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
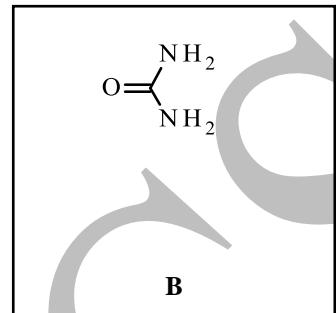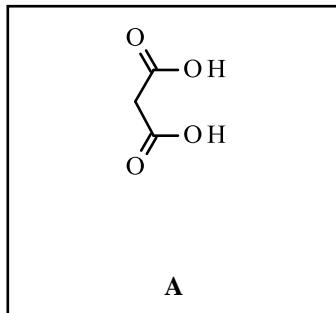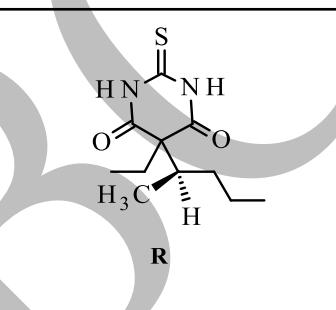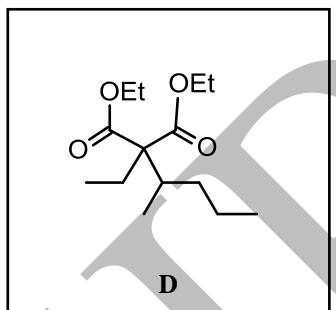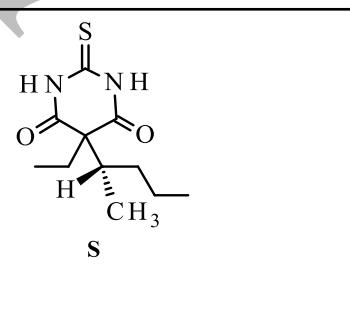
(2.5 marks)

1.3
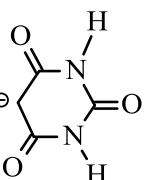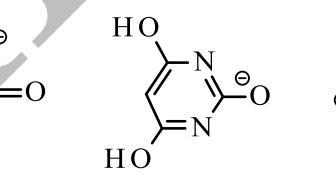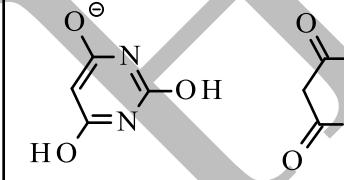
Or any equivalent resonance structure

