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අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2022(2023)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2022(2023)
General Certificate of Education (Adv. Level) Examination, 2022(2023)

රසායන විද්‍යාව I
இரசாயனவியல் I
Chemistry I

02 E I

පැය දෙකයි
இரண்டு மணித்தியாலம்
Two hours

Instructions:

- *Periodic Table is provided.*
- *This paper consists of* 09 *pages.*
- *Answer all the questions.*
- *Use of calculators is not allowed.*
- *Write your **Index Number** in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is **correct** or **most appropriate** and **mark** your response on the answer sheet with a cross* (×) *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 $c = 3 \times 10^{8}\ \text{m s}^{-1}$

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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 Na^+, Mg^{2+}, K^+ and Ca^{2+}, the two ions closest to each other in size are K^+ and Mg^{2+}.
(5) Electron gain energy of carbon is negative.

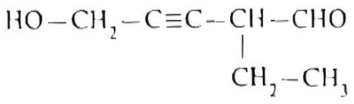
3. The **increasing** order of the second ionization energy ($X^+(g) \rightarrow X^{2+}(g) + e$) of Be, B and O is,

(1) Be < B < O
(2) Be < O < B
(3) B < O < Be
(4) B < Be < O
(5) O < Be < B

4. The shapes of F_3ClO, $FClO_2$ and $FClO_3$ 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?



$$HO-CH_2-C\equiv C-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-CHO$$

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

6. A saturated aqueous solution of a sparingly soluble salt AB_2 was prepared at 25 °C. Solubili product of AB_2 at 25 °C is 3.20×10^{-8} mol^3 dm^{-9}. The concentration of ion B^- (mol dm^{-3}) in t 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) 2.0×10^{-3} (5) 4.0×10^{-3}

7. Select the correct statement.
(1) The polarizability of F^-, Cl^- and S^{2-} ions increases in the order $F^- < S^{2-} < Cl^-$.
(2) The polarizing power of Li^+, Na^+ and Mg^{2+} decreases in the order $Mg^{2+} > Na^+ > Li^+$.
(3) The electronegativity of O, F, Cl and S decreases in the order F > O > S > Cl.
(4) The boiling points of Xe, CH_4, CH_3NH_2 and CH_3OH increase in the order $CH_4 < Xe < CH_3NH_2 < CH_3OH$.
(5) The interatomic bond distances of N_2, O_2, F_2 and HF increase in the order $N_2 < O_2 < F_2 <$ HF

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

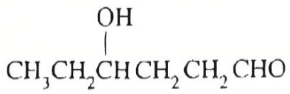
(1) C_5H_{10} (2) C_3H_6 (3) C_4H_6 (4) $C_4H_{10}O$ (5) C_4H_{10}

9. The **increasing** order of electronegativity of the carbon (C) atom in CH_4, CH_3Cl, H_2CO, HCN and NCO^- is

(1) $CH_4 < H_2CO < CH_3Cl < HCN < NCO^-$
(2) $CH_3Cl < CH_4 < H_2CO < HCN < NCO^-$
(3) $CH_4 < CH_3Cl < H_2CO < HCN < NCO^-$
(4) $CH_4 < CH_3Cl < NCO^- < H_2CO < HCN$
(5) $NCO^- < HCN < H_2CO < CH_4 < CH_3Cl$

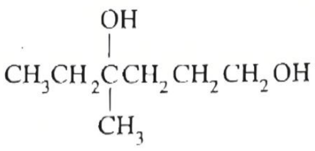
10. The organic compound **X** does not give a coloured precipitate when treated with 2,4-DNP. When compound **X** is treated with acidic $K_2Cr_2O_7$ product **Y** is formed. The product **Y** gives a coloured precipitate with 2,4-DNP. **Y** liberates CO_2 when treated with aqueous Na_2CO_3 solution. Compound **X** could be,

(1)



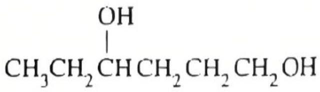
$$CH_3CH_2\overset{\displaystyle OH}{\overset{|}{C}}HCH_2CH_2CHO$$

(2)



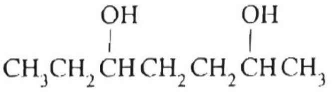
$$CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle OH}{\overset{|}{C}}}}CH_2CH_2CH_2OH$$

(3)



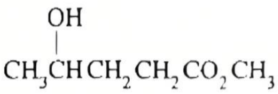
$$CH_3CH_2\overset{\displaystyle OH}{\overset{|}{C}}HCH_2CH_2CH_2OH$$

(4)



$$CH_3CH_2\overset{\displaystyle OH}{\overset{|}{C}}HCH_2CH_2\overset{\displaystyle OH}{\overset{|}{C}}HCH_3$$

(5)



$$CH_3\overset{\displaystyle OH}{\overset{|}{C}}HCH_2CH_2CO_2CH_3$$

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

$$A(g) + B(g) \rightleftharpoons 2C(g) : \Delta H < 0$$

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 $X(aq) + Y(aq) \longrightarrow Z(aq)$ at a given temperature are given in the table below.

