

Frozen Solutions

Problem 1

20 Marks

Sulphate dynamics in Wastewaters

1.1  $\Delta G^\circ = -201 \text{ kJ}$

(1 mark)

1.2  $K = \frac{[\text{HS}^-][\text{CO}_2]^2}{([\text{SO}_4^{2-}][\text{H}_3\text{O}^+]^2)}$

(1 mark)

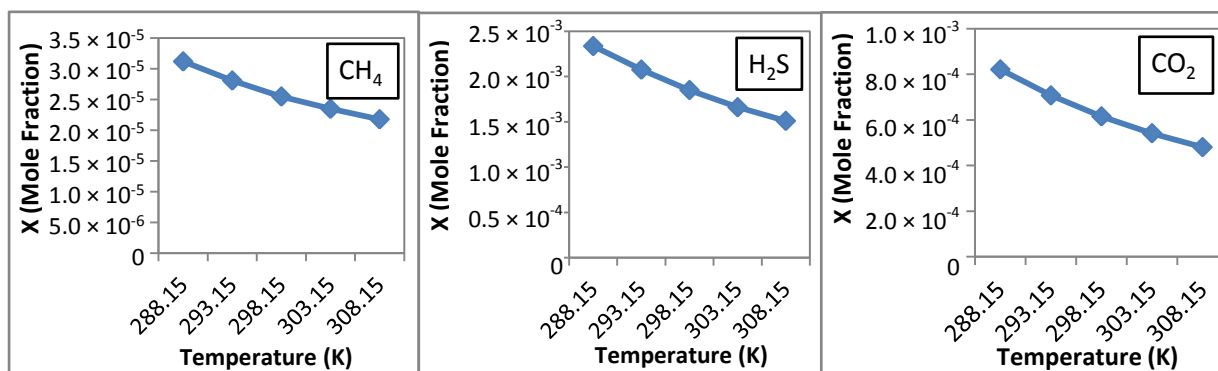
1.3  $K = 10^{34.7}$

(1 mark)

1.4 Concentration of  $\text{H}_2\text{S} = 0.25 \text{ mM}$

(2 marks)

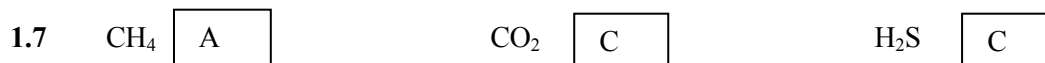
1.5 i)



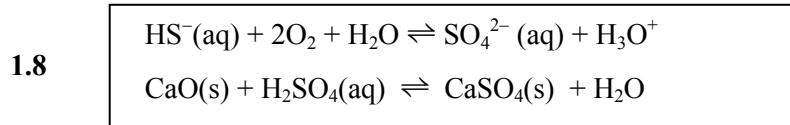
(2 marks)

1.6 Density of the air =  $1.16 \text{ kg m}^{-3}$

(2 marks)



(1.5 marks)



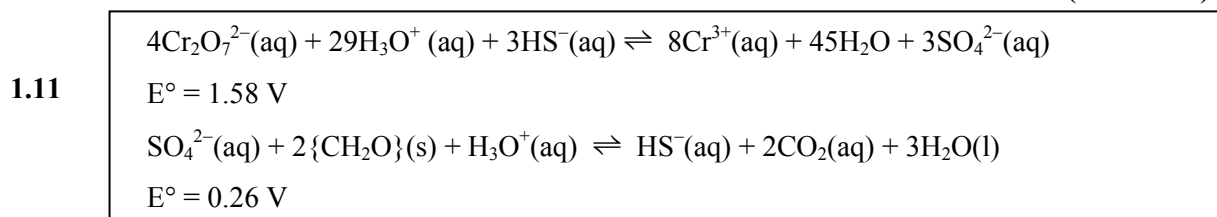
(1.5 marks)

1.9  $\frac{[\text{Cr}_2\text{O}_7^{2-}]}{[\text{Cr}^{3+}]} = 10^{20}$  (if  $p_{\text{O}_2}$  is taken in Pascal then  $10^{23}$  is also accepted as correct).

