Any alternative method of solution to any question that is scientifically and mathematically correct, and leads to the same answer is accepted with full credit. Partially correct answer gains partial credit.

For questions requiring calculations, full credit is given only if necessary steps of the calculations are written. In problems having related sub-parts, consistency of answers of the related sub-parts is also checked in evaluation.

Problem 1 — 19 marks

Water quality in aquaculture

1.1 ii) **X** (**0.5 marks**)

1.2

$2Mn^{2+}(aq) + O_2(aq) + 4OH^-(aq) \rightarrow 2\,MnO(OH)_2(s)$

$MnO(OH)_2(s) + 2I^-(aq) + 4H^+(aq) \rightarrow Mn^{2+}(aq) + I_2(aq) + 3H_2O$

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2\,I^-(aq)$

(**2.5 marks**)

1.3 4 (**1 mark**)

1.4

$n(O_2) = n(S_2O_3^{2-})/4$

Volume of water sample which reacted with Mn^{2+} = 246 mL

DO concentration in sample = 4.88×10^{-3} g L^{-1} = 4.88 ppm

(**2 marks**)

1.5

Moles of Mn^{2+} = 2* moles of O_2

Total moles of Mn^{2+} required = 0.211 mmol

(**2 marks**)

1.6

$N_3^-(aq) + 2H^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + N_2O(g) + H_2O$

(**1 mark**)

1.7

$H^+(aq) + OH^-(aq) \rightleftharpoons H_2O$

$H^+(aq) + CO_3^{2-}(aq) \rightleftharpoons HCO_3^-(aq)$

$H^+(aq) + HCO_3^-(aq) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons CO_2(g) + H_2O$

(**1.5 marks**)

1.8 (**3 marks**)

Relationship	Ion(s) present in water sample
P = **M**	OH^-
2**P** = **M**	CO_3^{2-}
M > 0; **P** = 0	HCO_3^-
P > **M**/2	$OH^- + CO_3^{2-}$
P < **M**/2	$CO_3^{2-} + HCO_3^-$

1.9 (**2 marks**)

$[H^+] = 10^{-6.4} \times [CO_2] / [HCO_3^-]$

pH = 7.4

1.10 **iii)** X (**1 mark**)

1.11 (**2.5 marks**)

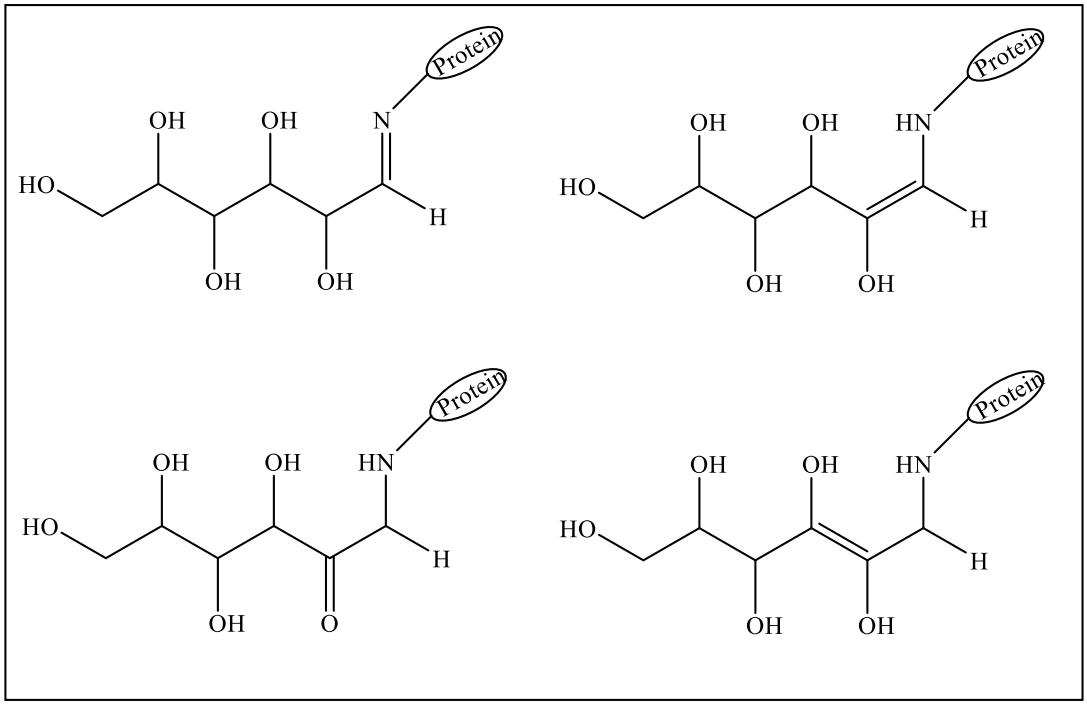
Chlorine dose = 8 ppm

The amount of bleaching powder required is 205.1 kg.

