Previous IPE

SOLVED PAPERS

MARCH-2023 (TS)

PREVIOUS PAPERS

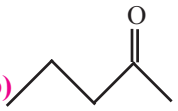
IPE: MARCH-2023(TS)

Time : 3 Hours **JR.CHEMISTRY** Max.Marks : 60

SECTION-A

I. Answer ALL questions : **10 × 2 = 20**

1. What is Biochemical Oxygen Demand (BOD)?
2. What happens when magnesium metal is burnt in air?
3. Describe the important uses of sodium carbonate.
4. Why pressure cooker is used for cooking food on hills?
5. Give the hybridisation of carbon in a) CO_3^{-2} b) diamond c) graphite d) fullerene
6. What is PAN? What effect is caused by it?
7. The empirical formula of a compound is CH_2O. Its molecular weight is 90. Calculate the molecular formula of the compound.
8. All Lewis acids are not Bronsted acids. Why?
9. Diamond has high melting point - explain.
10. Write IUPAC names of : **a)** $CH_3-CH_2-CH_2-CH=CH_2$ **b)**



SECTION-B

II. Answer any SIX of the following Questions. **6 × 4 = 24**

11. State Fajan's rules and give suitable examples.
12. Deduce (a) Boyle's law (b) Charle's law from kinetic gas equation.
13. State and explain the Hess's law of constant Heat summation.
14. Derive the relation between K_p & K_c for the equilibrium reaction:
15. Balance the following redox reactions by ion-electron method.
    $MnO_4^-(aq) + SO_2(g) \rightarrow Mn^{2+}(aq) + HSO_4^-(aq)$ (in acidic solution)
16. Explain the hybridisation involved in SF_6 molecule.
17. Write a few lines on the utility of hydrogen as a fuel.
18. Explain Borax bead test with a suitable examples.

SECTION-C

III. Answer any TWO of the following Questions. **2 × 8 = 16**

19. What are the postulates of Bohr's model of hydrogen atom? Discuss the importance of this model to explain various series of line spectra in hydrogen atom.
20. Define IE_1 and IE_2. Why is $IE_2 > IE_1$ for a given atom? Discuss the factors that effect IE of an element.
21. How does acetylene react with the following reagents? Give the corresponding equations and name the products formed in the reactions.
    a) Water b) Hydrogen c) Halogens d) Hydrogen halide

IPE TS MARCH-2023
ANSWERS

SECTION-A

1. What is Biochemical Oxygen Demand (BOD)?

A: **1) Biochemical Oxygen Demand (BOD):** It is the 'amount of oxygen used' by suitable micro organisms present in the water, during five days, at 20^0C .

2) It is used to measure the 'degree of pollution of water'.

---

2. What happens when magnesium metal is burnt in air?

A: 1) When Magnesium is burnt in air, it burns with dazzling light and gives MgO and Mg_3N_2.

2) $2\ Mg + O_2 \rightarrow 2\ MgO$; $3\ Mg + N_2 \rightarrow Mg_3N_2$

---

3. Describe the important uses of sodium carbonate.

A: **Sodium Carbonate (Na_2CO_3)** is used

1) to remove hardness of water.
2) in the preparation of glass, caustic soda.
3) in laundries as washing soda.
4) in paper, paints and petroleum industries.

---

4. Why pressure cooker is used for cooking food on hills?

A: At high altitudes, atmospheric pressure is low. So at hills, water boils at lower temperatures when compared to that at sea level. Hence the pressure cooker is used for cooking food, so that boiling point of water can be increased by increasing the pressure above the atmospheric pressure.

---

5. Give the hybridisation of carbon in a) CO_3^{-2} b) diamond c) graphite d) fullerene

A: a) Hybridisation of 'C' in CO_3^{-2} is sp^2

b) Hybridisation of 'C' in diamond is sp^3

c) Hybridisation of 'C' in graphite is sp^2

d) Hybridisation of 'C' in fullerene is sp^2

6. What is PAN? What effect is caused by it?

A: 1) PAN means Peroxy acetyl nitrate($C_2H_3O_5N$).

2) It is a component of Photochemical smog.

3) Effects of PAN:

i) It has toxic effect.

ii) It is respiratory irritant and eye irritant.

iii) It causes corrosion of metals, building materials, rubber, painted surfaces.