(4 marks)

1.10  $[\text{SO}_4^{2-}] = 1.49 \text{ mM}$        $[\text{Cr}^{3+}] \sim 0 \text{ mM}$        $[\text{Cr}_2\text{O}_7^{2-}] = 0.68 \text{ mM}$

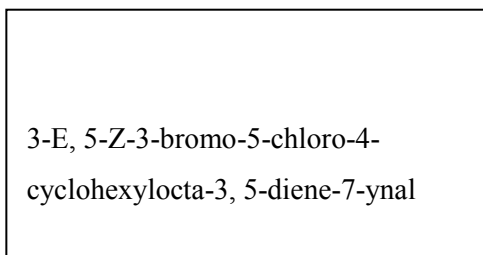
(1.5 marks)



(2.5 marks)

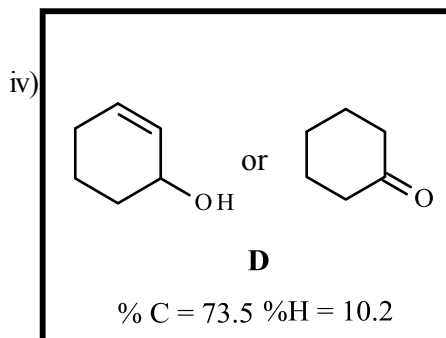
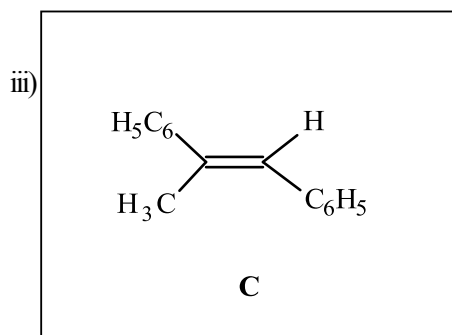
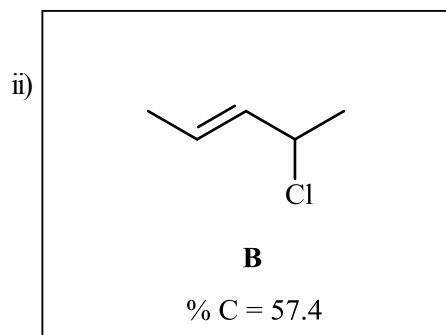
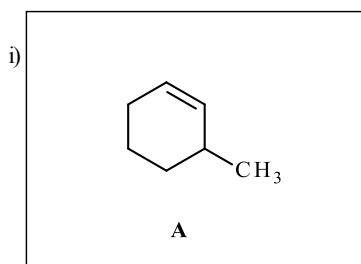
Olefin Chemistry

2.1



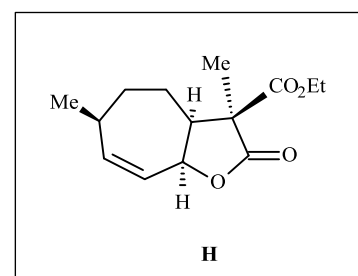
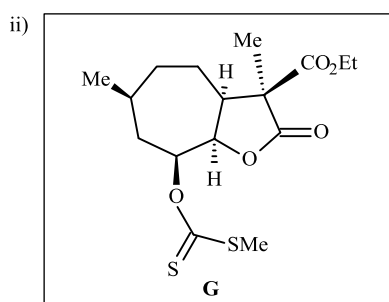
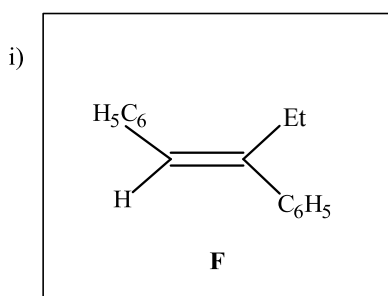
(2 marks)

