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KARPAGAM ACADEMY OF HIGHER EDUCATION

(Established Under Section 3 0f UGC Act,1956)
COIMBATORE - 641021

DEPARTMENT OF CHEMISTRY

Semester-II

17CHP204 INDUSTRIAL CHEMICALS AND ENVIRONMENT 4H 4C

Instruction Hours/week:L: 4 T:0 P:0 Marks: Internal:40 External: 60 Total:100

UNIT I

Industrial Gases and Inorganic Chemicals:

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

UNIT II

Industrial Metallurgy:

General Principles of Metallurgy:

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy, methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, Van Arkel-de Boer process and Mond’s process. Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

UNIT III

Environment and its segments:

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.

Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates.

Unit IV

Water Pollution:

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

Unit V

Energy & Environment:

Sources of energy: Coal, petrol and natural gas. Nuclear fusion / fission, solar energy, hydrogen, geothermal, tidal and hydel, etc. Nuclear pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis:

Introduction to biocatalysis: Importance in "Green chemistry" and chemical industry.

SUGGESTED READINGS:

Text Books:

1. Stocchi, E. (1990). *Industrial Chemistry Vol-I*. UK: Ellis Horwood Ltd.
2. Felder, R. M., & Rousseau, R. W. (2010). *Elementary Principles of Chemical Processes*. (III Edition). New Delhi. Wiley India Pvt. Ltd
3. Kent, K. A. (1997). Riegel's Handbook of Industrial Chemistry (IX Edition). New Delhi: CBS Publishers and Distributors Private Limited.

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DEPARTMENT OF CHEMISTRY

LECTURE PLAN

Name of the Staff	:	**K. SATHYA**
Department	:	**CHEMISTRY**
Title of the Paper	:	**INDUSTRIAL CHEMICALS AND ENVIRONMENT**
Paper Code	:	**17CHP204**
Class	:	**I-M.sc-Chemistry**
Year and Semester	:	**2017–2018 and II-Semester**
Total Hours	:	**60 Hours**

UNIT-I **HOURS REQUIRED -15**

S.No	Lecture Hour	Topics	Support Materials
1	1	Introduction : Industrial Gases and Inorganic Chemicals	T1:669
2	1	Large scale production uses storage and hazards in handling of oxygen, nitrogen.	T1:683
3	1	Large scale production, uses, storage and hazards in handling of neon, Argon.	T1:674
4	1	Large scale production uses storage and hazards in handling of helium, hydrogen.	T1: 675
5	1	Large scale production uses storage and hazards in handling of acetylene, carbon monoxide.	T1:689-691
6	1	Large scale production uses storage and hazards in handling of chlorine, fluorine.	T1:818-820
7	1	Manufacture, application, analysis and hazards in handling of sulphur dioxide and phosgene and.	T2:980
8	1	Introduction : Inorganic Chemicals	T1:695
9	1	Manufacture, application, analysis and hazards in handling of, hydrochloric acid, nitric acid	T1:706-708
10	1	Manufacture, application, analysis and hazards in handling of sulphuric acid, caustic soda	T1:805-807
11	1	Manufacture, application, analysis and hazards in handling of bleaching powder, common salt, borax.	T1:825,826
12	1	Manufacture, application, analysis and hazards in handling hydrogen peroxide, sodium thiosulphate.	T1:1162
13	1	Manufacture, application, analysis and hazards in handling of potash alum, chrome alum.	T2: 943,944
14	1	Manufacture, application, analysis and hazards in handling of	T2:1460,1471

		Potassium dichromate, potassium permanganate.	
15		Recapitulations and discussion of important questions	

S.No	Lecture Hour	Topics	Support Materials
UNIT-II HOURS REQUIRED -11			
1	1	General Principles of Metallurgy: Introduction	T1:729
2	1	Chief modes of occurrence of metals based on standard electrode potentials.	T1:652,653
3	1	Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.	T1:744,745
4	1	Hydrometallurgy: methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn) : Introduction	T1:737,738
5	1	Purification methods of metals Electrolytic, oxidative refining.	T1:739
6	1	Purification methods of metals Parting process and Kroll process	T2:1379
7	1	Purification methods of metals Van Arkel-de Boer process and Mond’s process	T2:1396,1428
8	1	Preparation of metals (ferrous)	T1:1345
9	1	Preparation of metals (nonferrous)	T1:1346
10	1	Ultrapure metals for semiconductor technology	T1:94
11	1	Recapitulations and discussion of important questions	