---

7. The empirical formula of a compound is CH_2O. Its molecular weight is 90. Calculate the molecular formula of the compound.

A: Molecular weight of the given compound = 90

Empirical formula weight = 12 + 2 + 16 = 30;

$$n = \frac{\text{Molecular weight}}{\text{Empirical formula weight}} = \frac{90}{30} = 3$$

Molecular formula = $(\text{Empirical formula})_n = (CH_2O)_3 = C_3H_6O_3$

---

8. All Lewis acids are not Bronsted acids. Why?

A: Lewis acid is an electron pair acceptor.
Bronsted acid is a Proton donor.

All the Lewis acids may not have hydrogen to donate protons.

Hence all Lewis acids are not Bronsted acids

BF_3 is a Lewis acid since it can accept an electron pair from other substances.

But BF_3 can't donate protons. Hence, It is not a Bronsted acid.

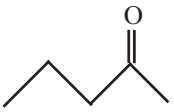
---

9. Diamond has high melting point - explain.

A: In Diamond sp^3 hybridisation. It has a three dimensional network involving strong C-C bonds, which are very difficult to break. Hence diamond has high melting point.

---

10. Write IUPAC names of : a) $CH_3 - CH_2 - CH_2 - CH = CH_2$ **b)**



A: **a)** 1- Pentene **b)** 2 -Pentanone,

SECTION-B

11. State Fajan's rules and give suitable examples.

A: Fajan's rules:

1) 'Covalent character' **increases** with **increase in the size of Anion**.

   Ex: Bigger I^- has more covalent character than Br^-

2) 'Covalent character' **increases** with **decrease in the size of Cation**.

   Ex: Smaller Li^+ has more covalent character than Na^+

3) Covalent character increases with increasing charge of either Cations or Anions.

4) Cations with 'Pseudo inert gas configuration' favour 'covalent bonds'.

   Ex: $ZnCl_2$ is Covalent.

5) Cations with 'inert gas configuration' form Ionic bonds.

   Ex: $CaCl_2$ is ionic.

---

12. Deduce (a) Boyle's law (b) Charle's law from kinetic gas equation.

A: (a) Boyle's law:

From kinetic gas equation $PV = \frac{1}{3}mnu^2_{rms} = \frac{2}{3}\times\frac{1}{2}mnu^2_{rms}$

$$PV = \frac{2}{3}KE \text{ .....(1),} \qquad \left(\text{Since, K.E} = \frac{1}{2}mnu^2_{rms}\right)$$

According to kinetic gas theory, $KE \propto T \Rightarrow KE = kT$ .....(2)

From (1) & (2), $PV = \frac{2}{3}kT$ .....(3)

If 'T' is kept constant in the above relation then PV = constant.

Thus Boyle's law is proved.

(b) Charle's Law:

From (3), $PV = \frac{2}{3}kT \Rightarrow \frac{V}{T} = \frac{2}{3}\times\frac{k}{P}$

If 'P' is kept constant in the above relation then $\frac{V}{T}$ = constant .

Thus Charle's law is proved.

13. State and explain the Hess's law of constant Heat summation.

A: 1) Hess Law: 'The total heat change in a chemical reaction is the same, whether the chemical reaction takes place in one step or several steps'.

2) Suppose that D is formed from A in two different paths.

Path - I: $A \rightarrow D, \Delta H$

Path - II: $A \rightarrow B, \Delta H_1$

$B \rightarrow C, \Delta H_2$

$C \rightarrow D, \Delta H_3$

Total heat change in path - II= $\Delta H_1+\Delta H_2+\Delta H_3$

Total heat change in path - I $= \Delta H$

From Hess law, $\Delta H = \Delta H_1+\Delta H_2+\Delta H_3$

3) Example: CO_2 can be obtained from $C_{(graphite)}$ and $O_{2(g)}$ in two different ways.

Path - I : $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H = -393.5$ KJ

Path - II : $C_{(graphite)} + 1/2\ O_{2(g)} \rightarrow CO_{(g)}$; $\Delta H_1 = -110.5$ KJ

$CO_{(g)} + 1/2O_{2(g)} \rightarrow CO_{2(g)}$; $\Delta H_2 = -283.02$ KJ

4) Total heat change in path-II = $\Delta H_1+\Delta H_2 = (-110.5)+(-283.02) = -393.52$ KJ.

