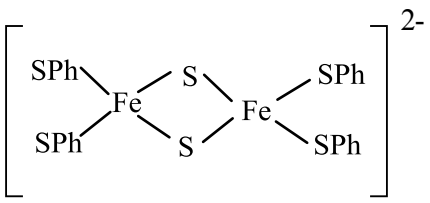
$2[Fe(SPh)_4]^{2-} + 2S \rightarrow [Fe_2S_2(SPh)_4]^{2-} + PhSSPh + 2PhS^-$ (X)

Or

$2[Fe(SPh)_4]^{2-} + 3S \rightarrow [Fe_2S_2(SPh)_4]^{2-} + 2PhSSPh + S^{2-}$ (X)

(1 mark)

2.3



(1.5 marks)

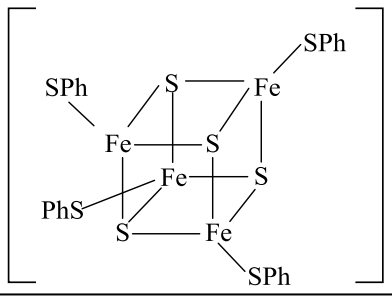
2.4

$2[Fe_2S_2(SPh)_4]^{2-} \rightarrow [Fe_4S_4(SPh)_4]^{2-} + Ph–S–S–Ph + 2PhS^-$

(Y) (Z)

(1 mark)

2.5

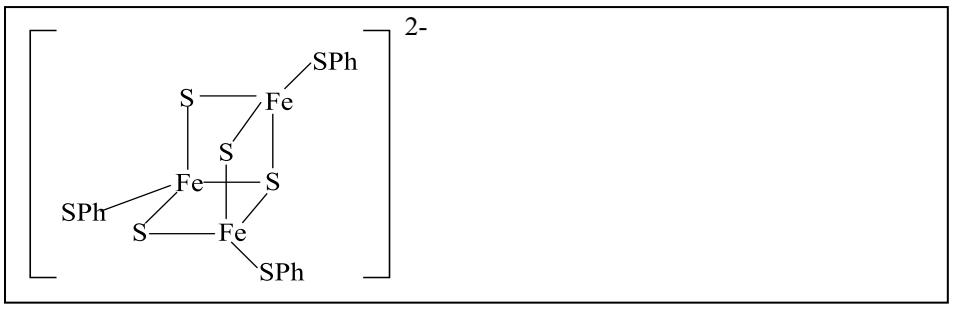


(1 mark)

2.6 a) Fe (III) in $[Fe_2S_2(SPh)_4]^{2-}$ [2] b) Fe (II) in $[Fe_2S_2(SPh)_4]^{2-}$ [0]

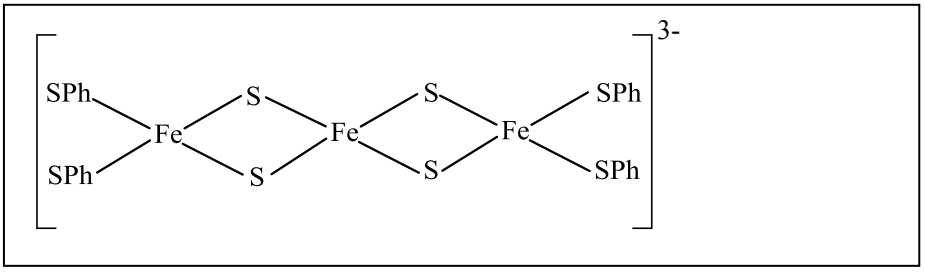
c) Fe (III) in $[Fe_4S_4(SPh)_4]^{2-}$ [2] d) Fe (II) in $[Fe_4S_4(SPh)_4]^{2-}$ [2] **(2 marks)**

2.7



(1 mark)

2.8



(1 mark)

2.9 **This subpart has been deleted.**

2.10 b) $[Fe_2S_2(SR)_4]^{2-}$ [X] c) $[Fe_4S_4(SR)_4]^{2-}$ [X] **(2 marks)**

2.11 A [X] **(1 mark)**

2.12 **A** is [Copper] **B** is [Zinc] **(1 mark)**

If **A** = Copper but **B** = left blank then also 1 mark is awarded.

