Chapter-10: Mineral Resources: Metal-Nonmetal

Ques. ▶1 Two important metals to us:
(i) Aluminium; (ii) Iron

[All Board-18]

a. What is Galvanic cell? 1
b. Between Bauxite and Galena ores, which ore goes through roasting? 2
c. Describe the extraction process from ore of element no. (i) in the stem. 3
d. Only one of the elements mentioned in the stem corrodes if kept under open air– Analyze with equations. 4

Answer to the question no. 1

a The cell where chemical elements undergo redox reaction and produce electrical energy is called Galvanic cell.

b Between bauxite and galena ores, roasting is applied to only galena ore. Bauxite ($Al_2O_3.\ 2H_2O$) is aluminium ore and galena (PbS) is lead ore. Generally, roasting is applied for sulfide ores. Since galena is lead sulphide or PbS so galena ore is roasted to lead oxide and lead metal is extracted and sulphur dioxide gas is also produced in this roasting.

$$PbS + O_2 \xrightarrow{\Delta} PbO + SO_2$$

c Element no. (i) in the stem is aluminium. Extraction process of aluminium from ore is described below:
Aluminium ore is bauxite or hydrous aluminium oxide $Al_2O_3.2H_2O$. This can be purified in different methods to get aluminium oxide and pure aluminium metal can be extracted by its electrolysis.
Bauxite is purified by eliminating different impurities, then the water is dried by heating to get dry aluminium oxide. Melting point of aluminium oxide is 2050°C. Reaching this high temperature is expensive; so instead of using directly aluminium oxide, a mineral solution named cryolite is mixed with it. Melting point of cryolite (Na_3AlF_6) is 1000°C. The mixture melts between 900°–950°C temperature.
The inside of a steel tank is wrapped with graphite layer. This graphite layer works as the cathode. Some graphite rods are used as the anode. Electricity is run through the melted bauxite in this tank. Cryolite (Na_3AlF_6) is added to decrease the melting point of bauxite. This electric flow creates electrolysis of aluminium oxide. Aluminium metal starts to accumulate in the cathode. Since aluminium is heavier than cryolite, it accumulates in the bottom. This aluminium metal is taken out by opening the plug of emission tube at the bottom of the tank. On the other hand, oxygen is produced in the anode, which reacts with carbon in this high temperature and produces carbon monoxide and carbon dioxide. The chemical reactions in the electrolysis—

$$Al_2O_3\ (l) \longrightarrow 2Al^{3+}\ (l) + 3O^{2-}\ (l)$$

Oxidation in anode: $O^{2-}\ (l) \longrightarrow O + 2e^-$

$$2O \longrightarrow O_2\ (g)$$

Reduction in cathode: $Al^{3+}\ (l) + 3e^- \longrightarrow Al\ (l)$

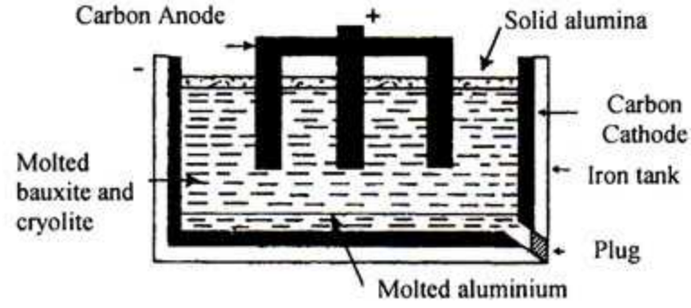


Fig: Aluminium Extraction Using Electrolysis

d The two elements in the stem is aluminium and iron. If this aluminium and iron is left at open then iron corrodes but aluminium doesn't. The reaction of iron and aluminium with oxygen in the air is discussed below:
If iron is kept open in air then it reacts with oxygen and water vapor. Iron reacts with water vapor in air and produces iron oxide (rust). This iron oxide separates from metal iron and again brings the metal surface in contact with air which produces iron oxide or rust. The number of water molecules attached to each molecule of rust is unknown. So, the number of free water molecules is represented by n.

$$4Fe + 6H_2O + 3O_2 \longrightarrow 4Fe(OH)_3$$

$$2Fe(OH)_3 \xrightarrow{-H_2O} Fe_2O_3.\ nH_2O$$

On the other hand, when aluminium is kept open in air, it also reacts similarly with oxygen and produces aluminium oxide. But this aluminium oxide doesn't separate from the metal rod rather remains as a cover over the aluminium metal. This aluminium oxide prevents the metal aluminium below from coming in contact with air again.
So, from the above discussion it can be said that, iron kept in open reacts with oxygen and produces harmful iron oxide or rust which corrodes iron but aluminium oxide doesn't corrode similarly rather it keeps aluminium away from the contact of air. So, aluminium doesn't corrode even if it is kept in open.

Ques. ▶2 Aluminium oxide is produced by the combustion of Aluminium. (Atomic mass of Al = 27)

$$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$$ *[R.B.-17]*

a. What is the formula of edible salt? 1
b. Why Neon is inert? Explain. 2
c. What amount of product will be produced from 20 gm Al? Determine. 3
d. Oxidation-reduction occurs in this reaction simultaneously— explain according to electronic concept. 4

Answer to the question no. 2

a The formula of edible salt is NaCl.

b Atomic number of neon is 10. Its electron configuration is–

$$_{10}Ne \longrightarrow 1s^2\ 2s^2 2p^6$$

From the electron configuration we see that, there are 8 electrons in the last orbit of Ne. This is a really stable electronic structure for Ne. Ne doesn't lose, gain or share electron with any other element due this stable electronic structure. So, it doesn't form chemical bonds. Therefore, it doesn't react with anyone and presents an inert state. This is why neon is inert.

Teachingbd24.com

c The combustion reaction of Al in the stem is–

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

From the reaction we see that, 4 mol Al produces 2 mol Al_2O_3.

4 mol Al = 4 × 27 = 108 g

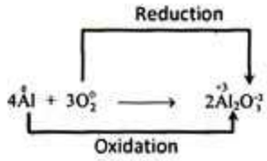
2 mol Al_2O_3 = 2 × (27 × 2 + 16 × 3) = 204 g

108 g Al produces product of 204 g

∴ 20 g Al " " " $\frac{204 \times 20}{108}$ g

= 37.78 g

So, 20 g Al produces 37.78 g product.



d The stem reaction is– The oxidation number of Al in reactant is 0 and in product is +3. Since Al has lost three electrons so its oxidation number changed from 0 to +3. According to the electronic theory, losing electron is oxidation, so, oxidation of Al has occurred. Again, oxidation number of O in reactant is 0 and –2 in product. Since oxygen gained two electrons, its oxidation number changed from 0 to –2. Since gaining electron is reduction so, reduction of oxygen has occurred. So, reduction is not possible without oxidation. Therefore, oxidation and reduction occur simultaneously.

Ques. ▶3 Zinc blend $+O_2 \xrightarrow{\Delta}$ A (Ionic compound) + B (covalent compound) *[R.B.-17]*

a. What is sublimation? 1

b. Why potassium is called alkali metal? Explain. 2

c. How Zinc is extracted from 'A'? Describe with reaction. 3

d. A dehydrating acid can be produced from 'B' — Justify the statement with process. 4

Answer to the question no. 3

a If a solid matter directly turns into gas in when heated and directly returns to solid when cooled down, then this process is called sublimation.

b Potassium is in group no. I in periodic table. This reacts with water to produce H_2 gas and basic solution of KOH. Potassium forms ionic compound by donating the only electron in the outermost energy level to a nonmetal. The reaction of K and H_2O is–

$$2K + 2H_2O \longrightarrow 2KOH + H_2$$

So, since potassium creates basic solution so it is called basic metal.

c The stem reaction is– Zinc Blend + $O_2 \xrightarrow{\Delta}$ A (Ionic Compound) + B (Covalent Compound)

Zinc blend is ZnS. Therefore, if the mixture of ZnS and O_2 heated then the reaction that occurred is–

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO(A) + 2SO_2(B)$$

ZnO compound is ionic and SO_2 compound is covalent. Compound A and B are SO_2 and ZnO respectively. Zn can be extracted from ZnO.

The produced zinc oxide is mixed with coke powder (carbon) and then taken in a one end closed cylinder shaped retort. This retort is made of firewood. Receiver pipe made of clay is attached to the open end of it. This pipe works as a condenser for the zinc vapour. There is a smaller condenser made of iron at the end of the condenser, it is called prolong. The zinc vapour that isn't condensed in the first condenser, collecting that vapour is the work of prolong.

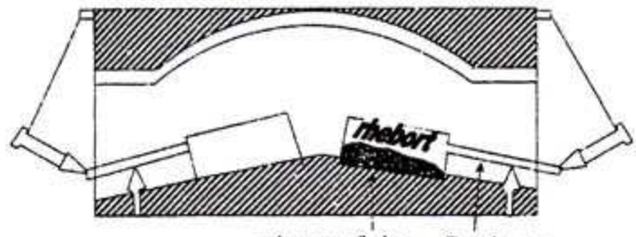


Figure : Zinc extraction by carbon reduction

The mixture of zinc oxide and coke is heated for around 24 hours using gas. Zinc oxide reduces to zinc and carbon oxidizes to produce carbon monoxide, which burns at the opening of the condenser.

$$ZnO(s) + C(s) \longrightarrow Zn(s) + CO(g)$$

The produced zinc comes out of the retort in the form of vapour and its bigger part is accumulated as liquid zinc in the condenser after cooling down. This is how produced zinc is 97-98% purified. It can be more purified using electropurification as necessary.