Total heat change in path-I $= \Delta H = -393.5$ KJ.

Thus $\Delta H \simeq \Delta H_1+\Delta H_2$. Hence the Hess law is proved.

14. Derive the relation between K_p & K_c for the equilibrium reaction:

(a) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **(b)** $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

A: 1) Relation between K_P & K_C is $K_P = K_C(RT)^{\Delta n}$

Given equation is $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Here $n_R = 4$ and $n_P = 2$

$\Delta n = n_P - n_R = 2 - (1+3) = -2$

$\therefore K_P = K_C(RT)^{-2}$

$\therefore K_P < K_C$

2) Relation between K_P & K_C is $K_P = K_C(RT)^{\Delta n}$

Given equation is $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

Here $n_R = 3$ and $n_P = 2$

$\Delta n = n_P - n_R = 2 - 3 = -1$

$\therefore K_P = K_C(RT)^{-1}$

$\therefore K_P < K_C$

15. Balance the following redox reactions by ion-electron method.

$MnO_4^-(aq) + SO_2(g) \rightarrow Mn^{2+}(aq) + HSO_4^-(aq)$ (in acidic solution)

A. 1) Skeleton ionic equation: $\overset{+7}{M}nO_4^- + \overset{+4}{S}O_2 \rightarrow \overset{+2}{M}n^{+2} + \overset{+6}{H}SO_4^-$

2) **Oxidation half reaction** | **Reduction half reaction**

$SO_2 \rightarrow HSO_4^-$ | $MnO_4^- \rightarrow Mn^{+2}$

3) Balance the atoms other than O and H

$SO_2 \rightarrow HSO_4^-$ | $MnO_4^- \rightarrow Mn^{+2}$

4) Balance of oxygen atoms

$SO_2 + 2H_2O \rightarrow HSO_4^-$ | $MnO_4^- \rightarrow Mn^{+2} + 4H_2O$

5) Balance of hydrogen atoms

$SO_2 + 2H_2O \rightarrow HSO_4^- + 3H^+$ | $MnO_4^- + 8H^+ \rightarrow Mn^{+2} + 4H_2O$

6) Balance of charges

$SO_2 + 2H_2O \rightarrow HSO_4^- + 3H^+ + 2e^-$ | $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O$

7) Equalizing of electrons

$5(SO_2 + 2H_2O \rightarrow HSO_4^- + 3H^+ + 2e^-)$ | $2(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{+2} + 4H_2O)$

$5SO_2 + 10H_2O \rightarrow 5HSO_4^- + 15H^+ + 10e^- \ldots(1)$ | $2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{+2} + 8H_2O \ldots(2)$

8) Adding the two half reactions

$$5SO_2 + 10H_2O \rightarrow 5HSO_4^- + 15H^+ + 10e^-$$
$$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{+2} + 8H_2O$$

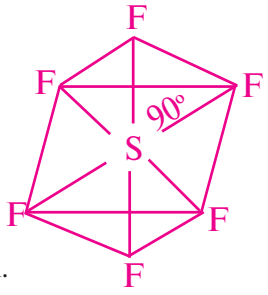
$$2MnO_4^- + 5SO_2 + 2H_2O + H^+ \rightarrow 2Mn^{+2} + 5HSO_4^-$$

This is the balanced equation.

16. Explain the hybridisation involved in SF_6 molecule.

A: I) sp^3d^2 hybridisation: One s-orbital, three p-orbitals and two d-orbitals mix together to form six sp^3d^2 hybrid orbitals .

II) Structure of SF_6 molecule:



1) In SF_6, the central atom is S(16).
2) It's ground state E.C is $[Ne]3s^23p^4$

   It's excited state E.C is $[Ne]\,3s^1 3p_x^1 3p_y^1 3p_z^1 3d^1_{(x^2-y^2)} 3d^1_{z^2}$
3) In its excited state, the central S atom undergoes sp^3d^2 hybridisation.
4) Central S forms 'six sp^3d^2 hybrid orbitals', each with one electron.
5) 'Six sp^3d^2 hybrid orbitals' of S overlap axially with p orbital of six F atoms to form six σ bonds.
6) Shape of SF_6 is Octahedral and the bond angles are 90° and 180°.