S.No	Lecture Hour	Topics	Support Materials
UNIT-III HOURS REQUIRED -12			
1	1	Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur	R1:182-185,195
2	1	Air Pollution: Major regions of atmosphere, Chemical and photochemical reactions in atmosphere	R2:200
3	1	Air pollutants: types, sources, particle size and chemical nature	R1:466,467
4	1	Photochemical smog: its constituents and photochemistry	R1:304
5	1	Environmental effects of ozone, Major sources of air pollution	R1:281,341
6	1	Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smelling gases.	R1:319
7	1	Methods of estimation of CO, NO_x, SO_x and control procedures	R1:322,325,330
8	1	Effects of air pollution on living organisms and vegetation, Greenhouse effect and Global warming	R1:294-296
9	1	Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens	R1:291,281
10	1	Removal of sulphur from coal	R1:302,316
11	1	Control of particulates	R1:273,355
12	1	Recapitulations and discussion of important questions	

S.No	Lecture Hour	Topics	Support Materials
UNIT-IV HOURS REQUIRED -12			
1	1	Hydrological cycle, water resources, aquatic ecosystems	R2: 195,196 R1:76
2	1	Sources and nature of water pollutants	R2 :197

3	1	Techniques for measuring water pollution	R2: 234-237
4	1	Impacts of water pollution on hydrological and ecosystems	R2: 392
5	1	Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment).	R1: 419,421,422
6	1	Industrial effluents from the following industries and their treatment: electroplating, textile and tannery.	R1: 476
7	1	Industrial effluents from the following industries and their treatment: Petroleum, petrochemicals and dairy	R1: 477
8	1	Industrial effluents from the following industries and their treatment: agro, fertilize and Sludge disposal.	R2: 291
9	1	Industrial waste management, incineration of waste.	R1: 670
10	1	Water treatment and purification (reverse osmosis, electro dialysis, ion exchange).	R1:425-429 R2: 290,232
11	1	Water quality parameters for waste water, industrial water and domestic water.	R1:392, R2:228
12		Recapitulations and discussion of important questions	

S. No	Lecture Hour	Topics	Support Materials
UNIT-V			**HOURS REQUIRED -10**
1	1	Sources of energy: Coal, petrol and natural gas.	R2:318-320
2	1	Nuclear fusion and Nuclear fission	R1:638
3	1	Solar energy, Hydrogen, geothermal, tidal and hydel	R2:321
4	1	Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management	R2: 322,324
5	1	Introduction to bio catalysis	R1:684
6	1	Importance in “Green chemistry” and chemical industry	R1: 725-727
7	1	Recapitulations and discussion of important questions	
8	1	Discussion of ESE question paper	
9	1	Discussion of ESE question paper	
10	1	Discussion of ESE question paper	

TEXT BOOKS

T1: Dr. B.K. Sharma, Industrial chemistry (2002) industrial chemistry, 13th edition, Goel publishing house, meerut-250 001

T2: Dr. R.D Madan (2014), modern inorganic chemistry, S. Chand & company Pvt. Ltd, New Delhi.

REFERENCE BOOKS

R1: Asim K.Das (2010) Environmental chemistry with Green chemistry, Books and Allied (P) Ltd. Kolkata-700010

R2: A. K. De (2013) Environmental chemistry 7th edition, New Age International publishers, New Delhi-110002

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KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF CHEMISTRY
EVEN SEMESTER 2017- 2018 (EVEN SEMESTER)
M.sc CHEMISTRY (I Year)

DAY ORDER Hrs	**(9.30-10.20) 1**	**(10.20-11.10) 2**	**(11.25-12.15) 3**	**(1.00-1.50) 4**	**(1.50-2.40) 5**	**(2.55- 3.45) 6**
MONDAY		**IC-1**		**IC-1**		
TUESDAY				**IC-1**		
WEDNESDAY	**IC-1**			**IC-1**		
THURSDAY						
FRIDAY						

INDUSTRIAL CHEMICALS AND ENVIRONMENT

UNIT I

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INDUSTRIAL CHEMISTRY

Industrial chemistry as the branch of chemistry which applies physical and chemical procedures towards the transformation of natural raw materials and their derivatives to products that is of benefit to humanity.

The chemical industry

The chemical industry can also be classified according to the type of main raw materials used and type of principal products made.

1. Industrial inorganic chemical industries and
2. Industrial organic chemical industries.

Industrial inorganic chemical Industries extract inorganic chemical substances, make composites of the same and also synthesize inorganic chemicals. Heavy industrial organic chemical industries produce petroleum fuels, polymers, petrochemicals and other synthetic materials, mostly from petroleum. Light organic industries produce specialty chemicals which include pharmaceuticals, dyes, pigments and paints, pesticides, soaps and detergents, cosmetic products and miscellaneous products.

