Chapter-9: Acid-Base Balance

Ques. ▶ 1 Different salts dissolve in the water from "Acid Rain" when it flows along the Earth surface and this creates water's special characteristics "Hardness of water". *[All Board-18]*

a. What is pH? 1
b. Why doesn't soap produce foam in hard water? 2
c. Explain how the special characteristics of water mentioned in the stem forms using equations. 3
d. Analyze the causes and results of the rain mentioned in the stem. 4

Answer to the question no. 1

a pH is the concentration of hydrogen ion.

b Soap is a sodium or potassium salt of higher organic acid. On the other hand, calcium or magnesium chloride, sulfate, carbonate or bicarbonate etc. salts dissolved in the water creates hardness. Sodium or magnesium ion in soap produces soluble sodium or potassium salt by reacting with calcium or magnesium salt. But calcium or magnesium salt in hard water doesn't give similar reaction with soap rather it forms an insoluble precipitate. So, soap doesn't produce any foam in hard water.

c The special characteristics of water mentioned in the stem is hardness. The causes of hard water are discussed below with reactions:

We know, a certain part of water in the water cycle flows along the surface of Earth. While flowing, this water comes in contact with different mineral salts present in the soil. So, salts are dissolved in the water. Rainwater reacts with CO_2 to form carbonic acid. This carbonic acid present in rainwater slowly reacts while flowing over limestone $CaCO_3$, dolomite $CaCO_3$, $MgCO_3$ etc. rocks and dissolve these salts.

$$H_2O(l) + CO_2(g) \rightarrow \underset{\text{Carbonic Acid}}{H_2CO_3(aq)}$$

$$CaCO_3(s) + H_2CO_3(aq) \rightarrow Ca(HCO_3)_2(aq)$$

$$MgCO_3(s) + H_2CO_3(aq) \rightarrow Mg(HCO_3)_2(aq)$$

The presence of these elements or $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ causes hardness in water.

d The causes and results of acid rain is analyzed below:

Usually sulphur and nitrogen oxides (SO_x and NO_x) create acid rain.

Sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) has a lot of effect on the environment. Lightning produces nitrogen dioxide in the atmosphere. The produced nitrogen dioxide reacts with water present in water and produces nitric and nitrous acid.

$$2NO_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$$

Nitrous acid is a weak acid. Oxygen present in the air oxidizes it and forms nitric acid.

$$HNO_2(l) + O_2(g) \rightarrow HNO_3(l)$$

Similarly, power plants, brick kilns, industries use coal and petroleum with sulfur which produces sulphur oxides in the atmosphere. This sulphur dioxide reacts with oxygen and ozone in the air and produces sulphur trioxide. Later, sulphur trioxide reacts with the water in air and again produces sulphuric acid.

$$SO_2(g) + H_2O(l) \longrightarrow H_2SO_3(aq)$$

$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$$

These acids come down with rainwater as acid rain on Earth. This acid rain drops pH value of water bodies and soil to 4 or even less than 4. So, soil and water become acidic. Acidic soil reduces soil fertility and crop production. On the other hand, acidic water bodies become uninhabitable for fishes and other water organisms. Acid rain harms buildings and other heritage sites, sculptures etc.

Ques. ▶ 2

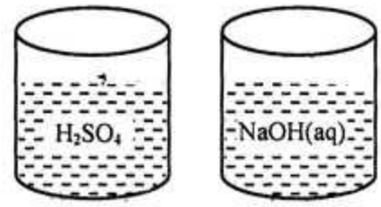


Fig-1 Fig-2

[Ctg.B.-17]

a. What is called the valency electron? 1
b. Why are not Hydrolysis and Hydration reaction same? Explain. 2
c. Calculate the number of molecule of 10gm of the salt that will formed from the reaction between the two compounds in fig-1 and fig-2. 3
d. Between two compounds from the given stem "One is acid and other is alkali"— Analyse their chemical properties. 4

Answer to the question no. 2

a The total electron number of the last main energy shell of an element is the valency electron of that element.

b The process of two parts of a compound combining with the two opposite charged parts (H^+, OH^-) of water to form a new compound is called hydrolysis reaction. For example–

$$AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl$$

On the other hand, ionic compound attaches to one or more than one number of water molecules while forming crystal. This reaction is called hydration reaction. For example–

$$CuSO_4 + 5H_2O \longrightarrow CuSO_4.5H_2O$$

So, according to the two reactions above we can say that, hydrolysis and hydration are not the same reaction.

c The neutralisation reaction between the two compounds of jar-1 and jar-2 is as follows–

$$H_2SO_4 + 2NaOH \longrightarrow \underset{\text{Salt}}{Na_2SO_4} + 2H_2O$$

Molar mass of $Na_2SO_4 = 23 \times 2 + 32 + 16 \times 4$
$= 142$ g

We know,

The amount acquired when the molar mass of chemical matter is expressed in gram unit is called one mole of the relevant matter.

So, 142 g Na_2SO_4 has number of molecules $= 6.02 \times 10^{23}$

$\therefore$ 10 g Na_2SO_4 " " " " $= \dfrac{6.02 \times 10^{23} \times 10}{142}$
$= 4.23 \times 10^{22}$

So, there are 4.23×10^{22} number of molecules in 10g of Na_2SO_4 salt acquired from the reaction of the two compounds of jar-1 and jar-2.

d We know that, the matters which are able to provide protons (H^+) in aqueous solution are called acid. Compound H_2SO_4 of jar-1 is an acid. This is because, it dissociates in aqueous solution and provides proton (H^+).

$$H_2SO_4 + H_2O \longrightarrow \underset{\text{Proton}}{2H^+} + SO_4^{-2}$$

On the other hand, the matters that dissociate in aqueous solution and provide hydroxyl ion (OH^-) are called base. So, compound NaOH of jar-2 is a base, because it dissolves in an aqueous solution and provides OH^- ions.