Experiment	$[X(aq)]_0$/mol dm^{-3}	$[Y(aq)]_0$/mol dm^{-3}	Initial rate/mol dm^{-3} 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 (FeC_2O_4) was dissolved in excess dilute H_2SO_4. The entire solution was titrated with 0.060 mol dm^{-3} $KMnO_4$ solution. The burette reading at the end point is (relative molecular mass of FeC_2O_4 = 143.8)

(1) 20.00 cm^3 (2) 25.00 cm^3 (3) 30.00 cm^3 (4) 40.00 cm^3 (5) 50.00 cm^3

14. At a given temperature a certain number of moles of $H_2S(g)$ was inserted into an evacuated 1.0 dm^3 closed rigid container and the system was allowed to reach the equilibrium shown below.

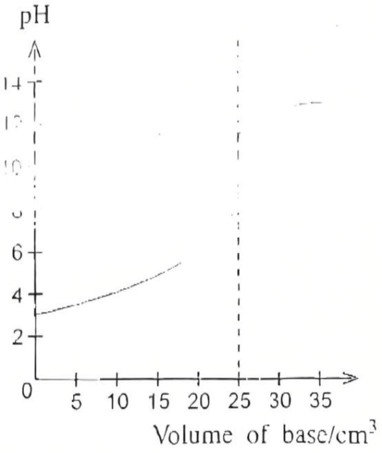
$$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$$

At equilibrium, it was found that a fraction x of $H_2S(g)$ 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) $\frac{x^2P}{(2+x)(1-x)^2}$ (2) $\frac{(2+x)(1-x)^2P}{x^3}$ (3) $\frac{x^3P}{(2+x)(1-x)^2}$

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

15. The pH curve obtained for a titration of 25.00 cm^3 of 0.10 mol dm^{-3} unknown acid with 0.10 mol 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?
    (1) Although xenon (Xe) is an inert gas, it forms compounds with oxidation number: +2, +4 and +6.
    (2) Among the hydrogen halides, HF has the highest bond dissociation energy.
    (3) The solubility of the hydroxides of Group two (II) elements in water decreases on descendin the group, while the solubility of their sulfates increases.
    (4) Among the Group one (I) metals (Li to Cs) cesium has the lowest melting point.
    (5) The oxidation number of nitrogen in NH_2OH is −1.

17. At 25 °C, to V_1 cm^3 of x mol dm^{-3} $CH_3COOH(aq)$ solution in a beaker, V_2 cm^3 ($V_2 > V_1$) o y mol dm^{-3} ($y > x$) NaOH(aq) solution was added. The pH of the final mixture is,
    (K_w is the dissociation constant of water at 25 °C)
    (1) $\mathrm{p}K_w - \log\left\{\frac{V_2y - V_1x}{V_1 + V_2}\right\}$
    (2) $\mathrm{p}K_w + \log\left\{\frac{V_2y - V_1x}{V_1 + V_2}\right\}$
    (3) $\mathrm{p}K_w$
    (4) $-\mathrm{p}K_w - \log\left\{\frac{V_2y - V_1x}{V_1 + V_2}\right\}$
    (5) $-\mathrm{p}K_w + \log\left\{\frac{V_2y - V_1x}{V_1 + V_2}\right\}$

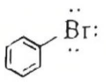
18. Which of the following statements is **incorrect** with regard to the reaction given below undc standard conditions?

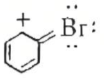
$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g) : \Delta H^o = -483.7 \text{ kJ mol}^{-1}$$

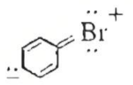
    (1) For one mole of reaction 483.7 kJ heat energy is evolved.
    (2) For two moles of $H_2(g)$ consumed, 483.7 kJ heat energy is evolved.
    (3) For two moles of $H_2O(g)$ produced, 483.7 kJ heat energy is evolved.
    (4) For the reaction $4H_2(g) + 2O_2(g) \longrightarrow 4H_2O(g)$, 967.4 kJ heat energy is evolved.
    (5) For one mole of $O_2(g)$ consumed, 241.85 kJ heat energy is evolved.

