END SEMESTER EXAMINATION, DECEMBER 2023

CHEMISTRY — I

Question 1: Fill in the Blanks (1×5=5)

(a) Temporary hard water contains ___ of Ca and Mg.
Answer: bicarbonates of calcium (Ca) and magnesium (Mg).

(b) One Faraday = ___ Coulomb.
Answer: 96500 Coulomb.

(c) $AlCl_3$ is an example of ___ acid.
Answer: Lewis acid.

(d) Nitrogen molecule contains ___ bond(s).
Answer: one sigma and two pi bonds.

(e) Magnetic quantum number determines the ___ of electrons.
Answer: orientation.

2. Choose the correct answers(1×5=5)

(a) The boiling point of HF is greater than HCl due to the presence of:
Answer: (iii) Hydrogen bond

(b) One mole of Hydrogen gas is equal to:
Answer: (ii) Two grams of Hydrogen

(c) Isotones are the elements having:
Answer: (iii) Same number of neutrons

(d) pH of 0.01(M) NaOH solution is:
Answer: (ii) 12

(e) An aqueous solution of Sodium Carbonate is:
Answer: (iii) Alkaline

3. Write short answers (one word/sentence each):
(1×5=5)
(a) What is the relationship between E.C.E and C.E?
Answer: E.C.E = C.E / Faraday’s constant.

(b) Which element has the highest electron affinity?
Answer: Chlorine (Cl).

(c) What is the oxidation number of Mn in $KMnO_4$?
Answer: +7.

(d) What is the name of the catalyst used in the manufacture of Ammonia by the Haber process?
Answer: Iron (Fe) with molybdenum as a promoter.

(e) What is a decinormal solution?
Answer: A solution with 1/10th of the normal concentration (0.1 N).

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4. Match the following
(1×5=5)

Column A	Column B
(a) Charles's Law	(iii) Volume-Temperature relationship
(b) Eriochrome Black-T	(ii) Hardness of water
(c) Chemical Equilibrium	(i) Dynamic in nature
(d) Ionisation Enthalpy	(iv) Electron volt per atom
(e) Ammonia	(v) Lone pair of electrons

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5. State True or False
(1×5=5)
(a) The addition of a catalyst does not change the state of equilibrium.
Answer: True

(b) KCN molecule contains covalent bonding.
Answer: True

(c) The conjugate acid of NH_3 is NH_4^+.
Answer: True

(d) In a redox reaction, oxidation and reduction take place simultaneously.
Answer: True

(e) 22 grams of CO_2 occupies 11.2 liters at STP.
Answer: False

6.
(a) State and explain Dalton's law of partial pressures. ***(2)***
Answer: Dalton's Law of Partial Pressures states that the total pressure exerted by a mixture of non-reacting gases is the sum of the partial pressures of the individual gases.

Mathematically, it can be expressed as:

P total = P 1 + P 2 + P 3 + ⋯ + P n

Where:

- P total is the total pressure exerted by the gas mixture.
- P1,P2,P3,…,Pn are the partial pressures of the individual gases.

(b) What is an ideal gas? Derive the ideal gas equation PV = nRT. ***(4)***
Answer: A gas which obeys all the gas laws at all conditions of temperature and pressur pressure is termed as an ideal gas.

Derivation: As per Boyle's law, V x 1/P at a constant temperature

As per Charle's law, V x T at constant pressure

As per Avogadro's law, V x n at constant pressure and temperature

Combining the three laws, we get, V x nT/P or V = nRT/P

Or PV = nRT, where R is the universal gas constant. This equation is called the ideal gas equation.

In terms of molar mass and density, the ideal gas equation can be written as

M=dRT/P (M is the molar mass and is d density)

(c) Balance the following equation by the ion-electron method (any one): ***(3)***
(i) $CrO_3 + H^+ + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+} + H_2O$

Answer: $CrO_3 + 6H^+ + 3Fe^{2+} \rightarrow Cr^{3+} + 3H_2O + 3Fe^{3+}$
(ii) $MnO_4^- + Cl^- + H^+ \rightarrow Mn^{2+} + H_2O + Cl_2$

Answer: $MnO_4^- + 8H^+ + 10Cl^- \rightarrow Mn^{2+} + 4H_2O + 5Cl_2$

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7. (a) Discuss the electronic concept of oxidation and reduction with examples. ***(2)***
Answer: Oxidation involves the loss of electrons, while reduction involves the gain of electrons.