(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
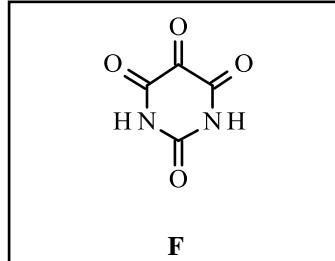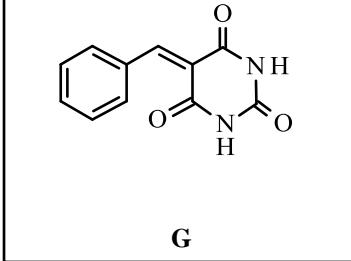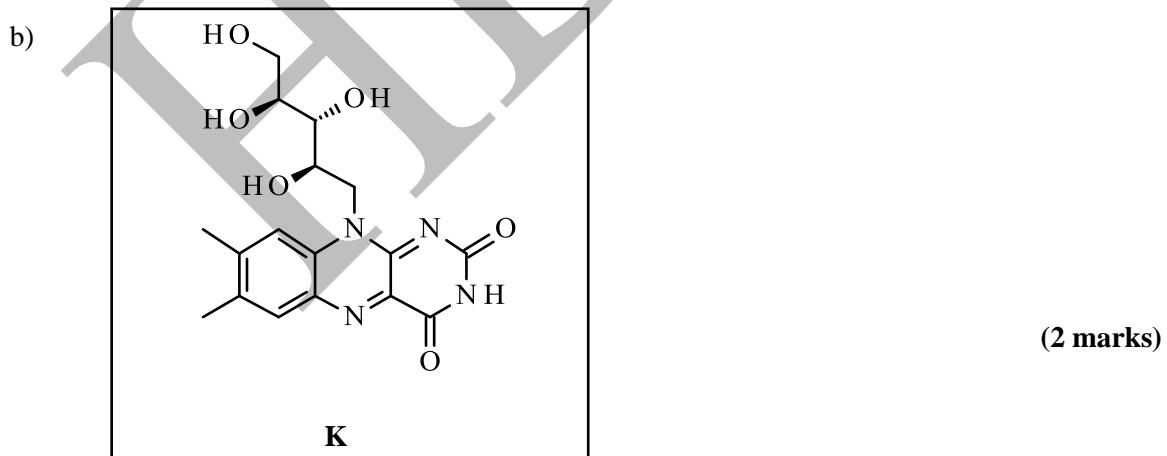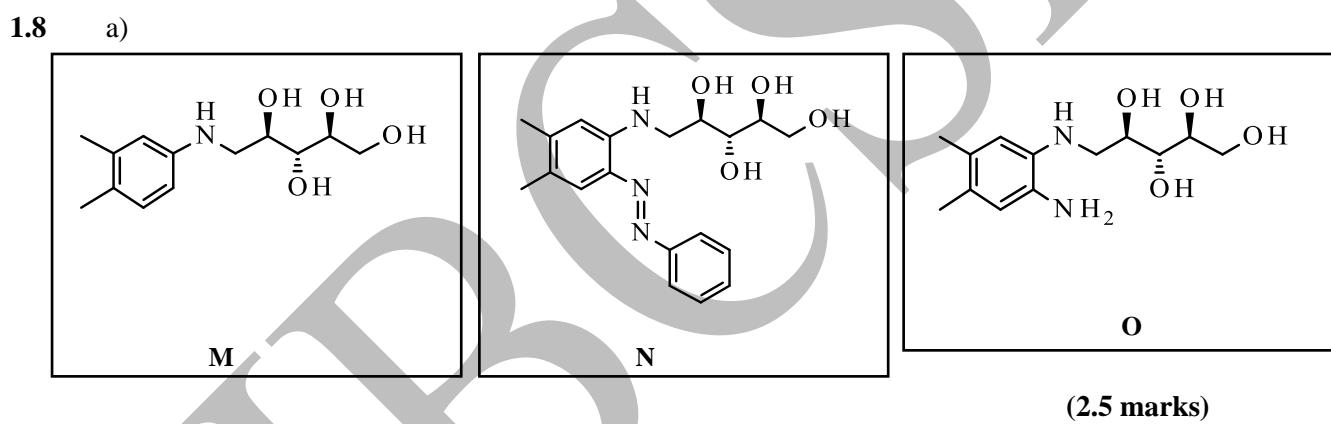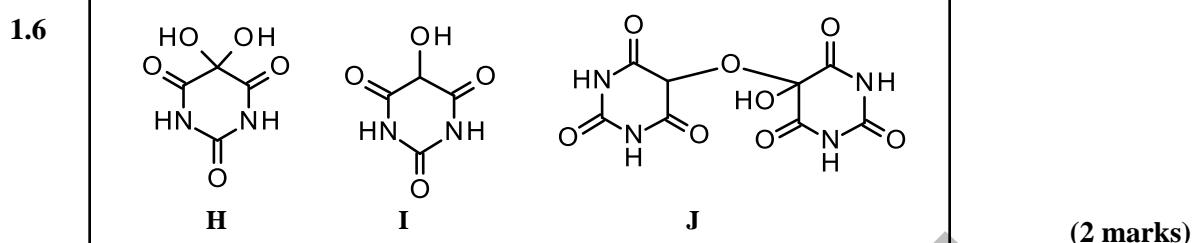
(2 marks)

1.9
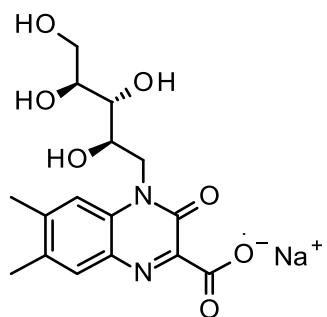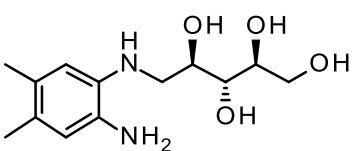
P   **Q**