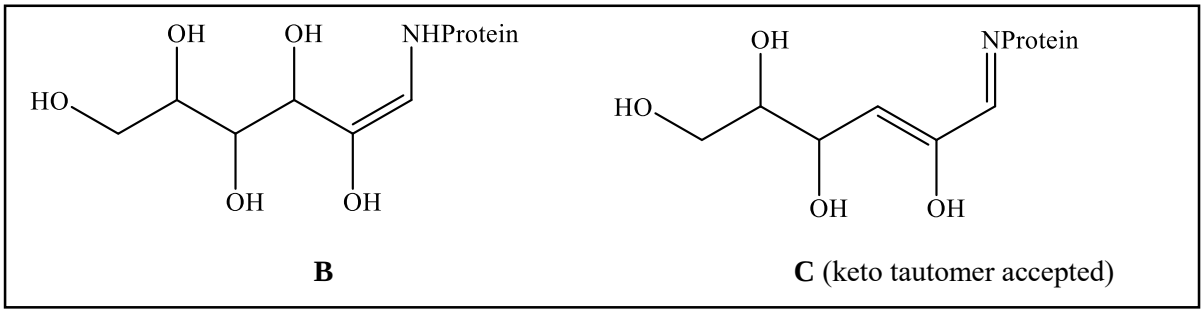
Problem 2 — 23 marks

Maillard reaction in cooking

2.1 **(2 marks)**



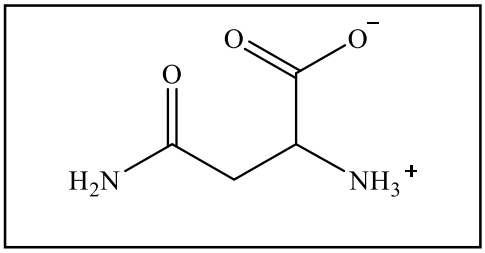
2.2



B **C** (keto tautomer accepted)

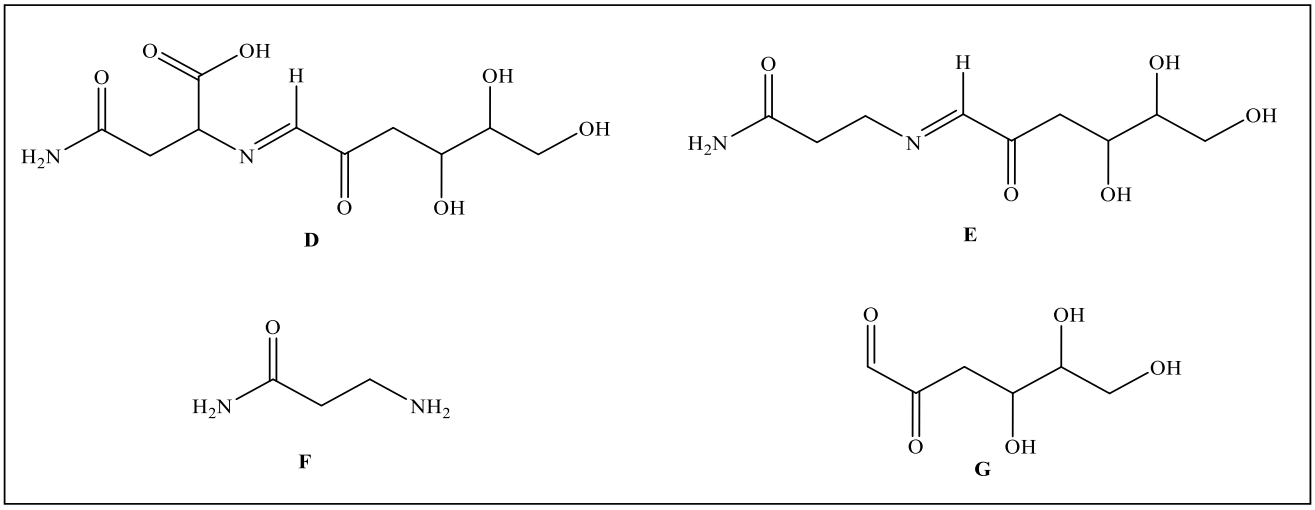
(1.5 marks)