Example:

$Na \rightarrow Na^+ + e^-$ (oxidation);

$Cl_2 + 2e^- \rightarrow 2Cl^-$ (reduction).

(b) What is Normal solution and Molar solution? ***(2)***
Answer:

- Normal solution: A normal solution is a solution in which 1 gram-equivalent of solute is dissolved in 1 liter of solution. It is calculated by dividing the molar mass of the solute by its valency
- Molar solution: A molar solution is a solution in which 1 mole of solute is dissolved in 1 liter of solution. It Refers to the molecular weight (in grams) of the solute.

(c) How much NaOH is required to prepare 250 mL of 0.1(N) NaOH solution? (3)
Answer:
We Know That,

Number of equivalents=Normality×Volume in liters &

Mass of NaOH=Number of equivalents×Equivalent weight

Now,

Number of equivalents=0.1 N×0.250 L=0.025 equivalents

Total molar mass of NaOH = 23+16+1=40 g mol

Mass of NaOH=0.025 equiv×40 g equiv=1.0 g

(d) What are the limitations of Bohr's atomic model? ***(2)***
Answer:

- Bohr's theory couldn't explain the splitting of lines in magnetic field (Zeeman effect) and electric field (Stark effect).
- Bohr's theory couldn't give the theoretical basis fore the quantization of angular momentum of an electron.
- This theory didn't consider the wave character of an electron as postulated by de-Broglie.

8.
(a) What are Quantum numbers? Discuss their physical significance. ***(4)***

Ans: Quantum numbers are a set of numerical values that describe the unique quantum state of an electron in an atom. These numbers are used to specify the energy, position, and behavior of electrons in atoms.

There are four types of quantum numbers, each providing distinct information about the electron's state.

1. Principal Quantum Number (n):

- The principal quantum number represents the main energy level & size of the orbital.
- It can take positive integer values (n = 1, 2, 3, 4, …).
- **Example:**
  - n = 1 (K-shell), n = 2 (L-shell), n = 3 (M-shell), etc.
- The total number of electrons that can occupy a shell is given by 2n^2.

2. Azimuthal Quantum Number (l):

- The azimuthal quantum number determines the shape of the orbital within a given energy level (shell).
- The value of ll depends on the principal quantum number nn and can range from 0 to n−1n-1.
- **Example:**
  - For n=2n = 2, ll can be 0 (s-orbital) or 1 (p-orbital).
  - For n=3n = 3, ll can be 0 (s-orbital), 1 (p-orbital), or 2 (d-orbital).

3. Magnetic Quantum Number (m):

- The magnetic quantum number determines the orientation of the orbital in space relative to an external magnetic field.
- **Example:**
  - For l=1l = 1 (p-orbital), mm can be -1, 0, or +1 (three possible orientations).
  - For l=2l = 2 (d-orbital), mm can be -2, -1, 0, +1, or +2 (five possible orientations).

4. Spin Quantum Number (ms):

- The spin quantum number describes the intrinsic angular momentum (spin) of the electron.
- It can have one of two values: +½ (clockwise rotation) or -½ (anticlockwise rotation).
- **Example:**
  - An electron in an orbital may have spin +½ or -½, which helps in explaining electron pairing in

(b) State the modern periodic law. What is periodicity in the properties of elements? ***(3)***
Answer: The modern periodic law says that the properties of elements depend on their atomic numbers. When elements are arranged by increasing atomic number, their properties repeat in a regular pattern.

Periodicity refers to how certain properties of elements repeat in the periodic table. Here's how some key properties change:

1. **Atomic Radius**:
   - Across a row: Decreases as atoms get smaller.
   - Down a column: Increases as atoms get larger.
2. **Ionization Energy**:
   - Across a row: Increases as it's harder to remove electrons.
   - Down a column: Decreases as it's easier to remove electrons.
3. **Electronegativity**:
   - Across a row: Increases as atoms attract electrons better.
   - Down a column: Decreases as atoms attract electrons less.