2.2



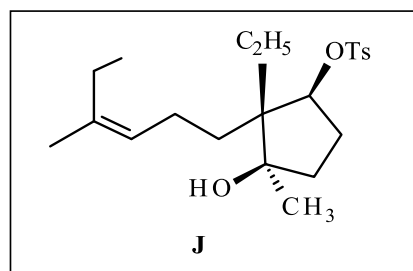
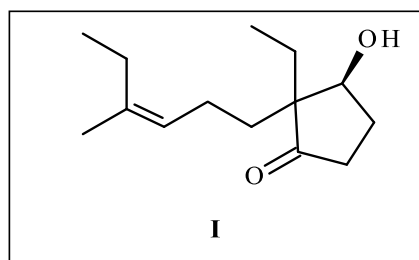
(2.5 marks)

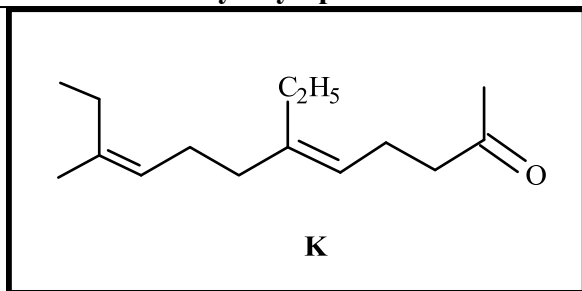
2.3



(3 marks)

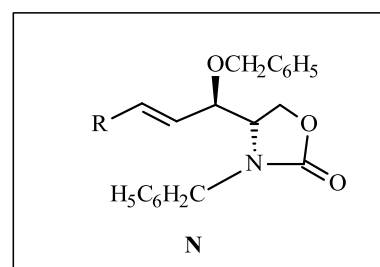
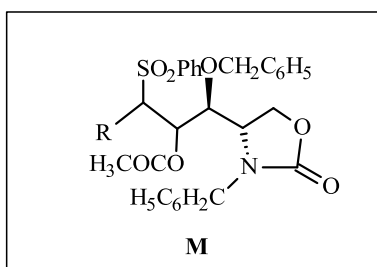
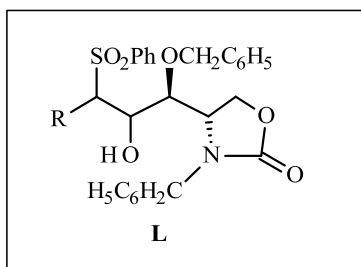
2.4





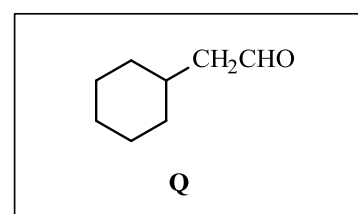
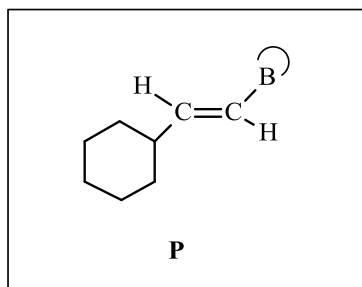
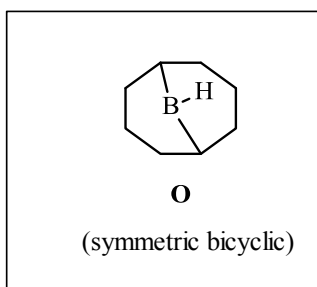
(3.5 marks)