Raw materials from the atmosphere

The atmosphere is the field above ground level. It is the source of air from which six industrial gases namely N_2, O_2, Ne, Ar, Kr and Xe are manufactured. The mass of the earth's atmosphere is approximately 5x 10^{15} tons and therefore the supply of the gases is virtually unlimited.

Oxygen

The majority of the oxygen produced by BOC Gases is used by the Glenbrook steel mill to oxidize unwanted impurities in the steel. The remainder is in the food industry, for medical oxygen for respiration and in oxy-acetylene torches.

Nitrogen

Nitrogen has two main uses: cooling and as an inert atmosphere. As liquid nitrogen it is used for cooling in many industrial processes and in the food industry. As gaseous nitrogen it is used to form an inert blanket over substances that would otherwise be oxidised by the air. Nitrogen is used for cooling various mechanical equipment that needs to be kept extremely cold and for snap-freezing foods such as chicken, hamburger patties and fruit to be eaten out of season. Inert blankets of nitrogen are used over reactive liquids in tankers, in varnish manufacture and also inside potato chip packets.

Argon

Argon is highly unreactive and so, like nitrogen, can be used as a protective blanket to prevent substances from oxidizing. Argon is mainly used to protect very hot metal, as this is highly reactive. Most of it is used in welding to protect the molten metal, and a small amount is used in light bulbs to prevent the white-hot tungsten filament from oxidizing.

Hydrogen

A small proportion of the hydrogen is used by BOC Gases to react with traces of oxygen in other gas streams. The two gases react forming water, which can be easily condensed out of a gas mixture. The majority of the hydrogen is sold to the edible fats and oils industry where it is used to hydrogenate vegetable oils to make margarine.

The Manufacturing and Purification Processes

The carbon dioxide is bought in liquid form from the Kapuni natural gas plant (where it is a by-product of their process). Nitrogen, oxygen and argon are all extracted from the fractional distillation of air, so these gases are all covered together. The acetylene and hydrogen manufacturing processes are covered below. Overall figures for purity and production capacity are given in Table.

Gases	**Purity %**	**Contaminates**
Acetylene	99.50	Traces of air and low levels of NH_3
Hydrogen	99.99	O_2
Carbon dioxide	99.98	Traces of air and hydrocarbons
Nitrogen	99.99	Ar and O_2
Oxygen	99.50	N_2, H_2O, Ar and CH_4
Argon	99.99	N_2, O_2 and H_2O

