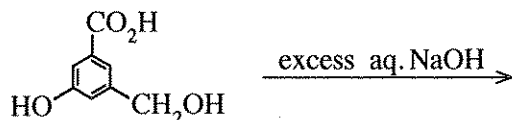


12. Which of the following answers gives the maximum hydroxide concentration that can exist in a $1.775 \text{ mol dm}^{-3}$ aqueous solution of MgCl_2 at 25°C ? At this temperature, solubility product of Mg(OH)_2 is $7.1 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$.

- (1) $4.0 \times 10^{-6} \text{ mol dm}^{-3}$ (2) $2.0 \times 10^{-6} \text{ mol dm}^{-3}$ (3) $1.775 \times 10^{-12} \text{ mol dm}^{-3}$
 (4) $\sqrt{7.1} \times 10^{-6} \text{ mol dm}^{-3}$ (5) $1.0 \times 10^{-6} \text{ mol dm}^{-3}$

13. What is the major product of the following reaction?



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

14. Identify the correct statement from the following.

- (1) The bond angle of NF_3 is larger than the bond angle of NH_3 .
 (2) Elements in group 17 (or 7A) exhibit oxidation states from -1 to $+7$.
 (3) Monoclinic sulphur is the most stable allotrope of sulphur at room temperature.
 (4) The density of graphite is higher than the density of diamond.
 (5) Aluminium chloride satisfies the octet rule in the gaseous state.

15. The standard electromotive force of the electrochemical cell $\text{Mn(s)}|\text{Mn}^{2+}(\text{aq})||\text{Br}^-(\text{aq})|\text{Br}_2(\text{g})|\text{Pt(s)}$ is 2.27 V . The standard reduction potential of $\text{Br}_2(\text{g})|\text{Br}^-(\text{aq})$ is 1.09 V . The standard reduction potential of $\text{Mn}^{2+}(\text{aq})|\text{Mn(s)}$ is,

- (1) -3.36 V (2) -1.18 V (3) 0.59 V (4) 1.18 V (5) 3.36 V

16. The enthalpy change of vaporization and the entropy change of vaporization of a liquid are, $45.00 \text{ kJ mol}^{-1}$ and $90.0 \text{ J K}^{-1} \text{ mol}^{-1}$ respectively. The boiling point of the liquid is,

- (1) 45.0°C (2) 62.7°C (3) 100.0°C (4) 135.0°C (5) 227.0°C

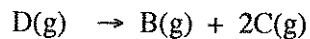
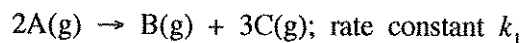
17. What is the **incorrect** statement about $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$?

- (1) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ can be obtained by reacting aniline with HNO_2 (NaNO_2/HCl) at $0 - 5^\circ\text{C}$.
 (2) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ reacts with KI to give iodobenzene.
 (3) The $\text{C}_6\text{H}_5\text{N}^+\equiv\text{N}$ ion can act as an electrophile.
 (4) When an aqueous solution of $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ is heated, it decomposes to give benzene.
 (5) $\text{C}_6\text{H}_5\text{N}^+\equiv\text{NCl}^-$ reacts with phenols in a basic medium to give coloured compounds.

18. $\text{H}_2\text{S(g)}$ reacts with $\text{O}_2(\text{g})$ to give only water vapour ($\text{H}_2\text{O(g)}$) and $\text{SO}_2(\text{g})$, as products. When 4 dm^3 of $\text{H}_2\text{S(g)}$ reacts with 10 dm^3 of $\text{O}_2(\text{g})$ at a constant pressure and 250°C , the final volume of the mixture is,

- (1) 6 dm^3 (2) 8 dm^3 (3) 10 dm^3 (4) 12 dm^3 (5) 14 dm^3

19. A mixture of A(g) and D(g) was introduced into a rigid evacuated container at the temperature T . At this temperature, both A(g) and D(g) decompose according to the elementary reactions given below.



The initial pressure of the container P , changed to $2.7P$ after the complete decomposition of both reactants. The initial rate of decomposition of A(g) at this temperature is, (R is the universal gas constant)

- (1) $1.7k_1 \left(\frac{P}{RT} \right)$ (2) $2.7k_1 \left(\frac{P}{RT} \right)$ (3) $0.09k_1 \left(\frac{P}{RT} \right)^2$
 (4) $2.89k_1 \left(\frac{P}{RT} \right)^2$ (5) $7.29k_1 \left(\frac{P}{RT} \right)^2$

20. An organic compound (X) decolourizes bromine water (Br_2/H_2O). X does not give a precipitate with ammoniacal CuCl. When X is treated with an acidic $K_2Cr_2O_7$ solution, a green coloured solution is obtained. X could be:

- (1) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2C \equiv C-H \end{array}$ (2) $\begin{array}{c} OH \\ | \\ CH_3CCH_2C \equiv C-CH_3 \\ | \\ CH_3 \end{array}$ (3) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2CH=CHCH_3 \end{array}$
 (4) $\begin{array}{c} CH_3 \\ | \\ HOCH_2CHC \equiv C-H \end{array}$ (5) $\begin{array}{c} OH \\ | \\ CH_3CHCH_2CH_2CH_2CH_3 \end{array}$

21. A buffer solution of pH 5.0 was prepared by mixing equal volumes of a 0.10 mol dm^{-3} monobasic weak acid solution and a 0.10 mol dm^{-3} solution of the sodium salt of this acid. The pH of the resultant solution, when 20.00 cm^3 of this buffer solution was mixed with 90.00 cm^3 of 0.10 mol dm^{-3} weak acid solution, is,

- (1) 3.0 (2) 4.0 (3) 4.5 (4) 5.5 (5) 6.0

22. Consider the following three aqueous solutions.

P - a weak acid,

Q - an equimolar mixture of the weak acid and its sodium salt,

R - titration mixture at the equivalence point of the titration of the weak acid and a strong base

When each solution is diluted by the same amount at constant temperature, the pH of P, Q and R respectively, will

- (1) decrease, increase, not change. (2) increase, not change, decrease.
 (3) increase, not change, not change. (4) increase, not change, increase.
 (5) increase, increase, increase.