2.3



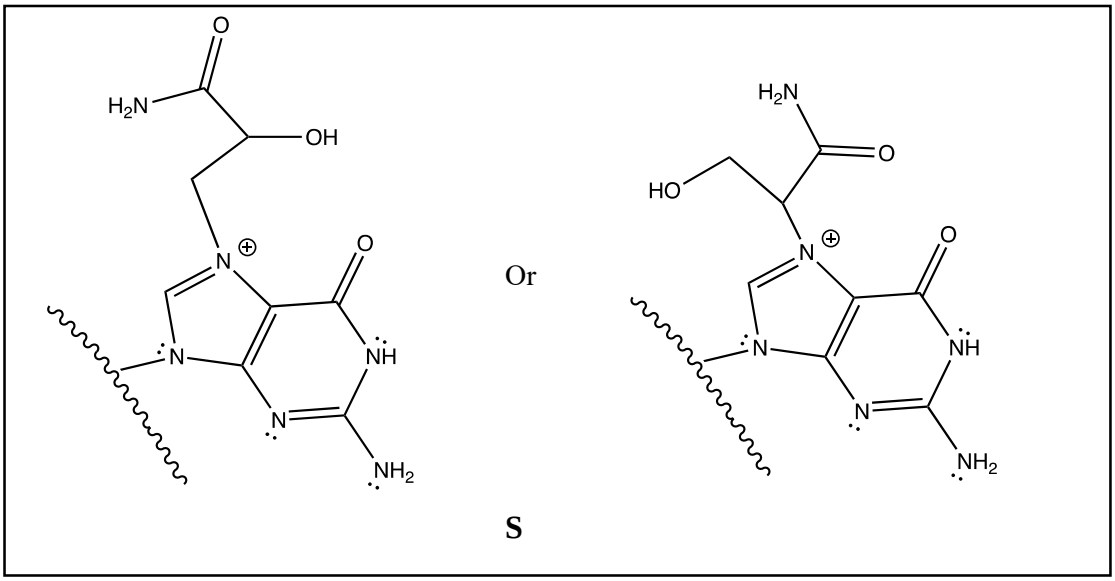
(1 mark)

2.4



(2.5 marks)

