

ශ්‍රී ලංකා රිජය දෙපාර්තමේන්තුව සියලු ත්‍රිත්‍ය අංශය/පුද්‍ර ප්‍රතිඵ්‍යාමය  
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ශ්‍රී ලංකා රිජය දෙපාර්තමේන්තුව සියලු ත්‍රිත්‍ය අංශය/පුද්‍ර ප්‍රතිඵ්‍යාමය Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka

### ඉංගෝ ටියාග දෙපාර්තමේන්තුව

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අධ්‍යාපක පොදු ප්‍රාග්‍රැන්ඩ් ත්‍රිත්‍ය අංශය/පුද්‍ර ප්‍රතිඵ්‍යාමය

General Certificate of Education (Adv. Level) Examination, 2022(2023)

රිසායන විද්‍යාව I  
උග්‍රාම්‍ය විද්‍යාව I  
Chemistry I

02 E I

පැය දෙකකි  
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  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

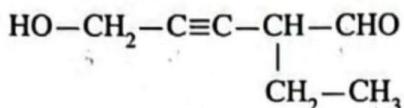
Avogadro constant  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Planck's constant  $h = 6.626 \times 10^{-34} \text{ J s}$

Velocity of light  $c = 3 \times 10^8 \text{ m s}^{-1}$

1. Which of the following electronic transitions belongs to the visible region of the line spectrum of atomic hydrogen? ( $n$  = Principal quantum number)
  - (1)  $n = 5 \rightarrow n = 3$
  - (2)  $n = 4 \rightarrow n = 2$
  - (3)  $n = 1 \rightarrow n = 2$
  - (4)  $n = 3 \rightarrow n = 1$
  - (5)  $n = 2 \rightarrow n = 1$
2. Select the incorrect statement.
  - (1) Pauli exclusion principle excludes the possibility of the presence of a third electron in an orbital.
  - (2) In a potassium atom, the number of electrons having quantum numbers  $n$  (principal quantum number) = 3 and  $m_l$  (magnetic quantum number) = 0 is 4.
  - (3) The effective nuclear charge felt by a valence electron in nitrogen (N), is greater than the effective nuclear charge felt by a valence electron in carbon (C).
  - (4) Among the ions  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$  and  $\text{Ca}^{2+}$ , the two ions closest to each other in size are  $\text{K}^+$  and  $\text{Mg}^{2+}$ .
  - (5) Electron gain energy of carbon is negative.
3. The increasing order of the second ionization energy ( $\text{X}^+(\text{g}) \rightarrow \text{X}^{2+}(\text{g}) + \text{e}^-$ ) of Be, B and O is,
  - (1)  $\text{Be} < \text{B} < \text{O}$
  - (2)  $\text{Be} < \text{O} < \text{B}$
  - (3)  $\text{B} < \text{O} < \text{Be}$
  - (4)  $\text{B} < \text{Be} < \text{O}$
  - (5)  $\text{O} < \text{Be} < \text{B}$
4. The shapes of  $\text{F}_3\text{ClO}$ ,  $\text{FClO}_2$  and  $\text{FClO}_3$  are respectively,
  - (1) tetrahedral, trigonal planar and see-saw.
  - (2) square planar, trigonal planar and tetrahedral.
  - (3) see-saw, trigonal pyramidal and square planar.
  - (4) tetrahedral, trigonal pyramidal and see-saw.
  - (5) see-saw, trigonal pyramidal and tetrahedral.

5. What is the IUPAC name of the following compound?



- (1) 5-hydroxy-2-ethylpent-3-yneal
- (2) 3-formylhex-4-yn-6-ol
- (3) 2-ethyl-5-hydroxypent-3-yneal
- (4) 4-formyl-1-hydroxy-2-hexyne
- (5) 4-formylhex-2-yn-1-ol

6. A saturated aqueous solution of a sparingly soluble salt  $\text{AB}_2$  was prepared at  $25^\circ\text{C}$ . Solubility product of  $\text{AB}_2$  at  $25^\circ\text{C}$  is  $3.20 \times 10^{-8} \text{ mol}^3 \text{ dm}^{-9}$ . The concentration of ion  $\text{B}^-$  ( $\text{mol dm}^{-3}$ ) in the saturated solution is,

- (1)  $(1.6)^{\frac{1}{2}} \times 10^{-4}$
- (2)  $(3.2)^{\frac{1}{2}} \times 10^{-4}$
- (3)  $(3.2)^{\frac{1}{3}} \times 10^{-3}$
- (4)  $2.0 \times 10^{-3}$
- (5)  $4.0 \times 10^{-3}$

7. Select the correct statement.

- (1) The polarizability of  $\text{F}^-$ ,  $\text{Cl}^-$  and  $\text{S}^{2-}$  ions increases in the order  $\text{F}^- < \text{S}^{2-} < \text{Cl}^-$ .
- (2) The polarizing power of  $\text{Li}^+$ ,  $\text{Na}^+$  and  $\text{Mg}^{2+}$  decreases in the order  $\text{Mg}^{2+} > \text{Na}^+ > \text{Li}^+$ .
- (3) The electronegativity of O, F, Cl and S decreases in the order  $\text{F} > \text{O} > \text{S} > \text{Cl}$ .
- (4) The boiling points of Xe,  $\text{CH}_4$ ,  $\text{CH}_3\text{NH}_2$  and  $\text{CH}_3\text{OH}$  increase in the order  $\text{CH}_4 < \text{Xe} < \text{CH}_3\text{NH}_2 < \text{CH}_3\text{OH}$ .
- (5) The interatomic bond distances of  $\text{N}_2$ ,  $\text{O}_2$ ,  $\text{F}_2$  and HF increase in the order  $\text{N}_2 < \text{O}_2 < \text{F}_2 < \text{HF}$ .

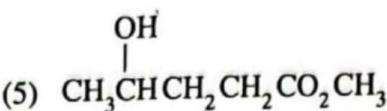
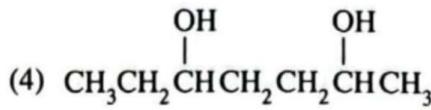
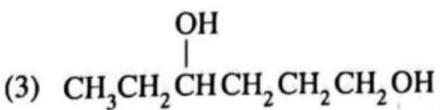
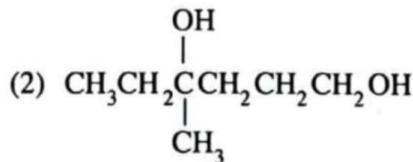
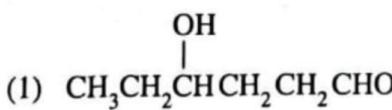
8. Compounds **P** and **Q** are diastereoisomers of each other. Which of the following could be the molecular formula of compounds **P** and **Q**?

- (1)  $\text{C}_5\text{H}_{10}$
- (2)  $\text{C}_3\text{H}_6$
- (3)  $\text{C}_4\text{H}_6$
- (4)  $\text{C}_4\text{H}_{10}\text{O}$
- (5)  $\text{C}_4\text{H}_{10}$

9. The increasing order of electronegativity of the carbon (C) atom in  $\text{CH}_4$ ,  $\text{CH}_3\text{Cl}$ ,  $\text{H}_2\text{CO}$ , HCN and  $\text{NCO}^-$  is

- (1)  $\text{CH}_4 < \text{H}_2\text{CO} < \text{CH}_3\text{Cl} < \text{HCN} < \text{NCO}^-$
- (2)  $\text{CH}_3\text{Cl} < \text{CH}_4 < \text{H}_2\text{CO} < \text{HCN} < \text{NCO}^-$
- (3)  $\text{CH}_4 < \text{CH}_3\text{Cl} < \text{H}_2\text{CO} < \text{HCN} < \text{NCO}^-$
- (4)  $\text{CH}_4 < \text{CH}_3\text{Cl} < \text{NCO}^- < \text{H}_2\text{CO} < \text{HCN}$
- (5)  $\text{NCO}^- < \text{HCN} < \text{H}_2\text{CO} < \text{CH}_4 < \text{CH}_3\text{Cl}$

10. The organic compound **X** does not give a coloured precipitate when treated with 2,4-DNP. When compound **X** is treated with acidic  $\text{K}_2\text{Cr}_2\text{O}_7$  product **Y** is formed. The product **Y** gives a coloured precipitate with 2,4-DNP. **Y** liberates  $\text{CO}_2$  when treated with aqueous  $\text{Na}_2\text{CO}_3$  solution. Compound **X** could be,



11. Consider the following equilibrium that exists in a closed rigid container at 500 K.



Which of the following describes/explains the effect on the equilibrium constant  $K_p$  when the temperature is increased to 750 K?

- (1)  $K_p$  does not change because the pressure does not change.
- (2)  $K_p$  will increase because the activation energy of the forward reaction is decreased.
- (3)  $K_p$  does not change because the number of reactant molecules and the number of product molecules are equal to each other.
- (4)  $K_p$  will decrease because the backward reaction is endothermic which favours the forward reaction.
- (5)  $K_p$  will decrease because the forward reaction is exothermic which favours the backward reaction.

12. The details of an initial rate measuring experiment carried out for the reaction  $X(aq) + Y(aq) \rightarrow Z(aq)$  at a given temperature are given in the table below.

Experiment	$[X(aq)]_0/\text{mol dm}^{-3}$	$[Y(aq)]_0/\text{mol dm}^{-3}$	Initial rate/ $\text{mol dm}^{-3} \text{s}^{-1}$
①	0.40	0.10	R
②	0.20	0.20	?

The initial rate of formation of  $Z(aq)$  in experiment ① is R. The reaction is first order with respect to  $X(aq)$  and second order with respect to  $Y(aq)$ . The initial rate of formation of  $Z(aq)$  in experiment ② is,

- (1)  $\frac{R}{4}$
- (2)  $\frac{R}{2}$
- (3) R
- (4) 2R
- (5) 4R

13. A 0.4314 g sample of pure iron(II) oxalate ( $\text{FeC}_2\text{O}_4$ ) was dissolved in excess dilute  $\text{H}_2\text{SO}_4$ . The entire solution was titrated with 0.060 mol  $\text{dm}^{-3}$   $\text{KMnO}_4$  solution. The burette reading at the end point is (relative molecular mass of  $\text{FeC}_2\text{O}_4 = 143.8$ )

- (1) 20.00  $\text{cm}^3$
- (2) 25.00  $\text{cm}^3$
- (3) 30.00  $\text{cm}^3$
- (4) 40.00  $\text{cm}^3$
- (5) 50.00  $\text{cm}^3$

14. At a given temperature a certain number of moles of  $\text{H}_2\text{S(g)}$  was inserted into an evacuated 1.0  $\text{dm}^3$  closed rigid container and the system was allowed to reach the equilibrium shown below.



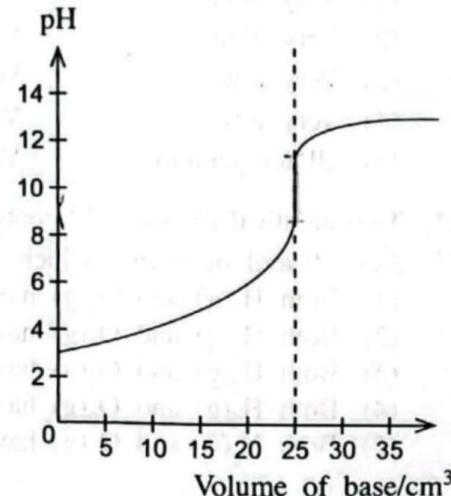
At equilibrium, it was found that a fraction  $x$  of  $\text{H}_2\text{S(g)}$  has dissociated. At equilibrium the total pressure in the container was  $P$ . Which of the following gives the equilibrium constant  $K_p$  of the system?

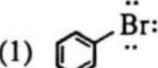
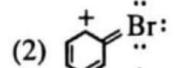
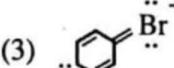
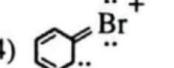
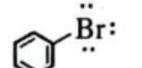
- |                                  |                                  |                                  |
|----------------------------------|----------------------------------|----------------------------------|
| (1) $\frac{x^2 P}{(2+x)(1-x)^2}$ | (2) $\frac{(2+x)(1-x)^2 P}{x^3}$ | (3) $\frac{x^3 P}{(2+x)(1-x)^2}$ |
| (4) $\frac{(1-x)P}{x^2(1-x)^2}$  | (5) $\frac{(2+x)(1-x)^2}{x^3 P}$ |                                  |

15. The pH curve obtained for a titration of 25.00  $\text{cm}^3$  of 0.10 mol  $\text{dm}^{-3}$  unknown acid with 0.10 mol  $\text{dm}^{-3}$  unknown base at a given temperature is shown on the right.