(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 $[Fe(SPh)_4]^{2-}$
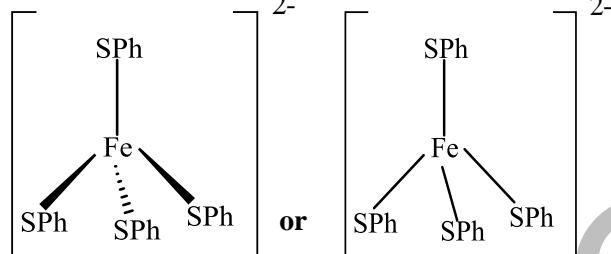
Geometry: Tetrahedral

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)
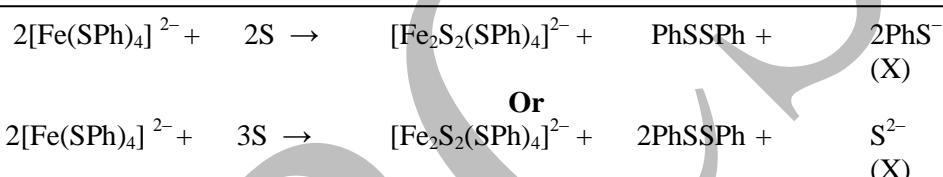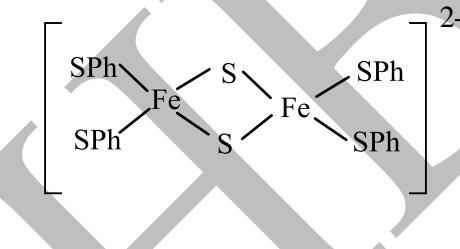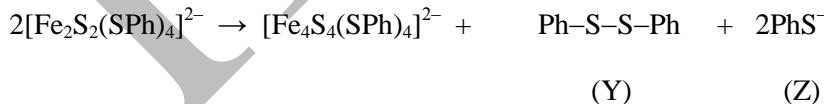
(1 mark)

2.5
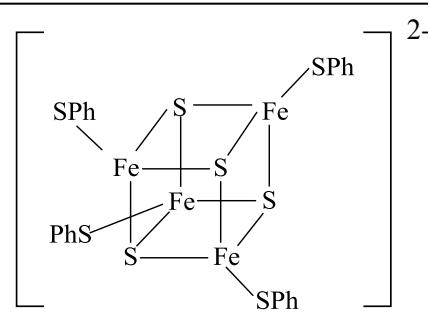
(1 Mark)

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
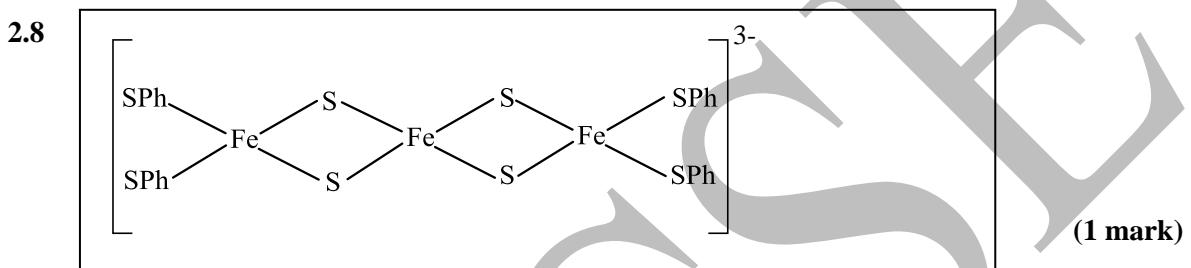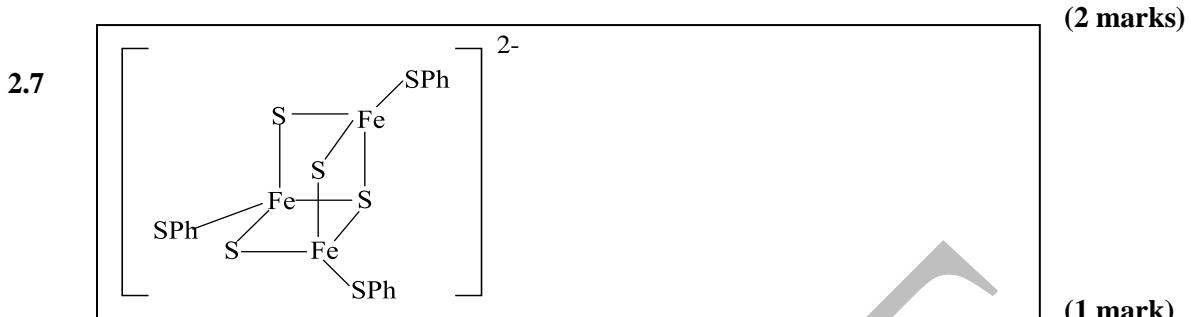
(1 mark)

