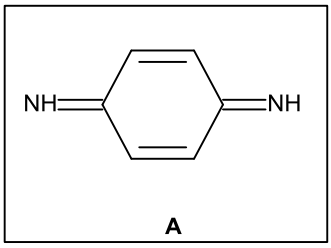
Problem 1 16 marks

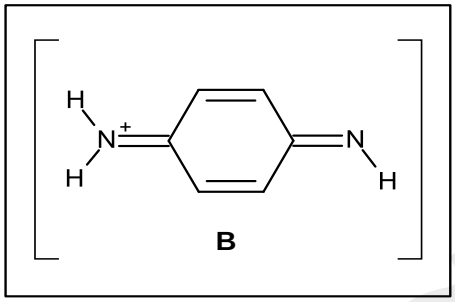
Chemistry of the artificial hair dyes

1.1 **(1 mark)**



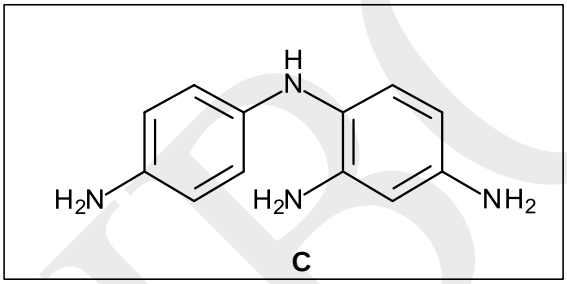
A

1.2 **(0.5 mark)**

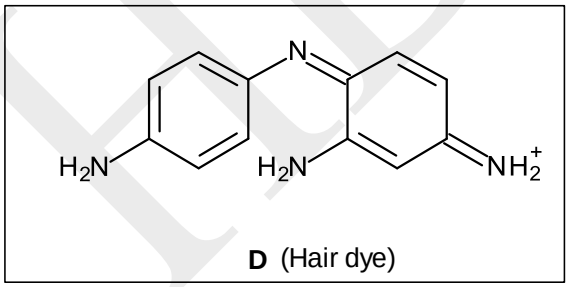


B

1.3 **(2.5 marks)**

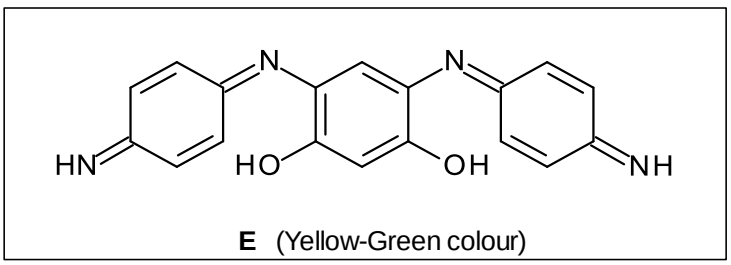


C



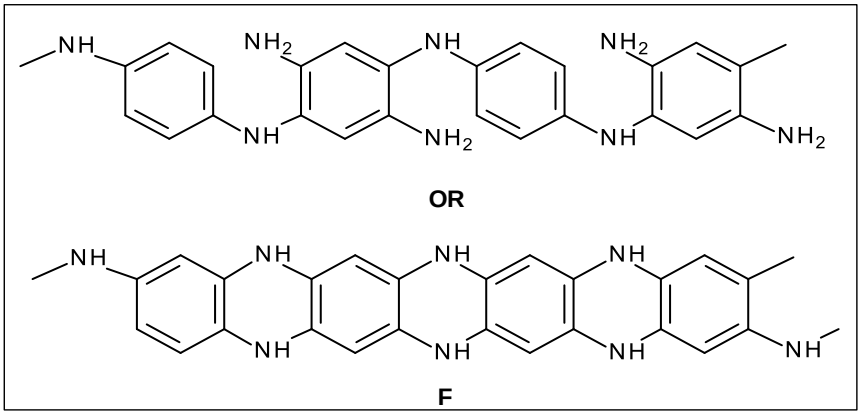
D (Hair dye)

