INChO 2005

Problem 1 16 marks

Rates of Chemical Reactions and Arrhenius Equation

1.1

$r = 2.0 \times 10^{-6} \times 0.1 = 2.0 \times 10^{-7}$ mol dm^{-3} s^{-1}

$= 1.2 \times 10^{-8}$ mol mL^{-1} min^{-1}

1.2 (iv) the concentration of **A** decreases with time ☒

1.3

Units of A = units of k = s^{-1} (those of frequency)

1.4

A= 3.14×10^{11} dm^3 mol^{-1}s^{-1}

E_a = 193.2 kJ/mol

1.5

$\Delta H = -226$ kJ mol^{-1}

1.6

E_a (reverse) = 170.3 kcal mol^{-1}

1.7

$k_2[CH_3][CH_3CHO] = k_3 [CH_3CO]$

$[CH_3] = (k_1/2k_4)^{1/2} [CH_3CHO]^{1/2}$

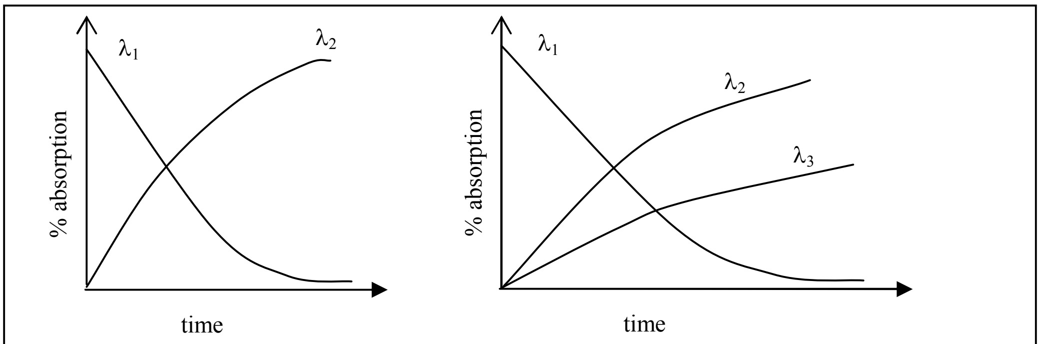
$d[CH_4] / dt = k_2 (k_1/2k_4)^{1/2} [CH_3CHO]^{3/2}$

1.8

$E = E_2 + ½ (E_1 - E_4)$

1.9 (ii) X + Y → Z ; Z → W ☒

1.10



Problem 2 18 marks

Electrochemistry

2.1

$\Lambda(NaOH) = 221$

$\Lambda(NaCl) = 112$

$\Lambda(HCl) = 403$

$\Lambda(H^+ \ \& \ OH^-) = 512$

2.2

κ (KCl) = 0.0812 S m^{-1}

2.3

Oxidation state of gold = 3

2.4

$E°_2 = E°_1$

$K_2 = (K_1)^2$

2.5

change in the cell potential is – 0.01 V

2.6

It is easier to carry out the oxidation $Cu^+ \rightarrow Cu^{++} + e^-$

Problem 3 14 marks

Molecular Structure and Spectroscopy

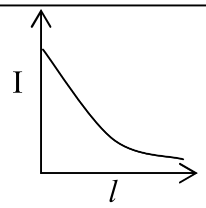
3.1

$$\int_{I_0}^{I} \frac{dI}{I} = -kc\int_{0}^{\ell} dx \,;\, \ln\frac{I_0}{I} = k.c.\ell$$