Zn can be extracted from ZnO or compound A of the stem in the process described above.

d From the answer no. (c) we can see that, the covalent compound B of stem is SO_2. The production of dehydrator acid H_2SO_4 can be performed from this SO_2.

If SO_2 is oxidized by oxygen in the presence of Pt powder or V_2O_5 catalyst at 400 – 450°C temperature in the contact chamber then SO_3 is produced.

$$2SO_2(g) + O_2(g) \xrightarrow[Pt/V_2O_5]{400 - 500°C} 2SO_3(g)$$

The addition of H_2O with SO_3 produces H_2SO_4. But in this case, the problem is, SO_3 attaches with the water vapour in air and produce thick fog of H_2SO_4, which is hard to condense.

$$SO_3(g) + H_2O(g) \longrightarrow H_2SO_4 \text{ (Thick fog)}$$

So, SO_3 is absorbed by 98% H_2SO_4 to produce fuming H_2SO_4. This is called oleum.

$$H_2SO_4(l) + SO_3(g) \longrightarrow \underset{\text{Oleum}}{H_2S_2O_7(l)}$$

Pure H_2SO_4 is a thick oily liquid matter which is mixable in water at all ratios. If water is added to H_2SO_4 lots of heat is generated and explosion occurs. This is why, H_2SO_4 is diluted by adding drop by drop in water with constantly stirring.

$$H_2S_2O_7(l) + H_2O(l) \rightleftharpoons 2H_2SO_4(l)$$

So, from the discussion above we can say that it is possible to produce a dehydrator acid H_2SO_4 from compound B of stem SO_2.

Ques. ▶4 (i) Bauxite (ii) Celcoisite (iii) Calamine *[Dj.B.-17]*

a. What is orbit? 1

b. Write the conversion method into oxide of ore no. (iii). 2

c. Determine the percent composition of oxide of ore no. (i). 3

d. Describe the purification method of the metal which is extracted from ore no. (ii). 4

Answer to the question no. 4

a The still circular orbit for electrons to rotate around the nucleus of atom is called orbit.

b Ore no (iii) is calamine. Its formula is $ZnCO_3$. This ore is heated at temperature less than the melting point in the calcination process. As a result, organic material and water vapour is eliminated from the ore. Ore can be converted into metal carbonate and metal oxide in this process.

$$ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$$

This is how calamine is converted into metal oxide or ZnO.

Teachingbd24.com

c The given ore no. (i) is bauxite. Its formula is:

$Al_2O_3 . 2H_2O$

Molar mass of bauxite = $27 \times 2 + 16 \times 3 + 4 + 32 = 138$

Relative mass of oxygen in bauxite compound

$= 16 \times 3 + 32 = 80$

$\therefore$ Composition of oxygen = $\frac{80}{138} \times 100\%$

$= 57.97\%$

So, the composition of oxygen in the given bauxite ore is 57.97%.

d Ore no. (ii) is Chalcocite. Its formula is Cu_2S.

$Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

The extracted Cu metal is purified in electrolytic purification method.

Chemical reaction is performed by using electric energy in electrolysis. A thick sheet of impure copper is attached to the positive end of the electric source and a think sheet of pure copper is attached to the negative end. Both of the sheets are immersed in a tank filled with $CuSO_4$ solution and H_2SO_4 mixture. Whe current flow is applied inside this solution the impure copper is dissolved and pure copper accumulates in the thin sheet using reduction reaction.

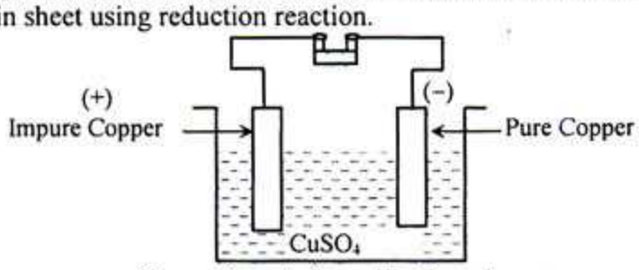


Figure: Electrolytic purification of copper

The impurities from the impure copper accumulates as dreg at the bottom of the tank. This is how the produced Cu is 99.9% purified.

By reviewing the above-mentioned process, we get that the impurities of the copper acquired from the copper ore can be eliminated by the action of electrolytic cell and this method is the most accepted. So, this is how copper is purified.

Ques. ▶5 Carbon is an important non-metal element. It has three isotopes and is respect of percent abundance, the amount of ^{12}C, ^{13}C and ^{14}C are 99%, 0.75% and 0.25% respectively.

[Ctg.B-17]

a. What is the dictionary meaning of pH? 1

b. Show the two differences between thermoplastic and thermosetting plastic. 2

c. Determine the relative atomic mass of stem's element. 3

d. Explain the role of stem element during metal extraction. 4

Answer to the question no. 5

a The dictionary meaning of pH is the power of hydrogen ion.

b

Thermoplastic	Thermosetting plastic
1. Weak attraction works between the carbons in this kind of polymer chain.	1. Carbon atoms in this kind of polymer are in covalent bonds and at the same time are in hydrogen bonds with the carbons of the nearby chain.
2. Thermoplastic can be melted again and again and transformed into objects of different sizes. Ex: polyethene, PVC etc.	2. Thermosetting plastic turns into coal instead of melting when heated. Ex: bakelite, fiber glass etc.

c Determining relative atomic mass of carbon:

Isotope	^{12}C	^{13}C	^{14}C
Mass number	12	13	14
Percent amount	99	0.75	0.25
Relative atomic mass	$\frac{99 \times 12}{100} + \frac{0.75 \times 13}{100} + \frac{0.25 \times 14}{100} = 12.0125$		

So, from the above data, the relative atomic mass of the element or carbon = 12.0125

d The ores of different metals are metallic oxide and this metallic oxide is freed of metal when heated with carbon, this process is called carbon reduction. Carbon combines with oxygen to form carbon dioxide. For example–

$M_2On + nC \longrightarrow 2M + nCO$

$M_2On + nCO \longrightarrow 2M + nCO_2$ [Here, n = Valence of metal]

For example,

$2PbO + C \longrightarrow 2Pb + CO_2$

This process is called smelting or metal extraction by melting ore. Here metal ion of ore reduces by gaining electron and carbon is oxidizes by losing electron.

$Pb^{+2} + 2e^- \longrightarrow Pb$ [Reduction]

From the discussion above, we can say that, carbon has various usages in extracting metal by eliminating carbon from ore or reducing carbon. So, we can say that, carbon performs an important role in metal extraction.

Ques. ▶6 $A \xrightarrow{H_2} B \xrightarrow{HBr} C \xrightarrow{NaOH} D \xrightarrow[H_2SO_4]{K_2Cr_2O_7} E \xrightarrow[H_2SO_4]{K_2Cr_2O_7} F$

[Here A is hydrocarbon. In A compound, composition of Carbon is 92.31% and its molecular mass is 26.] *[Ctg.B-17]*

a. Write the molecular formula of Bleach. 1

b. Why the inert gases are chemically inactive? 2

c. Determine the molecular formula of 'A' compound. 3

d. Describe the preparation of the stem's compound "F" with equations. 4

Answer to the question no. 6

a The molecular formula of bleach is – Ca(OCl)Cl.

b The elements in group-18 of the periodic table are called inert gases. The elements in this group are– Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn). They do not show reactivity in forming compounds by sharing or gaining-losing electrons because their outermost energy shell are filled with the required number of electrons. So, these elements act inert towards forming bonds or chemical reactions.

c The given A is hydrocarbon compound which is formed by carbon and hydrogen. 92.31% carbon is present in the compound. So, the composition of hydrogen= (100 – 92.31)% = 7.69%

Determining the molecular formula of A compound:

Subject	Hydrogen H	Carbon C	Empirical formula of compound
Composition percentage of element	7.69	92.31	
Composition percentage of element/Relative atomic mass	$\frac{7.69}{1} = 7.69$	$\frac{92.31}{12} = 7.69$	CH
Number ratio of the two atoms in the compound	7.69 : 7.69 = 1:1		

Empirical formula of compound A= CH

Molecular formula of compound = $(CH)_n$

Molar mass of compound

= (Mass of carbon × 1 + Mass of hydrogen × 1) × n

= (12 + 1) × n

= 13 n

Teachingbd24.com

Therefore, $13n = 26$

$n = 2$

So, molecular formula of compound A = $(CH)_2$

$= C_2H_2$

= Ethyne

So, the molecular formula determined from the above data of compound A or hydrocarbon is C_2H_2.

d The preparation of compound F is discussed along with equations–

From the answer of no. (c), compound A is ethyne ($HC \equiv CH$). Ethyne reacts with hydrogen and produces ethene ($CH_2 = CH_2$) which again later reacts with HBr to produce ethyl bromide ($CH_3 - CH_2Br$). The produced ethyl bromide reacts with base or NaOH to produce ethanol $CH_3 - CH_2OH$). If the produced ethanol is oxidized with strong oxidant ($K_2Cr_2O_7 + H_2SO_4$) then first ethanal ($CH_3 - CHO$) and then later turns into organic acid or ethanoic acid ($CH_3 - COOH$) because of reoxidizing. The relevant reactions are as following–

$HC \equiv CH + H_2 \longrightarrow H_2C = CH_2$

"A" "B"

$H_2C = CH_2 + HBr \longrightarrow H_3C - CH_2Br$

"B" "C"

$CH_3 - CH_2Br + NaOH \longrightarrow CH_3CH_2OH + NaBr$

"C" "D"

$CH_3 - CH_2OH + [O] \longrightarrow CH_3 - CHO$

"D" "E"

$CH_3 - CHO + [O] \longrightarrow CH_3 - COOH$

"E" "F"

So, through chronological methods the hydrocarbon ethyne (A) from the above data produces B and C by gradual addition reactions and the produces D by adding base and then produces E and F through consecutive oxidation.

