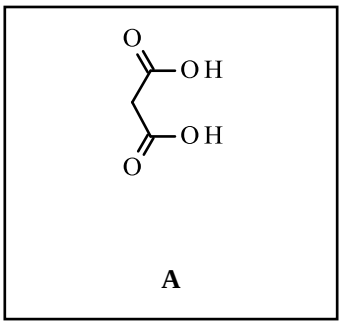
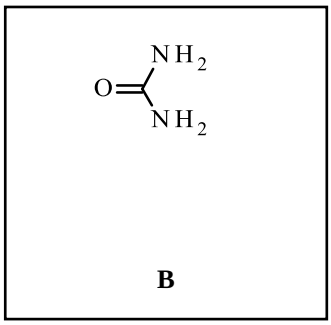
Problem 1 — 17 Marks

Barbiturates in our lives

1.1



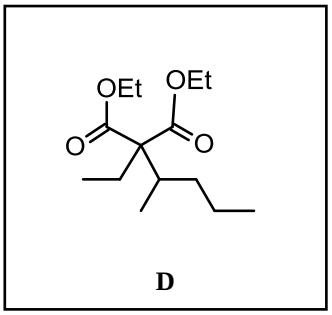
A



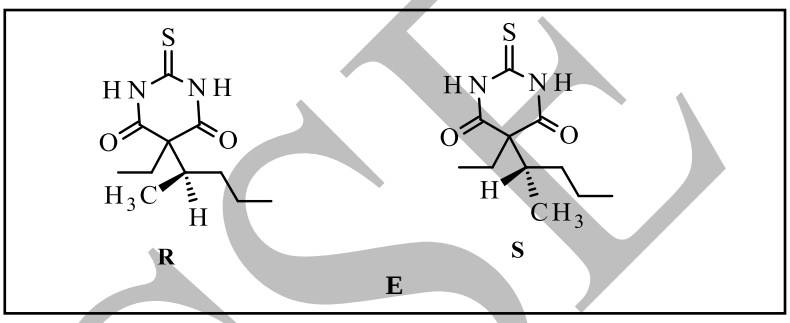
B

(1 mark)

1.2



D

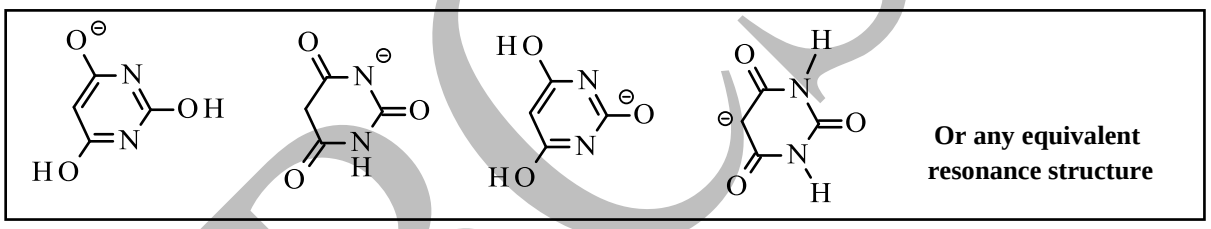


R **S**

E

(2.5 marks)

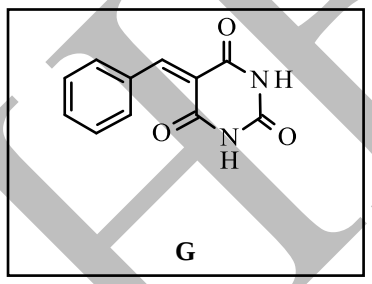
1.3



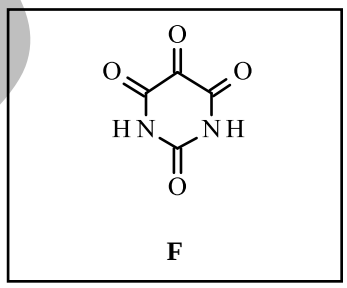
Or any equivalent resonance structure

(2 marks)

