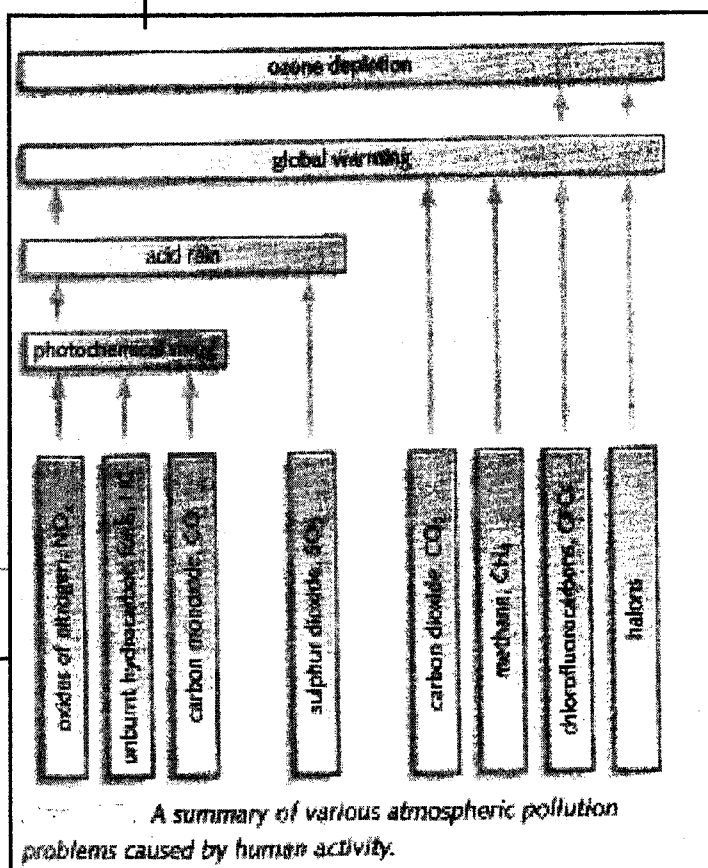
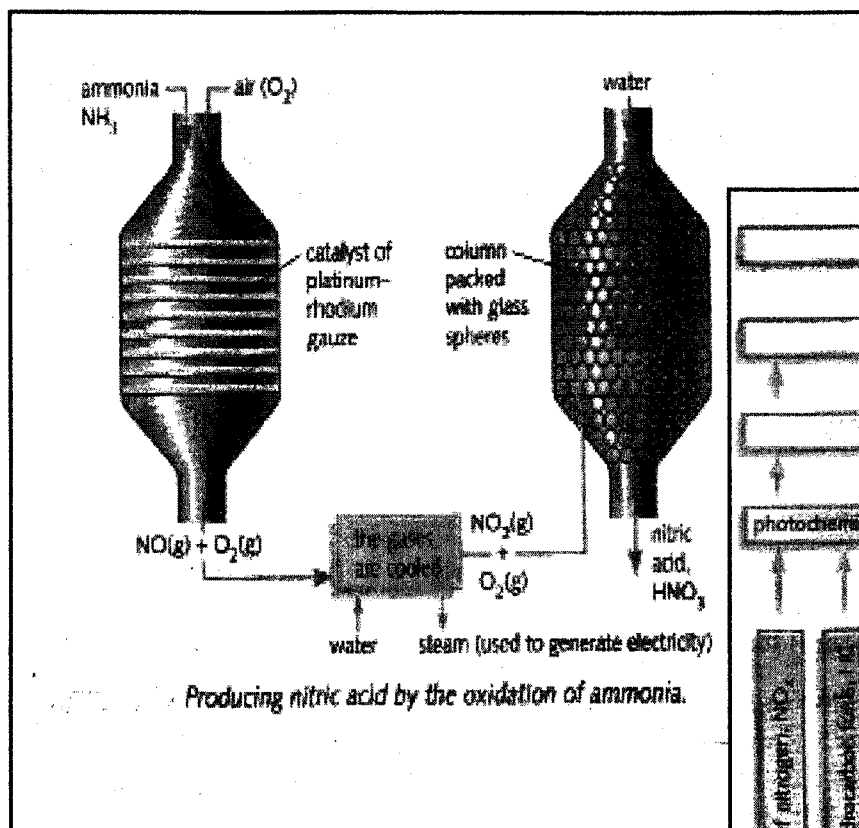




Department of Examinations - Sri Lanka  
 G.C.E. (A/L) Examination - 2018

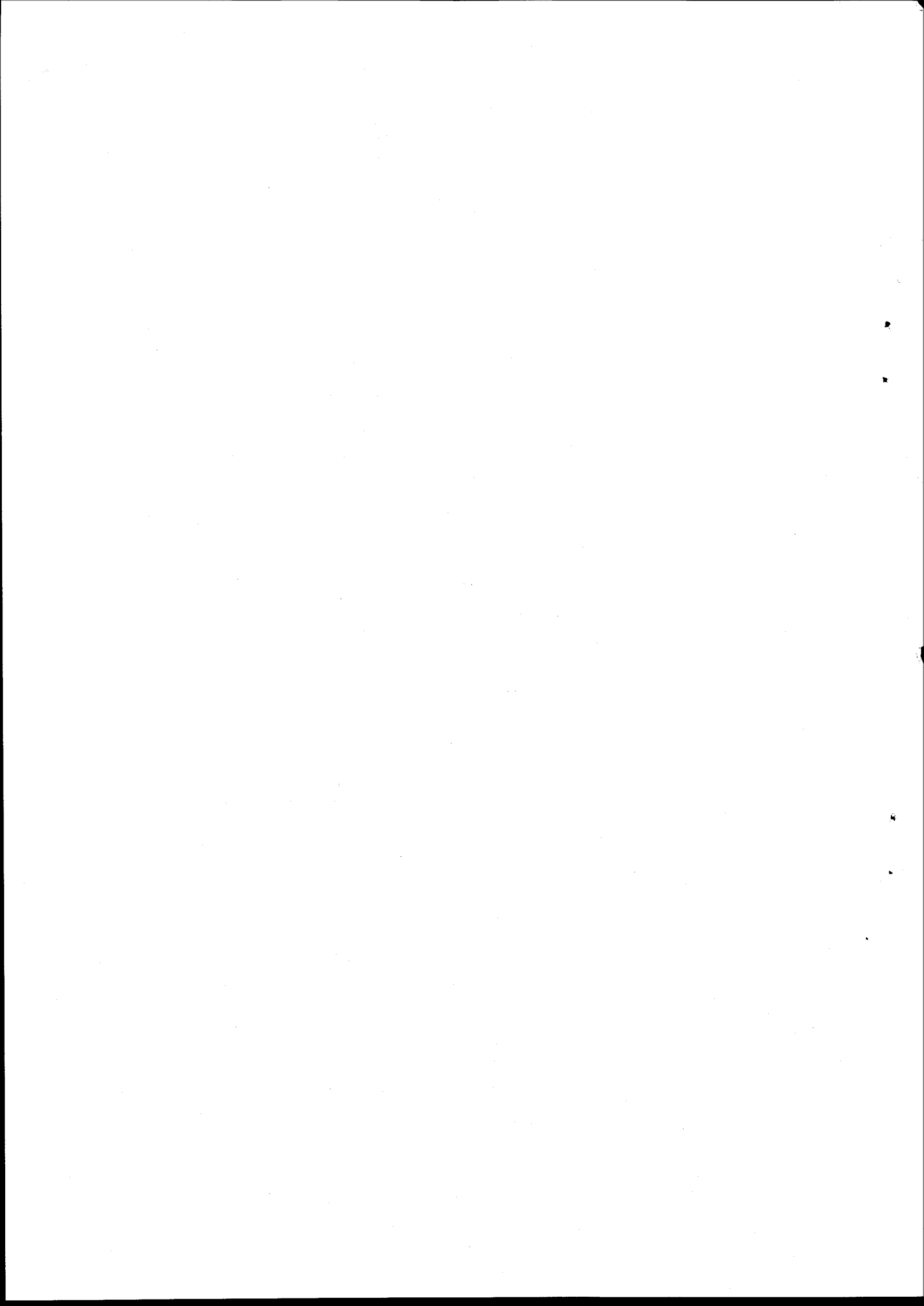
# 02 - Chemistry

## Marking Scheme



This document has been prepared for the use of Marking Examiners. Some changes would be made according to the views presented at the Chief Examiners' meeting.

Amendments to be included



**G.C.E. (A/L) Examination - 2018****02 - Chemistry****Distribution of Marks**

Paper I : 1 X 50 = 50

Paper II :

Part A : 100 X 4 = 400

Part B : 150 X 2 = 300

Part C : 150 X 2 = 300

**Total** = 1000


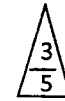
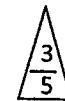
**Paper II - Final Marks** = 100

### උත්තරපත්‍ර ලකුණු කිරීමේ පොදු ශිල්පීය ක්‍රම

උත්තරපත්‍ර ලකුණු කිරීමේ හා ලකුණු ලැයිස්තුවල ලකුණු සටහන් කිරීමේ සම්මත ක්‍රමය අනුගමනය කිරීම අනිවාර්යයෙන් ම කළ යුතුවේ. ඒ සඳහා පහත පරිදි කටයුතු කරන්න.

1. උත්තරපත්‍ර ලකුණු කිරීමට රතුපාට බෝල් පොයින්ට් පෑනක් පාවිච්චි කරන්න.
2. සෑම උත්තරපත්‍රයකම මුල් පිටුවේ සහකාර පරීක්ෂක සංකේත අංකය සටහන් කරන්න.  
ඉලක්කම් ලිවීමේදී පැහැදිලි ඉලක්කමෙන් ලියන්න.
3. ඉලක්කම් ලිවීමේදී වැරදුණු අවස්ථාවක් වේ නම් එය පැහැදිලිව තනි ඉරකින් කපා හැර නැවත ලියා කෙටි අත්සන යොදන්න.
4. එක් එක් ප්‍රශ්නයේ අනු කොටස්වල පිළිතුරු සඳහා හිමි ලකුණු ඒ ඒ කොටස අවසානයේ  $\Delta$  ක් තුළ ලියා දක්වන්න. අවසාන ලකුණු ප්‍රශ්න අංකයත් සමඟ  $\square$  ක් තුළ, භාග සංඛ්‍යාවක් ලෙස ඇතුළත් කරන්න. ලකුණු සටහන් කිරීම සඳහා පරීක්ෂකවරයාගේ ප්‍රයෝජනය සඳහා ඇති තීරුව භාවිත කරන්න.

උදාහරණ : ප්‍රශ්න අංක 03

(i)	..... ..... .....	✓	
(ii)	..... ..... .....	✓	
(iii)	..... ..... .....	✓	

(03) (i)  $\frac{4}{5}$  + (ii)  $\frac{3}{5}$  + (iii)  $\frac{3}{5}$  =  $\frac{10}{15}$

**බහුවරණ උත්තරපත්‍ර : (කවුළු පත්‍රය)**

1. අ.පො.ස. (උ.පෙළ) හා තොරතුරු තාක්ෂණ විභාගය සඳහා කවුළු පත්‍ර දෙපාර්තමේන්තුව මගින් සකසනු ලැබේ. නිවැරදි වරණ කපා ඉවත් කළ සහතික කරන ලද කවුළුපතක් ඔබ වෙත සපයනු ලැබේ. සහතික කළ කවුළු පත්‍රයක් භාවිත කිරීම පරීක්ෂකගේ වගකීම වේ.
2. අනතුරුව උත්තරපත්‍ර හොඳින් පරීක්ෂා කර බලන්න. කිසියම් ප්‍රශ්නයකට එක් පිළිතුරකට වඩා ලකුණු කර ඇත්නම් හෝ එකම පිළිතුරක්වත් ලකුණු කර නැත්නම් හෝ වරණ කැපී යන පරිදි ඉරක් අඳින්න. ඇතැම් විට අයදුම්කරුවන් විසින් මුලින් ලකුණු කර ඇති පිළිතුරක් මකා වෙනත් පිළිතුරක් ලකුණු කර තිබේන්නට පුළුවන. එසේ මකන ලද අවස්ථාවකදී පැහැදිලිව මකා නොමැති නම් මකන ලද වරණය මත ද ඉරක් අඳින්න.
3. කවුළු පත්‍රය උත්තරපත්‍රය මත නිවැරදිව තබන්න. නිවැරදි පිළිතුර ✓ ලකුණකින් ද, වැරදි පිළිතුර 0 ලකුණකින් ද වරණ මත ලකුණු කරන්න. නිවැරදි පිළිතුරු සංඛ්‍යාව ඒ ඒ වරණ තීරයට පහළින් ලියා දක්වන්න. අනතුරුව එම සංඛ්‍යා එකතු කර මුළු නිවැරදි පිළිතුරු සංඛ්‍යාව අදාළ කොටුව තුළ ලියන්න.

**ව්‍යුහගත රචනා හා රචනා උත්තරපත්‍ර :**

1. අයදුම්කරුවන් විසින් උත්තරපත්‍රයේ හිස්ව තබා ඇති පිටු හරහා රේඛාවක් ඇඳ කපා හරින්න. වැරදි හෝ නුසුදුසු පිළිතුරු යටින් ඉරි අඳින්න. ලකුණු දිය හැකි ස්ථානවල හරි ලකුණු යෙදීමෙන් එය පෙන්වන්න.
2. ලකුණු සටහන් කිරීමේදී ඕවර්ලන්ඩ් කඩදාසියේ දකුණු පස තීරය යොදා ගත යුතු වේ.
3. සෑම ප්‍රශ්නයකටම දෙන මුළු ලකුණු උත්තරපත්‍රයේ මුල් පිටුවේ ඇති අදාළ කොටුව තුළ ප්‍රශ්න අංකය ඉදිරියේ අංක දෙකකින් ලියා දක්වන්න. ප්‍රශ්න පත්‍රයේ දී ඇති උපදෙස් අනුව ප්‍රශ්න තෝරා ගැනීම කළ යුතුවේ. සියලු ම උත්තර ලකුණු කර ලකුණු මුල් පිටුවේ සටහන් කරන්න. ප්‍රශ්න පත්‍රයේ දී ඇති උපදෙස්වලට පටහැනිව වැඩි ප්‍රශ්න ගණනකට පිළිතුරු ලියා ඇත්නම් අඩු ලකුණු සහිත පිළිතුරු කපා ඉවත් කරන්න.
4. පරීක්ෂාකාරීව මුළු ලකුණු ගණන එකතු කොට මුල් පිටුවේ නියමිත ස්ථානයේ ලියන්න. උත්තරපත්‍රයේ සෑම උත්තරයකටම දී ඇති ලකුණු ගණන උත්තරපත්‍රයේ පිටු පෙරළමින් නැවත එකතු කරන්න. එම ලකුණු ඔබ විසින් මුල් පිටුවේ එකතුව ලෙස සටහන් කර ඇති මුළු ලකුණට සමාන දැයි නැවත පරීක්ෂා කර බලන්න.

**ලකුණු ලැයිස්තු සකස් කිරීම :**

මෙවර සියලු ම විෂයන්හි අවසාන ලකුණු ඇගයීම් මණ්ඩලය තුළදී ගණනය කරනු නොලැබේ. එබැවින් එක් එක් පත්‍රයට අදාළ අවසාන ලකුණු වෙත වෙනම ලකුණු ලැයිස්තුවලට ඇතුළත් කළ යුතු ය. I පත්‍රයට අදාළ ලකුණු ලකුණු ලැයිස්තුවේ "I වන පත්‍රය" තීරුවේ ඇතුළත් කර අකුරෙන් ද ලියන්න. අදාළ විස්තර ලකුණු ඇතුළත් කර "II වන පත්‍රය" තීරුවේ II පත්‍රයේ අවසාන ලකුණු ඇතුළත් කරන්න. 51 විත්‍ර විෂයයේ I, II හා III පත්‍රවලට අදාළ ලකුණු වෙත වෙනම ලකුණු ලැයිස්තුවල ඇතුළත් කර අකුරෙන් ද ලිවිය යුතු වේ.

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සියලු ම හිමිකම් ඇවිරිණි / முழுப் பதிப்புரிமையுடையது / All Rights Reserved

ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව  
 இலங்கைப் பரீட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம் இலங்கைப் பரීட்சைத் திணைக்களம்  
 Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka  
 ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව  
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 Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka

අධ්‍යයන පොදු පෙළ (උසස් පෙළ) විභාග, 2018 අගෝස්තු  
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர) பரீட்சை, 2018 - ஆகஸ்ட்  
 General Certificate of Education (Adv. Level) Examination, August 2018

15.08.2018 / 08:30 - 10:30

රසායන විද්‍යාව I  
 இரசாயனவியல் I  
 Chemistry I

02 E I

පැය දෙකයි  
 இரண்டு மணித்தியாலம்  
 Two hours

Instructions:

- \* Periodic Table is provided.
- \* This paper consists of 09 pages.
- \* Answer all the questions.
- \* Use of calculators is not allowed.
- \* Write your Index Number in the space provided in the answer sheet.
- \* Follow the instructions given on the back of the answer sheet carefully.
- \* In each of the questions 1 to 50, pick one of the alternatives from (1), (2), (3), (4), (5) which is correct or most appropriate and mark your response on the answer sheet with a cross (x) in accordance with the instructions given on the back of the answer sheet.