Ques. ▶7 (i) $S + O_2 \longrightarrow SO_2 \xrightarrow[\text{heat}]{O_2,\ \text{catalyst}} X(g)$

(ii) $X(g) + H_2O(l) \longrightarrow Y(l)$

(iii) $X(g) + H_2SO_4(l) \longrightarrow Z(l) \xrightarrow{H_2O} 2Y.$ *[S.B.-17]*

a. What is the formula of oleum? 1

b. Why eyes are irritating during cutting onion? Write with equation. 2

c. Which compound of the stem used to prepare ethelene from ethanal? Explain with logic. 3

d. To prepare Y compound reaction (iii) is better than reaction (ii) — Explain with logic. 4

Answer to the question no. 7

a The formula of oleum is– $H_2S_2O_7$.

b Sulfur compound is in onion. This compound is dissociated by the oxygen in air while cutting onion and produce sulfur dioxide (SO_2). The produced SO_2 becomes sulfurous acid in contact with water in the eye. As a result, eye irritation occurs.

$SO_2 + H_2O \longrightarrow H_2SO_3$

Sulfurous Acid

c By completing the given reactions–

(i) $S + O_2 \rightarrow SO_2 \xrightarrow[\text{Heat}]{O_2;\ \text{Catalyst}} SO_3(X)$

(ii) $SO_3 + H_2O \rightarrow H_2SO_4(Y)$

(iii) $H_2SO_4 + SO_3 \rightarrow H_2S_2O_7 \xrightarrow{H_2O} 2H_2SO_4$

(z) (2Y)

Therefore, according to the reaction, ethene can be produced from ethanol by using Y or H_2SO_4. H_2SO_4 is a dehydrating agent which is a water absorber. H_2SO_4 eliminates water from ethanol. As a result, ethene with double bonds is produced.

$C_2H_5OH \xrightarrow[-H_2O]{H_2SO_4} C_2H_4$

Ethanol Ethene

So, we can see that, due to the dehydrating characteristic of H_2SO_4 ethanol is dehydrated using H_2SO_4 or ethene is produced by eliminating 1 molecule of water.

d Here, equation (iii) is more advantageous than equation (ii) in preparing Y or H_2SO_4 compound. The reason is because according to equation (ii), SO_3 attaches with water vapour (H_2O) in air and creates thick fog of H_2SO_4 which is very hard to condense.

(ii) $SO_3 + H_2O \rightarrow H_2SO_4$

Again, according to equation (iii), SO_3 is absorbed by 98% H_2SO_4 to produce oleum ($H_2S_2O_7$). That oleum is mixed with water to produce diluted H_2SO_4 as necessary.

(iii) $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7 \xrightarrow{H_2O} 2H_2SO_4$

So, according to description, preparation of H_2SO_4 compound using equation no. (iii) than equation no. (iii) is more advantageous.

Ques. ▶8

Materials	Iron	Chromium	Nickel	Carbon
X	99%	–	–	1%
Y	74%	18%	7%	1%

[J.B.-17]

a. Write the formula of bauxite? 1

b. Why does Zn not call transition element? 2

c. The oxidation number and valency are different in the mixed oxide of the main element of X — Explain. 3

d. Which one is more durable among X and Y? — Analyze. 4

Answer to the question no. 8

a The formula of bauxite is $Al_2O_3.2H_2O$.

b The elements that have partially filled d-orbital in the electron configuration of their stable ions, they are called transition metals. The electron distribution of the stable ion of Zn is:

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

From electron distribution we can see that, d-orbital is completely filled in stable ion. d-orbital needs to be partially filled to be a transition element. Since, d-orbital is completely filled in the stable ion of Zn, so we can say that, Zn is not a transition element.

c X of the stem is a mixed metal which has 99% iron and 1% carbon. So, this is steel. The main element of steel is iron (Fe). The mixed oxide of Fe is Fe_3O_4. Fe_3O_4 is mainly the mixture of FeO and Fe_2O_3. So, $Fe_3O_4 = FeO + Fe_2O_3$.

The oxidation number of Fe in FeO compound is +2 and the oxidation number of Fe in Fe_2O_3 + 3.

If the oxidation number of Fe in Fe_3O_4 is x–

$x \times 3 + (-2) \times 4 = 0$

$\therefore x = +\frac{8}{3}$

Therefore, the oxidation number of Fe in Fe_3O_4 is $+\frac{8}{3}$

But valence of Fe is 2 and 3. So, the oxidation number and valence of Fe in the mixed oxide of Fe is different.

d The X object of the stem is steel. Object Y has 74% iron, 18% Cr, 7% Ni and 1% C. So, object Y is stainless steel.

Rust occurs in steel if it comes in contact with water and O_2 and it is [$Fe_2O_3.nH_2O$].

So, rust occurs if steel is kept for a few days. The structure of steel changes because of rust. Steel doesn't have any ingredient to protect from corrosion. This is used in making different machines but it is not long lasting.

Teachingbd24.com

Again, stainless steel has 18% Cr and 7% nickel. This Cr forms a thin sheet of Cr_2O_3 on the metal when it comes in contact with O_2. This thin sheet doesn't let corrosion or rust to occur. Again, the presence of Ni increases the toughness of metal or makes it sturdy. Stainless steel can be operated in high temperature. The presence of Cr and Ni makes it more durable than normal steel.
So, stainless steel is more durable between normal steel and stainless steel.

Ques. ▶9 The three isotopes of carbon are ^{12}C, ^{13}C, ^{14}C. There aboundance percent compositions are 99.35%, 0.50% and 0.15% respectively. *[R.B.-16]*

a. Define metallic bond. 1
b. How does the baking powder blow up cake? 2
c. Determine the relative atomic mass of the element in the stem. 3
d. How "Zinc" is extracted from calamine ore by using the stem's element? Analyze with reactions. 4

Answer to the question no. 9

a The attractive force by which the metal atoms are bonded together is called metallic bond.

b The main ingredient of baking powder is sodium hydrogen carbonate ($NaHCO_3$). Baking powder mixing with the flour to prepare cake is heated. Then baking powder decomposes to Na_2CO_3, H_2O and CO_2.

$$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$$

Thus, the produced CO_2 helps to blow up cakes.

c Here,

$^{12}C = 99.35\%$
$^{13}C = 0.50\ \%$
$^{14}C = 0.15\ \%$

Relative atomic mass of carbon

$$= \frac{12 \times 99.35 + 13 \times 0.50 + 14 \times 015}{100} = 12.008$$

d The given element is carbon. Zinc can be extracted from calamine ore by using carbon through carbon reduction process.
At first step, on heating calamine ($ZnCO_3$) dissociates into ZnO and CO_2.

$$ZnCO_3(s) \xrightarrow{\Delta} ZnO\ (s) + CO_2\ (g)$$

Thus the produced Zn metal is removed by reducing ZnO with C.

$$2ZnO\ (s) + C \longrightarrow 2Zn + CO_2$$

So, it is possible to extract Zn metal from Zn calamine ore.

Ques. ▶10 See the given pictures and answer following questions :

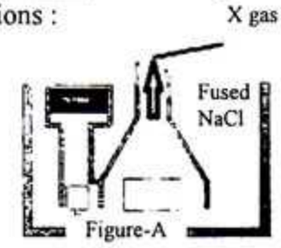


Figure-A

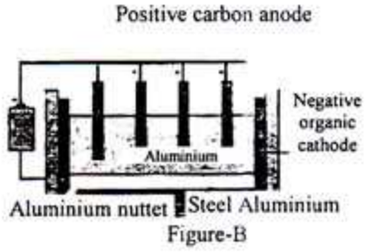


Figure-B

[Mymensingh Girls' Cadet College, Mymensingh]

a. What is bond energy? 1
b. Why roasting is needed during metal extraction? 2
c. Explain the metal extraction process using the figure-B. 3
d. How would you explain the effect of X gas over environment? 4

Answer to the question no. 10

a The chemical energy by which the elements are joined together by forming chemical bonds is called bond energy.

b Generally roasting is applied for sulfide ores. If sulfide ores are heated at temperature below the melting point in presence of air, organic substances and moisture will be removed from the ore. Mineral impurities such as sulfur, arsenic, phosphorus etc. are removed as volatile oxides.

$$2ZnS\ (\text{Zinc bland}) + 3O_2 \longrightarrow 2ZnO + 2SO_2$$
$$2PbS\ (\text{Galena}) + 3O_2 \longrightarrow 2PbO + 2SO_2$$

c The usual aluminium ore is bauxite.
The mineral impurities (gangue) are separated by filtration. Then the concentrated ores are collected from the solution with appropriate process. Such as iron oxide, titanium oxide, sand etc. are found in mixture with bauxite. Adding sodium hydroxide solution with bauxite and heating it up to 1500-2000°C, bauxite will be dissolved. Iron oxide, titanium oxide, sand etc. will not be dissolved. The mineral impurities are removed by filtration.

