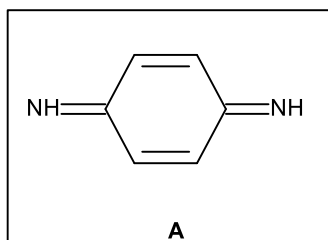Any alternative method of solution to any question that is scientifically and mathematically correct, and leads to the same answer will be accepted with full credit. Partially correct answers will gain partial credit.

For questions requiring calculations, full credit is given only if necessary steps of the calculations are written.

In problems having related subparts, consistency of answers of the related subparts is also checked in evaluation.

Problem 1   16 marks

Chemistry of the artificial hair dyes

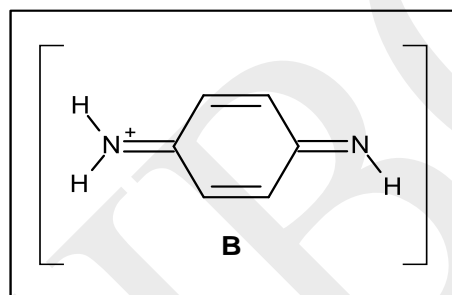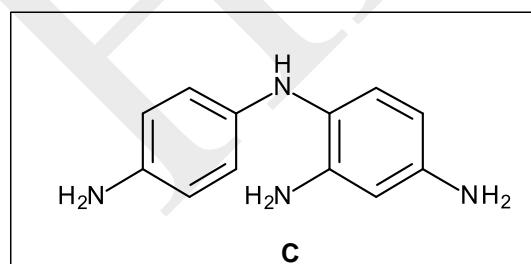1.1   (1 mark)