$NaOH + H_2O \longrightarrow Na^+ + OH^-$

(Hydroxyl ion)

Again, acids and bases react with each other and produce neutral salt compound and water. Acid (H_2SO_4) of jar-1 and base (NaOH) of jar-2 react with each other to produce salt and water.

$H_2SO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$

Acid Base Salt

Since the given compounds react with each other to produce salt and water only, according to the definition of a chemical reaction, it is a neutralisation reaction, and one of them is an acid and the other is a base. So between the two compounds, H_2SO_4 is the acid and NaOH is the base.

Ques. ▶3 $FeCl_2 + AgCl \longrightarrow Ag + FeCl_3$

A (salt) B (salt) *[C.B.-17]*

a. What is ionic bond? 1

b. Explain the isotopes of Chlorine. 2

c. Which metallic ion is reduced of the stem? Explain with equations. 3

d. What will happen if NaOH (aq) is added separately in A and B salt of the stem — Analyze with reactions. 4

Answer to the question no. 3

a The cations and anions formed by electron gaining-losing are attached to the compound molecule with a static electric attraction force which is called ionic bond.

b Atoms of the same element having different mass number are called isotopes of each other. There are 2 isotopes of chlorine in nature. In terms of sufficiency, the percentage of these two isotopes or ^{35}Cl and ^{37}Cl is 75% and 25% respectively. Relative atomic mass of chlorine atom = $\left(\frac{35 \times 75}{100} + \frac{37 \times 25}{100}\right) = 35.5$

c The relevant reaction is as follows:

$FeCl_2 + AgCl \rightarrow Ag + FeCl_3$

Ionic form of the reaction:

$Fe^{+2} + Ag^+ \rightarrow Ag + Fe^{+3}$

The reaction occurred from the transfer of electrons is called redox reaction. Fe^{+2} loses 1 electron and gets oxidized to Fe^{+3} and Ag^+ gains 1 electron and gets reduced to Ag in this reaction. So, this is a redox reaction. Ag^+ was reduced among the two metal ions present in the reactant. Metallic Ag^+ ion gained one electron to become Ag metal. Since gaining electron is reduction so here Ag^+ has been reduced and this reduction reaction is–

$Ag^+ \rightarrow Ag_{(s)}$

So, silver ion has been reduced in this reaction.

d The two salts A and B are $FeCl_2$ and $FeCl_3$. The two reactions of NaOH occurred with the two salts separately is as follows:

$FeCl_2 + NaOH \rightarrow NaCl + Fe(OH)_2\downarrow$

$FeCl_3 + NaOH \rightarrow NaCl + Fe(OH)_3\downarrow$

The two reactions are precipitation reaction. In the first reaction, ferrous ion (Fe^{+2}) of ferrous chloride and hydroxide ion (OH^-) of sodium hydroxide combine to form green precipitate of $Fe(OH)_2$. Similarly, in the second reaction, ferric ion (Fe^{+3}) of ferric chloride and hydroxide ion (OH^-) of sodium hydroxide combine to produce reddish brown precipitate of $Fe(OH)_3$. Na^+ ion and Cl^- ion of sodium chloride does not take part in the reaction rather remains as Na^+ ion and Cl^- ion in the aqueous solution. This is why they are called spectator ion and no electron transfer took place in this reaction.

$FeCl_2 + NaOH_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + Fe(OH)_2\downarrow$

$FeCl_3 + NaOH_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + Fe(OH)_3\downarrow$

So, from the two reactions above we understand that, the two salts $FeCl_2$ and $FeCl_3$ form two hydroxide precipitates of different colours where no form of electron transfer occurred. So, naturally, these are precipitation reaction.

Ques. ▶4 A compound having same empirical formula and molecular formula is composed of hydrogen, sulphur and oxygen containing 2.04% hydrogen and 32.65% sulphur. *[Dj.B.-16]*

a. What is heat of combustion? 1

b. Why neutralisation reaction is a non-redox reaction? 2

c. Determine the molecular formula of the compound stated in the stem. 3

d. The compound stated in the stem does not react with copper in its dilute state but reacts in its concentrated state. What is the reason? Analyse, stating reactions. 4

Answer to the question no. 4

a The amount of heat produced by complete burning of 1 mole of substance in oxygen is called heat of combustion of that substance.

b In neutralisation reaction there is no change of oxidation number of reactants and products. That means, neutralisation reaction is non-redox reaction. Such as –

$HCl_{(aq)}$, $NaOH\ (aq) \longrightarrow NaCl_{(s)} + H_2O\ (e)$

Or, $H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O$

There is no electron transfer occurs. Only ions change their places with each other. So, the neutralisation reaction is non-redox reaction.

c The compound composed of 2.04% hydrogen, 32.65% sulphur and 100 – (2.04 + 32.65) or, 65.31% oxygen. Determination of molecular formula by percentage composition :

Subject	Hydrogen	Sulphur	Oxygen	Empirical/ molecular formula
Percentage composition of element	2.04	32.65	65.31	
Percentage composition of element / Relative atomic mass	$\frac{2.04}{1}$	$\frac{32.65}{32.07}$	$\frac{65.31}{16.0}$	H_2SO_4
	2.04	1.04	4.08	
The ratio of atoms in compound	$\frac{2.04}{1.02} = 2$	$\frac{1.02}{1.02} = 1$	$\frac{4.08}{1.02} = 4$	

That means, the molecular formula of given compound is $-H_2SO_4$.