1.4



G

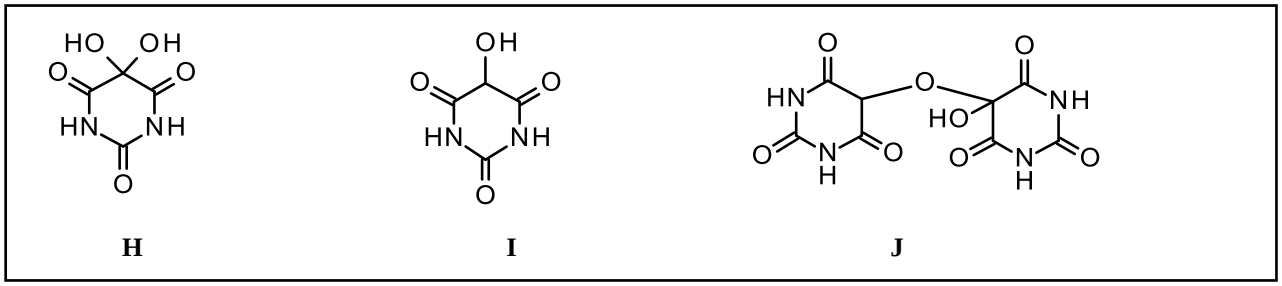


F

(1.5 marks)

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

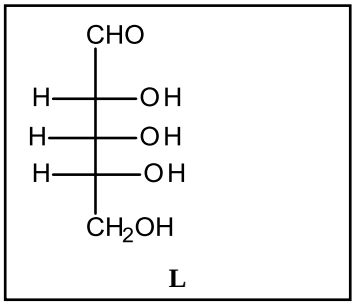
1.6



H **I** **J**

(2 marks)

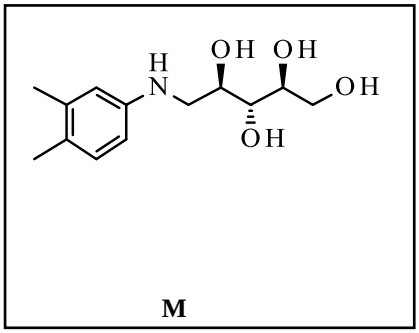
1.7



L

(2 marks)

1.8 a)



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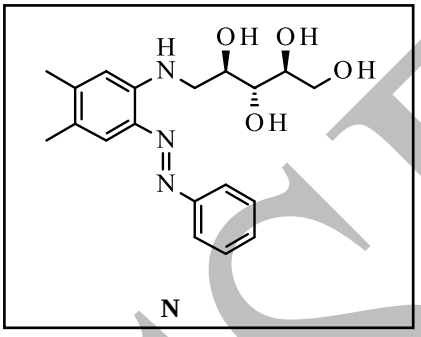
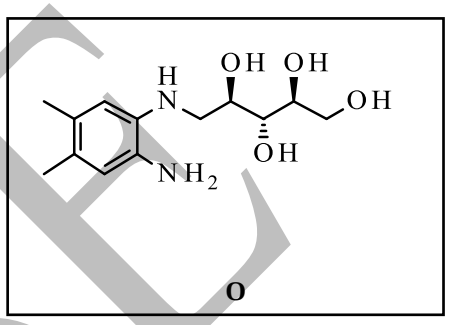


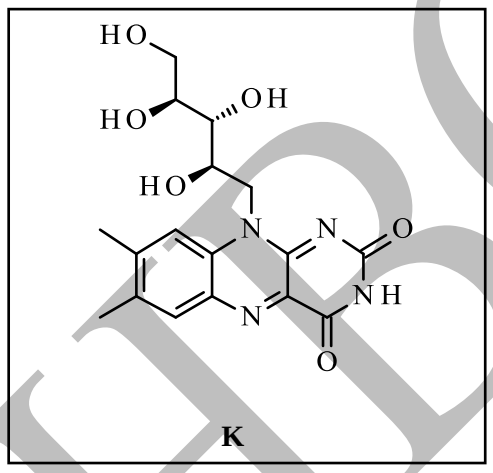
N



O

(2.5 marks)