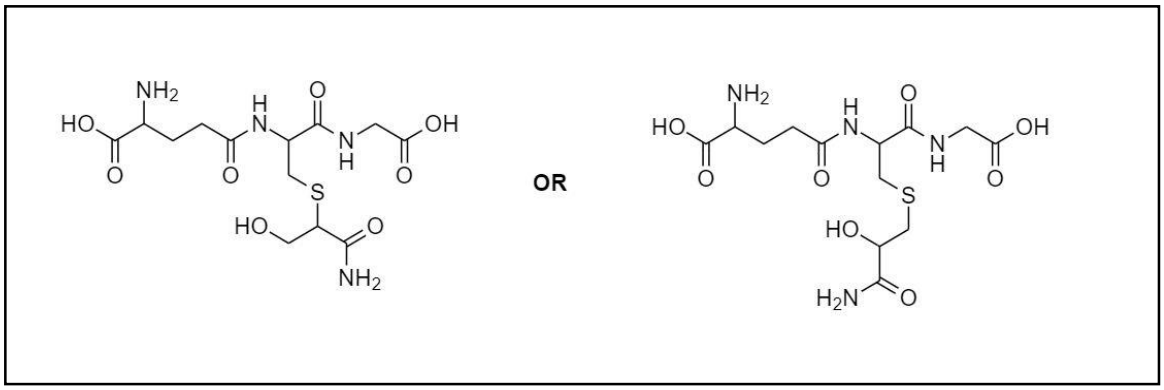
2.5



S

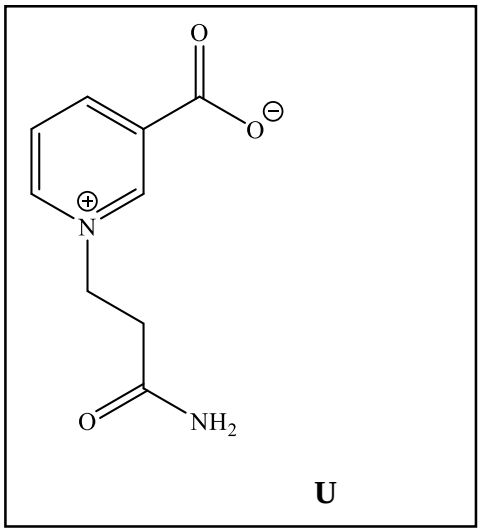
(1 mark)

2.6



(1 mark)

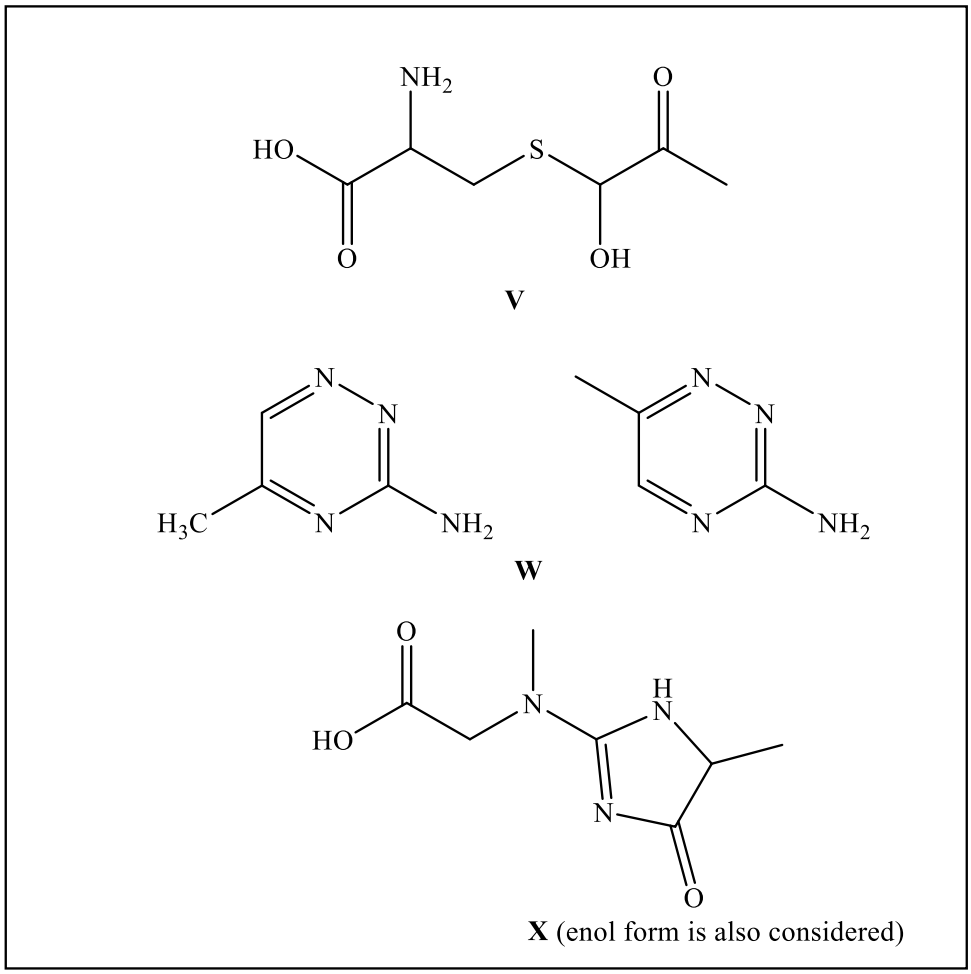
2.7 i)



U

(1 mark)

ii)



(4 marks)

2.8 **(9 marks)**

	T/F	Supporting/ Correlating Fact(s)
a)	T	Fact IV
b)	F	Fact III
c)	F	Fact IV
d)	T	Facts II and V
e)	T	Facts I and V
f)	F	Facts I and III