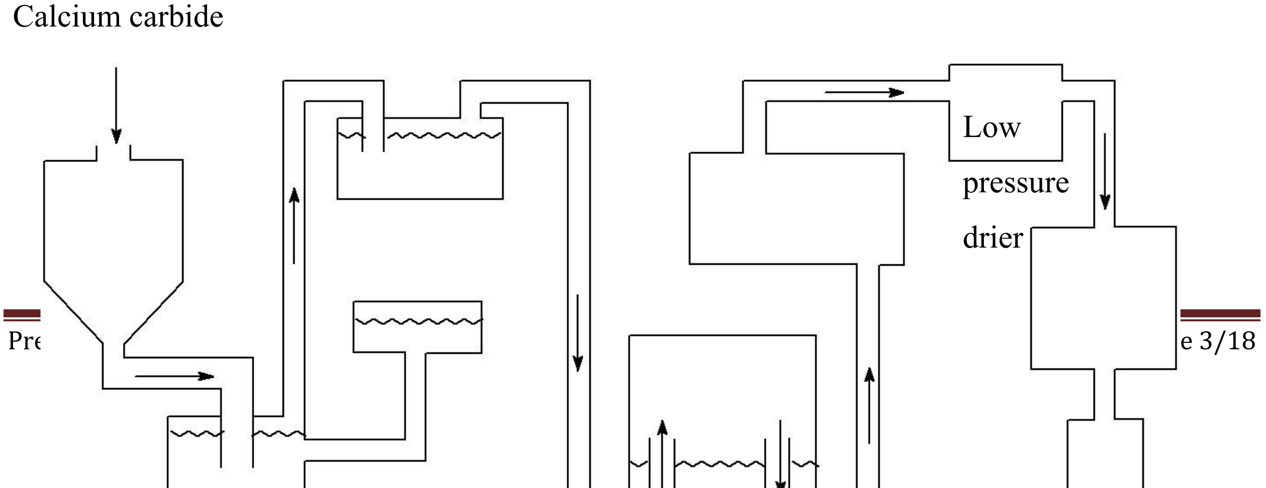
Acetylene

Acetylene is manufactured by the action of water on calcium carbide: A sealed hopper is kept filled with crushed calcium carbide (imported mainly from Norway) and a slow moving worm carries the solid forward to fall into a three meter high reaction vessel. The reaction occurs spontaneously on mixing and the gas formed passes via. A hydraulic main to a gas holder where it is stored above water. The addition of water to the reaction vessel is regulated manually. If the gas production becomes too rapid the reaction is slowed by the addition of more water, which lowers the temperature and hence the rate.

$$\mathbf{CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2}$$

The acetylene flows from the gas holder through a series of trays containing mainly ferric chloride to remove impurities such as hydrogen sulfide, phosphine and ammonia.

The gas then passes through a drier containing calcium chloride. It is then compressed to 20 atmospheres and passed through another bed of calcium chloride to remove the last traces of water. The compressed gas is then pumped into cylinders or tankers where it dissolves in acetone to ensure it can be transported and handled safely.



Hydraulic main

Trays to
absorb
impurities

Generator

Compressor

Cold water

Gas holders
(Impure C_2H_2)

Production of acetylene

The major by product from the process is slaked lime ($Ca(OH)_2$). This is dewatered in a series of settling ponds then sent to a waste disposal company. Some of the lime is dumped but the majority is used for lowering the pH of effluent water.

Hydrogen

Hydrogen is manufactured by the electrolysis of water. The water used is first distilled and then passed through several ion exchange columns to remove any mineral contaminants. It is then pumped to electrolysis cells which containing potassium hydroxide. The hydroxide acts as an electrolyte so it is not consumed, so while the cells need to be continually topped up with water they only rarely need extra hydroxide.

The electrolysis occurs at low current but relatively high voltage in steel tanks with nickel-plated steel electrodes in a solution with a specific gravity of 1.225.

Reaction at cathode: $2H_2O (l) + 2e \rightarrow H_2(g) + 2OH^-$

Reaction at anode: $2H_2O (l) \rightarrow O_2(g) + 4H+(aq) + 4e$

Overall: $2H_2O (l) \rightarrow O_2(g) + 2H_2(g)$

The two gases are collected in separate pipes. The oxygen is simply vented, if it is compressed any further the acetylene decomposes. Atmosphere, while the hydrogen is further treated. It is compressed to 172 bar and heated to 90°C (the compression alone heats it to about 70 °C) and passed over a mixture of palladium and alumina. Any contaminating oxygen is catalytically reduced to water, but the gas is of a sufficiently high temperature to prevent this from condensing out and deactivating the catalyst.

The gas is then dried over a mixture of alumina and silica gel then passed through a gas filter, compressed and pumped into cylinders or tankers.

Carbon dioxide

Carbon dioxide is produced at Kapuni by the Natural Gas Corporation and then sent to BOC Gases as liquid in pressurized tankers. In addition to selling it in liquid form some is converted into dry-ice, solid CO_2 which sublimes at atmospheric pressure at -78 °C. (Sublimation is the process of a solid changing to a gas without going through a liquid form.) To make dry-ice the liquid is rapidly depressurized, causing some of the CO_2 to solidify and the rest to be vented as a gas. The gaseous fraction is collected and recycled for both economic and environmental reasons. The CO_2 'snow' is then compressed into pellets and sold to industry.

The fractional distillation of air

Air is composed largely of nitrogen, with a significant amount of oxygen and traces of the noble gases and other compounds (Table 2). Nitrogen, oxygen and argon are separated on the basis of boiling point and any compounds that will interfere with the end users are removed before distribution.

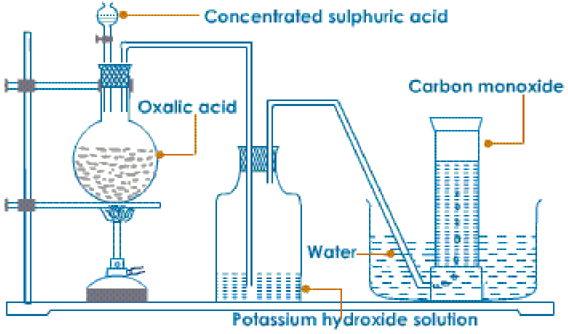
Gases	% by volume	Boiling point / °C
Nitrogen (N_2)	78.08	-196
Oxygen (O_2)	20.95	-183
Argon (Ar)	0.93	-186
Carbon-di-oxide (CO_2)	≈ 0.035	-78
Neon (Ne)	0.0018	-246
Helium (He)	0.00052	-269
Krypton (Kr)	0.00011	-152
Xenon (Xe)	0.00009	-108
Hydrogen (H_2)	0.00005	-253
Nitrous oxide (N_2O)	0.00005	-88
Water (H_2O)	Up to 4.0	100