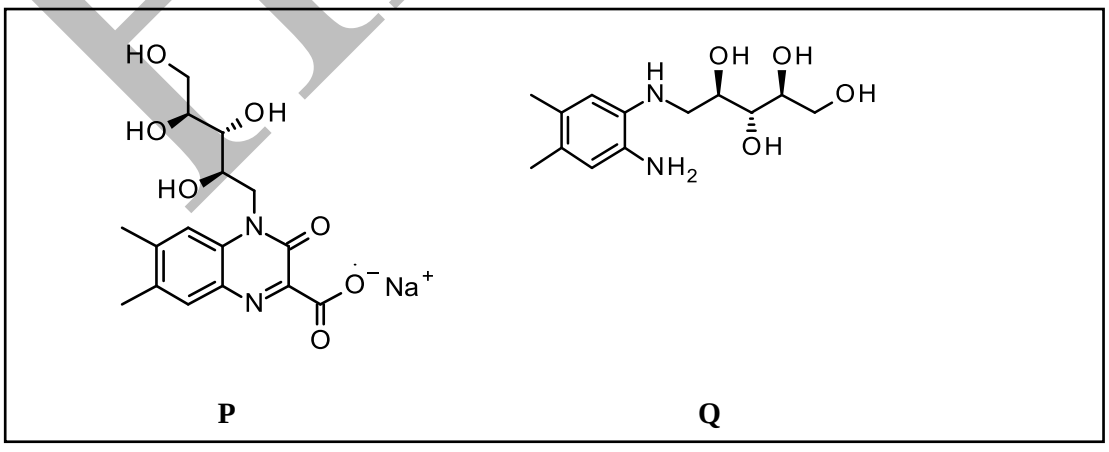
b)



K

(2 marks)

1.9



P **Q**

(1 mark)

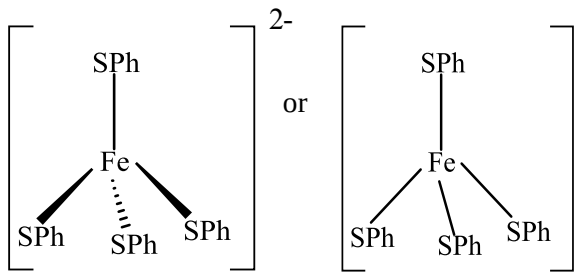
Problem No. 2 **26 Marks**

Chemistry of Iron

Part A: Iron Sulphur proteins

2.1

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



Calculation for magnetic moment:

d^6 system

4 unpaired electrons, 4.89 BM

(2 marks)

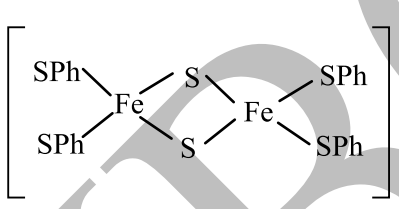
2.2

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

(X)

(1mark)

2.3



(1.5 marks)

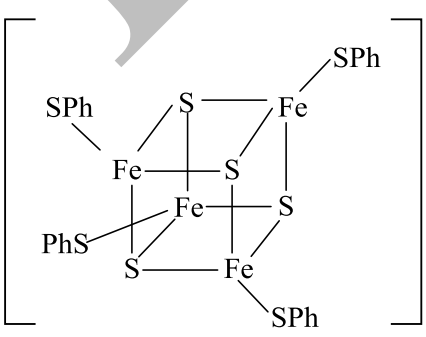
2.4

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

(Y) **(Z)**

(1 mark)