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:
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
$Fe^{2+} \rightarrow Fe^{3+} + e^-$
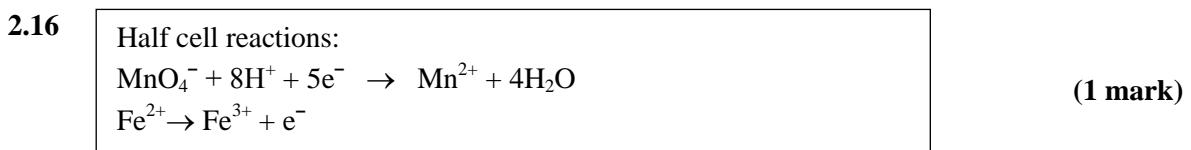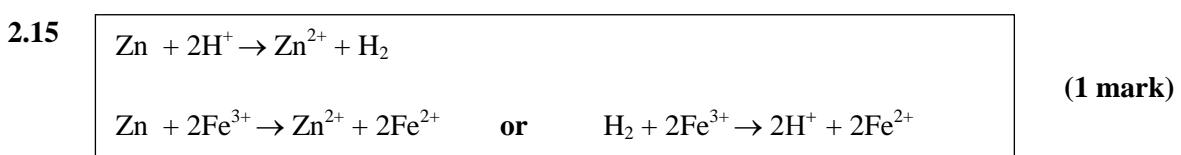
(1 mark)

2.17

Moles of oxalate ion $= 1.52 \times 10^{-3}$ 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

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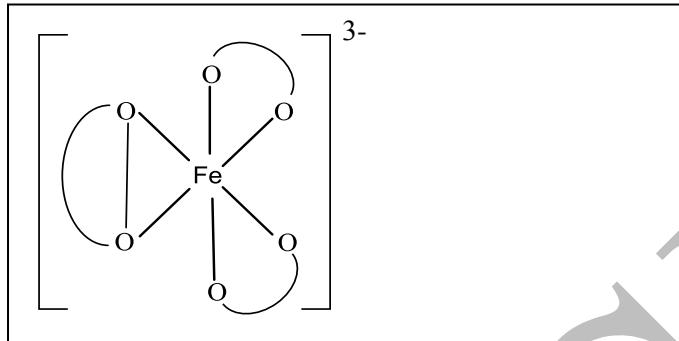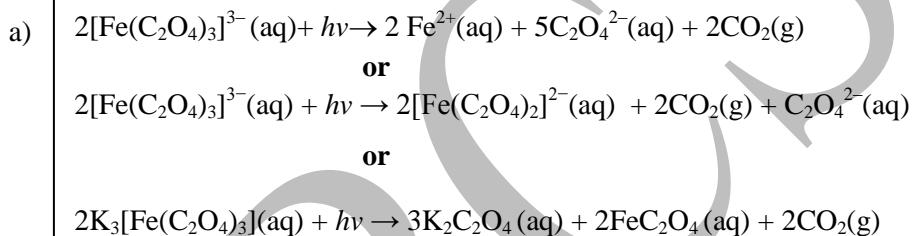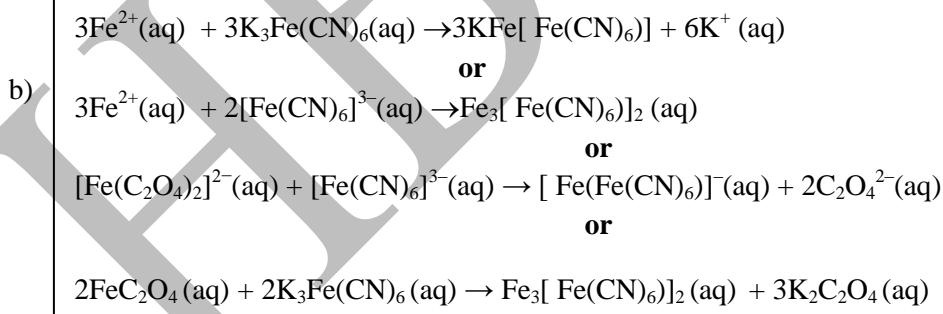
(1 mark)

