INCHO 2007

Problem 1 **13 Marks**

Chemical Kinetics and Reaction Rates

1.1

$v = k[O_2]^2[NO]$ or $v = k[NO]^2[O_2]$

1.2

$2O_2(g) + NO(g) \rightarrow NO_5$

$O_2(g) + 2NO(g) \rightarrow 2NO_2$

Chemically correct reaction from the above two is

$O_2(g) + 2NO(g) \rightarrow 2NO_2(g)$

1.3

$$v = -\frac{1}{2}\frac{d[NO]}{dt} = -\frac{d[O_2]}{dt} = \frac{1}{2}\frac{d[NO_2]}{dt}$$

1.4

$$\frac{d[NO_2]}{dt} = \frac{k_1k_2}{k_{-1}}[NO]^2[O_2]$$

1.5

$$\frac{d[N_2O_2]}{dt} = \frac{k_1}{k_{-1}}[NO]^2[O_2] \quad \text{for } k_{-1} >> k_2[O_2]$$

1.6

NO_3 is a radical species produced in mechanism – 1 and may be detected by an appropriate techniques such as ESR.

1.7

$K_c = = 6.44 \times 10^5$

1.8

$\Delta E = -111.52\,kJ$

1.9

The total number of gas molecules diminishes when the reaction proceeds to completion. So ΔS is –ve.

1.10

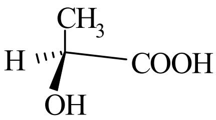
$[H^+] = k^{1/2}c^{1/2}$

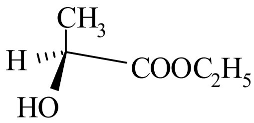
Hence, rate $=$ const.[conc. of acid]$^{1/2}$

Problem 2 **16 marks**

Pheromones – A Case of Sulcatol

2.1

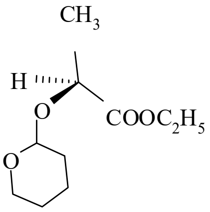




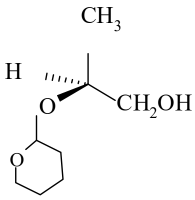
2.2 **I**

2.3 2

2.4



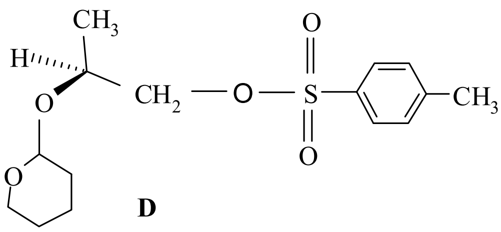
B



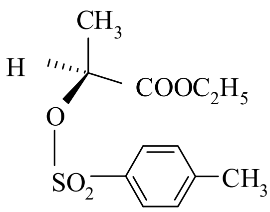
C

2.5 (iii) to increase nucleophilicity of hydroxyl group X

2.6

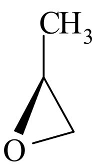


D



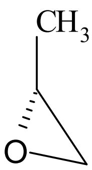
F

2.7



(S)

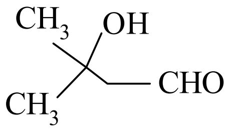
E



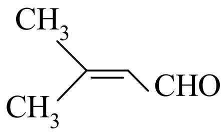
(R)