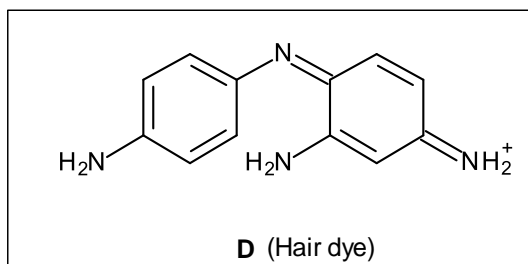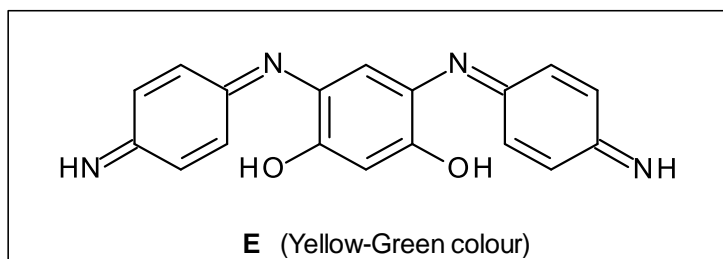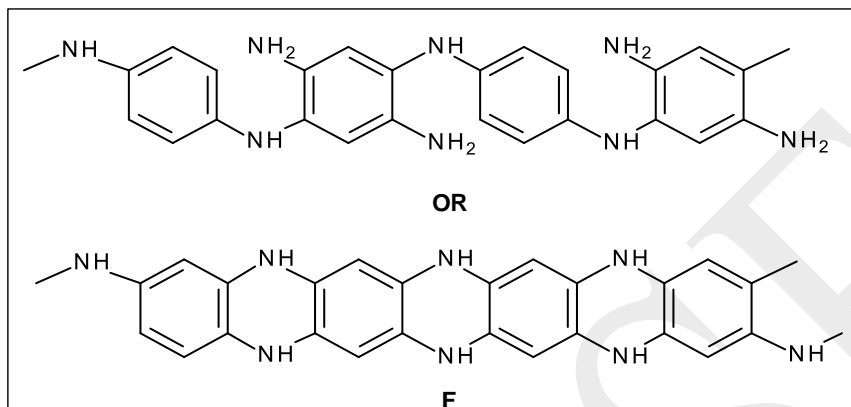1.2   (0.5 mark)
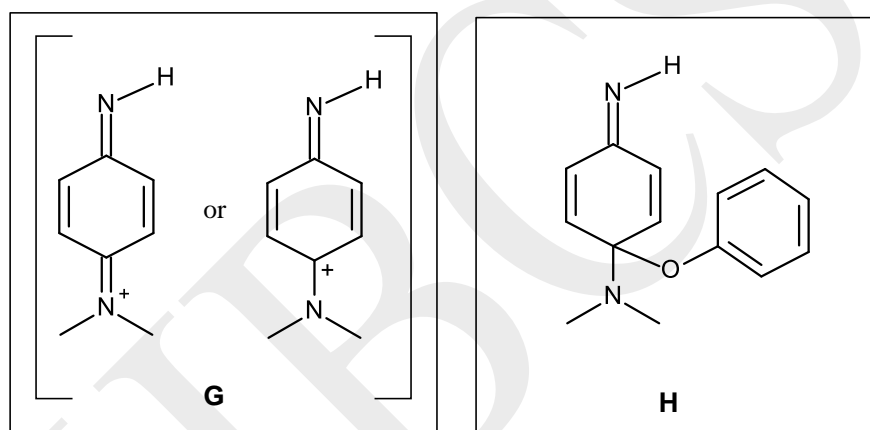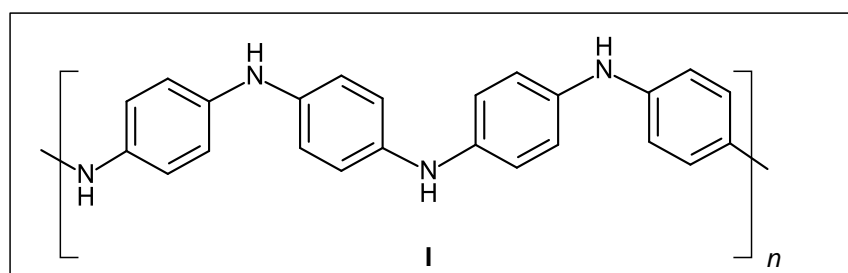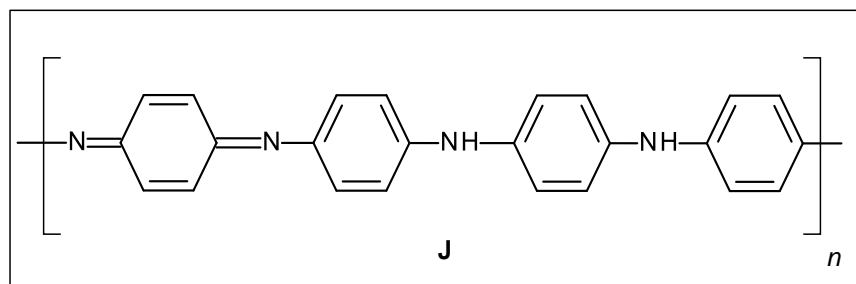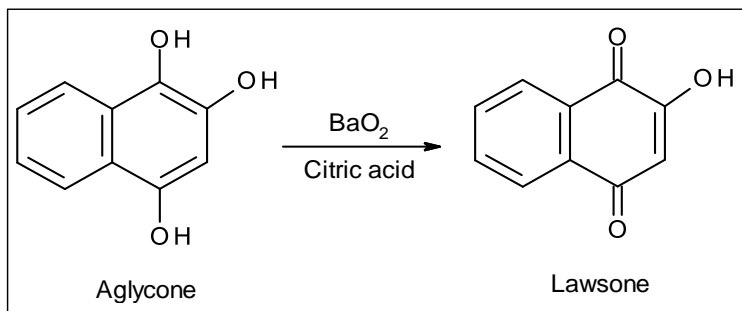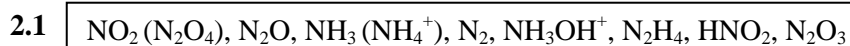

1.3   (2.5 marks)

1.4

E (Yellow-Green colour)

(**1 mark**)

1.5

OR

F

(**1 mark**)

1.6

G

H

(**3 marks**)

1.7

I

J

(**1.5 marks**)

1.8

(1.5 marks)

1.9
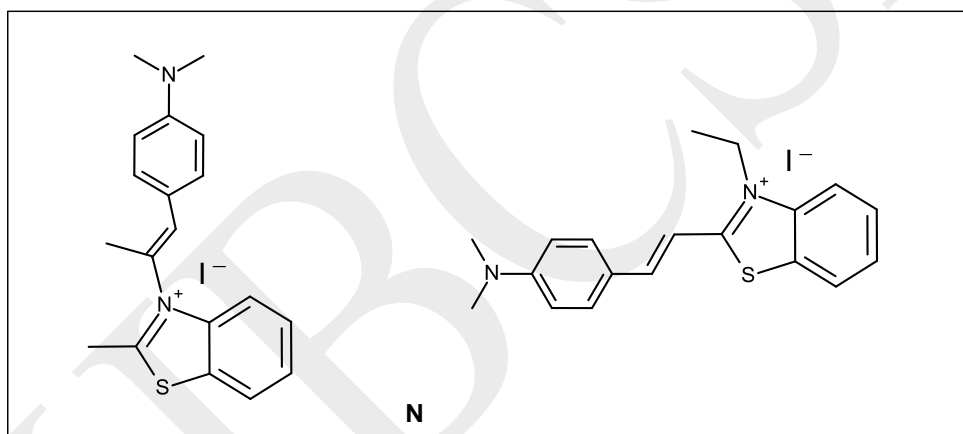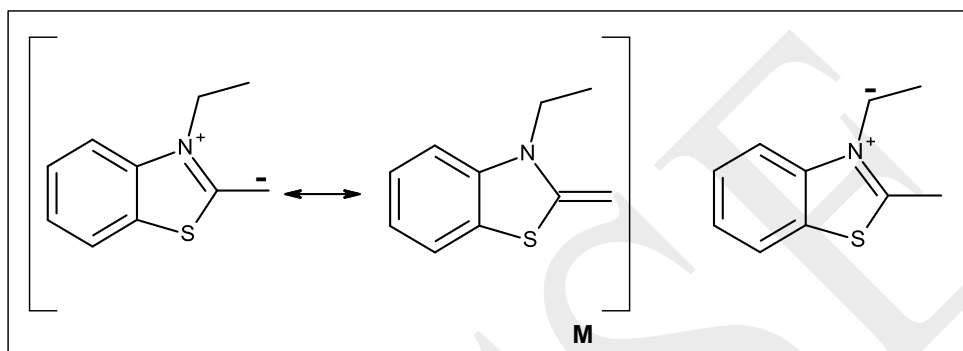
(4 marks)