2.5



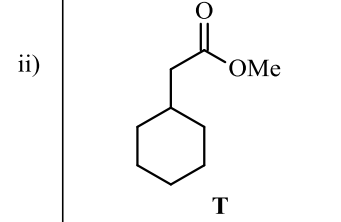
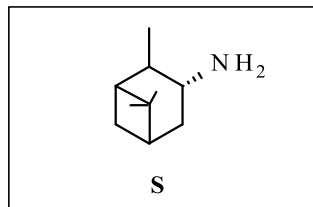
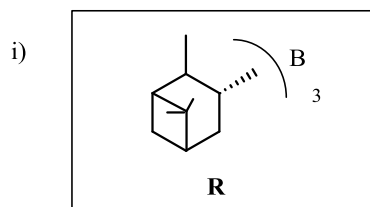
(2.5 marks)

2.6



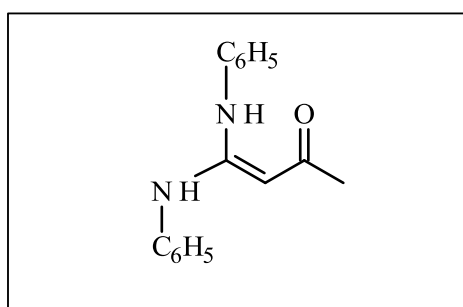
(3 marks)

2.7



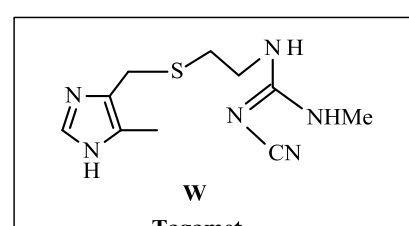
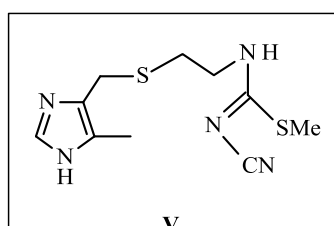
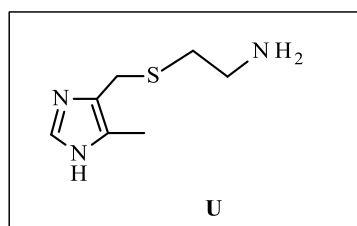
(3 marks)

2.8



(1 mark)

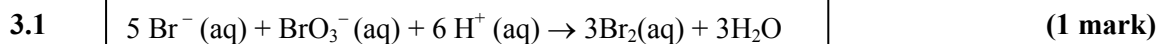
2.9



(3.5 marks)

Chemical Kinetics and Nuclear Reactions

Part A



3.2 Total order = 4 (1 mark)

3.3  $r = k_{\text{eff}} [\text{BrO}_3^-]$ ,  $k_{\text{eff}} = k [\text{Br}^-] [\text{H}^+]^2$  (1 mark)

- 3.4
- i)
  - ii)
  - iii)
  - iv)
  - v)

(2 marks)

3.5  $0.314 \text{ M}^{-3} \text{ sec}^{-1}$  (3 marks)

- 3.6
- (i)
  - (ii)
  - (iii)
  - (iv)
  - (v)

Answer marked with only (v) is also accepted as correct.

(2 marks)

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**Part B**

3.7 i)  $^{238}\text{U}_{92} \rightarrow ^{206}\text{Pb}_{82} + 8\ ^4\text{He}_2 + 6\beta$  (1 mark)

