Indian Olympiad Qualifier in Chemistry (IOQC) 2021-2022

conducted jointly by

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

and

Association of Chemistry Teachers (ACT)

Part II: Indian National Chemistry Olympiad (INChO)

Homi Bhabha Centre for Science Education (HBCSE-TIFR)

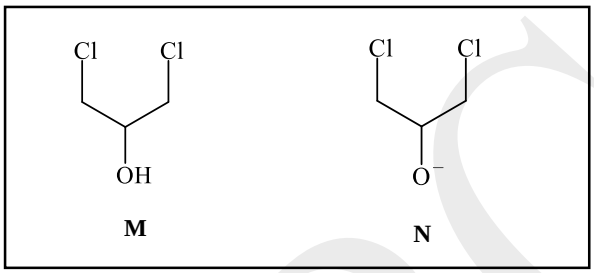
Date of Exam- March 20, 2022

Solutions May 2, 2022

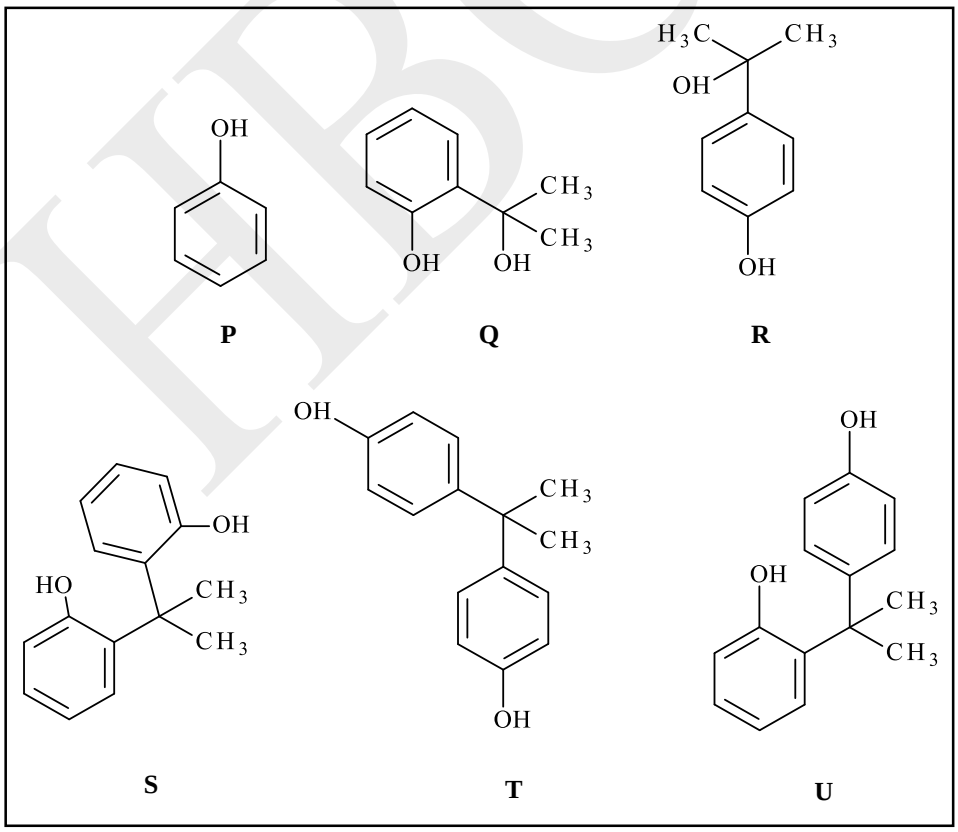
Problem 1 — 20 marks

A journey into epoxy resins

1.1 **(2 marks)**

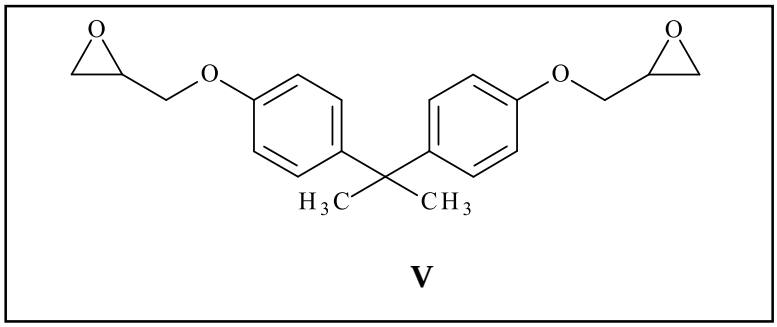


1.2 i) **(3 marks)**



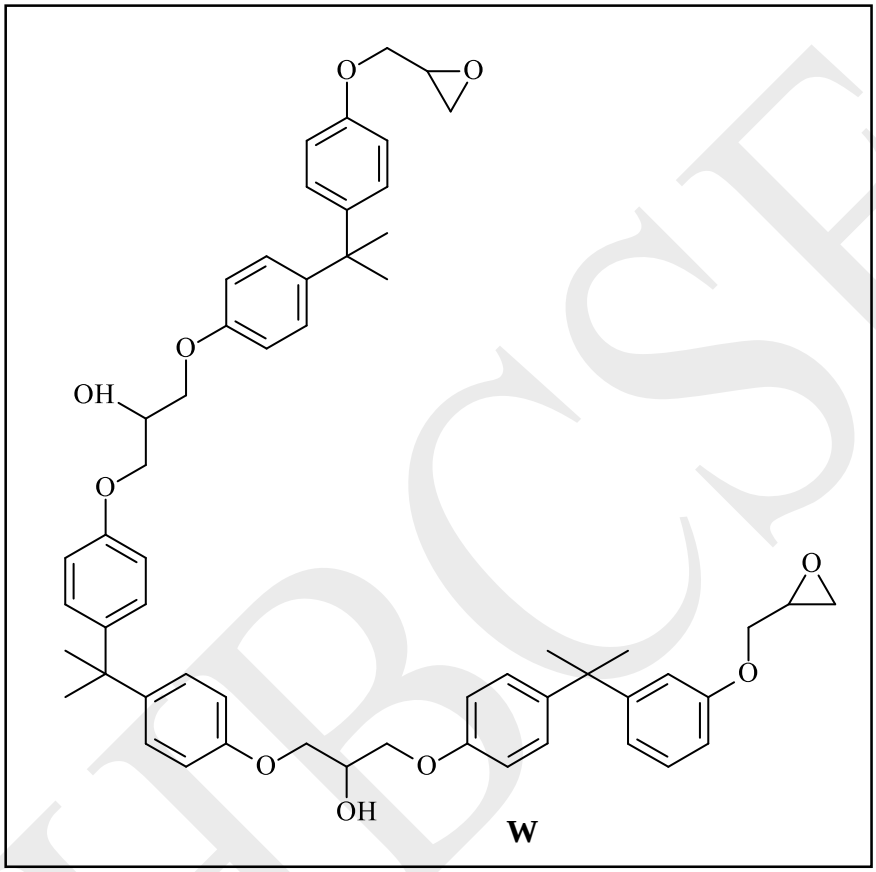
1.2 ii) T (isomer with the two –OH groups at para position of benzene rings) **(1 mark)**