Problem 3 20 marks

Historical alum production and dyeing

3.1 ii) X **(0.5 marks)**

3.2 i) **(2 marks)**

$FeS_2(s) + 3O_2(g) \rightarrow FeSO_4(s) + SO_2(g)$ **OR** **A**

$FeS_2(s) + 3.5O_2(g) \rightarrow FeSO_4(s) + SO_3(g)$ **A**

$2FeS_2(s) + 7O_2(g) + 2H_2O(g) \rightarrow 2FeSO_4(s) + 2H_2SO_4(aq)$ **OR** **B**

$FeS_2(s) + 3O_2(g) + H_2O(g) \rightarrow FeSO_4(s) + H_2SO_3(aq)$ **B**

ii) **(2 marks)**

$4FeS_2(s) + 7H_2O(l) \rightarrow 7H_2S(g) + FeSO_4(aq) + 3FeO(s)$

OR

$2FeS_2(s) + 2H_2O(l) + 3O_2 \rightarrow 2H_2S(g) + 2FeSO_4(aq)$

OR

$FeS_2(s) + H_2O(l) \rightarrow H_2S(g) + FeO(s) + S(s)$

OR

$FeS_2(s) + 3H_2O(l) + H^+ \rightarrow 2H_2S(g) + Fe(OH)_3(s)$

iii) **c)** X **(2 marks)**

iv)

$CO(NH_2)_2 \rightarrow NH_3\ (aq) + HNCO$

OR

$CO(NH_2)_2 + H_2O \rightarrow 2NH_3\ (aq) + CO_2$

$NH_3\ (aq) + H_2SO_4\ (aq) \rightarrow (NH_4)_2SO_4$

$Al_2(SO_4)_3 + (NH_4)_2SO_4 + 24H_2O\ (l) \rightarrow 2(NH_4)Al(SO_4)_2.12H_2O\ (s)$

$K_2O + H_2SO_4(aq) \rightarrow K_2SO_4 + H_2O(l)$

$Al_2(SO_4)_3 + K_2SO_4 + 12H_2O \rightarrow 2KAl(SO_4)_2.12H_2O\ (s)$

(**3 marks**)

3.3

$CaO\ (s) + 2NH_4Al(SO_4)_2.12H_2O\ (s) \rightarrow CaSO_4\ (s) + 2NH_3(g) + 2Al_2(SO_4)_3 + 25H_2O\ (l)$

$CaO\ (s) + KAl(SO_4)_2.12H_2O\ (s) \rightarrow$ No perceptible change

(**1.5 marks**)

3.4

$3Fe^{2+}\ (aq) + 2K_3[Fe(CN)_6]\ (aq) \rightarrow Fe_3[Fe(CN)_6]_2 + 6K^+\ (aq)$

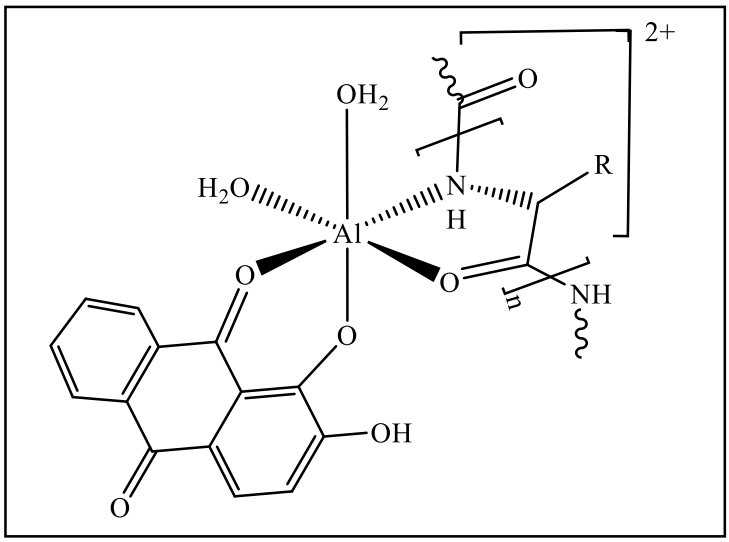
Balanced reaction producing Prussian blue is also considered

(**1 mark**)

3.5 iv) X

(**1.5 marks**)

3.6 i)



