CBSE Class 11 Chemistry

Sample Paper 05 (2020-21)

Maximum Marks: 70

Time Allowed: 3 hours

General Instructions:

i. There are 33 questions in this question paper. All questions are compulsory.
ii. Section A: Q. No. 1 to 16 are objective type questions. Q. No. 1 and 2 are passage based questions carrying 4 marks each while Q. No. 3 to 16 carry 1 mark each.
iii. Section B: Q. No. 17 to 25 are short answer questions and carry 2 marks each.
iv. Section C: Q. No. 26 to 30 are short answer questions and carry 3 marks each.
v. Section D: Q. No. 31 to 33 are long answer questions carrying 5 marks each.
vi. There is no overall choice. However, internal choices have been provided.
vii. Use of calculators and log tables is not permitted.

Section A

1. **Read the passage and answer the following questions:**

   The group 2 elements comprise beryllium, magnesium, calcium, strontium, barium and radium. They follow alkali metals in the periodic table. The alkaline earth metals are less reactive than alkali metals. The reactivity of alkaline earth elements increases on going down the group. The alkaline earth metals dissolve in liquid ammonia to give deep blue-black solutions forming ammoniated ions.

   $Na_{(s)} + (x + y)NH_3 \rightarrow [Na(NH_3)_x]^+ + [e(NH_3)_y]^-$

   Beryllium and magnesium are kinetically inert to oxygen and water because of the formation of an oxide film on their surface. However, powdered beryllium burns brilliantly on ignition in the air to give BeO and Be_3N_2. Calcium, strontium, and barium are readily attacked by air to form the oxide and nitride. All the elements except beryllium combine with hydrogen upon heating to form their hydrides, MH_2. Beryllium is used in the manufacture of alloys. Copper-beryllium alloys are used in the preparation of high strength springs. Metallic beryllium is used for making windows of X-ray tubes.

i. Magnesium is more electropositive and burns with dazzling brilliance in the air to give
   a. MgO
   b. Mg_3N_2
   c. both (a) and (b)
   d. none of these

ii. Thermal decomposition of $(NH_4)_2BeF_4$ is the best route for the preparation of compound A. Identify the compound A?
   a. BeF_2
   b. BeF_4
   c. Be
   d. F

OR

Find the incorrect trend for alkaline earth metals
   a. atomic size Be < Mg < Ca < Sr
   b. second ionization energy Be < Mg < Ca < Sr
   c. Hydration enthalpy Sr < Ca < Mg < Be
   d. Density Ca < Mg < Be < Sr

iii. Which of the following element is used for the treatment of cancer?
   a. calcium
   b. strontium
   c. barium
   d. radium

iv. The reducing nature of beryllium is due to
   a. large hydration energy
   b. small size of Be^{2+} ion
   c. large value of the atomization enthalpy
   d. all of these

2. **Read the passage and answer the following questions:**

The orbital wave function or ψ for an electron in an atom has no physical meaning. 1s orbital the probability density is maximum at the nucleus and it decreases sharply as we

move away from it. After reaching a small maxima it decreases again and approaches zero as the value of r increases further. These probability density variation can be visualised in terms of charge cloud diagrams. Boundary surface diagrams of constant probability density for different orbitals give a fairly good representation of the shapes of the orbitals. A boundary surface or contour surface is drawn in space for an orbital on which the value of probability density $|\psi|^2$ is constant. The size of the s orbital increases with increase in n, that is, 4s > 3s > 2s > 1s and the electron is located further away from the nucleus as the principal quantum number increases.

In these questions, a statement of assertion followed by the statement of reason is given. Choose the correct answer out of the following choices:

a. Assertion and reason both are correct statements and reason is the correct explanation for assertion.
b. Assertion and reason both are correct statements and reason is not the correct explanation for assertion.
c. Assertion is the correct statement but reason is wrong statement.
d. Assertion is the wrong statement but reason is correct statement.

i. **Assertion:** The square of the wave function (i.e.,ψ 2) at a point gives the probability density of the electron at that point.
Reason: For 2s orbital the probability density first decreases sharply to zero and again starts increasing.

ii. **Assertion:** The total number of nodes are given by (n–2).
Reason: The probability density functions for the np and nd orbitals are zero at the plane.

iii. **Assertion:** Number of nodes for 2s orbital is one, two for 3s.
Reason: Number of nodes increases with increase of principal quantum number n.

iv. **Assertion:** The region where the probability density function reduces to zero is called nodal surfaces.
Reason: The five d-orbitals are designated as d_{xy^2} , d_{xy} , d_{zy^3} , d_{x^2} and d_{z^2}.

OR

Assertion: The probability density function is zero on the plane where the two lobes touch each other.
Reason: Each p orbital consists of two sections called lobes.

3. How many molecules of H_2O are there in 18g of water? (Hint: Avogadro's Number = 6.02 $\times 10^{23}$ atoms/mol)
   a. 6.02×10^{23}
   b. 5.02×10^{23}
   c. 8.02×10^{23}
   d. 7.02×10^{23}
4. How many neutrons and protons are there in the ${}^{13}_{6}C$ nucleus?
   a. 0, 13
   b. 8, 5
   c. 8, 6
   d. 7, 6

OR

Number of protons in sodium are 11. number of electrons in outermost shell will be

   a. 8
   b. 1
   c. 2
   d. 3
5. A gas decolourised by $KMnO_4$ solution but gives no precipitate with ammoniacal cuprous chloride is _____.
   a. Methane
   b. Ethene
   c. Ethane
   d. Acetylene
6. By convention, standard enthalpy for the formation of an element in reference state is:
   a. zero
   b. < 0
   c. unity
   d. different for each element.