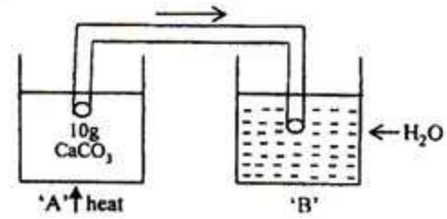
d The given compound as H_2SO_4 has no oxidation property at dilute state. So, it does not react with copper.

$Cu + H_2SO_4$ (dilute) $\longrightarrow$ No reaction

On the other hand, concentrated H_2SO_4 is highly oxidising agent. So, in heated condition or even at normal temperature it oxidises Cu by reacting with it and reduced. In this case, Cu oxidises to copper sulphate ($CuSO_4$) and conc. H_2SO_4 reduced to sulphur di oxide.

$Cu + 2H_2SO_4 = CuSO_4 + SO_2\uparrow + 2H_2O$

Ques. ▶5



[S.B.-16]

a. Write the full form of COD. 1
b. Na is an alkaline metal— Explain. 2
c. Determine the amount of lime in the beaker 'A'. 3
d. Analyze the reason for left the P^H range of the solution of beaker 'B'. 4

Answer to the question no. 5

a The full form of COD is Chemical Oxygen Demand.

b Na (sodium) is a metal of group–1. The metals of this group react with water and produces alkali.

$$2Na + 2H_2O \longrightarrow \underset{\text{(Alkali)}}{2NaOH} + H_2$$

For the above reaction group–1 element or Na is called as an alkaline metal.

c Beaker A has 10g $CaCO_3$. By heating, $CaCO_3$ produces CaO and CO_2.

$$CaCO_3(s) \xrightarrow{\Delta} CaO_{(s)} + CO_2(g)$$

Molecular mass of $CaCO_3 = (40 + 12 = 48) = 100$,
and the molecular mass of $CaO = 40 + 16 = 56$
So, according to reaction, on heating of 100g $CaCO_3$, 56 g of CaO and 44g of CO_2 produce.
That means, 56g CaO produces from 100g $CaCO_3$.
So, 10g $CaCO_3$ produces, $\frac{56}{100} \times 10 = 5.6$ g CaO.

That means, the rest of lime in the beaker 'A' is 5.6 g.

d H_2O is kept in beaker B. CO_2 reaches to beaker B produced from $CaCO_3$ A by beaker on heating. By dissolving with water CO_2 produces a weak acid H_2CO_3 or carbonic acid.
Carbonic acid is a weak acid. It is partially ionised: H_2CO_3 (aq) $\rightleftharpoons 2H^+_{(aq)} + CO_3^{2-}$ (aq)
Because of partial ionization the amount of H^+ ion is less in aqueous solution of H_2CO_3. The range of pH of weak acids is generally from > 3 to < 7.
So, the range of pH of H_2CO_3 is from > 4 to < 6.

Ques. ▶6 i. $Mg(OH)_2 + HCl \rightarrow MgCl_2 + H_2O$
ii. $SO_2 + O_2 \rightarrow SO_3$
[Mymensingh Girls' Cadet College, Mymensingh]

a. What is salt bridge? 1
b. How does KCl dissolve in water? 2
c. Explain the importance of reaction type-i in human life. 3
d. How could you explain the affect of reaction type-ii on nature? 4

Answer to the question no. 6

a Salt bridge is such an arrangement in a electrolytic cell if added salt bridge containing positive and negative ion will remove the imbalance of positive and negative ions in anode and cathode container.

b After bond formation in water molecule, both nucleuses attract the shared electron pair between atoms. Due to the attraction the shared electron pair are transferred toward oxygen atom. That is why there arises partial negative charge on oxygen atom and partial positive charge on hydrogen atom. Ionic compounds like KCl have positive and negative ends. The positive end of ionic compounds are attracted by the negative oxygen end of water and the negative end are attracted by the positive hydrogen end of water. The covalent compounds which have polarity are also attracted similarly and dissolve in water.

c Acid is secreted in the stomach for the need of digestion. If for some reasons, the amount of acid in the stomach increases, we feel uneasy. Generally, it is called acidity. If this acidity continues for long time, it creates infection in the stomach. We take antacid to neutralize this acidity. Antacid contains $Al(OH)_3$ and $Mg(OH)_2$, which are alkaline in nature. They neutralize the excess acid inside our stomach. The reaction is —

$$2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$$

Thus reaction (i) plays important role in human life by neutralizing excess acid inside the stomach.

d If fuel contains particularly sulfur and nitrogen-containing compounds, then on burning of fuel various oxides of nitrogen and sulfur harmful to the health and environment is produced. Sulfur-di-oxide with presence of thunderstorm produce sulfur-tri-oxide.

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

Sulfur-tri-oxide combines with atmospheric water vapor and produced sulfuric acids which cause acid rain.