23. The **incorrect** statement with regard to the oxoacids of chlorine HOCl, $HClO_2$, $HClO_3$ and $HClO_4$ is,

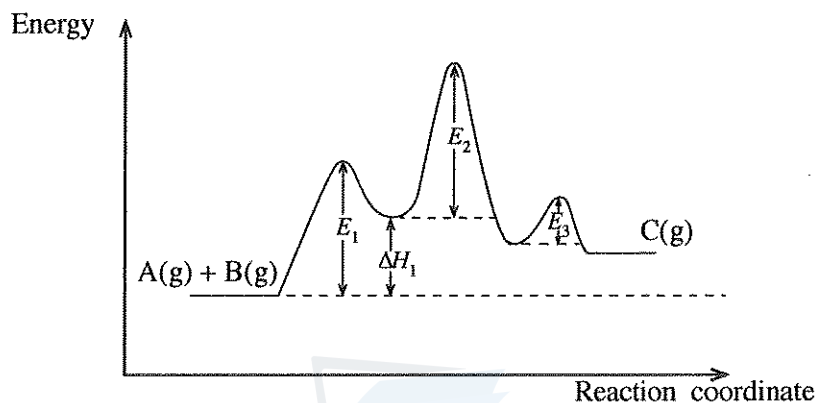
- (1) The shapes around chlorine in $HClO_2$, $HClO_3$ and $HClO_4$ respectively are angular, pyramidal and tetrahedral.
 (2) The oxidation states of chlorine in HOCl, $HClO_2$, $HClO_3$ and $HClO_4$ respectively are +1, +3, +5 and +7.
 (3) The acid strength of the oxoacids varies as $HOCl < HClO_2 < HClO_3 < HClO_4$.
 (4) All these oxoacids contain at least one double bond.
 (5) All these oxoacids contain at least one OH group.

24. The density of an aqueous acidic solution at $25^\circ C$ is 1.0 kg dm^{-3} . If the pH of this solution is 1.0, its H^+ concentration in ppm would be,

- (1) 0.1 (2) 1 (3) 100 (4) 1000 (5) 10,000

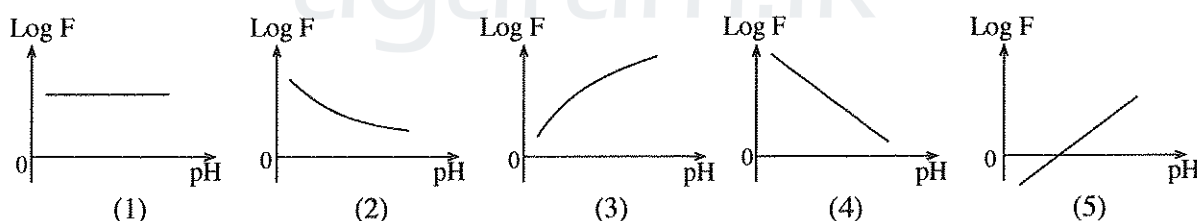
[See page five

25. A 25.0 g sample of polluted air containing ozone (O_3) is treated with an acidic solution containing excess KI. Ozone is converted to O_2 and H_2O during this reaction. The iodine liberated is titrated with $0.002 \text{ mol dm}^{-3}$ $Na_2S_2O_3$ solution. Volume of $Na_2S_2O_3$ required was 25.0 cm^3 . The mass percent of O_3 in the air sample is, ($O = 16$)
- (1) 4.8×10^{-3} (2) 6.4×10^{-3} (3) 9.6×10^{-3} (4) 1.0×10^{-2} (5) 3.2×10^{-2}
26. Which of the following reaction steps is **not** present in the Born-Haber cycle of $NaCl(s)$ formation?
- (1) $Na^+(aq) + Cl^-(aq) \longrightarrow NaCl(aq)$ (2) $Na(s) \longrightarrow Na(g)$ (3) $Cl_2(g) \longrightarrow 2Cl(g)$
 (4) $Cl(g) + e \longrightarrow Cl^-(g)$ (5) $Na^+(g) + Cl^-(g) \longrightarrow NaCl(s)$
27. Activation energy of the elementary reaction $A(g) + B(g) \longrightarrow C(g)$ is E_a . This reaction is catalysed by the metal M . The energy diagram of the catalysed reaction is given below.



Which of the following is always correct with regard to this reaction?

- (1) $E_a < E_1$ (2) $E_a = E_1 + E_2 + E_3 - \Delta H_1$ (3) $E_a < E_1, E_a < E_2$ and $E_a < E_3$
 (4) $E_a > E_1 + E_2$ (5) $E_a > \Delta H_1 + E_2$
28. For a weak acid, it can be given that $F = \frac{\text{Amount of the acid dissociated}}{\text{Amount of the acid undissociated}}$
- Which of the following graphs shows the relationship between $\log F$ and pH ?



29. Which of the following statements with regard to polymers is correct?
- (1) Nylon is an addition polymer.
 (2) Teflon is a condensation polymer.
 (3) Bakelite is a linear polymer.
 (4) The number of carbon atoms in the repeating unit of natural rubber is 4.
 (5) Small covalent molecules are eliminated when monomers combine to form condensation polymers.
30. Two ideal gases that do not react with each other are separated by a valve and kept in a rigid container. This system is maintained at constant temperature and pressure. Which of the following correctly describes the change in Gibbs energy, enthalpy and entropy of the system respectively when the valve is opened?
- (1) decreased, decreased, decreased (2) decreased, decreased, increased
 (3) decreased, unchanged, increased (4) decreased, increased, increased
 (5) increased, increased, increased

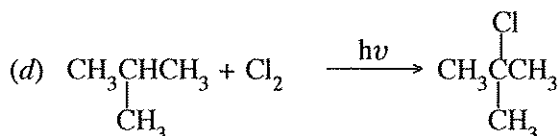
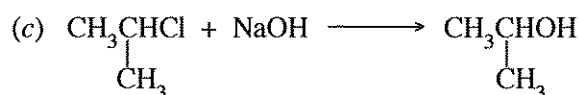
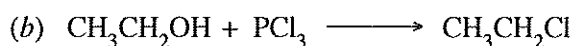
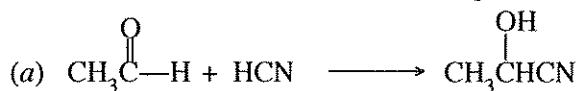
- For each of the questions 31 to 40, one or more responses out of the four responses (a), (b), (c) and (d) given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

- (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.