OR

Which of the following statement is not correct?

a. ΔG is positive for a non-spontaneous reaction
b. ΔG is zero for a reaction at equilibrium
c. ΔG is positive for a spontaneous reaction
d. ΔG is negative for a spontaneous reaction

7. Alkaline earth metals are:
   A. more reactive
   B. less reducing
   C. more oxidizing
   D. less basic than alkali metals
   a. A and C
   b. B and D
   c. A and B
   d. C and D

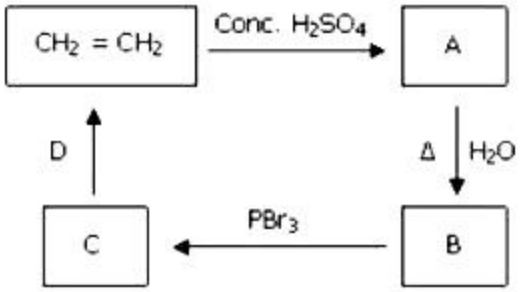
OR

Which one of the following is highly radioactive?

a. Francium
b. Lithium
c. Rubidium
d. Caesium

8. Which product is obtained by passing ethanol vapours over heated alumina?
   a. C_2H_2
   b. C_2H_6
   c. C_2H_4
   d. CH_4
9. In the Thomson Model of Atom:
   a. electrons move in circular orbits around nucleus
   b. electrons are embedded in a positively charged pudding or water melon
   c. electrons swarm like flies around nucleus
   d. electrons oscillate about the nucleus

10. Identify B and D in the following sequence of reactions.



   a. Ethyl - hydrogensulphate + alcoholic KOH
   b. Methanol, and Bromoethane
   c. Ethanol and alcoholic KOH
   d. Ethyl - hydrogensulphate + aqueous KOH

11. The product of the magnitude of the charge and the distance between the centres of positive and negative charge is called _____.
   a. Dipole moment
   b. ionic character
   c. covalent character
   d. electronegativity

12. **Assertion:** The sum of 154.2 + 6.1 + 23 is 183.
   Reason: The result of addition is reported to the same number of decimal places as that of the term with least number of decimal places.
   a. Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.
   b. Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.
   c. Assertion is CORRECT but, reason is INCORRECT.
   d. Assertion is INCORRECT but, reason is CORRECT.

13. **Assertion:** Diamond is a bad conductor of electricity.
   Reason: All C-C bond lengths in diamond are of 154 pm.
   a. Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.
   b. Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.
   c. Assertion is CORRECT but, reason is INCORRECT.
   d. Assertion is INCORRECT but, reason is CORRECT.

14. **Assertion (A):** The temperature at which vapour pressure of a liquid is equal to the external pressure is called boiling temperature.
    Reason (R): At high altitude atmospheric pressure is high.
    a. Both A and R are true and R is the correct explanation of A.
    b. Both A and R are true but R is not the correct explanation of A.
    c. A is true but R is false.
    d. A is false but R is true.

    OR

    Assertion (A): Liquids tend to have maximum number of molecules at their surface.
    Reason (R): Small liquid drops have spherical shape.

    a. Both A and R are true and R is the correct explanation of A.
    b. Both A and R are true but R is not the correct explanation of A.
    c. A is true but R is false.
    d. A is false but R is true.
15. **Assertion (A):** In the reaction between potassium permanganate and potassium iodide, permanganate ions act as an oxidising agent.
    Reason (R): Oxidation state of manganese changes from +2 to +7 during the reaction.
    a. Both A and R are true and R is the correct explanation of A.
    b. Both A and R are true but R is not the correct explanation of A.
    c. A is true but R is false.
    d. Both A and R are false.
16. **Assertion:** Trans-but -2-ene on reaction with Br gives meso-2, 3-dibromobutane.
    Reason: The reaction involves syn-addition of bromine.
    a. Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.
    b. Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.
    c. Assertion is INCORRECT but, reason is CORRECT.
    d. Assertion is CORRECT but, the reason is INCORRECT.

Section B

17. Give four examples of species which are isoelectronic with Ca^{2+} .

OR

Name the species that will be isoelectronic with the following atoms or ions:

i. Na

ii. Cl^-

iii. Ca^{2+}

iv. Rb^+

18. i. $CH_3—CH_2—CH_2—CH_2—OH$

ii. $CH_3 - CH_2 - \underset{\underset{OH}{|}}{CH} - CH_3$

iii. $CH_3 - \underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_3$

iv. $CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH_2 - OH$

v. $CH_3—CH_2—O—CH_2—CH$

vi. $CH_3—O—CH_2—CH_2—CH_3$

vii. $CH_3 - O - \underset{\underset{CH_3}{|}}{CH} - CH_3$

Identify the pairs of compounds that represent chain isomerism.

19. The solubility of product constants of Ag_2CrO_4 and AgBr are 1.1×10^{-12} and 5.0×10^{-13} respectively. Calculate the ratio of molarities of their saturated solutions.

OR

Which of the following reactions involve homogeneous equilibrium and which involve heterogeneous equilibrium?

i. $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$

ii. $2Cu(NO_3)_2(s) \rightleftharpoons 2CuO(s) + 4NO_2(g) + O_2(g)$

iii. $CH_3COOC_2H_5(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + C_2H_5OH(aq)$

iv. Fe_3+(aq) + 30H$^-$(aq) $\rightleftharpoons$ $Fe(OH)_3$(s)

20. Show the polarization of carbon-magnesium bond in the following structure: CH_3—CH_2—CH_2—CH_2—Mg—X.

OR

Why is a solution of potassium hydroxide used to absorb carbon dioxide evolved during the estimation of carbon present in an organic compound?