1.3 i) **(1 mark)**



V

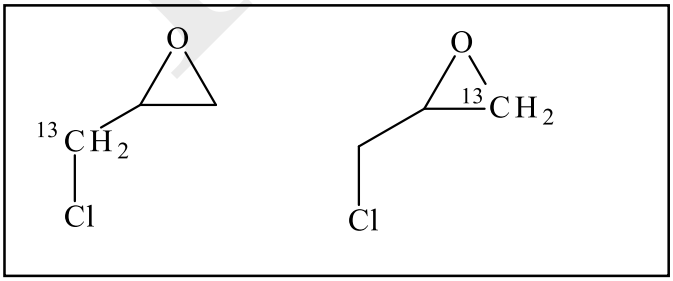
1.3 ii) **(1.5 marks)**



W

1.3 iii) **b)** **X** **c)** **X** **d)** **X** **(1 mark)**

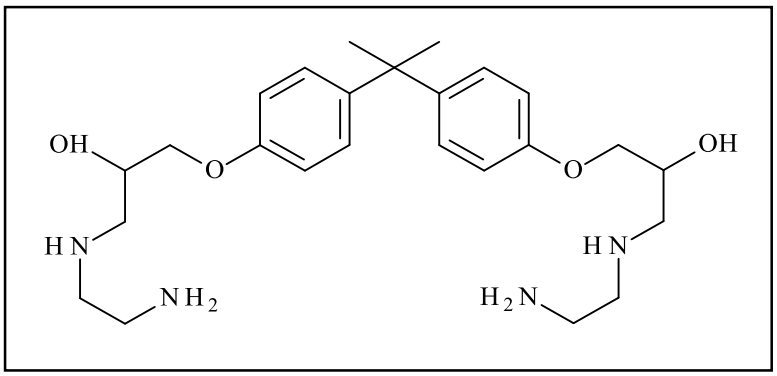
1.3 iv) **(2 marks)**



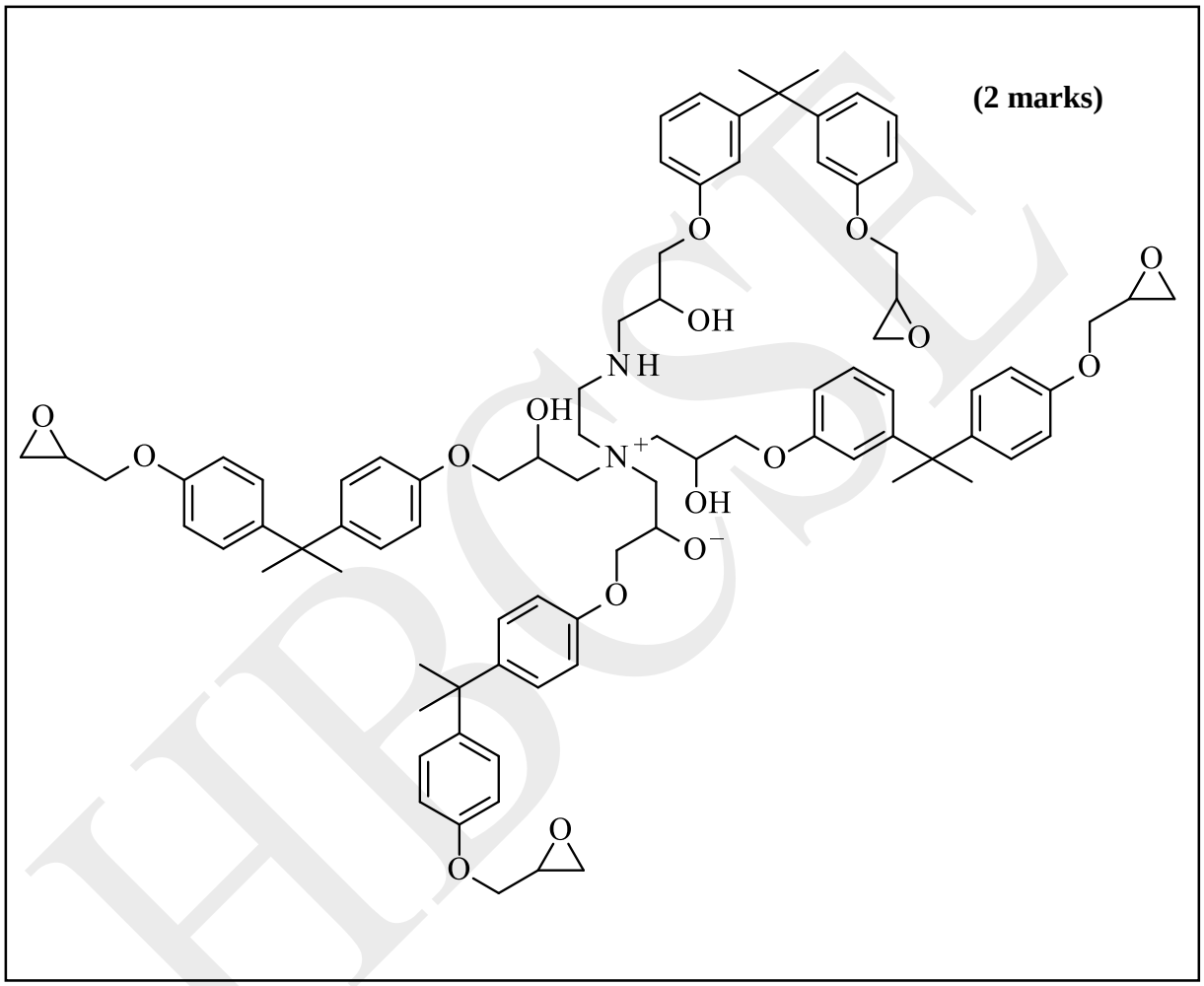
1.3 v) **(1.5 marks)**

NaCl, increases tensile strength

1.4 i) **(1 mark)**



1.4 ii) **(2 marks)**



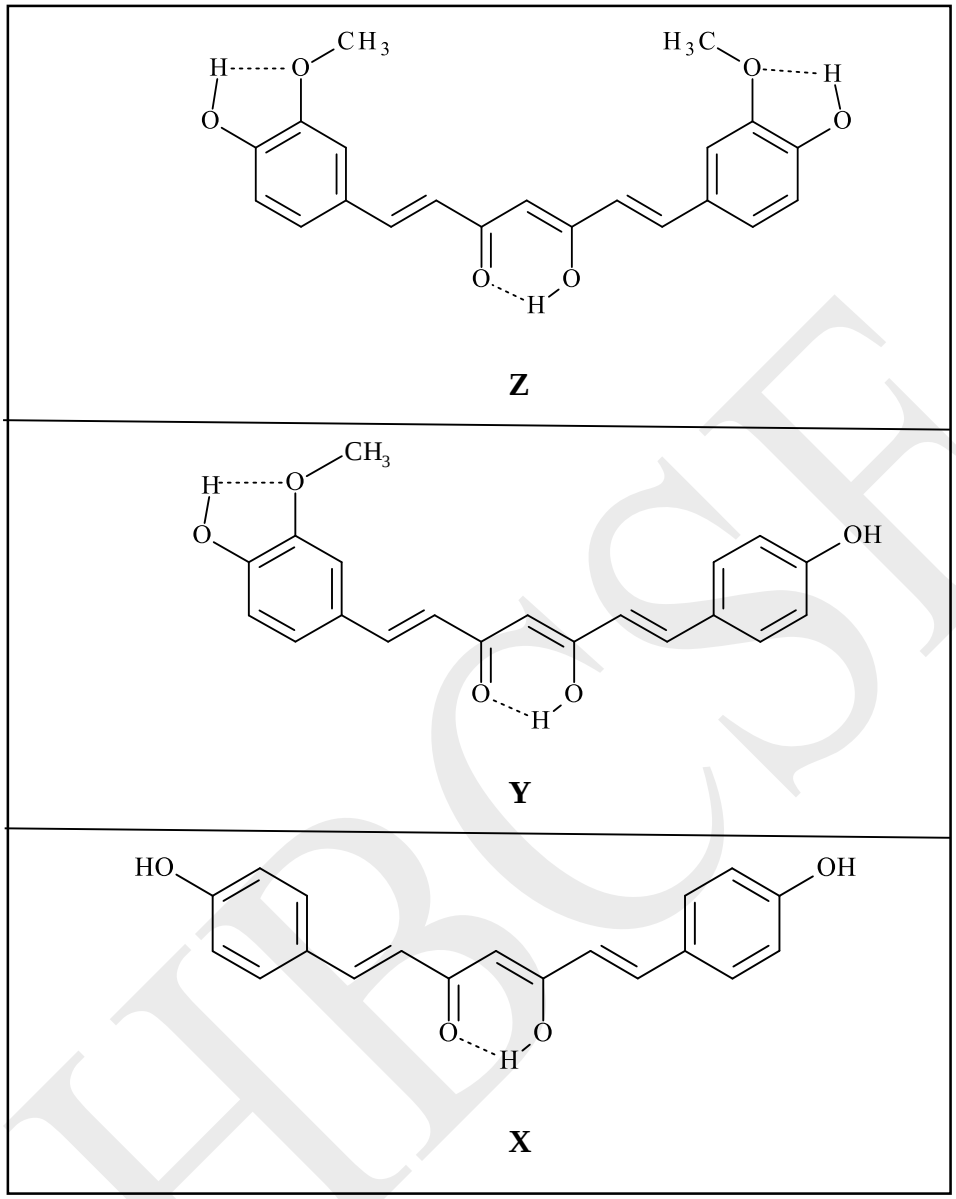