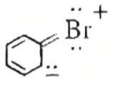
19. Which of the following statements is **incorrect** with regard to a galvanic cell?
    (1) Cell reaction is spontaneous.
    (2) Cell produces electrical energy.
    (3) Cathode is negatively charged.
    (4) Reduction half-reaction occurs at the cathode.
    (5) Oxidation half-reaction occurs at the anode.

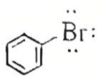
20. Which of the following is **not** a resonance structure of bromobenzene?

(1) 

(2) 

(3) 

(4) 

(5) 

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 H_2 and 2.0 mol of $O_2(g)$. Which of the following is true of the above two systems?
    (1) Both $H_2(g)$ and $O_2(g)$ have the same average kinetic energy.
    (2) Both $H_2(g)$ and $O_2(g)$ have the same average speed.
    (3) Both $H_2(g)$ and $O_2(g)$ have the same mass.
    (4) Both $H_2(g)$ and $O_2(g)$ have the same density.
    (5) Both $H_2(g)$ and $O_2(g)$ have the same effusion rate.

[*See page five*

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

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

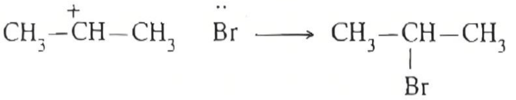
24. Consider the major product of the electrophilic addition reaction between $CH_3-CH=CH_2$ and HBr. Which of the following shows a correct step in the mechanism of the reaction which gives the major product?

(1) $CH_3-CH_2-\overset{+}{C}H_2 \quad \overset{\cdot\cdot\,-}{Br} \longrightarrow CH_3-CH_2-CH_2-Br$

(2) $CH_3-CH=CH_2 \quad \overset{+}{H} \longrightarrow CH_3-CH_2-\overset{+}{C}H_2$

(3) $CH_3-CH=CH_2 \quad H-Br \longrightarrow CH_3-\overset{+}{C}H-CH_3 + \overset{\cdot\cdot\,-}{Br}$

(4) $CH_3-CH=CH_2 \quad H-Br \longrightarrow CH_3-CH_2-\overset{+}{C}H_2 + \overset{\cdot\cdot\,-}{Br}$

(5) 
$CH_3-\overset{+}{C}H-CH_3 \quad \overset{\cdot\cdot}{Br} \longrightarrow CH_3-\underset{Br}{\underset{|}{C}H}-CH_3$

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 $\left(\frac{1}{4}\right)$. (2) becomes halved $\left(\frac{1}{2}\right)$.
(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.

$$Mg_3N_2(s) + 6H_2O(l) \rightarrow 3Mg(OH)_2(aq) + 2NH_3(g)$$
$$Li_3N(s) + 3H_2O(l) \rightarrow 3LiOH(aq) + NH_3(g)$$

A mixture containing three moles of magnesium metal and an unknown amount of lithium metal was reacted completely with excess N_2 gas. When the product mixture resulting from this reaction was completely reacted with excess water, 44.2 g of NH_3 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.

$$NO(g) + H_2(g) \rightarrow NH_3(g) + H_2O(g)$$

The maximum amount of NH_3 in grams that can be synthesized from 45.0 g of NO and 12.0 g of H_2 is
(Relative molecular mass: H_2 = 2, NO = 30, NH_3 = 17)

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

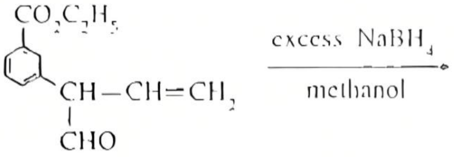
28. At a temperature of 25 °C, the E°_{cell} of the reaction $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ occurring in an electrochemical cell is +0.55 V while the half-reactions of this process are,

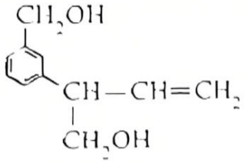
$$O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l) \text{ ------------ (1)}, \; E^{\circ}_1 = 1.23 \text{ V}$$
$$O_2(g) + 2H^+(aq) + 2e \rightarrow H_2O_2(aq) \text{ ------------ (2)}, \; E^{\circ}_2 = ?$$

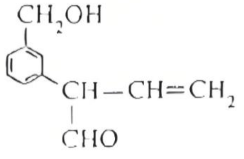
The standard reduction potential E°_2 of reaction (2) is

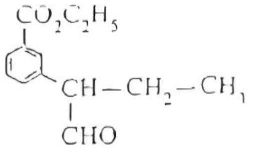
(1) −1.78 V (2) −0.68 V (3) 0.00 V (4) +0.68 V (5) +1.78 V

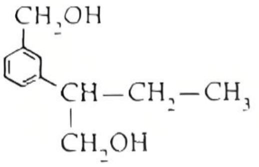
29. What could be the major product of the following reaction?