Which of the following is most appropriate regarding the acid and base used in this titration?

- (1) Mono-basic strong acid with a mono-protic strong base
- (2) Mono-basic strong acid with a mono-protic weak base
- (3) Di-basic strong acid with a mono-protic strong base
- (4) Mono-basic weak acid with a mono-protic weak base
- (5) Mono-basic weak acid with a mono-protic strong base

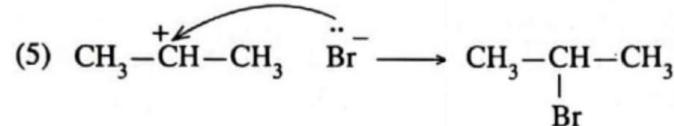
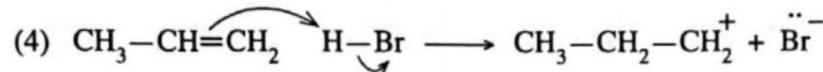
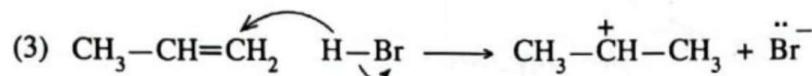
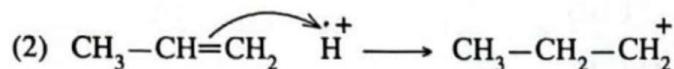
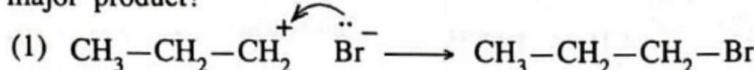


16. Which of the following statements is **false** with regard to the elements in the s and p blocks?
- Although xenon (Xe) is an inert gas, it forms compounds with oxidation numbers +2, +4 and +6.
  - Among the hydrogen halides, HF has the highest bond dissociation energy.
  - The solubility of the hydroxides of Group two (II) elements in water decreases on descending the group, while the solubility of their sulfates increases.
  - Among the Group one (I) metals (Li to Cs) cesium has the lowest melting point.
  - The oxidation number of nitrogen in  $\text{NH}_2\text{OH}$  is -1.
17. At  $25^\circ\text{C}$ , to  $V_1 \text{ cm}^3$  of  $x \text{ mol dm}^{-3}$   $\text{CH}_3\text{COOH(aq)}$  solution in a beaker,  $V_2 \text{ cm}^3$  ( $V_2 > V_1$ ) of  $y \text{ mol dm}^{-3}$  ( $y > x$ )  $\text{NaOH(aq)}$  solution was added. The pH of the final mixture is, ( $K_w$  is the dissociation constant of water at  $25^\circ\text{C}$ )
- $\text{p}K_w - \log \left\{ \frac{V_2y - V_1x}{V_1 + V_2} \right\}$
  - $\text{p}K_w + \log \left\{ \frac{V_2y - V_1x}{V_1 + V_2} \right\}$
  - $\text{p}K_w$
  - $-\text{p}K_w - \log \left\{ \frac{V_2y - V_1x}{V_1 + V_2} \right\}$
  - $-\text{p}K_w + \log \left\{ \frac{V_2y - V_1x}{V_1 + V_2} \right\}$
18. Which of the following statements is **incorrect** with regard to the reaction given below under standard conditions?
- $$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) : \Delta H^\circ = -483.7 \text{ kJ mol}^{-1}$$
- For one mole of reaction 483.7 kJ heat energy is evolved.
  - For two moles of  $\text{H}_2(\text{g})$  consumed, 483.7 kJ heat energy is evolved.
  - For two moles of  $\text{H}_2\text{O}(\text{g})$  produced, 483.7 kJ heat energy is evolved.
  - For the reaction  $4\text{H}_2(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 4\text{H}_2\text{O}(\text{g})$ , 967.4 kJ heat energy is evolved.
  - For one mole of  $\text{O}_2(\text{g})$  consumed, 241.85 kJ heat energy is evolved.
19. Which of the following statements is **incorrect** with regard to a galvanic cell?
- Cell reaction is spontaneous.
  - Cell produces electrical energy.
  - Cathode is negatively charged.
  - Reduction half-reaction occurs at the cathode.
  - Oxidation half-reaction occurs at the anode.
20. Which of the following is **not** a resonance structure of bromobenzene?
- 
  - 
  - 
  - 
  - 
21. Under which of the following conditions of temperature and pressure, would a real gas tend to behave as an ideal gas?
- | Temperature          | Pressure  |
|----------------------|-----------|
| (1) Very high        | Very high |
| (2) Very high        | Very low  |
| (3) Very low         | Very high |
| (4) Very low         | Very low  |
| (5) all temperatures | Very low  |
22. Two identical closed rigid containers at standard temperature and pressure contain 1.0 mol of  $\text{H}_2(\text{g})$  and 2.0 mol of  $\text{O}_2(\text{g})$ . Which of the following is true of the above two systems?
- Both  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have the same average kinetic energy.
  - Both  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have the same average speed.
  - Both  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have the same mass.
  - Both  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have the same density.
  - Both  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have the same effusion rate.

23. At 25 °C the molar entropy change of dissolution  $\Delta S_{\text{dissol}}^{\circ}$  of the solid X(s) is 70 J K<sup>-1</sup> mol<sup>-1</sup>, and the molar entropy of X(s) is 100 J K<sup>-1</sup> mol<sup>-1</sup>. Which of the following gives the molar entropy (J K<sup>-1</sup> mol<sup>-1</sup>) of X(aq)?

(1) -170      (2) -30      (3) 0      (4) +30      (5) +170

24. Consider the major product of the electrophilic addition reaction between CH<sub>3</sub>-CH=CH<sub>2</sub> and HBr. Which of the following shows a correct step in the mechanism of the reaction which gives the major product?



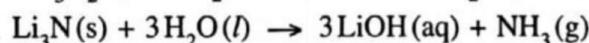
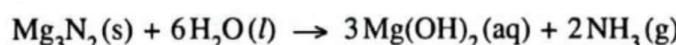
25. Consider a gaseous equilibrium reaction at constant temperature taking place in a closed system. When doubling the pressure and volume of the system the equilibrium constant of the system,

(1) becomes one-fourth ( $\frac{1}{4}$ ).      (2) becomes halved ( $\frac{1}{2}$ ).

(3) remains the same.      (4) becomes doubled.

(5) becomes four times.

26. Magnesium nitride and lithium nitride react with water according to the following equations.



A mixture containing three moles of magnesium metal and an unknown amount of lithium metal was reacted completely with excess N<sub>2</sub> gas. When the product mixture resulting from this reaction was completely reacted with excess water, 44.2 g of NH<sub>3</sub> gas was produced. The mass of lithium in the metal mixture is,

(H = 1, Li = 7, N = 14, Mg = 24)

(1) 1.8 g      (2) 4.2 g      (3) 12.6 g      (4) 14.2 g      (5) 20.2 g

27. Ammonia can be synthesized at high temperatures as shown by the following unbalanced chemical equation.

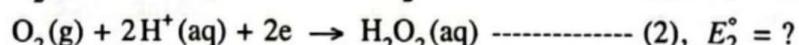
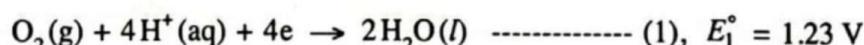


The maximum amount of NH<sub>3</sub> in grams that can be synthesized from 45.0 g of NO and 12.0 g of H<sub>2</sub> is

(Relative molecular mass: H<sub>2</sub> = 2, NO = 30, NH<sub>3</sub> = 17)

(1) 2.4      (2) 4.8      (3) 12.8      (4) 25.5      (5) 40.8

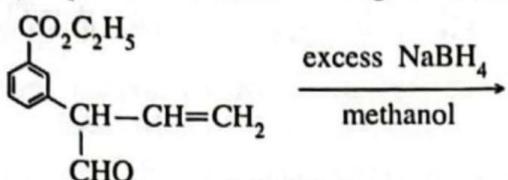
28. At a temperature of 25 °C, the  $E_{\text{cell}}^{\circ}$  of the reaction  $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$  occurring in an electrochemical cell is +0.55 V while the half-reactions of this process are,

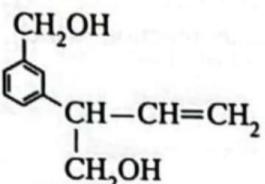
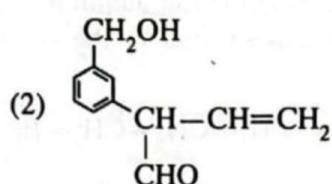
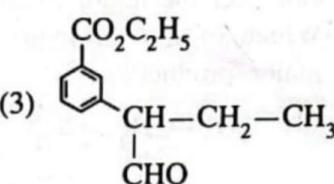
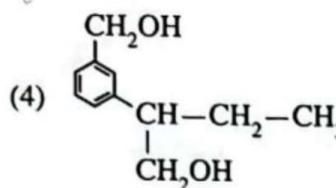
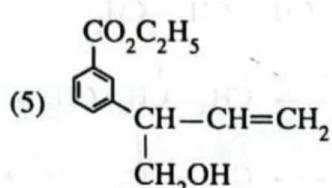


The standard reduction potential  $E_2^{\circ}$  of reaction (2) is

(1) -1.78 V      (2) -0.68 V      (3) 0.00 V      (4) +0.68 V      (5) +1.78 V

29. What could be the major product of the following reaction?



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

30. Consider the reaction  $3\text{O}_2(\text{g}) \rightleftharpoons 2\text{O}_3(\text{g})$ , ( $K_C = 2.0 \times 10^{-56} \text{ mol}^{-1} \text{ dm}^3$ ) at temperature  $25^\circ\text{C}$ .  $\text{O}_2(\text{g})$  0.30 mol and  $\text{O}_3(\text{g})$  0.005 mol were inserted into an evacuated closed rigid  $1.0 \text{ dm}^3$  container at  $25^\circ\text{C}$  and the system was allowed to reach the equilibrium above. Which of the following best describes the system approaching equilibrium at  $25^\circ\text{C}$ ?

( $Q_C$  is the reaction quotient)

- (1) The amount of  $\text{O}_3(\text{g})$  increases to reach the equilibrium because  $Q_C < K_C$   
 (2) The amount of  $\text{O}_3(\text{g})$  decreases to reach the equilibrium because  $Q_C < K_C$   
 (3) The amount of  $\text{O}_3(\text{g})$  decreases to reach the equilibrium because  $Q_C > K_C$   
 (4) The amount of  $\text{O}_3(\text{g})$  increases to reach the equilibrium because  $Q_C > K_C$   
 (5) The amount of  $\text{O}_3(\text{g})$  does not change because  $Q_C = K_C$

- 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

- if only (a) and (b) are correct.
- if only (b) and (c) are correct.
- if only (c) and (d) are correct.
- if only (d) and (a) are correct.
- if any other number or combination of responses is correct.

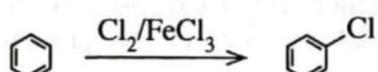
#### Summary of above Instructions

(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

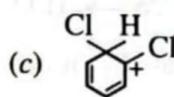
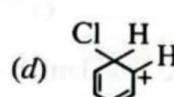
31. For a given chemical reaction, which of the following is/are affected by the temperature?

- (a) Collision frequency of reactant molecules      (b) Kinetic energy of colliding molecules  
 (c) Standard enthalpy change of the reaction at  $25^\circ\text{C}$     (d) Activation energy of the reaction

32. Consider the mechanism of the following reaction.



Which of the following ions is/are formed while this reaction is taking place?

