Solutions and Marking grid for the Theoretical Problems of the 27th IChO

Problem 1 (total 17 points)

1.

i) **ii)** **(1. total 6 points)**

chemical equation	$\frac{\Delta_f G_m^\ominus(298K)}{kJ\cdot mol^{-1}}$
a) $2CuCl_{(s)} + H_2O_{(l)} = Cu_2O_{(s)} + 2H^+_{(aq)} + 2Cl^-_{(aq)}$	69
b) $Cu_2O_{(s)} + 1/2O_{2(g)} + H_2O_{(l)} + H^+_{(aq)} + Cl^-_{(aq)} = Cu_2(OH)_3Cl_{(s)}$	– 824
c) $2\,CuCl_{(s)} + 1/2O_{2(g)} + 2H_2O_{(l)} = Cu_2(OH)_3Cl_{(s)} + H^+_{(aq)} + Cl^-_{(aq)}$	– 755

i) 2 points

ii) 2 points

iii) Calculation (dilute HCl solution can be considered as an ideal solution)

$$\Delta_r G_m(298K) = \Delta_r G_m^\ominus(298K) + 2RT\ln[C_{H^+}/C_{H^+}^\ominus \cdot C_{Cl^-}/C_{Cl^-}^\ominus]$$

$$= -22.3\ kJ\ mol^{-1} < 1$$

A. → **iii) 2 points**

2. **i) Formula :** $\ln\frac{k_c(T_2)}{k_c(T_1)} = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$ **(2. total 4 points)** **i) 1 point**

E_a **= 34.2 kJ· mol^{-1}** **+ 1 point**

ii) overall reaction order = 0 **ii) 1 point**

when $bp_{O2} \gg 1$, $r = k_c\theta = \frac{k_c bP_{O_2}}{1 + bP_{O_2}}$ **;** $r = k_c$, **zero order** **+ 1 point**

3. **i) (C)** $E > 0$ **(3. total 3 points)**

ii) Net cell reaction: **i) 1 point**

$Cu_{(1)} = Cu_{(2)}$

Thermodynamic reason for choosing 3 (C) is

$\Delta_r G_m < 0$, $\Delta_r G_m = -nFE$ $\therefore E > 0$ **ii) 2 points**

4. $r = 1.30\times10^{-10}$ **m(4. total 4points)**

formula: $a = 2\sqrt{2}r$ **1 point**

$$d = \frac{4(63.5\times0.75 + 65.4\times0.25)\times10^{-3}}{a^3 N_A}$$ **1.5 points**

$$= 8.51\times10^{-3}\,kg\cdot m^{-3}$$

$r^3 = 2.209\times10^{-30}$ **m^3** **1 point**

$r = 1.30\times10^{-10}$ **m** **0.5 point**

total (17 points)

Problem 2 (total 20 points)

1. A 1 point

2. B 2 points

$(1.4\times10^{-3}\times0.01)\div[Cl^-] = 4.9\times10^{-4}$ mol·dm^{-3},

$[Cl^-] = 2.9\times10^{-4}$ mol·dm^{-3} 1 point

Excess $[Cl^-] = 1.6\times10^{-2} - 2.9\times10^{-3}$

$\cong 1.6\times10^{-2}$ mol·dm^{-3} 1 point

To reduce the interference of Cl^-, at least 1.6×10^{-2} mol Ag^+ ion,

or 8.0×10^{-3} Ag_2SO_4 has to be added to 1 dm^3 sample solution.

1 point

(2. total 5 points)

3.D$E = E_2 - E_1 = 0.059$ lg $\{(C_X V_X + C_S V_S)(C_X [V_X + V_S])\}$

2 points

$0.03 = 0.059$ lg $[(25.00\ V_X + 0.10)\div(26.00\times C_X)]$ 1 point

$C_X = 1.7\times10^{-3}$ mol·dm^{-3} 1 point

$pNO_3 = 2.77$ 1 point

(3. total 5 points)

4. pH = 4.4 1 point

$(1.4\times10^{-3}\times x)\div1.6\times10^{-2} = 2.7\times10^{-3}$ 2 points

$x = 3.1\% > 1\%$ 1 point

$(1.4\times10^{-3}\times0.01)\div[CH_3COO^-] = 2.7\times10^{-3}$ 1 point

$[CH_3COO^-] = 5.2\times10^{-3}$ mol·dm^{-3} 1 point

$1.6\times10^{-2} - 5.2\times10^{-3} = 1.08\times10^{-2}$ mol·dm^{-3} 1 point

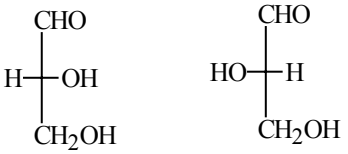
$\{[H^+]\times5.2\times10^{-3}\}\div(1.08\times10^{-2}) = 2.2\times10^{-5}$ 1 point

$[H^+] = 4.3\times10^{-5}$ mol·dm^{-3} 1 point

pH = 4.4 (4. total 9 points)

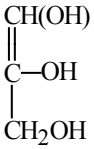
Problem 3 (total 15 points)

1.