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

We can certainly realize that acid rain is an obstacle to plants and animals of environment to survive. Besides, this carbon-mono-oxide, nitrous oxide and unburnt gaseous fuel (methane) comes into air from exhaust of vehicles forms various toxic gases and fumes by different chemical reaction in presence of sunlight. This is called photochemical smog. The constituent gases of photochemical smog cause dangerous corrosion to atmospheric ozone (O_3) layer. So it is very important to ensure the uses of pure fuels for the safety of health and the environment.

Ques. ▶7 (i) $FeCl_2$ (aq) + X(aq) → $\underset{\text{(Green ppt)}}{Fe(OH)_2}$ + NaCl
(ii) Y (aq) + NaOH (aq) → $\underset{\text{(Reddish brown ppt)}}{Z(s)}$ + NaCl
[Rajshahi Cadet College, Rajshahi]

a. What is hydrogen fuel cell? 1
b. What do you mean by nuclear fission reaction? Write with example. 2
c. How is colorless liquid found due to the reaction between X and the chloride of the metal situated exactly at the upper position to 'Fe' in reactivity series? 3
d. 'X' is electro conductive, but 'Z' is not — analyze the statement. 4

Answer to the question no. 7

a Hydrogen fuel cells is a kind of electrolysis cell where hydrogen is converted directly to electricity by electrolysis.

b The kind of nuclear reaction where heavy nucleus dissociate into smaller nucleus, which is called nuclear fission reaction. Radioactivity is a nuclear fission reaction. The rate of radioactivity of an element can be increased for many times. If any radioactive element is heated by a high energetic neutron, then the nucleus of the radioactive element will dissociate and form instantly many small nucleuses. Such as- 30 different elements are formed from fission reaction by heating of uranium-235 with high energetic neutron.

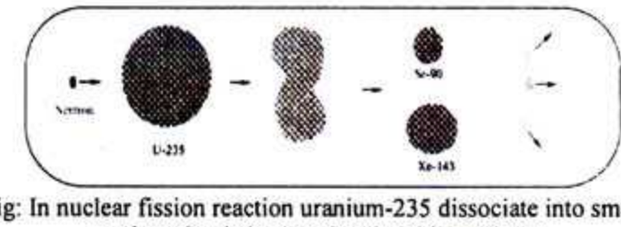


Fig: In nuclear fission reaction uranium-235 dissociate into smaller nucleus that is in atom by absorbing neutron.

c The completed reaction is —

$$FeCl_2(aq) + 2NaOH(aq) \longrightarrow Fe(OH)_2(s) + NaCl(aq)$$

The compound 'X' is NaOH.

The element above Fe in the reactivity series is Zn. But chloride salt of Zn that is $ZnCl_2$. But no colorless compound is found by the reaction between NaOH and $ZnCl_2$.

$$ZnCl_2(aq) + 2NaOH(aq) \longrightarrow Zn(OH)_2(s) + NaCl(aq)$$

Actually a white precipitation of $Zn(OH)_2$ is found. But no colorless compound is found.

d The second reaction is —

$$FeCl_3(aq) + 3NaOH(aq) \longrightarrow Fe(OH)_3(s) + NaCl(aq)$$

The compound Z is $Fe(OH)_3$.

We have seen earlier that compound 'X' is NaOH. NaOH is a strong electrolyte. It is an alkali-a water soluble strong base. NaOH conducts electricity even in the molten state, like ionic salts such as NaCl. In aqueous solution they form ions.

$$NaOH\ (aq) + H_2O(l) \longrightarrow Na^+ + OH^- + H_2O(l)$$

A strong electrolyte is a solute that completely, or *almost* completely, ionizes or dissociates in a solution. But $Fe(OH)_3$does not dissolve in a solution. They are precipitated. So they do not form any kind of ion. That's why the compound $Fe(OH)_3$ is not an electrolyte.

Ques. ▶8 $_{26}A^{2+}$, $_{29}E^{2+}$, $_{11}D^{2+}$ $_{30}F^{2+}$

[Joypurhat Girls' Cadet College, Joypurhat]

a. What is photochemical smoke? 1
b. Why all metals are electrical conductor? 2
c. Write down the electronic configuration of stem ions A and E. 3
d. How can you detect stem E and F ion in a solution using $DOH_{(aq)}$? Explain with related reaction. 4

Answer to the question no. 8

a Photochemical smog is a mixture of pollutants that are formed when nitrogen oxides and volatile organic compounds react to sunlight.

b Materials through which electricity can pass easily are electrical conductor. Metal particles are held by metallic bonds. Thus free electrons in metals can move through the metals allowing electricity to pass through the metals. Therefore, all metals are electrical conductor.

c A in the stem is Fe. $_{26}A^{2+}$ is therefore $_{26}Fe^{2+}$.
Electronic configurtion of $_{26}Fe^{2+}$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^6$
E in the stem is Cu. $_{29}E^{2+}$ is $_{29}Cu^{2+}$
Electronic configuration of $_{29}Cu^{2+}$: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^9$

d Ion of stem E is $_{29}Cu^{2+}$ and F is $_{30}Zn^{2+}$
DoH in the stem is NaoH

Detection of Cu^{2+} ion: When NaOH is added to Cu^{2+} ion, $Cu(OH)_2$ will precipitate. It has light blue color, which helps detect Cu^{2+} ion.

$$Cu^{2+}_{(aq)} + 2OH^- \longrightarrow Cu(OH)_2{}^{(s)}$$

Light blue precipitate

e.g. $CuSO_4 + 2NaOH \longrightarrow Na_2SO_4 + Cu(OH)_2$

Detection of Zn^{2+} ion: When NaOH is added to Zn^{2+} ion, $Zn(OH)_2{}^{(s)}$ is formed. Which is a white precipitate. The color helps detect the presence of Zn^{2+} ion.