The separation involves liquefaction of air followed by fractional distillation. Nitrogen (which has a lower boiling point) is more volatile than oxygen or argon. Water and carbon dioxide must be removed, and oxygen must be removed from the argon and nitrogen streams (as these are used as blankets to prevent oxidation) but the other constituents need not be because of their low concentration and inertness. Several important principles are involved in the process and are summarized below:

1. When work is done on air, by compressing it, it becomes hotter.
2. When compressed air is expanded through and opening or valve it becomes cooler.
3. When air is expanded in a turbine it does work on the rotors and cools by approximately ten times as much as in simple expansion.
4. When a mixture of liquids is in equilibrium with its vapour, the vapour above the liquid is richer in the more volatile component (i.e. more of the lower boiling liquid vapourises).
5. The boiling point of a liquid is lower at lower pressure.

Carbon monoxides

Laboratory preparation, properties and uses of carbon monoxides Carbon monoxide was first prepared in the laboratory in 1776 by J.M.F. de Lassone, a French chemist. As carbon monoxide is extremely poisonous, its preparation should be carried out only in a fume chamber. Under no circumstances must the gas be inhaled or smelled. Preparation of carbon monoxide by dehydrating oxalic acid with hot concentrated sulphuric acid. Carbon monoxide is prepared with the help of oxalic acid and concentrated sulphuric acid as shown in figure



Prepartion of carbon monoxide from oxalic acid

a)Nature
Carbon monoxide is colorless, almost odorless and tasteless gas.

b) Density
It is very slightly lighter than air.

Vapor Density=14 [Vapor density of air =14.4].

c) Solubility

Carbon monoxide is only very slightly soluble in water.100 volumes of water can dissolve only 3.5 volumes of the gas at S.T.P

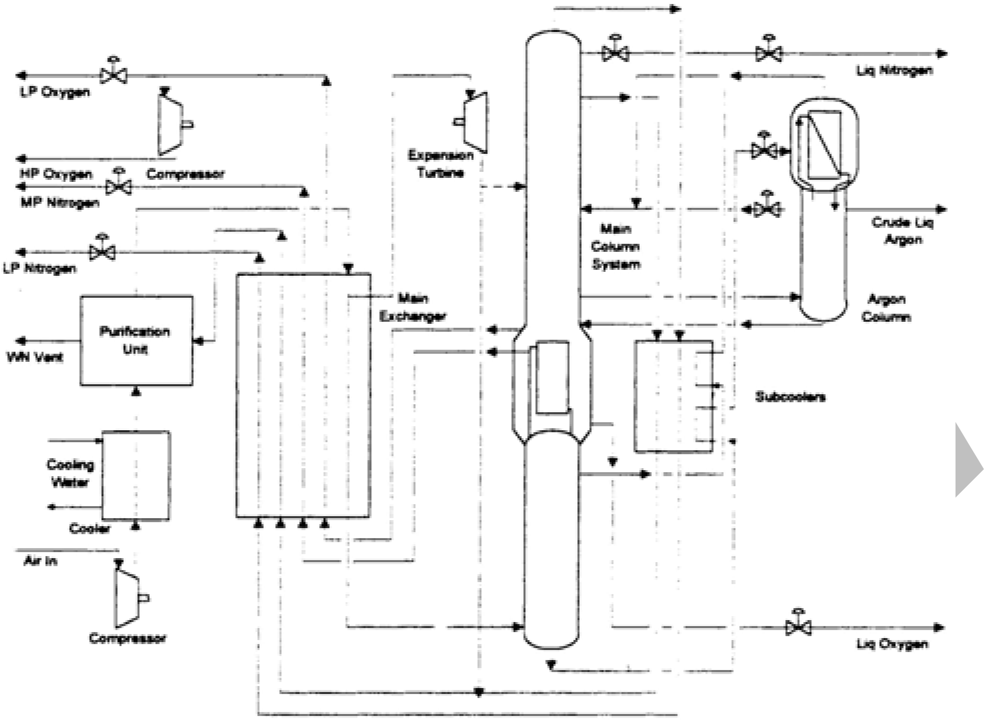
d) Poisonous nature

This is a highly poisonous gas. Air containing even less than 1% of carbon monoxide, can be fatal, if breathed in for about 10 to 15 minutes.