(**2 marks**)

ii) 8

(**1.5 marks**)

3.7

i) Mordant required for 2 Kg Fabric = 300 g

ii) mass of Al in effluent (hydrated aluminium sulphate) > mass of Al in effluent (potash alum)

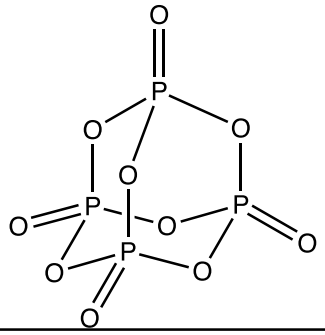
(**3 marks**)

Problem 4 — 23 marks

The Odyssey of Match sticks

4.1 Initiator fuel: White Phosphorous Oxidizer: Aerial Oxygen (**1 mark**)

4.2 $P_4 + 5O_2 \rightarrow P_4O_{10}$ (**2 marks**)



4.3 **iii)** X (**1 mark**)

4.4 Initiator fuel: Sugar Oxidizer: $KClO_3/HClO_3$ (**1.5 marks**)

4.5 Sugar or Gum (**1 mark**)

4.6 **ii)** X (**1.5 marks**)

4.7 Initiator fuel: Antimony (III) sulfide Oxidizer: $KClO_3$ (**1 mark**)

4.8

i) $2KClO_3 \rightarrow 2KCl + 3O_2$

ii) $\Delta H^0_{rxn} = 2(\Delta H^0_{KCl}) + 3\,(\Delta H^0_{O_2}) - 2\,(\Delta H^0_{KClO_3})$

$= -77.6$ kJ mol^{-1} of reaction **or**

$= -38.8$ kJ mol^{-1} of $KClO_3$

iii) $\Delta S^0_{rxn} = 2(S^0_{KCl}) + 3\,(S^0_{O_2}) - 2\,(S^0_{KClO_3})$

$= 499.6$ J K^{-1} mol^{-1}

Gibbs free energy (ΔG^0_{rxn}) at the flame temperature (450 K) would be

$\Delta G^0_{rxn} = \Delta H^0_{rxn} - T\Delta S^0_{rxn}$

$= -302.4$ kJ mol^{-1} of reaction **or**

$= -151.2$ kJ mol^{-1} of $KClO_3$

(**4 marks**)

4.9 iv) X **(0.5 marks)**

4.10 $2Sb_2S_3 + 9O_2 \rightarrow 2Sb_2O_3 + 6SO_2$ **(1 mark)**

4.11 i) X **(1 mark)**

4.12 Combustion of 5.0 μg white phosphorous releases 0.12 J
Rise in temperature = 285.7 K
Final temperature = 585.7 K **(3 marks)**

4.13 The volume of the matchstick head is = 0.034 cm^3
The total mass of decomposing mixture in the matchstick head = 0.068 g
Out of this, 0.0272 g is potassium chlorate and 0.0122 g is antimony sulfide
Total heat released is = 42.47 J
Temperature rise = 1206.5 °C
(4.5 marks)

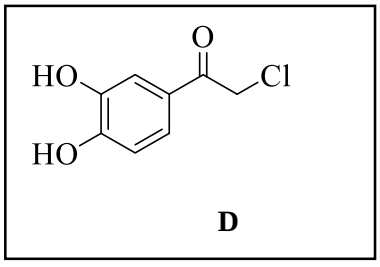
Problem 5 21 marks

Chemistry and Brain

5.1 i) **B** **ii)** **B** **(1 mark)**

5.2 4-(2'-aminoethyl)-2-methoxyphenol **(1 mark)**

5.3



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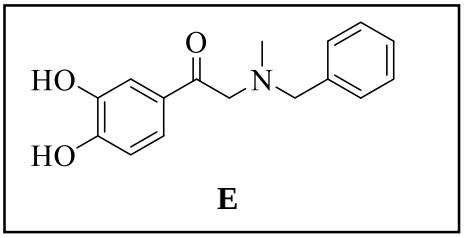

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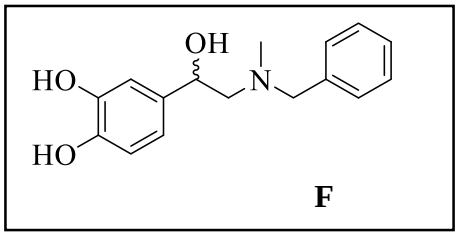