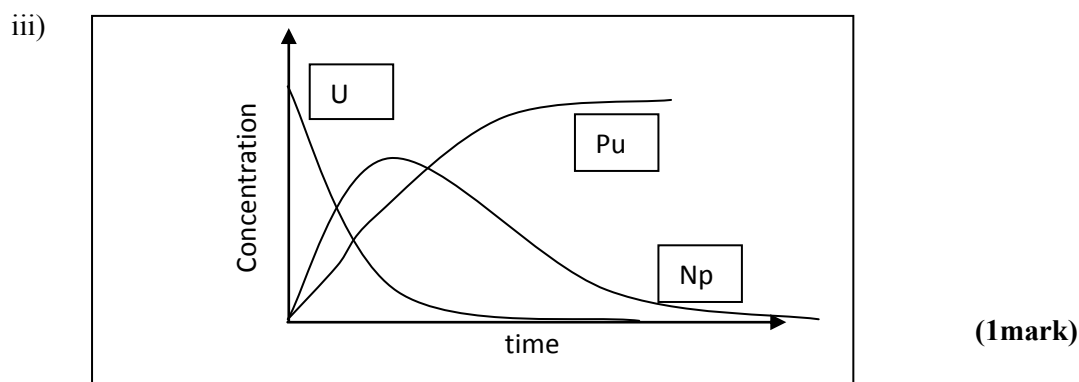
ii) a) 0.16 g (1 mark)

b) 1 billion years. (1 mark)

3.8 i) 
$$\frac{d[^{239}\text{U}_{92}]}{dt} = -k_1 [^{239}\text{U}_{92}]$$

$$\frac{d[^{239}\text{Np}_{93}]}{dt} = k_1 [^{239}\text{U}_{92}] - k_2 [^{239}\text{Np}_{93}]$$
 (1.5 marks)

ii)  $[^{239}\text{Np}_{93}] = k_1 [^{239}\text{U}_{92}]_0 / k_2 (e^{-k_2 t}) = [^{239}\text{U}_{92}]_0 \times e^{-k_2 t}$  (1 mark)



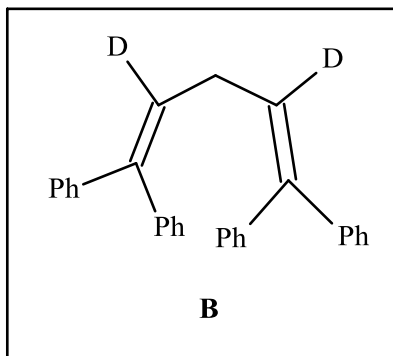
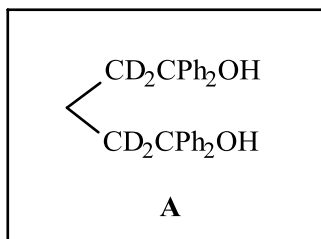
iv)

True  False

(0.5 mark)

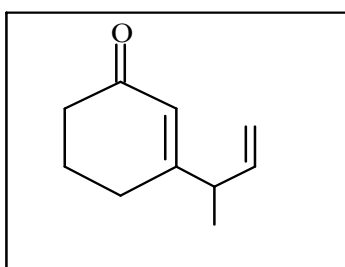
Synthesis of Natural Products

4.1



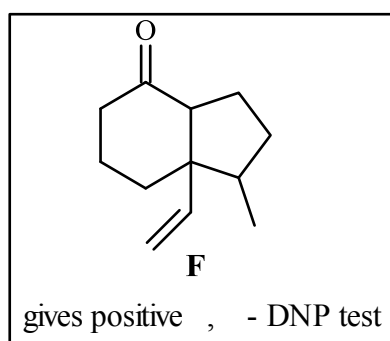
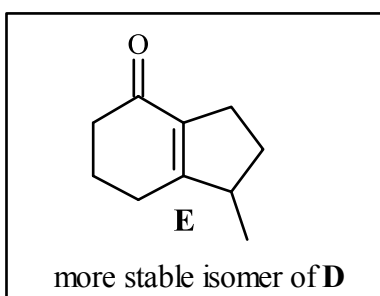
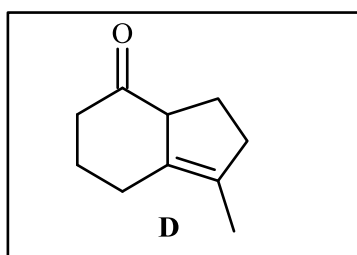
(1.5 marks)