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.

or

I   **(1 mark)**

7
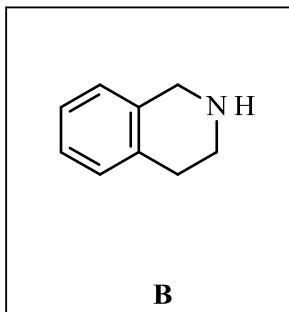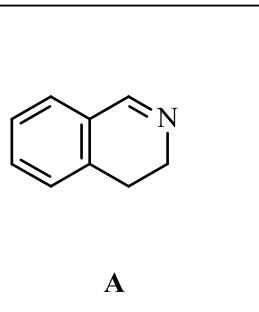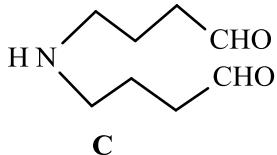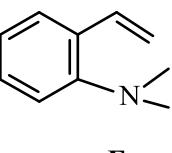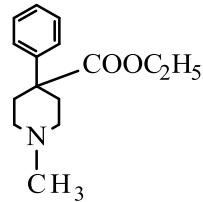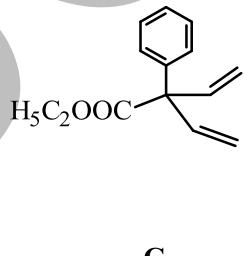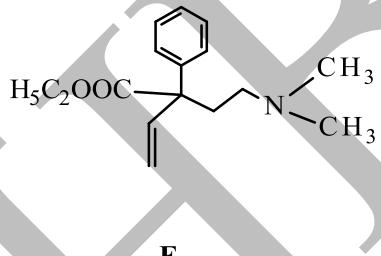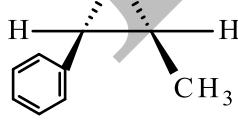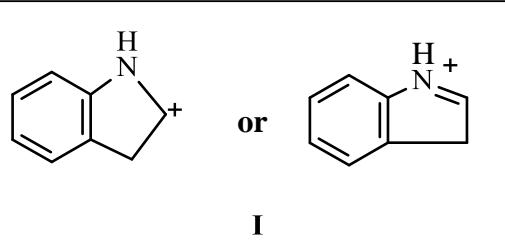
3.7
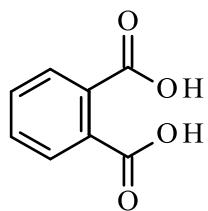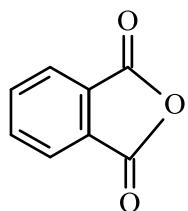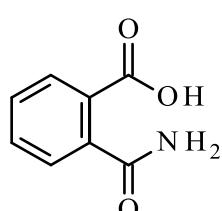
J　　　　　　K　　　　　　L
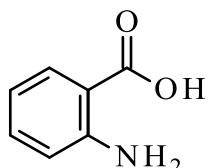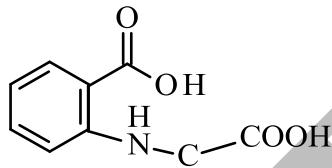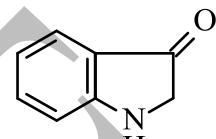
M　　　　　N　　　　　O