Problem 2   **22 marks**

Towards a new Metallurgy from e-waste
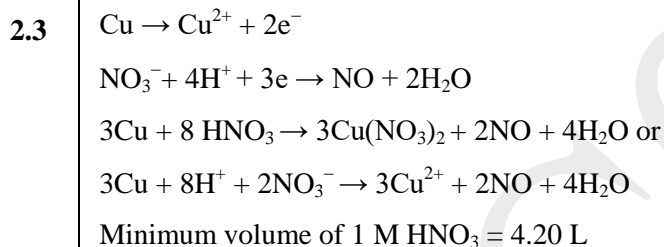
2.1 | NO_2 (N_2O_4), N_2O, NH_3 (NH_4^+), N_2, NH_3OH^+, N_2H_4, HNO_2, N_2O_3

          (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)   **(1.5 marks)**

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

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

2.11 | M_3 - NiS, M_4 - ZnS   **(1 mark)**
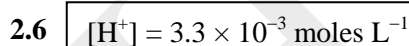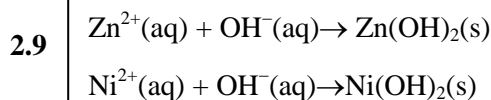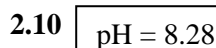
2.12 | K_2CrO_4 **(1 mark)**

NaOH is also accepted if written with K_2CrO_4

Problem 3   **24 Marks**

Growth Hormones for Apples

3.1

A   B

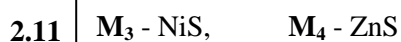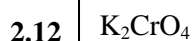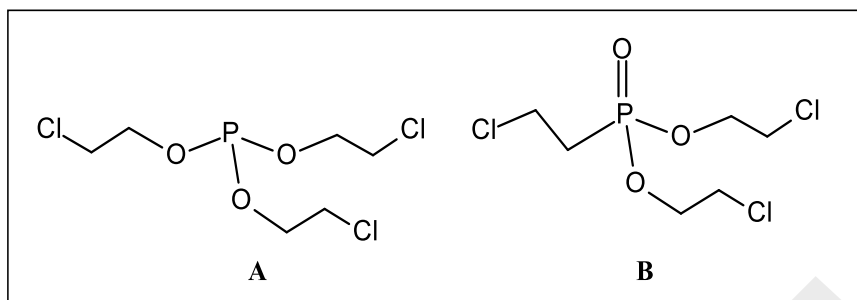**(2 marks)**

3.2

$\Delta H_{transformation} = -115 \text{ kJ mole}^{-1}$

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

(2.5 marks)

3.3

pH = 1.22

(2.5 marks)

3.4

C   D   E
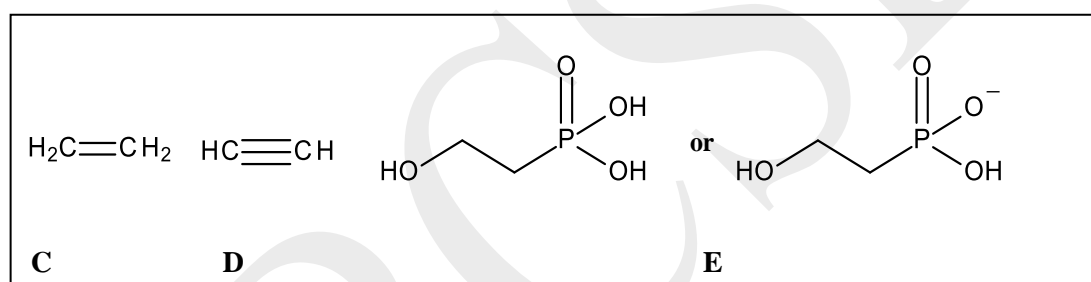
(2.5 marks)