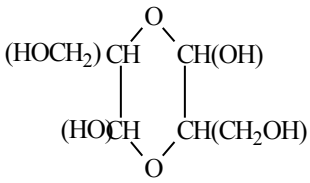
D(+) 1 point L(-) 1 point

2.



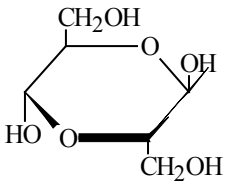
2 points

3.

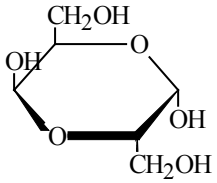


3 points

4.

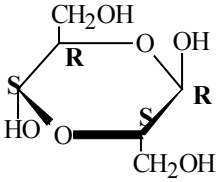


2 points

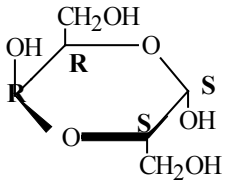


2 points

5.



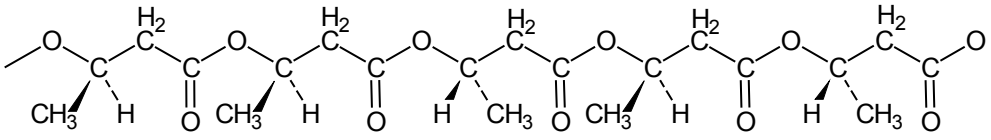
2 points



2 points

Problem 4 (total 16 points)

1. Atactic PHB:



(S) (S) (R) (S) (R)

1 point

other arrangements with (R) and (S) randomly distributed along the chain are correct, e.g.,

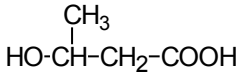
RSRRS, SRSSR, RRSRS, etc.

Syndiotactic PHB: This polymer has (R) and (S) units positioned along the chain in an alternating manner: RSRSR (or SRSRS). 1 point

Isotactic PHB: All the chiral centers have the same configuration. There are 2 types of the isotactic PHBs: SSSSS and RRRRR 2 points

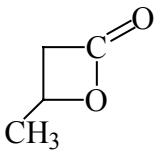
(ref. Preparatory Problem 52)

2. Monomer 1

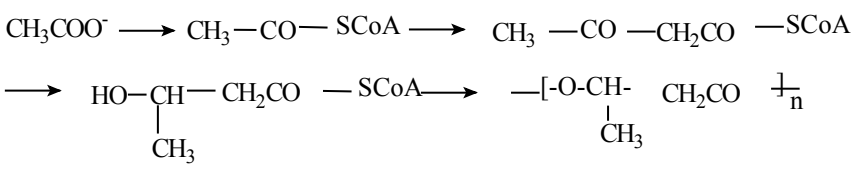


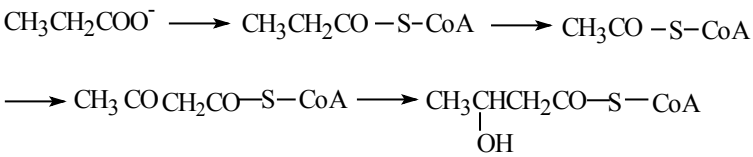
3-hydroxybutanoic acid **2 points**

Monomer 2



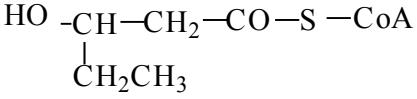
(Ref. Preparatory Problem 52) 2 points

3. 

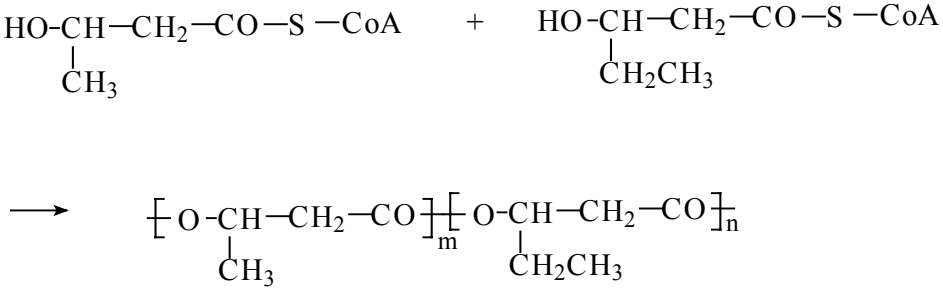
4. 