Universal gas constant  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$   
 Avogadro constant  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$   
 Planck's constant  $h = 6.626 \times 10^{-34} \text{ Js}$   
 Velocity of light  $c = 3 \times 10^8 \text{ m s}^{-1}$

1. The number of unpaired electrons present in a gaseous  $\text{Co}^{3+}$  ion in its ground state is,  
 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5
2. Which quantum number(s) ( $n, l, m_l, m_s$ ) is/are associated with the shape of an atomic orbital of an atom?  
 (1)  $l$  (2)  $m_l$  (3)  $n$  and  $l$  (4)  $n$  and  $m_l$  (5)  $l$  and  $m_l$
3. What is the IUPAC name of the compound shown below?  

$$\text{CH}_3\text{CH}_2\underset{\text{Br}}{\text{CH}}-\underset{\text{NO}_2}{\text{C}}=\text{CHCO}_2\text{H}$$
 (1) 4-bromo-3-nitro-2-hexenoic acid (2) 4-bromo-3-nitro-2-hexenoic acid  
 (3) 3-nitro-4-bromo-2-hexenoic acid (4) 3-nitro-4-bromo-2-hexenoic acid  
 (5) 3-bromo-4-nitro-4-hexenoic acid
4. The correct answer when the molecules  $\text{O}_2, \text{H}_2\text{O}, \text{H}_2\text{O}_2, \text{OF}_2$  and  $\text{O}_2\text{F}_2$  (structure similar to  $\text{H}_2\text{O}_2$ ) are arranged in the decreasing order of the oxidation state of oxygen (O) is,  
 (1)  $\text{O}_2\text{F}_2 > \text{OF}_2 > \text{O}_2 > \text{H}_2\text{O} > \text{H}_2\text{O}_2$  (2)  $\text{H}_2\text{O} > \text{H}_2\text{O}_2 > \text{O}_2 > \text{O}_2\text{F}_2 > \text{OF}_2$   
 (3)  $\text{H}_2\text{O}_2 > \text{O}_2\text{F}_2 > \text{O}_2 > \text{OF}_2 > \text{H}_2\text{O}$  (4)  $\text{OF}_2 > \text{O}_2\text{F}_2 > \text{O}_2 > \text{H}_2\text{O} > \text{H}_2\text{O}_2$   
 (5)  $\text{OF}_2 > \text{O}_2\text{F}_2 > \text{O}_2 > \text{H}_2\text{O}_2 > \text{H}_2\text{O}$
5. The most acceptable Lewis structure for the thiocyanate ion  $\text{SCN}^-$  is,  
 (1)  $\text{:}\ddot{\text{S}}\text{:}-\text{C}\equiv\ddot{\text{N}}\text{:}$  (2)  $\ddot{\text{S}}\text{:}=\text{C}=\ddot{\text{N}}\text{:}$  (3)  $\text{:}\overset{\oplus}{\text{S}}\equiv\text{C}-\overset{\ominus}{\text{N}}\text{:}$  (4)  $\ddot{\text{S}}\text{:}=\overset{\ominus}{\text{C}}\equiv\text{N}\text{:}$  (5)  $\overset{\oplus}{\text{S}}\equiv\overset{\ominus}{\text{C}}=\ddot{\text{N}}\text{:}$
6. The molarity ( $\text{mol dm}^{-3}$ ) of a NaI solution which has a density of  $1.03 \text{ g cm}^{-3}$  and is 3% NaI by mass is,  
 (Na = 23, I = 127)  
 (1) 0.21 (2) 0.23 (3) 0.25 (4) 0.28 (5) 0.30

7. Precipitates of AgI and AgBr were added to a small amount of distilled water. This mixture was allowed to reach equilibrium at 25 °C. It was observed that both the solids were present in the system at equilibrium. Which of the following relations is applicable to this solution?

$$(K_{sp(\text{AgI})} = 8.0 \times 10^{-17} \text{ mol}^2 \text{ dm}^{-6}, K_{sp(\text{AgBr})} = 5.0 \times 10^{-13} \text{ mol}^2 \text{ dm}^{-6} \text{ at } 25 \text{ }^\circ\text{C})$$

(1)  $[\text{Br}^-] = \sqrt{5.0 \times 10^{-13}} \text{ mol dm}^{-3}$  and  $[\text{I}^-] = \sqrt{8.0 \times 10^{-17}} \text{ mol dm}^{-3}$

(2)  $[\text{Br}^-] [\text{I}^-] = [\text{Ag}^+]^2$

(3)  $[\text{Ag}^+] = \left( \sqrt{5.0 \times 10^{-13}} + \sqrt{8.0 \times 10^{-17}} \right) \text{ mol dm}^{-3}$

(4)  $\frac{[\text{Br}^-]}{[\text{I}^-]} = \frac{5.0}{8.0} \times 10^4$

(5)  $[\text{Ag}^+] = [\text{Br}^-] = [\text{I}^-]$

8. Which of the following statements is **false**?

- (1) Although the carbonates of all the group two metals in the Periodic Table are insoluble in water, their bicarbonates are soluble.
- (2) The hydroxides of all the group two metals in the Periodic Table are soluble in water.
- (3) The nitrates of all the group two metals in the Periodic Table are soluble in water.
- (4) The oxides and hydroxides of Na and Mg show basic properties whereas the oxide and hydroxide of Al show amphoteric properties.
- (5) The hydrides of Si and S show weakly acidic properties.

9. In which list are the elements given in the order of **increasing** (left to right) atomic radii?

- (1) Li, Na, Mg, S
- (2) C, Si, S, Cl
- (3) B, C, N, P
- (4) Li, Na, K, Ca
- (5) B, Be, Na, K

10. Liquids A and B form an ideal solution. Consider a mixture of liquids A and B in equilibrium with the vapour in a closed rigid container at constant temperature.  $P_A^o$  and  $P_B^o$  respectively are the saturated vapour pressures of A and B while P is the total pressure of the container and  $X_A^g$  is the mole fraction of A in the vapour phase. Which of the following is correct about this system?

(1)  $P = (P_A^o - P_B^o) X_A^g + P_B^o$

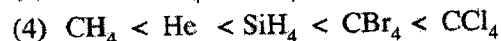
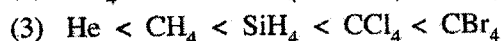
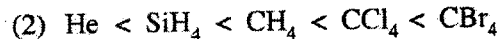
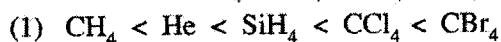
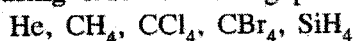
(2)  $\frac{1}{P} = \left( \frac{1}{P_A^o} - \frac{1}{P_B^o} \right) X_A^g + \frac{1}{P_B^o}$

(3)  $P = (P_A^o + P_B^o) X_A^g - P_B^o$

(4)  $\frac{1}{P} = \left( \frac{1}{P_B^o} - \frac{1}{P_A^o} \right) \frac{1}{X_A^g}$

(5)  $\frac{1}{P} = \left( \frac{1}{P_A^o} - \frac{1}{P_B^o} \right) \frac{1}{X_A^g}$

11. The **increasing** order of boiling points of the following substances is,



12. Identify the **correct** statement from the following.

(1) Among the electronic transitions  $n=2 \rightarrow n=1$ ,  $n=3 \rightarrow n=2$  and  $n=4 \rightarrow n=3$  in a hydrogen atom, most energy is released in  $n=3 \rightarrow n=2$ .

(2) Among the species  $\text{OF}_2$ ,  $\text{OF}_4$  and  $\text{SF}_4$ , the least stable is  $\text{SF}_4$ .

(3) Among the elements Li, C, N, Na and P, the least electronegative element is Li.

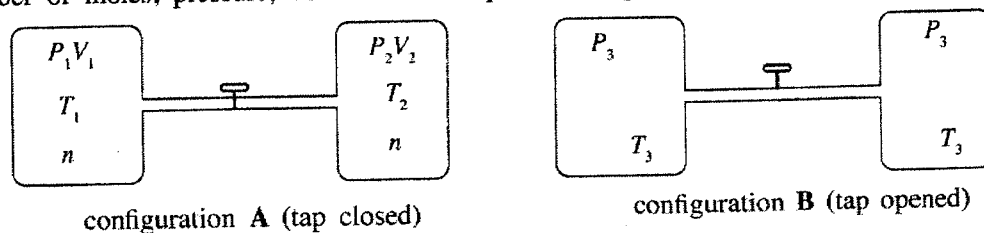
(4) In the following pairs (Li & F),  $(\text{Li}^+ \text{ \& \; } \text{F}^-)$ ,  $(\text{Li}^+ \text{ \& \; } \text{O}^{2-})$  and  $(\text{O}^{2-} \text{ \& \; } \text{F}^-)$ , the difference in radii is greatest between  $\text{Li}^+$  and  $\text{O}^{2-}$ .

(5) The only type of intermolecular force present in  $\text{CH}_2\text{Cl}_2$  in the liquid phase is dipole-dipole forces.

13. Consider the reaction:  $\text{CH}_4(\text{g}) \longrightarrow \text{CH}_3(\text{g}) + \text{H}(\text{g})$   
 The standard change in enthalpy of the above reaction is,  
 (1) the standard enthalpy change for the dissociation of the first C—H bond in methane.  
 (2) the standard atomisation enthalpy change of methane.  
 (3) the standard first ionisation enthalpy change of methane.  
 (4) the standard bond dissociation enthalpy change of methane.  
 (5) the standard radical formation enthalpy change of methane.
14. The elementary reaction  $2\text{A}(\text{g}) \longrightarrow \text{B}(\text{g})$  occurs in a closed rigid container at a constant temperature. Initial pressure of the container is  $P_0$  and the pressure when the rate of reaction is 50% of the initial value is  $P_t$ . Which of the following gives the correct value for  $\frac{P_t}{P_0}$ ?
- (1)  $\frac{P_t}{P_0} = \frac{1}{2}$       (2)  $\frac{P_t}{P_0} = \frac{1}{\sqrt{2}}$       (3)  $\frac{P_t}{P_0} = \frac{1+\sqrt{2}}{2\sqrt{2}}$       (4)  $\frac{P_t}{P_0} = \frac{\sqrt{2}}{1+\sqrt{2}}$       (5)  $\frac{P_t}{P_0} = \frac{\sqrt{2}-1}{1+\sqrt{2}}$
15. An equimolar aqueous solution of the weak acids HA and HB ( $1.0 \text{ mol dm}^{-3}$  in each acid) with  $\text{p}K_a$  values 4.7 and 5.0 respectively is at equilibrium. The value of  $\log \left( \frac{[\text{A}^-]}{[\text{B}^-]} \right)$  is approximately equal to,  
 (1) 23.5      (2) -0.3      (3) 0.3      (4) 0.94      (5) 1.06
16. Which of the following statements about  $\text{C}_6\text{H}_5\text{OH}$  is **false**?  
 (1) Reacts with  $\text{CH}_3\text{COCl}$  to form a phenyl ester.  
 (2) Reacts with bromine water to give a white precipitate.  
 (3) Evolves  $\text{CO}_2$  gas when treated with  $\text{NaHCO}_3$ .  
 (4) Gives a coloured compound when treated with  $\text{C}_6\text{H}_5\text{N}_2^+\text{Cl}^-$  in the presence of  $\text{NaOH}$ .  
 (5) Gives a coloured (purplish) solution when treated with neutral  $\text{FeCl}_3$ .
17. The half life of a reaction is,  
 (1) always independent of the initial concentration of reactants.  
 (2) always dependent on the rate constant.  
 (3) always independent of the order of the reaction.  
 (4) always independent of temperature.  
 (5) equal to twice the total reaction time.
18. Electromotive force of an electrochemical cell does **not** depend on,  
 (1) the nature of the electrolytes.  
 (2) temperature.  
 (3) the concentrations of the electrolytes.  
 (4) the surface areas of the electrodes.  
 (5) the types of metals that form the electrodes.
19.  $\text{IO}_3^-$  (iodate ion) oxidizes the  $\text{SO}_3^{2-}$  ion to  $\text{SO}_4^{2-}$  in acidic medium. The mass of  $\text{KIO}_3$  required to totally oxidize the amount of  $\text{Na}_2\text{SO}_3$  present in  $25.0 \text{ cm}^3$  of a solution of  $\text{Na}_2\text{SO}_3$  ( $0.50 \text{ mol dm}^{-3}$ ) to  $\text{Na}_2\text{SO}_4$  is 1.07 g. ( $\text{O} = 16, \text{K} = 39, \text{I} = 127$ )  
 The final oxidation state of iodine after the completion of the reaction is,  
 (1) -1      (2) 0      (3) +1      (4) +2      (5) +3
20. Which of the following statements is **false** with regard to the *s*-block elements in the Periodic Table?  
 (1) All elements in group I react with water liberating  $\text{H}_2$  gas.  
 (2) All elements in group I except Li react with  $\text{N}_2$  gas.  
 (3) All elements in group II react with  $\text{N}_2$  gas.  
 (4) Na reacts with excess  $\text{O}_2$  to give  $\text{Na}_2\text{O}_2$  whereas K gives  $\text{KO}_2$ .  
 (5) All elements in the *s*-block are good reducing agents.



21. A system consisting of two rigid containers containing an ideal gas is shown in the diagram. The containers can be connected to each other by opening the tap. The system changes from configuration A to configuration B when the tap is opened. In general  $n$ ,  $P$ ,  $V$  and  $T$  represent number of moles, pressure, volume and temperature respectively.



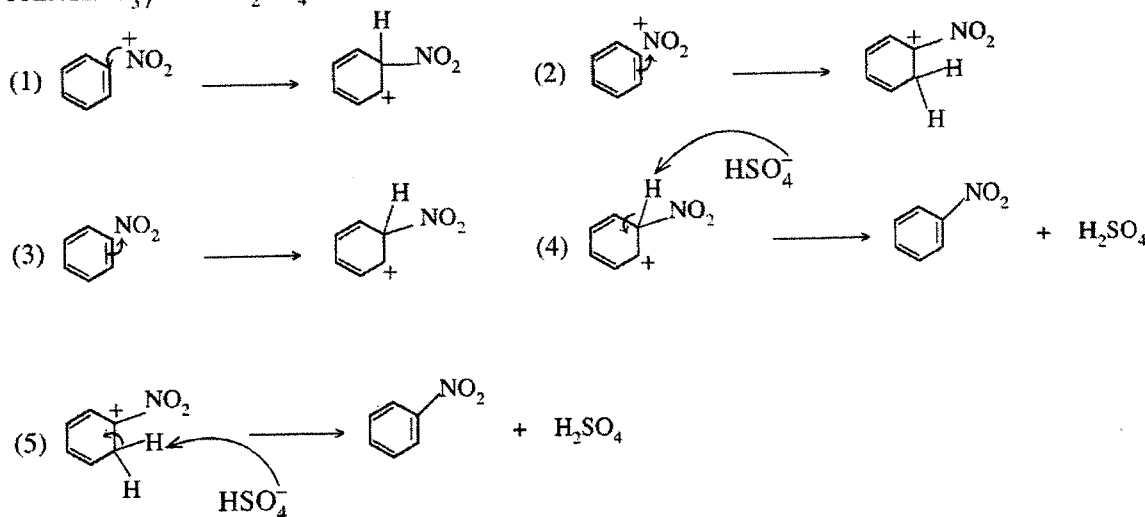
Which of the following relations is **correct** about this system?

- (1)  $P_1V_1 = P_2V_2$                       (2)  $\frac{P_3T_1}{P_1} + \frac{P_3T_2}{P_2} = 2T_3$                       (3)  $\frac{T_1}{P_1} = \frac{T_2}{P_2}$   
 (4)  $P_1T_1 = P_2T_2$                       (5)  $P_1V_1 + P_2V_2 = P_3(V_1 + V_2)$
22. Which of the following statements is **false** with regard to 3d-elements of the Periodic Table?
- (1) Atomic radii are smaller than the atomic radii of the s-block elements in the same period.  
 (2) Densities are higher than the densities of the s-block elements in the same period.  
 (3)  $V_2O_5$ ,  $CrO_3$  and  $Mn_2O_7$  are acidic oxides.  
 (4) First ionization energies are less than the first ionization energies of the s-block elements in the same period.  
 (5) The most common oxidation states of cobalt in cobalt compounds are +2 and +3.
23. Standard Gibbs energy changes for the reaction,  $MO(s) \rightarrow M(s) + \frac{1}{2}O_2(g)$  at two different temperatures are given below.

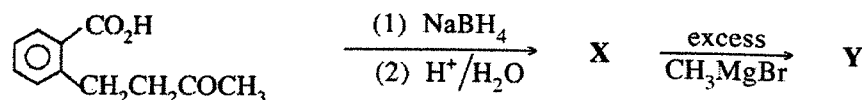
T/K	$\Delta G^\circ/kJ \text{ mol}^{-1}$
1000	-100.2
2000	-148.6

The standard entropy change of the reaction is,

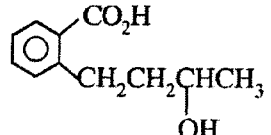
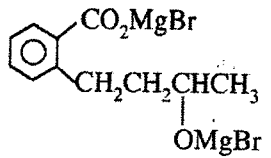
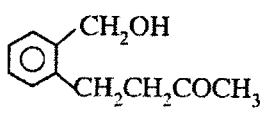
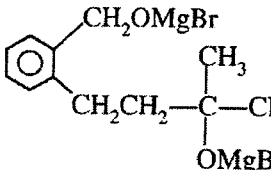
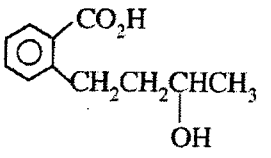
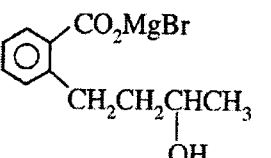
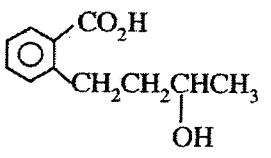
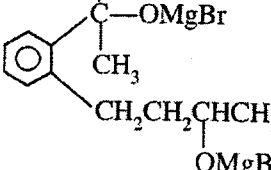
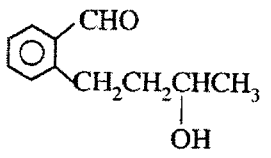
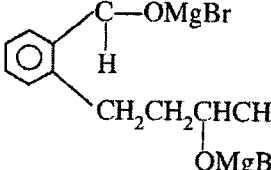
- (1)  $248.8 \text{ J K}^{-1} \text{ mol}^{-1}$                       (2)  $-248.8 \text{ J K}^{-1} \text{ mol}^{-1}$                       (3)  $-48.4 \text{ J K}^{-1} \text{ mol}^{-1}$   
 (4)  $348.4 \text{ J K}^{-1} \text{ mol}^{-1}$                       (5)  $48.4 \text{ J K}^{-1} \text{ mol}^{-1}$
24. Which of the following represents a **correct** step in the mechanism of nitration of benzene with conc.  $HNO_3$  / conc.  $H_2SO_4$ ?