2.5



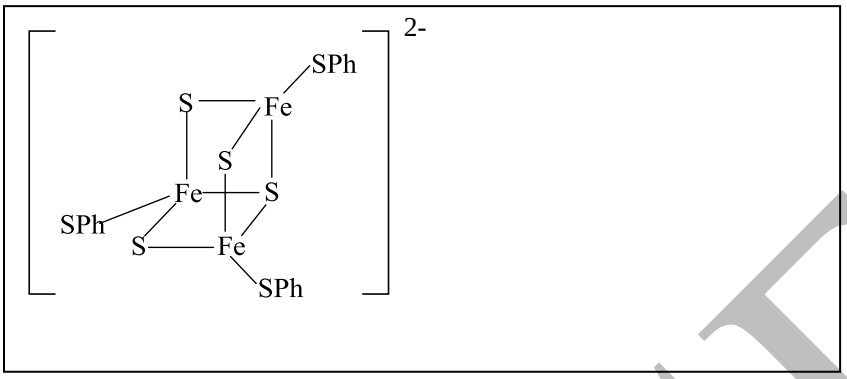
(1 mark)

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]

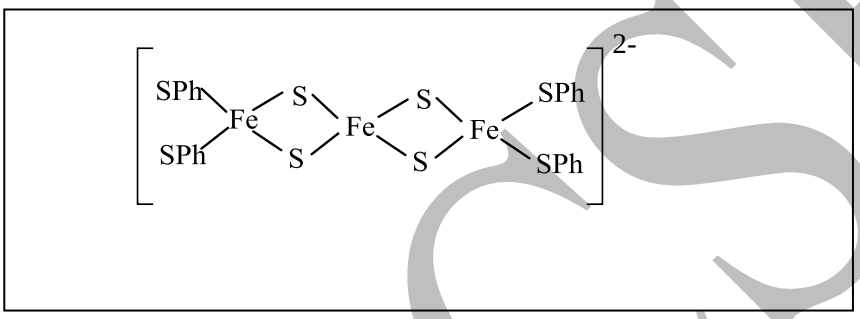
(2 marks)

2.7



(1 mark)

2.8



(1 mark)

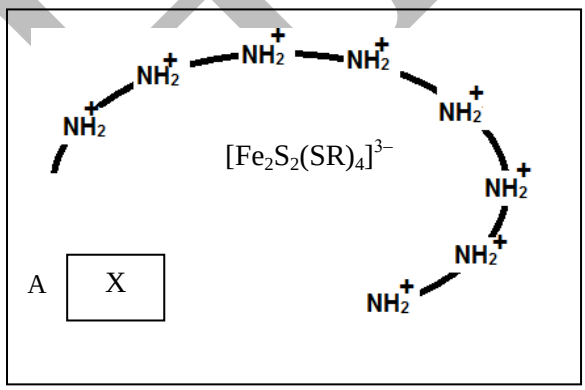
2.9 the most ionic Fe-S bond the least ionic Fe-S bond

a) C_6H_5S-Fe(III) [X] d) S-Fe(II) [X]

(1 mark)

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)**

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

Part B: Use of iron in "blue" colours

2.14

Half cell equations:

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

$C_2O_4^{-2} \rightarrow 5CO_2 + 5e^-$

(1.5 marks)

2.15

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

$Zn + 2Fe^{3+} \rightarrow Zn^{2+} + 2Fe^{2+}$

(1 mark)

2.16

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

$5Fe^{2+} \rightarrow 5Fe^{3+} + 5e^-$

(1 mark)

2.17

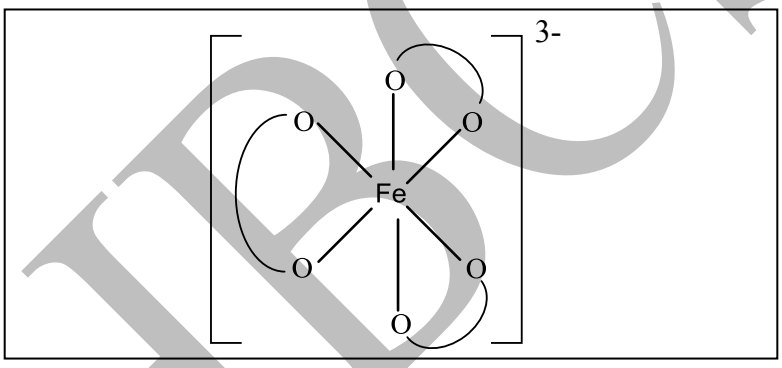
Calculations for oxalate content: moles of oxalate ion = 1.52×10^{-3} moles