(4 marks)

3.8
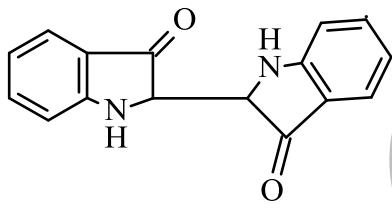
P

(1 mark)

3.9

Q

(1 mark)

3.10

2
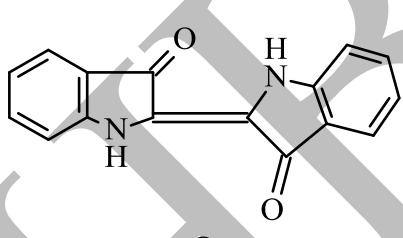
(0.5 mark)

3.11
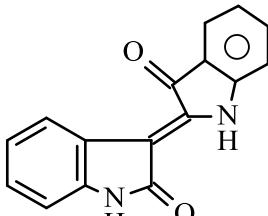
R

(1 mark)

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

3.13
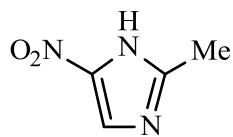
S ($C_4H_5O_2N_3$)
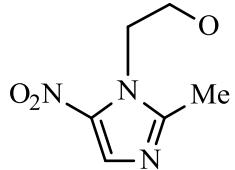
T

(1 mark)

3.14

V

W

X
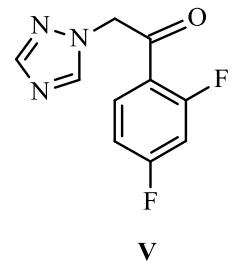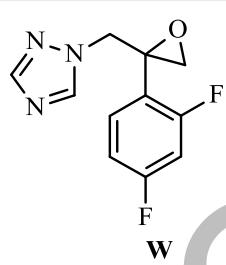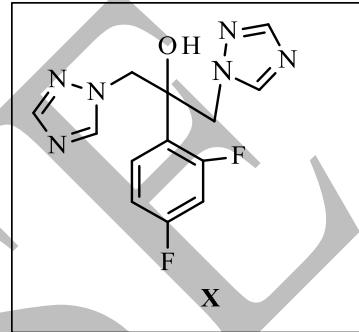
(2.5 marks)

Problem 4   **26 marks**

Understanding Milk

Part A: Proteins in Milk

4.1
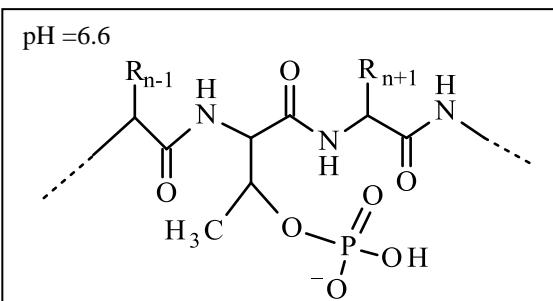
pH =6.6	pH=1.8
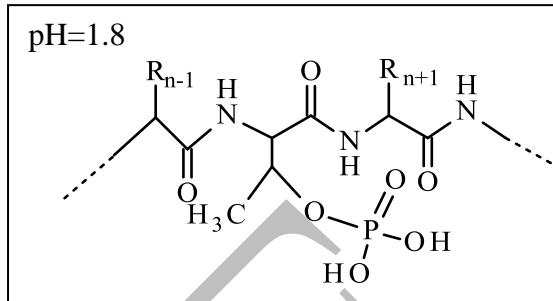
                                                                                                                   (1.5 marks)

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

$$NH_3 + H_2O + H_3BO_3 \rightarrow NH_4^+ B(OH)_4^-$$
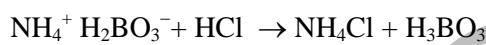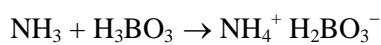
$$NH_4^+ B(OH)_4^- + HCl \rightarrow NH_4Cl + H_3BO_3 + H_2O$$ **(1.5 marks)**