21. Explain the following: Soft water lathers with soap but not hard water.
22. Give chemical reactions to show the amphoteric nature of water.
23. Write equations for the preparation of
    i. HC≡CD and
    ii. DC≡CD
24. Predict the periods and blocks to which each of the following elements belong?
    i. $_{13}$Al
    ii. $_{24}$Cr
    iii. $_{29}$Cu
    iv. $_{11}$Na
25. Given the standard electrode potentials,

    K^+ /K = - 2.93V, Ag^+ /Ag = 0.80V,

    Hg^{2+}/Hg = 0.79V

    Mg^{2+}/Mg = - 2.37V. Cr^{3+}/Cr = - 0.74V

    arrange these metals in their increasing order of reducing power.

Section C

26. 2.9 g of a gas at 95°C occupied the same volume as 0.184 g of hydrogen at 17°C at the same pressure. What is the molar mass of the gas?

OR

A gaseous mixture containing 50 g of nitrogen and 10 g of oxygen were enclosed in a vessel of 10 L capacity at 27^{o}C. Calculate

i. the number of moles of each gas.

ii. the partial pressure of each gas.

iii. the total pressure of gaseous mixture.

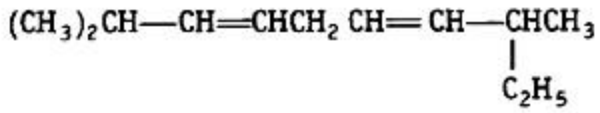
27. Two oxides of a metal contain 27.6% and 30.0% of oxygen respectively. If the formula of the first oxide is M_3O_4, find that of the second.

OR

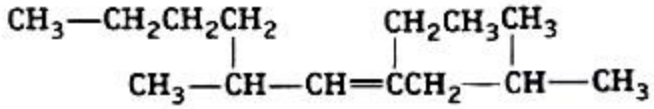
Balance the following skeleton equation by the method of partial equations

$$KMnO_4 + H_2SO_4 + (COOH)_2 \longrightarrow K_2SO_4 + MnSO_4 + CO_2 + H_2O$$

28. Write the IUPAC names of the following compounds.

i. 

ii. 

iii. 

Also calculate the number of σ and π -bonds.

29. Why is H_2O a liquid and H_2S a gas?

30. Calculate the work done when 11.2 g of iron dissolves in hydrochloric acid in

i. a closed vessel

ii. an open beaker at $25^\circ C$

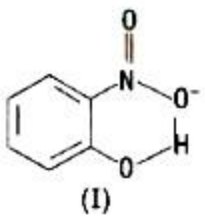
(Atomic mass of Fe = 56 u)

Section D

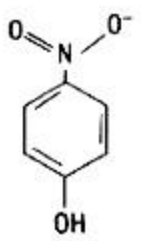
31. What is meant by the term bond order? Calculate the bond order of: N_2, O_2, O_2^+, O_2^-

OR

Structures of molecules of two compounds are given below.



(I)



(II)

i. Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding?

ii. The melting point of a compound depends on among other things, the extent of hydrogen bonding. On this basis, explain which of the above two compounds will show higher melting point?

iii. The solubility of compounds in water depends on the power to form hydrogen bonds with water. Which of the above compounds will form a hydrogen bond with water easily and be more soluble in it?

32. Reaction between nitrogen and oxygen takes place as follows:

$2N_2(g) + O_3(g) \rightleftharpoons 2N_2O(g)$

If a mixture of 0.482 mol of N_2 and 0.933 mol of O_2 is placed in a reaction vessel of volume

10 L and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37}$ determine the composition of the equilibrium mixture.

OR

The ionization constant of benzoic acid is 6.46×10^{-5} and K_{sp} for silver benzoate is 2.5×10^{-13}. How many times is silver benzoate more soluble in a buffer of pH 3.19 compared to its solubility in pure water?

33. Draw the structure of

i. 2-Chlorohexane,

ii. Pent-4-en-2-ol,

iii. Nitrocyclohaxene,

iv. Benzylpent-1-ene.

v. 6-Methyl,6-Hydroxyheptanal

OR

Explain the terms inductive and electromeric effects. Which electron displacement effect explain the following correct orders of acidity of the carboxylic acids?

i. Cl_3 CCOOH > Cl_2CHOOH > $ClCH_2COOH$

ii. CH_3CH_2COOH > $(CH_3)_2$ CHOOH > $(CH_3)_3$ C · COOH

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Solution

Section A

1. i. (c) both (a) and (b)

   ii. (a) BeF_2

OR

(b) second ionization energy Be < Mg < Ca < Sr

   iii. (d) radium

   iv. (d) all of these

2. i. (b) Assertion and reason both are correct statements and reason is not the correct explanation for assertion.

   ii. (d) Assertion is wrong statement but reason is correct statement.

   iii. (a) Assertion and reason both are correct statements and reason is the correct explanation for assertion.

   iv. (c) Assertion is correct statement but reason is wrong statement.

OR

(b) Assertion and reason both are correct statements and reason is not the correct explanation for assertion.

3. (a) 6.02×10^{23}

   Explanation: Since the molar mass of water

   = 18 g / mol

   ∴ 1 mol of water (ie. 18 g) would contain a number of molecules

   = Avogadro No. (N)

   = 6.02×10^{23}

   * Note that Avogadro number (N) represents the number of entities (atoms, molecules, ions, or any other particle) constituting one mole of a particular substance.