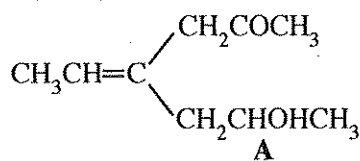
Summary of above Instructions

(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	Any other number or combination of responses is correct

31. Which of the following statement/statements is/are correct with regard to simple covalent molecules containing oxygen and sulphur atoms?
- (a) H₂O shows amphoteric properties.
 - (b) The boiling point of H₂O₂ is higher than the boiling point of H₂O.
 - (c) H₂O₂ can act as an oxidizing agent only in an acidic medium.
 - (d) Both H₂S and SO₂ have the capacity to act only as reducing agents.
32. Which of the following statement/statements is/are correct with regard to hydrocarbons?
- (a) All hydrocarbons give CO₂ and H₂O when completely reacted with excess O₂.
 - (b) All alkynes react with Grignard reagents to give alkynylmagnesium halides.
 - (c) The boiling point of a branched alkane is higher than the boiling point of an unbranched alkane with the same relative molecular mass.
 - (d) None of the hydrocarbons react with aqueous NaOH.
33. If an endothermic reaction occurs spontaneously at constant temperature and pressure, then,
- (a) enthalpy of the system decreases.
 - (b) entropy of the system increases.
 - (c) enthalpy of the system increases.
 - (d) entropy of the system does not change.
34. Which of the following statement/statements is/are correct regarding the precipitation of metal ions by passing H₂S(g) in to their aqueous solutions?
- (a) When the pressure of H₂S(g) is decreased, the sulphide ion concentration is increased.
 - (b) When the temperature is increased, the sulphide ion concentration is decreased.
 - (c) Addition of Na₂S(s) to the solution, decreases the dissociation of dissolved H₂S(aq).
 - (d) Increase in pH of the solution decreases sulphide ion concentration.
35. Which of the following is/are nucleophilic substitution reaction/reactions?



36. Which of the following statement/statements is/are correct regarding the elevation of carbon dioxide level in the atmosphere?
- It contributes to the increase in acidity of sea water.
 - It reduces the hardness of water bodies.
 - It strongly absorbs UV radiation coming from the sun.
 - It does not contribute to acid rain.
37. Which of the following statement/statements is/are correct with regard to 3d-block elements?
- Zn has the highest first ionization energy among the 3d-block elements.
 - In contrast to the ions of most main group elements (*s* and *p*-block), 3d-block metal ions rarely attain the noble gas configuration.
 - Although the electronegativities of 3d-block elements are higher than the electronegativities of the corresponding *s*-block elements, their atomic radii are smaller than the atomic radii of the corresponding *s*-block elements.
 - The 3d-block elements that form colourless compounds are Ti and Zn.
38. Volatile liquids **A** and **B** having saturated vapour pressures P_A° and P_B° ($P_A^\circ \neq P_B^\circ$) form an ideal solution. A mixture of the liquids **A** and **B** is in equilibrium with their vapour phase, in a closed container. When the volume of the container is increased and the equilibrium is re-established at the same temperature, which of the following statement/statements is/are correct?
- While some amount of **A** and **B** go to the gas phase, the composition of the liquid phase remains unchanged.
 - While some amount of **A** and **B** go to the gas phase, the composition of the gas phase remains unchanged.
 - While some amount of **A** and **B** go to the gas phase, the composition of the liquid phase changes.
 - While some amount of **A** and **B** go to the gas phase, the composition of the gas phase changes.
39. Which of the following statement/statements is/are correct regarding an aqueous solution of a weak acid?
- Conductivity of the solution increases as the concentration of the weak acid decreases.
 - Conductivity of the solution increases as the temperature increases.
 - Conductivity of the solution decreases but the fraction dissociated of the weak acid increases as more water is added to the solution.
 - When NaCl(s) is dissolved in the weak acid solution, conductivity decreases.
40. Which of the following statement/statements regarding compound **A** is/are correct?



- A** exhibits geometric isomerism.
- A** does not exhibit optical isomerism.
- The product obtained when **A** is reacted with pyridinium chlorochromate (PCC) exhibits optical isomerism.
- The product obtained when **A** is reacted with pyridinium chlorochromate does not exhibit geometric isomerism.

- 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 not explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	Among the halogens, I ₂ is a solid whereas Br ₂ is a liquid.	London forces become stronger with increase in molecular surface area.
42.	At a given pressure, the spontaneity of the reaction between N ₂ and H ₂ to give NH ₃ drops with increasing temperature.	Entropy change of the reaction between N ₂ and H ₂ to give NH ₃ is negative.
43.	Essential oils are generally extracted from plant materials by steam distillation.	Essential oils have a high solubility in water.
44.	A spontaneous reaction always has a negative Gibbs energy change no matter what the conditions are.	Gibbs energy change can be used to predict the direction of a reaction only under constant temperature and constant pressure conditions.
45.	Solubility of 1-butanol in water is less than the solubility of methanol in water.	The solubility of alcohols in water decreases as the size of the non-polar alkyl group increases relative to the polar OH group.
46.	The reaction, $\text{CH}_3-\text{CH}=\text{CH}_2 \xrightarrow{\text{HBr}} \text{CH}_3-\underset{\text{Br}}{\text{CH}}-\text{CH}_3$ is a nucleophilic addition reaction.	A secondary carbocation is formed as a reaction intermediate in the following reaction. $\text{CH}_3-\text{CH}=\text{CH}_2 \xrightarrow{\text{HBr}} \text{CH}_3-\underset{\text{Br}}{\text{CH}}-\text{CH}_3$
47.	Coke is used in several industrial processes.	Coke is only used industrially as a fuel.
48.	The carbonyl carbon atom of a ketone and the other atoms bonded to it lie in the same plane.	The carbonyl carbon atom of a ketone is sp ² hybridized.
49.	Any two ideal gases have the same average kinetic energies at the same temperature.	At a given temperature, the average speed of gas molecules adjust according to their masses.
50.	Although CFC contribute to ozone layer depletion, the contribution from HFC is negligible.	HFC undergoes complete decomposition before reaching the upper atmosphere.