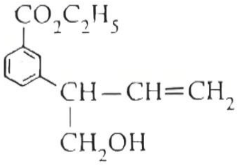


(1) 

(2) 

(3) 

(4) 

(5) 

30. Consider the reaction $3O_2(g) \rightleftharpoons 2O_3(g)$, ($K_C = 2.0 \times 10^{-56}$ mol^{-1} dm^3) at temperature 25 °C. $O_2(g)$ 0.30 mol and $O_3(g)$ 0.005 mol were inserted into an evacuated closed rigid 1.0 dm^3 container at 25 °C and the system was allowed to reach the equilibrium above. Which of the following best describes the system approaching equilibrium at 25 °C?

(Q_C is the reaction quotient)

(1) The amount of $O_3(g)$ increases to reach the equilibrium because $Q_C < K_C$
(2) The amount of $O_3(g)$ decreases to reach the equilibrium because $Q_C < K_C$
(3) The amount of $O_3(g)$ decreases to reach the equilibrium because $Q_C > K_C$
(4) The amount of $O_3(g)$ increases to reach the equilibrium because $Q_C > K_C$
(5) The amount of $O_3(g)$ 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

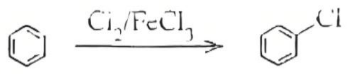
(1) if only (*a*) and (*b*) are correct.
(2) if only (*b*) and (*c*) are correct.
(3) if only (*c*) and (*d*) are correct.
(4) if only (*d*) and (*a*) are correct.
(5) if **any other** number or combination of responses is correct.

Summary of above Instructions

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

31. 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 °C
(*d*) Activation energy of the reaction

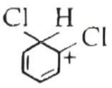
32. Consider the mechanism of the following reaction

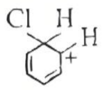


Which of the following ions is/are formed while this reaction is taking place?

(*a*) $\overset{-}{FeCl_4}$

(*b*) $\overset{+}{FeCl_4}$

(*c*) 

(*d*) 

33. At 25 °C, a 1.0 dm^3 aqueous solution of lead iodide (PbI_2) in equilibrium with an excess of solid lead iodide contains *a* mol of Pb^{2+}(aq) ions. Which of the following is/are correct for this system?
(*a*) The amount of Pb^{2+}(aq) will be 2*a* mol when the volume is doubled.
(*b*) The concentration of Pb^{2+}(aq) will be 2*a* mol dm^{-3} when the volume is doubled.
(*c*) The amount of Pb^{2+}(aq) will decrease when a small amount of solid NaI(s) is added.
(*d*) The amount of Pb^{2+}(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*) Cr_2O_3 is expected to react with strong acids and strong bases.
(*b*) When NaOH(aq) is added to solutions containing Fe^{2+}(aq), Fe^{3+}(aq), Mn^{2+}(aq) and Ni^{2+}(aq) precipitates which are insoluble in excess NaOH(aq) are formed.
(*c*) Both $KMnO_4$ and $K_2Cr_2O_7$ are strong oxidizing agents capable of converting H_2O_2 to O_2 gas under acidic conditions.
(*d*) The IUPAC name of $[CuCl_4]^{2-}$ 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 (HNO_3) and its salts?
(*a*) Both dilute and concentrated HNO_3 act as oxidizing agents.
(*b*) Thermal decomposition of NH_4NO_3 gives N_2O and water.
(*c*) N—O bonds of HNO_3 are all equal in length.
(*d*) Carbon does not react with concentrated 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^3 volume of 0.135 mol dm^{-3} aqueous solution of methylamine (CH_3NH_2) was shaken thoroughly with 75.00 cm^3 of water immiscible organic solvent in a closed bottle at 25 °C, and allowed to reach equilibrium. When 50.00 cm^3 of the aqueous layer was titrated with 0.200 mol dm^{-3} HCl solution, the end-point was 15.00 cm^3. No reaction occurs between methylamine and organic solvent. Which of the following is/are correct?
(*a*) Partition coefficient K_D of CH_3NH_2 between organic and aqueous layers is 1.67.
(*b*) Partition coefficient K_D of CH_3NH_2 between organic and aqueous layers is 4.67.
(*c*) CH_3NH_2 is more soluble in the aqueous layer.
(*d*) CH_3NH_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*) H_2S 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.