3.2

$dm^3.mol^{-1}.cm^{-1}$

3.3



3.4

Energy absorbed = 327 kJ mol^{-1}

3.5

$p = 8.8 \times 10^{-22}\, kg.m.s^{-1}$

$\upsilon = 9.7 \times 10^{8}\, m.s^{-1}$

3.6

$\Delta\vartheta_{min} = 1.1 \times 10^{-28}\, m.s^{-1}$

3.7

The general solution of this differential equation is

$x(t) = A \sin \omega t + B\cos \omega t$ where $\omega = (k/\mu)^{1/2}$

$\nu=\omega/2\pi$ cycles/sec = $(1/2\pi)\,(k/\mu)^{1/2}$

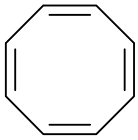
3.8

$k = 512.1\ Nm^{-1}$

Problem 4 16 marks

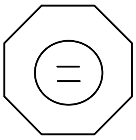
Cyclooctatetraene and Aromaticity

4.1



4.2 (b) a tub-shaped structure X

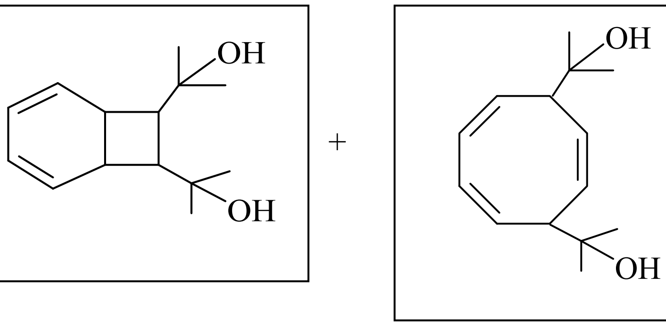
4.3



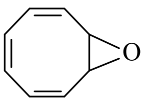
4.4 Planar

4.5 (c) the dianion is aromatic X

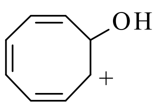
4.6



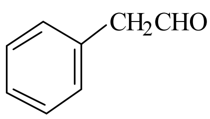
4.7



E

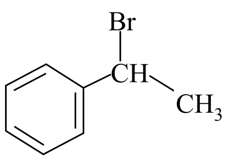


F (intermediate)



G

4.8



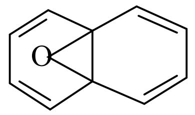
4.9 (a) substitution by an electrophile ✓

(b) addition of bromine ☒

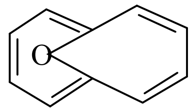
(c) catalytic hydrogenation under mild condition ☒

(d) addition reaction with maleic anhydride ☒

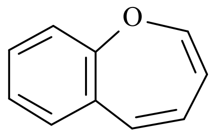
4.10



K (unstable)