25.



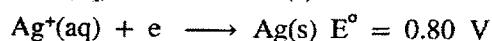
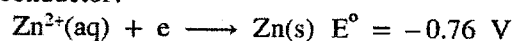
In the reaction sequence given above, the structures of X and Y respectively are,

- (1)  , 
- (2)  , 
- (3)  , 
- (4)  , 
- (5)  , 

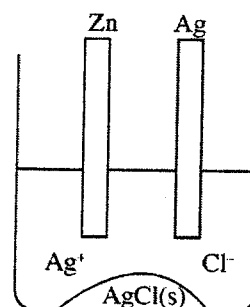
26. When  $(\text{NH}_4)_2\text{CO}_3(\text{s})$ ,  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7(\text{s})$  and  $\text{NH}_4\text{NO}_3(\text{s})$  are heated, the nitrogen containing compounds obtained are respectively,

- (1)  $\text{NH}_3$ ,  $\text{N}_2$  and  $\text{NO}_2$                       (2)  $\text{N}_2\text{O}$ ,  $\text{N}_2$  and  $\text{NH}_3$                       (3)  $\text{NH}_3$ ,  $\text{N}_2$  and  $\text{N}_2\text{O}$   
 (4)  $\text{N}_2$ ,  $\text{N}_2\text{O}$  and  $\text{NH}_3$                       (5)  $\text{N}_2$ ,  $\text{NH}_3$  and  $\text{N}_2\text{O}$

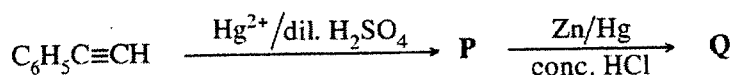
27. Which of the following would occur soon after connecting a rod of Zn and a rod of Ag immersed in a saturated solution of AgCl and AgCl(s) kept in a beaker as shown in the diagram, by a conductor?



- (1) Zn dissolves, Ag deposits, AgCl(s) dissolves.  
 (2) Zn dissolves, Ag dissolves, AgCl(s) dissolves.  
 (3) Zn dissolves, Ag dissolves, AgCl(s) deposits.  
 (4) Zn deposits, Ag dissolves, AgCl(s) dissolves.  
 (5) Chloride concentration in the solution decreases.



28. In the reaction sequence given below, the structures of P and Q respectively are,



- (1)  $\text{C}_6\text{H}_5\text{C}(\text{OH})=\text{CH}_2$ ,  $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$       (2)  $\text{C}_6\text{H}_5\text{CH}=\text{CH}(\text{OH})$ ,  $\text{C}_6\text{H}_5\text{CH}=\text{CH}_2$
- (3)  $\text{C}_6\text{H}_5-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$ ,  $\text{C}_6\text{H}_5-\overset{\text{OH}}{\underset{\text{H}}{\text{C}}}-\text{CH}_3$       (4)  $\text{C}_6\text{H}_5-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$ ,  $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_3$
- (5)  $\text{C}_6\text{H}_5\text{C}(\text{OH})=\text{CH}_2$ ,  $\text{C}_6\text{H}_5\text{CH}(\text{OH})\text{CH}_3$

29. Which of the following statements is **incorrect** regarding polymers?

- (1) Bakelite is a thermosetting polymer.
- (2) Teflon is a thermoplastic polymer.
- (3) Nylon 6,6 is formed by addition polymerisation between 1,6-diaminohexane and hexanedioic acid.
- (4) Terelene is formed by condensation polymerisation between ethylene glycol and terephthalic acid.
- (5) Natural rubber consists of *cis*-polyisoprene chains.

30. An experiment was carried out to find the order ( $m$ ) with respect to  $\text{S}_2\text{O}_3^{2-}$  of the reaction  $\text{S}_2\text{O}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l}) + \text{SO}_2(\text{g}) + \text{S}(\text{s})$ . Initial rate of the reaction ( $R$ ) was measured by adding different volumes ( $v$ ) of  $0.01 \text{ mol dm}^{-3}$   $\text{S}_2\text{O}_3^{2-}$  into a solution of an acid. The  $\text{H}^+$  concentration of the reaction mixture was kept constant, but the total volume ( $V$ ) was allowed to vary. Which of the following relations regarding the initial rate of the reaction is correct?

- (1)  $R \propto \left(\frac{v}{V}\right)^m$       (2)  $R \propto v^m$       (3)  $R \propto v^{\frac{1}{m}}$       (4)  $R \propto \left(\frac{v}{V}\right)^{\frac{1}{m}}$       (5)  $R \propto V^m$

● For each of the questions 31 to 40, one or more responses out of the four responses (a), (b), (c) and (d) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

- (1) if only (a) and (b) are correct.
- (2) if only (b) and (c) are correct.
- (3) if only (c) and (d) are correct.
- (4) if only (d) and (a) are correct.
- (5) if **any other** number or combination of responses is correct.

#### Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (a) and (b) are correct	Only (b) and (c) are correct	Only (c) and (d) are correct	Only (d) and (a) are correct	<b>Any other</b> number or combination of responses is correct

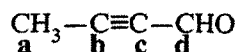
31. Consider a titration between a weak acid (fixed volume) and a strong base. Which of the following is/are independent of the weak acid concentration?

- (a) pH at the equivalence point.
- (b) Volume of the strong base required to reach the end point.
- (c) Dissociation constant of the weak acid.
- (d) Value of  $[\text{H}^+] \times [\text{OH}^-]$  of the solution in the titration flask.

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32. Which of the following statements is/are **true** regarding the molecule given below?



- (a) All four carbon atoms lie in the same plane.  
 (b) The angle between  $\text{C}_d\text{-H}$  and the  $\text{C}_d\text{-C}_c$  bonds is approximately  $120^\circ$ .  
 (c) Between  $\text{C}_b$  and  $\text{C}_c$ , there are two  $\sigma$ -bonds and one  $\pi$ -bond.  
 (d) Between  $\text{C}_b$  and  $\text{C}_c$ , there is one  $\sigma$ -bond and two  $\pi$ -bonds.
33. Which of the following statement/s is/are **true** with regard to the manufacture of  $\text{Na}_2\text{CO}_3$ ?
- (a)  $\text{CO}_2$  is one of the raw materials used.  
 (b) The reaction between  $\text{CO}_2$  and aqueous  $\text{NaCl}$  saturated with  $\text{NH}_3$  is endothermic.  
 (c) The manufacturing process involves five stages.  
 (d) Most of the  $\text{NH}_3$  used in the process can be recovered.
34. Temperature must be maintained at a constant value during the experimental determination of the order of an elementary reaction, because,
- (a) the order of the reaction depends on temperature.  
 (b) the activation energy changes with temperature.  
 (c) the mechanism of the reaction changes with temperature.  
 (d) the rate constant changes with temperature.
35. Which of the following statement/s is/are **true** regarding ethene and ethyne?
- (a)  $\text{CaC}_2$  reacts with water to form ethyne.  
 (b)  $\text{CaC}_2$  reacts with water to form ethene.  
 (c) Ethene reacts with ammoniacal  $\text{AgNO}_3$  to give a precipitate.  
 (d) Ethyne reacts with ammoniacal  $\text{Cu}_2\text{Cl}_2$  to give a precipitate.
36. Which of the following statement/s is/are **true** with regard to halogens?
- (a) The boiling points of halogens increase down the group.  
 (b) Unlike other halogens, fluorine always has an oxidation state of  $(-1)$  except in  $\text{F}_2$ .  
 (c) All halogens are good reducing agents.  
 (d) Although fluorine is the most reactive of all the elements in the Periodic Table, it does not react with inert gases.
37. For the reaction  $\text{C(s)} + \text{CO}_2(\text{g}) \rightleftharpoons 2\text{CO(g)}$  occurring in a closed rigid container, percentage yields of  $\text{CO(g)}$  at  $700^\circ\text{C}$  and  $800^\circ\text{C}$  are 60% and 80% respectively. Which of the following statement/s is/are **correct** regarding the above reaction?
- (a) The reaction is endothermic.  
 (b) The reaction is exothermic.  
 (c) Reverse reaction is favoured by decreasing the temperature.  
 (d) Equilibrium can be shifted towards the reactants by removing  $\text{C(s)}$ .
38. Cyclopropane  $\longrightarrow$  propene is an elementary reaction.  
 Which of the following statement/s is/are **correct** regarding the above reaction?
- (a) Half life of the reaction depends on cyclopropane concentration.  
 (b) Rate of the reaction does not depend on propene concentration.  
 (c) The fraction of cyclopropane molecules having energy greater than the activation energy increases with increasing temperature.  
 (d) Reaction occurs *via* a bimolecular collision (molecularity = 2).
39. Which of the following statement/s is/are **true** regarding 3-hexene?
- (a) Does not show geometric isomerism.  
 (b) Shows optical isomerism.  
 (c) The compound obtained when reacted with  $\text{H}_2/\text{Pd}$  does not show optical isomerism.  
 (d) The compound obtained when reacted with  $\text{HBr}$  shows optical isomerism.

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40. Which of the following statements is/are **correct** with regard to the nitrogen cycle?
- $N_2$  in the atmosphere is fixed only by atmospheric and industrial fixation.
  - $N_2$  is reduced during atmospheric fixation.
  - $N_2$  is oxidized during industrial fixation.
  - Nitrates and nitrites formed during atmospheric fixation are utilized by plants to make proteins when the rainfall deposit them on the ground.

- In question Nos. 41 to 50, two statements are given in respect of each question. From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that **best** fits the two statements and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement
(2)	True	True, but does <b>not</b> explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	$BaCO_3$ is more thermally stable than $MgCO_3$ .	Polarizing power of group two cations decreases down the group.
42.	The lone pair of electrons on nitrogen in an amine has a lower tendency to form a bond with $H^+$ , than the lone pair of electrons on oxygen in an alcohol.	Nitrogen is less electronegative than oxygen.
43.	A reaction at equilibrium can be driven forward (i.e. shift of equilibrium point to the right) by adding a catalyst.	The catalyst provides a pathway with a low activation energy only to the forward reaction.
44.	$CO_3^{2-}$ and $SO_3^{2-}$ ions have similar shapes.	Central atoms of both $CO_3^{2-}$ and $SO_3^{2-}$ have lone pairs of electrons.
45.	The boiling point of $CH_3CH_2CH_2OH$ is higher than the boiling points of $CH_3CH_2CHO$ and $CH_3COCH_3$ .	The carbon oxygen double bond is stronger than the carbon oxygen single bond.
46.	A reaction occurring spontaneously in an <b>isolated</b> system <b>always</b> has a negative Gibbs energy change.	A process in an <b>isolated</b> system cannot be changed from outside.
47.	Commonly used soap contain the sodium or potassium salts of fatty acids formed by the reaction of NaOH or KOH with oils and fats.	The reaction of an ester with aqueous NaOH or KOH gives the sodium or potassium salt of the carboxylic acid and the alcohol.
48.	$C_6H_5Br$ does not react easily with NaOH to form $C_6H_5OH$ .	The phenyl carbocation is very stable.
49.	When an aqueous solution of a weak acid is diluted, both the fraction of dissociated acid molecules and pH of the medium are increased.	Dissociation of weak acid molecules occur in such a way that the acid dissociation constant $K_a$ remains constant.
50.	In the presence of sunlight $CO_2$ is fixed in green plants.	Increase of $CO_2$ level in the atmosphere cannot be controlled by green plants.

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ශ්‍රී ලංකා විභාග දෙපාර්තමේන්තුව  
இலங்கைப் பரீட்சைத் திணைக்களம்

අ.පො.ස. (උ.පෙළ) විභාගය/ க.பொ.த. (உயர் தர)ப் பரீட்சை - 2018

විෂය අංකය  
பாட இலக்கம்

02

විෂය  
பாடம்

Chemistry

ලකුණු දීමේ පටිපාටිය/புள்ளி வழங்கும் திட்டம்

I පත්‍රය/பத்திரம் I

ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.	ප්‍රශ්න අංකය வினா இல.	පිළිතුරු අංකය விடை இல.
01.	04	11.	3	21.	2	31.	3	41.	1
02.	1 or 5 or both	12.	4	22.	4	32.	5	42.	4
03.	2	13.	1	23.	5	33.	3	43.	5
04.	5	14.	3	24.	4	34.	5	44.	5
05.	2	15.	3	25.	1	35.	4	45.	2
06.	1	16.	3	26.	3	36.	1 or 5 or both	46.	4
07.	4	17.	2	27.	1	37.	5	47.	1
08.	2	18.	4	28.	4	38.	2	48.	3
09.	5	19.	2	29.	3	39.	3	49.	1
10.	2	20.	2	30.	1	40.	5	50.	3

❖ විශේෂ උපදෙස්/ விசேட அறிவுறுத்தல் :

එක් පිළිතුරකට/ ஒரு சரியான விடைக்கு 01 ලකුණු ලැබේ/புள்ளி வீதம்

මුළු ලකුණු/மொத்தப் புள்ளிகள் 1 × 50 = 50

## PART A — STRUCTURED ESSAY

Answer all four questions on this paper itself. (Each question carries 10 marks.)

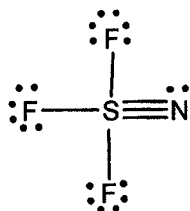
1. (a) State whether the following statements are **true** or **false**. (Reasons are **not** required.)

- (i) The polarizability of halide ions increases with increasing size. .... **True**.....
- (ii) The O—N—O bond angle of  $\text{NO}_2$  is greater than that of  $\text{NO}_2^-$ . .... **True**.....
- (iii) London dispersion forces among  $\text{CCl}_4$  molecules are smaller than the London dispersion forces among  $\text{SO}_3$  molecules. .... **False**.....
- (iv) The shape of the  $\text{HSO}_4^-$  ion is trigonal bipyramidal. .... **False**.....
- (v) All 3d atomic orbitals of an atom are represented by quantum numbers ( $n, l, m_l$ ) 3, 2, 1. .... **False**.....
- (vi) The addition of an electron to a gaseous phosphorus atom is an exothermic process whereas for a gaseous nitrogen atom it is endothermic. .... **True**.....

(✓ = True    ✗ = False can be accepted.)

(04 marks x 6 = 24)

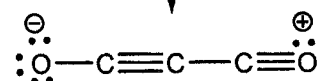
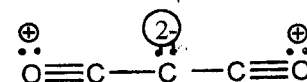
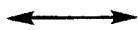
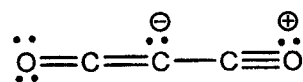
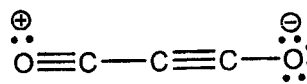
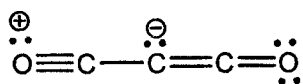
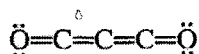
1(a) = 24 marks

(b) (i) Draw the **most** acceptable Lewis structure for the molecule  $\text{SF}_3\text{N}$ .

(08)

(ii) The most stable Lewis structure for the molecule  $\text{C}_3\text{O}_2$  (carbon suboxide) is shown below. Draw another **two** Lewis structures (resonance structures) for this molecule.

(Note: Marks will not be awarded for Lewis structures drawn with octet rule violated.)



(any two)

(07 marks x 2 = 14)

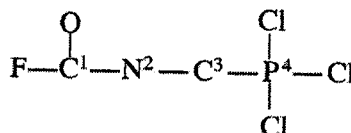
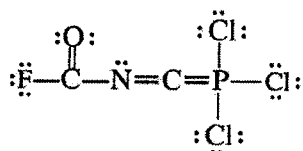
(resonance arrows are not required for award of marks)

(iii) Based on the Lewis structure given below, state the following regarding the C, N and P atoms given in the table below.

I. VSEPR pairs around the atom  
III. shape around the atom

II. electron pair geometry around the atom  
IV. hybridization of the atom

The atoms are numbered as follows:



		C <sup>1</sup>	N <sup>2</sup>	C <sup>3</sup>	P <sup>4</sup>
I	VSEPR pairs	3	3	2	4
II	Electron pair geometry	trigonal planar	trigonal planar	linear	tetrahedral
III	Shape	Trigonal planar	Angular / V	linear	tetrahedral
IV	Hybridization	$sp^2$	$sp^2$	$sp$	$sp^3$

(01 mark x 16 = 16)

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following  $\sigma$  bonds in the Lewis structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I.	F—C <sup>1</sup>	F..... $2p$ or $sp^3$	C <sup>1</sup> ..... $sp^2$
		$sp^2$	$sp^2$
II.	C <sup>1</sup> —N <sup>2</sup>	C <sup>1</sup> .....	N <sup>2</sup> .....
III.	N <sup>2</sup> —C <sup>3</sup>	N <sup>2</sup> ..... $sp^2$	C <sup>3</sup> ..... $sp$
		$sp$	$sp^3$
IV.	C <sup>3</sup> —P <sup>4</sup>	C <sup>3</sup> .....	P <sup>4</sup> .....
V.	P <sup>4</sup> —Cl	P <sup>4</sup> ..... $sp^3$	Cl ..... $3p$ or $sp^3$

(01 mark x 10 = 10)

(v) Identify the atomic orbitals involved in the formation of the following  $\pi$  bonds in the Lewis structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

I.	N <sup>2</sup> —C <sup>3</sup>	N <sup>2</sup> ..... $2p$	C <sup>3</sup> ..... $2p$
II.	C <sup>3</sup> —P <sup>4</sup>	C <sup>3</sup> ..... $2p$	P <sup>4</sup> ..... $3d$ (award 01 mark for any answer OR no answer)

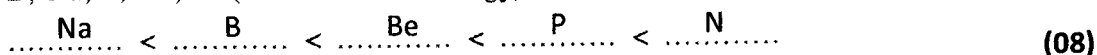
(01 mark x 4 = 04)

1(b) = 52 marks

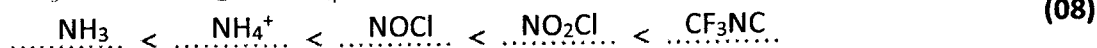


(c) Arrange the following in the **increasing** order of the property indicated in parenthesis (Reasons are **not** required.)