- (a)  $\bar{\text{FeCl}}_4$       (b)  $\text{Fe}^{+}\text{Cl}_4^-$  
- (c)       (d) 

33. At 25 °C, a 1.0 dm<sup>3</sup> aqueous solution of lead iodide ( $\text{PbI}_2$ ) in equilibrium with an excess of solid lead iodide contains  $a$  mol of  $\text{Pb}^{2+}(\text{aq})$  ions. Which of the following is/are correct for this system?
- (a) The amount of  $\text{Pb}^{2+}(\text{aq})$  will be  $2a$  mol when the volume is doubled.
  - (b) The concentration of  $\text{Pb}^{2+}(\text{aq})$  will be  $2a$  mol dm<sup>-3</sup> when the volume is doubled.
  - (c) The amount of  $\text{Pb}^{2+}(\text{aq})$  will decrease when a small amount of solid  $\text{NaI(s)}$  is added.
  - (d) The amount of  $\text{Pb}^{2+}(\text{aq})$  will be  $\frac{a}{2}$  mol when the volume is doubled.
34. Which of the following statements is/are correct with regard to the compounds/ions formed by  $d$  block elements that belong to the fourth period?
- (a)  $\text{Cr}_2\text{O}_3$  is expected to react with strong acids and strong bases.
  - (b) When  $\text{NaOH(aq)}$  is added to solutions containing  $\text{Fe}^{2+}(\text{aq})$ ,  $\text{Fe}^{3+}(\text{aq})$ ,  $\text{Mn}^{2+}(\text{aq})$  and  $\text{Ni}^{2+}(\text{aq})$  precipitates which are insoluble in excess  $\text{NaOH(aq)}$  are formed.
  - (c) Both  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  are strong oxidizing agents capable of converting  $\text{H}_2\text{O}_2$  to  $\text{O}_2$  gas under acidic conditions.
  - (d) The IUPAC name of  $[\text{CuCl}_4]^{2-}$  is tetrachlorocuprate(II) ion.
35. Which of the following statements is/are correct?
- (a) The boiling point of propanoic acid is higher than that of 1-butanol.
  - (b) The boiling point of pentane is higher than that of 2-methylbutane.
  - (c) The boiling point of butanal is higher than that of 1-butanol.
  - (d) The boiling point of hexane is higher than that of 1-pentanol.
36. Which of the following statements is/are correct with regard to nitric acid ( $\text{HNO}_3$ ) and its salts?
- (a) Both dilute and concentrated  $\text{HNO}_3$  act as oxidizing agents.
  - (b) Thermal decomposition of  $\text{NH}_4\text{NO}_3$  gives  $\text{N}_2\text{O}$  and water.
  - (c) N—O bonds of  $\text{HNO}_3$  are all equal in length.
  - (d) Carbon does not react with concentrated  $\text{HNO}_3$  even when heated.
37. Which of the following statements is/are correct regarding the ozone layer?
- (a) It is a region in the upper atmosphere (stratosphere) where only ozone is present.
  - (b) It is a region in the atmosphere where atomic oxygen is abundant.
  - (c) It is a region that prevents ultra-violet radiation that is emitted from the sun from reaching the earth surface.
  - (d) It is a region where ozone breakdown only occurs via a chlorine free radical mechanism.
38. A 100.00 cm<sup>3</sup> volume of 0.135 mol dm<sup>-3</sup> aqueous solution of methylamine ( $\text{CH}_3\text{NH}_2$ ) was shaken thoroughly with 75.00 cm<sup>3</sup> of water immiscible organic solvent in a closed bottle at 25 °C, and allowed to reach equilibrium. When 50.00 cm<sup>3</sup> of the aqueous layer was titrated with 0.200 mol dm<sup>-3</sup> HCl solution, the end-point was 15.00 cm<sup>3</sup>. No reaction occurs between methylamine and organic solvent. Which of the following is/are correct?
- (a) Partition coefficient  $K_D$  of  $\text{CH}_3\text{NH}_2$  between organic and aqueous layers is 1.67.
  - (b) Partition coefficient  $K_D$  of  $\text{CH}_3\text{NH}_2$  between organic and aqueous layers is 4.67.
  - (c)  $\text{CH}_3\text{NH}_2$  is more soluble in the aqueous layer.
  - (d)  $\text{CH}_3\text{NH}_2$  is more soluble in the organic layer.
39. Which of the following statements is/are correct with regard to dissolved oxygen level of water in water bodies.
- (a) Composition of dissolved oxygen in water is the same as that of atmospheric oxygen.
  - (b) Dissolved oxygen level in water decreases due to eutrophication.
  - (c)  $\text{H}_2\text{S}$  could be produced in water when the dissolved oxygen level in water is high.
  - (d) Aquatic plants contribute to the dissolved oxygen level in water via photosynthesis.

40. Which of the following statements is/are correct regarding the given industrial processes?
- Coke, a raw material used in the extraction of iron by the Blast Furnace, functions only as a reducing agent.
  - A raw material used in the extraction of magnesium (Dow Process) can be regenerated utilizing a by-product formed during the electrolysis step.
  - In the manufacture of high purity  $\text{TiO}_2$  using rutile, inorganic impurities are removed in the chlorination step.
  - The manufacture of nitric acid using Ostwald method uses Fe as the catalyst.
- 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.	The decreasing order of the acid strengths of oxoacids of chlorine is $\text{HClO}_4 > \text{HClO}_3 > \text{HClO}_2 > \text{HOCl}$	When the oxidation number of the chlorine atom in the oxoacids of chlorine increases, the acidity of the oxoacid increases.
42.	When $\text{H}_2\text{S}$ gas reacts with an acidic solution of $\text{K}_2\text{Cr}_2\text{O}_7$ , elemental sulphur is formed.	$\text{H}_2\text{S}$ gas can act as a reducing agent in acidic medium.
43.	An electrochemical cell based on the reaction $\text{Cl}_2(\text{g}) + 2\text{I}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{I}_2(\text{s})$ can be used to generate electricity.	$\text{Cl}_2(\text{g})$ is a stronger reducing agent than $\text{I}_2(\text{s})$ .
44.	Grignard reagents react with water to give alcohols.	The carbon atom of the carbon-magnesium bond in a Grignard reagent has a partial negative charge.
45.	While diazonium salts formed from aniline are stable at low temperatures ( $0\text{--}5^\circ\text{C}$ ), diazonium salts formed from primary aliphatic amines are unstable at these temperatures.	The lone pair of electrons on the nitrogen atom of aniline is delocalized on the benzene ring.
46.	The enthalpy change would be zero when an ideal binary liquid mixture is formed by two completely miscible liquids at a given temperature.	At a given temperature, all intermolecular forces that exist in an ideal binary liquid mixture are equal.
47.	When a pH value of 6.5 is reported in rain water, it is considered as acid rain.	Lowering of pH to below 7 in rain water occurs only due to the dissolution of the acidic gases $\text{SO}_3$ and $\text{NO}_2$ .
48.	At a given temperature, the half-life $t_{1/2}$ of a first order reaction is given by the equation $t_{1/2} = 0.693/k$ where $k$ is the first order rate constant.	In a first order reaction with $t_{1/2} = 50\text{ s}$ , 87.5% of the reaction is completed after 150 s.
49.	In the manufacture of $\text{NH}_3$ gas by the Haber-Bosch process temperatures higher than $600^\circ\text{C}$ are used.	The activation energy of $\text{NH}_3$ gas producing equilibrium reaction in the Haber-Bosch process decreases with increasing temperature.
50.	Bakelite is classified as an addition polymer.	Bakelite has a three dimensional network structure.

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ඩීප්‍රේ රෝග උපයාධිත්වය සහ නො ඇඟන්සුල් මුද්‍රාව පත්වා තිබූ හැකියාවනු ලබයි  
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Department of Examinations, Sri Lanka Department of Examination, Sri Lanka Department of Examination, Sri Lanka  
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කළමනීප පොතුන් තුරාතුරු පත්තිර (ඉයුර තු)ප ප්‍රශ්න, 2022 (2023)  
General Certificate of Education (Adv. Level) Examination, 2022 (2023)

රෝගන විද්‍යාව II  
උරුසායෙන්සියාල් II  
Chemistry II

02 E II

උග්‍ර තුව සෑවනය  
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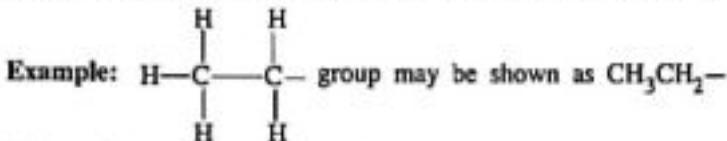
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Three hours

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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 15.
- \* 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 02 - 08)

- \* 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 09 - 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 :	

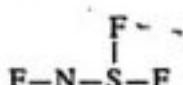
**PART A — STRUCTURED ESSAY***Answer all four questions on this paper itself. (Each question carries 100 marks.)*Do not  
write  
in this  
column.

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

- (i) The Lyman series observed in the emission spectrum of atomic hydrogen lies in the ultra-violet region of the electromagnetic spectrum. ....
- (ii) There are only 10 electrons in a calcium atom with the azimuthal quantum number  $l=0$ . ....
- (iii) The number of Lewis dot-dash structures (resonance structures) that can be drawn for the  $\text{N}_2\text{O}$  molecule is 3. ....
- (iv) Among the second row elements of the Periodic Table, fluorine has the largest negative value of electron gain energy. ....
- (v) The boiling point of argon ( $\text{Ar}$ ) is higher than that of chlorine ( $\text{Cl}_2$ ). ....
- (vi) Ne has the highest first ionization energy, among the noble gases He, Ne and Ar. ....

(24 marks)

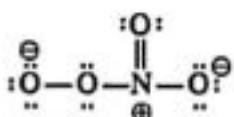
- (b) (i) The skeleton of a molecule containing only the elements N, F and S is given below. Draw the most acceptable Lewis dot-dash structure for this molecule.



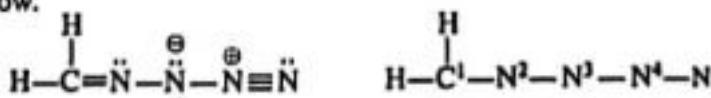
- (ii) Give, (I) shapes around the N and S atoms and (II) oxidation numbers of the atoms in the structure drawn in (i) above.

- (I) N ..... , S ..... (shape)
- (II) N ..... , S ..... (oxidation number)

- (iii) A Lewis dot-dash structure for the  $\text{NO}_4^-$  ion is given below. Draw three more Lewis dot-dash structures (resonance structures) for the  $\text{NO}_4^-$  ion .



- (iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.



	$\text{C}^1$	$\text{N}^2$	$\text{N}^3$	$\text{N}^4$
I. the number of VSEPR pairs around the atom				
II. electron pair geometry around the atom				
III. shape around the atom				
IV. hybridization of the atom				

Do not  
write  
in this  
column.

- Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

- (v) Identify the atomic/hybrid orbitals involved in the formation of  $\sigma$  bonds between the two atoms given below.

I.	$\text{H}-\text{C}^1$	$\text{H}$ .....	$\text{C}^1$ .....
II.	$\text{C}^1-\text{N}^2$	$\text{C}^1$ .....	$\text{N}^2$ .....
III.	$\text{N}^2-\text{N}^3$	$\text{N}^2$ .....	$\text{N}^3$ .....
IV.	$\text{N}^3-\text{N}^4$	$\text{N}^3$ .....	$\text{N}^4$ .....
V.	$\text{N}^4-\text{N}$	$\text{N}^4$ .....	$\text{N}$ .....

- (vi) Identify the atomic orbitals involved in the formation of  $\pi$  bonds between the atoms given below.

I.	$\text{C}^1-\text{N}^2$	$\text{C}^1$ .....	$\text{N}^2$ .....
II.	$\text{N}^4-\text{N}$	$\text{N}^4$ .....	$\text{N}$ .....
		$\text{N}^4$ .....	$\text{N}$ .....

- (vii) State the approximate bond angles around  $\text{C}^1$ ,  $\text{N}^2$ ,  $\text{N}^3$  and  $\text{N}^4$  atoms.

$\text{C}^1$ .....,     $\text{N}^2$ .....,     $\text{N}^3$ .....,     $\text{N}^4$ .....

- (viii) Arrange the atoms  $\text{N}^2$ ,  $\text{N}^3$  and  $\text{N}^4$  in the increasing order of their electronegativity.

..... < ..... < ..... (56 marks)

- (c) Arrange the following species in the increasing order of the property indicated in parentheses. Reasons are not required.

- (i)  $\text{CaF}_2$ ,  $\text{CaCl}_2$ ,  $\text{CaBr}_2$ ,  $\text{CaI}_2$  (ionic character)

..... < ..... < ..... < .....

- (ii)  $\text{ClF}_5$ ,  $\text{ClF}_2^+$ ,  $\text{ClF}_2^-$  (bond angle)

..... < ..... < .....

- (iii)  $\text{Na}^+$ ,  $\text{S}^{2-}$ ,  $\text{Cl}^-$ ,  $\text{K}^+$  (ionic radius)

..... < ..... < ..... < .....