(coenzyme A activated monomer 3-hydroxypentanoic acid)

This monommmer may also be written in the following way:



Polymerization together of these two monomers will result in the desired copolymer:



(Ref. Preparatory Problem 52 and 55) 4 points for Question 3
4 points for Question 4

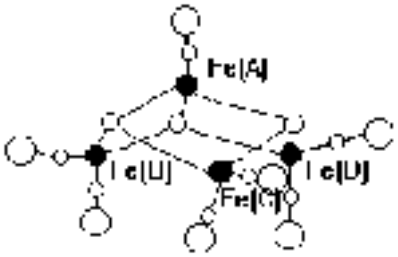
Problem 5 (total 18 points)

1. The HOMO of NO molecule is π^*, its electron arrangement is ↑;
the LUMO of NO molecule is π^*. 1+1+1= 3 points

2. B. 1 point

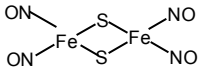
3. B. 2 points

4.



Fe(A) having $3d^7$ configuration; Fe(B), Fe(C), Fe(D) having $3d^9$ configuration.
0.5×4 + 0.5×4 + 2 = 6 points

5. i) 2 points

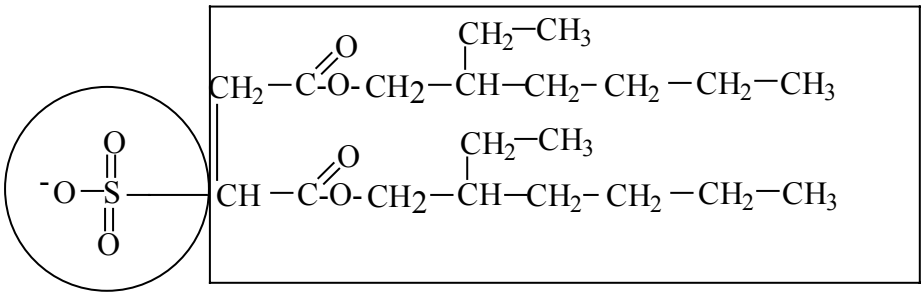


ii) Fe (-1) Fe (-1) 1+1 = 2 points

iii) The species added to S atom is CH_3^+ ; n= 0 .
1+1= 2 points

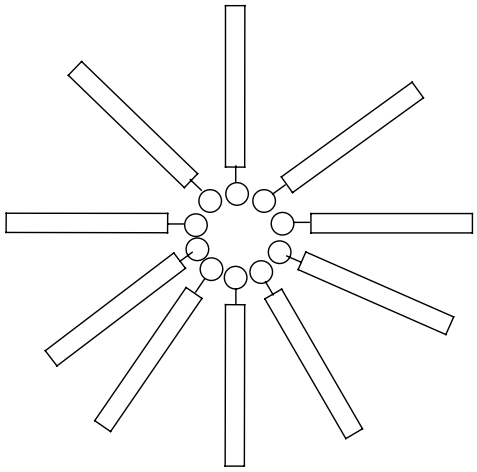
Problem 6 (total 13 points)

1. i) AOT molecule model: 1 point for PH; 1 point for NT.



ii) B. 1 point (3 points for question 1)

2. i)



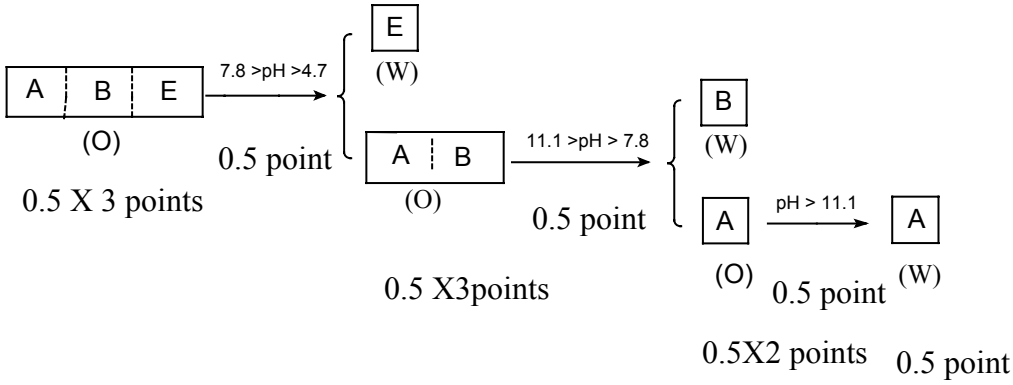
1 point for direction of the molecules

ii) H_2O, Na^+ **1 point for species in the cavity**

(2 Points for question 2)

3. A. B. E. (3 Points For question 3)

4. Fill the letters represented the extracted proteins in the frames and the separation conditions above the arrows respectively: (6 points for question 4)



0.5 X 3 points

0.5 point

0.5 X3points

0.5 point

0.5X2 points

0.5 point

The Conceptual Links between the Preparatory Problems and the Theoretical Problems

Theoretical Problem	Preparatory Problem
1	2, 5, 38-47
2	21-32
3	11-20
4	33-36, 52, 54-55
5	3-4, 8-9, 56-57
6	10, 48

Marking Grid for the Theoretical Problems

Problem	Blue points	Red points	
1	17	10	
2	20	10	
3	15	10	
4	16	10	
5	18	10	
6	13	10	
		total	60