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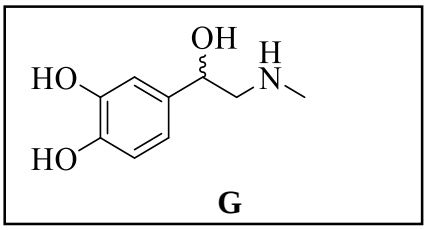
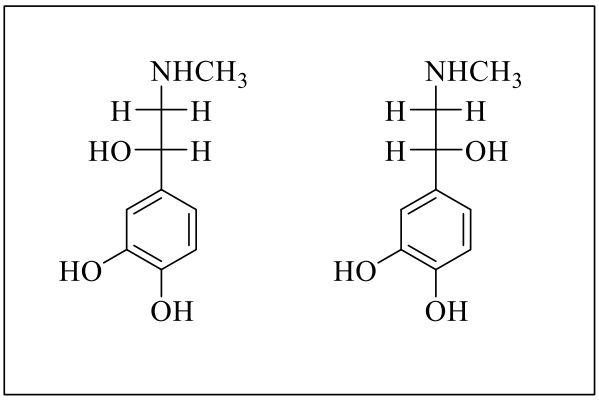


G

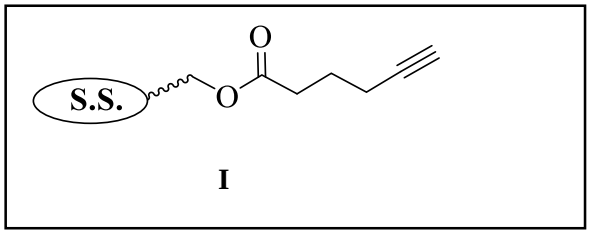
(2.5 marks)

5.4

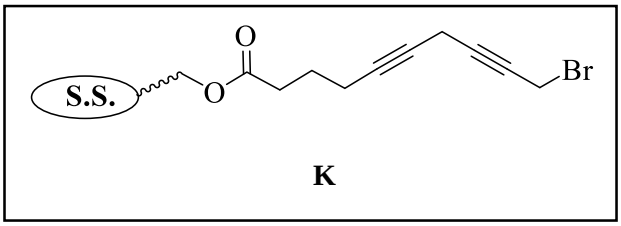


(1 mark)

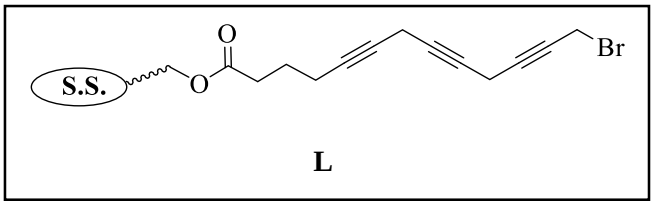
5.5



I



K



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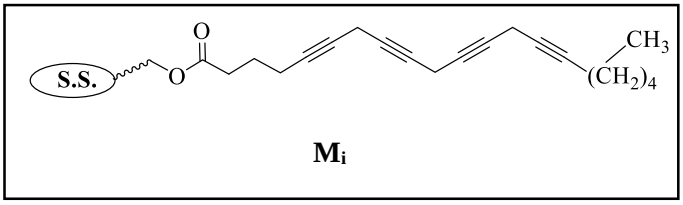
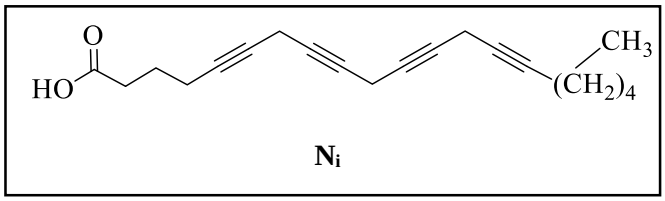
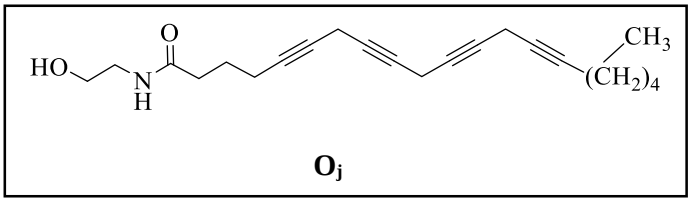