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)**

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Part B: Carbohydrates in Milk

4.9

COOH
—OH
HO—
HO—
—OH
COOH
Q

Optically inactive | X |

(1.5 marks)

4.10

HO—
OH   O   OH
OH
OH

(0.5 mark)

4.11

OH
OH   O   H   OH   O
H   H   H   OH   H
H   H   O   HO   OH   H
HO—   OH   H   OH
H   OH
H

(2 marks)

4.12

HO—
—OH
HO—   OH   NOH
HO   O   O
OH   OH
OH   **R**
OH
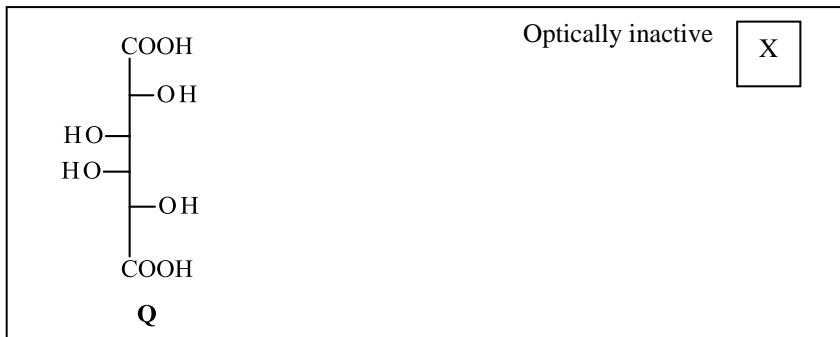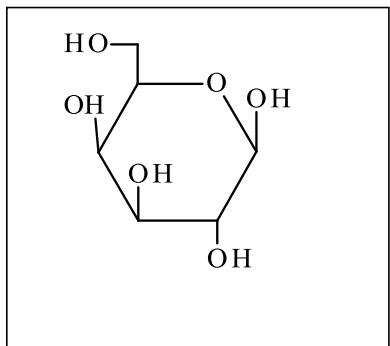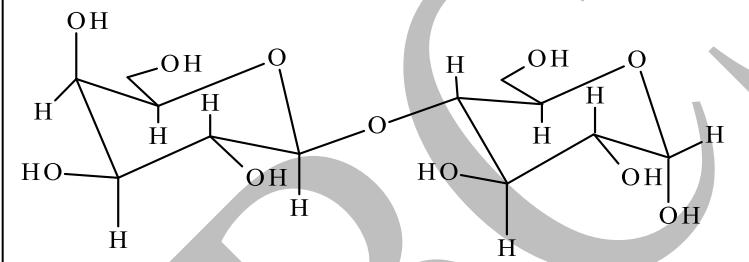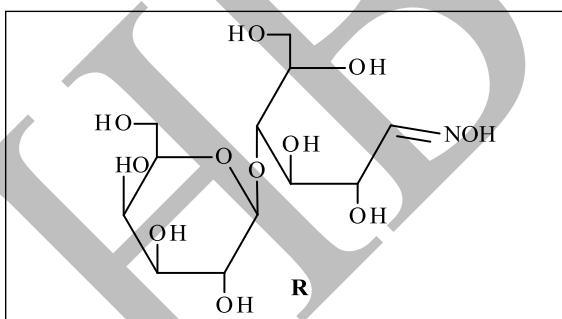
(1 mark)

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 $\lambda_H - \lambda_D = 1.8 \text{ Å}$ **(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) ☒   c) ☒

       False: a) ☒   d) ☒   **(2 marks)**

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

5.8   ii) ☒   **(1 mark)**

5.9   **(2.5 marks)**
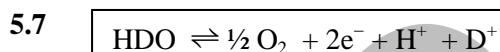
If $K_{eq} = [HDO(l)]/[D_2O(l)] [H_2O(l)]$ is taken (as mistakenly given in the question paper), then

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 $K_{eq} = [HDO(l)]^2/[D_2O(l)] [H_2O(l)]$ 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.

5.10   b) ☒   c) ☒   **(2 marks)**

5.11   a) ☒   **(1.5 marks)**