Liquifaction

The layout of a typical air liquifaction plant is shown in Figure. At the BOC plant at Glenbrook air is drawn in from the atmosphere and passed through a series of compression stages which increase the pressure to about 6 atmospheres as isothermally as possible, the final temperature being ~30 °C. To keep the temperature down the air is passed through water coolers after each of the first three compression cycles. After the 5th stage the compressed gas passes through a direct cooler, i.e. it is in contact with the cooling water. It then passes through a reversible heat exchanger of a honeycomb design where the coolant, flowing in a different pipe and in the reverse direction, is cold nitrogen gas at -167 °C and 0.5 atm pressures from the fractionating column. The temperature of the air at the mid-point is ~ -105°C and -165 °C when it emerges. During this process carbon dioxide and water vapour freeze out from the air stream on to the cold surface. To prevent these blocking the pipe the flow streams are reversed every 12 minutes, i.e. the cold nitrogen flows through the pipe that had carried the air stream and vice versa. The lower pressure nitrogen stream removes the ice and solids CO_2.

This fully compressed air now enters the main heat exchange block. This block has pipes for several different gas streams. The coolants of this block are waste N_2 and O_2 from the fractionating column and 10% of the air stream which is taken from the near the bottom of the lower fractionating column. The 10% air stream emerging from the main heat exchanger passes through the expansion turbine and cools to -162 °C by doing work on the rotor blades as it undergoes a pressure drop from 6 to 0.5 atm. This turbine drives a generator and power is returned to the national grid. This further cooled air then goes back to the reversible heat exchanger. After passing through the heat exchangers the air is now cooled to just above the dew point and enters the bottom of the first and lower fractionating column.



Typical layout of an air liquifaction plant

Fractional distillation

The liquid air is fractionally distilled to separate the more volatile nitrogen from the less volatile oxygen according to the fourth principle mentioned earler. The air separation unit consists of two columns (lower and upper) in which a large number of successive distillations and condensations can be carried out on a continuous basis. The columns contain a series of horizontal metal trays, each containing a number of small holes and two drain pipes to the tray below. Liquid is held on the trays while vapour bubbles up through the holes with sufficient velocity to prevent the liquid dripping back. The vapour entering a tray from beneath is warmer than the liquid on the tray, with the result that some of the vapour condenses and some of the liquid vaporizes and rises to the tray above.

The vapour evaporating from each tray is richer in nitrogen than is the liquid remaining. Consequently, as we proceed up the columns both liquid and vapour phases become enriched in nitrogen, while the oxygen concentration increases towards the bottom of the columns.

The lower column with ~25 trays operates at six atmospheres pressure and yields a liquid at the bottom at a temperature of -180 °C containing 30 - 35% oxygen. This is run off, passed through an expansion valve causing a pressure drop to 0.4 atmospheres and run into the upper column with ~75 trays about two thirds of the way up. Almost pure liquid oxygen collects at the bottom of the upper column at -180 °C. This liquid is divided by thin walls from the top of the lower column. Because the lower column is run at higher pressure this temperature is low enough to condense the gaseous nitrogen at the top of the lower column since at six atmospheres pressure the boiling point of nitrogen is -177 °C (principle 5).

Thus liquid nitrogen containing < 10 vpm2 oxygen is run off at the top of the lower column, and the heat exchanged causes oxygen vapour to rise up the upper column. Some of this liquid nitrogen is run off to storage while the remainder passes through an expansion valve into the top of the upper column. Gaseous nitrogen is continuously drawn off from the top of this column at -193 °C, used in heat exchangers as previously described and then discharged to the atmosphere. The plant produces oxygen at very high purity, while a minor amount of the oxygen originally in the air goes to waste with nitrogen. If a single stage column were used, 40% of the oxygen would be lost. Oxygen is then removed from the argon stream by Pd catalyzed reaction with hydrogen, and then the moisture from this process is removed with alumina ready for cylinder filling.