Calculations for iron content: moles of $Fe^{2+} = 4.998 \times 10^{-4}$ moles

Molar ratio of iron: oxalate (to the nearest whole number) = 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

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

(1 mark)

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

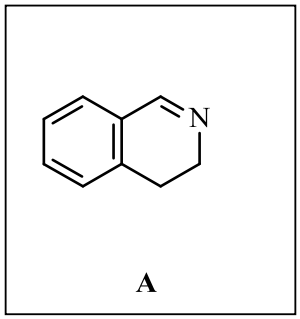
$[Fe(C_2O_4)_2]^{2-}(aq) + [Fe(CN)_6]^{3-}(aq) \rightarrow [\,Fe(Fe(CN)_6\,)]^-(aq) + 2C_2O_4^{2-}(aq)$

(1 mark)

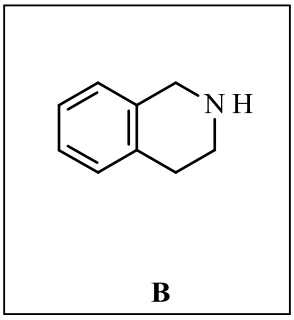
Problem 3 **23 Marks**

Alkaloids

3.1



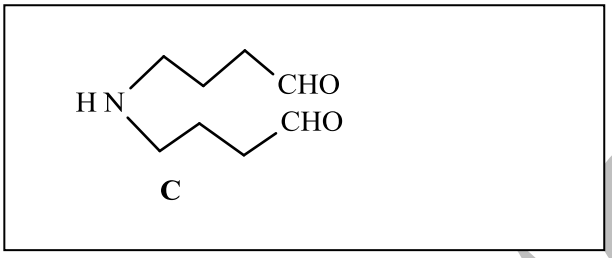
A



B

(2 marks)

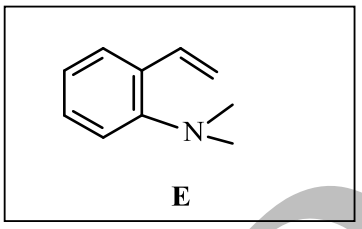
3.2



C

(1.5 marks)

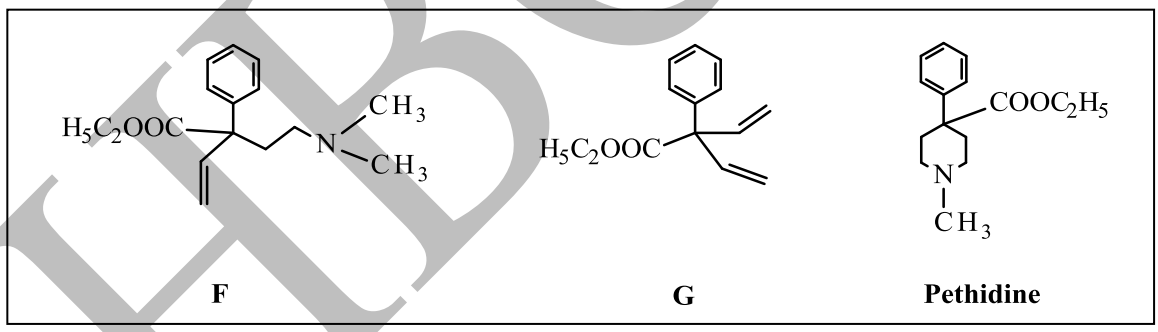
3.3



E

(1 mark)

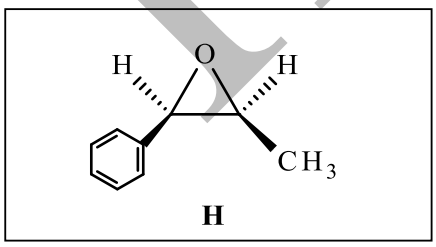
3.4



F **G** **Pethidine**

(3 marks)

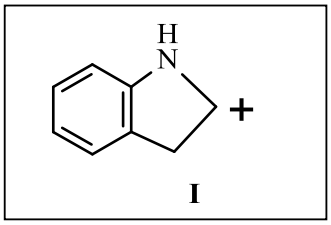
3.5



H

(2 marks)

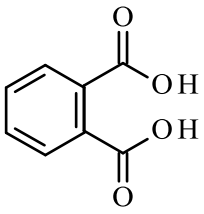
3.6.