[See page nine

The Periodic Table

1	1																	2
	H																	He
2	3	4											5	6	7	8	9	10
	Li	Be											B	C	N	O	F	Ne
3	11	12											13	14	15	16	17	18
	Na	Mg											Al	Si	P	S	Cl	Ar
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	55	56	La-	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	87	88	Ac-	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



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නව කීර්දේශය / புதிய பாடத்திட்டம் / New Syllabus

NEW Department of Examinations, Sri Lanka

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2019 අගෝස්තු
 கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2019 ஆகஸ்ட்
 General Certificate of Education (Adv. Level) Examination, August 2019

රසායන විද්‍යාව II
 இரசாயனவியல் II
 Chemistry II

02 E II

19.08.2019 / 0830 - 1140

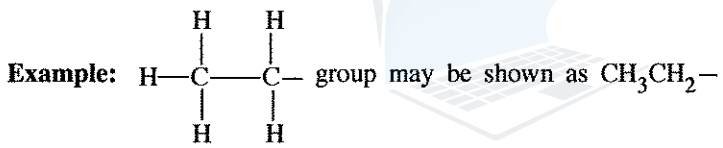
පැය තුනයි
 மூன்று மணித்தியாலம்
 Three hours

අමතර කියවීමේ කාලය - මිනිත්තු 10 යි
 மேலதிக வாசிப்பு நேரம் - 10 நிமிடங்கள்
 Additional Reading Time - 10 minutes

Use additional reading time to go through the question paper, select the questions and decide on the questions that you give priority in answering.

Index No. :

- * A Periodic Table is provided on page 16.
- * Use of calculators is not allowed.
- * Universal gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
- * Avogadro constant, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- * In answering this paper, you may represent alkyl groups in a condensed manner.



□ PART A – Structured Essay (pages 2 - 8)

- * Answer all the questions on the question paper itself.
- * Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.

□ PART B and PART C – Essay (pages 9 - 15)

- * Answer four questions selecting two questions from each part. Use the papers supplied for this purpose.
- * At the end of the time allotted for this paper, tie the answers to the three Parts A, B and C together so that Part A is on top and hand them over to the Supervisor.
- * You are permitted to remove only Parts B and C of the question paper from the Examination Hall.

For Examiner's Use Only

Part	Question No.	Marks
A	1	
	2	
	3	
	4	
B	5	
	6	
	7	
C	8	
	9	
	10	
Total		

Total	
In Numbers	
In Letters	

Code Numbers	
Marking Examiner 1	
Marking Examiner 2	
Checked by :	
Supervised by :	

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PART A – STRUCTURED ESSAY

Answer all four questions on this paper itself. (Each question carries 100 marks.)

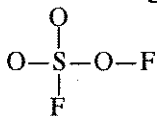
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column.

1. (a) The following questions are related to the elements of the second row in the Periodic Table. Write the **symbol** of the element in the space provided in answering parts (i) to (vi).

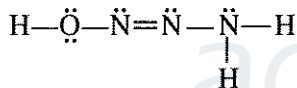
- (i) Identify the element that has the highest electronegativity (disregard the noble gas).
- (ii) Identify the element that has an allotrope which conducts electricity.
- (iii) Identify the element that forms the monoatomic ion largest in size (this should be a stable ion).
- (iv) Identify the element that has **no** *p* electrons but has a stable *s* configuration.
- (v) Identify the element that has the highest first ionization energy.
- (vi) Identify the element that forms mostly electron deficient trigonal planar covalent compounds.

(24 marks)

(b) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule SO_3F_2 . Its skeleton is given below.



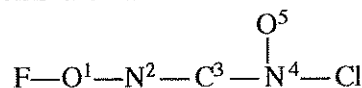
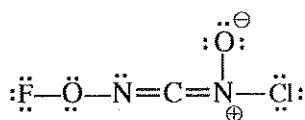
(ii) The most stable Lewis dot-dash structure for the molecule $\text{H}_3\text{N}_3\text{O}$ is shown below. Draw **two** more Lewis dot-dash structures (resonance structures) for this molecule. Write 'unstable' under the more unstable structure drawn by you.



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

- I. VSEPR pairs around the atom II. electron pair geometry around the atom
III. shape around the atom IV. hybridization of the atom

The atoms are numbered as follows.



	O ¹	N ²	C ³	N ⁴
I. VSEPR pairs				
II. electron pair geometry				
III. shape				
IV. hybridization				

[see page three]

Do not
write
in this
column.

(iv) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

- I. F—O¹ F O¹
- II. O¹—N² O¹ N²
- III. N²—C³ N² C³
- IV. C³—N⁴ C³ N⁴
- V. N⁴—O⁵ N⁴ O⁵
- VI. N⁴—Cl N⁴ Cl

(v) Identify the atomic orbitals involved in the formation of the following π bonds in the Lewis dot-dash structure given in part (iii) above. (Numbering of atoms is as in part (iii).)

- I. N²—C³ N² C³
- II. C³—N⁴ C³ N⁴

(vi) I. How are the two double bonds oriented in the Lewis dot-dash structure given in part (iii)?

.....

II. Give an example of a molecule/ion that has a similar orientation of double bonds.

.....

Note: Your example should not contain more than 3 atoms.

The elements in your example should be restricted to the first and second periods of the Periodic Table. (52 marks)

(c) (i) An atomic orbital is described by three quantum numbers n , l and m_l .

Write the appropriate quantum numbers and the name of the atomic orbital in the boxes given below.

	n	l	m_l	atomic orbital
I.	<input type="text"/>	<input type="text"/>	+1	3p
II.	3	2	-2	<input type="text"/>
III.	<input type="text"/>	<input type="text"/>	<input type="text"/>	2s

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

I. LiF, LiI, KF (melting point)

..... < <

II. NO₂⁻, NO₄³⁻, NF₅ (stability)

..... < <

III. NOCl, NOCl₃, NO₂F (N—O bond distance)

..... < <

(24 marks)

100

[see page four

Do not write in this column.

2.(a) X is an s-block element in the Periodic Table. The first, second and third ionization energies of X, in kJ mol^{-1} are 738, 1451 and 7733 respectively. X reacts slowly with hot water, liberating $\text{H}_2(\text{g})$ and forming its hydroxide. The hydroxide is basic. X also liberates $\text{H}_2(\text{g})$ on reaction with dilute acids. X burns in air with a bright white light. The cation of X contributes to hardness of water.

(i) Identify X. X:

(ii) Write the ground state electronic configuration of X.

(iii) Write the chemical formulae of the **two** compounds formed when X burns in air.

..... and

(iv) Consider the given compounds of the elements in the group in the Periodic Table to which X belongs. In the given boxes, write whether the indicated property **increases** or **decreases** down the group.

I. Solubility of sulphates in water

II. Solubility of hydroxides in water

III. Thermal stability of metal carbonates

Give reasons for your answer in III.

.....

(v) Identify the element in the s-block of the Periodic Table, which reacts in a similar manner to X with $\text{H}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{N}_2(\text{g})$, but does **not** belong to the same group as X.

.....