2.13 A^{2+} [X] **(0.5 mark)**

Part B: Use of iron in "blue" colours

2.14

Half cell equations:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$

$C_2O_4^{-2} \rightarrow 2CO_2 + 2e^-$

(1.5 marks)

2.15

$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$

$Zn + 2Fe^{3+} \rightarrow Zn^{2+} + 2Fe^{2+}$ **or** $H_2 + 2Fe^{3+} \rightarrow 2H^+ + 2Fe^{2+}$

(1 mark)

2.16

Half cell reactions:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

(1 mark)

2.17

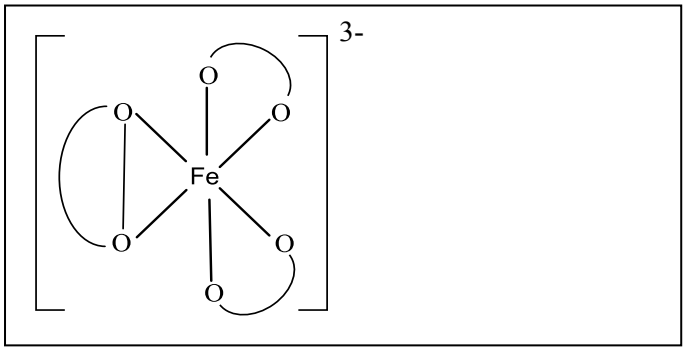
Moles of oxalate ion = 1.52×10^{-3} moles

Moles of $Fe^{2+} = 4.998 \times 10^{-4}$ moles

Molar ratio of iron: oxalate (to the nearest whole number) : $4.998 \times 10^{-4} / 1.52 \times 10^{-3} = 1:3$

(3 marks)

2.18 a)



(1 mark)

b) ii) X **(0.5 mark)**

2.19

a)

$2[Fe(C_2O_4)_3]^{3-}(aq) + h\nu \rightarrow 2\,Fe^{2+}(aq) + 5C_2O_4^{2-}(aq) + 2CO_2(g)$

or

$2[Fe(C_2O_4)_3]^{3-}(aq) + h\nu \rightarrow 2[Fe(C_2O_4)_2]^{2-}(aq) + 2CO_2(g) + C_2O_4^{2-}(aq)$

or

$2K_3[Fe(C_2O_4)_3](aq) + h\nu \rightarrow 3K_2C_2O_4\,(aq) + 2FeC_2O_4\,(aq) + 2CO_2(g)$

(1mark)

b)

$3Fe^{2+}(aq) + 3K_3Fe(CN)_6(aq) \rightarrow 3KFe[\,Fe(CN)_6)] + 6K^+\,(aq)$

or

$3Fe^{2+}(aq) + 2[Fe(CN)_6]^{3-}(aq) \rightarrow Fe_3[\,Fe(CN)_6)]_2\,(aq)$

or

$[Fe(C_2O_4)_2]^{2-}(aq) + [Fe(CN)_6]^{3-}(aq) \rightarrow [\,Fe(Fe(CN)_6)]^-(aq) + 2C_2O_4^{2-}(aq)$

or

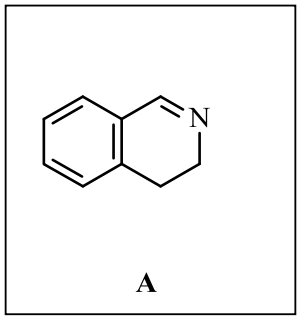
$2FeC_2O_4\,(aq) + 2K_3Fe(CN)_6\,(aq) \rightarrow Fe_3[\,Fe(CN)_6)]_2\,(aq) + 3K_2C_2O_4\,(aq)$