(i) B, Na, P, Be, N (first ionization energy)

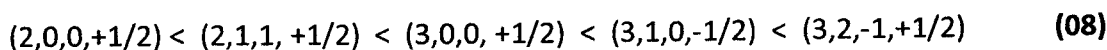
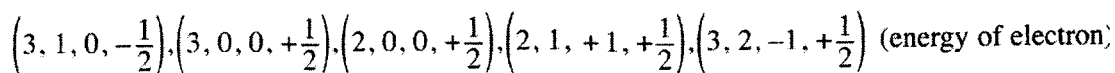


(ii)  $\text{NH}_3$ ,  $\text{NOCl}$ ,  $\text{NO}_2\text{Cl}$ ,  $\text{NH}_4^+$ ,  $\text{F}_3\text{C}-\text{NC}$  (electronegativity of nitrogen)



**Note:**  $\text{NH}_3 < \text{NOCl} < \text{NH}_4^+ < \text{NO}_2\text{Cl} < \text{CF}_3\text{NC}$  (only for this year) (08)

(iii) Quantum numbers of electrons in an atom ( $n, l, m_l, m_s$ )



(08 marks x 3 = 24)

1(c) = 24 marks

2.(a) **X** is a *p*-block element in the Periodic Table. It exists as a diatomic gas. **X** exhibits a wide range of oxidation states. **Y** is the most common hydride of **X**. **Y** dissolves readily in water to give a basic solution. **Y** acts as an oxidizing agent, a reducing agent, an acid and a base. The diatomic gas of **X** is used in the manufacture of **Y**.

(i) Identify **X** and **Y**.

X – N or Nitrogen (No marks for  $\text{N}_2$ ) (05)

Y –  $\text{NH}_3$  or Ammonia (05)

(ii) The diatomic gas of **X** is generally considered as inert. Briefly explain.

$\text{N}_2$  contains a triple bond. (03)

Therefore, high bond dissociation energy (03)

(iii) Write the chemical formulae of **three** oxides of **X**, and indicate the oxidation state of **X** in each compound.

$\text{N}_2\text{O}$	+1	$\text{NO}$	+2	$\text{N}_2\text{O}_3$	+3	
$\text{NO}_2/\text{N}_2\text{O}_4$	+4	$\text{N}_2\text{O}_5$	+5			(03 + 03 + 03)

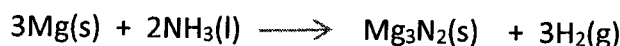
**Note:** Award mark for oxidation state only if formula is correct.

Mark distribution, formula (02), oxidation state (01)

(Any three can be accepted)

- (iv) In each of the following instances, give a balanced chemical equation to indicate the action of Y.

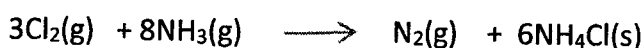
I. Y as an oxidizing agent



(Any one)

(03)

II. Y as a reducing agent

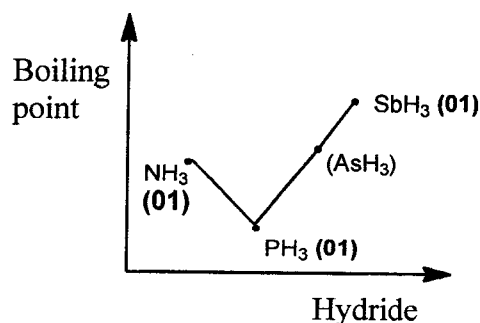


(Any one)

(03)

**Note: Physical states are not required for award of marks.**

- (v) Consider the hydrides of the elements in the group to which X belongs, which are analogous to Y. Sketch the variation in boiling points of these hydrides (including Y) in the graph below. In your sketch indicate the hydrides using their chemical formulae. (Note: Values of boiling points are **not** required.)



(05)

**Note: Shape (02). Shape needs to be correct for award of marks for labeling.**  
(i.e. Max.  $\text{SbH}_3$ ; Min.  $\text{PH}_3$ ; In between  $\text{NH}_3$ )

- (vi) Give reasons for the variation in boiling points in part (v) above.

As molecular mass / size increases, boiling point increases. (03)

But with  $\text{NH}_3$ , boiling point is higher than expected because  
of H-bonding between  $\text{NH}_3$  molecules. (03)

(vii) I. Write what you would observe when an excess of an aqueous solution of Y is added to a solution of  $\text{Al}_2(\text{SO}_4)_3$ .

white precipitate / white gelatinous precipitate ..... (03)...

II. Write the chemical formula of the species that gives rise to your observation in part I above.

$\text{Al}(\text{OH})_3$  ..... (03).....

(viii) Give **one chemical** test to identify Y.

Test: Test with Nessler's reagent ..... (03)

Observation: Brown precipitate / Brown coloration ..... (03)

**OR**

Test with HCl vapour ..... (03)

White fumes ..... (03)

**OR**

Test with red litmus ..... (03)

Red litmus turns blue ..... (03)

**OR**

Add to a solution of Cu(II) ions ..... (03)

Deep blue colour solution ..... (03)

(ix) Z is an oxo-acid of X and a strong oxidizing agent.

I. Identify Z.  $\text{HNO}_3$  OR Nitric acid ..... (03)

II. State the products obtained when hot concentrated Z reacts with sulphur.

$\text{H}_2\text{SO}_4(\text{l})$ ,  $\text{NO}_2(\text{g})$ ,  $\text{H}_2\text{O}(\text{l})$  ..... (01+01+01)

**Note: physical states are not required.**

**2(a) = 60 marks**

(b) A and B are compounds of two *p*-block elements that belong to the same group in the Periodic Table. A exists as a colourless, odourless liquid at room temperature and atmospheric pressure. It is also found in the gaseous and solid states. The solid state of A is less dense than its liquid state. Ionic and polar compounds are readily soluble in A.

B is a colourless gas at room temperature and atmospheric pressure. A filter paper moistened with lead acetate turns black on treatment with B.

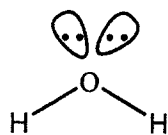
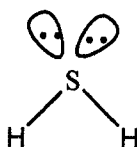
(i) Identify A and B.

A -  $\text{H}_2\text{O}$

B -  $\text{H}_2\text{S}$

(04 + 04)

(ii) Sketch the shapes of **A** and **B** showing lone pairs of electrons where necessary.

**A****B****(03 + 03)**

(iii) Giving reasons, state whether **A** or **B** has the larger bond angle.

Oxygen is more electronegative than sulphur. **(01)**

Therefore, bonding pairs of electrons are located closer to the oxygen atom in  $\text{H}_2\text{O}$ , than to the sulphur atom in  $\text{H}_2\text{S}$ . **(01)**

Therefore, repulsion of bonding electron pairs is greater in  $\text{H}_2\text{O}$  than in  $\text{H}_2\text{S}$ . **(01)**

Bond angle of **A**/ $\text{H}_2\text{O}$  is greater than bond angle of **B**/ $\text{H}_2\text{S}$  **(02)**

(iv) In each of the following instances, give a balanced chemical equation to indicate the action of **A**.

I. **A** as an acid:  $\text{H}_2\text{O}(\text{l}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$  (OR  $\text{NH}_4\text{OH}(\text{aq})$ ) **(03)**

OR

$2\text{Na}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{NaOH}(\text{aq}) + \text{H}_2(\text{g})$

(OR any other metal that reacts with water liberating  $\text{H}_2$ )

(Note:  $\longrightarrow$  accepted)

II. **A** as a base:  $\text{H}_2\text{O}(\text{l}) + \text{HCl}(\text{aq}) \longrightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$  OR **(03)**

$\text{H}_2\text{O}(\text{l}) + \text{CH}_3\text{COOH}(\text{aq}) \longrightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq})$

(v) Write the balanced chemical equation for the reaction of **B** with aqueous lead acetate.

$\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq}) + \text{H}_2\text{S}(\text{g}) \longrightarrow \text{PbS}(\text{s}) + 2\text{CH}_3\text{COOH}(\text{aq})$  **(03)**

(OR  $2\text{CH}_3\text{COO}^- + 2\text{H}^+$ )

(vi) I. Write what you would observe when **A** and **B** are added separately to an acidified solution of  $\text{BiCl}_3$ .

with **A** (excess) - white precipitate / white solid/ white turbidity **(03)**

with **B** - black precipitate **(03)**

II. Write balanced chemical equations for your observations in part I above.

$\text{BiCl}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{BiOCl}(\text{s}) + 2\text{HCl}(\text{aq})$  **(03)**

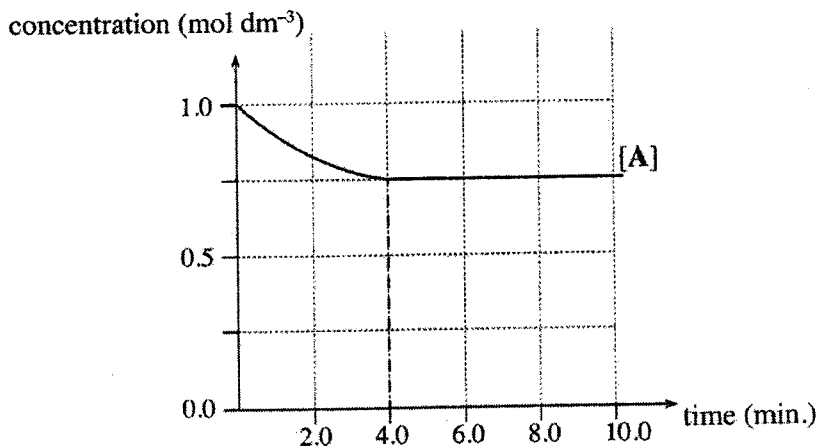
( $\longrightarrow$  can be accepted.)

$2\text{BiCl}_3(\text{aq}) + 3\text{H}_2\text{S}(\text{g}) \longrightarrow \text{Bi}_2\text{S}_3(\text{s}) + 6\text{HCl}(\text{aq})$  **(03)**

Note: Physical states are not required for parts (iv), (v), (vi)

**2(b) = 40 marks**

3. The reaction  $A + B \rightleftharpoons 2C + D$  (elementary in both directions) was carried out at 25 °C. Initially, the reaction mixture was made by dissolving 0.10 mol of A and 0.10 mol of B in distilled water (total volume 100.00 cm<sup>3</sup>). Variation in the concentration of A in this solution with time is shown in the graph.



(i) Calculate the amount of A (in moles) reacted during the first 4.0 minutes of the reaction.

Initial amount of A	= 0.1 mol	
Concentration of A after 4.0 min	= 0.75 mol dm <sup>-3</sup>	
Amount of A reacted	= (0.1 - 0.75) × 100 × 10 <sup>-3</sup> mol	(04+01)
	= 0.025 mol.	(04+01)

(ii) Would the rate of the forward reaction be less than the rate of the reverse reaction after 4.0 minutes? Explain your answer. (05)

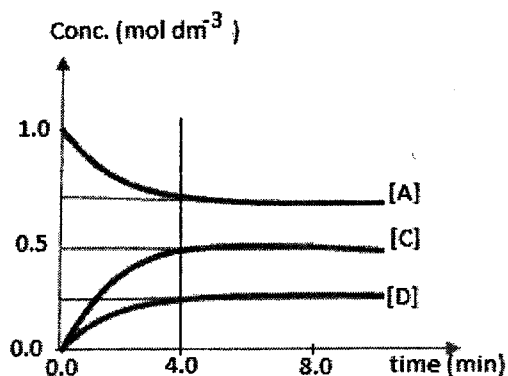
No ..... (05)  
 Forward and reverse rates will be equal after 4.0 min. ....  
 OR The reaction has reached the equilibrium. .... (05)

(iii) Given that the rate constant of the forward reaction ( $k_{\text{forward}}$ ) is 18.57 mol<sup>-1</sup> dm<sup>3</sup> min<sup>-1</sup>, calculate the initial rate of the forward reaction. (05)

Rate of the forward reaction,  $R_f = k [A][B]$  ..... (05)  
 Initial rate of the forward reaction = 18.57 mol<sup>-1</sup> dm<sup>3</sup> min<sup>-1</sup> × 1.0 mol dm<sup>-3</sup> × 1.0 mol dm<sup>-3</sup> ..... (04+01)  
 = 18.57 mol dm<sup>-3</sup> min<sup>-1</sup> ..... (04+01)

(iv) Calculate the concentrations of C and D at equilibrium. Draw the relevant curves showing the variation of the concentrations of C and D with time in the above graph and label them.

Concentration of C at equilibrium ..... = 2 × 0.025 mol / (100.00 × 10<sup>-3</sup> dm<sup>3</sup>) ..... (02+01)  
 = 0.50 mol dm<sup>-3</sup> ..... (02+01)  
 Concentration of D at equilibrium ..... = 0.025 mol / (100.00 × 10<sup>-3</sup> dm<sup>3</sup>) ..... (02+01)  
 = 0.25 mol dm<sup>-3</sup> ..... (02+01)



Curve C (04)

Curve D (04)

Note : Do not award marks if the curves do not become flat after 4.0 min, if the curves do not reach the respective concentrations at 4.0 min, if the curves for C and D are not labeled and if the curves do not start from zero.

- (v) Write the expression for the equilibrium constant  $K_c$  of the above reaction and calculate its value.

$$\text{..... (Equilibrium constant), } K_c = \frac{[C]^2 [D]}{[A] [B]} \text{..... (05)}$$

$$\text{..... } K_c = \frac{(0.5 \text{ mol dm}^{-3})^2 (0.25 \text{ mol dm}^{-3})}{(0.75 \text{ mol dm}^{-3})(0.75 \text{ mol dm}^{-3})} \text{..... (04+01)}$$

$$\text{..... } K_c = 1.11 \times 10^{-1} \text{ mol dm}^{-3} \text{..... (04+01)}$$

- (vi) Calculate the value of the rate constant ( $k_{\text{reverse}}$ ) of the reverse reaction.

$$\text{..... Using } K = \frac{k_f}{k_r}, k_r \text{ can be calculated } k_r = \frac{18.57 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1}}{1.11 \times 10^{-1} \text{ mol dm}^{-3}} \text{..... (04+01)}$$

$$\text{..... } k_r = 1.67 \times 10^2 \text{ mol}^{-2} \text{ dm}^6 \text{ min}^{-1} \text{..... (04+01)}$$

- (vii) After reaching equilibrium, the volume of the solution was doubled by adding 100.00 cm<sup>3</sup> of distilled water. Predict the direction of the net reaction soon after doubling the volume of the solution, by means of a suitable calculation.

New concentrations,

$$[A] = 0.75/2 \text{ mol dm}^{-3}, [B] = 0.75/2 \text{ mol dm}^{-3}, [C] = 0.5/2 \text{ mol dm}^{-3}, [D] = 0.25/2 \text{ mol dm}^{-3}$$

Rate of forward reaction,

$$R_f = 18.57 \text{ mol}^{-1} \text{ dm}^3 \text{ min}^{-1} (0.75/2 \text{ mol dm}^{-3})^2 \text{..... (05+01)}$$

$$= 2.61 \text{ mol dm}^{-3} \text{ min}^{-1}$$

Rate of the reverse reaction,

$$R_r = 1.67 \times 10^2 \text{ mol}^{-2} \text{ dm}^6 \text{ min}^{-1} (0.5/2 \text{ mol dm}^{-3})^2 (0.25/2 \text{ mol dm}^{-3}) \text{..... (05+01)}$$

$$= 1.30 \text{ mol dm}^{-3} \text{ min}^{-1}$$

$R_f > R_r$  Net reaction occurs in the forward direction. (03)

Alternate answer

$$Q = \frac{(\frac{0.5}{2} \text{ mol dm}^{-3})^2 (\frac{0.25}{2} \text{ mol dm}^{-3})}{(\frac{0.75}{2} \text{ mol dm}^{-3})^2} \text{..... (05+01)}$$

$$Q = 0.056 \text{ mol dm}^{-3} \text{..... (05+01)}$$

$Q < K$ , therefore, the net reaction occurs in the forward direction. (03)

- (viii) Consider that the above experiment was conducted at a temperature lower than 25 °C. How would this affect the rate of the reverse reaction? Explain your answer giving reasons.

Rate of the reverse reaction will decrease (01)

Because

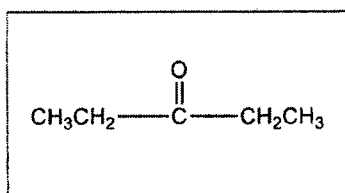
the fraction of molecules having sufficient energy to overcome the activation energy barrier decreases (02)

and

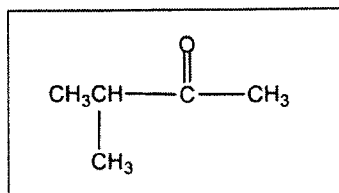
the collision rate decreases. (02)

**Q3 = 100 marks**

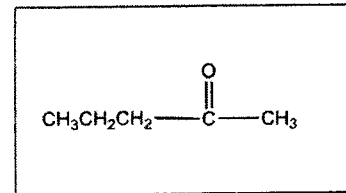
4. (a) (i) Compounds **A**, **B** and **C** are structural isomers of each other having the molecular formula  $C_5H_{10}O$ . All three compounds give yellow-orange precipitates with 2, 4-DNP. None of them give a silver mirror in the silver mirror test. When **A**, **B** and **C** were separately reacted with  $NaBH_4$ , compounds **D**, **E** and **F** respectively were obtained. Only **E** and **F** showed optical isomerism. When **B** and **C** were separately reacted with  $CH_3CH_2CH_2MgBr$  followed by hydrolysis, compounds **G** and **H** respectively, were obtained. Only **G** showed optical isomerism. Draw the structures of **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** in the boxes given below. (It is **not** necessary to show stereoisomeric forms.)