1.4 **(1 mark)**

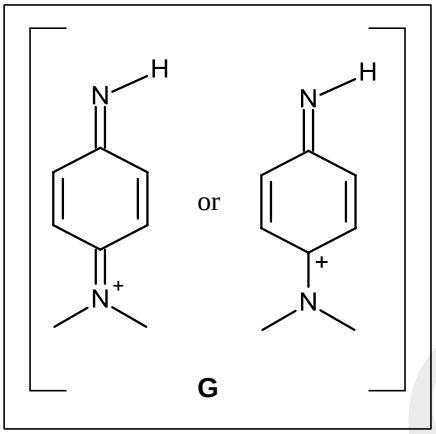


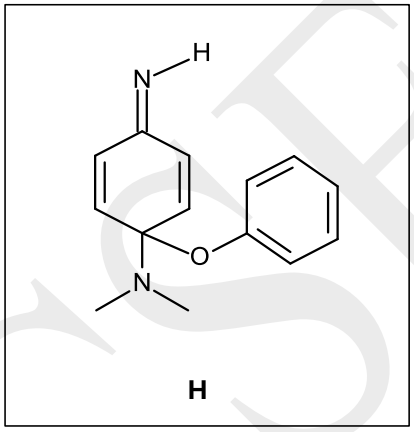
E (Yellow-Green colour)