- (iv)  $\text{CO}$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_2^-$ ,  $\text{H}_2\text{CO}$ ,  $\text{CH}_3\text{OH}$  (C—O bond length)

..... < ..... < ..... < ..... < .....

- (v)  $\text{Li}$ ,  $\text{N}$ ,  $\text{F}$ ,  $\text{Mg}$ ,  $\text{P}$  (first ionization energy)

..... < ..... < ..... < ..... < .....

(20 marks)

100

2. (a) The questions (i), (ii) and (iii) are based on the following reactions.

A is an ionic compound composed of three elements in the ratio 1:4:1 (Not in order of the chemical formula). One of these is a d-block element that belongs to the fourth period of the Periodic Table. When A is subjected to the flame test, a lilac (purple) flame is observed. On dissolving A in water, a purple coloured solution is obtained.

B is also an ionic compound composed of the same three elements as in A. B dissolves in water to give a green coloured solution.

C is a viscous colourless liquid composed of two elements. It disproportionates to give another colourless liquid D as one of the products. C can act as an oxidizing agent as well as a reducing agent. When C is added to a solution of B, the brown precipitate E is obtained.

F is a compound composed of three elements. One of these elements is a 3d element found in hematite. When  $\text{BaCl}_2(\text{aq})$  is added to an aqueous solution of F, the white precipitate G that is insoluble in dil.  $\text{H}_2\text{SO}_4$  is formed.

H is composed of three elements. When an aqueous solution of H in a test tube is treated with a saturated solution of F, followed by addition of a small volume of conc.  $\text{H}_2\text{SO}_4$  slowly, along the wall of the test tube, a brown colouration is seen on the surface where the liquids meet. The species responsible for the brown colouration is I. Brown fumes are not evolved when dil.  $\text{H}_2\text{SO}_4$  is added to H. When H is subjected to the flame test, a yellow flame is observed.

J is the sodium salt of a weak dibasic acid. On treatment of a solution of J with  $\text{CaCl}_2(\text{aq})$ , the white precipitate K is formed. K reacts with dil.  $\text{H}_2\text{SO}_4$  to give the weak dibasic acid L as one of the products. A warm solution of J acidified with dil.  $\text{H}_2\text{SO}_4$  decolorizes an aqueous solution of A.

(i) Identify A to L. Note: Write the chemical formulae.

A .....

G .....

B .....

H .....

C .....

I .....

D .....

J .....

E .....

K .....

F .....

L .....

(ii) Give balanced chemical equations for the following (physical states not required).

I. Formation of D from C.

II. Formation of I.

III. Formation of K.

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column.

(iii) Give balanced ionic equations for the reactions that take place when A is added to the following solutions (physical states not required).

I. an acidified solution of C

II. an aqueous solution of F acidified with dil.  $H_2SO_4$

III. an acidified solution of J

(20 marks)

(b) Give balanced chemical equations for the reactions that take place between the following (physical states not required). State the function (oxidizing agent/reducing agent) of  $H_2S$  and  $SO_2$  in reactions (i)-(iii).

(i) Mg(s) and  $H_2S(g)$  .....

$H_2S$ : .....

(ii) Mg(s) and  $SO_2(g)$  .....

$SO_2$ : .....

(iii)  $H_2S(g)$  and  $SO_2(g)$  .....

$H_2S$ : .....,  $SO_2$ : .....

(iv) S(s) and conc.  $HNO_3(aq)$  .....

100

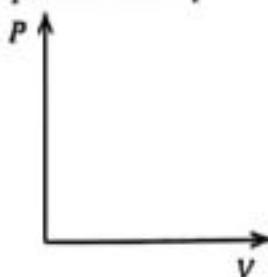
(20 marks)

3. (a) (i) A closed container equipped with a piston contains a given mass of an ideal gas at a constant temperature  $T$ . Give the relationship between pressure  $P$  and volume  $V$  of the gas using a mathematical expression.

(ii) Show that the density  $d$  of the ideal gas in (i) above, at a constant temperature  $T$  is directly proportional to the pressure  $P$ .

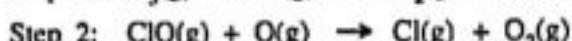
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- (iii) Show the variation of  $P$  with  $V$  of the system in (i) above at the two different temperatures of 300 K and 500 K, by drawing two graphs in the figure given below. Indicate clearly the temperature corresponding to each graph.



(30 marks)

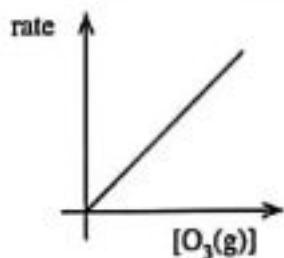
- (b) Depletion of  $O_3(g)$  occurs according to the mechanism given below in the presence of  $Cl(g)$  and  $O(g)$  atoms,



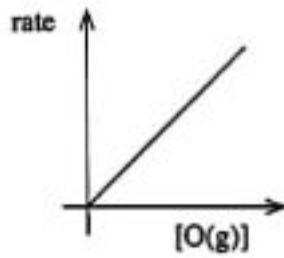
- (i) Write the overall reaction for the mechanism given above.

- (ii) Giving reasons, identify the catalyst and the intermediate product of the above mechanism.

- (iii) The following graphs were obtained from an experiment carried out in relation to the overall reaction in (i) above at temperature  $T$ . Rates and concentrations are measured in units of  $\text{mol dm}^{-3} \text{ s}^{-1}$  and  $\text{mol dm}^{-3}$  respectively.



Graph 1



Graph 2

Graph 1 was obtained by keeping  $[O(g)]$  constant.

Graph 2 was obtained by keeping  $[O_3(g)]$  constant.

- I. With the help of graphs 1 and 2, deduce orders of the reaction with respect to  $O_3(g)$  and  $O(g)$ . What is the overall order of the reaction?

- II. If the rate constant of the reaction is  $k$  at temperature  $T$ , write the rate law of the reaction.

III. Derive the units of  $k$ .

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column.

IV. In an experiment carried out at temperature  $T$ , the concentrations of  $O_3(g)$  and  $O(g)$  were  $1.0 \times 10^{-3} \text{ mol dm}^{-3}$  and  $1.0 \times 10^{-4} \text{ mol dm}^{-3}$  respectively. The rate of the reaction was found to be  $1.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$ . Calculate the value of  $k$ .

100

(70 marks)

4. (a) A, B and C are hydrocarbons having the molecular formula  $C_5H_{10}$ . None of them show geometric isomerism. Both A and B are chain isomers of C. When A and B are separately treated with cold concentrated  $H_2SO_4$  and the products obtained are diluted with water and heated, D and E are formed respectively. Of the two compounds D and E, only D shows optical isomerism. On catalytic hydrogenation, both compounds A and B give the same compound F, while compound C gives G. When B reacts with HBr in the presence of peroxide, H which is a primary alkyl halide is formed. Compound H when treated with aqueous NaOH gives I.

(i) Draw the structures of A, B, C, D, E, F, G, H and I in the boxes given below.

A

B

C

D

E

F

G

H

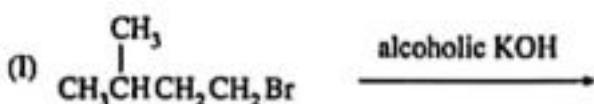
I

(ii) Describe a chemical test to distinguish D, E and I from one another.

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column.

(60 marks)

(b) (i) Draw the structures of the products J, K, L, M and N of the following reactions (I–V) in the given boxes.



J



K



L



M



N

(ii) Selecting from the reactions I–V, give one example each, for each type of reaction given below.

Nucleophilic addition .....

Electrophilic addition .....

Elimination reaction .....

(40 marks)

100

මාත්‍ර ම රීඛන අයිතිවාසිකාරී පත්‍රපිටියෙහියා/All Rights Reserved]

දෙශපාලන සංඝ්‍යා මධ්‍යම තුළ මෙය අනුමත කළ නො යොමැකියි  
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 Department of Examinations, Sri Lanka Department of Examinations, Sri Lanka  
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**Department of Examinations Sri Lanka**

අධ්‍යක්ෂ පොදු සහිත පත්‍ර (උග්‍ර පොදු) තිබා ඇල, 2022(2023)  
 කළමනිප් පොතුත් තුරාතුරු පත්‍තර (උය්‍ර තුරු) ප්‍රාග්‍රහණ, 2022(2023)  
 General Certificate of Education (Adv. Level) Examination, 2022(2023)

රිසායන විද්‍යාව II  
 තුර්සායනවියාල II  
 Chemistry II

**02 E II**

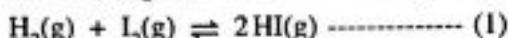
\* Universal gas constant  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

\* Avogadro constant  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

### PART B — ESSAY

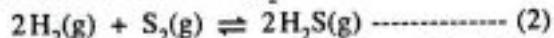
Answer two questions only. (Each question carries 150 marks.)

5. (a) Consider the reaction (1) given below at a temperature of 800 °C.

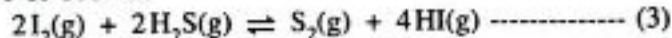


Initially, 0.45 mol of HI(g) was introduced into a 1.0 dm<sup>3</sup> evacuated rigid closed container at 800 °C, and allowed to reach the equilibrium given above. It was found that 0.05 mol of H<sub>2</sub>(g) was present at equilibrium.

- Calculate the equilibrium constant  $K_{C_1}$ , for the above equilibrium at a temperature of 800 °C.
- In a separate similar evacuated container at a temperature of 800 °C, reaction (2) takes place with an equilibrium constant  $K_{C_2} = 1.2 \times 10^8 \text{ mol}^{-1} \text{ dm}^3$ .



When the two containers are connected together, the following reaction (3) takes place at a temperature of 800 °C.

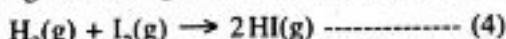


Calculate the equilibrium constant  $K_{C_3}$  for the reaction (3) at a temperature of 800 °C.

- A 1.0 dm<sup>3</sup> rigid closed container at a temperature of 800 °C contains an equilibrium mixture of (3) in (ii) above with  $5.00 \times 10^{-5}$  mol HI(g),  $1.25 \times 10^{-6}$  mol S<sub>2</sub>(g) and  $2.50 \times 10^{-5}$  mol H<sub>2</sub>S(g). Calculate the number of moles of I<sub>2</sub>(g) in the above mixture.
- An extra  $2.50 \times 10^{-5}$  mol I<sub>2</sub>(g) was added to the equilibrium mixture in (iii) above at a temperature of 800 °C.
  - Calculate the reaction quotient ( $Q_C$ ) at the moment the extra I<sub>2</sub>(g) is added.
  - Explain the change in the equilibrium that takes place upon the addition of extra I<sub>2</sub>(g).
  - Sketch the variation in the concentrations of each constituent in the mixture, with time, upon the addition of extra I<sub>2</sub>(g).

(60 marks)

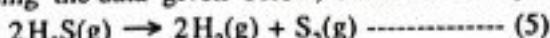
- (b) (i) Using the data given below, calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$  and  $\Delta G^\circ$  for the reaction (4) at 27 °C.



At 27 °C :  $\text{H}_2(\text{g}) + \text{I}_2(\text{s}) \rightarrow 2 \text{HI}(\text{g}) ; \Delta H^\circ = 53 \text{ kJ mol}^{-1}, \Delta S^\circ = 410 \text{ J K}^{-1} \text{ mol}^{-1}$

$\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g}) ; \Delta H^\circ = 63 \text{ kJ mol}^{-1}, \Delta S^\circ = 260 \text{ J K}^{-1} \text{ mol}^{-1}$

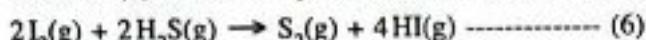
- (ii) Using the data given below, calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$  and  $\Delta G^\circ$  for the reaction (5) at 27 °C.



At 27 °C:  $\Delta H_f^\circ / \text{kJ mol}^{-1}$        $\Delta S_f^\circ / \text{J K}^{-1} \text{ mol}^{-1}$

H <sub>2</sub> (g) :	0	130
S <sub>2</sub> (g) :	127	230
H <sub>2</sub> S(g) :	-20	200

- (iii) Using the answers obtained in (b)(i) and (b)(ii) above, predict giving reasons whether the reaction (6) below is spontaneous or not at 27 °C.