4. (d) 7, 6

   Explanation: Number of protons = Atomic number = 6

   Number of neutrons = atomic mass - no. of protons = 13 - 6 = 7

   OR

   (b) 1

   Explanation: 1

5. (b) Ethene

   Explanation: Due to unsaturation, ethene decolourises $KMnO_4$ solution forming glycol. However, it shows no reaction with ammoniacal cupric chloride.

6. (a) zero

   Explanation: By convention, enthalpies of formation of all elements in their most stable state of aggregation (reference state) at 25°C and 1atm are taken as zero.

   OR

   (c) ΔG is positive for a spontaneous reaction

   Explanation: ΔG < 0 (negative) for a spontaneous change.

7. (b) B and D

   Explanation: Alkali earth metals are weaker reducing agents then that of alkali metals and oxides of alkali metals are very basic in nature due to its highly electropositive nature.

   OR

   (a) Francium

   Explanation: Fr is a highly radioactive metal, that decays into astatine, radium, and radon. It is also highly unstable element found only in trace amount on earth.

8. (c) C_2H_4

   Explanation: It is an example of dehydration of alcohols to give alkenes.

   $$\underset{alcohol}{RCH_2 - CH_2OH} \xrightarrow[-H_2O]{Al_2O_3, 623K} \underset{alkene}{RCH = CH_2}$$

   For example,

$$\underset{ethanol}{C_2H_5OH} \xrightarrow[-H_2O]{Al_2O_3,623K} \underset{ethene}{CH_2=CH_2}$$

Thus, when ethanol vapours are passed over heated alumina, the alcohol gets dehydrated to form ethene, as given above.

9. (b) electrons are embedded in a positively charged pudding or water melon

   Explanation:

   - J. J. Thomson, who discovered the electron in 1897, proposed the plum pudding model of the atom in 1904 before the discovery of the atomic nucleus in order to include the electron in the atomic model.
   - In Thomson's model, the atom is composed of electrons surrounded by a soup of positive charge to balance the electrons' negative charges, like negatively charged "plums" surrounded by positively charged "pudding".
   - The 1904 Thomson model was disproved by Hans Geiger's and Ernest Marsden's 1909 gold foil experiment.

10. (c) Ethanol and alcoholic KOH

    Explanation: The given sequence of reactions conform to following stepwise conversions:

    Step (1) $C_2H_5OH \xrightarrow[110^oC]{conc.H_2SO_4} C_2H_5HSO_4$

    Step (2) $C_2H_5HSO_4 + H_2O \rightarrow CH_3CH_2OH + H_2SO_4$

    Step (3) $C_2H_5OH \xrightarrow{PBr_3} CH_3CH_2Br$

    Step (4) $CH_3CH_2Br \xrightarrow[heat]{alc.KOH} H_2C=CH_2 + HBr$

    Thus, the above sequence of reaction shows that the product 'B ' is C_2H_5OH (i.e. ethanol) and D is a reactant alcoholic KOH.

11. (a) Dipole moment

    Explanation: A dipole moment is a measurement of the separation of two opposite electrical charges. Dipole moments are a vector quantity. The magnitude is equal to the charge multiplied by the distance between the charges and the direction is from negative charge to positive charge: μ = q × r

12. (a) Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

Explanation: Both assertion and reason are CORRECT and reason is the CORRECT explanation of the assertion.

13. (b) Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

    Explanation: Both assertion and reason are CORRECT but, reason is NOT THE CORRECT explanation of the assertion.

14. (c) A is true but R is false.

    Explanation: Assertion is correct but the reason is wrong.

    The temperature at which the vapour pressure of a liquid becomes equal to the external pressure is called its boiling point. As the altitude is high, the pressure is low.

    OR

    (d) A is false but R is true.

    Explanation: Liquid try to reduce the number of the molecules and tends to reduce surface tension at their surface that's why liquid drops have a spherical shape.

15. (c) A is true but R is false.

    Explanation: As permanganate ion changes to MnO_2^-.

16. (d) Assertion is CORRECT but, the reason is INCORRECT.

    Explanation: Assertion is CORRECT but, the reason is INCORRECT.

Section B

17. Ca^{2+} has 18 electrons. Atoms or ions like Ar, K^+, Cl^-, S^{2-} or P^{3-} too have 18 electrons and are isoelectronic with Ca^{2+}.

    OR

    Isoelectronic species are those species which have same number of electrons.

    i. Na consists of 10 electrons.

       Also, the species N^{3-}, O^{2-}, Al^{3+} etc., contains 10 electrons.

       So they are isoelectronic with it.

    ii. Cl^- consists of 18 electrons.

       Also, the species P^{3-}, S^{2-}, Ca^{2+} etc., contains 18 electrons.

       So they are isoelectronic with it.

iii. Ca^{2+} consists of 18 electrons.

Also, the species P^{3-}, S^{2-}, K^{+} etc., contains 18 electrons.

So they are isoelectronic with it.

iv. Rb^{+} consists of 36 electrons.

Also, the species, Br^{-}, Kr, Sr^{2+} etc., contains 36 electrons.

So they are isoelectronic with it.

18. When two or more compounds have a similar molecular formula but different carbon skeletons, these are referred to as chain isomers and the phenomenon is termed as chain isomerism.

(i) and (iii); (i) and (iv); (ii) and (iii); (ii) and (iv) are chain isomers.