$$Al_2O_3 + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2O$$

If filtrate is heated adding water aluminum hydroxide will be precipitated. Heating at high-temperature aluminium hydroxide will convert to alumina.

$$NaAlO_3 + 3H_2O \longrightarrow Al(OH)_3 + 3NaOH$$
$$Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$$

Aluminium is released at the cathode. Aluminium ions are reduced by gaining 3 electrons.

$$Al^{3+} + 3e^- \longrightarrow Al$$

Oxygen is produced initially at the anode.

$$2O^{2-} \longrightarrow O_2 + 4e^-$$

However, at the temperature of the cell, the carbon anodes burn in this oxygen to give carbon dioxide and carbon monoxide.

d The liberated gas is chlorine.
Although it is a naturally occurring element, chlorine can have impacts on the environment. Both chlorine gas and chlorine in a soluble form can negatively impact the environment, humans and other organisms.
Environmental Entrance: In its natural state, chlorine is a gas, but it can also make its way into the environment as a compound combined with other elements or chemicals. Chlorine is used as a bleaching agent in the paper industry, chlorine enters the environment through air and surface water. Chlorine is a soluble substance. It usually dissolves rapidly and is carried away in water systems, such as streams and rivers.
Chlorine Reactivity: Chlorine is reactive. Even when it is released into the air in a gaseous state, it can react with chemicals in water to form substances, such as chloride salts and chlorinated organic chemicals. Because it is so reactive, chlorine usually does not enter groundwater systems, but its impacts on surface water systems can be severe.
Environmental Harm: The impacts of chlorine on the environment depend largely on how long the exposure period was and how large an amount of chlorine was present. Although chlorine itself usually does not cause environmental harm, it combines rapidly to form chemicals that pollute water, contaminate fish and transfer to humans and larger animals that eat the fish.
Animal Harm: In humans, chlorine gas exposure can irritate lungs and cause respiratory disorders, as well as burning eyes and skin. When chlorine forms other compounds, it can also be damaging. Organisms living in soil may also be affected by doses of chlorine.

Ques. ▶11 (i) $Zn + H_2SO_4(\text{Conc}) \rightarrow ZnSO_4 + H_2O + A$

(ii) $2A + O_2 \xrightarrow[\text{pt. 2atm}]{400-500°C} 2B$

[Rajshahi Cadet College, Rajshahi]

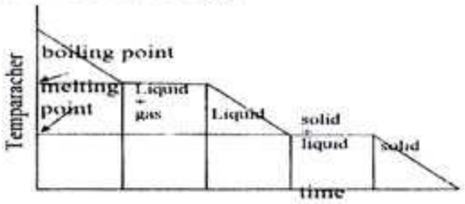
Teachingbd24.com

a. What is dry ice? 1
b. What is meant by cooling curve? 2
c. Describe that the compound 'A' acts as reductant. 3
d. "If 'A' and 'B' compound exist high amount in the air, it pollutes the environment greatly." Describe this statement. 4

Answer to the question no. 11

a Solid carbon di oxide is called Dry Ice.

b Cooling curve shows the changes in state of matter graphically. It mainly shows the changes from gaseous state to the solid state. The curve changes if the state changes. The independent variable (X-axis) is time and the dependent variable (Y-axis) is temperature. Below is an example of a **cooling curve** used in castings.



General cooling curve

c The completed reaction is –

$$Zn + 2\,H_2SO_4(conc.) \longrightarrow ZnSO_4 + SO_2 + 2\,H_2O$$

So we have to show that SSO2 works as a reducing agent. Sulfur dioxide is fairly soluble in water. It is in fact the actual reducing agent present:

$$SO_2 + H_2O \rightleftharpoons HSO_3^- + H^+$$

Featuring sulfur in the +4 oxidation state, sulfur dioxide is a reducing agent. It is oxidized by halogens such as chlorine to give the sulfuryl halides:

$$SO_2 + Cl_2 \longrightarrow SO_2Cl_2$$

d The completed reaction is –

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

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 reacts with atmospheric oxygen in thunderbolt and oxidized to SO_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. This gas 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 (O3) layer.

Ques. ▶ 12 (i) $S + O_2 \rightarrow X(g)$
(ii) $NO + O_2 \rightarrow Y(g)$
(iii) $C + O_2 \rightarrow Z(g)$ *[Joypurhat Girls' Cadet College, Joypurhat]*

a. What is P^H? 1
b. Why Benzene is called aromatic hydrocarbon? 2
c. Calculate the number of bond pair and lone pair electrons in molecule X and Z. 3
d. Analyze the effect of X, Y and Z gas on environment. 4

Answer to the question no. 12

a pH is the capacity of hydrogen ion.

b Benzene, C_6H_6 has chemical structure as follows –

It has alternative double bond.

As Benzene follows Huckel's rule.
It has $(4n + 2)$ π-electrons, where n = 1.
Three double bond contains this π-electrons,

$$4n + 2 = 6;\ n = 1.$$

Therefore, Benzene is aromatic.

c

$$S + O_2 \longrightarrow SO_{2\,(g)}$$
$$C + O_2 \longrightarrow CO_{2\,(g)}$$

Molecule X as mentioned in the stem is SO_2. Molecule Z is CO_2.
SO_2 is formed by covalent bond between sulphur and oxygen.

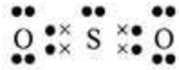


Fig: Formation of SO_2 molecule

In SO_2, number of lone pair electrons is 1 and number of bond pair electrons are 4.
For, CO_2 the covalent bonds are between carbon and oxygen.

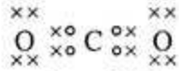


Fig: Formation of CO_2 molecule

From the above figure number of lone pair electrons is zero and number of bond pair electrons is 4.

d X, Y and Z gas given in the stem corresponds to SO_2, NO_2 and CO_2 gas respectively.
NO_2 gas and CO_2 gas dissolves in rain water. All living beings produce carbon dioxide during respiration and release it to atmosphere. Any fire or volcanic eruption causes the deposition of carbon dioxide in atmosphere. Brick fields, industries and exhaust of vehicles emit carbon dioxide. Nitrogen dioxide and carbon dioxide react with water present in air and produce acid.

$$CO_{2\,(g)} + H_2O_{\,(l)} \longrightarrow H_2CO_{3\,(aq)}$$
$$2NO_{2\,(g)} + H_2O_{\,(l)} \longrightarrow HNO_{2\,(aq)} + HNO_{3\,(aq)}$$

Sulphur di-oxide, SO_2 reacts with oxygen and ozone of atmosphere and produce sulphur trioxide which reacts with atmospheric water and produces sulphuric acid.

$$SO_{2\,(g)} + H_2O_{\,(l)} \longrightarrow SO_3 + H_{2)}$$
$$SO_{3\,(g)} + H_2O_{\,(l)} \longrightarrow H_2SO_{4\,(aq)}$$

These acid falls on the earth surface with rain which reduces pH value of ponds and soil. That means soil and water becomes acidic. That affects the ecosystem badly and causes extinction of many living beings.

Ques. ▶ 13 'M' is a metal. The electronic configuration of valance shell of 'M' metal is $ns^2\,np^1$; where n = 3. *[Joypurhat Girls' Cadet College, Joypurhat]*

a. What is the composition of stainless steel? 1
b. Metal extraction is a reduction process– Explain. 2
c. Oxide of the metal of the stem is amphoteric– Explain. 3
d. Describe the extraction process of 'M' metal from pure oxide of the metal. 4

Answer to the question no. 13

a Stainless steel : Iron – 74%
Chromium – 18%
Nickel – 8%

b Usually metal salt is the source of metal form where metal is extrcted. Metal ions recieve electrons to transform into metal any reaction where electron is recieved is called reduction reaction.

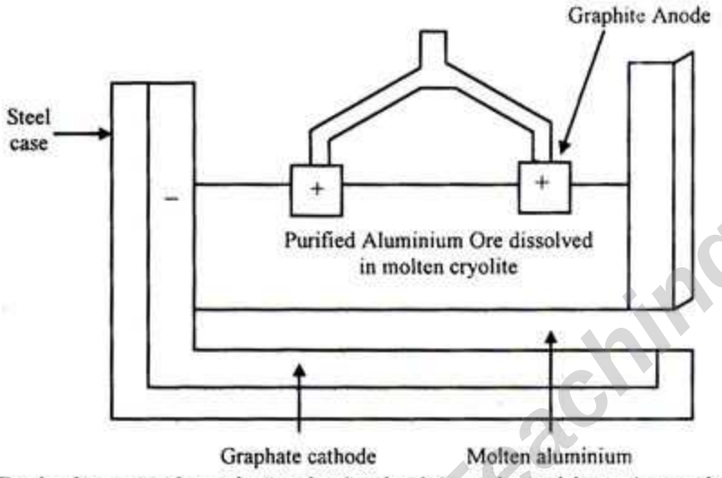
$$M^{2+} + 2e^- \longrightarrow M$$

For example, $Zn^{2+} + 2e^- \longrightarrow Zn$
Therefore, metal extraction is a reduction process.

https://teachingbd24.com

c 'M' mention in the stem is Aluminium.
In chemistry, an amphoteric compound is a molecule or ion that can react both as an acid as well as a base.
Amphoterism depends on the oxidation states of the oxide. Al_2O_3 is an example of an amphoteric oxide.
In acid: $Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$
In base: $Al_2O_3 + 2NaOH \longrightarrow 3H_2O + 2NaAl[(OH)_4]$
hydrated sodium aluminate
In first reaction Al_2O_3 acts as base
in 2nd reaction Al_2O_3 acts as an acid.
Therefore, oxide at Aluminium is amphoteric.

d The metal of the stem is Aluminium which is shown in (C).
The extraction process of Al from pure Al_2O_3 is described below:
Aluminium is extracted by electrolysis of Al_2O_3. Firstly. Al_2O_3 must be molten so that electricity can pass through it.
Aluminium oxide has a very high melting point (over 2000°C). So it would be expensive to melt it. Instead, it is dissolved in molten cryolite (Na_3AlF_6), an aluminium compound with a lower melting point than aluminium oxide. Thus, use of crylite reduces some of the energy costs involved in extracting aluminium.
The diagram below shows an aluminium oxide electrolysis tank.