1.4 iii) c) X **(2 marks)**

1.5 **ii)** X **iii)** X **iv)** X **(2 marks)**

Problem 2 19 marks

An edible compound and a colouring agent

2.1 **(4.5 marks)**



Z

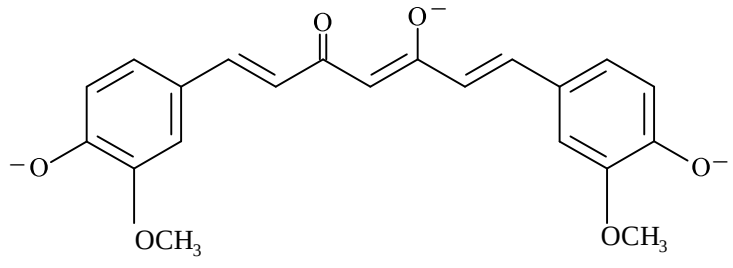
Y

X

2.2 **(1 mark)**

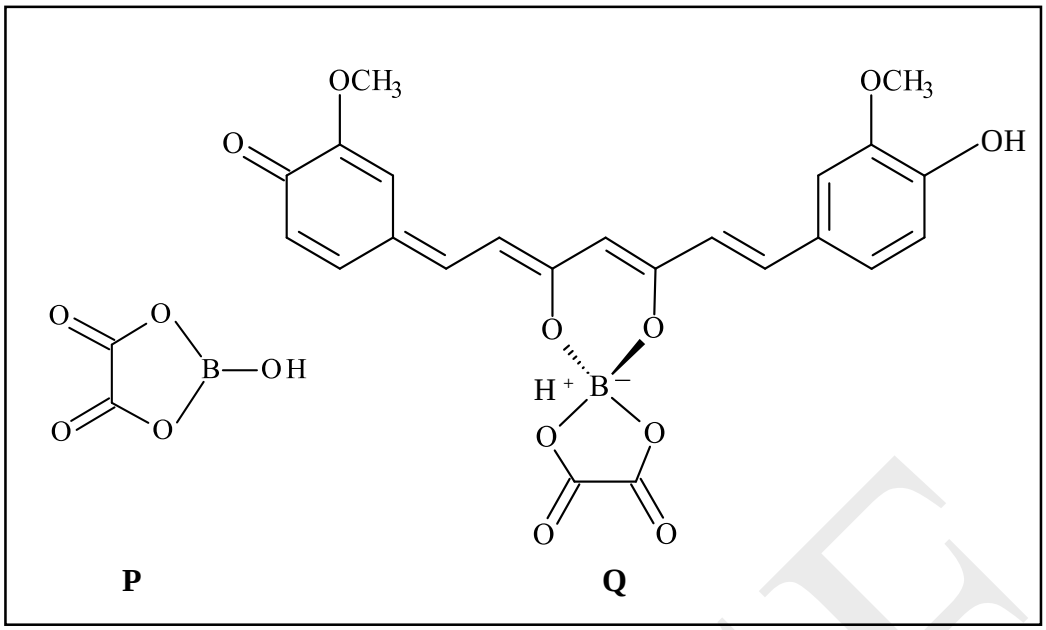
1 - **Z**	2 - **Y**	4 - **X**

2.3 **(1.5 marks)**

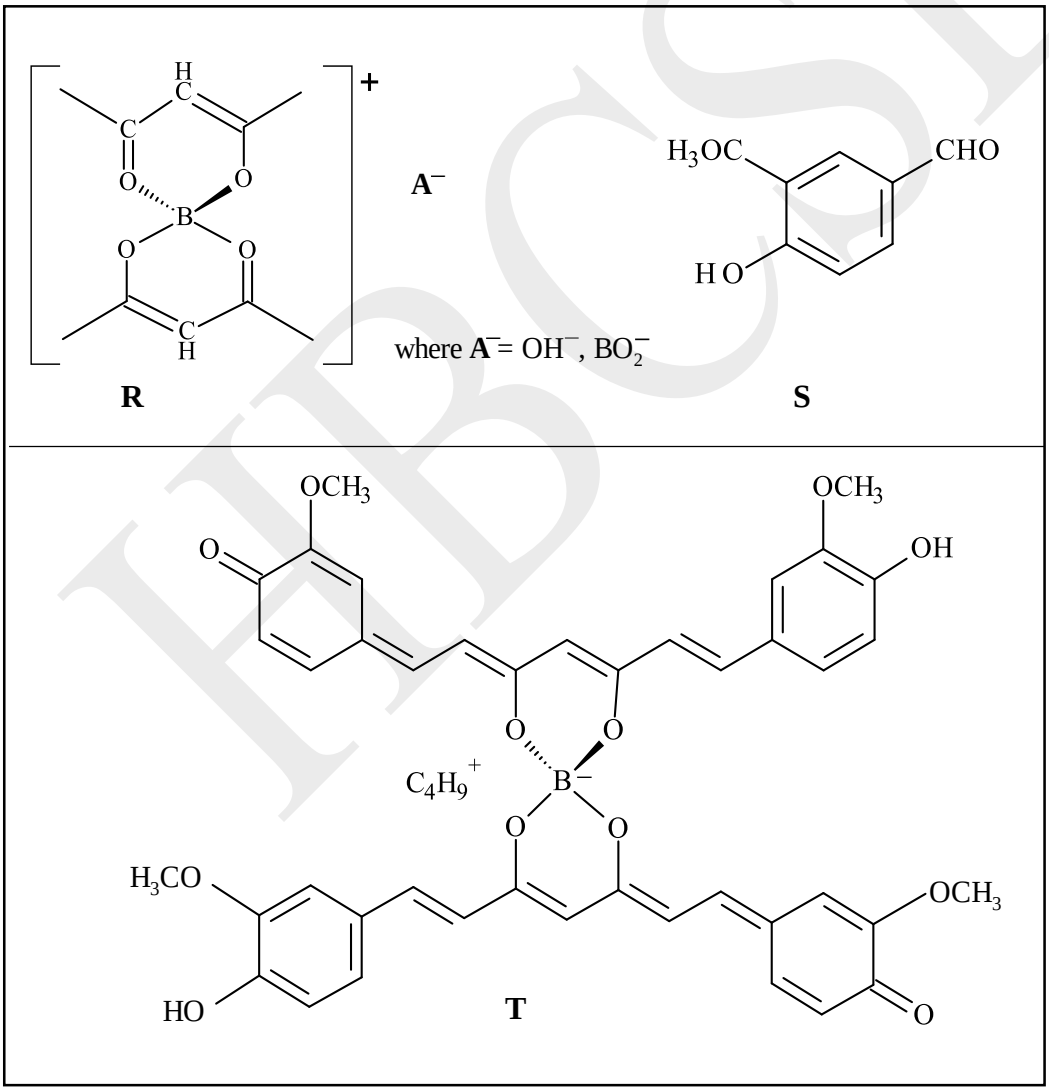


Z at pH 14

2.4 **(3 marks)**



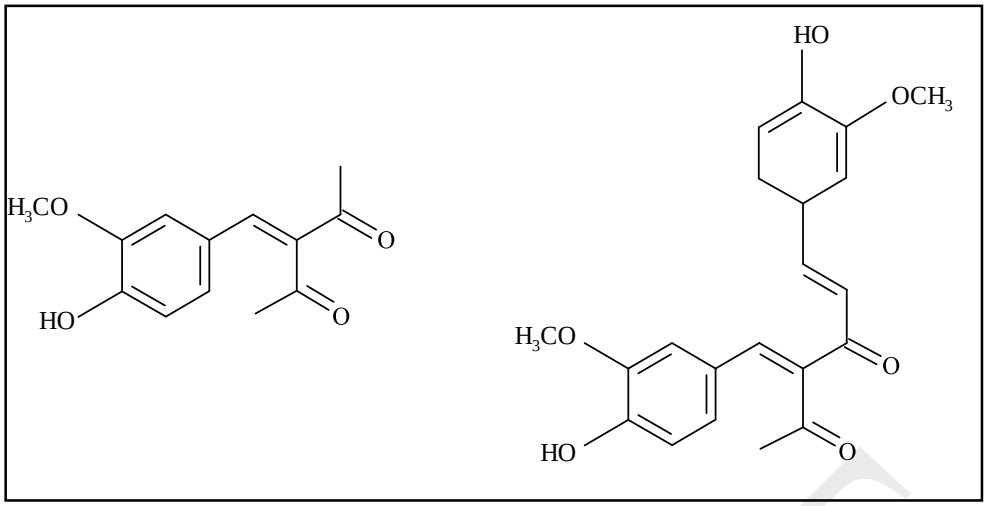