$$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Zn(OH)_{2(s)}$$

white precipitate

e.g. $ZnSO_4 + 2NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)} + Na_2SO_4$

Ques. ▶9 XZ_2, YZ_2, Z_2 are the molecules produced from three elements : $_6X$, $_7Y$ $_8Z$ *[Sylhet Cadet College, Sylhet]*

a. Draw the risk sign for radioactive ray? 1
b. Explain that Bhor's atom model overcomes the limitation of Rutherfords atom model in some extent. 2
c. Which of the above molecules will show maximum diffusion rate and why? 3
d. Describe the harmful effect of first two compounds on environment. 4

Answer to the question no. 9

a The risk sign for radioactive ray is trefoil. It is drawn below:

b Bohr's atom model overcomes the limitations of Rutherford's atom model to some extent. It is explained below:

i) Rutherford compared the orbits of electrons around nucleus to that of the planets in the solar system. It did not mention anything about the size of the energy levels. Bohr's atomic model specifies the circular size of the energy levels.

ii) Rutherford's model does not mention about the changes in structure of atom when they absorb or emit energy. The Bohr model states that the electron moves from lower to upper energy level when the atom absorbs heat and it moves from upper to lower energy level when the atom emits heat.

c The elements X, Y and Z represents C(carbon), N(nirogen) and O(oxygen) respectively as their atomic numbers are 6,7 and 8 respectively.
So, the compounds XZ_2, YZ_2 and Z_2 are CO_2, NO_2 and O_2 respectively.
The diffusion rate of an object refers to how much the object spreads around in a medium per unit time. An object that has less density or molar mass will have more diffusion rate. And the one that has more molar mass will have less diffusion rate.
The molecular mass of CO_2, NO_2 and O_2 are 44, 46 and 32 respectively. Therefore, the diffusion rate of O_2 or Z_2 of the stem is maximum as it is the lightest of these three.

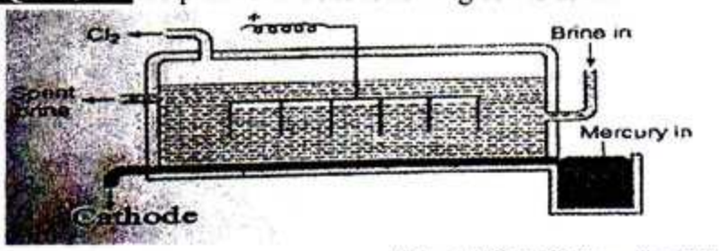
d The first two compounds of the stem are XZ_2 and YZ_2. They represent CO_2 and NO_2 respectively. Their harmful effects on the environment is described below:
CO_2 and NO_2 get dissolved in the rain water and produce some acids which come down to earth with rain water. Rain with these acids is called acid rain.

$$CO_2(g) + H_2O(l) \longrightarrow H_2CO_3(aq)$$

$$2NO_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$$

That is why the pH value of rain water is 5-6. However, some man-made reasons like carbon dioxide emitted from vehicles, power plants and industries mix with air which undergoes reaction with rain water and produces carbonic acid (H_2CO_3). Besides, the power plants, brick kilns etc. use coal and petroleum rich with nitrogen and sulfur which again produce oxides of these elements. These also produce acids which come down with rain water. That is why, in some places, the amount of acid in rain sometimes goes higher than expected. As a result the pH of rain water in these spots may drop down to 4 or below 4, which is acid rain. This rain results in a drop down of pH of soil. This has severe harmful effect on crops and plants. The pH value of water in the water bodies also goes down and makes the situation uninhabitable for the lives there. Fish production is hampered. Acid rain also harms the buildings, metallic structures, marble architectures and sculptures.

Ques. ▶ 10 To produce NaOH following cell is used.



[Jhenidah Cadet College, Jhenidah]

a. What is glass cleaner? 1
b. Explain that metal extraction is a reduction process. 2
c. Mention the reactions that happen in above cell. 3
d. Explain the role of the compound that obtains in above cell to identify metal ion. 4

Answer to the question no. 10

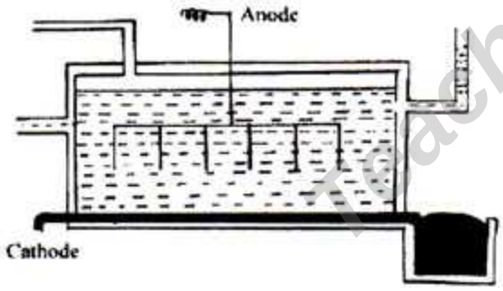
a The detergent which is used for cleaning glass is called glass cleaner. Glass cleaner is usually prepared by mixing isopropyl alcohol, $CH_3CH(OH)CH_3$ with ammonium hydroxide (NH_4OH)

b Metals exist in nature as compounds which are also called ores. Metals remain as ions in compounds. In the process of extraction of metal, it gets reduced. Because here metal ion is accepting electron

$$Mn^+ + ne^- \longrightarrow M$$

So, metal extraction is a reduction process.

c Sodium has great affinity for mercury. So when mercury is used as cathode it forms a compound with the mercury called sodium amalgam (Na-Hg).Addition of water with this compound makes Caustic Soda (NaOH).
Caustic soda (NaOH) is produced by the electrolysis of brine or concentrated solution of table salt (NaCl). In aqueous solution of sodium chloride (NaCl) there presence Na^+, H^+, Cl^-, OH^-. Among these Na^+ and H^+ are cations and Cl^-, OH^- are anions.



