Topics Covered by Chemistry Aptitude Test for Admission and Placement

Subject	Items
1- Atomic structure for chemical compounds and their physical properties	Elements, compounds and mixtures - State of Matter and Properties - Chemical symbols - Predicting the number of elements in a compound - Predicting the number of atoms in a compound - Density - Periodic table - Atomic structure - Eelectronic configuration - Predicting the number of protons, neutrons and electrons - Chemical bonds .
2- Chemical equations and naming of inorganic compounds-chemical calculations	Chemical formulae - Naming of inorganic compounds – Ionic compounds - Calculating the formula mass - Calculating the number of moles - Calculating the number of grams - Calculating the mass of one atom - Atom and mole ratio in a compound - Calculating the number of atoms and molecules - Balancing chemical equations - Predicting the products of chemical reactions - Predicting the mole ratio from a balanced chemical equation - Predicting the type of chemical reaction.
3- Chemical equilibrium for acids, bases, salts and oxidation - reduction reactions	Predicting the number of ions in a formula unit - Assigning oxidation numbers - Assigning atoms changing their oxidation state in redox reactions - Acids and bases - Acid-base reactions - Calculating the $[H^+]$ and pH - Calculating the $[OH^-]$ and pOH - Acid dissociation constants (K_a) - Base dissociation constants (K_b) - Buffer solutions - Acid - base titration - Equilibrium expressions - Equilibrium constants - The solubility and solubility product (K_{sp}).
4- Solution chemistry	Molarity.
5- Organic compounds and functional groups	Hydrocarbon compounds - Aromatic hydrocarbons – Functional groups.

Details of the Test Topics

The students should be able to understand the following basic concepts in chemistry and solve problems related to items for each concept.

1- Atomic Structure for Chemical Compounds and Their Physical Properties:

i) Elements, Compounds and Mixtures:

Example 1.1: Vitamin B_{12} is necessary for proper health. It is used in the treatment of anemia. Vitamin B_{12} has the molecular formula, $C_{63}H_{88}CoN_{14}O_{14}P$. How many elements are present in Vitamin B_{12}?

A) 5 B) 181 C) 6 D) 7

Example 1.2: Which of the following is classified as a mixture?

A) Water B) A pure gold coin C) Table salt D) Air

ii) State of Matter and Properties:

Example 1.3: Which of the following substances exist as a liquid under ordinary conditions of temperature and pressure?

A) Sodium carbonate B) Carbon monoxide
C) Mercury D) Hydrogen

Example 1.4: How many phases are present in the following well-mixed system: [sand + salt + sugar + water + gasoline]

A) 5 B) 3 C) 2 D) 4

Example 1.5: All of the following are properties of oxygen. Which one represents a chemical property?

A) It is a gas at 25˚C B) It causes iron to form rust
C) It can be compressed D) It freezes at -219˚C

Example 1.6: A safety razor blade, made of iron and with a density greater than that of water, can be made to float on water if placed carefully. Which of the following properties is responsible for this phenomenon?

A) Specific heat B) Surface tension C) Melting point D) Viscosity

iii) Chemical Symbols:

Example 1.7: Which of the following elements is paired with the wrong symbol?

A) Silver - Ag B) Nitrogen - Ni
C) Magnesium - Mg D) Lithium - Li

iv) Predicting the Number of Elements in a Compound & Predicting the Number of Atoms in a Compound:

Example 1.8: Which of the following oxyanions (anion containing oxygen atoms) contain four oxygen atoms?

A) Nitrate B) Sulfate C) Carbonate D) Bicarbonate

See example 1.1

v) Density:

Example 1.9: A graduated cylinder contains 50.0 mL of water. Uniform stones, each weighing 5.000 g and having a density of 2.5 g/mL, are placed into the graduated cylinder until the water level rises to 130.0 mL. How many stones are in the cylinder?

A) 60 B) 40 C) 32 D) 25

vi) Periodic Table, Atomic Structure and Electronic Configuration-Predicting the Number of Protons, Number of Neutrons and Electrons:

Example 1.10: The electron configuration of the magnesium atom (Mg) in the outermost shell (last energy level) is:

A) $2s^2 2p^5$ B) $3s^2$ C) $2s^2 2p^1$ D) $3s^2 3p^1$

Example 1.11: How many neutrons are in the ion $^{52}_{24}Cr^{3+}$?

A) 24 B) 28 C) 25 D) 27

vii) Chemical Bonds:

Example 1.12: The bond formed between ammonia molecule (NH_3) and hydrogen ion (H^+) is known as:

A) Ionic bond B) Covalent bond
C) Coordinate covalent bond (dative bond) D) Metallic bond

2- Chemical Equations and Naming of Inorganic Compounds-Chemical Calculations:

i) Chemical Formulae & Naming of Inorganic Compounds:

Example 2.1: Choose the pair of name and formula that <u>do not match</u>?