(1 mark)

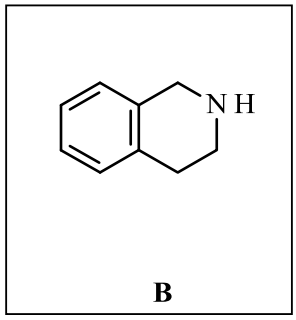
Problem 3 **22.5 Marks**

Alkaloids

3.1



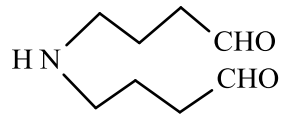
A



B

(2 marks)

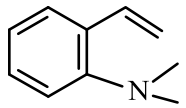
3.2



C

(1.5 marks)

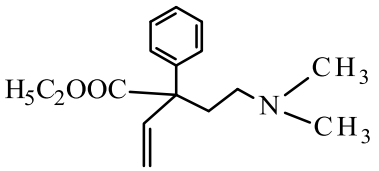
3.3



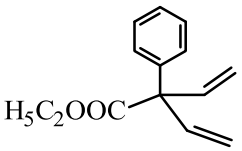
E

(1 mark)

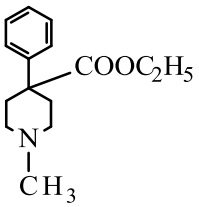
3.4



F



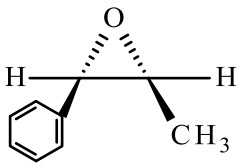
G



Pethidine

(3 marks)

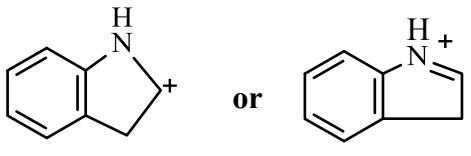
3.5



H

(2 marks)

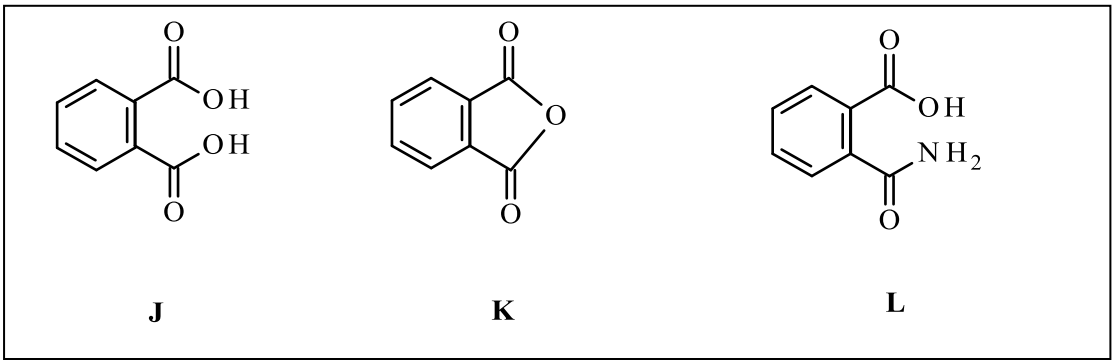
3.6.



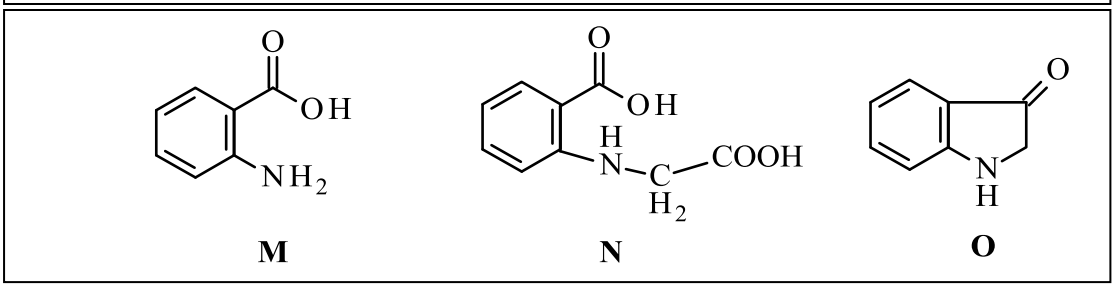
I

(1 mark)