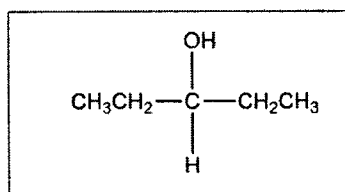
**A**



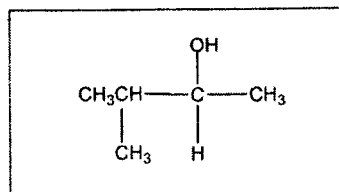
**B**



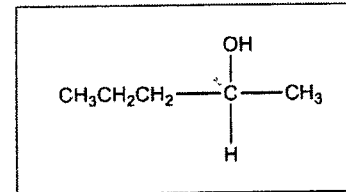
**C**



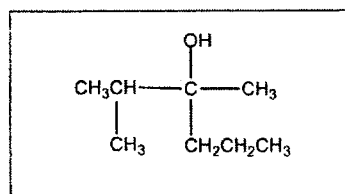
**D**



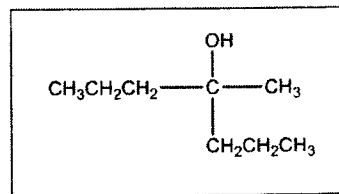
**E**



**F**



**G**



**H**

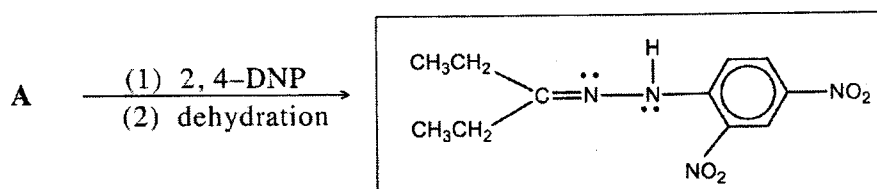
Note:  $C_3H_7$  can be accepted in place of  $CH_3CH_2CH_2$ .  $C_2H_5$  can be accepted in place of  $CH_3CH_2$ .

Note: **A**, **B**, **C** should be correct to award marks for **D**, **E**, **F**

**B**, **C** should be correct to award marks for **G**, **H**

(05 marks x 8 = 40 marks)

- (ii) Draw the structure of the product of the following reaction.

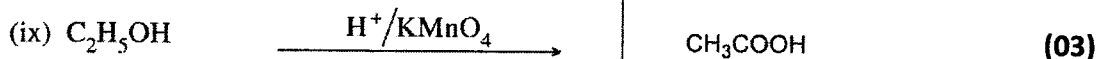
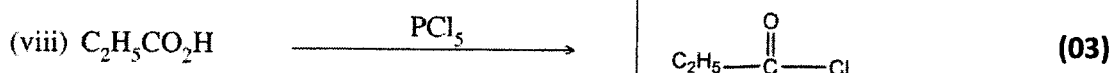
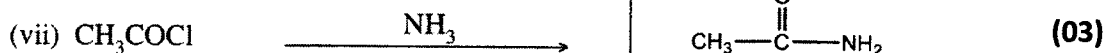
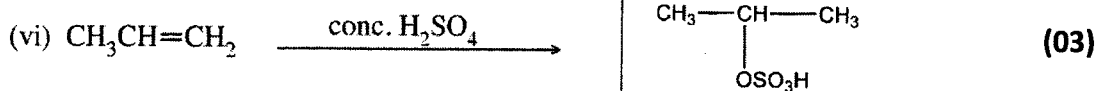
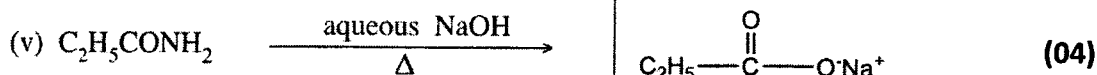
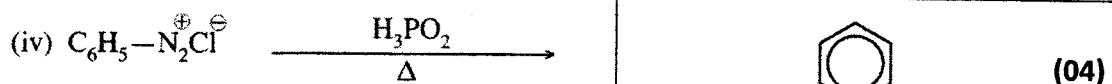
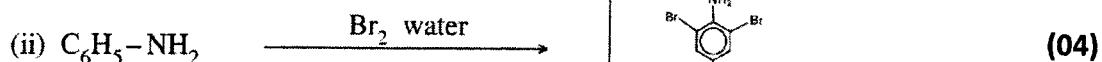
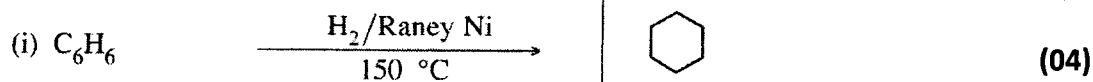



(05)

Note : Lone pairs are not necessary. Award mark if **B** or **C** is used instead of **A**, with the correct corresponding product.


**4.(a): 45 marks**

(b) Draw the structure of the **major** organic product in each of the following reactions.



(i) structure showing hydrogens on  can be accepted.

(iii)  $CH_3CH=CHCHO$  can be accepted. No marks for  $CH_3CH=CHCOH$

(iv)  can be accepted

(v) Charges on O and Na are not required for award of marks. No marks if given as  
O—Na

(vi)  $OSO_2OH$  can be accepted.

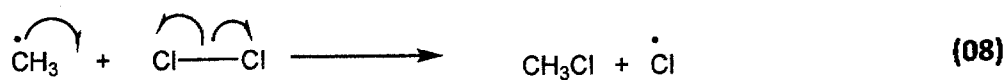
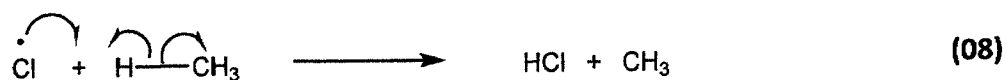
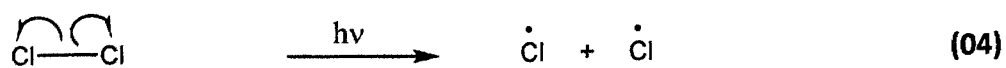
(vii)  $CH_3CONH_2$  can be accepted.

(viii)  $C_2H_5COCl$  can be accepted.

(ix)  $CH_3CO_2H$  can be accepted.

**4(b): 35 marks**





OR (for third step)



4.(c): 20 marks

**Note: if no half arrow are drawn, deduct (01) mark once in each line.**

**Radical needs to be shown for award of marks.**

**Mark each step as an independent step.**

**PART B – ESSAY***Answer two questions only. (Each question carries 15 marks.)*

5. (a) Consider the following reactions.



A small amount (0.10 mol) of  $M(\text{CO}_3)_2 \cdot n\text{H}_2\text{O}(s)$  is present in an evacuated rigid container of volume  $0.08314 \text{ m}^3$ . The temperature of the container was raised to 400 K. The metal carbonate,  $M(\text{CO}_3)_2$  does not decompose at this temperature but the crystalline water evaporates completely. The pressure of the container was measured to be  $1.60 \times 10^4 \text{ Pa}$ . Volume occupied by the solids is negligible.

Determine the value of 'n' in the formula  $M(\text{CO}_3)_2 \cdot n\text{H}_2\text{O}(s)$ .



The amount of  $M(\text{CO}_3)_2 \cdot n\text{H}_2\text{O}$  used = 0.10 mol

Water is completely evaporated.

Using  $PV=nRT$ ,

(05)

$$n_{\text{H}_2\text{O}} = \frac{1.60 \times 10^4 \text{ Pa} \times 0.08314 \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 400 \text{ K}}$$

(04+01)

$$= 0.40 \text{ mol}$$

(04+01)

0.1 mol of  $M(\text{CO}_3)_2 \cdot n\text{H}_2\text{O}(s)$  has generated 0.40 mol of  $\text{H}_2\text{O}$ . Therefore,  $n = 4$

(04+01)

5 (a) = 20 marks

(b) The temperature of the above system was then increased to 800 K. It was observed that some amount of the solid metal carbonate is decomposed and is in equilibrium with the gas phase. The pressure of the container was measured to be  $4.20 \times 10^4 \text{ Pa}$ .

(i) Calculate the partial pressure of water vapour in the container at 800 K.

Partial pressure of  $\text{H}_2\text{O}$  at 800 K,

$$P_{\text{H}_2\text{O}} = \frac{n_{\text{H}_2\text{O}}RT}{V}$$

$$= \frac{0.4 \text{ mol} \times 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 800 \text{ K}}{0.08314 \text{ m}^3}$$

(04+01)

$$= 3.20 \times 10^4 \text{ Pa}$$

(04+01)

**Alternate Answer 01**

Total pressure at 800 K,  $P_T = 4.20 \times 10^4 \text{ Pa}$

$$\text{Total number of moles } n_T = \frac{4.20 \times 10^4 \text{ Pa} \times 0.08314 \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 800 \text{ K}}$$

(04+01)

$$= 0.525 \text{ mol}$$

$$\text{Partial pressure of water} = P_{\text{H}_2\text{O}} = P_T \times \frac{n_{\text{H}_2\text{O}}}{n_T}$$

$$= 3.20 \times 10^4 \text{ Pa}$$

(04+01)

**Alternate Answer 02**

Because  $V$  and  $n_{\text{H}_2\text{O}}$  are constant, at 800 K,

$$\text{partial pressure of water} = P_{\text{H}_2\text{O}} = 2 \times 1.60 \times 10^4 \text{ Pa}$$

$$= 3.20 \times 10^4 \text{ Pa}$$

(04+01)

(04+01)

- (ii) Calculate the partial pressure of
- $\text{CO}_2$
- in the container at 800 K.

Partial pressure of  $\text{CO}_2$  at 800K,

$$P_{\text{CO}_2} = P_{\text{total}} - P_{\text{H}_2\text{O}}$$

$$= 4.2 \times 10^4 \text{ Pa} - 3.2 \times 10^4 \text{ Pa} \quad (04+01)$$

$$= 1.00 \times 10^4 \text{ Pa} \quad (04+01)$$

- (iii) Write an expression for the pressure equilibrium constant,
- $K_p$
- for the decomposition of
- $\text{M}(\text{CO}_3)_2(\text{s})$
- . Calculate
- $K_p$
- at 800 K.

$$K_p = P^2_{\text{CO}_2} \quad (05)$$

$$K_p = (1.0 \times 10^4 \text{ Pa})^2 = 1.00 \times 10^8 \text{ Pa}^2 \quad (04+01)$$

- (iv) Calculate the molar percentage of the metal carbonate decomposed at 800 K.

Initial amount = 0.10 mol

Amount of  $\text{CO}_2$  generated =  $n_{\text{CO}_2}$ 

$$n_{\text{CO}_2} = \frac{P_{\text{CO}_2} V}{RT}$$

$$n_{\text{CO}_2} = \frac{1.0 \times 10^4 \text{ Pa} \times 0.08314 \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 800 \text{ K}} \quad \text{OR} \quad \frac{3.2 \times 10^4 \text{ Pa}}{1.0 \times 10^4 \text{ Pa}} = \frac{0.4}{n_{\text{CO}_2}} \quad (04+01)$$

$$n_{\text{CO}_2} = 0.125 \text{ mol}$$

Amount of  $\text{M}(\text{CO}_3)_2$  decomposed =  $\frac{1}{2}$  amount of  $\text{CO}_2$  generated.

$$\text{mol \% of } \text{M}(\text{CO}_3)_2 \text{ decomposed} = \frac{0.0625 \text{ mol}}{0.10 \text{ mol}} \times 100 \quad (03)$$

$$= 62.5 \% \quad (02)$$

- (v) Enthalpy change (
- $\Delta H$
- ) for the decomposition of the metal carbonate under the above conditions is
- $40.0 \text{ kJ mol}^{-1}$
- . Calculate the corresponding entropy change (
- $\Delta S$
- ).

System is at equilibrium, therefore  $\Delta G = 0$ . (05)

$$\Delta S = \frac{\Delta H}{T}$$

$$\Delta S = \frac{40.0 \times 10^3 \text{ J mol}^{-1}}{800 \text{ K}} \quad (04+01)$$

$$\Delta S = 50.0 \text{ J mol}^{-1} \text{ K}^{-1} \quad \text{OR} \quad 0.05 \text{ kJ mol}^{-1} \text{ K}^{-1} \quad (04+01)$$

**Note :  $\Delta S^0$ ,  $\Delta H^0$  cannot be accepted.**

- (vi) Suggest
- two**
- ways to drive the decomposition reaction of
- $\text{M}(\text{CO}_3)_2(\text{s})$
- in the forward direction.

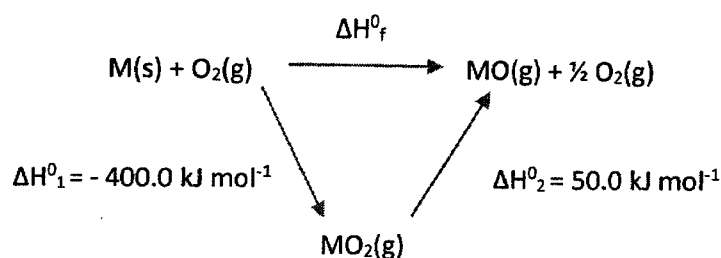
Increase temperature (05)Remove  $\text{CO}_2$  (05)

5 (b) = 65 marks

- (c) With the aid of thermochemical cycles and the data given in the table, answer the following questions.

Species	Standard enthalpy of formation ( $\Delta H_f^\circ$ ) (kJ mol <sup>-1</sup> )
M(s)	0.0
M(g)	800.0
O <sub>2</sub> (g)	0.0
O(g)	249.2
MO <sub>2</sub> (g)	-400.0

- (i) Given that  $\text{MO(g)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{MO}_2(\text{g})$   $\Delta H^\circ = -50.0 \text{ kJ mol}^{-1}$ , calculate the standard enthalpy of formation of MO(g).



(02+02+02 = 06)

**Note :** To award marks for the cycle, reactions must be balanced and physical states must be given.

Standard formation enthalpy of MO(g),  $\Delta H_f^\circ$

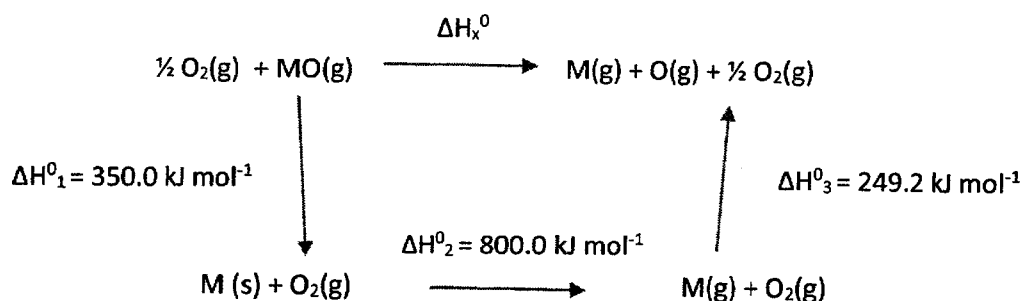
$$\Delta H_f^\circ = (-400.0 + 50.0) \text{ kJ mol}^{-1}$$

$$= -350.0 \text{ kJ mol}^{-1}$$

(04+01)

(04+01)

- (ii) Calculate M–O bond dissociation enthalpy in MO(g).



(02+02+02 +02 = 08)

**Note :** To award marks for the cycle, reactions must be balanced and physical states must be given.

MO bond dissociation enthalpy change =  $\Delta H_x^\circ$

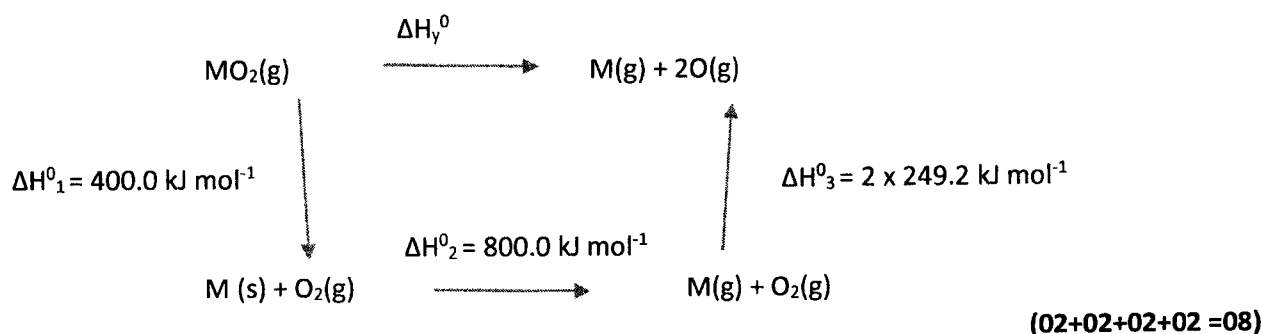
$$\Delta H_x^\circ = (350.0 + 800.0 + 249.2) \text{ kJ mol}^{-1}$$

$$= 1399.2 \text{ kJ mol}^{-1}$$

(04+01)

(02+01)

(iii) Calculate M–O bond dissociation enthalpy in  $\text{MO}_2(\text{g})$ .



**Note :** To award marks for the cycle, reactions must be balanced and physical states must be given.

$$\Delta H_v^0 = (400.0 + 800.0 + 2 \times 249.2) \text{ kJ mol}^{-1} \quad (04+01)$$

$$= 1698.4 \text{ kJ mol}^{-1}$$

$$\text{MO bond dissociation energy in } \text{MO}_2 = \frac{1}{2} \Delta H_v^0 = 849.2 \text{ kJ mol}^{-1} \quad (04+01)$$

(iv) By means of a suitable calculation, predict whether the reaction,  $\text{MO}_2(\text{g}) \rightarrow \text{MO}(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$  is spontaneous under standard conditions and 2000 K. Standard entropy change of this reaction is  $30.0 \text{ J K}^{-1} \text{ mol}^{-1}$ .

$$\Delta G^0 = \Delta H^0 - T \Delta S^0 \quad (03)$$

For the reaction,  $\text{MO}_2(\text{g}) \longrightarrow \text{MO}(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$  at 2000 K,

$$\Delta G^0 = 50.0 \times 10^3 \text{ J mol}^{-1} - 2000 \text{ K} \times 30.0 \text{ J K}^{-1} \text{ mol}^{-1} \quad (04+01)$$

$$= -10000.0 \text{ J mol}^{-1} = -10.0 \text{ kJ mol}^{-1} \quad (04+01)$$

The given reaction is spontaneous at 2000K. (02)

**Note :** Standard states are required for award of marks.

5 (c) = 65 marks

6. (a) An experiment was carried out to determine the partition coefficient of iodine ( $\text{I}_2$ ) between water (A) and an organic solvent (B) which form an immiscible liquid system.