---

17. Write a few lines on the utility of hydrogen as a fuel.

A: 1) Hydrogen has high 'Heat of combustion'. When compared to any other fuels like methane, L.P.G etc. Hence it is used for industrial purposes.
2) Pollutants in combustion of hydrogen will be less than petrol. The only pollutants will be the oxides of nitrogen and it can be minimised by injecting small amount of water into the hydrogen cylinder.
3) Hydrogen is used as a rocket fuel.
4) Hydrogen is used in fuel cells for generating electrical energy.
5) Atomic hydrogen and oxy hydrogen torches are used for welding and cutting metals.

---

18. Explain Borax bead test with a suitable examples.

A: 1) Borax bead test: This test is useful for the identification of basic radicals in 'qualitative analysis'.

2) On heating, borax swells into a white, opaque mass of anhydrous sodium tetraborate. When it is fused, borax glass is obtained. This contains sodium metaborate and B_2O_3.

3) The boric anhydride combines with metal oxides to form metal metaborates as coloured beads.

4) The reactions:

$$Na_2B_4O_7.10H_2O \longrightarrow Na_2B_4O_7 \xrightarrow{\text{fused}} \underbrace{2NaBO_2 + B_2O_3}_{\text{Borax glass}}$$

$$B_2O_3 + Co.O \longrightarrow \underset{\substack{\text{Cobalt metaborate}\\(\text{Blue bead})}}{Co(BO_2)_2}$$

SECTION-C

19. What are postulates of Bohr's model of hydrogen atom? Discuss the importance of this model to explain various series of line spectra in hydrogen atom.

A: I) Postulates of Bohr's model :

1) Electron in an atom revolve around the nucleus in certain fixed **circular paths** called **orbits.**

2) Each orbit has **fixed amount of energy**. So these orbits are also called **energy levels**.

These orbits are denoted by 1,2,3,4,..... (or) K, L, M, N.....

3) As long as an electron revolves around the nucleus in a fixed orbit it **does not emit** (or) **absorb energy**. So these orbits are also called as **Stationary orbits**.

4) **Angular momentum** of revolving electron is **quantised** and is an integral multiple of $\frac{h}{2\pi}$.
$\therefore mvr = \frac{nh}{2\pi}$. Here, m= mass of electron, v= velocity, r= radius and h= Planck's constant

5) Energy is emitted (or) absorbed when electron jumps from one orbit to another orbit.

The energy difference between two orbits is $\Delta E = E_2 - E_1 = h\nu$

Here, E_2= Energy of the higher orbit, E_1= Energy of the lower orbit

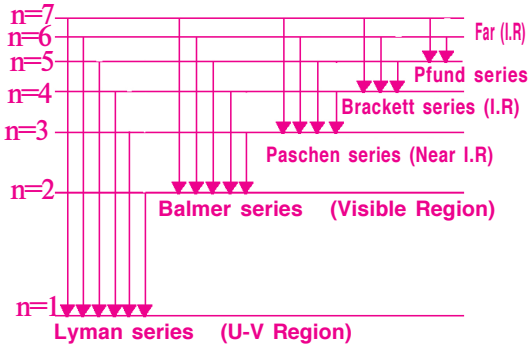
II) Hydrogen spectrum- Bohr's Explanation:

1) When electric discharge is passed through gaseous hydrogen, the electrons in atoms **absorb** energy.

2) Then they **jump** into **higher energy orbits**.

3) In higher orbits, they have **more energy and less stability.**

4) Then the excited electrons **come back** to **lower orbits** in **one** or **multiple steps**.



Hydrogen Spectrum

5) **Energy** is **released** during this process and it appears in the form of **spectral lines.**

6) When an electron jumps from any higher orbit to

i) **n=1** produces spectral lines in the **UV** region.This is named as **Lyman series.**

ii) **n=2** produces spectral lines in the **visible** region.This is named as **Balmer series.**

iii) **n=3,4,5** produces spectral lines in near IR, IR, far IR regions.

These are named as **Paschen** ,**Brackett** and **Pfund** series respectively.