Both the negative electrode (cathode) and positive electrode (anode) are made of graphite, a form of carbon.
Aluminium metal gets reduced at the negative electrode (cathode) and sinks to the bottom of the tank where it is tapped off.
The reduction reaction is —
$$Al^{3+} + 3e^- \rightarrow Al$$
Thus Aluminium is extracted by electrolysis from pure Al_2O_3.

Ques. ▶ 14 | S | O_2 | SO_2 | V_2O_5 | SO_3 | $H_2S_2O_7$ |

[Sylhet Cadet College, Sylhet]

a. What is Galvanic cell? 1
b. What do you mean by spectator ion? Explain with example. 2
c. Describe the extraction process of the first substance from mineral. 3
d. How can you relate the above substances to manufacture H_2SO_4 in industry? Describe the process with reaction. 4

Answer to the question no. 14

a The cell where chemical elements undergo reaction and produce electrical energy is called Galvanic cell.

b In a chemical reaction, the ions which don't undergo chemical reaction are called spectator ions. In the reaction between NaOH and HCl, sodium ion (Na^+) and chloride ion (Cl^-) do not undergo reaction. These are called Spectator ion. No electron transition occurs in this reaction.
$$HCl\ (aq) + NaOH\ (aq) \rightarrow Na^+(aq) + Cl^-(qn) + H_2O(l)$$

c The first substance of the stem is S or Sulfur. The extraction process of Sulfur from mineral is described below:
Sulfur is a yellow coloured substance. Sulfur mines are situated deep inside the earth. The substance is extracted from mine by Frasch method. Three tubes with a single center is inserted into the depth of sulfur layer which is known as Frasch pipe. Sulfur melts at 115°C temperature.

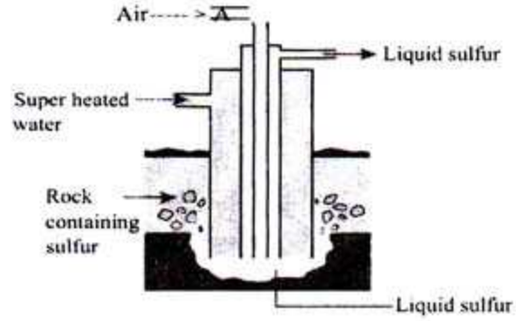


Fig: Frasch Method of Sulfur Extraction

That is why super heated water is entered through the pipe to the layer so that the element melts. We know, at 1 atm pressure, the boiling point of water is 100°C but if pressure is increased the boiling point rises up. Water at any temperature between 100-374°C temperature in extra pressure is called super heated water. Hot air is passed at 20-22 atm pressure through the centre tube. Molten sulfur comes out through the middle tube due to the effect of the pressure. It is collected in containers.

d The substances mentioned in the stem are S, O_2, SO_2, V_2O_5, SO_3 and $H_2S_2O_7$. All of these substances are related to the production of H_2SO_4 in industry. The whole process is described below:
Firstly, sulfur and dehydrated air are supplied in a furnace. Sulfur and oxygen undergo reaction here to produce sulfur dioxide.
$$S + O_2 = SO_2$$
The SO_2 gas is channeled with some more oxygen to another furnace. This furnace has the temperature of 450-500°C and the catalyst vanadium penta-oxide (V_2O_5). SO_2 gas and O_2 gas undergo reaction here in that temperature and produce sulfur tri-oxide.
$$SO_2 + O_2 \xrightarrow[450°C - 500°C]{V_2O_5} SO_3$$
When SO_3 will come in contact with H_2O, they will produce H_2SO_4. However, direct reaction between them will produce gaseous H_2SO_4 which will create a state of dense fog. That is a hazard for the industries. Besides, getting liquid H_2SO_4 from this gaseous H_2SO_4 by condensation is a tough task. So, first, sulfur tri-oxide is absorbed in concentrated H_2SO_4 and that forms fuming sulfuric acid ($H_2S_2O_7$).
$$H_2SO_4 + SO_3 = H_2S_2O_7$$
Finally, the fuming sulfuric acid is driven into reaction with H_2O which produces liquid sulfuric acid.
$$H_2S_2O_7 + H_2O = 2\ H_2SO_4$$
Thus, H_2SO_4 is produced and all the substances mentioned in the stem are related to this process.

Ques. ▶ 15 Read the stem carefully and answer the following questions.

i	Cu_2S
ii	$Al_2O_3.2H_2O$

[Barishal Cadet College, Barishal]

https://teachingbd24.com

a. Define metal alloy. 1
b. Show the spot removing process of bleaching powder. 2
c. Discuss the conversion of free metal from ore–ii 3
d. How will you get 99.9% pure metal from ore-i? Analyze. 4

Answer to the question no. 15

a Metal alloy is a mixture of metals made by mixing some molten metals and cooling them.

b When water is added to bleaching powder (Ca(OCl)Cl) after putting it on the dirt spot of clothes, it reacts with water and produces calcium chloride ($CaCl_2$) and hypochloras acid (HOCl).

$$Ca(OCl)Cl + H_2O \longrightarrow CaCl_2 + HOCl$$

HOCl breaks up and produces HCl and nascent oxygen [O]

$$HOCl \longrightarrow HCl + [O]$$

Nascent oxygen [O] reacts with colourful material and makes the colourful materials colourless.

$$\text{Colourful material} + [O] \longrightarrow \text{Colourless material}$$

Thus bleaching powder or Ca(OCl)Cl removes spot from fabrics.

c Ore(ii) of the stem is $Al_2O_3.2H_2O$ or bauxite which is an ore of Al (aluminium). In this case for aluminium extraction from bauxite, it is melted and dry bauxite is used. To reduce the high melting point 2050 degree centigrade cryolite Na_3AlF_6 is added. Due to this, the melting point reduces to 800-1000 degree centigrade.

As a result alumina creates Al^{3+} and O^{2-} ions and electrolysis is done. The following reactions occur in the process of electrolysis:

$$Al_2O_3 \longrightarrow Al^{3+} + O^{2-}$$
$$Al^{3+} + 3e^- \longrightarrow Al$$
$$O^{-2} + 2e^- \longrightarrow [O]$$
$$[O] + [O] \longrightarrow O_2$$
$$C + O_2 \longrightarrow CO_2$$

Thus, free aluminium metal is extracted from its ore by electrolysis.

d Ore no. (i) is Chalcocite. Its formula is Cu_2S.

$$Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$

The extracted Cu metal is purified in electrolytic purification method.

Chemical reaction is performed by using electric energy in electrolysis. A thick sheet of impure copper is attached to the positive end of the electric source and a think sheet of pure copper is attached to the negative end. Both of the sheets are immersed in a tank filled with $CuSO_4$ solution and H_2SO_4 mixture. The current flow is applied inside this solution the impure copper is dissolved and pure copper accumulates in the thin sheet using reduction reaction.

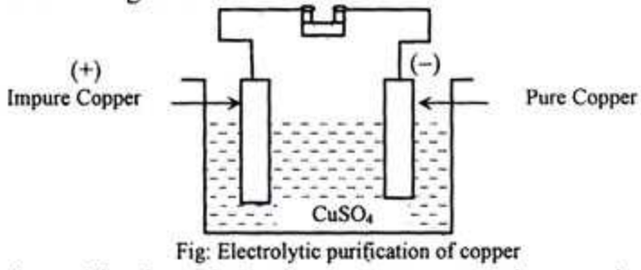


Fig: Electrolytic purification of copper

The impurities from the impure copper accumulates as dreg at the bottom of the tank. This is how the produced Cu is 99.9% purified.

Ques. ▶ 16

Ore	Bauxite	Zinc Blende
Element	A	D

[RAJUK Uttara Model College, Dhaka]

a. What is rate of reaction? 1
b. Why the aqueous solution of Na_2CO_3 is basic? 2
c. Explain the condensation process of the ore of the element 'A' 3
d. How the element 'D' is extracted from the ore. 4

Answer to the question no. 16

a The amount of product produced from reactant per unit time is called the rate of reaction.

b Aqueous solution of salt produced from the reaction between strong acid and strong base is neutral in nature. But the aqueous solution of Na_2CO_3 is basic. Because aqueous solution of Na_2CO_3 is produced in the reaction between strong base and weak acid. So, it has a basic nature.

c Bauxite ore contains sand as impurity when it is excavated from the mine. The process that is employed to separate these impurities from the intended metal is called condensation of ores. Hydrolytic method is usually applied for bauxite ore. The particles of oxide are comparatively heavy while the impurities are light. In the process the ore is poured on a slanted, chambered table and water is flown on the ore. At this, the heavy ore becomes condensed and goes inside the chamber while the impurities are washed away with water. This way, the ore is condensed.

d **Condensation:** Zinc Blende ore is condensed in froth floatation method. The ore is first taken inside a large tank and added with water. Later, oil is slowly added to the mix. When air is blown on the ore, the sulfide ore dissolves in the oil and floats up as froth. The froth is collected while the impurities remain at the bottom of the tank.