$20.00 \text{ cm}^3$  of B containing 'n' moles of  $\text{I}_2$  is mixed with  $20.00 \text{ cm}^3$  of A and allowed to reach equilibrium at room temperature.

The concentration of  $\text{I}_2$  in phase A is determined by titrating a  $5.00 \text{ cm}^3$  sample drawn from phase A with a  $0.005 \text{ mol dm}^{-3}$  solution of  $\text{Na}_2\text{S}_2\text{O}_3$ . The volume of  $\text{Na}_2\text{S}_2\text{O}_3$  required to reach the end point was  $22.00 \text{ cm}^3$ . The concentration of  $\text{I}_2$  in phase B was determined to be  $0.040 \text{ mol dm}^{-3}$ .

(i) Write the balanced chemical equation for the reaction between  $\text{Na}_2\text{S}_2\text{O}_3$  and  $\text{I}_2$ .



OR



(ii) Calculate the concentration of  $\text{I}_2$  in phase A.

$$\text{Concentration of } \text{I}_2 \text{ in phase A} = \frac{22.00 \text{ cm}^3 \times 0.005 \text{ mol dm}^{-3}}{2 \times 5.0 \text{ cm}^3} \quad (04+01)$$

$$= 0.011 \text{ mol dm}^{-3} \quad (04+01)$$

(iii) Calculate the value of the partition coefficient,  $K_D$  where  $K_D = \frac{[I_2]_B}{[I_2]_A}$ .

$$\text{Partition coefficient, } K_D = \frac{[I_2]_B}{[I_2]_A} = \frac{0.04 \text{ mol dm}^{-3}}{0.011 \text{ mol dm}^{-3}} \quad (04+01)$$

(iv) Calculate the total number of moles of  $I_2$  in the two phases A and B.

$$K_D = 3.64 \quad (04+01)$$

Total number of moles of  $I_2$

$$n_{I_2} = 0.04 \text{ mol dm}^{-3} \times 20.0 \times 10^{-3} \text{ dm}^3 + 0.011 \text{ mol dm}^{-3} \times 20.0 \times 10^{-3} \text{ dm}^3$$

$$= 1.02 \times 10^{-3} \text{ mol} \quad \begin{array}{l} 2 \times (04+01) \\ (04+01) \end{array}$$

6 (a) = 45 marks

(b) The above experiment was repeated under the same conditions, that is, at the same temperature, using the same amount of  $I_2$  and the same volumes, but with the addition of  $I^-$  ions to phase A. The system was then thoroughly shaken and allowed to reach equilibrium. The volume of  $0.005 \text{ mol dm}^{-3} \text{ Na}_2\text{S}_2\text{O}_3$  solution required to titrate the  $I_2$  in a  $5.00 \text{ cm}^3$  sample of phase A was  $41.00 \text{ cm}^3$ . The concentration of  $I_2$  in phase B was then determined to be  $0.030 \text{ mol dm}^{-3}$ .

(i) Calculate the amount of  $I_2$  (moles) expected in  $5.00 \text{ cm}^3$  of phase A, based on the partition coefficient for the distribution of  $I_2$  between the phases A and B.

Concentration of  $I_2$  in phase A (when excess  $I^-$  is added)

$$[I_2]_A = [I_2]_B / K_D \quad (05)$$

$$[I_2]_A = \frac{0.030 \text{ mol dm}^{-3}}{3.64} \quad (02+01)$$

$$= 8.242 \times 10^{-3} \text{ mol dm}^{-3} \quad (01+01)$$

The amount of  $I_2$  in  $5.00 \text{ cm}^3$  of phase A = n

$$n = 8.242 \times 10^{-3} \text{ mol dm}^{-3} \times 5.00 \times 10^{-3} \text{ dm}^3 \quad (02+01)$$

$$= 4.121 \times 10^{-5} \text{ mol} \quad (01+01)$$

(ii) Calculate the amount (moles) of  $I_2$  reacted with  $\text{Na}_2\text{S}_2\text{O}_3$  in the above titration.

The amount of  $I_2$  in  $5.00 \text{ cm}^3$  of phase A, after the addition of iodide = n'

$$n' = 0.005 \text{ mol dm}^{-3} \times 41.00 \times 10^{-3} \text{ dm}^3 \times 0.5 \quad (04+01)$$

$$= 1.025 \times 10^{-4} \text{ mol (or } 1.03 \times 10^{-4} \text{ mol)} \quad (04+01)$$

(iii) Considering the different iodine species present in phase A, explain why the answers obtained in parts (b)(i) and (b)(ii) above are different.

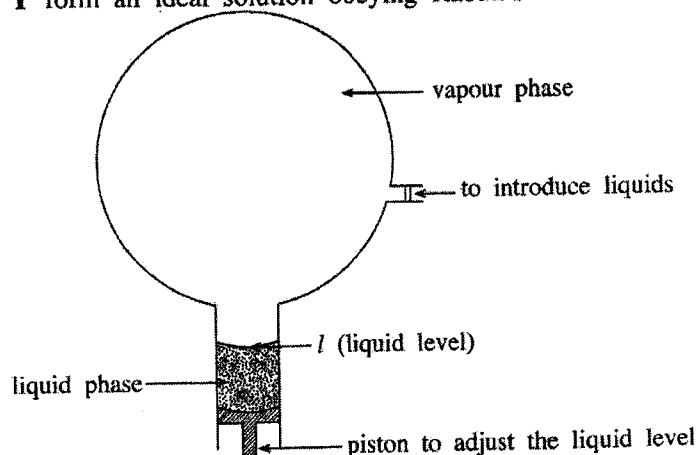
When  $I^-$  ions are added to the phase A,  $I_2$  and  $I^-$  combine to form  $I_3^-$ . (05)

When phase A is titrated with  $\text{Na}_2\text{S}_2\text{O}_3$ ,  $I_2$  released from  $I_3^-$  is also reacted with  $\text{Na}_2\text{S}_2\text{O}_3$ .

Therefore,  $n' > n$ . (05)

6 (b) = 35 marks

(c) Liquids X and Y form an ideal solution obeying Raoult's law.



Initially only liquid X was introduced in to an evacuated rigid container as shown in the figure.

Maintaining the liquid level at  $l$ , the system was allowed to reach equilibrium at 400 K. The pressure of the container was measured to be  $3.00 \times 10^4$  Pa. The volume of the vapour phase when the liquid level is at  $l$  was  $4.157 \text{ dm}^3$ . Then liquid Y was introduced in to the container mixed with liquid X and the system was allowed to reach equilibrium at 400 K. The liquid level was maintained at  $l$ . The molar ratio of X:Y in the liquid phase was found to be 1:3. The pressure of the container was measured to be  $5.00 \times 10^4$  Pa.

(i) What is the saturated vapour pressure of X at 400 K?

$$\text{Saturated vapour pressure of X at 400K} = 3.00 \times 10^4 \text{ Pa.} \quad (04+01)$$

(ii) Calculate the mole fractions of X and Y in the liquid phase at equilibrium.

$$\begin{aligned} \text{Mole fraction of X in the liquid phase} &= \frac{1}{(1+3)} && (04+01) \\ &= \frac{1}{4} \text{ or } 0.25 \end{aligned}$$

$$\begin{aligned} \text{Mole fraction of Y in the liquid phase} &= \frac{3}{(1+3)} && (04+01) \\ &= \frac{3}{4} \text{ or } 0.75 \end{aligned}$$

(iii) Calculate the partial pressure of X at equilibrium after the addition of Y.

$$\begin{aligned} \text{At equilibrium, } P_x &= P_x^0 X_A && (05) \\ &= 0.25 \times 3.0 \times 10^4 \text{ Pa} && (02+01) \\ &= 7.5 \times 10^3 \text{ Pa} && (01+01) \end{aligned}$$

(iv) Calculate the partial pressure of Y at equilibrium.

$$\begin{aligned} P_y &= P_{\text{total}} - P_x && (02+01) \\ &= 5.0 \times 10^4 \text{ Pa} - 7.5 \times 10^3 \text{ Pa} && (01+01) \\ &= 4.25 \times 10^4 \text{ Pa} \end{aligned}$$

(v) Calculate the saturated vapour pressure of Y.

Saturated vapour pressure of Y,  $P_y^0 = \frac{P_y}{x_y}$

$$P_y^0 = \frac{4.25 \times 10^4 \text{ Pa}}{0.75} \quad (04+01)$$

$$= 5.67 \times 10^4 \text{ Pa} \quad (04+01)$$

(vi) Calculate the amounts (in moles) of X and Y in the vapour phase.

The amount of X in the gas phase,  $n_x = P_x V / RT$

$$n_x = \frac{7.5 \times 10^3 \text{ Pa} \times 4.157 \times 10^{-3} \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 400 \text{ K}} \quad (04+01)$$

$$n_x = 9.38 \times 10^{-3} \text{ mol} \quad (04+01)$$

Similarly,

$$n_y = \frac{4.25 \times 10^4 \text{ Pa} \times 4.157 \times 10^{-3} \text{ m}^3}{8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 400 \text{ K}} \quad (04+01)$$

$$n_y = 5.31 \times 10^{-2} \text{ mol} \quad (04+01)$$

(vii) When a mixture of the liquids X and Y is subjected to fractional distillation, state which compound would distill out first from the fractional distillation column. Give reason/s for your answer.

Compound Y can be obtained first. (05)

Y is the more volatile compound or saturated vapour pressure of Y ( $P_y^0$ ) is high. Therefore, its vapour comes out first from the fractional distillation column.

(05)

**Note :** To award marks for (vii) answers for  $P_x^0$  and  $P_y^0$  must have been calculated. Prediction must be according to the calculated  $P_x^0$  and  $P_y^0$  values.

6 (c) = 70 marks



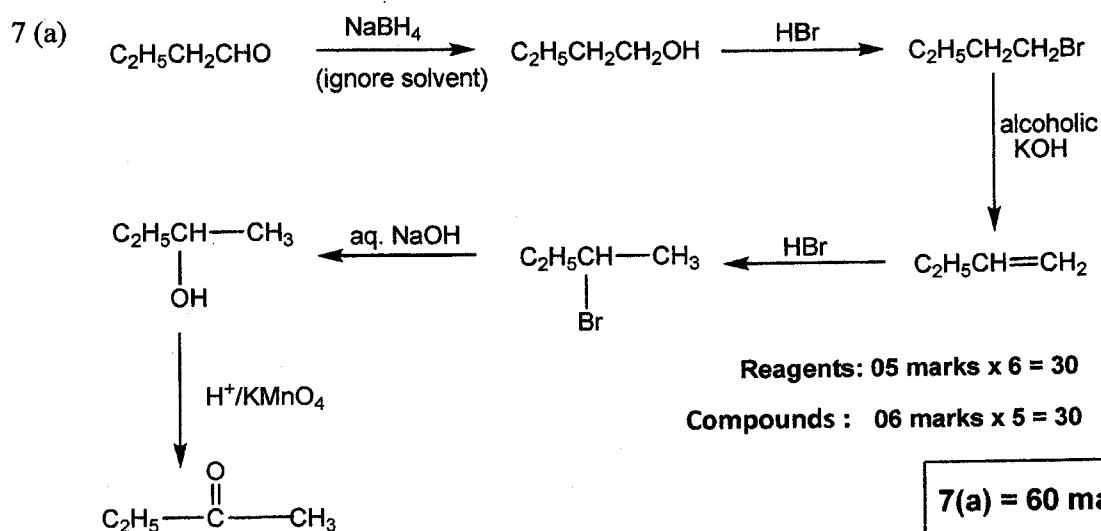
7. (a) Using only the chemicals given in the list, show how you would carry out the following conversion



**List of chemicals**

aqueous NaOH, HBr, alcoholic KOH, NaBH<sub>4</sub>, H<sup>+</sup>/KMnO<sub>4</sub>

Your conversion should not exceed 7 steps.



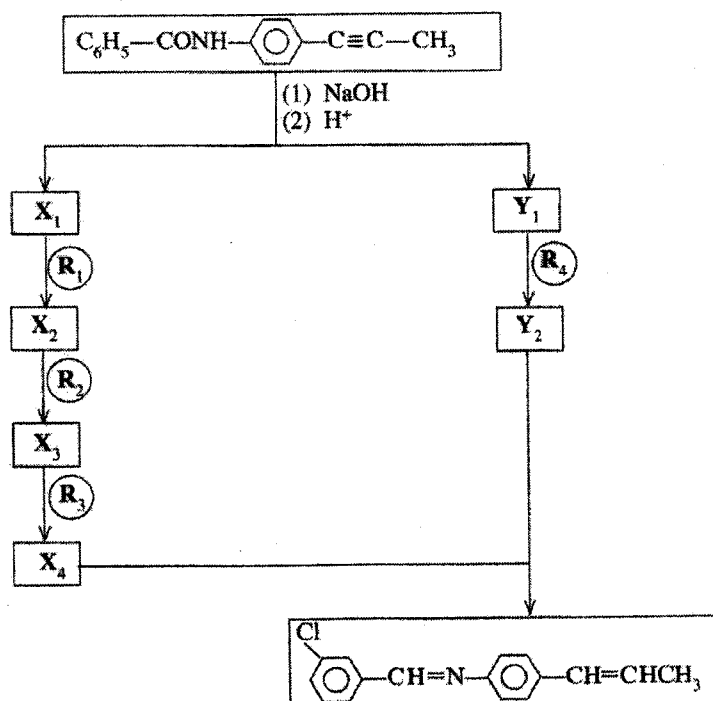
Note : Do not award 60 marks if there are more than seven steps. Do not award marks for C<sub>2</sub>H<sub>5</sub>CH<sub>2</sub>CHO and C<sub>2</sub>H<sub>5</sub>COCH<sub>3</sub>.

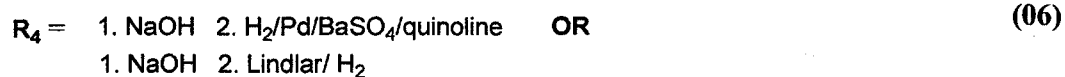
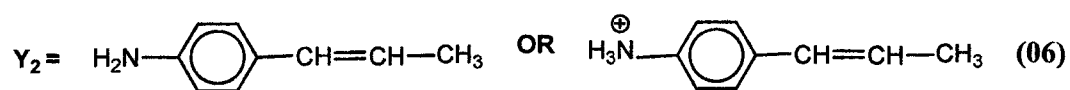
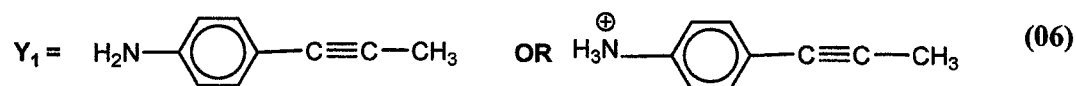
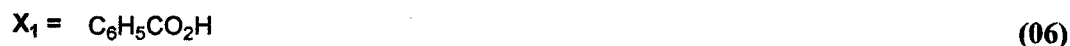
**Marking of partially correct answer**

Mark from the beginning till an incorrect answer (reagent or product) is found. Mark from the end till an incorrect answer (reagent or product) is found. Add the marks. Do not award marks for any isolated correct steps in the middle.

To award marks for reagent, both reactant and product have to be correct.

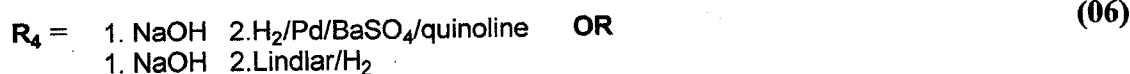
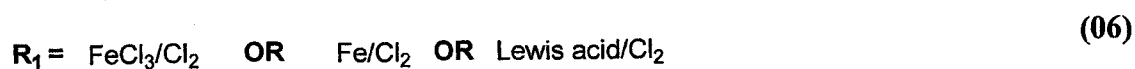
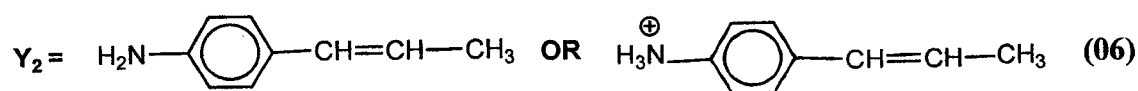
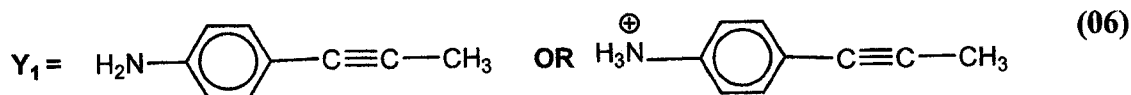
(b) Identify R<sub>1</sub>–R<sub>4</sub> and X<sub>1</sub>–X<sub>4</sub> and Y<sub>1</sub>, Y<sub>2</sub> in order to complete the following reaction scheme





(Note : NaOH is not required for award of 06 marks ) (06 marks x 10 = 06)

7(b) = 60 marks

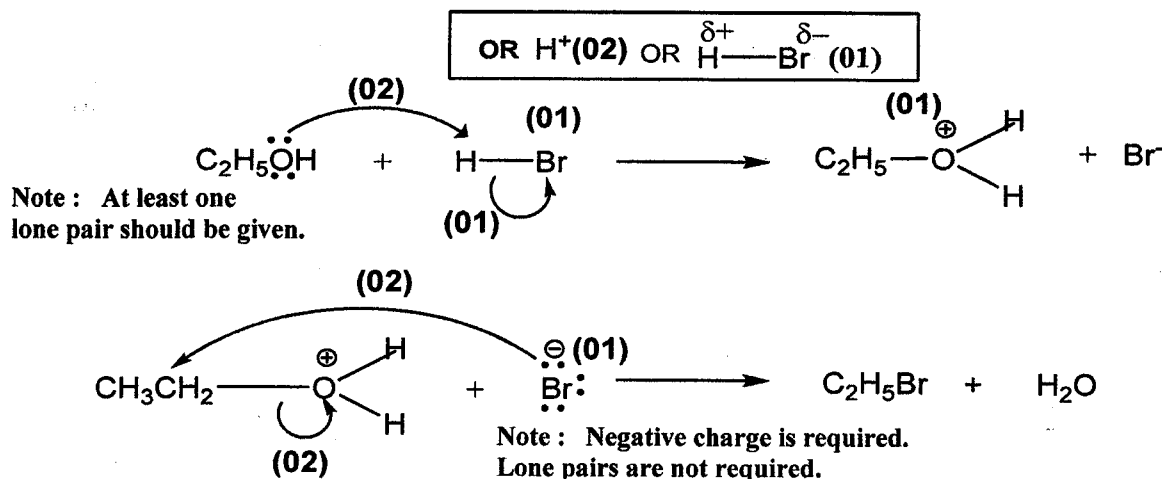
**Alternative Pathway**

(Note :  $\text{NaOH}$  is not required for award of 06 marks )

(06 marks x 10 = 60)

**7(b) = 60 marks**

(c) (i) Give the mechanism of the following reaction.