L



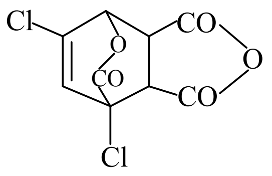
M

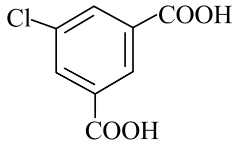
Is **L** aromatic? No X

Problem 5 **14 marks**

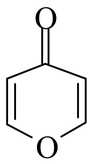
Diels-Alder Reaction

5.1

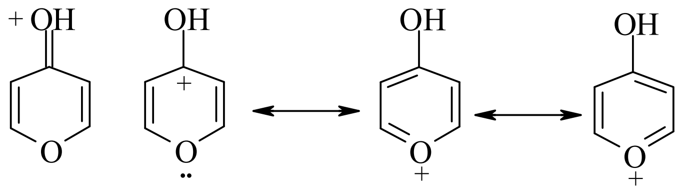




5.2

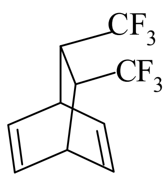


5.3

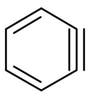


5.4 No ☒

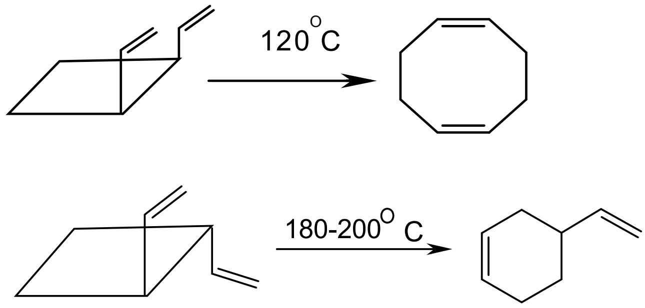
5.5



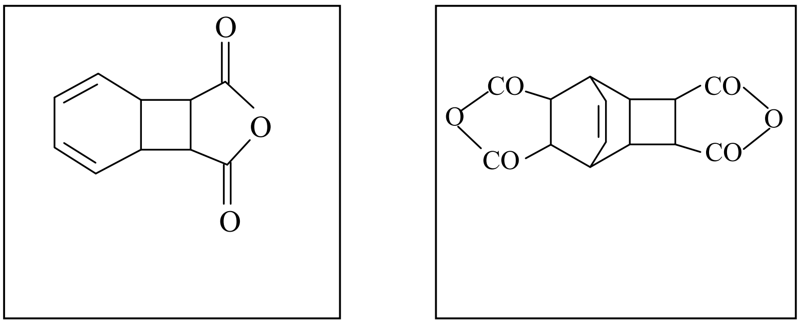
5.6

 + SO_2 + N_2

5.7



5.8



Problem 6 **12 marks**

Chemical Thermodynamics and Kinetic Theory of Gases

6.1

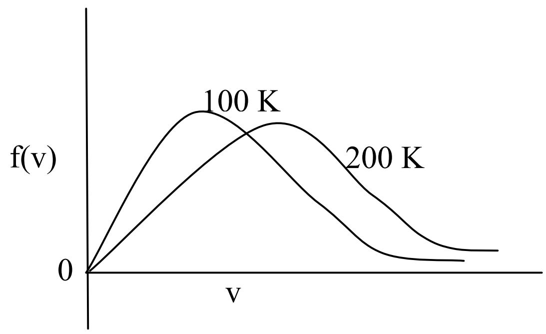
$H_2(g)$ = −120.9 kJ per g

$CH_3OH(l)$ = −19.9 kJ per g

$CH_4(g)$ = −50.1 kJ per g

$C_6H_{14}(g)$ = −453 kJ per g

6.2



6.3

$$v = \left(\frac{2kT}{m}\right)^{1/2}$$

6.4

$$v_{av} = \left(\frac{8kT}{\pi m}\right)^{1/2}$$

6.5

$v_{av} > v_{mp}$

Problem 7 **10 marks**

Halogen Compounds

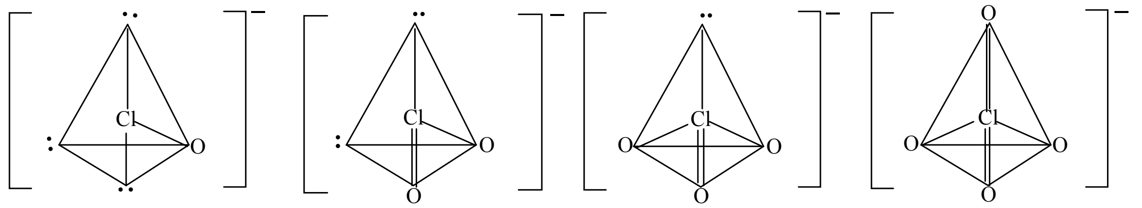
7.1 (c) F – F bond is weakened by strong repulsion between nonbonding electrons in small F_2 molecule [X]

7.2 (c) fluorine reacts with a metal to form a non-reactive metal fluoride film [X]

7.3 $SiF_4 > SiCl_4 > SiBr_4 > SiI_4$

7.4 $HClO_4 > HClO_3 > HClO_2 > HOCl$

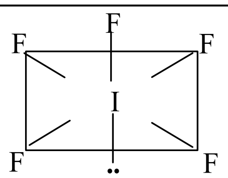
7.5



OCl^- ClO_2^- ClO_3^- ClO_4^-

7.6 Due to lack of pπ-dπ bond

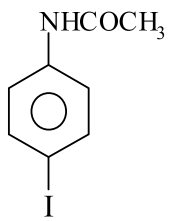
7.7



(Square) pyramidal

5s	5p			5d				
↑↓	↑↓	↑↓	↑↓	↑↓	↑↓			

7.8



Problem 8 **16 marks**

Proteins, amino acids, nucleic acids and buffers

8.1 $>CH-CH_2-S-S-CH_2-CH<$

(a) $S-C_2H_4-OH$ / $S-C_2H_4-OH$ (disulfide) + $>CH-CH_2-SH$

(b) $>CH-CH_2-S-CH_2-COO^-$

(c) $>CH-CH_2-SO_3H$

8.2 .

1) $H_3\overset{+}{N}-CH_2-CH_2-CH_2-CH(\overset{+}{N}H_3)-COOH$

2) $H_3\overset{+}{N}-CH_2-CH_2-CH_2-CH(\overset{+}{N}H_3)-COO^-$

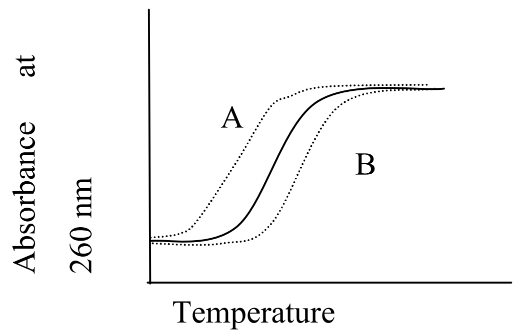
3) $H_3\overset{+}{N}-CH_2-CH_2-CH_2-CH(NH_2)-COO^-$

4) $H_2N-CH_2-CH_2-CH_2-CH(NH_2)-COO^-$

8.3 (a) Sample A:

Since the DNA of bacteria isolated from sample (A) will have less number of G-C pairs, it would contain less nmber of H-bond and hence less stable. It would lose the structure first.