2.5 **(4 marks)**



2.6 **(3 marks)**

Methanol, boric acid, butyl ammonium borate

2.7 **(2 marks)**



Problem 3 31 marks

Chemical Oxygen Generation and Oxygen safety

3.1 **(1 mark)**

$2NaClO_3 \rightarrow 2NaCl + 3O_2\uparrow$

3.2 **(2 marks)**

BaO_2 +	Cl_2	→	$BaCl_2$ +	$O_2\uparrow$
	A		**B**	**C**
			or	
BaO_2 +	$2OCl$	→	$BaCl_2$ +	$2O_2\uparrow$
	A		**B**	**C**
			or	
BaO_2 +	$2ClO_2$	→	$Ba(ClO_2)_2$ +	$O_2\uparrow$
	A		**B**	**C**
			or	
$2BaO_2$ +	$2Cl_2O$	→	$2BaCl_2$ +	$3O_2\uparrow$
	A		**B**	**C**

3.3 **(3.5 marks)**

D - KO_2 **E -** KOH **F –** K_2CO_3

$4MO_2 + 2H_2O \rightarrow 4MOH + 3O_2$
Molar mass of MO_2 must be: ¼ * (96/0.338) = 284/4 = 71
M should be potassium.

3.4 **(3 marks)**

x = 2 y = 3

3.5 (2.5 marks)

1 mol of peroxide produces 0.5 moles of oxygen

Molar mass of **G** = 60.1 g mol^{-1}

3.6 (3 marks)

G : Urea; **H**: Copper sulphate

$CO(NH_2)_2 \rightarrow NH_3 + HCNO$

$Cu^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+}$

3.7 (3 marks)

Amount of ethanol vapour in whole room = 255.5 g

Temperature rise = 28.1 K

3.8 (2 marks)

Average mole fraction of ethanol in the air space = 0.043
Decrease in oxygen mole fraction = 0.010
Thus, average mole fraction of oxygen = 0.224