Cylinder filling

Gases can be transported in cylinders as gas or liquid. All gases for lower volume industrial applications are dispatched from BOC Gases in cylinders. These come in a variety of sizes from A (the smallest) to G (the largest). The cylinders are all colour coded for identification3. Before it is filled a cylinder to contain liquefied gas is put onto very sensitive scales and filled through a valve until the correct weight is reached. Many applications require a mixture of gases (e.g. Guiness use a 1 : 4 carbon dioxide : nitrogen mixture to carbonate their beer) and these are calculated by adding the correct weight of one gas then the next. Once the cylinder is filled the liquid gas in the filling tube is vented off (to prevent it from expanding and destroying the tube) and the cylinder sealed. It is then daubed with soapy water so that the person filling the cylinder can easily see if it has any leaks. Cylinders containing compressed gas are filled to the required pressure. Some gases stored in liquid form must be kept in heat- insulated cylinders and kept at low temperatures. e.g. N2, O2, Ar, air. As the density of a liquid is far greater than that of a gas much greater amounts can be stored and transported in the liquid form.

Plant Safety

Great care must be taken around the hydrogen and acetylene plants to prevent fires, as these are both highly flammable substances. Stringent controls are maintained over sources of ignition and incompatible materials such as oil around the oxygen plant. In some cases metal tools are made of bronze (rather than steel) so that they don't give off sparks during use, cigarettes are not allowed and cell phones etc. must be turned off. In the acetylene plant there is also danger from the calcium carbide as it gives off a large volume of acetylene gas when wet so it must be stored in the complete absence of moisture.

Sulphur di oxide

Combining of sulfur and dioxygen (O_2) to form sulfur dioxide. Purifying the sulfur dioxide in a purification unit. Adding an excess of dioxygen to sulfur dioxide in the presence of the catalyst vanadium pentoxide at 450 °C and 1-2 atm. The sulfur trioxide formed is added to sulfuric acid which gives rise to oleum (disulfuric acid). The oleum is then added to water to form sulfuric acid which is very concentrated. Purification of the air and sulfur dioxide (SO2) is necessary to avoid catalyst poisoning (i.e. removing catalytic activities). The gas is then washed with water and dried with sulfuric acid. To conserve energy, the mixture is heated by exhaust gases from the catalytic converter by heat exchangers.

Sulfur dioxide and dioxygen then react as follows:

$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) : \Delta H = -197\ kJ\cdot mol^{-1}$

According to the Le Chatelier's principle, a lower temperature should be used to shift the chemical equilibrium towards the right, hence increasing the percentage yield. However too low of a temperature will lower the formation rate to an uneconomical level. Hence to increase the reaction rate, high temperatures (450 °C), medium pressures (1-2 atm), and vanadium(V) oxide (V2O5) are used to ensure an adequate (>95%) conversion. The catalyst only serves to increase the rate of reaction as it does not change the position of the thermodynamic equilibrium. The mechanism for the action of the catalyst comprises two steps:

Oxidation of SO_2 into SO_3 by V^{5+}:

$2SO_2 + 4V^{5+} + 2O^{2-} \rightarrow 2SO_3 + 4V^{4+}$

Oxidation of V^{4+} back into V^{5+} by dioxygen (catalyst regeneration):

$4V^{4+} + O_2 \rightarrow 4V^{5+} + 2O^{2-}$

Hot sulfur trioxide passes through the heat exchanger and is dissolved in concentrated H2SO4 in the absorption tower to form oleum:

H_2SO_4 (l) + SO_3 (g) → $H_2S_2O_7$ (l)

Note that directly dissolving SO_3 in water is impractical due to the highly exothermic nature of the reaction. Acidic vapor or mists are formed instead of a liquid.

Oleum is reacted with water to form concentrated H_2SO_4.

$H_2S_2O_7$ (l) + H_2O (l) → 2 H_2SO_4 (l)

The elements in group 18 are the noble gases (helium, neon, argon, krypton, xenon, and radon). They earned the name “noble” because they were assumed to be nonreactive since they have filled valence shells. In 1962, Dr. Neil Bartlett at the University of British Columbia proved this assumption to be false.

Helium and Neon

These elements are present in the atmosphere in small amounts. Some natural gas contains 1–2% helium by mass. Helium is isolated from natural gas by liquefying the condensable components, leaving only helium as a gas. The United States possesses most of the world’s commercial supply of this element in its helium-bearing gas fields. Argon, neon, krypton, and xenon come from the fractional distillation of liquid air. Radon comes from other radioactive elements. More recently, it was observed that this radioactive gas is present in very small amounts in soils and minerals. Its accumulation in well-insulated, tightly sealed buildings, however, constitutes a health hazard, primarily lung cancer.

The boiling points and melting points of the noble gases are extremely low relative to those of other substances of comparable atomic or molecular masses. This is because only weak London dispersion forces are present, and these forces can hold the atoms together only when molecular motion is very slight, as it is at very low temperatures. Helium is the only substance known that does not solidify on cooling at normal pressure. It remains liquid close to absolute zero (0.001 K) at ordinary pressures, but it solidifies under elevated pressure.