[*See page eight*

40. Which of the following statements is/are correct regarding the given industrial processes?
   (*a*) Coke, a raw material used in the extraction of iron by the Blast Furnance, functions on as a reducing agent.
   (*b*) A raw material used in the extraction of magnesium (Dow Process) can be regenerat utilizing a by-product formed during the electrolysis step.
   (*c*) In the manufacture of high purity TiO_2 using rutile, inorganic impurities are removed in t chlorination step.
   (*d*) 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 (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 $HClO_4 > HClO_3 > HClO_2 > HOCl$	When the oxidation number of the chlorine atom in the oxoacids of chlorine increases, the acidity o the oxoacid increases.
42.	When H_2S gas reacts with an acidic solution of $K_2Cr_2O_7$, elemental sulphur is formed.	H_2S gas can act as a reducing agent in acidi medium.
43.	An electrochemical cell based on the reaction $Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(s)$ can be used to generate electricity.	$Cl_2(g)$ is a stronger reducing agent than $I_2(s)$.
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 (0–5 °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 SO_3 and 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 $t_{1/2} = 50$ s, 87.5% of the reaction is completed after 150 s.
49.	In the manufacture of NH_3 gas by the Haber-Bosch process temperatures higher than 600 °C are used.	The activation energy of 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.

* * *

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 N_2O molecule is 3. ....

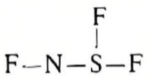
(iv) Among the second row elements of the Periodic Table, fluorine has the largest negative value of electron gain energy. ....

(v) The boiling point of argon (Ar) is higher than that of chlorine (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.

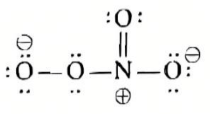


(ii) Give, (I) shapes around the N and S atoms and (II) oxidation numbers of the atoms in the structure drawn in (i) above.

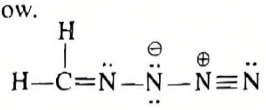
(I) N .... , S .... (shape)

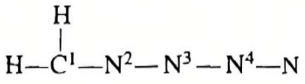
(II) N .... , S .... (oxidation number)

(iii) A Lewis dot-dash structure for the NO_4^- ion is given below. Draw **three** more Lewis dot-dash structures (resonance structures) for the NO_4^- ion .



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





		C^1	N^2	N^3	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				

[see page thre

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 σ bonds between the two atoms given below.

I. H—C^1 H .... C^1 ....

II. C^1—N^2 C^1 .... N^2 ....

III. N^2—N^3 N^2 .... N^3 ....

IV. N^3—N^4 N^3 .... N^4 ....

V. N^4—N N^4 .... N ....

(vi) Identify the atomic orbitals involved in the formation of π bonds between the atoms given below.

I. C^1—N^2 C^1 .... N^2 ....

II. N^4—N N^4 .... N ....

N^4 .... N ....

(vii) State the approximate bond angles around C^1, N^2, N^3 and N^4 atoms.

C^1............, N^2 ...., N^3 ...., N^4............

(viii) Arrange the atoms N^2, N^3 and 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) CaF_2, $CaCl_2$, $CaBr_2$, CaI_2 (ionic character)

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

(ii) ClF_5, ClF_2^+, ClF_2^- (bond angle)

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

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

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

(iv) CO, CO_3^{2-}, HCO_2^-, H_2CO, CH_3OH (C—O bond length)

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

(v) Li, N, F, Mg, P (first ionization energy)

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

(20 *marks*)

.00

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 3*d* element found in hematite. When $BaCl_2(aq)$ is added to an aqueous solution of **F**, the white precipitate **G** that is insoluble in dil. H_2SO_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. H_2SO_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. H_2SO_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 $CaCl_2(aq)$, the white precipitate **K** is formed. **K** reacts with dil. H_2SO_4 to give the weak dibasic acid **L** as one of the products. A warm solution of **J** acidified with dil. H_2SO_4 decolourizes 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**.

[see page five

Do not write in this 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**

(80 *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. $HNO_3(aq)$ ....

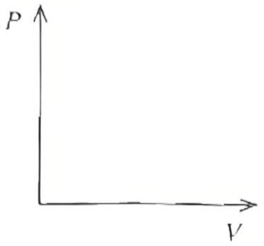
(20 *marks*)

100

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*.

(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.