Roasting: The ore is heated at temperature below the melting point in presence of air so that organic substances and moisture will be removed from the ore as oxide.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

Smelting: Metal is extracted by heating carbon along with metallic oxide. This method is called carbon reduction.

$$ZnO + C \xrightarrow{\Delta} Zn + CO$$

Purification: Some impurity still remains with the metal extracted after reduction. The substance that is added to purify it from the impurity is called smelting agent. If the impurity is alkaline, acidic smelting agent ($Si0_2$) will be added and if they are acidic, alkaline smelting agent will be added. Smelting agent and impurity combine together into slag. Since slag is insoluble, it is separated from upper layer of the solution of molten metal. Even the smelting process does not give pure metal. The metal is purified by electrolysis. The impure metal is used as anode a rod of the same metal in pure form is used as cathode. The salt solution of the metal that is to be purified is used as electrolytic solution. When electricity is passed in the cell, the atom of the metal from anode donates electron which enters the solution as ion. On the other hand, metallic ion accepts the electron and adds to the pure metal at cathode.

Ques. ▶ 17 $X\,(SO_3) \xrightarrow{98\%H_2SO4} Y \xrightarrow{H_2O} Z$

[Viqarunnisa Noon School and College, Dhaka]

a. What is Tollen reagent? 1
b. Why is cryolite used to extract aluminium from bauxite? 2
c. Write down the reaction of preparation of 'Z' from 'X' and show that 'Z' is a dehydrating agent. 3
d. Analyse the importance of use of 'Z' compound in chemical industry through pie chart. 4

Answer to the question no. 17

a Silver nitrate solution in basic medium is called "Tollen's reagent". Tollen's reagent when reacts with organic compounds like aldehyde form metallic silver which settle at the bottom of the container as precipitate.

Teachingbd24.com

b In the extraction of aluminium , solid aluminium oxide needs to be melted into liquid first. Aluminium oxide melts at 2050°C. To raise the temperature so high is very tough. If aluminium oxide is added with cryolite (Na_3AlF_6), it melts at 800°C-1000°C.
So, cryolite is used to reduce the melting point of bauxite.

c The compound Z and X of the stem represents H_2SO_4 and SO_3 respectively. Preparation of H_2SO_4 from SO_3 is as follows: Firstly, SO_3 is absorbed in 98%. H_2SO_4 to produce fuming sulphuric acid or $H_2S_2O_7$. Then water is added to it to make H_2SO_4.

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$
$$H_2S_2O_7 + H_2O \rightarrow 2\,H_2SO_4$$

Thus acid H_2SO_4 is produced.
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) $\longrightarrow$ 12 C (carbon) + 11 H_2O (water)
So, H_2SO_4 acts as a dehydrating agent.

d The compound Z of the stem represents H_2SO_4 or sulfuric acid. Among all chemical substances sulfuric acid is produced and used at a large amount. The amount of sulfuric acid production and its uses is considered as a scale of economical stability and industrialization of a country. Every year several tons of sulfuric acid is produced all over the world. This acid is used as raw material in production of many substances.
The use of sulfuric acid in chemical industries is shown below in a pie chart:

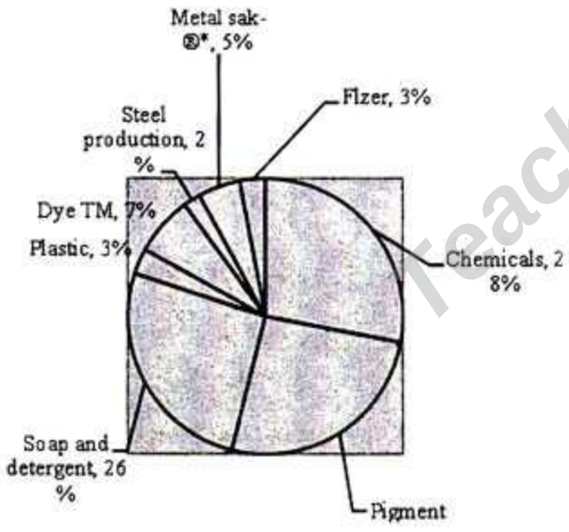


Fig: Usage of Sulfuric acid

Ques. ▶ 18 $Al_2O_3.2H_2O \xrightarrow{heat} X(s) + Y$

[Ideal School and College, Motijheel, Dhaka]

a. What is coke? 1
b. X is amphoteric oxide — explain. 2
c. Describe the electrolysis process of Y. 3
d. The main component of duralumin can be extracted from X-justify with logic. 4

Answer to the question no. 18

a Various volatile gaseous compounds come out by heating coal extracted from mine. After gas emission, the residue is known as coke.

b Compound X of the stem is Al_2O_3. It is amphoteric in nature. It reacts with both acid and base.

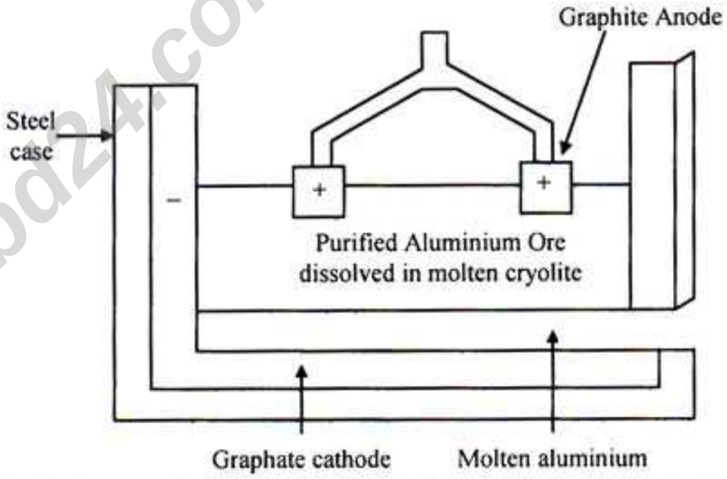
$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$
$$Al_2O_3 + 6NaOH \longrightarrow 2Na_3AlO_3 + 3H_2O.$$

c Y compound of the stem is H_2O. The electrolysis process of H_2O is described below:
Pure water is ionized at a very poor rate. To increase the rate of dissociation, a few drops of sulfuric acid is added to the water. The reaction is as follows:

$$H_2O = H^+ + OH^-$$

Now, electricity is supplied to the solution using a battery. The anode attracts OH^- ion and cathode attract H^+ ion.
Reaction at cathode: $2H^+ + 2e^- \rightarrow H_2$ (reduction)
Reaction at anode: $4OH^- - 4e^- \rightarrow O_2 + 2H_2O$ (oxidation)
Hydrogen is produced in cathode and oxygen is produced in anode.

d The main component of duralumin is Al (aluminium) and the compound X of the stem is Al_2O_3. Al can be extracted from Al_2O_3 . It is described below:
Aluminium is extracted by electrolysis of Al_2O_3. Firstly, Al_2O_3 must be molten so that electricity can pass through it.
Aluminium oxide has a very high melting point (over 2000°C). So it would be expensive to melt it. Instead, it is dissolved in molten cryolite (Na_3AlF_6), an aluminium compound with a lower melting point than aluminium oxide. Thus, use of crylite reduces some of the energy costs involved in extracting aluminium.
The diagram below shows an aluminium oxide electrolysis tank.

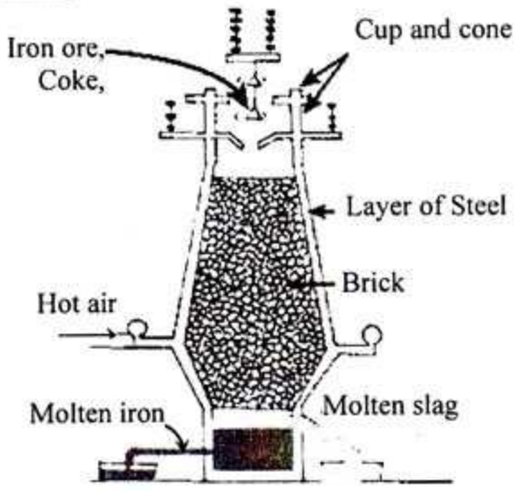


Both the negative electrode (cathode) and positive electrode (anode) are made of graphite, a form of carbon.
Aluminium metal gets reduced at the negative electrode (cathode) and sinks to the bottom of the tank where it is tapped off.
The reduction reaction is —

$$Al^{3+} + 3e^- \rightarrow Al$$

Thus Aluminium is extracted by electrolysis from pure Al_2O_3.