Anode reaction:

$$4OH^- - 4e^- \longrightarrow 2H_2O + O_2$$
$$Cl^- - e^- \longrightarrow Cl$$
$$Cl + Cl \longrightarrow Cl_2$$

Cathode reaction (mercury):

$$Na^+ + e^- \longrightarrow Na$$
$$Hg + Na \longrightarrow Na\text{-}Hg$$
$$Na\text{-}Hg + H_2O \longrightarrow NaOH + H_2 + Hg$$

d NaOH is a base. It reacts with many salts to produce hydroxides. Many of those hydroxides are insoluble in water and produce precipitation. Thus it helps to identify the different metal ions. Few examples are given below:

Reaction between dilute NaOH and $A1(NO_3)_3$:

$2Al(NO_3)_3 + 6NaOH \longrightarrow 2Al(OH)_3 \downarrow + 6NaNO_3$

$Al(OH)_3$ gathers as white precipitate at the bottom of test tube.

Reaction between dilute NaOH and $Fe(NO_3)_2$:

$Fe(NO_3)_2 + 2NaOH \longrightarrow Fe(OH)_2 \downarrow + 2NaNO_3$

$Fe(OH)_2$ gathers as green precipitate at the bottom of test tube.

Reaction between dilute NaOH and $Fe(NO_3)_3$

$Fe(N0_3)_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3NaNO_3$

$Fe(OH)_3$ gathers as reddish brown precipitate at the bottom of test tube.

Reaction between dilute NaOH and $Cu(NO_3)_2$

$Cu(NO_3)_2 + 2NaOH \longrightarrow Cu(OH)_2 \downarrow + 2NaNO_3$

$Cu(OH)_2$ gathers as light blue precipitate at the bottom of test tube.

Reaction between dilute NaOH and $Zn(NO_3)_2$

$Zn(NO_3)_2 + 2NaOH \longrightarrow Zn(OH)_2 \downarrow + 2NaNO_3$

$Zn(OH)_2$ gathers as white precipitate at the bottom of test tube.
Thus NaOH plays an important role in the identification of metal ions.

Ques. ▶ 11 $_{26}A^{2+}$, $_{29}B^{2+}$ $_{11}C^+$, $_{30}D^{2+}$

[St. Joseph Higher Seconadry School, Dhaka]

a. What is pH? 1
b. Why are metal s conductors of electricity? 2
c. Write down the electronic configuration of $_{26}A^{2+}$, $_{29}B^{2+}$ & $_{30}D^{2+}$ 3
d. Write the experiment (including reactions) to indentify. $_{26}A^{2+}$, $_{29}B^{2+}$, $_{30}D^{2+}$ by using $COH_{(aq)}$. 4

Answer to the question no. 11

a pH is the negative logarithm of the concentration of hydrogen ion.

b The elements that are capable of conducting electricity are known as conductors. On the last energy level of a metal, there usually is a free electron that isn't a part of any particular atom. Therefore, they can easily move freely. This free movement of an electron is the reason that metals can conduct electricity.

c In the stem, as the atomic number of A is 26, it is iron. The electronic configuration of iron is —

$Fe(26) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

$Fe^{2+}(24) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$

Also, B in the stem is copper as its atomic number is 29. As it has a filled orbital, its electronic configuration will be unique.

$Cu(29) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

$Cu^{2+}(27) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

Also, D in the stem is copper as its atomic number is 29. As it has a filled orbital, its electronic configuration will be unique.

$Zn(30) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

$Zn^{2+}(28) \longrightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

d In the stem, A, E and F respectively are iron, copper and zinc. And as C is sodium, COH is sodium hydroxide.
Identifying A^{2+}, B^{2+} and D^{2+} by using NaOH(aq):
If a diluted base named sodium hydroxide (NaOH) is added to the solution of $FeCl_2$ and $FeCl_3$ salt then, green $Fe(OH)_2$ precipitate and reddish-brown $Fe(OH)_3$ precipitate is produced respectively. The relevant reactions are as follows —

$FeCl_2 + 2NaOH \longrightarrow Fe(OH)_2$ (Green Precipitate) $+ 2NaCl$

$FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3$ (Reddish brown Precipitate) $+ 3NaCl$

Adding NaOH to the liquid solution of copper salts results in the blue precipitate of copper hydroxide.

$CuCl_2\ (aq) + 2\ NaOH\ (aq) \longrightarrow Cu(OH)_2\ (s)$ (Light blue precipitate) $+ 2NaCl$

Also, adding NaOH to the liquid solution of zinc salts results in the white precipitate of zinc hydroxide. Adding excessive NaOH helps the solution absorb the precipitate, and therefore helps the solution become colorless.

$ZnCl_2$ (aq) + NaOH(aq) $\longrightarrow$ $Zn(OH)_2$ (s) $\downarrow$ + NaCl (aq)
White precipitate

$Zn(OH)_2$ + excessive NaOH $\longrightarrow$ colorless solution

The colors of the precipitate in the aforementioned reactions easily help one to identify Fe, Cu and Zn.