3.7



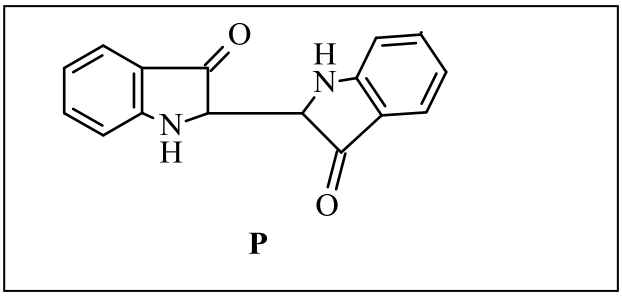
J **K** **L**



M **N** **O**

(4 marks)

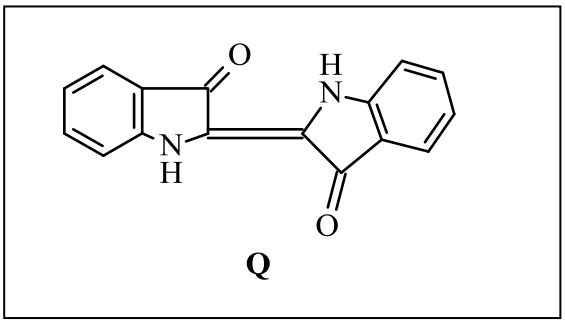
3.8



P

(1 mark)

3.9



Q

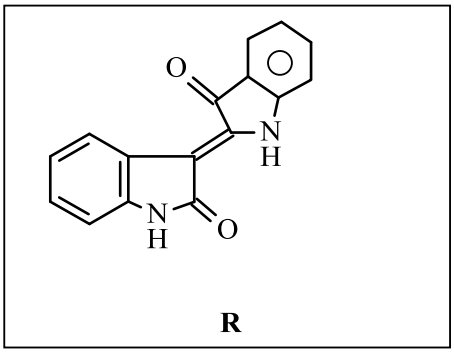
(1 mark)

3.10

2

(0.5 mark)

3.11

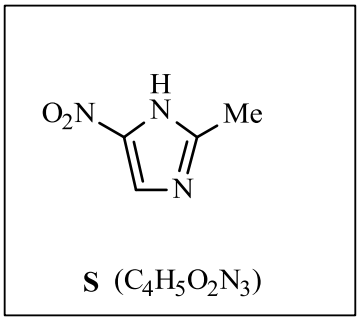


R

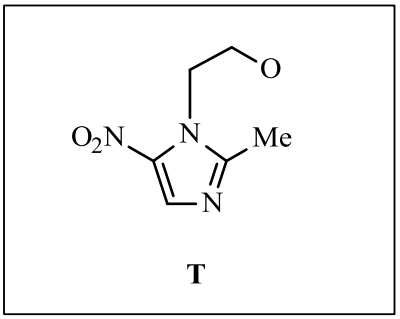
(1 mark)

3.12 iii) X **(1 mark)**

3.13



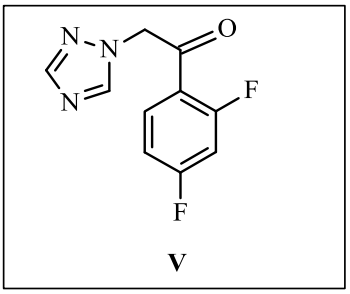
S ($C_4H_5O_2N_3$)