Ques. ▶ 19



[Dhaka Residential Model College, Dhaka]

Teachingbd24.com

a. Define alloy of metal. 1
b. Formalin is harmful for human health-explain it. 2
c. Explain the condensation process of the ore of above metal in the stem. 3
d. Analyzge the reactions that occured in the above metal extraction process in the stem. 4

Answer to the question no. 19

a An alloy is a substance made by melting two or more element together, at least one of them a metal.

b Formaldehyde is very poisonous to all animals. It is a scientifically proved carcinogen. If the excess extent of formaldehyde enters the body, it results in acute pain in the stomach, nausea, coma, kidney trouble and even can cause of death. In many countries of the world as well as Bangladesh preservation of fruits, fish-meat and other food commodities by formaldehyde is forbidden.

c Usually, the ores contain some substances apart from the metal that is to be extracted from it. This mixture of substances in the ore is called impurities. The crushed powder of ores still contains the impurities mixed with them. The process that is employed to separate these impurities from the intended metal is called condensation of ores.
The particles of iron oxide ore are comparatively heavy while the impurities are light. In the process the ore is poured on a slanted, chambered table and water is flown on the ore. At this, the heavy ore becomes condensed and goes inside the chamber while the impurities are washed away with water. This way, the ore is condensed.

d This is a blast furnace to extract iron. The main chemical reactions which occur inside a blast furnace are:

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

Coke (C) and hot air mix to produce CO.

$$2C(s) + O_2(g) \xrightarrow{\Delta} 2CO(g)$$

Fe from Fe_2O_3 is reduced in several steps using this CO. Temperature ranges from 200°C to 700°C at the top, where Fe_2O_3 partially reduced.

$$3Fe_2O_3(s) + CO(g) \longrightarrow 2Fe_3O_4(s) + CO_2(g)$$

Further down furnace

$$Fe_3O_4(s) + CO(g) \longrightarrow 3FeO(s) + CO_2(g)$$

To produce CaO, $CaCO_3$ is used.

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

CaO then reacts with acidic impurities of iron (mainly silica, SiO_2) and is separated.

$$SiO_2 + CaO \longrightarrow CaSiO_3$$

FeO moves down to the hotter area to reduce to Fe.

$$FeO(s) + CO(g) \xrightarrow{1200°C} Fe(s) + CO_2(g)$$

CO_2 formed in the process is re-reduced to form CO.

$$CO_2(g) + O_2(g) \xrightarrow{\Delta} CO(g)$$

This CO is again used at the beginning of the next cycle.

Ques. ▶20 The three isotopes of carbon are ^{12}C, ^{13}C, ^{14}C. There aboundance percent composition are 99.35%, 0. 50% and 0.15% respectively. *[St. Joseph Higher Seconadry School, Dhaka]*
a. Write down the formula of rust. 1
b. Explain the metal extraction is a reduction process. 2
c. Determine the relative atomic mass of the element in the stem. 3
d. How "Znic" is extracted from clamine ore by using the stem's element? Analyze with reactions. 4

Answer to the question no. 20

a The formula of rust is $Fe_2O_3.nH_2O$.

b The process by which metal is extracted is called carbon reduction. Carbon combines with oxygen to form carbon dioxide as the metal ore gets reduced.

$$M_2O_n + nC \longrightarrow 2M + nCO$$
$$M_2O_n + nCO \longrightarrow 2M + nCO_2$$

(Here, n = valence of the metal)

Such as, $PbO_{(s)} + C_{(s)} \longrightarrow 2Pb_{(s)} + CO_{2(g)}$
This process is called smelting or the extraction of minerals by melting. In this process the metal ion is reduced, because here the metal ion accepts electrons. So, metal extraction is a reduction process. The reduction reaction of lead ion is as follows:

$$Pb^{2+} + 2e^- \longrightarrow Pb(s)$$

So, metal extraction is a reduction process.

c Determining relative atomic mass of carbon:

Isotope	^{12}C	^{13}C	^{14}C
Mass number	12	13	14
Percent amount	99.35	0.50	0.15
Relative atomic mass	$\frac{99.35 \times 12}{100} + \frac{0.50 \times 13}{100} + \frac{0.15 \times 14}{100}$ $= 12.018$		

So, from the above data, the relative atomic mass of the element or carbon = 12.018

d The given element is carbon. Zinc can be extracted from calamine ore by using carbon through carbon reduction process.
At first step, on heating calamine ($ZnCO_3$) dissociates into ZnO and CO_2.

$$ZnCO_3(s) \xrightarrow{\Delta} ZnO(s) + CO_2(g)$$

Thus the produced Zn metal is removed by reducing ZnO with C.

$$2ZnO(s) + C \longrightarrow 2Zn + CO_2$$

So, it is possible to extract Zn metal from Zn calamine ore using carbon.

Ques. ▶21 i. Calamine ii. Bauxite
These are two important ores of Zinc and Aluminium. *[Scholars' School and College, Dhaka]*
a. What is electrolyte? 1
b. Write the formula of Rutile and Chromite. 2
c. Compare the reactivity of metals that are extracted from (i) and (ii). 3
d. The above two metals are extractive in two different ways – analyze it. 4

Answer to the question no. 21

a A substance that dissociates into ions in solution acquires the capacity to conduct electricity. Sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}) are examples of electrolytes.

b Cromite $FeO.Cr_2O_3$
Rutile TiO_2

c The higher the metal in the series, the more reactive it is and the more vigorously it reacts with water, oxygen and acid. A metal in the activity series can displace any metal below it in the series from its compound.
The position of Aluminium is above Zinc in the reactivity series. So Aluminium should be more reactive than Zinc.
If a piece of zinc metal is added to aluminium sulphate solution, no reaction takes place. So aluminium is more reactive than zinc.
Aluminium can displace Zn from zinc sulphate solution

$$2Al + 3ZnSO_4 \longrightarrow 2Zn + Al_2(SO_4)_3$$

So, aluminium is more reactive than zinc.

Teachingbd24.com

d Zinc is mainly extracted from Zinc Blende(ZnS) which is a sulfide ore. It is done by Carbon reduction process.

Generally roasting is applied for sulfide ores. If sulfide ores are heated at temperature below the melting point in presence of air, organic substances and moisture will remove from the ore. Mineral impurities (gangue) such as sulfur, arsenic, phosphorus etc. removed as volatile oxides.

$$2ZnS\ (\text{Zinc blende}) + 3O_2 = 2ZnO + 2SO_2$$

Ores of metals are metal oxides and metals become free in heating these metal oxides with carbon. This process is called the carbon reduction. Carbon combines with oxygen and form carbon dioxide.

$$2ZnO + C \longrightarrow 2Zn + CO_2$$
$$ZnO + CO \longrightarrow Zn + CO_2$$

But Aluminium is extracted by electrolysis process. To do so aluminium salt is produced from alumina. Heating at high temperature aluminium hydroxide will convert to alumina.

$$Al(OH)_3 \xrightarrow{\text{heating}} Al_2O_3 + 3H_2O$$

Eletricity is passed through it to separate aluminium ion (Al^{3+}) and oxide ion (O^{2-}).

Then Aluminium ion is reduced to produce metallic Aluminium. The reaction is –

$$Al_2O_3 \longrightarrow Al^{3+} + 3O^{2-}$$
$$Al^{3+} + 3e^- \longrightarrow Al$$

Ques. ▶ 22 i) $S + O_2 \rightarrow SO_2 \xrightarrow[\Delta]{\text{catalyst}} X(g)$

ii) $X\ (g) + H_2O(l) \rightarrow y\ (l)$

iii) $\times\ (g) + H_2SO_4 \rightarrow z\ (l) \rightarrow 2y$

[Chetona Model Academy, Dhaka]

a. What is formula of oleum? 1

b. Why eyes are irritating during cutting onium? Write with equation. 2

c. Which compound of the stem used to prepares ethylene from ethanol? Explain. 3

d. To prepare compound y, reaction (iii) is better than reaction (ii) Explain. 4

Answer to the question no. 22

a Formula of oleum is $H_2SO_4.O_3S$ or $H_2O_7S_2$

b At the time of slicing onions sulfur-dioxide (SO_2) is produced by dissociating this compound and comes in contact of eyes and forms sulfurous acid (H_2SO_3) reacting with eye water and irritate eyes.

$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3\ (aq)}$$

c To prepare ethylene from ethanol. H_2SO_4 or sulphuric acid is used.

$$\underset{\text{Ethanol}}{CH_3 - CH_2 - OH} \xrightarrow{H_2SO_4} \underset{\text{Ethene/ Ethylene}}{CH_2 = CH_2} + \underset{\text{Water}}{H_2O}$$

As, H_2SO_4 is a dehydrating agent, it will dehydrate 1 mole H_2O from Ehatnol and produce ethylene.

d When water is added to sulfur tri-oxide sulfuric acid is produced. But here is a problem that, a mist of fine drop of dilute sulfuric acid is formed by joining sulfur tri oxide with moisture of atmosphere, which is very difficult to condensed.

$$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(l)}$$

So, SO_3 is absorbed in 98% H_2SO_4 forming a fuming sulfuric acid. Fuming sulfuric acid is called oleaam. Oleaam is mixed with water to make necessary dilution.

$$H_2SO_{4(l)} + SO_{3(g)} \longrightarrow H_2S_2O_{7(l)} \longrightarrow 2H_2SO_{4(l)}$$

Ques. ▶ 23

A	B	C	D	E
NaOH	Fc	Al	Zn	Cu

[Cantonment English School & College, Chattogram]

a. State modern periodic law. 1

b. Explain the carbon reduction process. 2

c. Explain how the element 'C' can be extracted from its ore? 3

d. The reagent 'A' helps to identify the given elements. Analyze with reactions. 4

Answer to the question no. 23

a The modern periodic law is as follows:

In the periodic table, the physical and chemical properties of the elements repeat periodically with their atomic number depending upon the electronic arrangement of the elements.

b The process by which metal is extracted is called carbon reduction. Carbon combines with oxygen to form carbon dioxide as the metal ore gets reduced.

$$M_2O_n + nC \longrightarrow 2M + nCO$$
$$M_2O_n + nCO \longrightarrow 2M + nCO_2$$

(Here, n = valence of the metal)

c Aluminium ore is bauxite or hydrous aluminium oxide $Al_2O_3.2H_2O$. This can be purified in different methods to get aluminium oxide and pure aluminium metal can be extracted by its electrolysis.