Ques. ▶ 12 B is compound in which Hydrogen 2.04%, Sulfur 32.65% and Oxygen 65.31%. Vapour density of B is 49.
[Dinajpur Laboratory School and College, Dinajpur]

a. What is acid rain? 1
b. Mention the difference between oxidation number and valencey. 2
c. Determine the molecular formula of B. 3
d. Is B an acid and dehydrating agent? Put your opinion. 4

Answer to the question no. 12

a At high temperature, N_2 and 0_2 present in air undergo reaction and produce NO. This NO gets oxidized by oxygen and becomes $N0_2$. These oxides get dissolved in the rainwater and produce some acids which come down to earth with rainwater. Rain with these acids is called acid rain.

b Difference between the oxidation number and valency is as follows:

Oxidation Number	Valency
i. Oxidation number is the number of positive or negative charge associated with an atom in a compound.	i. It is ability of an element to react with another different or same element.
ii. Oxidation number can be a whole number, or fraction, even it could be 0.	ii. Valency can never be a fraction. It will always be a whole number.

c The compound B of the stem contains 2.04% Hydrogen, 32.65% Sulfur and 65.31% Oxygen.

Name of elements	Hydrogen	Sulfur	oxygen	Empirical Formula
Percentage of composition	2.04%	32.65 %	65.31%	H_2SO_4
Composition relative atomic mass	$\frac{2.04}{1}$ = 2.04	$\frac{32.65}{32}$ = 1.02	$\frac{65.31}{16}$ = 4.08	
Ratio of atoms	2	1	4	

Given that, vapour density = 49
So, molecular mass = 49×2 = 98
Let, the molecular formula is $(H_2SO_4)_n$
Therefore,
$n\times(2\times1+32+16\times4) = 98$
Or, $98\,n = 98$
So, $n = \frac{98}{98} = 1$

Therefore, the molecular formula of compound B is H_2SO_4

d Compound B of the stem is H_2SO_4 or sulphuric acid. It is an acid and a dehydrating agent as well. This is explained below:

H_2SO_4 as an acid: Neutralisation or acid-base reaction is a characteristics reaction of Acid. When the aqueous solution of acid and base is mixed together, salt is produced.

Acid + Base $\longrightarrow$ Salt + Water

H_2SO_4 reacts with strong base Sodium hydroxide NaOH and produce Sodium sulfate (Na_2SO_4) and water (H_2O).

$H_2SO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$

So, H_2SO_4 shows the properties of an acid.

H_2SO_4 as a dehydrating agent: When few drops of concentrated H_2SO_4 are added to the sugar or sucrose ($C_{12}H_{22}O_{11}$), it produces steaming black carbon foam. The sulphuric acid dehydrates the carbohydrate sugar, removing the water and heating it into steam leaving behind the carbon foam:

$C_{12}H_{22}O_{11}$ (sugar) + H_2SO_4 (sulphuric acid) $\longrightarrow$
12C (carbon) + H_2SO_4.11 H_2O

So, H_2SO_4 acts as a dehydrating agent.

Ques. ▶ 13 S + O_2 → X (g)
C + O_2 → Y (g) *[Mainamati International School, Cumilla]*

a. Which acid can be found in tamarind? 1
b. Will the pH of lime water be greater or less than 7? Explain. 2
c. Calculate the number of bond pair and lone pair electrons in molecule X. 3
d. X and Y are responsible for acid rain-Analyze. 4

Answer to the question no. 13

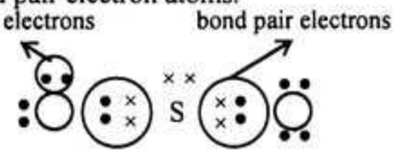
a Tartaric, malic and citric acid can be found in tamarind.

b pH is the negative logarithm of the concentration of hydrogen ion. pH = $-\log[H^+]$. The pH value of a solution will be 0 –14. If the pH value is less than 7, it is acidic. If the pH value is greater than 7, it is base. If the pH value is exactly 7, it is neutral. Lime water is base, so the pH value of lime water will be greater than 7.

c The reaction is –

$S + O_2 \longrightarrow SO_2$

Therefore the compound is SO_2.
The valence shell of Sulfur contains 6 electrons. So it needs two electrons to fulfill its octet.
Again Oxygen contains 6 electrons in its valence shell. So it requires 2 electrons to fulfill its octet too.
So Sulfur and Oxygen share their electrons to gain the inert structure. Sulfur shares its two electrons with Oxygen and oxygen shares its two electrons with sulfur too. Thus Sulfur makes bond with two oxygen atoms to form the compound. The outer shell thus contain 10 electrons. Octet expansion is not a problem for sulfur as it contains d-shell.
So there are 1 lone pair electron in Sulfur and 2 lone pair electrons in each of the oxygen atoms. Total 5 lone pair electrons are there.
There are 2 bond pair electrons with each of the oxygen atom. So there are 4 bond pair electron atoms.



d Naturally rainwater is slightly acidic the pH of it is 5.6 because carbon dioxide and nitrogen dioxide gas remain dissolved in rainwater. All living beings produces carbon dioxide during respiration and leave it to the atmosphere. Any firework and volcanic eruption causes the deposition of carbon dioxide in the atmosphere. Brickfields, industries and exhaust of vehicles emit carbon dioxide. During flushing in storm, nitrogen dioxide gas is produce in atmosphere. Nitrogen dioxide gas is also produced in the self-combustion engine by burning petroleum and released into the atmosphere. Carbon dioxide and nitrogen dioxide react with water present in air produce acid.