	Formula	**Name**
A)	$AlCl_3$	Aluminium chloride
B)	$NaNO_3$	Sodium nitrate
C)	CaO	Carbon monoxide
D)	H_2SO_4	Sulfuric acid

ii) Ionic Compounds:

Example 2.2: How many ions per formula unit would you find if you dissolve $(NH_4)_2[Ce(NO_3)_6]$ in water?

A) 3 B) 9 C) 2 D) 6

iii) Calculating the Formula Mass:

Example 2.3: Calculate the molar mass of $MgSO_4.7H_2O$.

A) 120.37 g/mole B) 126.14 g/mole
C) 246.54 g/mole D) 222.57 g/mole

iv) Calculating the Number of Moles:

Example 2.4: How many moles of nitrogen (N) atoms are in 75.0 g of penicillin, $C_{16}H_{18}O_4N_2S$? [molar mass of penicillin = 334.28 g/mole]

A) 0.224 B) 0.896 C) 0.449 D) 0.296

Example 2.5: Which of the following contains 2.00 moles of carbon atoms?

A) 60.0 g ethane (C_2H_6) B) 26.0 g benzene (C_6H_6)
C) 2.00 moles oxalic acid ($H_2C_2O_4$) D) 5.00 g methane (CH_4)

v) Calculating the Number of Grams:

Example 2.6: Which of the following substances contains the greatest mass of chlorine (Cl_2)?

A) 5.0 g Cl_2 B) 0.50 mole Cl_2

C) 0.10 mole KCl D) 30.0 g $MgCl_2$

vi) Calculating the Mass of one Atom:

Example 2.7: What is the mass of one atom of carbon, C?

A) 1.99×10^{-23} g B) 0.502×10^{23} g

C) 0.502×10^{-23} g D) 1.99×10^{23} g

vii) Atoms and Mole Ratio in a Compound:

Example 2.8: For baking soda, $NaHCO_3$, what is the molar ratio of C to O?

A) 1:1 B) 3:1 C) 1:2 D) 1:3

viii) Calculating the Number of Atoms and Molecules:

Example 2.9: One mole of any element contains:

A) 3.011×10^{23} atoms B) 6.022×10^{23} atoms

C) 1.506×10^{23} atoms D) 12.04×10^{23} atoms

ix) Balancing Chemical Equations:

Example 2.10: Considering the following reaction:

$$AgNO_3(aq) + CaBr_2(aq) \longrightarrow AgBr(s) + Ca(NO_3)_2(aq)$$

the coefficient before AgBr is:

A) 1 B) 2 C) 4 D) 5

x) Predicting the Products of Chemical Reactions:

Example 2.11: Sodium carbonate reacts with hydrochloric acid to form three products; salt, water and …… gas:

A) Hydrogen B) Carbon monoxide

C) Chlorine D) Carbon dioxide

xi) Predicting the Mole Ratio from a Balanced Chemical Equation:

Example 2.12: Given the balanced equation:

$$2NH_3(g) + 3O_2(g) + 2CH_4(g) \longrightarrow 2HCN(g) + 6H_2O(l)$$

the proper molar ratio for the mole conversion: $O_2 \longrightarrow HCN$ is:

A) 3 moles O_2/1 mole HCN B) 2 moles O_2/2 moles HCN

C) 2 moles HCN /3 moles O_2 D) 3 moles O_2/2 moles HCN

xii) Predicting the Type of Chemical Reaction:

Example 2.13: What type of reaction is the following?

$$2KClO_3(s) \xrightarrow[\text{Heat}]{MnO_2} 2KCl(s) + 3O_2(g)$$

A) Single displacement B) Decomposition

C) Double displacement D) Combustion

3- Chemical Equilibrium for Acids, Bases, Salts and Oxidation-Reduction Reactions:

i) Predicting the Number of Ions in a Formula Unit:

Example 3.1: How many ions per formula unit would you find if you dissolve $KClO_3$ in water?

A) 3 B) 9 C) 2 D) 6

See example 2.2

ii) Assigning Oxidation Numbers and Atoms changing their Oxidation State in Redox Reactions:

Example 3.2: Which of the following is an oxidation-reduction reaction?