4.2



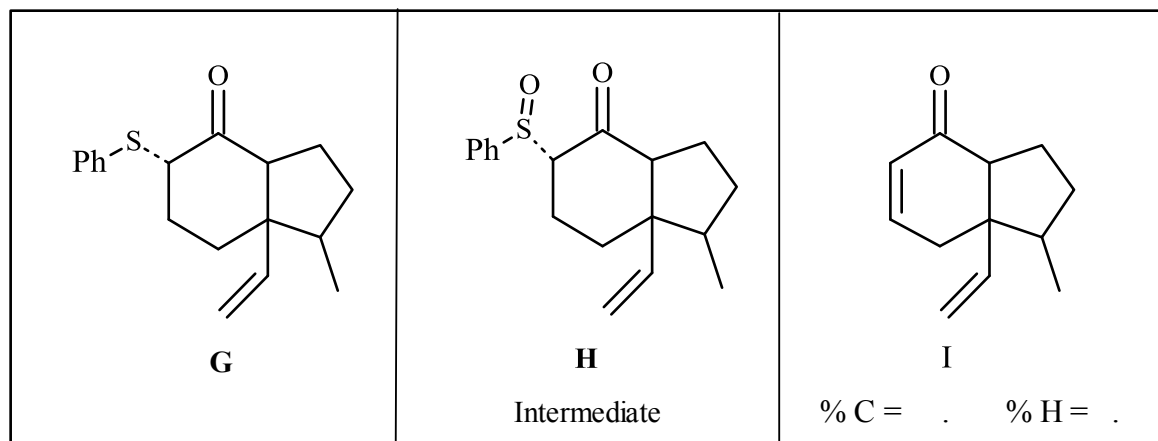
(1 mark)

4.3



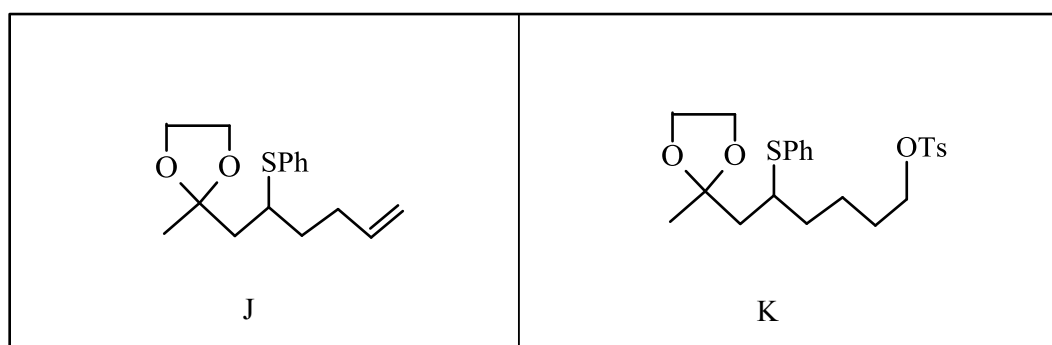
(2.5 Marks)

4.4



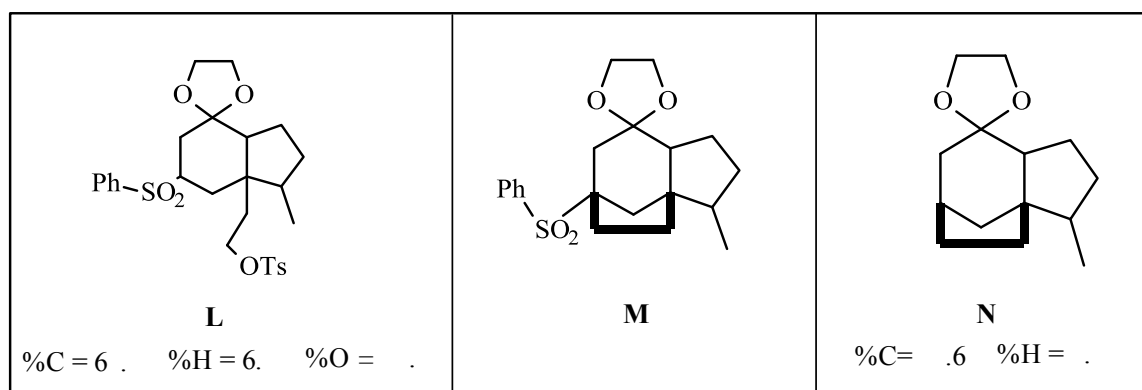
(2 marks)