1.5 **(1 mark)**

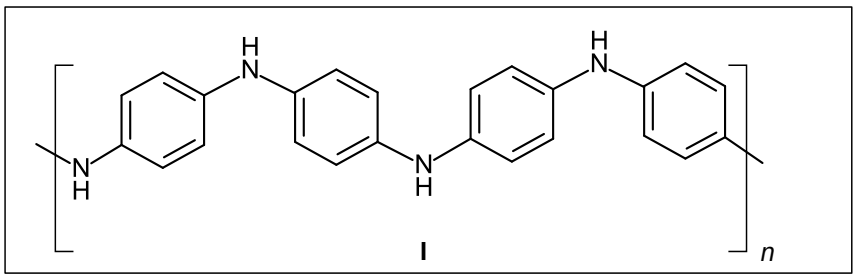


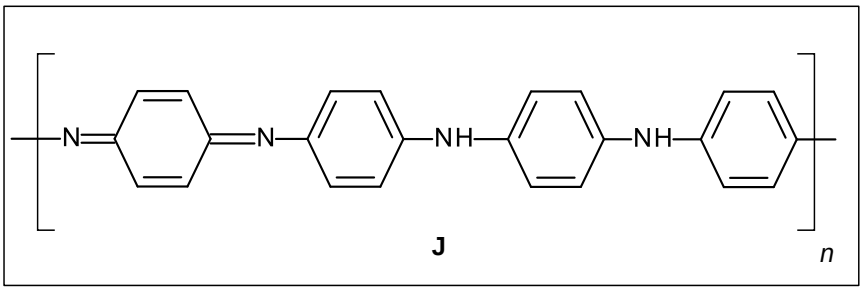
1.6 **(3 marks)**



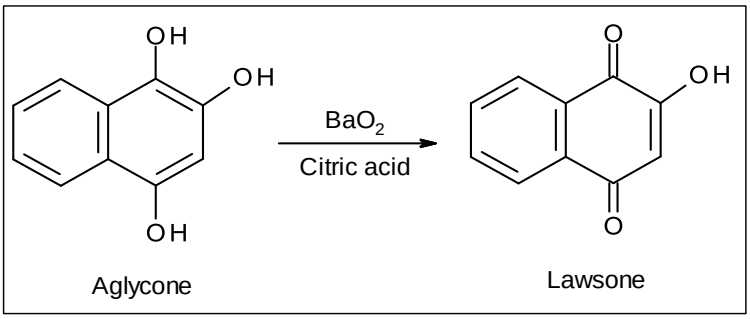


1.7 **(1.5 marks)**

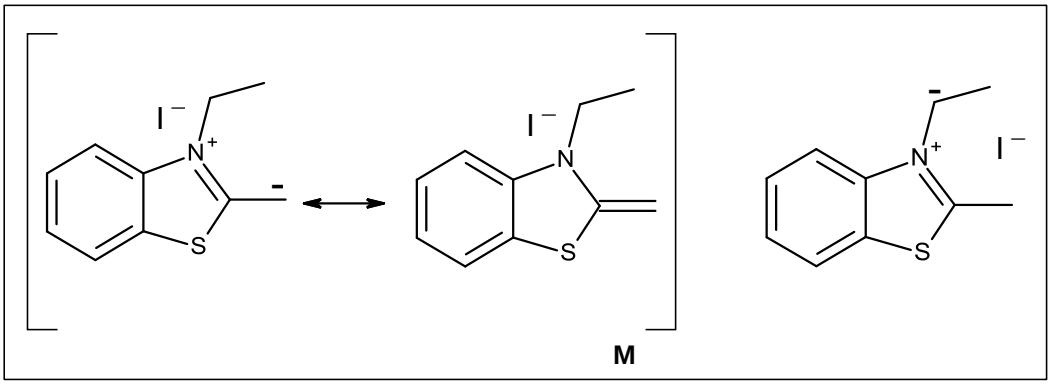


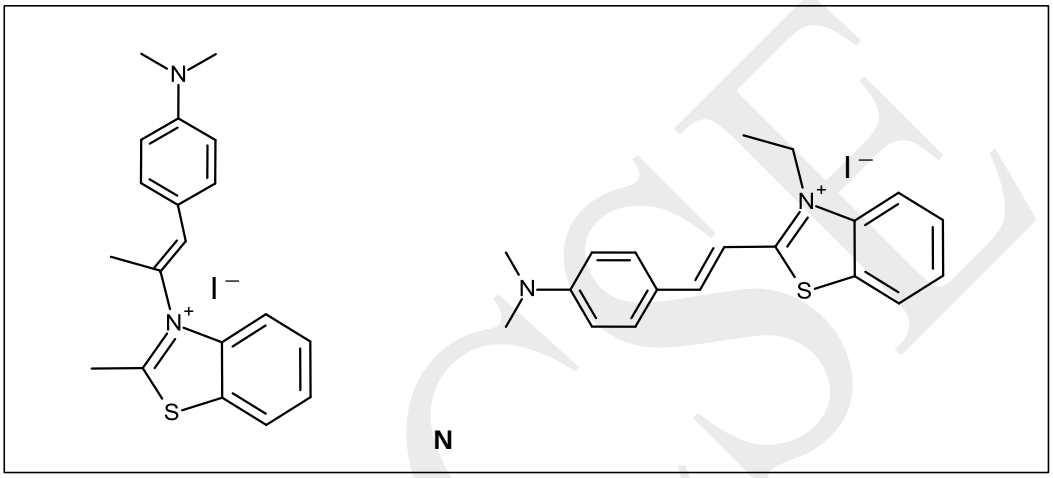


1.8 **(1.5 marks)**



1.9





(4 marks)

Problem 2 — 22 marks

Towards a new Metallurgy from e-waste

2.1 NO_2 (N_2O_4), N_2O, NH_3 (NH_4^+), N_2, NH_3OH^+, N_2H_4, HNO_2 **(3 marks)**

2.2 **(1 mark)**

a) X
b) X
c)
d) X
e) X
f)

2.3

$Cu \rightarrow Cu^{2+} + 2e^-$

$NO_3^- + 4H^+ + 3e \rightarrow NO + 2H_2O$

$3Cu + 8\,HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$ or

$3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{2+} + 2NO + 4H_2O$

Minimum volume of 1 M HNO_3 = 4.20 L

(3 marks)

2.4 **(1.5 marks)**

Metal: Sn

$Sn + 4HNO_3 \rightarrow H_2SnO_3$ (or $SnO_2.H_2O$) + $4NO_2 + H_2O$

2.5 **P_2** = $AgCl$, $PbCl_2$ **P_3** = $PbCrO_4$ **(1.5 marks)**

2.6 $[H^+] = 3.3 \times 10^{-3}$ moles L^{-1} **(3 marks)**

2.7 **P_5** = $PbSO_4$ **P_6** = CuS **(1 mark)**

2.8 **Gas**: H_2S **P_7**: $Fe(OH)_3$ and $Al(OH)_3$ **(1.5 marks)**

2.9

$Zn^{2+}(aq) + OH^-(aq) \rightarrow Zn(OH)_2(s)$

$Ni^{2+}(aq) + OH^-(aq) \rightarrow Ni(OH)_2(s)$

(1.5 marks)

2.10 pH = 8.28 (**3 marks**)

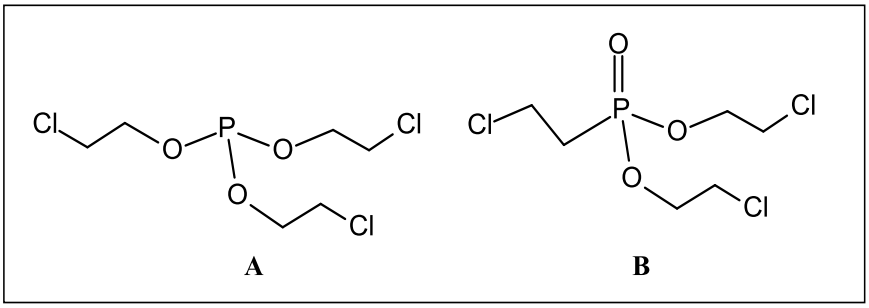
2.11 **M_3** - NiS, **M_4** - ZnS **(1 mark)**