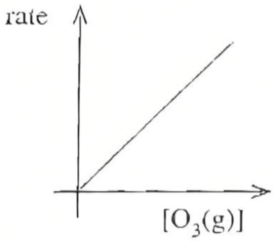
Step 1: $O_3(g) + Cl(g) \rightarrow O_2(g) + ClO(g)$

Step 2: $ClO(g) + O(g) \rightarrow Cl(g) + O_2(g)$

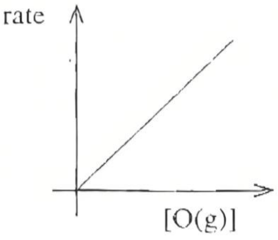
(i) Write the overall reaction for the mechanism given above.

(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 mol dm^{-3} s^{-1} and 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.

Do not write in this column.

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 1.0×10^{-3} mol dm^{-3} and 1.0×10^{-4} mol dm^{-3} respectively. The rate of the reaction was found to be 1.0×10^{-3} mol dm^{-3} s^{-1}. Calculate the value of k.

100

(70 *marks*)

(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

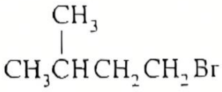
[see page eight

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

(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.

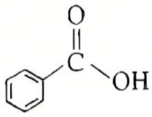
(I)



$CH_3\overset{\overset{CH_3}{|}}{C}HCH_2CH_2Br \xrightarrow{\text{alcoholic KOH}}$

J

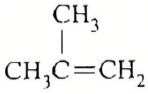
(II)



$\xrightarrow{\text{conc. } HNO_3\text{/conc. } H_2SO_4}$

K

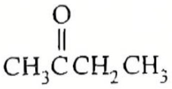
(III)



$CH_3\overset{\overset{CH_3}{|}}{C}=CH_2 \xrightarrow{HBr}$

L

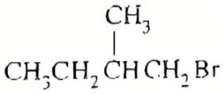
(IV)



$CH_3\overset{\overset{O}{\|}}{C}CH_2CH_3 \xrightarrow{HCN}$

M

(V)



$CH_3CH_2\overset{\overset{CH_3}{|}}{C}HCH_2Br \xrightarrow{KCN}$

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*)

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2022(2023)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2022(2023)
General Certificate of Education (Adv. Level) Examination, 2022(2023)

රසායන විද්‍යාව II
இரசாயனவியல் 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.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \text{ -------------- (1)}$$

Initially, 0.45 mol of HI(g) was introduced into a 1.0 dm³ evacuated rigid closed container at 800 °C, and allowed to reach the equilibrium given above. It was found that 0.05 mol of $H_2(g)$ was present at equilibrium.

(i) Calculate the equilibrium constant K_{C_1}, for the above equilibrium at a temperature of 800 °C.

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

$$2H_2(g) + S_2(g) \rightleftharpoons 2H_2S(g) \text{ -------------- (2)}$$

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

$$2I_2(g) + 2H_2S(g) \rightleftharpoons S_2(g) + 4HI(g) \text{ -------------- (3)}$$

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

(iii) A 1.0 dm³ rigid closed container at a temperature of 800 °C contains an equilibrium mixture of (3) in (ii) above with 5.00×10^{-5} mol HI(g), 1.25×10^{-6} mol $S_2(g)$ and 2.50×10^{-5} mol $H_2S(g)$. Calculate the number of moles of $I_2(g)$ in the above mixture.

(iv) An extra 2.50×10^{-5} mol $I_2(g)$ was added to the equilibrium mixture in (iii) above at a temperature of 800 °C.

I. Calculate the reaction quotient (Q_C) at the moment the extra $I_2(g)$ is added.

II. Explain the change in the equilibrium that takes place upon the addition of extra $I_2(g)$.

III. Sketch the variation in the concentrations of each constituent in the mixture, with time, upon the addition of extra $I_2(g)$.

(60 *marks*)

(*b*) (i) Using the data given below, calculate ΔH°, ΔS° and ΔG° for the reaction (4) at 27 °C.

$$H_2(g) + I_2(g) \longrightarrow 2HI(g) \text{ -------------- (4)}$$

At 27 °C : $H_2(g) + I_2(s) \longrightarrow 2HI(g)$; $\Delta H^\circ = 53\ \text{kJ mol}^{-1}$, $\Delta S^\circ = 410\ \text{J K}^{-1}\ \text{mol}^{-1}$

$I_2(s) \longrightarrow I_2(g)$; $\Delta H^\circ = 63\ \text{kJ mol}^{-1}$, $\Delta S^\circ = 260\ \text{J K}^{-1}\ \text{mol}^{-1}$