I

(1 mark)

3.7



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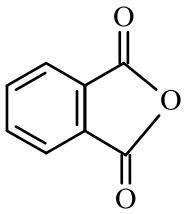
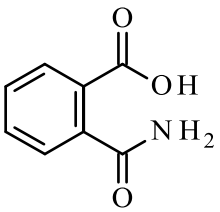
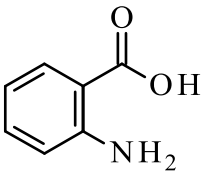


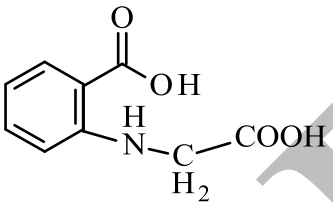
K



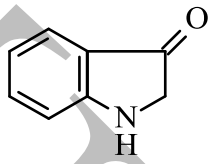
L



M



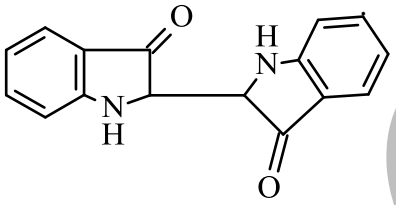
N



O

(4 marks)

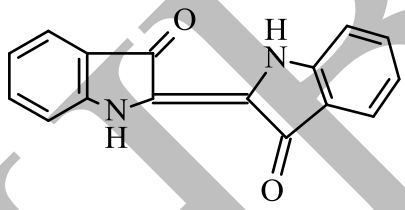
3.8



P

(1 mark)

3.9



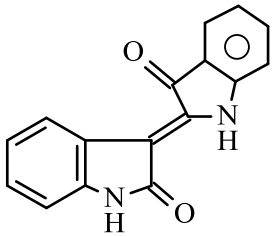
Q

(1 mark)

3.10 2

(0.5 mark)

3.11

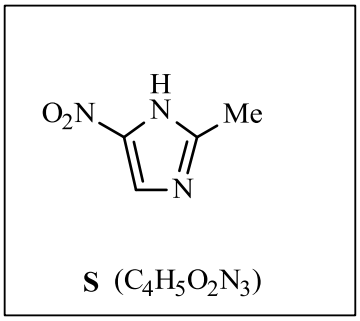


R

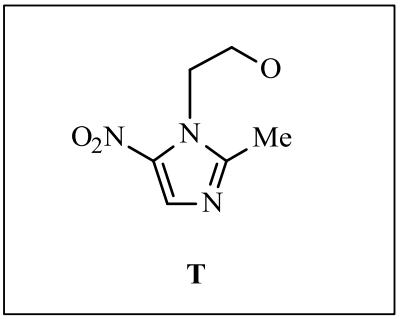
(1 mark)

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

3.13



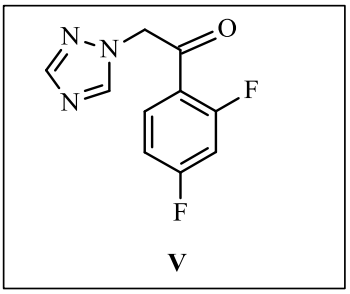
S ($C_4H_5O_2N_3$)



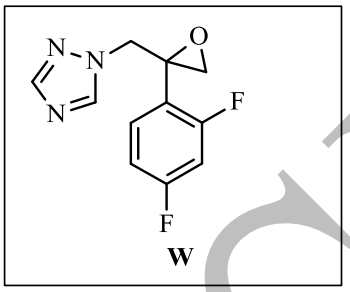
T

(1 mark)