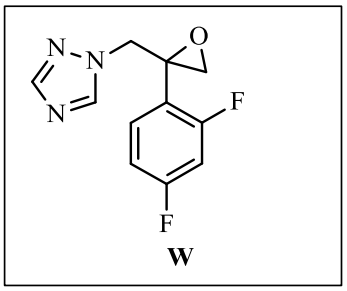
T

(1 mark)

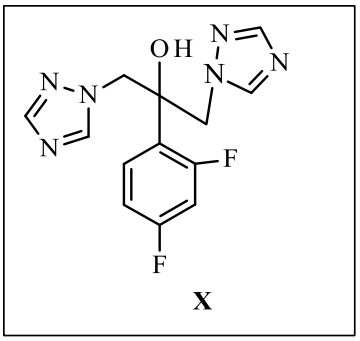
3.14



V



W



X

(2.5 marks)

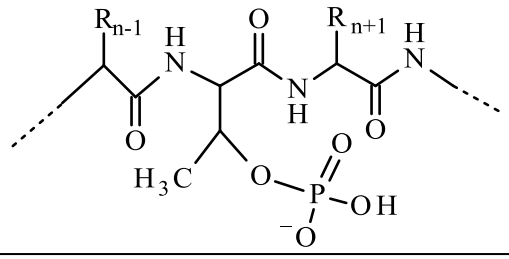
Problem 4 **26 marks**

Understanding Milk

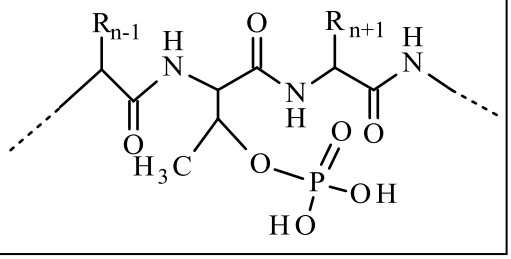
Part A: Proteins in Milk

4.1

pH =6.6



pH=1.8



(1.5 marks)

4.2. b) X e) X f) X **(2.5 marks)**

4.3

$NH_3 + H_3BO_3 \rightarrow NH_4^+ H_2BO_3^-$

$NH_4^+ H_2BO_3^- + HCl \rightarrow NH_4Cl + H_3BO_3$

Or

$NH_3 + H_2O + H_3BO_3 \rightarrow NH_4^+ B(OH)_4^-$

$NH_4^+ B(OH)_4^- + HCl \rightarrow NH_4Cl + H_3BO_3 + H_2O$

(1.5 marks)

4.4 a) X

(1 mark)

4.5 Mass of protein that would be reported = 43.5 g L^{-1}

(2 marks)

4.6. Concentration of caseins in milk sample = 34.3 g L^{-1}

(2 marks)

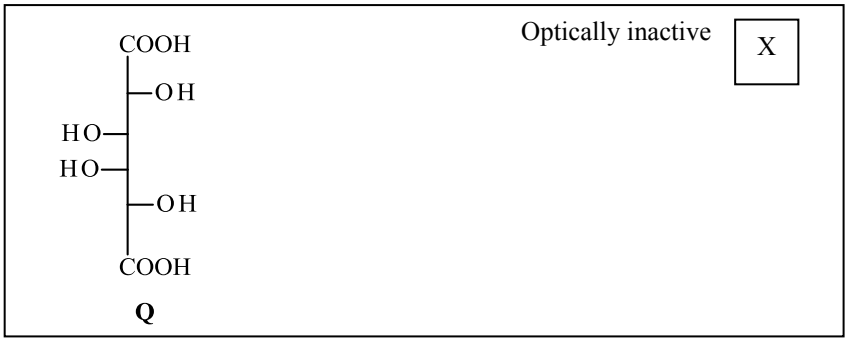
4.7 Concentration of non-protein N = 1.23 g L^{-1}

(3 marks)