7) From the Rydberg equation, wavenumber $\bar{\nu} = \frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

20. Define IE_1 and IE_2. Why is $IE_2 > IE_1$ for a given atom? Discuss the factors that effect IE of an element.

A: **1) First Ionisation Enthalpy (IE_1):** It is the **minimum** amount of energy required to remove a valence electron from an **isolated, neutral**, **gaseous atom(X)**.

$$X(g) \xrightarrow{IE_1} X^+(g) + e^-$$

2) Second Ionisation Enthalpy (IE_2): It is the minimum amount of energy required to remove the valence electron from the **unipositive gaseous ion(X^+).**

$$X^+(g) \xrightarrow{IE_2} X^{2+}(g) + e^-$$

3) $IE_2 > IE_1$:

Reason: When compared to the parent atom X, the unipositive ion X^+ contains more protons than electrons. So its positive nuclear charge increase. Hence the force of attraction on the valence electrons increases. So more energy is required to remove the electron in the second case . Hence IE_2 is greater than IE_1.

4) Factors that effect IE :

BULLET HINT

IE
↑AR ↑
↑NC↑
↑EC↑
↑SE ↓
↓PE ↓

i) Atomic Radius(AR) : As atomic radius decreases, the nuclear force of attraction on the valence electrons increases. So, IE value also increases.

ii) Nuclear Charge(NC): When the 'effective nuclear charge' increases, the force of attraction on the valence electrons increases. So, IE value also increases.

iii) Electronic Configuration(EC): Atoms with completely filled (or) half-filled sub-shells are more **stable** than the others. So, IE values are more for stable atoms.

iv) Screening Effect(SE): The electrons present in the 'inner orbits', act as a 'screen' between nucleus and valance electrons. When the number of electrons in the inner orbits increases, the screening effect also increases. This screening effect reduces the effective nuclear charge. So, IE value decreases.

v) Penetrating Effect (PE): In a given shell ,the penetrating power of the 'valence electrons' decreases in the order of s>p>d>f. So, IE value decreases in the same order.

21. How does acetylene react with the following reagents? Give the corresponding equations and name the products formed in the reactions. [TS 16,18,23]

a) Water b) Hydrogen

c) Halogens d) Hydrogen halide

A: **a) Action with water:** Acetylene gas when passed through dil.H_2SO_4 below 60°C in the presence of $HgSO_4$, undergoes addition reaction with water and forms acetaldehyde.

$$HC \equiv CH + HOH \xrightarrow[30\%H_2SO_4]{1\%HgSO_4} [CH_2 = CH.OH] \longrightarrow CH_3.CHO$$

Acetylene Water Vinyl alcohol Acetaldehyde

b) Action with Hydrogen: Acetylene reacts with H_2 in presence of Ni or Pt catalyst and undergoes addition reaction forming ethylene and ethane.

$$HC \equiv CH + H_2 \xrightarrow{Ni \text{ or } Pt} H_2C = CH_2 \xrightarrow[Ni \text{ or } Pt]{H_2} H_3C - CH_3$$

Acetylene Ethylene Ethane

c) Action with Halogens: Acetylene reacts with halogens in presence of CCl_4 and undergoes addition reaction giving finally 1, 1, 2, 2 -tetrachloroethane.

$$H - C \equiv C - H + Cl_2 \xrightarrow{CCl_4} H - \underset{Cl}{\overset{|}{C}} = \underset{Cl}{\overset{|}{C}} - H$$

1,2-dichloroethylene

$$H - \underset{Cl}{\overset{|}{C}} = \underset{Cl}{\overset{|}{C}} - H \quad (1,2-\text{dichloroethylene}) \quad + Cl_2 \xrightarrow{CCl_4}$$

$$H - \underset{Cl}{\overset{Cl}{\underset{|}{\overset{|}{C}}}} - \underset{Cl}{\overset{Cl}{\underset{|}{\overset{|}{C}}}} - H \quad (1,1,2,2-\text{tetrachloroethane (Westron)})$$

d) Action with Hydrogen halides: Acetylene undergoes addition with hydrogen halides and gives finally 1,1–dichloroethane. **[TS 20]**

$$H - C \equiv C - H + HCl \longrightarrow H_2C = \underset{Cl}{\overset{|}{C}}H \xrightarrow{HCl} CH_3 - \underset{Cl}{\overset{Cl}{\underset{|}{\overset{|}{C}}}}H \text{ or } CH_3 - CHCl_2$$

Acetylene Vinyl chloride 1,1-dichloroethane