(60 marks)

- (c) An aqueous solution of volume 1.0 dm<sup>3</sup> in a beaker at a temperature of 25 °C contains  $2.0 \times 10^{-2}$  mol of Cl<sup>-</sup>(aq) ions and  $2.0 \times 10^{-2}$  mol of CrO<sub>4</sub><sup>2-</sup>(aq) ions. Small portions of concentrated aqueous AgNO<sub>3</sub> solution were added slowly to the above solution. At 25 °C,  $K_{sp}$  (AgCl(s)) =  $1.60 \times 10^{-10}$  mol<sup>2</sup> dm<sup>-6</sup> and  $K_{sp}$  (Ag<sub>2</sub>CrO<sub>4</sub>(s)) =  $8.0 \times 10^{-12}$  mol<sup>3</sup> dm<sup>-9</sup>. Assume that there was no significant change in solution volume upon the addition of AgNO<sub>3</sub>(aq) solution.

(i) Show that AgCl precipitates first by a suitable calculation.

(ii) Calculate the concentration of Cl<sup>-</sup>(aq) ions present in the solution at the time Ag<sub>2</sub>CrO<sub>4</sub> starts to precipitate.

(30 marks)

6. (a) You are provided with an aqueous solution of sodium acetate (CH<sub>3</sub>COONa) at 25 °C.

(i) Write the equilibrium reaction for the hydrolysis of sodium acetate in aqueous medium.

(ii) Write the expression for the equilibrium constant  $K_h$  of the equilibrium in (i) above.

(iii) If the dissociation constants for CH<sub>3</sub>COOH(aq), and H<sub>2</sub>O(l) are  $K_a$  and  $K_w$  respectively at 25 °C, show that  $K_h = \frac{K_w}{K_a}$ .

(iv) Given that,  $K_a = 1.8 \times 10^{-5}$  mol dm<sup>-3</sup> and  $K_w = 1.0 \times 10^{-14}$  mol<sup>2</sup> dm<sup>-6</sup> at 25 °C, calculate the value of  $K_h$  at 25 °C.

(v) A portion of 25.00 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> CH<sub>3</sub>COONa solution is titrated with a solution of 0.10 mol dm<sup>-3</sup> HCl. What is the volume of 0.10 mol dm<sup>-3</sup> HCl required to reach the equivalence point? Calculate the pH of the solution at the equivalence point.

(vi) Sketch the titration curve (pH vs. volume of HCl) for the above titration in (v).

(vii) State an indicator which can be used for the titration in (v) above.

(viii) Explain why it is not possible to titrate a 0.10 mol dm<sup>-3</sup> CH<sub>3</sub>COOH solution with a solution of 0.10 mol dm<sup>-3</sup> aqueous ammonia.

(90 marks)

- (b) An ideal binary liquid mixture was prepared by mixing two volatile liquids A and B at a given temperature. When the composition of the liquid phase was  $X_A = 0.2$  and  $X_B = 0.8$ , the pressure of the vapour phase was  $P$  ( $X_A$  and  $X_B$  are mole fractions of A and B respectively in the liquid phase). When the composition of the liquid phase was changed to  $X_A = 0.5$  and  $X_B = 0.5$ , the pressure of the vapour phase becomes  $\frac{5}{3}P$ . At this temperature, saturated vapour pressures of A and B are  $P_A^\circ$  and  $P_B^\circ$  respectively.

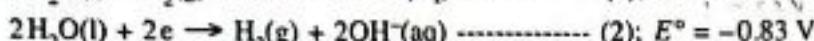
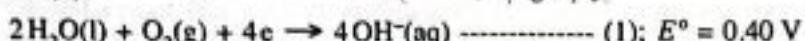
(i) Show that  $P_A^\circ = 5P_B^\circ$ .

(ii) Draw the corresponding composition - vapour pressure diagram for the mixture of A and B by showing the variations in  $P_A$ ,  $P_B$  and  $P_{\text{total}}$  and label the diagram.

(iii) Calculate the composition of the liquid phase at the point where  $P_A = P_B$ .

(60 marks)

7. (a) A galvanic electrochemical cell was constructed at 25 °C based on the following half - reactions (1) and (2).



- (i) Identify the anodic and cathodic half reactions of the cell.
- (ii) Write the overall balanced cell reaction of the cell.
- (iii) Calculate  $E_{\text{cell}}^\circ$  of the cell at 25 °C.
- (iv) The cell was operated for a duration of 600 s. During this period, 1.0 mol  $\text{H}_2(\text{g})$  was consumed.
  - I. Calculate the number of moles of electrons which passed through the cell.
  - II. Calculate the amount of electricity (in coulombs) generated in the cell during its operation ( $1 \text{ F} = 96500 \text{ C mol}^{-1}$ ).
  - III. Assuming that the current drawn from the cell is constant during the operation, calculate its value.
- (v) In the above galvanic electrochemical cell propane ( $\text{C}_3\text{H}_8(\text{g})$ ) is used instead of  $\text{H}_2(\text{g})$ .
  - I. Write the half-cell reaction for the propane electrode assuming propane is converted to  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O(l)}$ .
  - II. Derive the balanced equation for the overall cell reaction by using propane instead of  $\text{H}_2(\text{g})$  in the answer given in (ii) above.
  - III. Giving reasons, state one environmental advantage of the cell which uses  $\text{H}_2(\text{g})$  over the cell that uses propane.

(75 marks)

- (b) (i) X is a d-block element that belongs to the fourth period of the Periodic Table. On reacting X with dil. HCl, the colourless solution  $\text{X}_1$  and the gas  $\text{X}_2$  are obtained. When  $\text{X}_1$  is treated with dil.  $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$  and  $\text{H}_2\text{S}$  is bubbled through the solution thereafter, the white precipitate  $\text{X}_3$  is obtained.  $\text{X}_3$  is soluble in dil. HCl. On addition of dil. NaOH to  $\text{X}_1$ , the gelatinous white precipitate  $\text{X}_4$  is formed.  $\text{X}_4$  dissolves in excess dil. NaOH and in excess dil.  $\text{NH}_4\text{OH}$  to give  $\text{X}_5$  and  $\text{X}_6$  respectively. Both  $\text{X}_5$  and  $\text{X}_6$  are colourless.

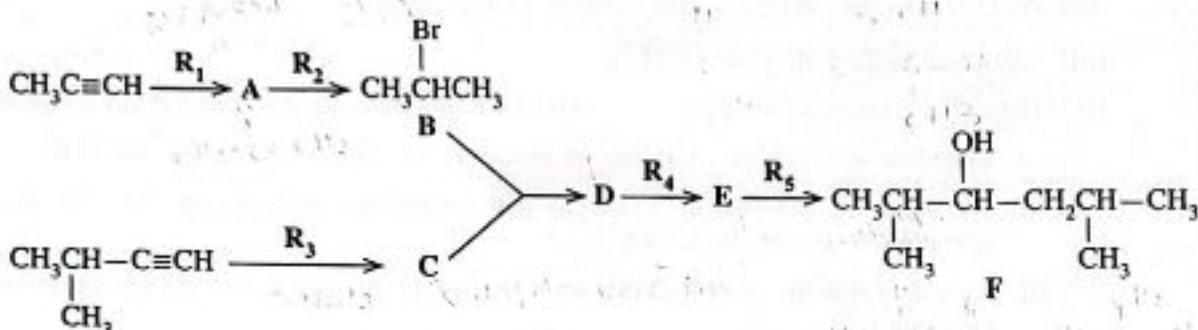
- I. Identify the species X and  $\text{X}_1$  to  $\text{X}_6$ . (Give chemical formulae) Note: Reasons are not required.
- II. Write the electronic configuration of X.
- III. Explain why  $\text{X}_1$  is colourless.
- IV. Write the IUPAC name of  $\text{X}_6$ .
- (ii) Y is also a d-block element that belongs to the same row as X in the Periodic Table. Y has two common oxidation numbers n and m. m is greater than n.  $\text{Y}^{n+}$  forms the pink coloured species  $\text{Y}_1$  in aqueous solution. On treatment of the solution containing  $\text{Y}_1$  with dil. NaOH the pink precipitate  $\text{Y}_2$  is formed. When  $\text{H}_2\text{S}$  is bubbled through a slightly basic solution containing  $\text{Y}_1$ , the black precipitate  $\text{Y}_3$  is obtained. The yellowish-brown species  $\text{Y}_4$  is formed on addition of excess conc. ammonia to a solution containing  $\text{Y}_1$ . On treatment of a solution containing  $\text{Y}_1$  with conc. HCl, the blue coloured species  $\text{Y}_5$  is obtained. On exposure of  $\text{Y}_4$  to air, the brownish-red species  $\text{Y}_6$  is formed.

- I. Give the values of n and m.
- II. Identify the species Y and  $\text{Y}_1$  to  $\text{Y}_6$ . (Give chemical formulae) Note: Reasons are not required.
- III. Write the electronic configurations of  $\text{Y}^{n+}$  and  $\text{Y}^{m+}$ .
- IV. Write the IUPAC name of  $\text{Y}_5$ .

(75 marks)

**PART C — ESSAY***Answer two questions only. (Each question carries 150 marks.)*

8. (a) Preparation of the compound F has been carried out using  $\text{CH}_3\text{C}\equiv\text{CH}$  and  $(\text{CH}_3)_2\text{CHC}\equiv\text{CH}$  according to the reaction scheme given below.



- (i) Give the structures of the compounds A, C, D and E and the reagents  $\text{R}_1$ ,  $\text{R}_2$ ,  $\text{R}_3$ ,  $\text{R}_4$  and  $\text{R}_5$ .

Only the chemical substances given below should be used either singly or as combinations as reagents.

**Chemical substances:**

$\text{H}_2$ ,  $\text{NaNH}_2$ ,  $\text{NaBH}_4$ ,  $\text{HgSO}_4$ ,  $\text{HBr}$ , dil.  $\text{H}_2\text{SO}_4$ ,  $\text{Pd-BaSO}_4/\text{Quinoline catalyst}$ ,  $\text{CH}_3\text{OH}$

- (ii) Compound F was reacted with  $\text{H}^+/\text{K}_2\text{Cr}_2\text{O}_7$ . When the product obtained from this reaction is reacted with 2,4-dinitrophenylhydrazine (2,4-DNP), compound G is formed. Give the structure of G.

(60 marks)

- (b) (i) Show how the transformation given below can be carried out using not more than four (04) steps.

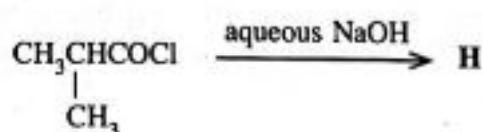


- (ii) Show how the transformation given below can be carried out using not more than three (03) steps.



(60 marks)

- (c) Give the structure of the product H of the following reaction. Write the mechanism of this reaction.



(30 marks)

9. (a) A and B are water soluble inorganic compounds. A is coloured while B is colourless. When aqueous solutions of A and B are mixed together, the white precipitate C and the water soluble compound D are formed. C dissolves in dil. HCl to give the gas E with a pungent smell as one of the products. When E is passed through a solution of acidified  $K_2Cr_2O_7$ , the solution turns green. Addition of dil.  $NH_4OH$  to an aqueous solution of A gives a green precipitate F. F dissolves in excess dil.  $NH_4OH$  to give a dark blue solution G. A black precipitate is formed when  $H_2S$  is bubbled through an aqueous solution of A to which  $NH_4OH/NH_4Cl$  has been added. On addition of  $AgNO_3(aq)$  to an aqueous solution of B, a white precipitate H that is soluble in dil.  $NH_4OH$  is formed. Addition of  $Pb(NO_3)_2(aq)$  to an aqueous solution of B gives a white precipitate I that is soluble in hot water. When dil.  $H_2SO_4$  is added to an aqueous solution of B, a white precipitate J that is insoluble in dil. HCl is formed. B gives a green coloured flame in the flame test.

- Identify the species A to J. (Give chemical formulae) Note: Reasons are not required.
- Write balanced chemical equations for the following.

I. Formation of C and D

II. Dissolution of C in dil. HCl

(75 marks)

(b) An iron ore, X, contains  $FeO$ ,  $Fe_2O_3$  and inert substances. The following experimental procedure was used to determine the mass percentages of  $FeO$  and  $Fe_2O_3$  in X.

A mass of 0.4800 g of X was dissolved in  $10\text{ cm}^3$  of concentrated acid. This solution was filtered to remove insoluble matter, and thereafter diluted to  $50.00\text{ cm}^3$  using distilled water. This entire diluted solution was titrated with  $0.020\text{ mol dm}^{-3}$   $KMnO_4$  solution. The titration reading at the end point was  $20.00\text{ cm}^3$ . The pH of the entire solution, obtained after the titration, was raised to 12. At this stage, the metal ions in solution were precipitated as their hydroxides. The precipitate was filtered and dried until a constant mass was obtained. The mass of the precipitate obtained was 0.5706 g.