H

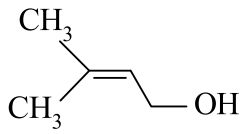
2.8



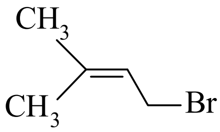
K



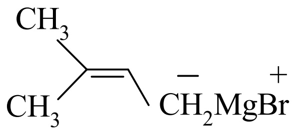
L



M

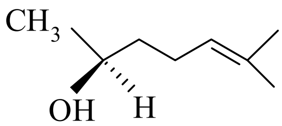


N

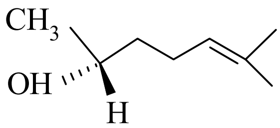


O

2.9

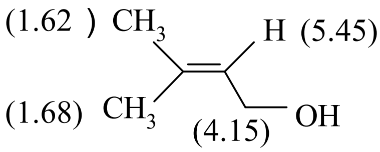


P



Q

2.10



Problem 3 — 16 Marks

Sea Water

3.1 (c) ice has an open cage-like structure X

3.2 Boiling point of sea water = 373.6 K (0.5 mark)

3.3 (A) (b) 1.25 X

(B) (c) is stronger than that observed in NaCl X

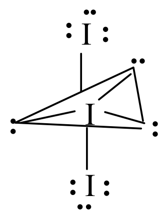
3.4 (A) **First extraction**

Layer	Normality	Amount
Organic	0.04645	0.0590g of I_2/10 mL CCl_4
Aqueous	5.354×10^{-4}	0.0680g of I_2/1000 mL H_2O
Second extraction		
Organic	0.02486	0.03158g of I_2/10 mL CCl_4
Aqueous	2.8677×10^{-4}	0.03642g of I_2/1000 mL H_2O

$K = 0.04645/5.354 \times 10^{-4} = 86.70$

(B) sp^3d and linear

or



tbp with lone pairs at 3 vertices

3.5 (A) Mass of $CaCO_3$ = $1.6 \times 50 = 80$ g per litre of sea water.

(B) Na^+

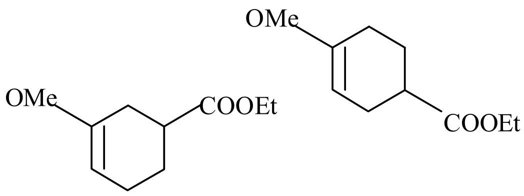
(C) % sites that underwent exchange = 0.08%

3.6 Volume of HCl at STP = 42.56 L.

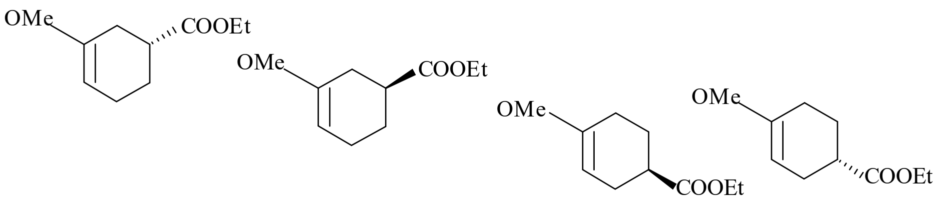
Problem 4 21 marks

Cycloaddition Chemistry

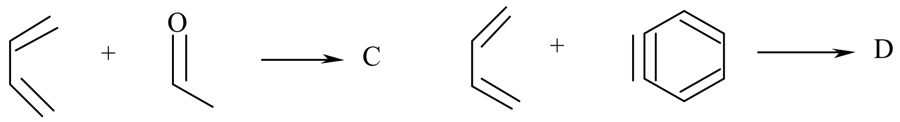
4.1



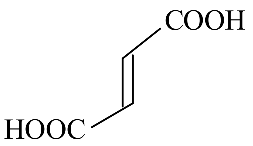
4.2



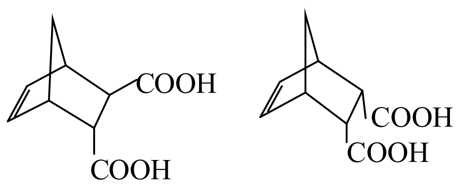
4.3



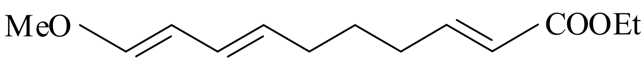
4.4



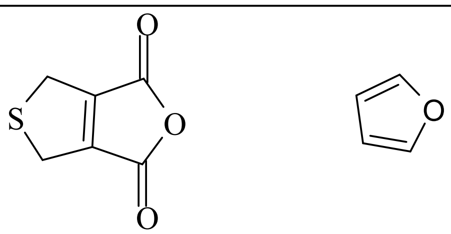
E



4.5



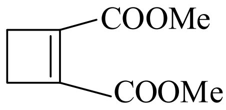
4.6



4.7

H_2/Ni

4.8



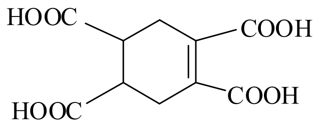
4.9 Equivalent weight of compound **L** is 64.5