2.12 K_2CrO_4 **(1 mark)**

Problem 3 — 24 Marks

Growth Hormones for Apples

3.1 **(2 marks)**

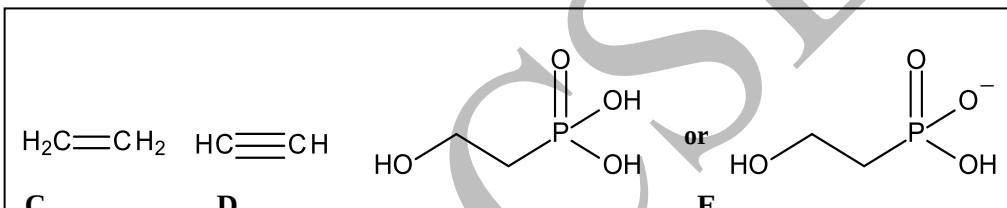


3.2 $\Delta H_{transformation} = -115$ kJ mole^{-1} **(2.5 marks)**

Rearrangement will lead to **heating** of the reaction mixture

3.3 pH = 1.22 **(2.5 marks)**

3.4



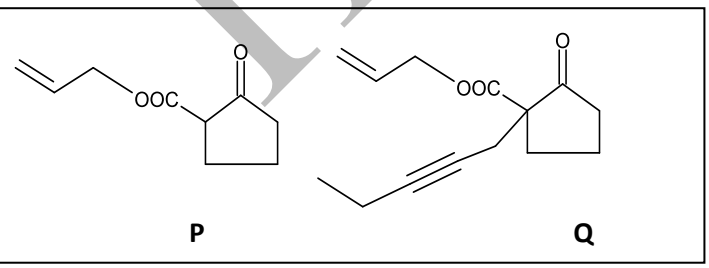
(2.5 marks)

3.5 Rate constant = 3.4×10^{-4} s^{-1} **(1.5 marks)**

3.6 Drop in concentration = 91.4 % **(2 marks)**

.

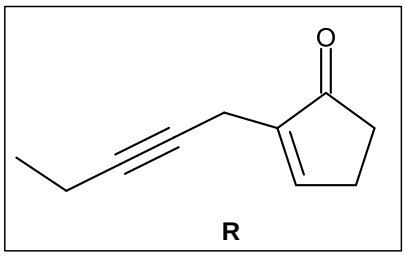
3.7 **(2.5 marks)**



3.8 i) concentrated [ ] ii) dilute [X] **(0.5 mark)**

3.9 i) N,N-dimethyl formamide [X] ii) ethanol [ ] iii) n-hexane [ ]

(1 mark)

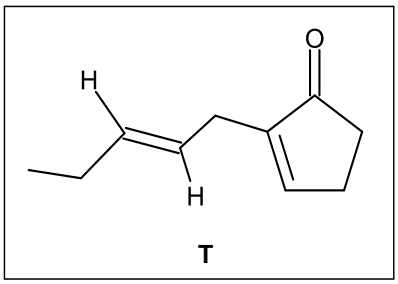
3.10 

R

(1.5 marks)

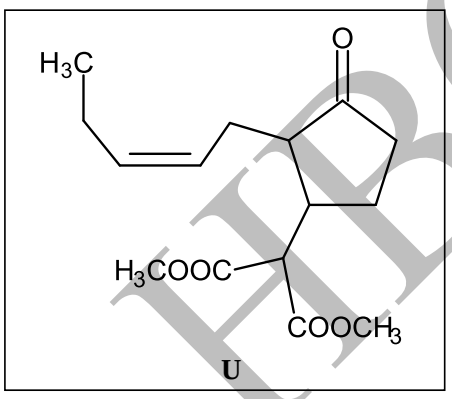
3.11 **(1 mark)**

a) X b) ☐
c) ☐ d) ☐
e) ☐ f) ☐

3.12 

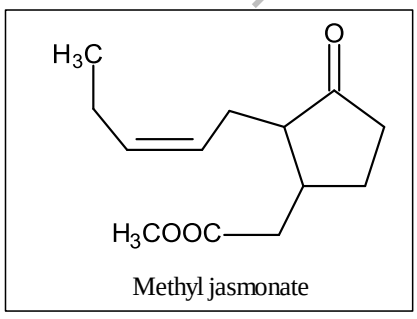
T

(0.5 mark)

3.13 

U

(1 mark)

3.14 

Methyl jasmonate

(2 marks)

3.15 4

(1 mark)

Problem 4 — 13 marks

Water and Heat

4.1 **(6 marks)**

Water evaporated in Stage 1 = 79.4 g
Water produced from combustion of butane = 23.6 g.
Increase in relative humidity of kitchen air = 38.7%