4.5



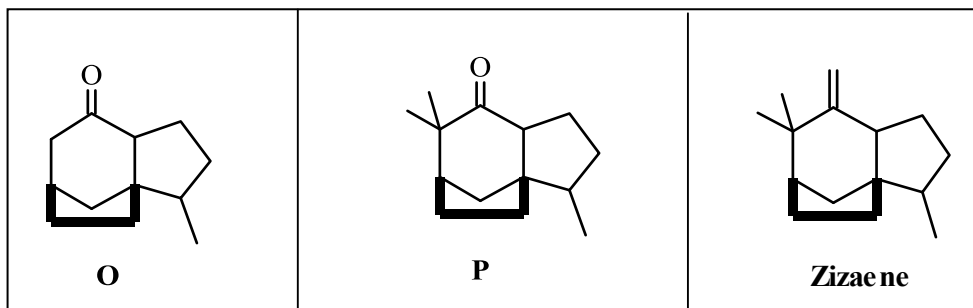
(3 marks)

4.6 Identify L, M and N.



(3.5 marks)

4.7



(3 marks)

4.8

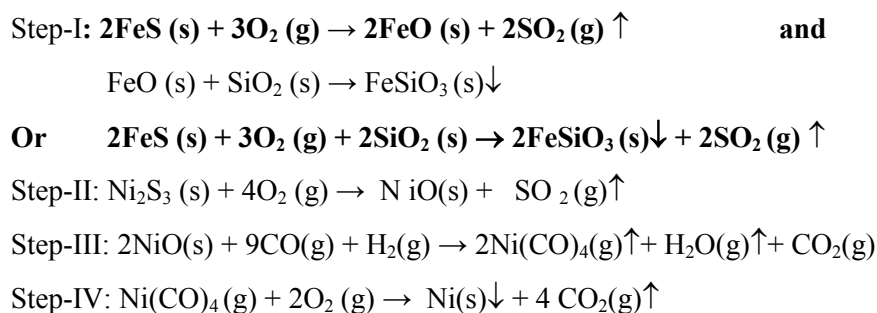
4

(0.5 Mark)



## Nickel and its chemistry

5.1 i)



(2.5 marks)

ii)

 a) 

 b) 

 c) 

 d) 

(1mark)

5.2 i)

Element	Coordination No.		Coordination geometry			
	6	4	Octahedral	Trigonal Prismatic	Square planar	Tetrahedral
Ni	6	4				
	X		X			
As	6	4				
	X			X		

(2 marks)

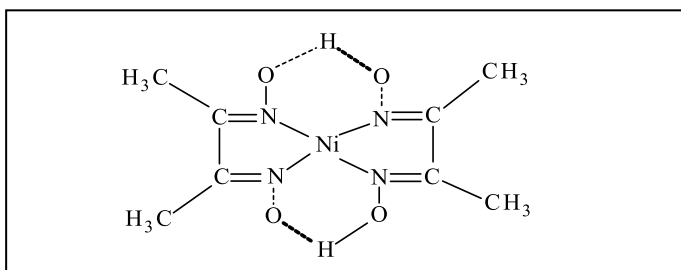
ii)

x = 1 or 6	y = 1 or 6
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(0.5 mark)

5.3

i)



(1 mark)