A) $HC_2H_3O_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_2H_3O_2^-(aq)$

B) $Zn^{2+}(aq) + H_2(g) \rightleftharpoons Zn(s) + 2H^+(aq)$

C) $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

D) $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$

Example 3.3: The oxidation number of nitrogen atom in $NaNO_2$ is:

A) +3 B) -2 C) -3 D) +1

iii) Acids and Bases, and Acid-Base Reactions:

Example 3.4: A neutral solution can be obtained by mixing equal volumes of the same concentration of:

A) HCl and NH_3 B) CH_3COOH and NaOH

C) HCOOH and KOH D) HCl and NaOH

iv) Calculating the $[H^+]$ and pH, and Calculating $[OH^-]$ and pOH:

Example 3.5: The pH is defined as:

A) $pH = -1\log [H^+]$ B) $pH = 1\log [H^+]$

C) $pH = [H^+]$ D) $pH = [H^+]^2$

Example 3.6: A solution in which $[H^+] = 10^{-6}$ has a pH of ……

A) -6 B) +6 C) -8 D) +8

Example 3.7: Lemon juice has a $[H^+]$ of 0.01 M. What is the $[OH^-]$?

A) 1.0×10^{-14} M B) 1.0×10^{-7} M C) 1.0×10^{-12} M D) 1.0×10^{2} M

v) Acid Dissociation Constants (K_a) and base Dissociation Constants (K_b):

Example 3.8: Given the following equilibrium system, what is the expression of K_a?

$$\mathbf{HC_2H_3O_2(aq) + H_2O(I) \rightleftharpoons C_2H_3O_2^-(aq) + H_3O^+(aq)}$$

A) $K_a = \dfrac{[C_2H_3O_2^-][H_3O^+]}{[HC_2H_3O_2]}$ B) $K_a = \dfrac{[HC_2H_3O_2]}{[C_2H_3O_2^-][H_3O^+]}$

C) $K_a = \dfrac{[C_2H_3O_2^-][H_3O^+]}{[HC_2H_3O_2][H_2O]}$ D) $K_a = \dfrac{[HC_2H_3O_2][H_2O]}{[C_2H_3O_2^-][H_3O^+]}$

vi) Buffer Solutions:

Example 3.9: Which of the following constitute a buffer?

A) HCl and NaCl B) KOH and HCl

C) NH_3 and NH_4Cl D) $BaCl_2$ and $AgNO_3$

vii) Acid-Base Titration:

Example 3.10: What volume of 1.80 M of an automobile sulfuric acid, (H_2SO_4) neutralizes 42.10 cm^3 of 1.90 M NaOH?

A) 22.2 cm^3 B) 42.1 cm^3 C) 44.4 cm^3 D) 39.9 cm^3

viii) Equilibrium Expressions and Equilibrium Constants:

Example 3.11: Given the following equilibrium system, what is the expression of K_c?

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

A) $K_c = [NH_3]^2 / [N_2] + 3[H_2]$
B) $K_c = [NH_3]^2 / [N_2][H_2]^3$
C) $K_c = [N_2][H_2]^3 / [NH_3]^2$
D) $K_c = 2[NH_3] / [N_2] + 3[H_2]$

ix) The Solubility and Solubility Product (K_{sp}):

Example 3.12: The solubility product (K_{sp}) of Ag_2CrO_4 is given by:

A) $K_{sp} = 2[Ag^+][CrO_4^{2-}]$
B) $K_{sp} = 1/[Ag^+]^2 [CrO_4^{2-}]$
C) $K_{sp} = [2Ag^+][CrO_4^{2-}]$
D) $K_{sp} = [Ag^+]^2 [CrO_4^{2-}]$

4- Solution Chemistry:

- Molarity:

Example 4.1: What is the molarity of a solution made by dissolving 2.40 mole of KI in enough water to make 2.75 L of solution?

A) 0.200 M B) 0.873 M C) 0.255 M D) 0.542 M

5- Organic Compounds and Functional Groups:

- Hydrocarbon Compounds, Aromatic Hydrocarbons, and Functional Groups:

Example 5.1: Not all carbon containing compounds are organic compounds. Which one of the following compounds is an <u>inorganic compound</u>?

A) CH_4(methane)
B) CH_3OH(methanol)
C) CH_2Cl_2(dichloromethane)
D) $CaCO_3$(calcium carbonate)

Example 5.2: Which of the following is an <u>aromatic compound</u>?

A) Methane B) Ethanol C) Benzene D) Acetaldehyde

Example 5.3: What is the functional group $(-\overset{\overset{O}{\|}}{C}-)$ in $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$.

A) Carbonyl group
B) Hydroxyl group
C) Carboxylic acid group
D) Aldehyde group

Data You May Need

Physical Constants:
Avogadro's number = 6.022×10^{23} objects/mole

Atomic Masses:
H = 1.01; C = 12.0; N = 14.0; O = 16.0; Mg = 24.3; S = 32.1
Cl = 35.5; K = 39.1

Atomic Number:
H = 1; N = 7; Mg = 12