4.2 a) $T_f = 329.1$ K **(2.5 marks)**

b) $T_f = 303.8$ K **(4.5 marks)**

Problem 5 — 29 marks

The different forms of Solid $CaCO_3$

5.1 For calcite, density = 2.71 g cm^{-3}
For Vaterite, density = 2.65 g cm^{-3} **(4 marks)**

5.2 i) from calcite to aragonite, volume change = –7.5%
ii) from aragonite to vaterite, volume change = 10.5% **(2.5 marks)**

5.3 Aragonite **(0.5 mark)**

5.4 94.1% **(3 marks)**

5.5 $\Delta S = 4.03\ J\ K^{-1}$ **(3 marks)**

5.6 Sr^{2+}, Pb^{2+} **(1 mark)**

5.7 Mass percentage of amorphous form = 21.3%
Mass percentage of vaterite form = 71.5% **(2 marks)**

5.8 t_{max} = 2975 s = ~ 50 min
$m_{v\text{-}max}$ = 0.774 kg (774 g) **(3 marks)**

5.9 **(3.5 marks)**

	Yes	No
(i)		X
(ii)		X
(iii)		X
(iv)		X
(v)		X
(vi)	X	

5.10 ratio of k_{H2Y2}: k_Y : k_H = 14.4 : 6 : 3000 **(3.5 marks)**

5.11 **(3 marks)**

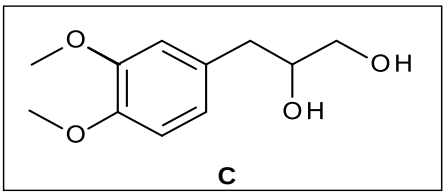
	i	ii	iii	iv
a.	**X**			
b.			**X**	
c.				**X**

Problem 6 — 15 Marks

Derivatizing Eugenol

6.1 (a) [x] (b) [x] (c) [ ]
(d) [ ] (e) [ ] **(1 mark)**

6.2 i) **(0.5 mark)**

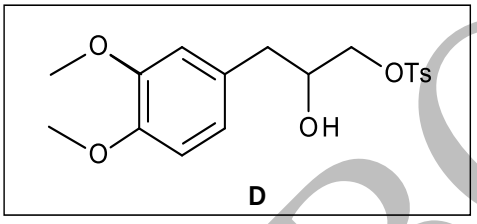


C

ii) a) [x] b) [x]
c) [ ] d) [ ] **(1 mark)**

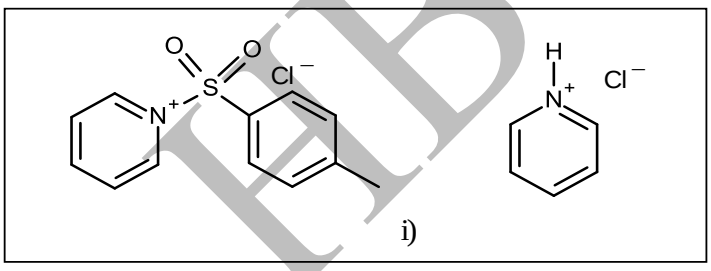
iii) $[Fe(CN)_6]^{4-}$, $[Fe(CN)_6]^{3-}$, *t*-Butanol, OsO_4 (or hydroxylated forms), K^+, HCO_3^-, CO_3^{2-}, pyridine **(5 marks)**

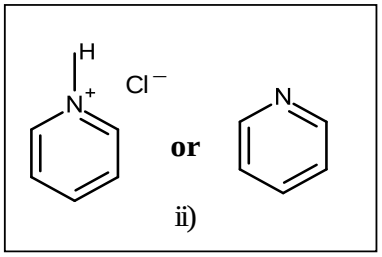
6.3 **(1 mark)**



D

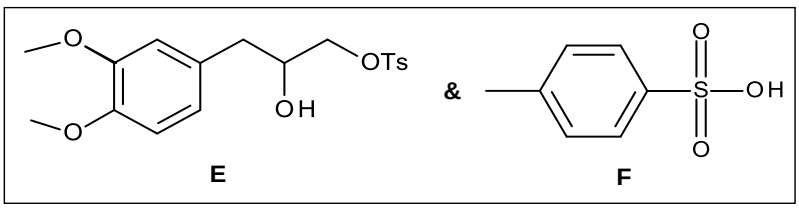
6.4





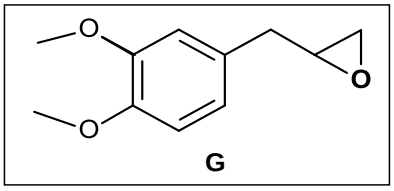
(3.5 marks)

6.5 **(2 marks)**



E **F**

6.6 **(1 mark)**



G