(vi) Identify another **metal ion** that contributes to hardness of water.

.....

(vii) Identify the compound most commonly used to remove hardness of water.

.....

(viii) X is a component of a well-known reagent used in organic chemistry. Give the **name** of this reagent.

.....

(50 marks)

[see page five

Do not write in this column.

(b) Test tubes labelled A to E contain aqueous solutions of $\text{Na}_2\text{S}_2\text{O}_3$, Na_2CO_3 , KNO_2 , KBr and Na_2S (not in order). The characteristics of the solutions obtained and gases evolved on addition of dil. HCl (warming if required) to each of the test-tubes A to E are given in the table below.

Test-tube	Appearance of solution	Gas
A	colourless	colourless and odourless
B	colourless	reddish-brown with a pungent odour
C	colourless	colourless with a rotten egg odour
D	turbid	colourless with a pungent odour
E	colourless	not evolved

(i) Identify the solutions in each of the test-tubes A to E.

A : C : E :
 B : D :

(ii) Write balanced chemical equations for the reactions that take place in test-tubes A, B, C and D.

In A :
 In B :
 In C :
 In D :

(iii) Write a chemical test to identify each of the gases evolved in A, C and D.

Note: Observations are also required.

In A :

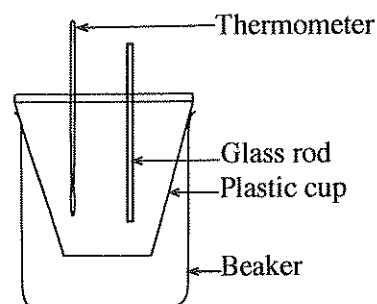
 In C :

 In D :

(50 marks)

100

3. The set up shown in the figure was used to calculate the heat change associated with the dissolution of $\text{MX}(s)$ in water. 100.00 cm^3 of distilled water was added to the cup. The initial temperature of distilled water was measured to be 25.0°C . Then 0.10 mol of $\text{MX}(s)$ was added to the water and stirred continuously. It was observed that the temperature of the solution decreased gradually. The lowest temperature measured was 17.0°C . The amount of water used was sufficient to completely dissolve $\text{MX}(s)$. Density and specific heat capacity of water are 1.00 g cm^{-3} and $4.20 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$ respectively. Assume that the density and the specific heat capacity of water are not changed due to the dissolution of $\text{MX}(s)$.



(i) Calculate the amount of heat that should be supplied to bring the system (solution) back to 25.0°C .

.....

[see page six

Do not write in this column.

(ii) Is the dissolution of MX(s) in water an endothermic or exothermic process? Explain your answer.

.....
.....

(iii) Calculate the enthalpy change (in kJ mol⁻¹) associated with reaction



.....
.....
.....
.....

(iv) If this experiment was conducted using 200.00 cm³ of water, would you expect the temperature change to be larger than the above value? Explain your answer.

.....
.....

(v) Show the variation of temperature of the system (solution) by drawing the temperature – time curve.

Note: Eventually the system reaches the room temperature (25.0 °C).



(vi) In this experiment, explain why a plastic cup is used instead of a metal cup.

.....
.....
.....

(vii) Gibbs energy change (ΔG) for the dissolution of MX(s) in water at the temperature of 25.0 °C and pressure of 1.0 atm was calculated to be $-26.0 \text{ kJ mol}^{-1}$. Calculate the entropy change (ΔS) of dissolution of MX(s) in water at 25.0 °C using the enthalpy change calculated above.

.....
.....
.....
.....

(viii) Would you expect the solubility of MX(s) to increase or decrease with increasing temperature? Give reasons for your answer.

.....
.....
.....

100

(100 marks)

[see page seven

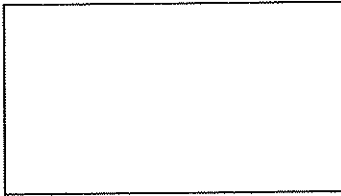
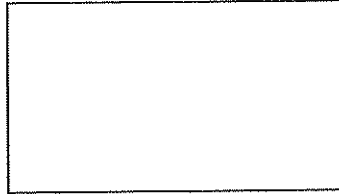
Agaram.LK - Keep your dreams alive!

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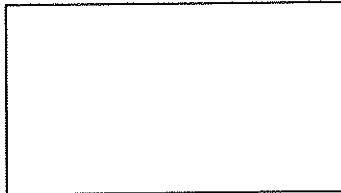
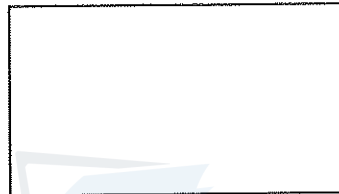
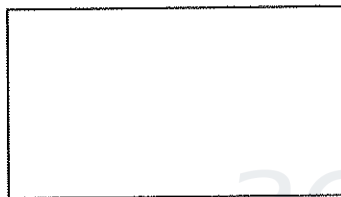
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4. (a) Compounds **A** and **B** both have the same molecular formula $C_5H_{10}O$. Both **A** and **B** give orange/red precipitates with 2,4-dinitrophenylhydrazine. When **A** and **B** are reacted separately with $NaBH_4$ in methanol, compound **A** gives **C** and compound **B** gives **D**. When **C** is heated with Al_2O_3 , two alkenes **E** (C_5H_{10}) and **F** (C_5H_{10}) are formed. When **E** and **F** are reacted separately with conc. H_2SO_4 and the products obtained are hydrolysed, compound **E** gives **G**, while compound **F** gives **H**. **G** gives a turbidity immediately with the Lucas reagent. **H** also gives a turbidity with the Lucas reagent but not immediately.

- (i) Draw the structures of **G** and **H**.

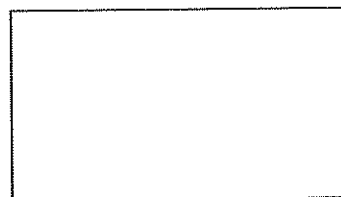
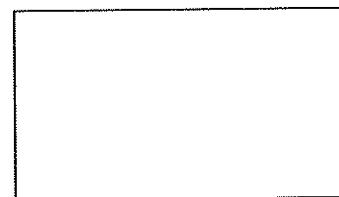
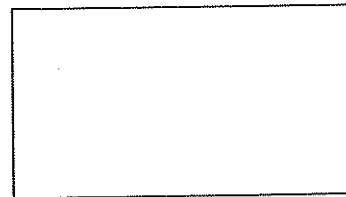
**G****H**

- (ii) Draw the structures of **A**, **C**, **E** and **F**.