(b)



(c) 5' AUGUUCGGCUGGCAAUC 3'

(d) 5 amino acids

(e) 120 * 5 = 600 daltons

8.4 (a) Starting pH of the assay mixture is 7.9. Since the reaction utilizes H^+ ion, the starting pH will be the lowest pH permissible to assay the enzyme activity, i.e. pH – 7.9.

(b) Total concentration of the buffer = 0.1786 M

Final concentration of conjugate acid $[Tris^+]_f$ = 0.0595 M

Final concentration of conjugate base $[Tris^0]_f$ = 0.1191 M

Final pH = 8.3

Problem 9 13 marks

Transition Metal Chemistry

9.1

Cr(24): $4s^1\ 3d^5$

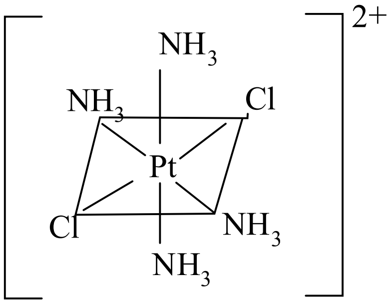
Cu(29): $4s^1\ 3d^{10}$

9.2

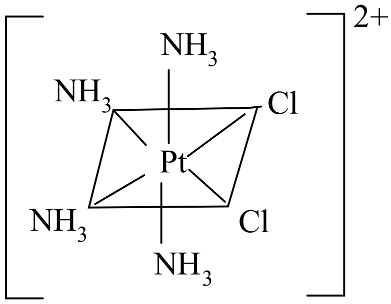
Diffuse nature of d orbital and increased nuclear charge due to added protons

9.3

Tetraaminedichloroplatinum(IV)



(trans)

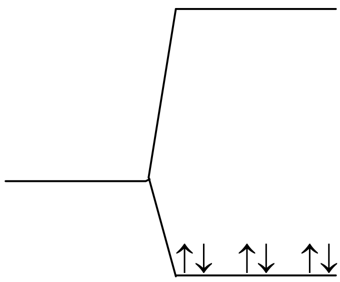


(cis)

9.4

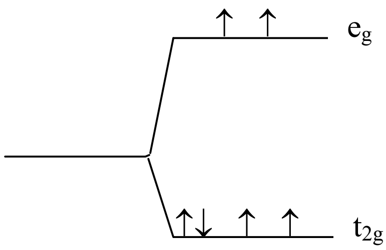
a] $[Co(NH_3)_6]^{3+}$

$Co^{3+} = d^6$



b] $[CoCl_6]^{3-}$

$Co^{3+} = d^6$ (high spin)

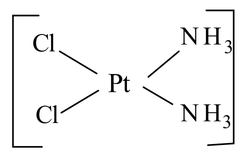


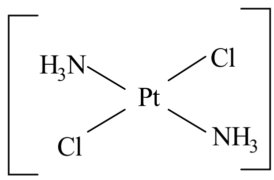
4 unpaired electrons, paramagnetic

$\mu = 2\sqrt{S(S+1)}$, where S =2

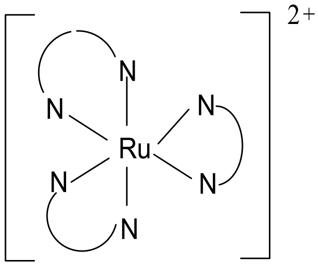
= 4.9 B.M

9.5



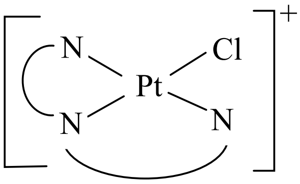


9.6 (a)



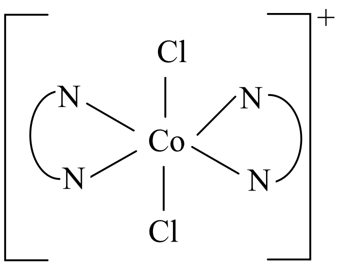
active ☒

(b)



inactive ☒

(c)



inactive ☒