(ii) Using the data given below, calculate ΔH°, ΔS° and ΔG° for the reaction (5) at 27 °C.

$$2H_2S(g) \longrightarrow 2H_2(g) + S_2(g) \text{ -------------- (5)}$$

At 27 °C:

		ΔH_f° / kJ mol^{-1}	ΔS_f° / J K^{-1} mol^{-1}
$H_2(g)$	:	0	130
$S_2(g)$	:	127	230
$H_2S(g)$	:	–20	200

[see page ten

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

$$2I_2(g) + 2H_2S(g) \longrightarrow S_2(g) + 4HI(g) \text{ -------------- (6)}$$

(60 *marks*)

(*c*) An aqueous solution of volume 1.0 dm^3 in a beaker at a temperature of 25 °C contain 2.0×10^{-2} mol of $Cl^-(aq)$ ions and 2.0×10^{-2} mol of $CrO_4^{2-}(aq)$ ions. Small portions o concentrated aqueous $AgNO_3$ solution were added **slowly** to the above solution. At 25 °C K_{sp} (AgCl(s)) = 1.60×10^{-10} mol^2 dm^{-6} and K_{sp} (Ag_2CrO_4(s)) = 8.0×10^{-12} mol^3 dm^{-9}. Assume that there was no significant change in solution volume upon the addition of $AgNO_3$(aq) solution.

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

(ii) Calculate the concentration of $Cl^-(aq)$ ions present in the solution at the time Ag_2CrO_4 starts to precipitate.

(30 *marks*)

6\. (*a*) You are provided with an aqueous solution of sodium acetate (CH_3COONa) 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_3COOH (aq), and H_2O (l) are K_a and K_w respectively at 25 °C, show that $K_h = \dfrac{K_w}{K_a}$.

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

(v) A portion of 25.00 cm^3 of 0.10 mol dm^{-3} CH_3COONa solution is titrated with a solution of 0.10 mol dm^{-3} HCl. What is the volume of 0.10 mol dm^{-3} 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^{-3} CH_3COOH solution with a solution of 0.10 mol dm^{-3} 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^o and P_B^o respectively.

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

(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_{total} and label the diagram.

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

(60 *marks*)

[see page eleven

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

$$2H_2O(l) + O_2(g) + 4e \rightarrow 4OH^-(aq) \text{ ------------- } (1);\ E^\circ = 0.40\ V$$

$$2H_2O(l) + 2e \rightarrow H_2(g) + 2OH^-(aq) \text{ ------------- } (2);\ E^\circ = -0.83\ V$$

(i) Identify the anodic and cathodic half reactions of the cell.

(ii) Write the overall balanced cell reaction of the cell.

(iii) Calculate E°_{cell} of the cell at 25 °C.

(iv) The cell was operated for a duration of 600 s. During this period, 1.0 mol $H_2(g)$ 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 ($1\ F = 96500\ C\ mol^{-1}$).

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 ($C_3H_8(g)$) is used instead of $H_2(g)$.

I. Write the half-cell reaction for the propane electrode assuming propane is converted to $CO_2(g)$ and $H_2O(l)$.

II. Derive the balanced equation for the overall cell reaction by using propane instead of $H_2(g)$ in the answer given in (ii) above.

III. Giving reasons, state one environmental advantage of the cell which uses $H_2(g)$ 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 $\mathbf{X_1}$ and the gas $\mathbf{X_2}$ are obtained. When $\mathbf{X_1}$ is treated with dil. NH_4OH/NH_4Cl and H_2S is bubbled through the solution thereafter, the white precipitate $\mathbf{X_3}$ is obtained. $\mathbf{X_3}$ is soluble in dil. HCl. On addition of dil. NaOH to $\mathbf{X_1}$, the gelatinous white precipitate $\mathbf{X_4}$ is formed. $\mathbf{X_4}$ dissolves in excess dil. NaOH and in excess dil. NH_4OH to give $\mathbf{X_5}$ and $\mathbf{X_6}$ respectively. Both $\mathbf{X_5}$ and $\mathbf{X_6}$ are colourless.

I. Identify the species **X** and $\mathbf{X_1}$ to $\mathbf{X_6}$. (Give chemical formulae) **Note:** Reasons are not required.