19. $\underset{s}{Ag_2CrO_4} \rightleftharpoons \underset{2s}{2Ag^+} + \underset{s}{CrO_4^{2-}}$; $K_{sp} = 1.1 \times 10^{-12}$ (*Solubility of Ag_2CrO_4 is 's' mol L^{-1}*)

$K_{sp} = [Ag^+]^2\,[CrO_4^{2-}]$

$\Rightarrow K_{sp} = (2s)^2 \times s = 4s^3$

$s^3 = \frac{K_{sp}}{4} = \frac{1.1\times10^{-12}}{4} = 0.275 \times 10^{-12}$

$\Rightarrow 3 \log s = \log 2.75 \times 10^{-13}$

$\Rightarrow \log s = -13 + 0.43393 = -12.5607$

$\Rightarrow \log s = \frac{-12.5607}{3} .1869 = \bar{5}.8131$

$\Rightarrow s = antilog\, \bar{5}.8131 = 6.503 \times 10^{-5}\, M$

$For,\ \underset{s}{AgBr} \rightleftharpoons \underset{s}{Ag^+} + \underset{s}{Br^-}$; $K_{sp} = 5.0 \times 10^{-13}$ (*Solubility of AgBr is 's' mol L^{-1}*)

$K_{sp} = [Ag^+]\,[Br]$

$\Rightarrow K_{sp} = (s) \times s = s^2$

$\Rightarrow s^2 = \sqrt{K_{sp}} = \sqrt{5.0 \times 10^{-13}} = 7.07 \times 10^{-7}$

Now, Ratio of their solubilities :

$\left[\frac{S(Ag_2CrO_4)}{S(AgBr)} = \frac{6.5\times10^{-5}}{7.07\times10^{-7}}\right] = 91.9 = 92.$

Ag_2CrO_4 is 92 times more soluble than AgBr.

OR

i. The reaction involves *Homogeneous* equilibrium as all the reactants and products are in same phase i.e. gas phase.

ii. The reaction involves *Heterogeneous* equilibrium as the reactants and products are in

different phases.

iii. The reaction involves *Homogeneous* equilibrium as all the reactants and products are in same phase.

iv. The reaction involves *Heterogeneous* equilibrium as the reactants and product are in different phases.

20. Carbon is more electronegative than magnesium.So, Mg has a partially positive charge and C has a partially negative charge because a bonded pair of electrons attracted towards carbon.$CH_3 - CH_2 - \overset{\delta-}{C}H_2 - CH_2 < -\overset{\delta+}{M}g - X$

OR

CO_2 is acidic in nature and therefore, it reacts with the strong base KOH to form K_2CO_3.

$$\mathbf{2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O}$$

21. Soft water lathers with soap but hard water doesn't because of the presence of Ca^{2+} and Mg^{2+} ions in hard water which exchange with Na^+ ions of the soap to form corresponding calcium and magnesium salts that form insoluble precipitates.

$$\underset{Soap}{RCOONa} + \underset{(Hardwater)}{Ca^{2+}} \rightarrow \underset{ppt.}{(RCOO)_2 Ca} + 2Na^+$$

$$\underset{Soap}{RCOONa} + \underset{(Hardwater)}{Mg^{2+}} \rightarrow \underset{ppt.}{(RCOO)_2 Ca} + 2Na^+$$

22. Water is amphoteric in nature because it act as an acid as well as base.

$$\underset{Base\ 1}{H_2O(l)} + \underset{Acid\ 2}{H_2S(aq)} \rightarrow \underset{Acid\ 1}{H_3O^+(aq)} + \underset{Base\ 2}{HS^-(aq)}$$

$$\underset{Acid\ 1}{H_2O(l)} + \underset{Base\ 2}{NH_3(aq)} \rightarrow \underset{Acid\ 2}{NH_4^+(aq)} + \underset{Base\ 1}{OH^-(aq)}$$

23. i. $\mathbf{HC \equiv CH \xrightarrow{NaNH_2} HC \equiv C^-Na^+ \xrightarrow{D_2O} HC \equiv CD}$

Here, Strong base $NaNH_2$ deprotonated the alkynes to give so-called acetylide ions.

ii. $\mathbf{HC \equiv CH \xrightarrow{2Na} Na^+C^- \equiv C^-Na^+ \xrightarrow{D_2O} DC \equiv CD}$

Here, sodium metal is one-electron reducing agent.

24. i. Electronic configuration of $_{13}$Al is [Ne] $3s^2\ 3p^1$.

As the last electron enters into p - subshell, it belongs to the 3rd period, 13th group and p-block.

ii. Electronic configuration of $_{24}$Cr is [Ar] $4s^1 3d^5$.

As the last electron enters into d - subshell, it belongs to the 4th period, 6th group and

d-block.

iii. Electronic configuration of $_{29}Cu$ is $[Ar]4s^1 3d^{10}$.

As the last electron enters into d - subshell, it belongs to the 11th period, 13th group and d-block.

iv. Electronic configuration of $_{11}Na$ is $[Ne]\ 3s^1$.

As the last electron enters into s - subshell, it belongs to the 3rd period, 1st group and s-block.

25. The lower the electrode potential, the stronger is the reducing agent the species is. Therefore, the increasing order of the reducing power of the given metals is Ag < Hg < Cr < Mg < K.