4.10 The number of –COOH groups present in compound **L** is 4

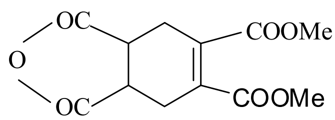
4.11 (ii) cyclohexane ring X

(iv) one double bond X **(1 mark)**

4.12

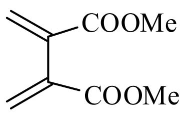


L

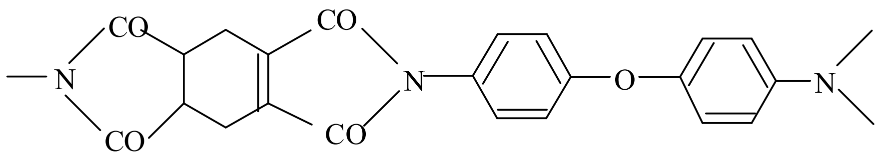


K

4.13



4.14



Problem 5 — 21 marks

Acetylene – Production, Structure & Uses

5.1

$$\rho = \frac{PM}{RT} = \frac{101.3\times10^{3}\times26}{8.314\times10^{3}\times300} = 1.06\,\text{kg m}^{-3}$$

5.2

Mass of commercial sample = (Since purity = 97 %) = 26.9 kg

5.3

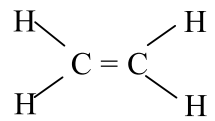
mass of water initially added 124.0 + 17.0 = 141.0 kg

mass of final slurry = 124.0 + 31.0 = 155.0 kg

5.4

Heat liberated on burning 16 kg of acetylene is ~ = 800 $\times10^{6}$ J

5.5



(sp^2)

H — C ≡ C — H (sp)

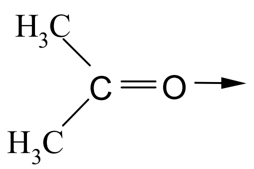
$CH_2 = C = CH_2$ (sp^2 for terminal and sp for central atom)

5.6 c) increasing s character with increasing unsaturation [X]

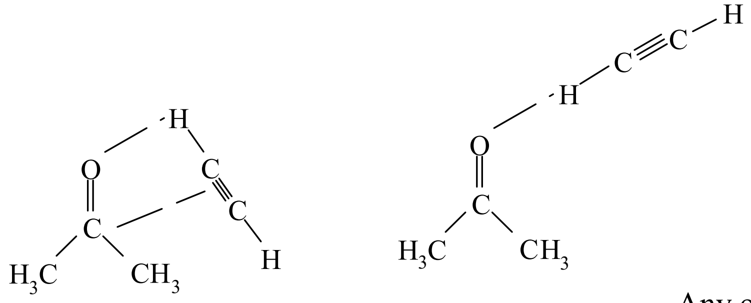
5.7 i) Hydrogen in acetylene [X]

ii) acetone [X] water [X]

iii)



iv)