3.5   Rate constant $= 3.4 \times 10^{-4} \text{ s}^{-1}$

(1.5 marks)

3.6   Drop in concentration $= 91.4 \%$

(2 marks)

3.7

P   Q
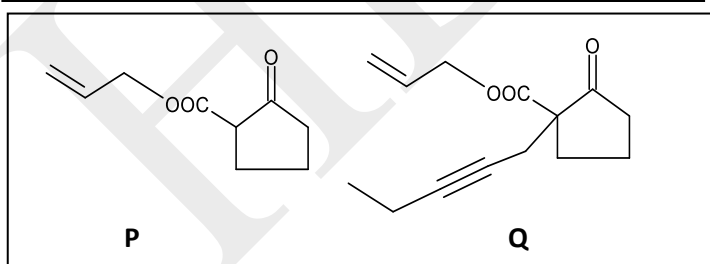
(2.5 marks)

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

(1.5 marks)

R

3.11   **(1 mark)**

a) [X]   b) [   ]

c) [   ]   d) [   ]

e) [   ]   f) [   ]

3.12

T

(0.5 mark)

3.13

U
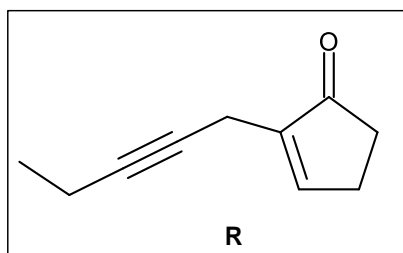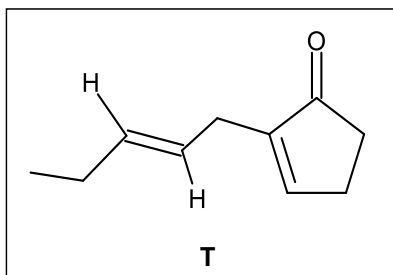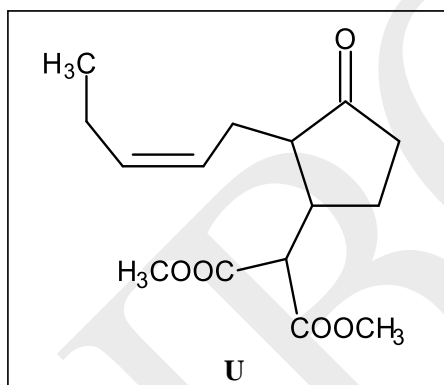
1,2 addition product across the carbonyl
group will also be accepted

(1 mark)

3.14

Methyl jasmonate
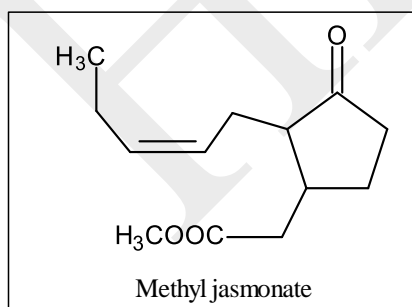
(2 marks)

3.15   [4]   **(1 mark)**

Problem 4   **13 marks**

Water and Heat

Values of C_p and C_v in the problem were mistakenly interchanged. Hence, solutions with either $C_v = 5R/2$ or $C_v = 7R/2$ are accepted provided related steps of calculation are correct.

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)** $T_f = 329.1 \text{ K}$ **(2.5 marks)**

            b) $T_f = 303.8 \text{ K}$ **(4.5 marks)**

Problem 5   29 marks

The different forms of Solid CaCO₃

5.1
> For Calcite, density $= 2.71 \text{ g cm}^{-3}$
>
> For Vaterite, density $= 2.65 \text{ g cm}^{-3}$

(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
> $\Delta S = 4.03 \text{ J K}^{-1} \text{mol}^{-1}$

(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
> $t_{max} = 2975 \text{ s} = \sim 50 \text{ min}$
>
> $m_{v\text{-max}} = 0.774 \text{ kg } (774 \text{ g})$

(3 marks)

5.9

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

(3.5 marks)

5.10
> ratio of $k_{H2Y2} : k_Y : k_H = 14.4 : 6 : 3000$

(3.5 marks)

5.11

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

(3 marks)

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

i)

ii)

or

　　　　　　　　　　　　　　　　　　　　　　　　　(3.5 marks)

6.5　　　　　　　　　　　　　　　　　　　　　　　　　**(2 marks)**

E　　　　　　　**&**　　　　　　　**F**

6.6　　　　　　　　　　　　　　　　　　　　　　　　　**(1 mark)**

G