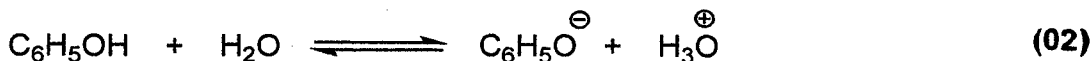
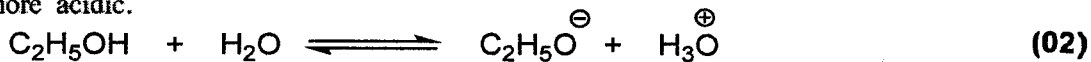
(10 marks)

(ii) State whether the above reaction is a nucleophilic substitution reaction or an electrophilic substitution reaction. Identify the nucleophile or electrophile as appropriate.

(ii) Nucleophilic substitution,  $\text{Br}^-$

(02 + 02)

(iii) State giving reasons which of the two compounds, phenol ( $\text{C}_6\text{H}_5\text{OH}$ ) or ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) is more acidic.



Note: If  $\text{H}_2\text{O}$  is not included in the equations, only (01) per equation

- In the above equilibria the equilibrium point for phenol is more toward the right than ethanol. (02)
- This is because the stability of phenate ion relative to phenol is greater than the stability of the alkoxide relative to alcohol. (02)
- The phenate ion is more stable because its negative charge gets delocalized by resonance. (02)
- Resonance structures drawn (02)
- In alkoxide ion there is no such charge dispersion/ No resonance (02)
- Phenol is more acidic than ethanol. (02)

7(c) = 30 marks

## PART C — ESSAY

Answer two questions only. (Each question carries 15 marks.)

8. (a) An aqueous solution **P** contains **two** cations and **two** anions. The following experiments were carried out to identify these cations and anions.

## Cations

	Experiment	Observation
①	<b>P</b> was acidified with dilute HCl and H <sub>2</sub> S was bubbled through the solution.	A clear solution was obtained.
②	The above solution was boiled till all the H <sub>2</sub> S was removed. A few drops of conc. HNO <sub>3</sub> were added and the solution was heated further. The resulting solution was cooled and NH <sub>4</sub> Cl/NH <sub>4</sub> OH was added.	A brown precipitate ( <b>Q</b> ) was formed.
③	<b>Q</b> was removed by filtration and H <sub>2</sub> S was bubbled through the filtrate.	A pale pink precipitate ( <b>R</b> ) was formed.
④	<b>R</b> was removed by filtration and the filtrate was boiled till all the H <sub>2</sub> S was removed. (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> was added to the solution.	A clear solution was obtained.
⑤	Dilute NaOH was added to a <b>fresh portion</b> of <b>P</b> .	A dirty-green precipitate and a white precipitate were formed.

Experiments for precipitates **Q** and **R**:

	Experiment	Observation
⑥	<b>Q</b> was dissolved in dil. HNO <sub>3</sub> and a salicylic acid solution was added.	A light purple solution was obtained.
⑦	<b>R</b> was dissolved in dilute acid and dil. NaOH was added to the solution.	A white precipitate was formed. It turned brown on standing.

## Anions

	Test	Observation
⑧	I. BaCl <sub>2</sub> solution was added to <b>P</b> .	A white precipitate was formed.
	II. The white precipitate was separated by filtration and dil. HCl was added to the precipitate.	The white precipitate was not dissolved.
⑨	Cl <sub>2</sub> water and chloroform were added to a portion of the filtrate from ⑧ II, and the mixture was thoroughly shaken.	Chloroform layer turned yellowish-brown.

- (i) Identify the **two** cations and the **two** anions in solution **P**. (Reasons are **not** required.)

Cations: Fe<sup>2+</sup> and Mn<sup>2+</sup> (10 + 10)

Anions: SO<sub>4</sub><sup>2-</sup> and Br<sup>-</sup> (08 + 07)

**Note: First correct anion (08), second anion (07)**

(ii) Write the chemical formulae of the precipitates **Q** and **R**.

**Q** -  $\text{Fe}(\text{OH})_3$  (10)

**R** -  $\text{MnS}$  (10)

(iii) Give reasons for the following:

I. Removal of  $\text{H}_2\text{S}$  in experiment ② for cations.

▪ If  $\text{H}_2\text{S}$  is not removed  $\text{MnS}/\text{FeS}/$  cations of group IV will also precipitate when  $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$  solution is added. (10)

OR

▪  $\text{H}_2\text{S}$  can be oxidized to sulphur by conc.  $\text{HNO}_3$ . (05)

▪ A fine precipitate of sulphur would be formed in solution if  $\text{H}_2\text{S}$  is not removed. (05)

II. Heating with conc.  $\text{HNO}_3$  in experiment ② for cations.

▪  $K_{sp}$  of  $\text{Fe}(\text{OH})_2 > K_{sp}$  of  $\text{Fe}(\text{OH})_3$  (05)

▪ Therefore,  $\text{Fe}^{2+}$  needs to be converted to  $\text{Fe}^{3+}$  to be completely precipitated. (05)

OR

▪ Conc.  $\text{HNO}_3$  must be added to oxidize iron if present, to the ferric state. (04)

▪ If originally present, it would have been reduced by the  $\text{H}_2\text{S}$  to the ferrous ion. (02)

▪ Ferrous ion is not completely precipitated by  $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$  solution. (will get a mixture of  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$ ) (04)

8(a): 75 marks

- (b) The sample **X** contains lead, copper and an inert material. The following procedure was carried out to analyse lead and copper in **X**.

**Procedure:**

A mass of 0.285 g of **X** was dissolved in a slight excess of dil.  $\text{HNO}_3$ . A clear solution was obtained. A  $\text{NaCl}$  solution was added to the resulting clear solution. A white precipitate (**Y**) was formed. The precipitate was separated by filtration and the precipitate (**Y**) and filtrate (**Z**) were analysed separately.

**Precipitate (Y)**

The precipitate was dissolved in hot water. A solution of  $\text{K}_2\text{CrO}_4$  was added in excess. A yellow precipitate was formed. The precipitate was separated by filtration and dissolved in dil.  $\text{HNO}_3$ . An orange coloured solution was obtained. Excess  $\text{KI}$  was added to this solution and the liberated  $\text{I}_2$  was titrated with  $0.100 \text{ mol dm}^{-3} \text{ Na}_2\text{S}_2\text{O}_3$ , with starch as the indicator. The volume of  $\text{Na}_2\text{S}_2\text{O}_3$  required to reach the end point was  $27.00 \text{ cm}^3$ .

(Assume that the  $\text{NO}_3^-$  ions do **not** interfere with the titration.)

**Filtrate (Z)**

The filtrate was neutralized and excess  $\text{KI}$  was added to it. The liberated  $\text{I}_2$  was titrated with  $0.100 \text{ mol dm}^{-3} \text{ Na}_2\text{S}_2\text{O}_3$ , with starch as the indicator. The volume of  $\text{Na}_2\text{S}_2\text{O}_3$  required to reach the end point was  $15.00 \text{ cm}^3$ .

(**Note:** Assume that the inert material was soluble in dil.  $\text{HNO}_3$  and did **not** interfere with the experiment.)

- (i) Calculate the mass percentages of lead and copper in **X**. Write balanced chemical equations where relevant.

**Determination of Cu**



**OR**



From (1) and (2)  $\text{Cu}^{2+} \equiv \text{S}_2\text{O}_3^{2-}$  **OR** Identification of correct stoichiometry (02)

$$\text{Moles of } \text{S}_2\text{O}_3^{2-} = \frac{0.10}{1000} \times 15.0 \quad \text{(03)}$$

$$\text{Therefore, moles of } \text{Cu}^{2+} = \frac{0.10}{1000} \times 15.0 \quad \text{(03)}$$

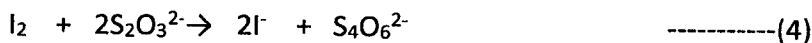
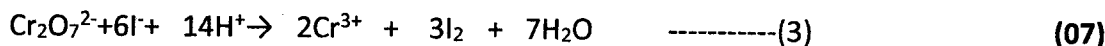
$$\text{Mass of Cu} = \frac{0.10}{1000} \times 15.0 \times 63.5 \quad \text{(03)}$$

$$= 0.095 \text{ g} \quad \text{(03)}$$

$$\text{Therefore, \%Cu} = \frac{0.095}{0.285} \times 100 \quad \text{(03)}$$

$$= 33.4\% \quad \text{(03)}$$

**(30 marks)**

**Determination of Pb**

From (3) + 3x (4)  $\text{Cr}_2\text{O}_7^{2-} \equiv 6\text{S}_2\text{O}_3^{2-}$  OR Identification of correct stoichiometry (03)

$$\text{Moles of } \text{S}_2\text{O}_3^{2-} = \frac{0.10}{1000} \times 27.0 \quad (03)$$

$$\text{Moles of } \text{Cr}_2\text{O}_7^{2-} = \frac{1}{6} \times \frac{0.10}{1000} \times 27.0 \quad (03)$$



$$\text{Therefore, moles of Cr} = 2 \times \frac{1}{6} \times \frac{0.10}{1000} \times 27.0 \quad (03)$$

Yellow precipitate is  $\text{PbCrO}_4$  (03)

$$\text{Therefore, moles of Pb} = 2 \times \frac{1}{6} \times \frac{0.10}{1000} \times 27.0 \quad (03)$$

$$\text{Therefore, mass of Pb} = 2 \times \frac{1}{6} \times \frac{0.10}{1000} \times 27.0 \times 207 \quad (03)$$

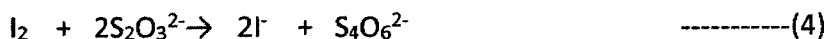
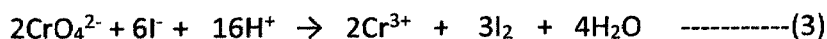
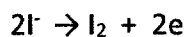
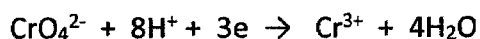
$$= 0.186 \text{ g} \quad (03)$$

$$\text{Therefore, \%Pb} = \frac{0.186}{0.285} \times 100 \quad (03)$$

$$= 65.3\% \quad (03)$$

**(40 marks)**



**Alternate method****Determination of Pb****OR**

From equations $\text{CrO}_4^{2-} \equiv 3\text{S}_2\text{O}_3^{2-}$	<b>OR</b> Identification of correct stoichiometry	<b>(03)</b>
Moles of $\text{S}_2\text{O}_3^{2-}$	$= \frac{0.10}{1000} \times 27.0$	<b>(03)</b>
Moles of $\text{I}_2$	$= \frac{1}{2} \times \frac{0.10}{1000} \times 27.0$	<b>(03)</b>
Moles of $\text{Cr}^{3+}$	$= \frac{2}{3} \times \frac{1}{2} \times \frac{0.10}{1000} \times 27.0$	<b>(03)</b>
	$= 9 \times 10^{-4}$	
Therefore, moles of $\text{PbCrO}_4$	$= \frac{2}{3} \times \frac{1}{2} \times \frac{0.10}{1000} \times 27.0 = 9 \times 10^{-4}$	<b>(03)</b>
Therefore, moles of Pb	$= \frac{2}{3} \times \frac{1}{2} \times \frac{0.10}{1000} \times 27.0 = 9 \times 10^{-4}$	<b>(03)</b>
Therefore, mass of Pb	$= 9 \times 10^{-4} \times 207 \text{ g}$	<b>(03)</b>
	$= 0.186 \text{ g}$	<b>(03)</b>
Therefore, %Pb	$= \frac{0.186}{0.285} \times 100$	<b>(03)</b>
	$= 65.3\%$	<b>(03)</b>

**(30 marks)**

(ii) What is the colour change at the end point in the titration carried out in the analysis of precipitate Y?

(Cu = 63.5, Pb = 207)

Blue  $\rightarrow$  Green

**(05)****8(b): 75 marks**

9. (a) The following questions are based on the environment and related issues.

- (i) Identify **three** greenhouse gases that contribute to global warming. State **two** consequences of global warming.

Greenhouse gases that contribute to global warming.

CO<sub>2</sub>, NO<sub>x</sub>, N<sub>2</sub>O, O<sub>3</sub>, CFC, methane, volatile hydrocarbons (03 + 03 + 03)

Consequences:

- Melting of polar ice caps
- Change in weather patterns
- Drying up of freshwater reservoirs
- Sinking of low lying countries due to thermal expansion of sea water/ sea level rise
- desertification
- loss of soil moisture
- changes in biodiversity
- decrease in dissolved oxygen content
- increase in populations of certain insects

(Any two)

(03 + 03)

- (ii) Global environmental issues caused by coal power plants are well known. Identify **one** such issue that contributes **significantly** to change in certain water quality parameters in rivers and lakes.

Acid rain

(03)

- (iii) Name the chemical species responsible for the environmental issue identified in (ii) above and state **three** water quality parameters that are likely to be affected by this issue.

SO<sub>2</sub>/ SO<sub>3</sub> / H<sub>2</sub>SO<sub>3</sub> / H<sub>2</sub>SO<sub>4</sub> (03)

Water parameters affected:

- pH (decreases) / acidity (increases)
- Salinity (increases)
- Concentration of heavy metals (increases)
- Hardness (increases)
- Conductivity (increases)

(Any three)

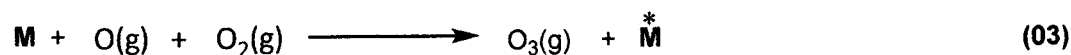
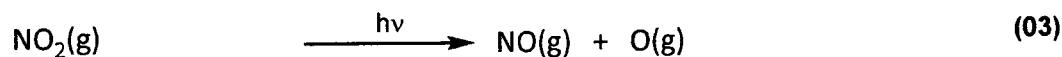
(03 + 03 + 03)

- (iv) Identify **two** environmental issues that change (increase or decrease) the ozone level in the atmosphere and explain briefly how these changes take place with the aid of balanced chemical equations.

photochemical smog (Ozone increases) (03)

How

Vehicle emissions contain  $\text{NO}_x$  (03)

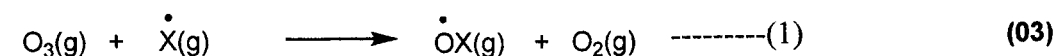


(M = third body)

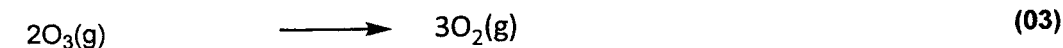
ozone layer depletion (Ozone decreases) (03)

How

Ozone destroyed by free radicals ( $\overset{\cdot}{\text{X}}$ ) (e.g.  $\overset{\cdot}{\text{H}}$ ,  $\overset{\cdot}{\text{NO}}$ ,  $\overset{\cdot}{\text{OH}}$ ,  $\overset{\cdot}{\text{Cl}}$ ) which act as a catalyst. (03)



(1)x2 + (2) + (3)x2



- (v) I. "Most of the harmful gases in vehicle exhausts are converted to relatively harmless gases by catalytic converters." Briefly explain this statement.

Catalytic converters convert

- $\text{NO}(\text{g})$  formed to  $\text{N}_2(\text{g})$  (03)
- $\text{CO}(\text{g})$  formed to  $\text{CO}_2(\text{g})$  (03)
- Unburnt or partially burnt hydrocarbons to  $\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$  (03)

- II. Name the harmful gas (except  $\text{CO}_2$ ) that is not converted to a less harmful gas by the catalytic converter. State briefly how this harmful gas is formed in the vehicle engine.

$\text{SO}_2$  (03)

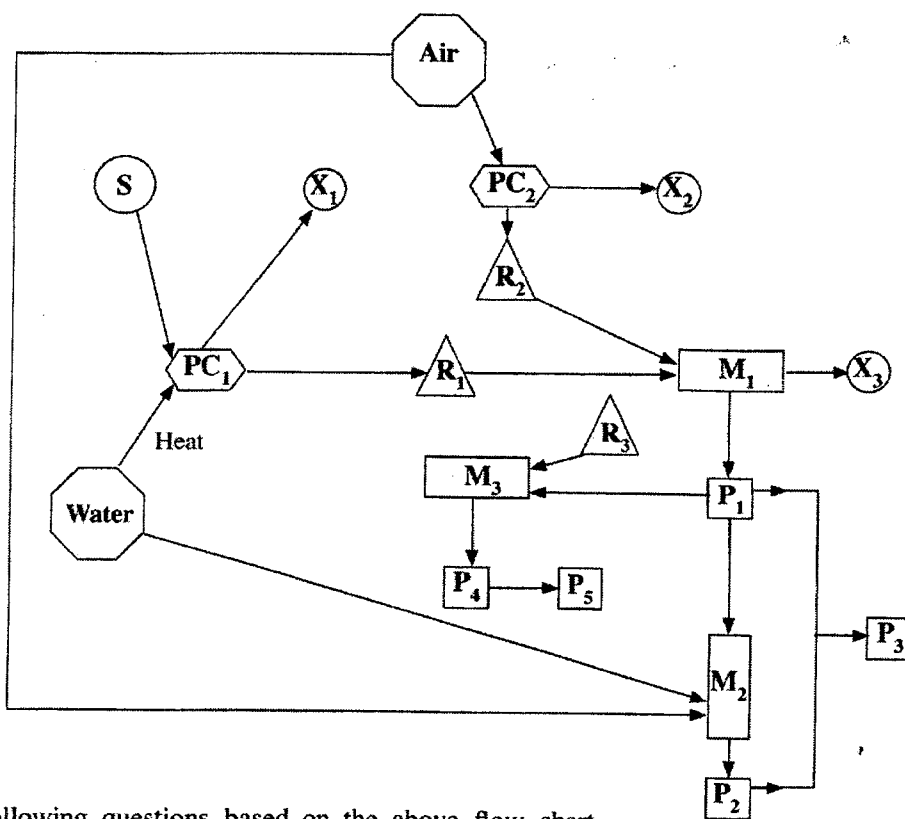
Certain fossil fuels contain sulphur. (02)

Burning of sulphur produces  $\text{SO}_2$ . (01)

9(a): 75 marks

(b) The flow chart given below shows the production of two important compounds  $P_1$  and  $P_2$  and three other important compounds  $P_3$ ,  $P_4$  and  $P_5$  derived from them.  $P_1$  is used as a raw material in the manufacture of  $Na_2CO_3$ .  $P_3$  can be manufactured by the reaction between  $P_1$  and  $P_2$ .  $P_3$  is used as a fertilizer and as an explosive.  $P_1$  is also used in the manufacture of  $P_4$  which is a widely used fertilizer.  $P_4$  is used to synthesize an important thermosetting polymer  $P_5$ .