- Write balanced chemical equations for titration and precipitation reactions.

- Calculate the mass percentages of  $FeO$  and  $Fe_2O_3$  in X.

Note: Assume that the composition does not change during drying of metal hydroxides and there is no effect from dissolved oxygen in solution.

(H = 1, O = 16, Mn = 55, Fe = 56)

(75 marks)

**10.(a)** The following questions [(i) – (v)] are based on the manufacture of sulphuric acid by the Contact Process.

- (i) State the three raw materials used.
- (ii) Write balanced chemical equations for the reactions taking place. State proper conditions where necessary.
- (iii) State two strategies used to increase the efficiency of the Contact Process.
- (iv) State two principles used in the determination of the optimum conditions for the Contact Process and briefly explain each principle using a reaction you specified in part (ii) above.
- (v) Name two industries which utilize sulphuric acid as a raw material.

(50 marks)

**(b)** Gaseous compounds of carbon, nitrogen and sulphur with various oxidation numbers directly contribute to global environment issues.

- (i) Name two non-halogenated carbon compounds and one nitrogen compound that directly contribute to global warming and state the oxidation numbers of C and N in these compounds.
- (ii) State how the three compounds you named in (i) above are released to the atmosphere due to human activities.
- (iii) Explain how the compounds you mentioned in (i) above contribute to global warming.
- (iv) Name two nitrogen compounds with the oxidation numbers of N that directly contribute to photochemical smog.
- (v) Write balanced chemical equations for the formation of tropospheric ozone by a nitrogen compound you stated in (iv) above.
- (vi) Explain why the tropospheric ozone level reaches its maximum level in the afternoon.
- (vii) State three water quality parameters that are affected as a result of the dissolution of oxides of nitrogen and sulphur in water bodies.

(50 marks)

**(c)** The following questions are based on chemical products related to plant sources.

- (i) Give relevant balanced equations to indicate the chemical changes that take place when ethanol in coconut toddy is produced by fermentation of sweet toddy.
- (ii) Explain why it is necessary to remove free fatty acids from plant oils taken as raw materials in the production of bio-diesel.
- (iii) Explain briefly why essential oils can be extracted from plant materials by steam distillation, at a temperature which is below the boiling points of both pure water and essential oil.

(50 marks)

\* \* \*



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අධ්‍යාපන පොදු සහතික පත්‍ර (උග්‍ර පෙළ) වියයය, 2022(2023)

කළුවිප් පොතුන් තුරාතුරු පත්තිර (ඉයර තුරු) ප්‍රතිසත්, 2022(2023)

General Certificate of Education (Adv. Level) Examination, 2022(2023)

රුයායන විද්‍යාව II  
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Chemistry II

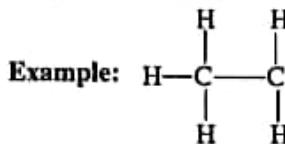
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Additional Reading Time - 10 minutes

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 15.
- \* 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.

Example: 

The diagram shows two carbon atoms connected by a single horizontal line. Each carbon atom has three vertical lines extending from it, representing hydrogen atoms. This is the condensed representation of an ethyl group, which is equivalent to CH<sub>3</sub>CH<sub>2</sub>-.

#### □ PART A – Structured Essay (pages 02 - 08)

- \* 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 09 - 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	
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Supervised by :	

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**PART A — STRUCTURED ESSAY**

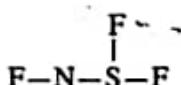
*Answer all four questions on this paper itself. (Each question carries 100 marks.)*

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

- (i) The Lyman series observed in the emission spectrum of atomic hydrogen lies in the ultra-violet region of the electromagnetic spectrum. ....
- (ii) There are only 10 electrons in a calcium atom with the azimuthal quantum number  $l=0$ . ....
- (iii) The number of Lewis dot-dash structures (resonance structures) that can be drawn for the  $\text{N}_2\text{O}$  molecule is 3. ....
- (iv) Among the second row elements of the Periodic Table, fluorine has the largest negative value of electron gain energy. ....
- (v) The boiling point of argon ( $\text{Ar}$ ) is higher than that of chlorine ( $\text{Cl}_2$ ). ....
- (vi) Ne has the highest first ionization energy, among the noble gases He, Ne and Ar. ....

(24 marks)

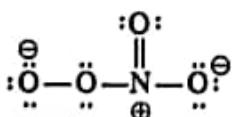
- (b) (i) The skeleton of a molecule containing only the elements N, F and S is given below. Draw the most acceptable Lewis dot-dash structure for this molecule.



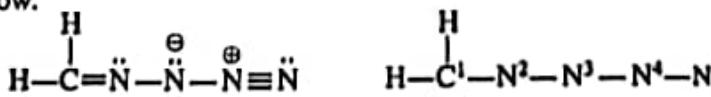
- (ii) Give, (I) shapes around the N and S atoms and (II) oxidation numbers of the atoms in the structure drawn in (i) above.

- (I) N ..... , S ..... (shape)
- (II) N ..... , S ..... (oxidation number)

- (iii) A Lewis dot-dash structure for the  $\text{NO}_4^-$  ion is given below. Draw three more Lewis dot-dash structures (resonance structures) for the  $\text{NO}_4^-$  ion .



- (iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.



	C <sup>1</sup>	N <sup>2</sup>	N <sup>3</sup>	N <sup>4</sup>
I. the number of VSEPR pairs around the atom				
II. electron pair geometry around the atom				
III. shape around the atom				
IV. hybridization of the atom				

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- Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

- (v) Identify the atomic/hybrid orbitals involved in the formation of  $\sigma$  bonds between the two atoms given below.

I.	$\text{H}-\text{C}^1$	$\text{H}$ .....	$\text{C}^1$ .....
II.	$\text{C}^1-\text{N}^2$	$\text{C}^1$ .....	$\text{N}^2$ .....
III.	$\text{N}^2-\text{N}^3$	$\text{N}^2$ .....	$\text{N}^3$ .....
IV.	$\text{N}^3-\text{N}^4$	$\text{N}^3$ .....	$\text{N}^4$ .....
V.	$\text{N}^4-\text{N}$	$\text{N}^4$ .....	$\text{N}$ .....

- (vi) Identify the atomic orbitals involved in the formation of  $\pi$  bonds between the atoms given below.

I.	$\text{C}^1-\text{N}^2$	$\text{C}^1$ .....	$\text{N}^2$ .....
II.	$\text{N}^4-\text{N}$	$\text{N}^4$ .....	$\text{N}$ .....

- (vii) State the approximate bond angles around  $\text{C}^1$ ,  $\text{N}^2$ ,  $\text{N}^3$  and  $\text{N}^4$  atoms.

$\text{C}^1$ .....,     $\text{N}^2$  .....,     $\text{N}^3$  .....,     $\text{N}^4$ .....

- (viii) Arrange the atoms  $\text{N}^2$ ,  $\text{N}^3$  and  $\text{N}^4$  in the increasing order of their electronegativity.

..... < ..... < ..... (56 marks)

- (c) Arrange the following species in the increasing order of the property indicated in parentheses. Reasons are not required.

- (i)  $\text{CaF}_2$ ,  $\text{CaCl}_2$ ,  $\text{CaBr}_2$ ,  $\text{CaI}_2$  (ionic character)

..... < ..... < ..... < .....

- (ii)  $\text{ClF}_5$ ,  $\text{ClF}_2^+$ ,  $\text{ClF}_2^-$  (bond angle)

..... < ..... < .....

- (iii)  $\text{Na}^+$ ,  $\text{S}^{2-}$ ,  $\text{Cl}^-$ ,  $\text{K}^+$  (ionic radius)

..... < ..... < ..... < .....

- (iv)  $\text{CO}$ ,  $\text{CO}_3^{2-}$ ,  $\text{HCO}_2^-$ ,  $\text{H}_2\text{CO}$ ,  $\text{CH}_3\text{OH}$  (C—O bond length)

..... < ..... < ..... < ..... < .....

- (v)  $\text{Li}$ ,  $\text{N}$ ,  $\text{F}$ ,  $\text{Mg}$ ,  $\text{P}$  (first ionization energy)

..... < ..... < ..... < ..... < .....

(20 marks)

100

2. (a) The questions (i), (ii) and (iii) are based on the following reactions.

A is an ionic compound composed of three elements in the ratio 1:4:1 (Not in order of the chemical formula). One of these is a *d*-block element that belongs to the fourth period of the Periodic Table. When A is subjected to the flame test, a lilac (purple) flame is observed. On dissolving A in water, a purple coloured solution is obtained.

B is also an ionic compound composed of the same three elements as in A. B dissolves in water to give a green coloured solution.

C is a viscous colourless liquid composed of two elements. It disproportionates to give another colourless liquid D as one of the products. C can act as an oxidizing agent as well as a reducing agent. When C is added to a solution of B, the brown precipitate E is obtained.

F is a compound composed of three elements. One of these elements is a 3d element found in hematite. When  $\text{BaCl}_2(\text{aq})$  is added to an aqueous solution of F, the white precipitate G that is insoluble in dil.  $\text{H}_2\text{SO}_4$  is formed.

H is composed of three elements. When an aqueous solution of H in a test tube is treated with a saturated solution of F, followed by addition of a small volume of conc.  $\text{H}_2\text{SO}_4$  slowly, along the wall of the test tube, a brown colouration is seen on the surface where the liquids meet. The species responsible for the brown colouration is I. Brown fumes are not evolved when dil.  $\text{H}_2\text{SO}_4$  is added to H. When H is subjected to the flame test, a yellow flame is observed.

J is the sodium salt of a weak dibasic acid. On treatment of a solution of J with  $\text{CaCl}_2(\text{aq})$ , the white precipitate K is formed. K reacts with dil.  $\text{H}_2\text{SO}_4$  to give the weak dibasic acid L as one of the products. A warm solution of J acidified with dil.  $\text{H}_2\text{SO}_4$  decolorizes an aqueous solution of A.

(i) Identify A to L. Note: Write the chemical formulae.

A .....

G .....

B .....

H .....

C .....

I .....

D .....

J .....

E .....

K .....

F .....

L .....

(ii) Give balanced chemical equations for the following (physical states not required).

I. Formation of D from C.

II. Formation of I.

III. Formation of K.

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(iii) Give balanced ionic equations for the reactions that take place when A is added to the following solutions (physical states not required).

I. an acidified solution of C

II. an aqueous solution of F acidified with dil.  $H_2SO_4$

III. an acidified solution of J

(20 marks)

(b) Give balanced chemical equations for the reactions that take place between the following (physical states not required). State the function (oxidizing agent/reducing agent) of  $H_2S$  and  $SO_2$  in reactions (i)–(iii).

(i) Mg(s) and  $H_2S(g)$  .....

$H_2S$ : .....

(ii) Mg(s) and  $SO_2(g)$  .....

$SO_2$ : .....

(iii)  $H_2S(g)$  and  $SO_2(g)$  .....

$H_2S$ : .....,  $SO_2$ : .....

(iv) S(s) and conc.  $HNO_3(aq)$  .....



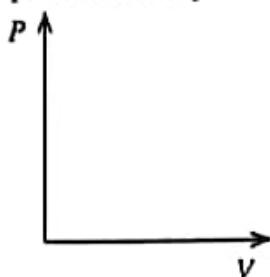
(20 marks)

3. (a) (i) A closed container equipped with a piston contains a given mass of an ideal gas at a constant temperature  $T$ . Give the relationship between pressure  $P$  and volume  $V$  of the gas using a mathematical expression.

(ii) Show that the density  $d$  of the ideal gas in (i) above, at a constant temperature  $T$  is directly proportional to the pressure  $P$ .

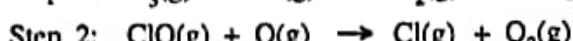
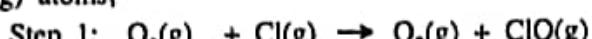
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- (iii) Show the variation of  $P$  with  $V$  of the system in (i) above at the two different temperatures of 300 K and 500 K, by drawing two graphs in the figure given below. Indicate clearly the temperature corresponding to each graph.