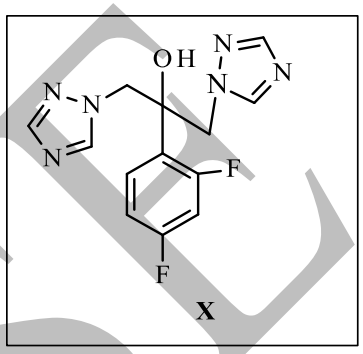
3.14



V



W



X

(2.5 marks)

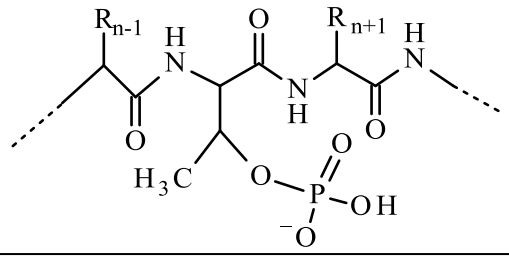
Problem 4 **26 marks**

Understanding Milk

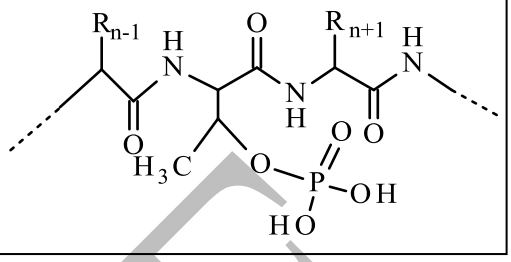
Part A: Proteins in Milk

4.1

pH =6.6



pH=1.8



(1.5 marks)

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

4.3

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

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

(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.

N concentration as caseins in milk = 6.86 – 1.49 g L^{-1}= 5.37 g L^{-1}

Concentration of caseins in milk sample = 5.37 × 100/15.65 = 34.3 g L^{-1}

(2 marks)

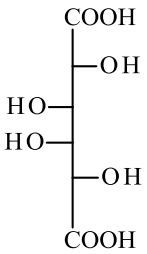
4.7

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

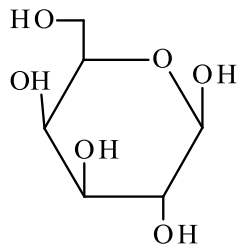


Q

Optically inactive [X]

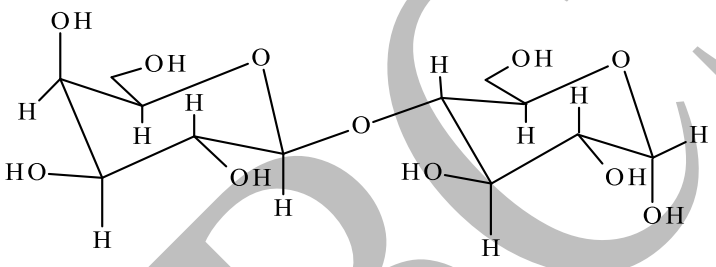
(1.5 marks)

4.10

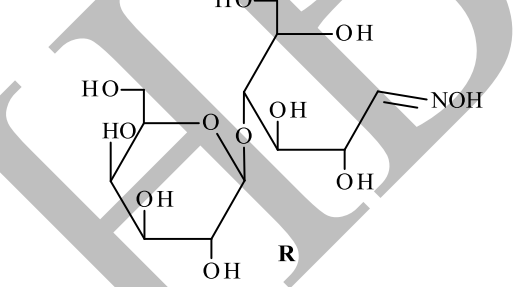


(0.5 mark)

4.11



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 = 0.35/0.20 = 1.75 **(1 mark)**

5.5 The mixture consists of 29.76 mol % H_2 and 70.24 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 35.5 mol dm^{-3} of H_2O and 2.27 mol dm^{-3} of D_2O and 17.6 mol dm^{-3} of HDO **(2.5 marks)**

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

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