4.8. a) X b) X **(1.5 marks)**

Part B: Carbohydrates in Milk

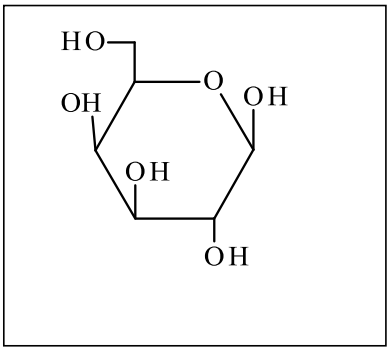
4.9



Optically inactive [X]

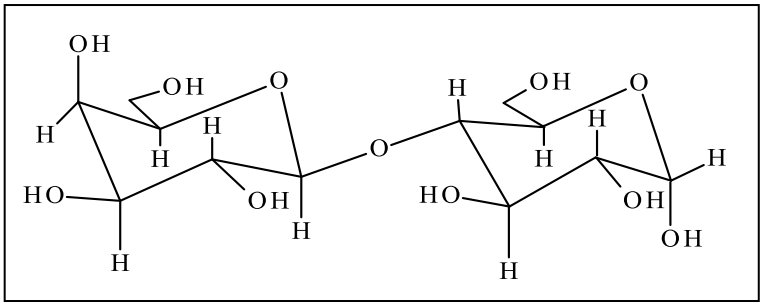
(1.5 marks)

4.10



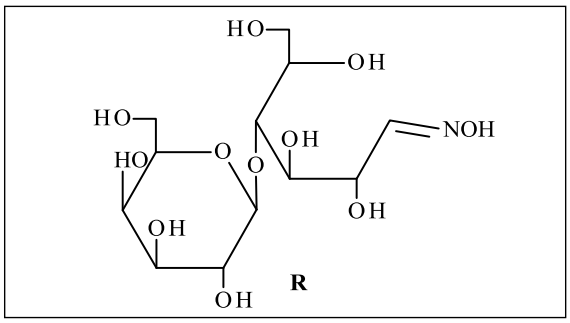
(0.5 mark)

4.11



(2 marks)

4.12



(1 mark)

4.13

L_1 = 38 % L_2 = 62%

(1 mark)

4.14

Lactose amount in the solution: 184.2 g

(2 marks)

4.15 **Yes:** a) [X] d) [X] e) [X]

No: b) [X] c) [X] f) [X]

(3 marks)

Problem 5 **21 Marks**

Isotope Effects

5.1 $\lambda_H - \lambda_D = 1.8$ Å **(2 marks)**

5.2 At equilibrium, total number of moles in the gas = 0.7269 mol **(2.5 marks)**

5.3 Mol% HD in liquid = 0.35% **(3.5 marks)**

5.4 Enrichment factor = 1.75 **(1 mark)**

5.5 The mixture consists of 52.47 mol % H_2 and 47.53 mol % of HD. **(2 marks)**

5.6 **True:** b) [X] c) [X]

False: a) [X] d) [X] **(2 marks)**

5.7 $HDO \rightleftharpoons \frac{1}{2} O_2 + 2e^- + H^+ + D^+$ **(1 mark)**

5.8 ii) [X] **(1 mark)**

5.9 If Keq = [HDO(l)] /[D_2O(l)] [H_2O(l)] is taken (as mistakenly given in the question paper), then
33.6 mol dm^{-3} of H_2O, 0.34 mol dm^{-3} of D_2O and 21.4 mol dm^{-3} of HDO.

or

If Keq = [HDO(l)]^2 /[D_2O(l)] [H_2O(l)] is taken, then
35.5 mol dm^{-3} of H_2O, 2.25 mol dm^{-3} of D_2O and 17.6 mol dm^{-3} of HDO.

Both solutions are given full credit. **(2.5 marks)**

5.10 b) [X] c) [X] **(2 marks)**

5.11 a) [X] **(1.5 marks)**