**A****C****E****F**

When heated with Al_2O_3 , **D** gives alkene **I** (C_5H_{10}). When **I** is reacted with conc. H_2SO_4 and the product obtained hydrolysed, **G** is obtained.

- (iii) Draw the structures of **B**, **D** and **I**.

**B****D****I**

- (iv) Describe a test/reaction to distinguish between **A** and **B**.

.....

.....

.....

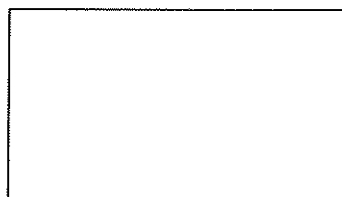
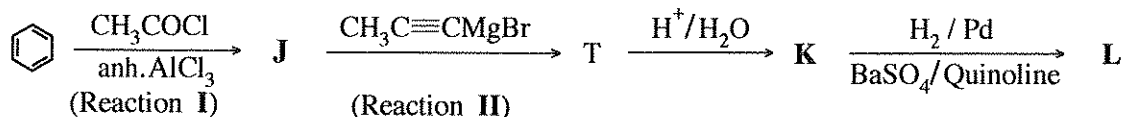
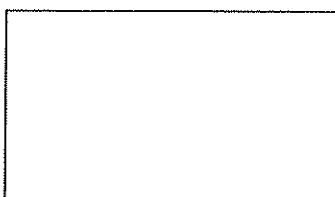
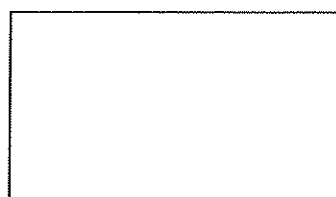
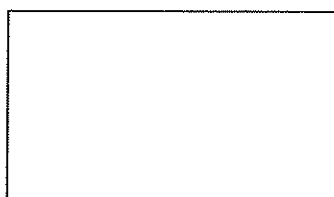
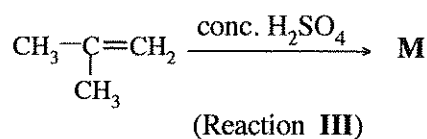
.....

.....

(50 marks)

[see page eight]

(b) (i) Give the structures of **J**, **K**, **L** and **M** in the following reaction sequences.

**J****K****L****M**

(ii) Selecting from the list given below, write the type of reaction taking place in reactions **I**, **II** and **III**.

Nucleophilic Addition, Nucleophilic Substitution,
Electrophilic Addition, Electrophilic Substitution, Elimination

Reaction **I**:

Reaction **II**:

Reaction **III**:

(iii) Using your knowledge of the mechanism of the reaction between alkenes and HBr, give the mechanism of reaction **III**.

Do not write in this column.

(50 marks)

100

[see page nine]

* *

6. (a) An organic solvent (org-1) and water(aq) are immiscible and form a biphasic system. Partition coefficient for the distribution of X between org-1 and water at temperature T is, $K_D = \frac{[X]_{\text{org-1}}}{[X]_{\text{aq}}} = 4.0$

An amount of 0.50 mol of X was added to a system containing 100.00 cm³ of org-1 and 100.00 cm³ of water. The system was allowed to reach equilibrium at temperature T.

- Calculate the concentration of X in org-1.
- Calculate the concentration of X in water.

(20 marks)

- (b) The compound Y is soluble only in the aqueous phase. In the aqueous phase, X and Y react to form Z. The presence of Y and Z does not affect the distribution of X between org-1 and water.

A series of biphasic systems containing org-1 and water were prepared. Then different amounts of X were distributed in the biphasic systems and the systems were allowed to reach equilibrium. The initial rate of the reaction between X and Y in the aqueous phase was measured after adding Y into the aqueous phase of these biphasic systems. Results of these experiments conducted at temperature T are given in the table.

Experiment Number	Volume of water (cm ³)	Volume of org-1 (cm ³)	Total amount of X added (mol)	Total amount of Y added (mol)	Initial rate of the reaction (mol dm ⁻³ s ⁻¹)
1	100.00	100.00	0.05	0.02	2.00×10^{-6}
2	100.00	100.00	0.10	0.04	1.60×10^{-5}
3	50.00	50.00	0.25	0.02	4.00×10^{-4}

Orders of the reaction with respect to X and Y are m and n respectively. The rate constant of the reaction at temperature T is k .

- Given that the concentrations of X and Y in the aqueous phase are $[X]_{\text{aq}}$ and $[Y]_{\text{aq}}$ respectively, write the rate expression for the reaction in terms of $[X]_{\text{aq}}$, $[Y]_{\text{aq}}$, m , n and k .
- Calculate the initial concentration of X in the aqueous phase in each experiment.
- Calculate the initial concentration of Y in the aqueous phase in each experiment.
- Calculate the orders m and n of the reaction with respect to X and Y respectively.
- Calculate the rate constant of the reaction.
- An experiment is designed to study the effect of temperature on the reaction rate using the partition coefficient given above.

Is this a suitable experiment to study the effect of temperature on the rate of the reaction? Explain your answer.

(105 marks)

- (c) The organic solvent org-2 and water are also immiscible and form a biphasic system. X (0.20 mol) was added to a system containing 100.00 cm³ of org-2 and 100.00 cm³ of water and allowed to reach equilibrium at the temperature T. Then Y (0.01 mol) was added to the aqueous phase and the initial rate of the reaction was measured. Y does not dissolve in org-2. The initial rate of the reaction between X and Y in the aqueous phase was found to be 6.40×10^{-7} mol dm⁻³ s⁻¹.

Calculate the partition coefficient $\frac{[X]_{\text{org-2}}}{[X]_{\text{aq}}}$ for the distribution of X between org-2 and water.

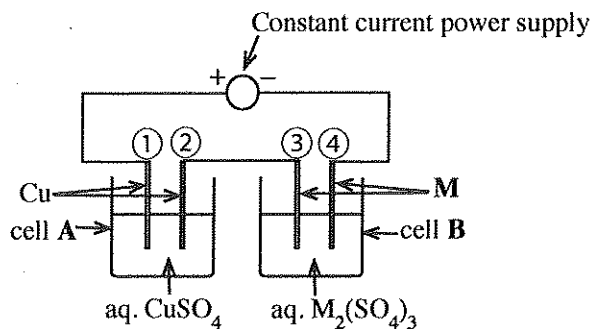
$[X]_{\text{org-2}}$ is the concentration of X in the org-2 phase.