- M** Manufacturing process
- PC** Physical/chemical process to obtain raw material
- R** Raw material
- P** Product
- S** Source of raw material
- X** Unreacted raw material(s) / substance discharged to the atmosphere during physical and/or chemical process



Answer the following questions based on the above flow chart.

(i) Identify  $P_1$ ,  $P_2$ ,  $P_3$ ,  $P_4$  and  $P_5$

- $P_1 = NH_3$  (03)
- $P_2 = HNO_3$  (03)
- $P_3 = NH_4NO_3$  (03)
- $P_4 = \text{urea} / CO(NH_2)_2$  (03)
- $P_5 = \text{urea-formaldehyde}$  (03)

(ii) Identify  $R_1$ ,  $R_2$  and  $R_3$

$R_1 = H_2$  (03)

$R_2 = N_2$  (03)

$R_3 = CO_2$  (03)

(iii) Identify  $X_1$ ,  $X_2$  and  $X_3$

$X_1 = CO / CO_2$  (03)

$X_2 = O_2$  (03)

$X_3 = N_2 + H_2$  (Both  $N_2$  and  $H_2$  must be present for the award of marks) (03)

(iv) Identify S.

S = natural gas /  $CH_4$  OR naphtha / ( $C_6H_{14}$ ) OR coal / (carbon) (02)

(v) Briefly state the processes taking place in  $PC_1$  and  $PC_2$  giving balanced chemical equations where applicable.

$PC_1$ :  $C_6H_{14}(s) + 6H_2O(g) \longrightarrow 6CO(g) + 13H_2(g)$  (02)

OR

$CH_4(g) + H_2O(g) \longrightarrow CO(g) + 3H_2(g)$  (02)

$PC_2$ : fractional distillation of liquid air (02)

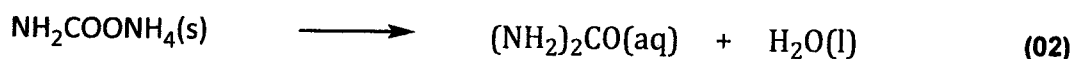
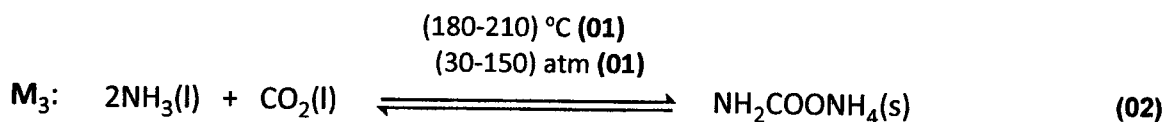
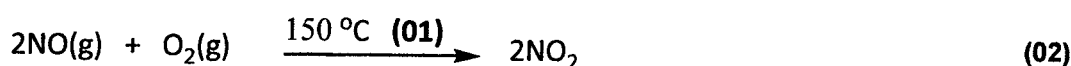
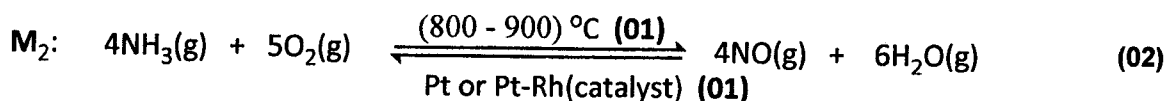
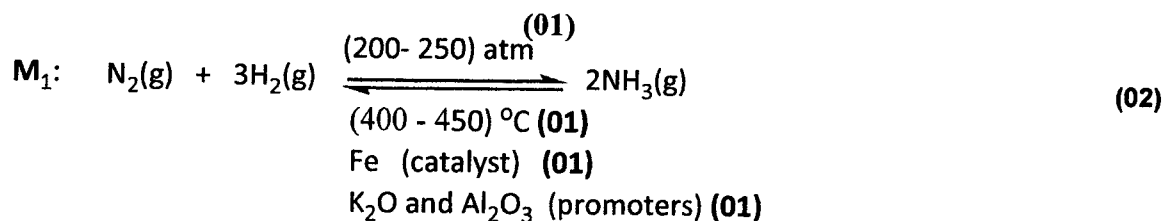
(vi) Identify manufacturing processes  $M_1$ ,  $M_2$  and  $M_3$ . (e.g. contact process or manufacture of  $H_2SO_4$ .)

$M_1 =$  Haber process OR manufacture of  $NH_3$  (02)

$M_2 =$  Ostwald process OR manufacture of  $HNO_3$  (02)

$M_3 =$  manufacture of urea (02)

(vii) Give balanced chemical equations with appropriate conditions, for reactions taking place in  $M_1$ ,  $M_2$  and  $M_3$ .



↓ Concentrate by evaporation (01)



**Note: Physical states are not required.**

(viii) I. Give one use of each compound  $P_1$  and  $P_2$  other than those mentioned above.

$P_1$ :

- Neutralizing acidic constituents in industry / emissions/ effluents / water treatment plants
- In stack emission control systems to neutralize sulphur oxides from combustion of sulphur-containing fuels
- As a refrigerant
- In the rubber industry / for the stabilization of natural and/or synthetic latex / to prevent premature coagulation
- In the paint industry

**(Any one)**

**(02)**

**P<sub>2</sub>:**

- To manufacture nitrates OR
- NaNO<sub>3</sub> - meat preservative OR
- AgNO<sub>3</sub> - prepare photographic films and paper
- For the preparation of aqua regia
- Used to clean soldering surfaces

**(Any one)**

**(02)**

II. Give one use of **R<sub>1</sub>** in the manufacturing process **P<sub>1</sub>** other than being used as a raw material.

As a fuel **OR** to heat the system (to 450 °C)

**(02)**

<b>9(b): 75 marks</b>
-----------------------

10.(a) **A** and **B** are **complex ions**, (i.e. metal ion and ligands coordinated to it) with an octahedral geometry. They have the same atomic composition of MnC<sub>5</sub>H<sub>3</sub>N<sub>6</sub>. In each complex ion, **two** types of ligands are coordinated to the metal ion. When an aqueous solution containing **A** is treated with a potassium salt, the **coordination compound C** is formed. **C** gives four ions in aqueous solution. When an aqueous solution containing **B** is treated with a potassium salt the **coordination compound D** is formed. **D** gives three ions in aqueous solution. Both **C** and **D** have an octahedral geometry.

(Note: The oxidation states of manganese in **A** and **B** do not change on treatment with the potassium salt).

(i) Identify the ligands coordinated to manganese in **A** and **B**.

CN<sup>-</sup> and NH<sub>3</sub>

**(05 + 05)**

(ii) Give the structures of **A**, **B**, **C** and **D**.

**A:** [Mn(CN)<sub>5</sub>(NH<sub>3</sub>)]<sup>3-</sup> OR [Mn(NH<sub>3</sub>)(CN)<sub>5</sub>]<sup>3-</sup> **(10)**

**B:** [Mn(CN)<sub>5</sub>(NH<sub>3</sub>)]<sup>2-</sup> OR [Mn(NH<sub>3</sub>)(CN)<sub>5</sub>]<sup>2-</sup> **(10)**

**C:** K<sub>3</sub>[Mn(CN)<sub>5</sub>(NH<sub>3</sub>)] OR K<sub>3</sub>[Mn(NH<sub>3</sub>)(CN)<sub>5</sub>] **(15)**

**D:** K<sub>2</sub>[Mn(CN)<sub>5</sub>(NH<sub>3</sub>)] OR K<sub>2</sub>[Mn(NH<sub>3</sub>)(CN)<sub>5</sub>] **(15)**

(iii) Write the electronic configurations of the manganese ions in **A** and **B**.

**A**, oxidation state of Mn = +2

Therefore, electronic configuration of Mn in **A** is, 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>5</sup> **(03)**

**B**, oxidation state of Mn = +3

Therefore, electronic configuration of Mn in **B** is, 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>4</sup> **(02)**

(iv) Write the IUPAC names of C and D.

- C potassium amminepentacyanidomanganate(II) (05)  
 D potassium amminepentacyanidomanganate(III) (05)

**Note : If spelling is incorrect do not award marks.**

10(a): 75 marks

(b) (i) I. Write the reduction half reaction corresponding to the electrode,  
 $\text{Ag(s)} \mid \text{AgCl(s)} \mid \text{Cl}^{\text{-}}(\text{aq})$ .

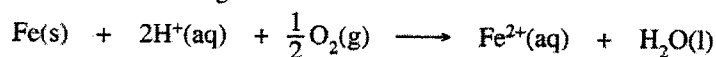


II. State whether the electrode potential of  $\text{Ag(s)} \mid \text{AgCl(s)} \mid \text{Cl}^{\text{-}}(\text{aq})$  depends on the  $\text{Ag}^+$  concentration in the solution. Explain your answer.

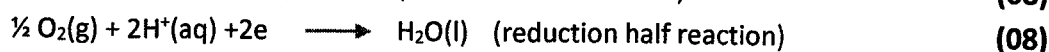
No. (05)

$\text{Ag}^+(\text{aq})$  does not appear in the electrode reaction (half reaction). (05)

(ii) Consider the following reaction.



I. Write the oxidation and reduction half reactions relevant to the above reaction.



( $\rightleftharpoons$  accepted) Physical states are required.

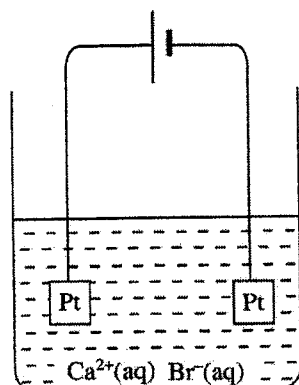
II. Given that the above reaction is the cell reaction of an electrochemical cell, determine the standard electromotive force of the cell.

$$E_{\text{Fe}^{2+}(\text{aq})/\text{Fe(s)}}^{\circ} = -0.44 \text{ V} \quad E_{\text{H}^+(\text{aq})/\text{O}_2(\text{g})/\text{H}_2\text{O(l)}}^{\circ} = 1.23 \text{ V}$$

$$\begin{aligned} \text{Standard cell potential} &= 1.23\text{V} - (-0.44\text{V}) \quad \text{OR} \quad (1.23 - (-0.44))\text{V} \quad (01+01) + (01+01) \\ &= 1.67 \text{ V} \quad (04+01) \end{aligned}$$

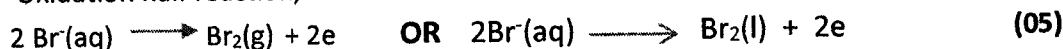


- (iii) A constant current of 100 mA was passed through 100.00 cm<sup>3</sup> of a 0.10 mol dm<sup>-3</sup> aqueous CaBr<sub>2</sub> solution as shown in the diagram. The temperature of the system was maintained at 25 °C.



- I. Write the oxidation and reduction reactions that take place at the electrodes.

Oxidation half reaction,



Reduction half reaction,



( $\rightleftharpoons$  accepted). Physical states are required.

- II. Calculate the time taken for the commencement of precipitation of Ca(OH)<sub>2</sub>(s). Solubility product of Ca(OH)<sub>2</sub> at 25 °C is 1.0 × 10<sup>-5</sup> mol<sup>3</sup> dm<sup>-9</sup>. Neglect the ionization of water. Assume that the volume of the aqueous phase remains constant.

$$K_{\text{sp}} = [\text{Ca}^{2+}(\text{aq})][\text{OH}^-(\text{aq})]^2 \quad (05)$$

Required concentration of OH<sup>-</sup> to start precipitation of Ca(OH)<sub>2</sub> = [OH<sup>-</sup>]

$$[\text{OH}^-] = \sqrt{\frac{1.0 \times 10^{-5} \text{ mol}^3 \text{ dm}^{-9}}{0.1 \text{ mol dm}^{-3}}} \quad \text{OR} \quad 1.0 \times 10^{-2} \text{ mol dm}^{-3} \quad (04+01)$$

The amount of OH<sup>-</sup> required to provide the above concentration = n<sub>OH<sup>-</sup></sub>.

$$n_{\text{OH}^-} = 1.0 \times 10^{-2} \text{ mol dm}^{-3} \times 100 \times 10^{-3} \text{ dm}^3 \quad \text{OR} \quad 1.0 \times 10^{-3} \text{ mol} \quad (04+01)$$

Amount of charge, that must be passed through the solution, Q,

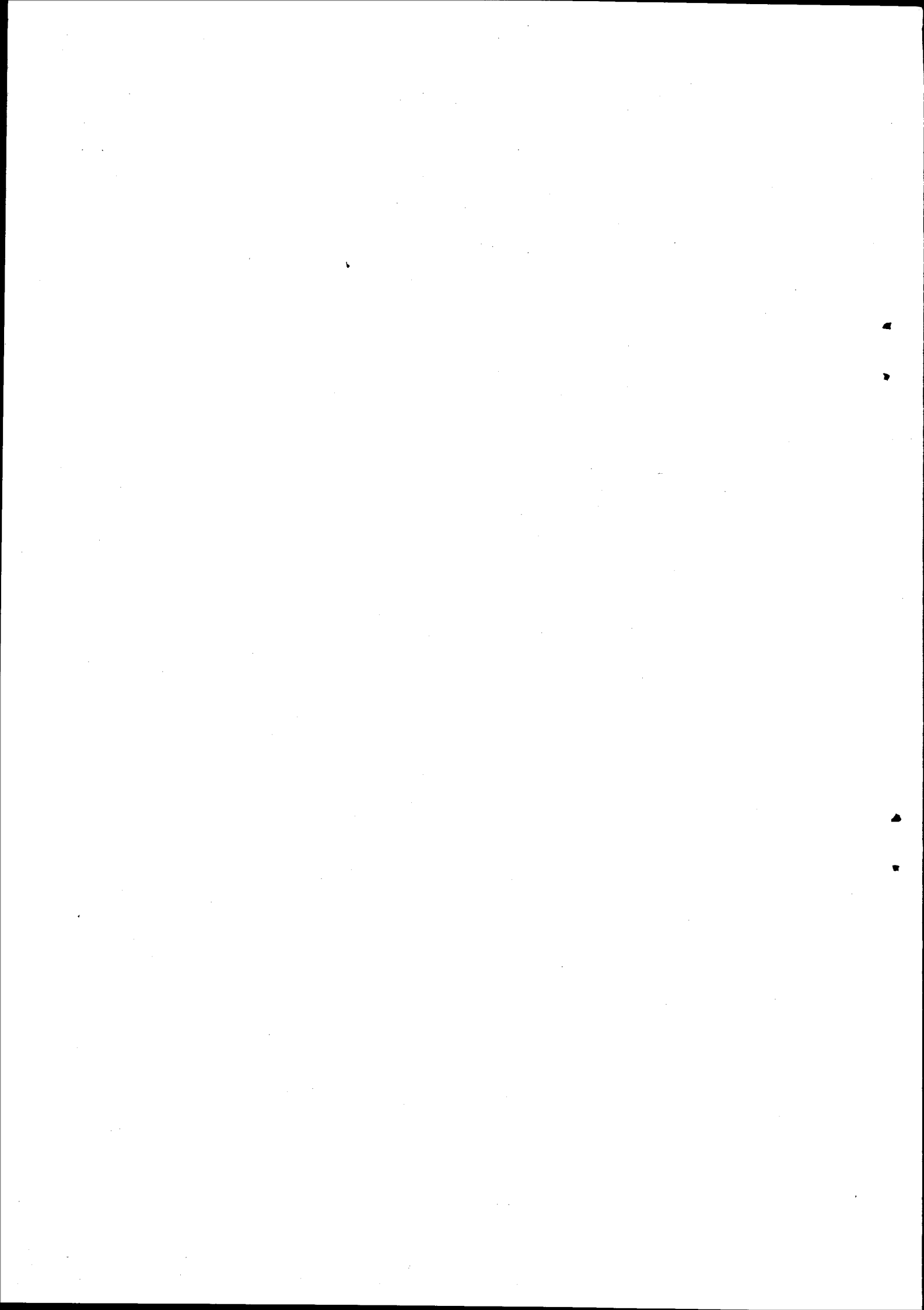
$$Q = 1.0 \times 10^{-3} \text{ mol} \times 96500 \text{ C mol}^{-1} \quad \text{OR} \quad 96.5 \text{ C} \quad (04+01)$$

Time required to pass the charge Q, when the current flow is 100 mA, = t

$$t = \frac{96.5 \text{ C}}{100 \times 10^{-3} \text{ C s}^{-1}} \quad \text{OR} \quad 965 \text{ s} \quad \text{OR} \quad 16.08 \text{ min} \quad (04+01)$$

(For the Faraday constant, a value between 96500 ± 100 C mol<sup>-1</sup> is accepted, if the symbol F is used for the Faraday constant, and t is calculated using F, full marks can be awarded. t = 16.08 min OR t = 16 min accepted.)

10 (b) = 75 marks





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