Section C

26. As Initial pressure P_1 = Final pressure P_2 and Initial volume V_1 = Final volume V_2, Initial temperature T_1=95°C, Final temperature T_2=17°C

$\therefore P_1V_2 = P_2V_2$ and hence $n_1RT_1 = n_2RT_2$

$\therefore n_1T_1 = n_2T_2$

or $\frac{w_1}{M_1}T_1 = \frac{w_2}{M_2}T_2$

Where w_1=mass of gas 1=2.9 g, w_2=mass of hydrogen=0.184 g, molar mass of gas 1=M_1, molar mass of hydrogen=2 g/mol

$\frac{2.9}{M_1} \times (95 + 273) = \frac{0.184}{2} \times (17 + 273)$ or $M_1 = \frac{2.9 \times 368 \times 2}{0.184 \times 290} = 40g\ mol^{-1}$

OR

Volume of vessel = 10 L

Temperature = 27 + 273 = 300 K

Step I. To calculate the moles of each gas

Weight of nitrogen = 50 g

Molar mass of nitrogen = 28

Mole of nitrogen = $\frac{50}{28}$ = 1.79

Weight of oxygen = 10 g

Molar mass of oxygen = 32

Moles of oxygen = $\frac{10}{32}$ = 0.31

Step II. To calculate the partial pressure of each gas.

According to general gas equation

pV = nRT or $p = \frac{n\text{RT}}{\text{V}}$

∴ Partial pressure of nitrogen,

$P_{\text{N}_2} = \frac{1.79 \times 0.082 \times 300}{10} = 4.40\text{atm}$

Partial pressure of oxygen,

$P_{\text{O}_2} = \frac{0.31 \times 0.082 \times 300}{10} = 0.76\text{atm}$

Step III. To calculate the total pressure.

According to Dalton's law of partial pressures, the total pressure of the gaseous mixture:

$p = p_{N_2} + p_{\text{O}_2}$

= 4.40 + 0.76 = 5.16 atm.

27. Ratio of metal and oxygen in first oxide, M_3O_4 = 72.4 : 27.6

Ratio of metal and oxygen in second oxide = 70:30

Let molecular mass of metal =M

Therefore, the percentage by weight of the metal in the oxide = $\frac{3 \times M \times 100}{3 \times M + 4 \times O} = 72.4$

$\frac{3 \times M \times 100}{3 \times M + 4 \times 16} = \frac{72.4}{1}$

300M = 217.2 M + 4633.6

$\Rightarrow 300M - 217.2M = 82.8M = 4633.6$

$\Rightarrow M = \frac{4633.6}{82.8} = 55.96 \approx 56$

Moles of of metal in second oxide = 70/56=1.25

Moles of oxygen in second oxide =30/16= 1.875

Ratio of moles of metal and oxygen in second oxide =1.25 : 1.875 = 1 :1.5 =2:3

Hence, Formula of second oxide =M_2O_3.

OR

The oxidation of oxalic acid, $(COOH)_2$, by potassium permanganate, $KMnO_4$ takes place in the following steps

I. $KMnO_4$ is a strong oxidising agent reacts with dil. H_2SO_4 to produce nascent oxygen as given by chemical equation:

$$\text{KMnO}_4 + \text{H}_2\text{SO}_4 \longrightarrow \text{K}_2\text{SO}_4 + \text{MnSO}_4 + 3\text{H}_2\text{O} + [\text{O}]$$

By balancing this skeleton equation by hit and trial method, we get

$$2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \longrightarrow \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 3\text{H}_2\text{O} + 5[\text{O}] \text{..... (i)}$$

II. Oxalic acid is oxidised to CO_2 and H_2O by the nascent oxygen produced in equation (i).

The balanced partial equation for this reaction is

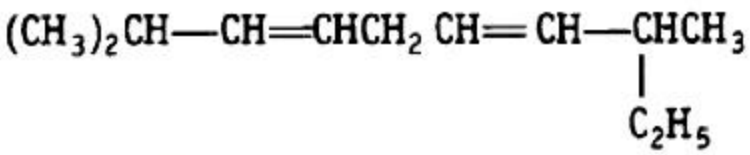
$$(COOH)_2 + [O] \longrightarrow 2CO_2 + H_2O \text{ ..... (ii)}$$

III. Now, (i) + 5 [(ii)] , We get

$$2KMnO_4 + 3H_2SO_4 + 5(COOH)_2 \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

This represents the balanced chemical equation for the above reaction.

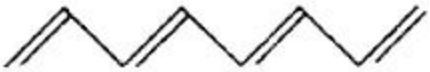
28. i. The IUPAC name of given compound is 2,8-dimethyldeca-3,6-diene



No of σ -bonds: 33

No of π - bonds: 2

ii. The IUPAC name of given compound is Octa-1, 3, 5,7-tetraene



No of σ -bonds: 17

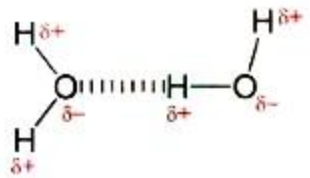
No of π - bonds: 4

iii. The IUPAC name of given compound is 4-ethyl-2, 6-dimethyldec-4-ene

No of σ -bonds: 41

No of π - bonds: 1

29. Due to greater electronegativity of O than S, H_2O undergoes extensive intermolecular H-bonding. As a result, H_2O is a liquid at room temperature. In contrast, H_2S does not undergo H-bonding. It exists as discrete molecules which are held together by weak Van der Waals forces of attraction. To break these forces of attraction, only a small amount of energy is required. Therefore, H_2S is a gas at room temperature.



30. Iron reacts with HCI acid to produce H_2 gas.

Reaction:

$$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$$

Here, 1 mole of Fe i.e. 56g Fe produces 1 mol of H_2 gas.

So, 11.2 g Fe will produce H_2 gas = $\frac{1}{56} \times 11.2 = 0.2\text{mol}$

i. If the reaction is carried out in closed vessel,

$\Delta V = 0$

We know that, $W = -p_{\text{ext}}\Delta V$

$\therefore W = 0$

ii. If the reaction is carried out in open beaker and external pressure is 1 atm,

initial volume = 0 because no gas is present.