(25 marks)

[see page eleven]

7. (a) The setup shown in the figure was used to find the relative atomic mass of the metal, M .

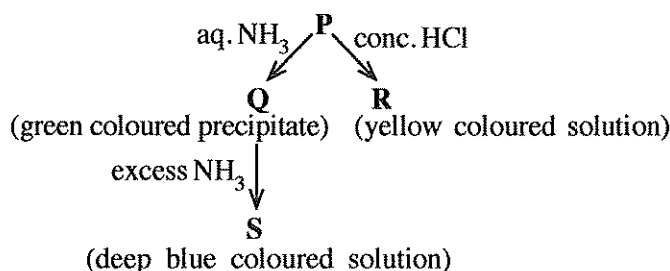
The electrolysis was carried out for 10 minutes using a constant current. The mass of the cathode in cell **A** was increased by 31.75 mg whereas the mass of the cathode in cell **B** increased by 147.60 mg during this time period. (Assume that the electrolysis of water does not take place in cells **A** and **B**.)



- Identify the anode and cathode in each of the cells **A** and **B** (in terms of the numbers ①, ②, ③, and ④).
 - Write the half reaction taking place at each electrode in each cell.
 - Calculate the constant current used in electrolysis.
 - Calculate the relative atomic mass of metal, M .
- (75 marks)
- (b) (i) **A**, **B** and **C** are coordination compounds. They have an octahedral geometry. In each compound, **two types** of ligands are coordinated to the metal ion. The molecular formulae of the compounds are (**not** in order): $\text{NiCl}_2\text{H}_{12}\text{N}_4$, $\text{NiI}_2\text{H}_{16}\text{N}_4\text{O}_2$ and $\text{NiCl}_2\text{H}_{15}\text{N}_3\text{O}_3$. Given below are the observations when aqueous solutions of the compounds are treated with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.

Compound	$\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$
A	A white precipitate that is soluble in hot water
B	No precipitate
C	A yellow precipitate that is soluble in hot water

- Give the structures of **A**, **B** and **C**.
 - Write the chemical formulae of the precipitates formed on treatment of the compounds with $\text{Pb}(\text{CH}_3\text{COO})_2(\text{aq})$.
(Note: Indicate compound and reagent)
 - State a chemical test, together with the observation, to identify each of the anion/s if present, that is/are not coordinated to the metal ion in the compounds given above.
(Note: The tests given by you should not be a test stated here.)
- (ii) A transition metal M forms a coloured complex ion **P** in aqueous medium. It has the general formula $[\text{M}(\text{H}_2\text{O})_n]^{m+}$. It undergoes the reactions given below.



- Identify the metal M . Give the oxidation state of M in complex ion **P**.
- Give the electronic configuration of M in the complex ion **P**.
- Give the values of n and m .
- Give the geometry of **P**.
- Give the structures of **Q**, **R** and **S**.
- Give the IUPAC names of the complex ions, **P**, **R** and **S**.

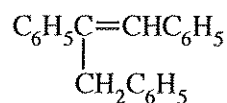
(75 marks)

[see page twelve

PART C — ESSAY

Answer two questions only. (Each question carries 150 marks.)

8. (a) Using $C_6H_5CO_2CH_3$ as the only organic starting material and as reagents only those given in the list, show how you would synthesize the following compound in **not more than seven (7) steps**.

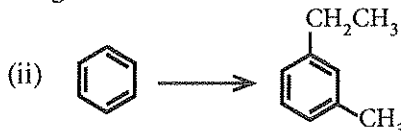
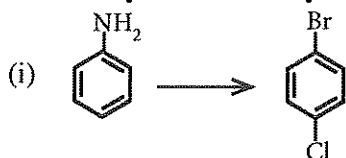


List of reagents

 PCl_3 , Mg/dry ether, H^+/H_2O , $LiAlH_4$, conc. H_2SO_4

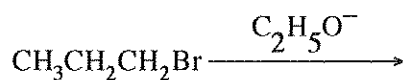
(60 marks)

- (b) Show how you would carry out each of the following conversions in **not more than three (3) steps**.



(60 marks)

- (c) The following reaction gives two products.



- (i) Write the structures of the two products.

- (ii) Write the mechanisms for the formation of these two products.

(30 marks)

9. (a) Solution X contains **four** metal cations. The following tests were carried out to identify these cations.

	Test	Observation
①	Dilute HCl was added to a small portion of X.	No precipitate.
②	H_2S was bubbled through the solution from ① above.	A black precipitate (P_1)
③	P_1 was separated by filtration. The filtrate was boiled to remove the H_2S , cooled, and NH_4Cl/NH_4OH was added.	A green precipitate (P_2)
④	P_2 was separated by filtration and H_2S was bubbled through the filtrate.	A white precipitate (P_3)
⑤	P_3 was separated by filtration. The filtrate was boiled to remove the H_2S , cooled, and $(NH_4)_2CO_3$ was added.	A white precipitate (P_4)

The following tests were carried out on precipitates P_1 , P_2 , P_3 and P_4 .

Precipitate	Test	Observation
P_1	P_1 was dissolved in hot dil. HNO_3 and conc. NH_4OH was added in excess.	A deep blue coloured solution (solution 1)
P_2	* Excess dil. NaOH was added to P_2 followed by H_2O_2 .	A yellow coloured solution (solution 2)
	* Dilute H_2SO_4 was added to solution 2.	An orange coloured solution (solution 3)
P_3	* P_3 was dissolved in dil. HCl and dil. NaOH was added gradually.	A white precipitate (P_5)
	* Addition of dil. NaOH was continued.	P_5 dissolved to give a colourless solution (solution 4)
P_4	P_4 was dissolved in conc. HCl and subjected to the flame test.	A brick-red flame

[see page thirteen]

- (i) Identify the **four** metal cations in solution **X** (**Reasons are not required.**)
- (ii) Identify the precipitates **P₁**, **P₂**, **P₃**, **P₄** and **P₅** and the chemical species responsible for the colours of **solutions 1, 2, 3** and **4**.
- (Note: Write chemical formulae only.)

(75 marks)

- (b) The water sample **Y** contains the anions SO_3^{2-} , SO_4^{2-} and NO_3^- . The following procedures were carried out for the quantitative analysis of the anions present in the water sample.