M_i



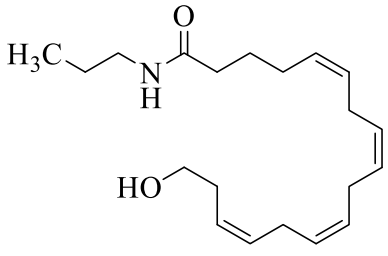
N_i



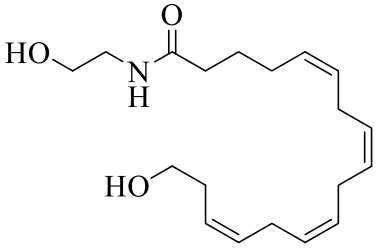
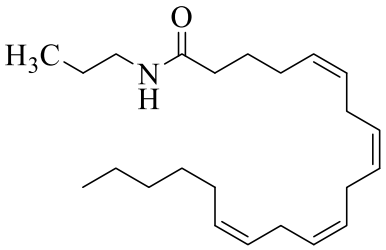
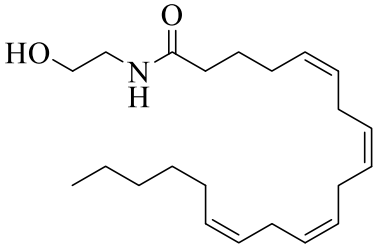
O_j

(7 marks)

5.6

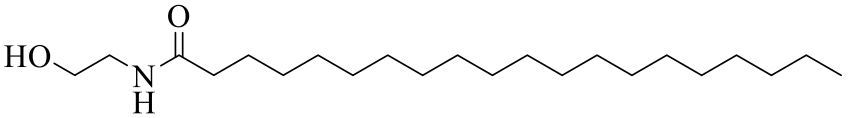
P_1 n=2, R_1 = OH and Z = CH_3	

P_1

P_2 n=2, R_1 = OH and Z = OH	 **P_2**
P_3 n= 5, R_1 = H and Z = CH_3	 **P_3**
P_4 n= 5, R_1 = H and Z = OH	 **P_4**

(3.5 marks)

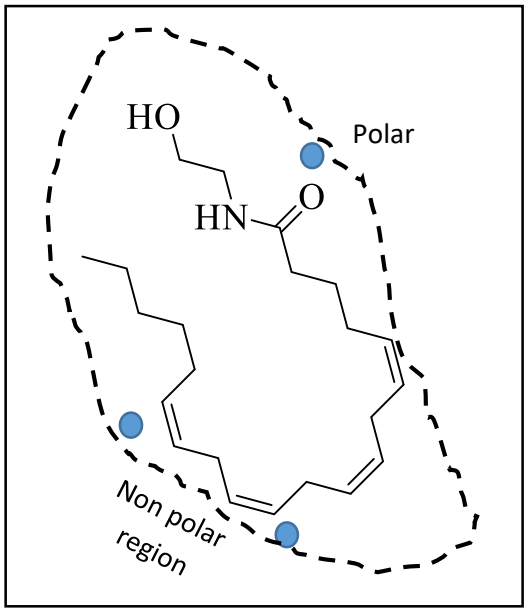
5.7



P_j

(1 mark)

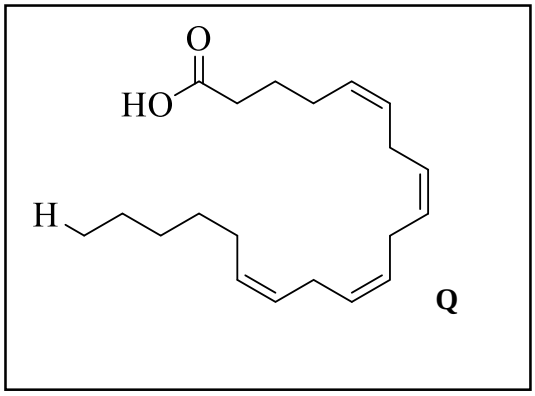
5.8



(1.5 marks)

5.9 **P_3** **X** **(1 mark)**

5.10



Q **(0.5 mark)**

5.11 **i)** X **iv)** X **(1 mark)**