Now we will calculate final volume,

We know that, $pV = nRT$

$\therefore V = \frac{nRT}{p}$

= $\frac{0.2 \times 0.0821 \times 298}{1}$

= 4.89 L

$\therefore \Delta V = V_{\text{final}} - V_{\text{initial}} = 4.89\text{L}$

$W = -p_{\text{ext}}\Delta V$

$= -1 \text{ atm } \times 4.89\text{L}$

$= -4.89 \text{ L atm}$

$= -4.89 \times 101.3 \text{ J}$

$= -495.4 \text{ J}$

Section D

31. Bond order is defined as half of the difference between the number of electrons present in bonding and antibonding molecular orbitals.

Bond order = $\frac{1}{2}(\text{N}_\text{b} - \text{N}_\text{a})$

E.C. of $\text{N}_2 = 1\text{s}^2 2\text{s}^2 2\text{p}_\text{x}^1 2\text{p}_\text{y}^1 2\text{p}_\text{z}^1$

M.O. configuration of N_2= $[\sigma 1s]^2 [\sigma * 1s]^2 [\sigma 2s]^2 [\sigma^* 2s]^2 [\pi 2p_x]^2 [\pi 2p_y]^2 [\sigma 2p_z]^2$

Bond order (B.O) = $\frac{1}{2}(\text{N}_\text{b} - \text{N}_\text{a})$

$= \frac{1}{2}[10 - 4] = 3$

B.O. of O_2

M.O. of configuration of O_2 =

$(\sigma 1S)^2 (\sigma^* 1S)^2 (\sigma 2S)^2 (\sigma^* 2S)^2 (\pi 2p_z)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\pi^* 2p_x)^2$

B.O. = $\frac{1}{2}(\text{N}_\text{b} - \text{N}_\text{a})$

= = $\frac{1}{2}[10 - 6] = 2$

M.O. of the configuration of O_2^+ = $\text{KK}[\sigma 2s]^2 \ [\sigma^* 2s]^2 \ [\sigma 2p_z]^2 \ [\pi 2p_x]^2 \ [\pi 2p_y]^2$ $[\pi * 2p_x]^1$

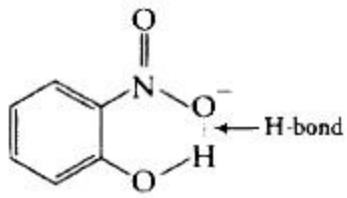
= $\frac{1}{2}$ [8-3] = 2.5

M.O. configuration of O_2^- = $KK[\sigma 2s]^2\,[\sigma^* 2s]^2\;[\sigma 2p_z]^2\;[\pi 2p_x]^2\;[\pi 2p_y]^2\;[\pi^* 2p_x]^2\;[\pi^* 2p_y]^1$

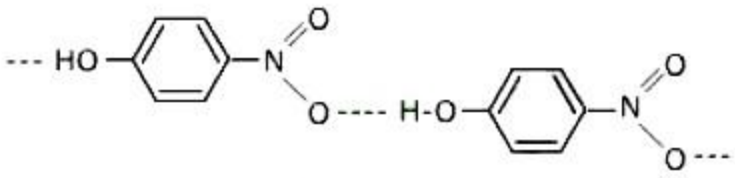
= $\frac{1}{2}$ [8-5] = 1.5

OR

i. The compound (II) will form intermolecular H-bonding and the compound (I) will form intramolecular H-bonding as shown below. In compund (I) ---OH group and -- NO_2 group are very close than that of compound (II) which facilitates the formation of intramolecular H-bonding in compound (I).



(I)



(II)

ii. The compound (II) can form H-bonding with water and hence more soluble in water. While compound (I) can't form H-bond with water due to the presence of intramolecular H-bonding and hence less soluble in water.

iii. Compound (II) will have a higher melting point because intermolecular H-bonding added extra attractive force between the molecules. While compound (I) will exist as discrete molecules because of intramolecular H-bonding

32. Let x moles of N_2(g) take part in the reaction. According to the equation, x / 2 moles of O_2 (g) will react to form r moles of N_2O(g). The molar concentration per litre of different species before the reaction and at the equilibrium point is:

$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g)$

Initial conc. (Mol/L) $\frac{0.482}{10}$ $\frac{0.933}{10}$ zero

At equilibrium point: $\frac{0.482-x}{10}$ $\frac{0.933-\frac{x}{2}}{10}$ $\frac{x}{10}$

The value of equilibrium constant (2.0×10^{-37}) is extremely small. This means that only small amounts of reactants have reacted. Therefore, x is extremely small and can be omitted as far as the reactants are concerned.

Applying Law of Chemical Equilibrium $K_c = \frac{[N_2O(g)]^2}{[N_2(g)]^2[O_2(g)]^2}$

$$2.0 \times 10^{-37} = \frac{\left(\frac{x}{10}\right)^2}{\left(\frac{0.482}{10}\right)^2 \times \left(\frac{0.933}{10}\right)} = \frac{0.01x^2}{2.1676 \times 10^{-4}}$$

$x^2 = 43.352 \times 10^{-40}$ or $x = 6.6 \times 10^{-20}$

As x is extremely small, it can be neglected.