These trends follow the arrangement of elements by atomic number.

(c) Draw the Lewis electron dot structure for any two of the following: ***(2)***
(i) CO_2: **:O=C=O:**
(ii) H_2O: **H:O:H**

9.
(a) What is homogeneous and heterogeneous catalysis? ***(3)***
Answer:

- Homogeneous catalysis: Catalyst and reactants are in the same phase. Example: Hydrolysis of ester in acid.
- Heterogeneous catalysis: Catalyst and reactants are in different phases. Example: Hydrogenation of ethene on Ni.

(b) State Le Chatelier's Principle and describe one industrial application. ***(3)***
Answer: A system at equilibrium will adjust to counteract any changes. Application: Ammonia production in the Haber process.

(c) A current of 0.4 A passing through $AgNO_3$ solution for 5 minutes deposits 0.2122 g of Ag. Calculate the E.C.E of Ag. ***(3)***

Answer: E.C.E = Mass / (Current × Time) = 0.2122 / (0.4 × 300) = **1.77×10^{-4} g/C**

10.

(a) State the differences between electrolytic cell and electrochemical cell. ***(3)***

Answer:

Electrolytic Cell	**Electrochemical Cell**
Converts electrical energy into chemical energy.	Converts chemical energy into electrical energy.
External power source drives the current.	Current flows naturally due to a spontaneous reaction.
Occurs at both electrodes (reduction at cathode, oxidation at anode).	Reduction occurs at the cathode, oxidation at the anode naturally.

(b) What difficulties arise in boilers when hard water is used? ***(2)***

Answer:When hard water is used in boilers, it causes several issues:

1. **Scale Formation**: Hard water leads to the buildup of calcium and magnesium salts on boiler surfaces, reducing heat transfer efficiency and increasing fuel consumption.

Corrosion: The minerals in hard water can cause corrosion of boiler parts, leading to leaks and reduced equipment lifespan.

(c) What is hardness of water? How is it removed by the ion-exchange method? *(4)*
Answer: Hardness is caused by Ca^{2+} and Mg^{2+} ions.
The ion-exchange method removes hardness by replacing calcium and magnesium ions with sodium ions using a resin. This process involves two main steps:

1. **Exchange Process**: Hard water passes through a resin bed containing sodium ions (Na^+). The resin beads have a negative charge that attracts and holds onto calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions from the water, while releasing sodium ions in exchange.
2. **Regeneration**: After the resin is saturated with calcium and magnesium ions, it is regenerated by flushing it with a concentrated sodium chloride (NaCl) solution. This displaces the calcium and magnesium ions, restoring the resin's ability to remove hardness.

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11. Write short notes on any three: *(3×3=9)*

(a) Buffer Solution:
A buffer solution is a solution that resists changes in its pH when small amounts of an acid or base are added. It contains a weak acid and its conjugate base, or a weak base and its conjugate acid. These components work together to neutralize any added acid or base, helping to maintain the pH of the solution within a narrow range.

(b) Hydrogen Bonding:
Hydrogen bonding is a strong type of dipole-dipole interaction that occurs between a hydrogen atom covalently bonded to an electronegative atom such as oxygen, nitrogen, or fluorine and another electronegative atom. This interaction is responsible for many of the unique properties of water and other molecules, such as high boiling points and surface tension.

(c) Conjugate Acid-Base Pair:
A conjugate acid-base pair consists of two species that differ by a single proton (H^+). When an acid loses a proton, it forms its conjugate base, and when a base gains a proton, it forms its conjugate acid. For example, ammonia (NH_3) is a base, and its conjugate acid is ammonium ion (NH_4^+).

(d) Electron Affinity:
Electron affinity is the amount of energy released or absorbed when an electron is added to a neutral atom in the gas phase to form a negative ion. It is usually exothermic (energy is released), although some atoms may absorb energy when gaining an electron. Electron affinity reflects the atom's tendency to attract and hold onto an additional electron.

Note: The answers are based on our research. If you notice any errors, kindly inform us. We appreciate your understanding and feedback.

Thank You!!