(30 marks)

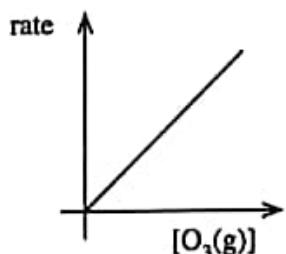
- (b) Depletion of  $O_3(g)$  occurs according to the mechanism given below in the presence of  $Cl(g)$  and  $O(g)$  atoms,



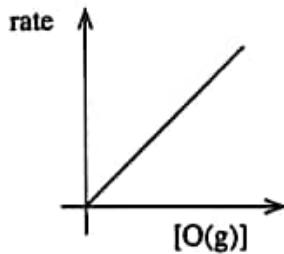
- (i) Write the overall reaction for the mechanism given above.

- (ii) Giving reasons, identify the catalyst and the intermediate product of the above mechanism.

- (iii) The following graphs were obtained from an experiment carried out in relation to the overall reaction in (i) above at temperature  $T$ . Rates and concentrations are measured in units of  $\text{mol dm}^{-3} \text{ s}^{-1}$  and  $\text{mol dm}^{-3}$  respectively.



Graph 1



Graph 2

Graph 1 was obtained by keeping  $[O(g)]$  constant.

Graph 2 was obtained by keeping  $[O_3(g)]$  constant.

- I. With the help of graphs 1 and 2, deduce orders of the reaction with respect to  $O_3(g)$  and  $O(g)$ . What is the overall order of the reaction?

- II. If the rate constant of the reaction is  $k$  at temperature  $T$ , write the rate law of the reaction.

III. Derive the units of  $k$ .

IV. In an experiment carried out at temperature  $T$ , the concentrations of  $O_3(g)$  and  $O(g)$  were  $1.0 \times 10^{-3}$  mol  $dm^{-3}$  and  $1.0 \times 10^{-4}$  mol  $dm^{-3}$  respectively. The rate of the reaction was found to be  $1.0 \times 10^{-3}$  mol  $dm^{-3} s^{-1}$ . Calculate the value of  $k$ .

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(70 marks)

4. (a) A, B and C are hydrocarbons having the molecular formula  $C_5H_{10}$ . None of them show geometric isomerism. Both A and B are chain isomers of C. When A and B are separately treated with cold concentrated  $H_2SO_4$  and the products obtained are diluted with water and heated, D and E are formed respectively. Of the two compounds D and E, only D shows optical isomerism. On catalytic hydrogenation, both compounds A and B give the same compound F, while compound C gives G. When B reacts with HBr in the presence of peroxide, H which is a primary alkyl halide is formed. Compound H when treated with aqueous NaOH gives I.

(i) Draw the structures of A, B, C, D, E, F, G, H and I in the boxes given below.

A

B

C

D

E

F

G

H

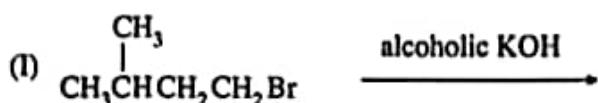
I

(ii) Describe a chemical test to distinguish D, E and I from one another.

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column.

(60 marks)

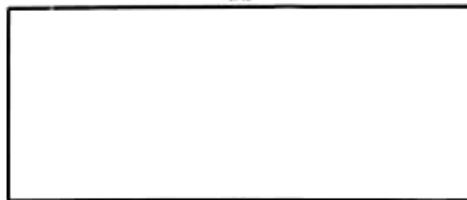
(b) (i) Draw the structures of the products J, K, L, M and N of the following reactions (I–V) in the given boxes.



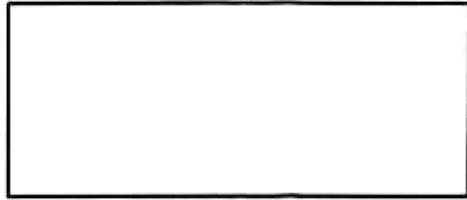

J




K

L

M




N

(ii) Selecting from the reactions I–V, give one example each, for each type of reaction given below.

Nucleophilic addition .....

Electrophilic addition .....

Elimination reaction .....

(40 marks)

100

මිලු ම හිමිකම් අවබෝධන මායුප් පත්‍රප්‍රිමියා යොදා වාය

ශ්‍රී ලංකා රිඟා දෙපාර්තමේන්තුව සියලු එහා උගා දෙපාර්තමේන්තුව සිලැස්කු විසින් උගා ආර්ථික සිලැස්කු විසින් සිලැස්කු ප්‍රතිශාසන ත්‍රිත්‍යාකාශකම් සිලැස්කු ප්‍රතිශාසන ත්‍රිත්‍යාකාශකම්

**අධ්‍යයන පොදු සහතික පත්‍ර (උස්ස පෙළ) විභාගය, 2022(2023)  
කළංඩ්ප පොත්ත තරාතරුප පත්‍තිර (ශ්‍රායුර තු)ප ප්‍රිත්සා, 2022(2023)  
General Certificate of Education (Adv. Level) Examination, 2022(2023)**

රසායන විද්‍යාව II  
ඵ්‍රිසායන්වියාල II  
Chemistry II

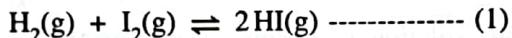
02 E II

\* Universal gas constant  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$   
\* Avogadro constant  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

### PART B — ESSAY

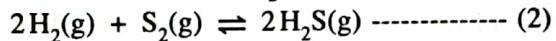
*Answer two questions only. (Each question carries 150 marks.)*

5. (a) Consider the reaction (1) given below at a temperature of 800 °C.

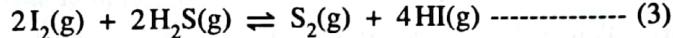


Initially, 0.45 mol of  $\text{HI}(\text{g})$  was introduced into a  $1.0 \text{ dm}^3$  evacuated rigid closed container at 800 °C, and allowed to reach the equilibrium given above. It was found that 0.05 mol of  $\text{H}_2(\text{g})$  was present at equilibrium.

- Calculate the equilibrium constant  $K_{C_1}$ , for the above equilibrium at a temperature of 800 °C.
- In a separate similar evacuated container at a temperature of 800 °C, reaction (2) takes place with an equilibrium constant  $K_{C_2} = 1.2 \times 10^8 \text{ mol}^{-1} \text{ dm}^3$ .



When the two containers are connected together, the following reaction (3) takes place at a temperature of 800 °C.

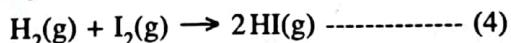


Calculate the equilibrium constant  $K_{C_3}$  for the reaction (3) at a temperature of 800 °C.

- A  $1.0 \text{ dm}^3$  rigid closed container at a temperature of 800 °C contains an equilibrium mixture of (3) in (ii) above with  $5.00 \times 10^{-5} \text{ mol HI(g)}$ ,  $1.25 \times 10^{-6} \text{ mol S}_2(\text{g})$  and  $2.50 \times 10^{-5} \text{ mol H}_2\text{S(g)}$ . Calculate the number of moles of  $\text{I}_2(\text{g})$  in the above mixture.
- An extra  $2.50 \times 10^{-5} \text{ mol I}_2(\text{g})$  was added to the equilibrium mixture in (iii) above at a temperature of 800 °C.
  - Calculate the reaction quotient ( $Q_C$ ) at the moment the extra  $\text{I}_2(\text{g})$  is added.
  - Explain the change in the equilibrium that takes place upon the addition of extra  $\text{I}_2(\text{g})$ .
  - Sketch the variation in the concentrations of each constituent in the mixture, with time, upon the addition of extra  $\text{I}_2(\text{g})$ .

(60 marks)

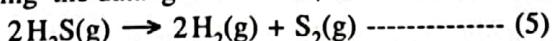
- (b) (i) Using the data given below, calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$  and  $\Delta G^\circ$  for the reaction (4) at 27 °C.



$$\text{At } 27^\circ\text{C : } \text{H}_2(\text{g}) + \text{I}_2(\text{s}) \rightarrow 2\text{HI}(\text{g}) ; \Delta H^\circ = 53 \text{ kJ mol}^{-1}, \Delta S^\circ = 410 \text{ J K}^{-1} \text{ mol}^{-1}$$

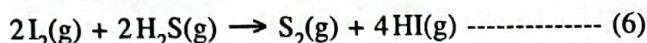
$$\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g}) ; \Delta H^\circ = 63 \text{ kJ mol}^{-1}, \Delta S^\circ = 260 \text{ J K}^{-1} \text{ mol}^{-1}$$

- (ii) Using the data given below, calculate  $\Delta H^\circ$ ,  $\Delta S^\circ$  and  $\Delta G^\circ$  for the reaction (5) at 27 °C.



At 27 °C:	$\Delta H_f^\circ / \text{kJ mol}^{-1}$	$\Delta S_f^\circ / \text{J K}^{-1} \text{ mol}^{-1}$
H <sub>2</sub> (g) :	0	130
S <sub>2</sub> (g) :	127	230
H <sub>2</sub> S(g) :	-20	200

- (iii) Using the answers obtained in (b)(i) and (b)(ii) above, predict giving reasons whether the reaction (6) below is spontaneous or not at 27 °C.



(60 marks)

- (c) An aqueous solution of volume 1.0 dm<sup>3</sup> in a beaker at a temperature of 25 °C contains  $2.0 \times 10^{-2}$  mol of Cl<sup>-</sup>(aq) ions and  $2.0 \times 10^{-2}$  mol of CrO<sub>4</sub><sup>2-</sup>(aq) ions. Small portions of concentrated aqueous AgNO<sub>3</sub> solution were added slowly to the above solution. At 25 °C,  $K_{\text{sp}}(\text{AgCl(s)}) = 1.60 \times 10^{-10}$  mol<sup>2</sup> dm<sup>-6</sup> and  $K_{\text{sp}}(\text{Ag}_2\text{CrO}_4(\text{s})) = 8.0 \times 10^{-12}$  mol<sup>3</sup> dm<sup>-9</sup>. Assume that there was no significant change in solution volume upon the addition of AgNO<sub>3</sub>(aq) solution.

(i) Show that AgCl precipitates first by a suitable calculation.

(ii) Calculate the concentration of Cl<sup>-</sup>(aq) ions present in the solution at the time Ag<sub>2</sub>CrO<sub>4</sub> starts to precipitate.

(30 marks)

6. (a) You are provided with an aqueous solution of sodium acetate (CH<sub>3</sub>COONa) at 25 °C.

(i) Write the equilibrium reaction for the hydrolysis of sodium acetate in aqueous medium.

(ii) Write the expression for the equilibrium constant  $K_h$  of the equilibrium in (i) above.

(iii) If the dissociation constants for CH<sub>3</sub>COOH (aq), and H<sub>2</sub>O (l) are  $K_a$  and  $K_w$  respectively at 25 °C, show that  $K_h = \frac{K_w}{K_a}$ .

(iv) Given that,  $K_a = 1.8 \times 10^{-5}$  mol dm<sup>-3</sup> and  $K_w = 1.0 \times 10^{-14}$  mol<sup>2</sup> dm<sup>-6</sup> at 25 °C, calculate the value of  $K_h$  at 25 °C.

(v) A portion of 25.00 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> CH<sub>3</sub>COONa solution is titrated with a solution of 0.10 mol dm<sup>-3</sup> HCl. What is the volume of 0.10 mol dm<sup>-3</sup> HCl required to reach the equivalence point? Calculate the pH of the solution at the equivalence point.

(vi) Sketch the titration curve (pH vs. volume of HCl) for the above titration in (v).

(vii) State an indicator which can be used for the titration in (v) above.

(viii) Explain why it is not possible to titrate a 0.10 mol dm<sup>-3</sup> CH<sub>3</sub>COOH solution with a solution of 0.10 mol dm<sup>-3</sup> aqueous ammonia.

(90 marks)

- (b) An ideal binary liquid mixture was prepared by mixing two volatile liquids A and B at a given temperature. When the composition of the liquid phase was  $X_A = 0.2$  and  $X_B = 0.8$ , the pressure of the vapour phase was  $P$  ( $X_A$  and  $X_B$  are mole fractions of A and B respectively in the liquid phase). When the composition of the liquid phase was changed to  $X_A = 0.5$  and  $X_B = 0.5$ , the pressure of the vapour phase becomes  $\frac{5}{3}P$ . At this temperature, saturated vapour pressures of A and B are  $P_A^\circ$  and  $P_B^\circ$  respectively.

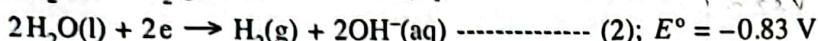
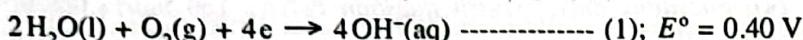
(i) Show that  $P_A^\circ = 5P_B^\circ$ .