Thus, in the equilibrium mixture

Molar conc. of N_2 = 0.0482 mol L^{-1}

Molar conc. of O_2 = 0.0933 mol L^{-1}

Molar conc. of $N_2O = 0.1 \times x = 0.1 \times 6.6 \times 10^{-20}\ mol\ L^{-1} = 6.6 \times 10^{-21}\ mol\ L^{-2}$

OR

$$C_6H_5COOAg \rightarrow C_6H_5COO^- + Ag^+$$

Solubility of water. Suppose solubility in water = x mol L^{-1} then

$[C_6H_5COO^-] = [Ag^+]$ = x mol L^{-1}

$x^2 = K_{sp}$ or $x = \sqrt{K_{sp}} = \sqrt{2.5 \times 10^{-13}}$

$= 5 \times 10^{-7}\ mol\ L^{-1}$

Solubility in buffer of pH = 3.19

pH = 3.19 means $-\log[H^+]$ = 3.19

or $\log[H^+] = -3.19 = \bar{4}.81$ or $[H^+] = 6.457 \times 10^{-4} M$

$C_6H_5COO^-$ ions now combine with the H^+ ions to form benzoic acid but $[H^+]$ remains almost constant because we have buffer solution. Now

$$C_6H_5COOH \rightleftharpoons C_6H_5COO^- + H^+$$

$\therefore K_a = \frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]}$ or $\frac{[C_6H_5COOH]}{[C_6H_5COO^-]} = \frac{[H^+]}{K_a} = \frac{6.457 \times 10^{-4}}{6.46 \times 10^{-5}} = 10$ .... (i)

Suppose solubility in the buffer solution is 'y' mol L^{-1}. Then as most of the benzoate ions are converted into benzoic acid molecules (which remain almost ionized), we have

$y = [Ag^+] = [C_6H_5COO^-] + [C_6H_5COOH] = [C_6H_5COO^-] + 10[C_6H_5COO^-] = 11[C_6H_5COO^-]$ using equation (i)

$\therefore [C_6H_5COO^-] = \frac{y}{11}\ \therefore K_{sp} = [C_6H_5COO^-][Ag^+]$

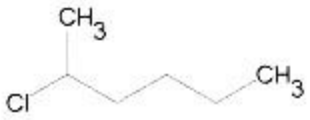
$2.5 \times 10^{-3} = \frac{y}{11} \times y$ or $y^2 = 2.75 \times 10^{-12}$ or $y = 1.66 \times 10^{-6}$

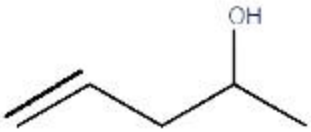
$\frac{y}{x} = \frac{1.66 \times 10^{-6}}{5 \times 10^{-7}} = 3.32$

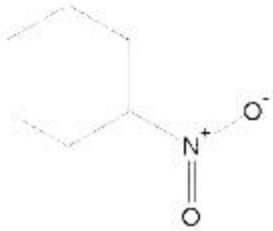
Note that in case of salts of weak acids, the solubility is more in the acidic solution than in water. The reason, in general, may be explained as follows: Taking example of C_6H_5COOAg, we have

$$C_6H_5COOAg \rightleftharpoons C_6H_5COO^- + Ag^+$$

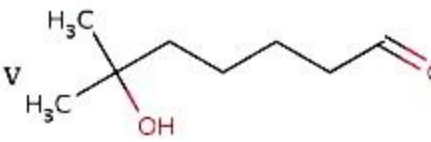
In acidic solution, the anions ($C_6H_5COO^-$ in the present case) undergo protonation in presence of acid. Thus, $C_6H_5COO^-$ ions are removed. Hence, equilibrium shifts forward producing more Ag^+ ions. Alternatively, as $C_6H_5COO^-$ ions are removed, Q_{sp} decreases. In order to maintain solubility product equilibrium ($Q_{sp} = K_{sp}$), Ag^+ ion concentration must increase. Hence, solubility is more.

33. i.  2-chlorohexane

ii  Pent-4-en-1-ol

iii  Nitrocyclohexane

iv.  Benzylpen-1-ene

v  6-Methyl,6-Hydroxyheptanal

OR

Inductive Effects:

The inductive effect refers to the polarity produced in a molecule as a result of higher electronegativity of one atom compared to another.

Atoms or groups which lose electron towards a carbons atom are said to have a + I Effect.

Those atoms or groups which draw electron away from a carbon atom are said to have -I Effect.

Common examples of -I effect are:

NO_2, F, Cl, Br, l, OH etc.

Examples of

+R effect are (Electron releasing)

$(CH_3)_2C$-, $(CH_3)_2CH$-, CH_3CH_2-, CH_3- etc.

Electromeric effect:

The electromeric effect refers to the polarity produced in a multiple bonded compound as it is approached by a reagent.

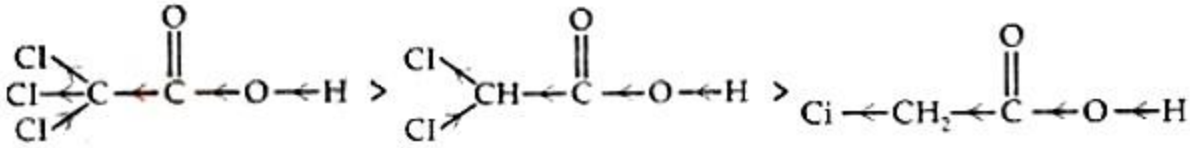
The atom A has lost its share in the electron pair and B has gained this share.

As a result A acquires a positive charge B a negative charge.

It is a temporary effect and takes place only in the presence of a regent.

i. -I-effect as shown below:

As the number of halogen atoms decreases, the overall -I- effect decreases and the acid strength decreases accordingly.



ii. +I-effect as shown below:

As the number of alkyl groups increases, the +I-effect increases and the acid strength decreases accordingly.