Procedure 1

To 25.00 cm³ of sample **Y**, an excess of a dilute solution of BaCl₂ was added with stirring. Thereafter, excess dilute HCl was added with stirring to the precipitate formed until there was no further evolution of a gas with pungent odour. The solution was allowed to stand for 10 minutes and filtered. The precipitate was washed with distilled water and dried in an oven at 105 °C until a constant mass was obtained. The mass of the precipitate was 0.174 g. The filtrate obtained was kept for further analysis (see **procedure 3**).

Procedure 2

To 25.00 cm³ of sample **Y**, an excess of dilute H₂SO₄ and acidified 5% KIO₃ solutions were added. The liberated I₂ was immediately titrated with 0.020 mol dm⁻³ Na₂S₂O₃ solution using starch as the indicator. The volume of Na₂S₂O₃ used was 20.00 cm³. (Assume that in this procedure, SO_3^{2-} ions are oxidized to sulphate ions (SO_4^{2-}) without any loss to the atmosphere.)

Procedure 3

The filtrate from **procedure 1** was neutralized with dilute NaOH and to it excess Al powder and dilute NaOH were added. The solution was heated and the gas evolved was transferred quantitatively to react with a 20.00 cm³ volume of 0.11 mol dm⁻³ HCl solution. Completion of the reaction was tested with litmus. The HCl remaining after reacting with the gas evolved was titrated with 0.10 mol dm⁻³ NaOH solution using methyl orange as the indicator. The volume of NaOH required was 10.00 cm³.

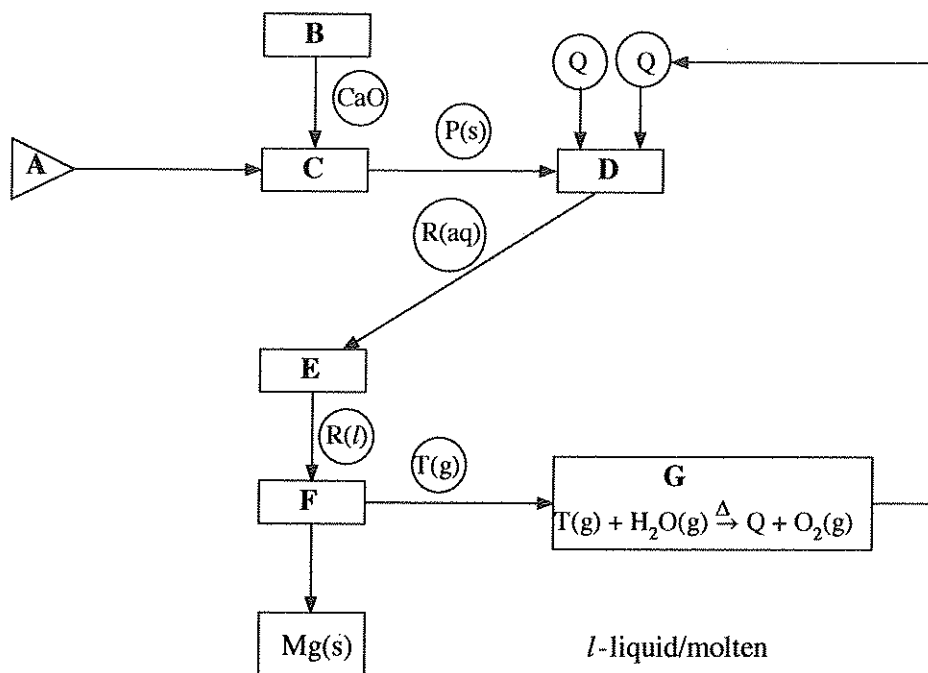
- (i) Write balanced ionic/non-ionic equations for the reactions taking place in **procedures 1, 2 and 3**.
- (ii) Determine the concentrations (mol dm⁻³) of SO_3^{2-} , SO_4^{2-} and NO_3^- in water sample **Y**.
(Ba = 137; S = 32; O = 16)
- (iii) Give colour changes that would be observed in the titrations in **procedures 2 and 3**.

(Note: Assume that other ions that may interfere with the analysis are not present in sample **Y**.)

(75 marks)

[see page fourteen]

10.(a)



The flow chart given above indicates the production of metal magnesium (Mg) using the Dow Process.

Answer the following questions based on the flow chart.

- (i) Identify the starting material **A**.
- (ii) Identify the processes employed at **B**, **C**, **D**, **E**, **F** and **G** from the list below.
evaporation, dissolution, thermal decomposition, electrolysis, recycling of a reagent, precipitation
- (iii) Identify the chemical compound used in **B**.
- (iv) Identify the chemical species **P**, **Q**, **R** and **T**.
- (v) Give balanced chemical equations/half reactions for the processes taking place in **B**, **C**, **D**, and **F**.
(Note: When writing half reactions, identify the anode and cathode where applicable.)
- (vi) State the importance of the reaction occurring in **G**.

(50 marks)

- (b) (i) Consider the industries given below.

Coal power plants
Refrigeration and air conditioning
Transport
Agriculture
Animal farming

- I. All five industries given above contribute to global warming. Identify the gaseous chemical species associated with each of these industries that contribute to global warming.
 - II. State **three** adverse climate changes that could occur due to global warming.
- (ii) Identify the main industry/industries given in (i) above that contribute to
- I. photochemical smog,
 - II. acid rain,
 - III. eutrophication.

[see page fifteen]

- (iii) Due to the reduction in rainfall in Sri Lanka, inducing artificial rain has been tested near catchment areas of reservoirs that are used for hydro-power generation. In this process, fine particles of hygroscopic salts (NaCl , CaCl_2 , NaBr) are sprayed to induce cloud formation by condensation of water vapour.

From the list given below, select the water quality parameters that are directly

I. affected

II. unaffected

due to salts entering water around catchment areas. Give reasons for your choice briefly.

List of water quality parameters:

pH, conductivity, turbidity, dissolved oxygen

(50 marks)

- (c) The following questions are based on biodiesel production.

(i) State the raw materials used in the manufacture of biodiesel.

(ii) Name the main chemical compound present in each raw material where applicable.

(iii) State the name of the chemical compound used as the catalyst in the manufacture of biodiesel in the school laboratory.

(iv) Give a balanced chemical equation to show the synthesis of biodiesel using the chemical compounds stated in part (ii) above.

(v) Identify a side reaction that would take place, along with its products, if the catalyst is used in excess.

(50 marks)

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[see page sixteen

The Periodic Table

1	1 H																2 He	
2	3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La- Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac- Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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