(ii) Draw the corresponding composition - vapour pressure diagram for the mixture of A and B by showing the variations in  $P_A$ ,  $P_B$  and  $P_{\text{total}}$  and label the diagram.

(iii) Calculate the composition of the liquid phase at the point where  $P_A = P_B$ .

(60 marks)

7. (a) A galvanic electrochemical cell was constructed at 25 °C based on the following half - reactions (1) and (2).



- (i) Identify the anodic and cathodic half reactions of the cell.
- (ii) Write the overall balanced cell reaction of the cell.
- (iii) Calculate  $E_{\text{cell}}^\circ$  of the cell at 25 °C.
- (iv) The cell was operated for a duration of 600 s. During this period, 1.0 mol  $\text{H}_2(\text{g})$  was consumed.
  - I. Calculate the number of moles of electrons which passed through the cell.
  - II. Calculate the amount of electricity (in coulombs) generated in the cell during its operation ( $1 \text{ F} = 96500 \text{ C mol}^{-1}$ ).
  - III. Assuming that the current drawn from the cell is constant during the operation, calculate its value.
- (v) In the above galvanic electrochemical cell propane ( $\text{C}_3\text{H}_8(\text{g})$ ) is used instead of  $\text{H}_2(\text{g})$ .
  - I. Write the half-cell reaction for the propane electrode assuming propane is converted to  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O(l)}$ .
  - II. Derive the balanced equation for the overall cell reaction by using propane instead of  $\text{H}_2(\text{g})$  in the answer given in (ii) above.
  - III. Giving reasons, state one environmental advantage of the cell which uses  $\text{H}_2(\text{g})$  over the cell that uses propane.

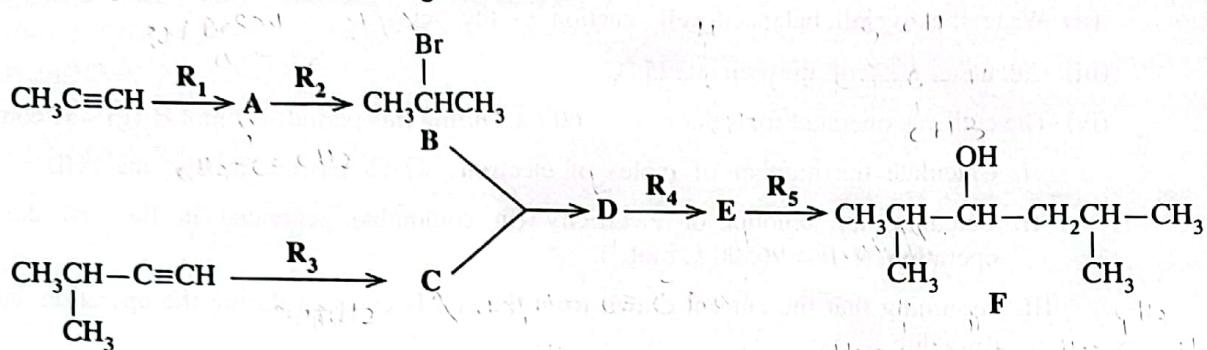
(75 marks)

- (b) (i) X is a *d*-block element that belongs to the fourth period of the Periodic Table. On reacting X with dil. HCl, the colourless solution  $\text{X}_1$  and the gas  $\text{X}_2$  are obtained. When  $\text{X}_1$  is treated with dil.  $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$  and  $\text{H}_2\text{S}$  is bubbled through the solution thereafter, the white precipitate  $\text{X}_3$  is obtained.  $\text{X}_3$  is soluble in dil. HCl. On addition of dil. NaOH to  $\text{X}_1$ , the gelatinous white precipitate  $\text{X}_4$  is formed.  $\text{X}_4$  dissolves in excess dil. NaOH and in excess dil.  $\text{NH}_4\text{OH}$  to give  $\text{X}_5$  and  $\text{X}_6$  respectively. Both  $\text{X}_5$  and  $\text{X}_6$  are colourless.
- I. Identify the species X and  $\text{X}_1$  to  $\text{X}_6$ . (Give chemical formulae) Note: Reasons are not required.
  - II. Write the electronic configuration of X.
  - III. Explain why  $\text{X}_1$  is colourless.
  - IV. Write the IUPAC name of  $\text{X}_6$ .
- (ii) Y is also a *d*-block element that belongs to the same row as X in the Periodic Table. Y has two common oxidation numbers  $n$  and  $m$ .  $m$  is greater than  $n$ .  $\text{Y}^{n+}$  forms the pink coloured species  $\text{Y}_1$  in aqueous solution. On treatment of the solution containing  $\text{Y}_1$  with dil. NaOH the pink precipitate  $\text{Y}_2$  is formed. When  $\text{H}_2\text{S}$  is bubbled through a slightly basic solution containing  $\text{Y}_1$ , the black precipitate  $\text{Y}_3$  is obtained. The yellowish-brown species  $\text{Y}_4$  is formed on addition of excess conc. ammonia to a solution containing  $\text{Y}_1$ . On treatment of a solution containing  $\text{Y}_1$  with conc. HCl, the blue coloured species  $\text{Y}_5$  is obtained. On exposure of  $\text{Y}_4$  to air, the brownish-red species  $\text{Y}_6$  is formed.
- I. Give the values of  $n$  and  $m$ .
  - II. Identify the species Y and  $\text{Y}_1$  to  $\text{Y}_6$ . (Give chemical formulae) Note: Reasons are not required.
  - III. Write the electronic configurations of  $\text{Y}^{n+}$  and  $\text{Y}^{m+}$ .
  - IV. Write the IUPAC name of  $\text{Y}_5$ .

(75 marks)

**PART C — ESSAY***Answer two questions only. (Each question carries 150 marks.)*

8. (a) Preparation of the compound **F** has been carried out using  $\text{CH}_3\text{C}\equiv\text{CH}$  and  $(\text{CH}_3)_2\text{CHC}\equiv\text{CH}$  according to the reaction scheme given below.



- (i) Give the structures of the compounds **A**, **C**, **D** and **E** and the reagents **R<sub>1</sub>**, **R<sub>2</sub>**, **R<sub>3</sub>**, **R<sub>4</sub>** and **R<sub>5</sub>**.

Only the chemical substances given below should be used either singly or as combinations as reagents.

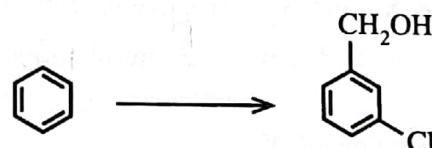
**Chemical substances:**

$\text{H}_2$ ,  $\text{NaNH}_2$ ,  $\text{NaBH}_4$ ,  $\text{HgSO}_4$ ,  $\text{HBr}$ , dil.  $\text{H}_2\text{SO}_4$ ,  $\text{Pd-BaSO}_4/\text{Quinoline catalyst}$ ,  $\text{CH}_3\text{OH}$

- (ii) Compound **F** was reacted with  $\text{H}^+/\text{K}_2\text{Cr}_2\text{O}_7$ . When the product obtained from this reaction is reacted with 2,4-dinitrophenylhydrazine (2,4-DNP), compound **G** is formed. Give the structure of **G**.

(60 marks)

- (b) (i) Show how the transformation given below can be carried out using not more than four (04) steps.

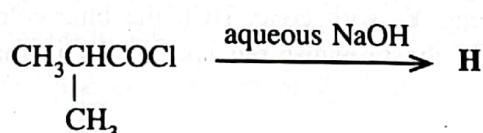


- (ii) Show how the transformation given below can be carried out using not more than three (03) steps.



(60 marks)

- (c) Give the structure of the product **H** of the following reaction. Write the mechanism of this reaction.



(30 marks)

9. (a) A and B are water soluble inorganic compounds. A is coloured while B is colourless. When aqueous solutions of A and B are mixed together, the white precipitate C and the water soluble compound D are formed. C dissolves in dil. HCl to give the gas E with a pungent smell as one of the products. When E is passed through a solution of acidified K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, the solution turns green. Addition of dil. NH<sub>4</sub>OH to an aqueous solution of A gives a green precipitate F. F dissolves in excess dil. NH<sub>4</sub>OH to give a dark blue solution G. A black precipitate is formed when H<sub>2</sub>S is bubbled through an aqueous solution of A to which NH<sub>4</sub>OH/NH<sub>4</sub>Cl has been added. On addition of AgNO<sub>3</sub>(aq) to an aqueous solution of B, a white precipitate H that is soluble in dil. NH<sub>4</sub>OH is formed. Addition of Pb(NO<sub>3</sub>)<sub>2</sub>(aq) to an aqueous solution of B gives a white precipitate I that is soluble in hot water. When dil. H<sub>2</sub>SO<sub>4</sub> is added to an aqueous solution of B, a white precipitate J that is insoluble in dil. HCl is formed. B gives a green coloured flame in the flame test.

- (i) Identify the species A to J. (Give chemical formulae) Note: Reasons are not required.
- (ii) Write balanced chemical equations for the following.

I. Formation of C and D

II. Dissolution of C in dil. HCl

(75 marks)

(b) An iron ore, X, contains FeO, Fe<sub>2</sub>O<sub>3</sub> and inert substances. The following experimental procedure was used to determine the mass percentages of FeO and Fe<sub>2</sub>O<sub>3</sub> in X.

A mass of 0.4800 g of X was dissolved in 10 cm<sup>3</sup> of concentrated acid. This solution was filtered to remove insoluble matter, and thereafter diluted to 50.00 cm<sup>3</sup> using distilled water. This entire diluted solution was titrated with 0.020 mol dm<sup>-3</sup> KMnO<sub>4</sub> solution. The titration reading at the end point was 20.00 cm<sup>3</sup>. The pH of the entire solution, obtained after the titration, was raised to 12. At this stage, the metal ions in solution were precipitated as their hydroxides. The precipitate was filtered and dried until a constant mass was obtained. The mass of the precipitate obtained was 0.5706 g.

- (i) Write balanced chemical equations for titration and precipitation reactions.

- (ii) Calculate the mass percentages of FeO and Fe<sub>2</sub>O<sub>3</sub> in X.

Note: Assume that the composition does not change during drying of metal hydroxides and there is no effect from dissolved oxygen in solution.

(H = 1, O = 16, Mn = 55, Fe = 56)

(75 marks)

[see page fourteen]

**10.(a)** The following questions [(i) – (v)] are based on the manufacture of sulphuric acid by the Contact Process.

- (i) State the three raw materials used.
- (ii) Write balanced chemical equations for the reactions taking place. State proper conditions where necessary.
- (iii) State two strategies used to increase the efficiency of the Contact Process.
- (iv) State two principles used in the determination of the optimum conditions for the Contact Process and briefly explain each principle using a reaction you specified in part (ii) above.
- (v) Name two industries which utilize sulphuric acid as a raw material.

(50 marks)

**(b)** Gaseous compounds of carbon, nitrogen and sulphur with various oxidation numbers directly contribute to global environment issues.

- (i) Name two non-halogenated carbon compounds and one nitrogen compound that directly contribute to global warming and state the oxidation numbers of C and N in these compounds.
- (ii) State how the three compounds you named in (i) above are released to the atmosphere due to human activities.
- (iii) Explain how the compounds you mentioned in (i) above contribute to global warming.
- (iv) Name two nitrogen compounds with the oxidation numbers of N that directly contribute to photochemical smog.
- (v) Write balanced chemical equations for the formation of tropospheric ozone by a nitrogen compound you stated in (iv) above.
- (vi) Explain why the tropospheric ozone level reaches its maximum level in the afternoon.
- (vii) State three water quality parameters that are affected as a result of the dissolution of oxides of nitrogen and sulphur in water bodies.

(50 marks)

**(c)** The following questions are based on chemical products related to plant sources.

- (i) Give relevant balanced equations to indicate the chemical changes that take place when ethanol in coconut toddy is produced by fermentation of sweet toddy.
- (ii) Explain why it is necessary to remove free fatty acids from plant oils taken as raw materials in the production of bio-diesel.
- (iii) Explain briefly why essential oils can be extracted from plant materials by steam distillation, at a temperature which is below the boiling points of both pure water and essential oil.

(50 marks)

\* \* \*





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මිනින්දෝ ශේෂක ඉකළතින්  
නිවසටම ගෙනවා ගනන



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කෙටි සටහන්, වැඩි පොත්, අතිරේක කියවීම් පොත්, සාරු  
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