II. Write the electronic configuration of **X**.

III. Explain why $\mathbf{X_1}$ is colourless.

IV. Write the IUPAC name of $\mathbf{X_6}$.

(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**. $\mathbf{Y^{n+}}$ forms the pink coloured species $\mathbf{Y_1}$ in aqueous solution. On treatment of the solution containing $\mathbf{Y_1}$ with dil. NaOH the pink precipitate $\mathbf{Y_2}$ is formed. When H_2S is bubbled through a slightly basic solution containing $\mathbf{Y_1}$, the black precipitate $\mathbf{Y_3}$ is obtained. The yellowish-brown species $\mathbf{Y_4}$ is formed on addition of excess conc. ammonia to a solution containing $\mathbf{Y_1}$. On treatment of a solution containing $\mathbf{Y_1}$ with conc. HCl, the blue coloured species $\mathbf{Y_5}$ is obtained. On exposure of $\mathbf{Y_4}$ to air, the brownish-red species $\mathbf{Y_6}$ is formed.

I. Give the values of **n** and **m**.

II. Identify the species **Y** and $\mathbf{Y_1}$ to $\mathbf{Y_6}$. (Give chemical formulae) **Note:** Reasons are not required.

III. Write the electronic configurations of $\mathbf{Y^{n+}}$ and $\mathbf{Y^{m+}}$.

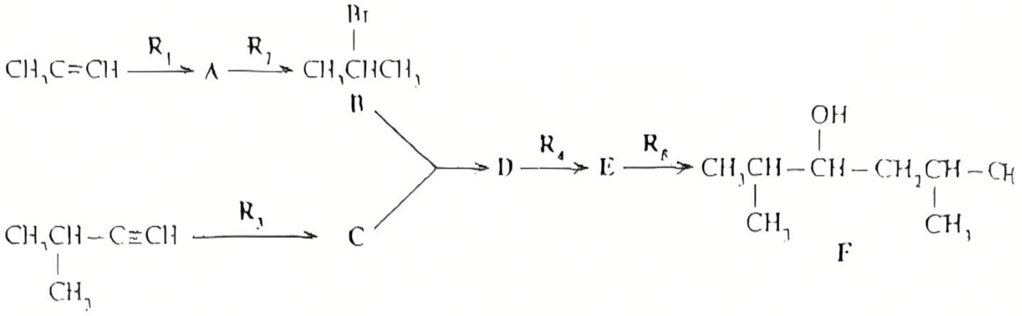
IV. Write the IUPAC name of $\mathbf{Y_5}$. (75 *marks*)

[*see page twelve*

PART C — ESSAY

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

8. (a) Preparation of the compound F has been carried out using $CH_3C\equiv CH$ and $(CH_3)_2CHC\equiv C$ according to the reaction scheme given below.



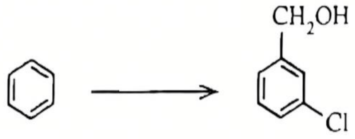
(i) Give the structures of the compounds A, C, D and E and the reagents R_1, R_2, R_3, R_4 and R_5.
Only the chemical substances given below should be used either **singly or as combinations** as reagents.

Chemical substances:
H_2, $NaNH_2$, $NaBH_4$, $HgSO_4$, HBr, dil. H_2SO_4, Pd-$BaSO_4$/Quinoline catalyst, CH_3OH

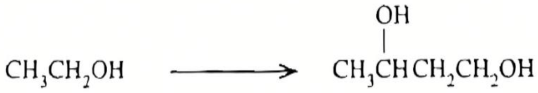
(ii) Compound F was reacted with $H^+/K_2Cr_2O_7$. When the product obtained from this reaction is reacted with 2, 4-dinitrophenylhydrazine (2, 4-DNP), compound **G** is formed. Give the structure of G.

(60 *marks*)

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



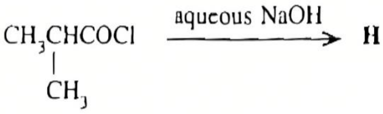
(ii) Show how the transformation given below can be carried out using not more than **three (03)** steps.



$$CH_3CH_2OH \longrightarrow CH_3\overset{OH}{\overset{|}{C}H}CH_2CH_2OH$$

(60 *marks*)

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



$$\underset{CH_3}{\underset{|}{CH_3CHCOCl}} \xrightarrow{\text{aqueous NaOH}} \mathbf{H}$$

(30 *marks*)

(*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.

(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_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 cm^3 of concentrated acid. This solution was filtered to remove insoluble matter, and thereafter diluted to 50.00 cm^3 using distilled water. This entire diluted solution was titrated with 0.020 mol dm^{-3} $KMnO_4$ solution. The titration reading at the end point was 20.00 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.

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

(ii) 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 Conta Process.

(i) State the **three** raw materials used.

(ii) Write balanced chemical equations for the reactions taking place. State proper condition 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 Contac 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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[*see page fifteen*