Any other logical choice

5.8 percentage conversion of C_2H_2 = 40 %

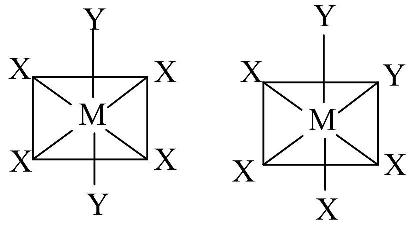
5.9 5% of initial water decomposed

Problem 6 — 33 marks

Transition Metal Chemistry

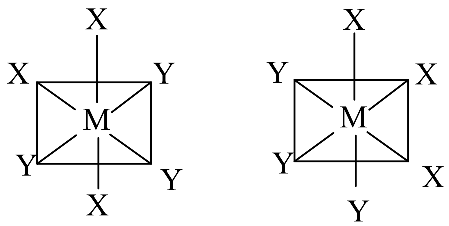
6.1

(i) MX_4Y_2



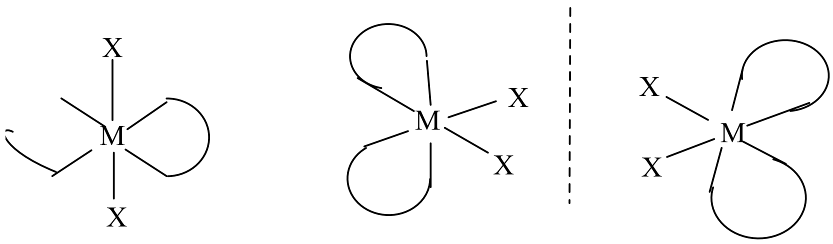
trans *cis*

(ii) MX_3Y_3



mer *fac*

(iii) $M(en)_2X_2$ (en: ethylenediamine) Represent en by ∩



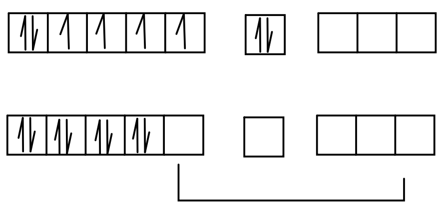
m*eso* *enantiomers*

diastereomers

6.2 (i) $Fe(CO)_5$

Fe [Ar]$3d^6$ $4s^2$ $4p^0$ (free metal) [Ar]

$Fe(CO)_5$ [Ar]



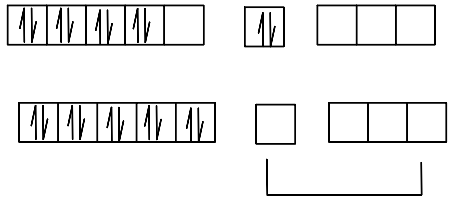
dsp^3

$Fe(CO)_5$ - dsp^3 hybridization, geometry = trigonal bipyramidal

(ii) $Ni(CO)_4$

Ni [Ar] $3d^8$ $4s^2$ $4p^0$ (free metal) [Ar]

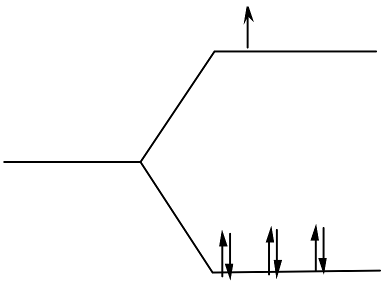
$Ni(CO)_4$ [Ar]



$Ni(CO)_4$ -sp^3 hybridization, geometry = tetrahedral geometry sp^3

6.3 (i) $K_4[Co(CN)_6]$

(i) Co^{2+} d^7

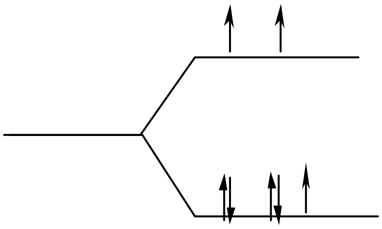


1 unpaired electron

Magnetic moment 1.73 BM

(ii) $K_4[Co(ox)_3]$

(ii) Co^{2+} d^7



3 unpaired electron

Magnetic moment 3.87 BM

6.4 i) Oxidation state of M III

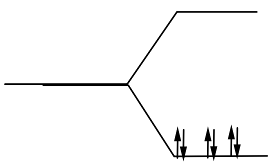
ii) Number of d electrons present 6

iii) Identify M Co

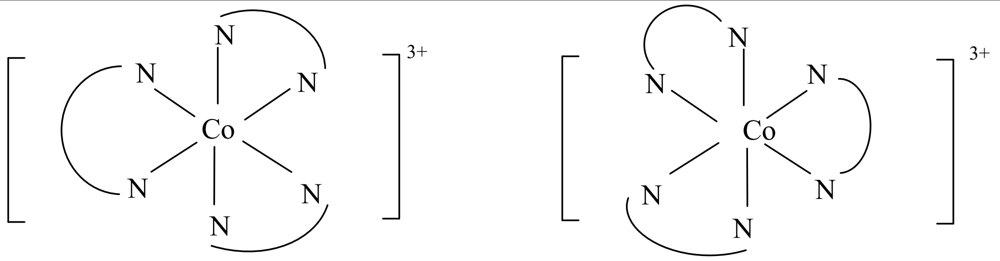
iv) No X

The complex is diamagnetic

d^6



(v)



6.5

TiO$_2$ has Ti^{4+} hence d^0 electronic configuration. Here d-d* transition is not possible hence it is color less. Fe$_2$O$_3$ has Fe^{3+} d^5 system hence, d-d* transition is possible.

6.6

[Co(NH$_3$)$_6$]Cl$_3$: Hexamminecobalt (III) chloride

K$_4$[Fe(CN)$_6$] : Potassium hexacyanoferrate (III)

Fe(C$_5$H$_5$)$_2$: Bis(cyclopentadienyl)iron(II)

6.7