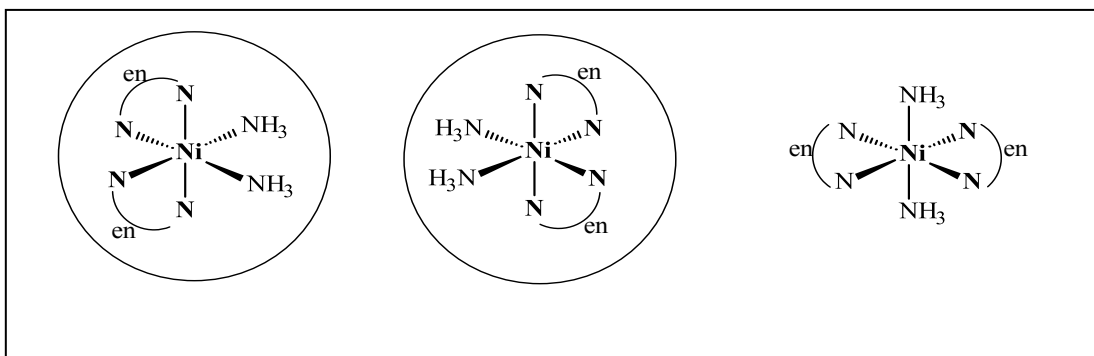
ii)

The % of Ni in stainless steel sample is 7.66% or 7.72%

(2 marks)

5.4

i)



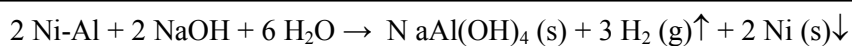
(2 marks)

ii)

$$\Delta S^{\circ} = + 39.79 \text{ JK}^{-1} \text{ mol}^{-1}$$

(2 marks)

5.5



or



(1 mark)

5.6

i)

ii)

iii)

iv)

(1 mark)

5.7

Case I

i) The CFSE of  $\text{Co}^{3+}$  in octahedral sites =  $-8,304 \text{ cm}^{-1}$  or  $-98.81 \text{ kJ mol}^{-1}$

ii) The CFSE of  $\text{Co}^{3+}$  in tetrahedral sites =  $-5,535.6 \text{ cm}^{-1}$  or  $-65.87 \text{ kJ mol}^{-1}$

Case II

i) The CFSE of  $\text{Fe}^{3+}$  in octahedral sites = 0

ii) The CFSE of  $\text{Fe}^{3+}$  in tetrahedral sites = 0

Case III

i) The CFSE of  $\text{Ni}^{2+}$  in octahedral sites =  $-10,200 \text{ cm}^{-1}$  or  $-121.38 \text{ kJ mol}^{-1}$

ii) The CFSE of  $\text{Ni}^{2+}$  in tetrahedral sites =  $-3,024 \text{ cm}^{-1}$  or  $-35.98 \text{ kJ mol}^{-1}$

(2.5 marks)

iii)

Octahedral site preference energy calculations:

Case I  $-2,768.4 \text{ cm}^{-1}$  or  $-32.94 \text{ kJ mol}^{-1}$

Case II zero

Case III  $-7,176 \text{ cm}^{-1}$  or  $-85.4 \text{ kJ mol}^{-1}$

(1 mark)

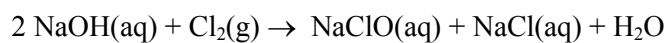
iv)

Compound	Normal	Inverse
$\text{NiFe}_2\text{O}_4$		X
$\text{NiCo}_2\text{O}_4$		X

(1 mark)

5.8

i)



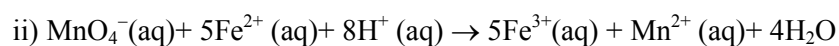
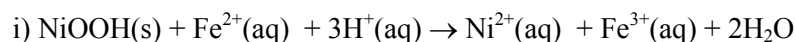
(0.5 mark)

ii)



(1 mark)

5.9



(1 mark)

iii)

96.5 %

(2 marks)