$CO_2(g) + H_2O(l) \longrightarrow H_2CO_3(aq)$
$2NO_2(g) + H_2O(l) \longrightarrow HNO_2(aq) + HNO_3(aq)$

Nitrous acid is very transient. It converts to nitric acid oxidized by atmospheric oxygen. During volcanic eruption sulphur dioxide and nitric oxide is produced. If the fuels of the electric power station, brick fields, industries, coal, and petroleum contain sulphur/nitrate they produce sulphur dioxide and nitric oxide which are released in the atmosphere. Sulphur dioxide reacts with atmospheric water and produces sulphurus acid. Sulphur dioxide reacts with oxygen and ozone of atmosphere and produce sulphur trioxide which reacts with atmospheric water and produces sulphuric acid.

$$SO_2(g) + H_2O(l) \longrightarrow H_2SO_3(aq)$$
$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$$

These acids fall on the earth surface with rain.

Ques. ▶ 14 A compound having same empirical and molecular formula is cmposed of 2.04% H and 32.65%S.

[Jalalabad Cantonment Public School & College, Sylhet]

a. What is limiting reactant? 1
b. Write the differences between electron affinity and electro negativity. 2
c. Determine the molecular formula of the compound stated in the stem. 3
d. 'The compound stated in the stem does not react with Cu in its dillute state but reacts in its concentrated state.' Analyse the reason of it with proper reactions. 4

Answer to the question no. 14

a In a chemical reaction among more than one reactants the reactant that does not remain in the reaction medium after the reaction is called limiting reactant.

b The difference between electron affinity & electronegativity are :

Electron affinity	Electronegativity
The electron affinity of an atom or molecule is defined as the amount of energy released when an electron is added to a neutral atom or molecule in the gaseous state to form a negative ion.	Electronegativity is a chemical property that says how well an atom can attract electrons towards itself.
Iit is a measurable quantity.	Electronegativity cannot be directly measured. It must be calculated from other properties such as bond energies, ionization energies, and electron affinities of the bonded atoms.

c The compound composed of 2.04% hydrogen, 32.65% sulfur and 100 – (2.04 + 32.65) or, 65.31% oxygen. Determination of molecular formula by percentage composition:

Subject	Hydrogen	Sulfur	Oxygen	Empirical/ molecular formula
Percentage composition of element	2.04	32.65	65.31	H_2SO_4
Percentate composition of element / Relative atomic mass	$\frac{2.04}{1} = 2.04$	$\frac{32.65}{32.07} = 1.04$	$\frac{65.31}{16.0} = 4.08$	
The ratio of atoms in compound	$\frac{2.04}{1.02} = 2$	$\frac{1.02}{1.02} = 1$	$\frac{4.08}{1.02} = 4$	

That means, the molecular formula of given compound is $-H_2SO_4$.

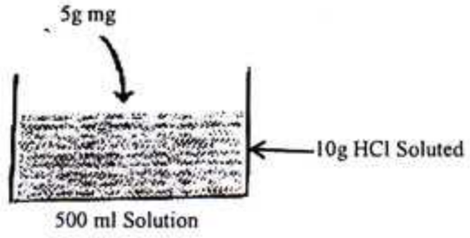
d The given compound as H_2SO_4 has no oxidation property at dilute state. So, it does not react with copper.

$$Cu + H_2SO_4 \text{ (dilute)} \longrightarrow \text{No reaction}$$

On the other hand, concentrated H_2SO_4 is highly oxidizing agent. So, in heated condition or even at normal temperature it oxidizes Cu by reacting with it and get reduced. In this case, Cu oxides to copper sulfate ($CuSO_4$) and conc. H_2SO_4 is reduced to sulfur dioxide.

$$Cu + 2H_2SO_4 = CuSO_4 + SO_2\uparrow + 2H_2O.$$

Ques. ▶ 15



[Navy Anchorage School, Khulna]

a. Write down the Mendellev's revised periodic table. 1
b. Why is the melting point of NaF High? Explain it. 2
c. What is the concentration of the acidic solution in the stem? Detect. 3
d. Which one is the limiting reagent here? Analyze mathematically. 4

Answer to the question no. 15

a The law of Dmitri Mendeleev and is, "When the elements are arranged in order of increasing atomic mass, certain sets of properties recur periodically."

b The tendency of an atom to attract a bonding pair of electrons is called electronegativity. In NaF, the electronegativity of F is very high. Therefore, it has a greater pull towards the electrons in the ionic bond. As it has a strong negative F ion and a strong positive Na ion, the melting point is very high.

c To find the concentration of acidic solution in the stem, we must do the following steps:
Here, the amount of HCl is 10g.

The amount of the solution is 500ml $= \frac{1L}{1000mL} \times 500\ mL$
$= 0.5\ L$

So, the concentration is, $\frac{10}{0.5} = 20\ g/L.$

d $Mg + 2HCl \longrightarrow MgCl_2 + H_2$
Here,
Amount of Mg = 5g
Amount of Cl = 10g

Mole of Mg $= \frac{5}{24} = 0.20$ mol Mg

Mole of HCl $= \frac{10}{36.5} = 0.27$ mol Cl

From the equation, 1 mol Mg reacts with 2 mol HCl.
So, Mg = 2×0.20 = 0.4 mol
This shows that 1 mol Mg requires 0.4mol HCl for the reaction to be balanced. As the amount of HCl is 0.27 < 0.4, it shows that there should be 0.4 mol of HCl for there to be no limiting reagent. Thus, HCl is the limiting reagent.