3.9 (7.5 marks)

i) Moles of ethanol in 1.5 m^3 of air space = 2.64 mol
Mass of air undergoing combustion = 1884 g
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
Increase in moles of gases during combustion = 1 mol per mol of ethanol.
Increase in temperature before expansion = 1902 K
Final temperature after expansion = 1394 °C

ii) Oxygen initially = 13.76 moles
Oxygen consumed = 7.92 moles
Average mole fraction of oxygen left = 5.84/64.14 = 9.10 % ~ 0.091

3.10 (2.5 marks)

i)	T
ii)	T
iii)	F
iv)	T
v)	T

3.11 (1 mark)

i)	X
iii)	X
iv)	X

Problem 4 — 19 marks

Polyoxometallates

4.1 (1.5 marks)

ii)	X
iv)	X

4.2 (1.5 marks)

i)	X
ii)	X
iv)	X

4.3 $7[MoO_4]^{2-} + 8H^+ \rightarrow [Mo_7O_{24}]^{6-} + 4H_2O$ **(2.5 marks)**

4.4 **i)** x = 13 **(1 mark)** **ii)** y = 40 **(1 mark)**

4.4 **iii)** O_a, = 12 O_b = 12 O_p = 4 **(1.5 marks)**

4.5 $PO_4^{3-} + 12[MoO_4]^{2-} + 27H^+ \rightarrow H_3[P(Mo_3O_{10})_4] + 12H_2O$ **(2 marks)**

4.6 **ii)** **X** **(1 mark)** **4.7 iii)** **X** **(1 mark)**

4.8 $Si(OH)_4 + 12MoO_4^{2-} + 2OH^- \rightarrow [Si(Mo_{12}O_{40})]^{4-} + 12H_2O$ **(1.5 marks)**

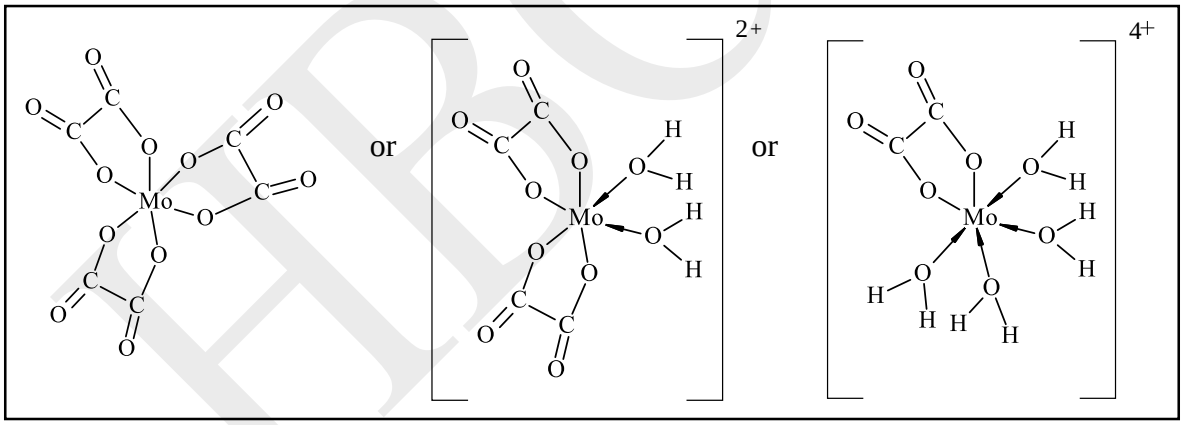
R

4.9 $SiO_2 + 4HF \rightarrow SiF_4 + H_2O$

$SiO_2 + 6HF \rightarrow H_2[SiF_6] + 2H_2O$ **(1.5 marks)**

4.10 $H_3BO_3 + 4HF \rightarrow HBF_4 + 3H_2O$ **(1 mark)**

4.11



(1 mark)

4.12 **ii)** **X** **iii)** **X** **(1 mark)**