Bauxite is purified by eliminating different impurities, then the water is dried by heating to get dry aluminium oxide. Melting point of aluminium oxide is 2050°C. Reaching this high temperature is expensive; so instead of using directly aluminium oxide, a mineral solution named cryolite is mixed with it. Melting point of cryolite (Na_3AlF_6) is 1000°C. The mixture melts between 900°C–950°C temperature.

The inside of a steel tank is wrapped with graphite layer. This graphite layer works as the cathode. Some graphite rods are used as the anode. Electricity is run through the melted bauxite in this tank. Cryolite (Na_3AlF_6) is added to decrease the melting point of bauxite. This electric flow creates electrolysis of aluminium oxide. Aluminium metal starts to accumulate in the cathode. Since aluminium is heavier than cryolite, it accumulates in the bottom. This aluminium metal is taken out by opening the plug of emission tube at the bottom of the tank. On the other hand, oxygen is produced in the anode, which reacts with carbon in this high temperature and produces carbon monoxide and carbon dioxide. The chemical reactions in the electrolysis —

$$Al_2O_3\ (l) \longrightarrow 2Al^{3+}\ (l) + 3O^{2-}\ (l)$$

Oxidation in anode: $O^{2-}\ (l) \longrightarrow O + 2e^-$

$$2O \longrightarrow O_2\ (g)$$

Reduction in cathode: $Al^{3+}\ (l) + 3e^- \longrightarrow Al\ (l)$

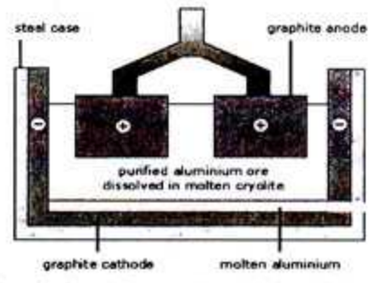


Fig: Aluminium Extraction Using Electrolysis

d NaOH reacts with the elements and produces their metal hydroxide. Metal hydroxides present in the solution will precipitate when dilute sodium hydroxide is added in the dilute solution of metal salts or ions. These precipitates help to identify the elements in the stem.

Teachingbd24.com

$Fe^{2+}_{(aq)} + NaOH_{(aq)} \longrightarrow Fe(OH)_{2(s)}$ (Green Precipitate)
$Al^{3+}_{(aq)} + NaOH_{(aq)} \longrightarrow Al(OH)_{3(s)}$ (White Precipitate)
$Zn^{2+}_{(aq)} + NaOH_{(aq)} \longrightarrow Zn(OH)_{2(s)}$ (White Precipitate)
$Cu^{2+}_{(aq)} + NaOH_{(aq)} \longrightarrow Cu(OH)_{2(s)}$ (Light Blue Precipitate)

Ques. ▶24 A non-metal is extracted from mine directly by frasch process. *[Jashore English School and College (JESC), Jashore]*

a. What is the formula of magnetite? 1
b. Explain the impirtance of recycling of metal? 2
c. Describe the extraction of above element from mine. 3
d. How will you preparation sulfuric acid from the element? Write chemical equation. 4

Answer to the question no. 24

a The formula of magnetite is Fe_3O_4

b The number of molecules of every element in the world is definite. It is not possible to produce fundamental elements. So every mineral is not infinite, they are finite. The resource of the metal will be finished within 120-150 years if we use the metal at present rate. So if we extract the metal in limited amount we can get it for many years. Besides this, recycling of metal is important in solving environmental problems. It will save both money and fuel.

c As Sulfur is found free in nature, it is extracted directly from the mine. Sulfur mine remain at deep inside the earth. To extract from mine three one centered tube is inserted into the depth of sulfur layer. Steam of 180°C temperature is passed through the outer most tube. Melting point of sulfur is 119°C, so it melts when comes to the contact of steams. Hot air is passed at high pressure through the center tube. Sulfur comes out through the middle tube due to the effect of pressure.

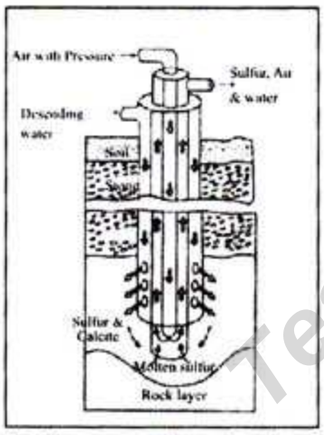


Fig: Sulfur extraction: frush process

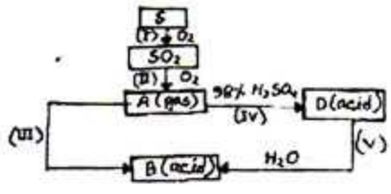
d Sulfur-di-oxide is a very stable compound. Sulfur di oxide is produced by burning sulfur in presence of air.

$$S\,(s) + O_2(g) \longrightarrow SO_2(g)$$

In normal condition sulfur-di-oxide is not oxidized by atmospheric oxygen. In contact chamber sulfur-di-oxide is oxidized to sulfur trioxide by oxygen at 400-450°C temperature in presence of granular platinum or vanadium pent oxide as catalyst.

$$2SO_2(g) + O_2(g) \xrightarrow[440-500^oC]{Pt/v\ 205} 2SO_3(g)\ ,\ \Delta H = -197\ kJmol^{-1}$$

Ques. ▶25



[Jalalabad Cantonment Public School & College, Sylhet]

a. What is metal slag? 1
b. Why is $CaCO_3$ used to remove the metal slag in case of iron extraction? Explain. 2
c. 'B is a strong dibasic acid'– explain with proper reactions. 3
d. Which path is more suitable to produce? Give logic to your answer. 4

Answer to the question no. 25

a In metal extraction process, smelting agent and impurity combine together, which are insoluble and are separated from upper layer of the solution of molten metal, is called metal slag.

b Iron ore often has silicon dioxide (sand) impurity which must be removed during the process. To do this limestone is added to the charge.

c Firstly, sulfur and dehydrated air are supplied in a furnace. Sulfur and oxygen undergo reaction here to produce sulfur dioxide.

$$S + O_2 = SO_2$$

SO_2 gas and O_2 gas undergo reaction here in that temperature and produce sulfur tri-oxide.

$$SO_2 + O_2 = SO_3$$

When SO_3 will come in contact with H_2O, they will produce H_2S0_4. However, direct reaction between them will produce gaseous H_2SO_4 which will create a state of dense fog. That is a hazard for the industries. Besides, getting liquid H_2SO_4 from this gaseous H_2SO_4 by condensation is a tough task. So, first, sulfur tri-oxide is absorbed in concentrated H_2SO_4 and that forms fuming sulfuric acid. The fuming sulfuric acid is then driven into reaction with H_2O which produces liquid sulfuric acid.

$$H_2SO_4 + SO_3 = H_2S_2O_7$$
$$H_2S_2O_7 + H_2O = 2H_2SO_4$$

H_2SO_4 is a dibasic acid because it has two oxygen ions to donate to a base in an acid-base reaction.

d The most important process for making sulfuric acid in industry is the Contact process. We can think of the Contact process as involving three stages. We can also obtain sulfur from the impurities in fossil fuels such as coal. In the first stage of the process, sulfur is burned in air to make sulfur dioxide gas:

$$\text{sulfur} + \text{oxygen} \longrightarrow \text{sulfur dioxide}$$
$$S(l) + O_2(g) \longrightarrow SO_2(g)$$

In the next stage, we convert the sulfur dioxide to sulfur trioxide:

$$\text{sulfur dioxide} + \text{oxygen} \rightleftharpoons \text{sulfur trioxide}$$
$$2SO_2(g) + O_2(g) \rightleftharpoons 2qSO_3(g)$$

The reaction happens on a catalyst of vanadium(V) oxide to speed up the reaction. As much sulfur dioxide as possible is changed into sulfur trioxide, and releases of sulfur dioxide are prevented because it is a gas that causes acid rain. In the final stage, the sulfur trioxide is converted into sulfuric acid. The sulfur trioxide gas is absorbed into very concentrated sulfuric acid (a 98 per cent solution of H_2SO_4in water)

$$\text{sulfur trioxide} + \text{water} \longrightarrow \text{sulfuric acid}$$
$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(l)$$

The forward reaction is exothermic (gives out heat), so the formation of sulfur trioxide will be favoured by low temperatures. However, the vanadium(V) oxide catalyst will not work below 400°C, so the reaction is conducted at 450°C to increase the rate of reaction. We can still get an excellent yield of sulfur trioxide (97 per cent) at this temperature, and at a reasonable rate with the help of the catalyst.

Teachingbd24.com