Helium is used for filling balloons and lighter-than-air craft because it does not burn, making it safer to use than hydrogen. Helium at high pressures is not a narcotic like nitrogen. Thus, mixtures of oxygen and helium are important for divers working under high pressures. Using a helium-oxygen mixture avoids the disoriented mental state known as nitrogen narcosis, the so-called rapture of the deep. Helium is important as an inert atmosphere for the melting and welding of easily oxidizable metals and for many chemical processes that are sensitive to air.

Liquid helium (boiling point, 4.2 K) is an important coolant to reach the low temperatures necessary for cryogenic research, and it is essential for achieving the low temperatures necessary to produce superconduction in traditional superconducting materials used in powerful magnets and other devices. This cooling ability is necessary for the magnets used for magnetic resonance imaging, a common medical diagnostic procedure. The other common coolant is liquid nitrogen (boiling point, 77 K), which is significantly cheaper.

Neon is a component of neon lamps and signs. Passing an electric spark through a tube containing neon at low pressure generates the familiar red glow of neon. It is possible to change the color of the light by mixing argon or mercury vapor with the neon or by utilizing glass tubes of a special color.

Argon was useful in the manufacture of gas-filled electric light bulbs, where its lower heat conductivity and chemical inertness made it preferable to nitrogen for inhibiting the vaporization of the tungsten filament and prolonging the life of the bulb. Fluorescent tubes commonly contain a mixture of argon and mercury vapor. Argon is the third most abundant gas in dry air.

Environmental Implications

Gas production is largely an extremely environmentally-friendly industry. With the exception of acetylene and hydrogen production, the processes concerned produce no waste. In acetylene production the waste produced is lime, which creates a small disposal problem, but most of it is used in water treatment. The only waste in hydrogen production is oxygen, which is naturally present in air and so does not create a problem.

When the gases are used, again there is little environmental damage. Nitrogen, oxygen and argon are simply different fractions of air, so returning them to the air has no detrimental effect. Hydrogen is also present in air, and is harmless. Carbon dioxide and acetylene (which is burnt, giving off carbon dioxide and water) are of more concern, but still do not cause serious damage. Any carbon dioxide that doesn't form into dry ice pellets is recycled on site. The only two areas of concern are energy consumption and the use, at Glenbrook, of large volumes of cooling water.

Applications Helium

Helium has many unique properties: low boiling point, low density, low solubility, high thermal conductivity and inertness, so it is use for any application which can exploit these properties. Helium was the first gas used for filling balloons and dirigibles. This application goes on in altitude research and for meteorological balloons. The main use of helium is as an inert protection gas in autogenously welding. Its biggest potential is found in applications at very low temperatures. Helium is the only cooler which is capable of reaching temperatures lower than 15 K (-434ºF). The main application of ultralow temperature is in the development of the superconductivity state, in which the resistance to the electricity flux is almost zero. Other applications are its use as pressurizing gas in liquid propellants for rockets, in helium-oxygen mixtures for divers, as working fluid in nuclear reactors cooled down by gas and as gas carrier in chemical analysis by gas chromatography.

Applications acetylene

Welding, Portable lighting, Plastics and acrylic acid derivatives, approximately 20% of acetylene is supplied by the industrial gases industry for oxyacetylene gas welding and cutting due to the high temperature of the flame. The polymerization of acetylene with ZieglerNatta catalysts produces polyacetylene films. Polyacetylene, a chain of CH centres with alternating single and double bonds, was one of the first discovered organic semi conductors. Acetylene is not especially toxic but, when generated from calcium carbide, it can contain toxic impurities such as traces of phosphine and arsine, which give it a distinct garlic like smell. It is also highly flammable, as most light hydrocarbons, hence its use in welding. Cylinders should be stored in an area segregated from oxidizers to avoid exacerbated reaction in case of fire/leakage. Acetylene cylinders should not be stored in confined spaces / enclosed vehicles / garages /

buildings to avoid unintended leakage leading to explosive atmosphere. Acetylene is mainly used in oxy-acetylene flames for cutting mild steel and for welding.

Applications Carbon dioxide

Carbon dioxide is used by the food industry, the oil industry, and the chemical industry. The compound has varied commercial uses but one of its greatest use as a chemical is in the production of carbonated beverages; it provides the sparkle in carbonated beverages such as soda water. Carbon dioxide is a food additive used as a propellant and acidity regulator in the food industry. Carbon dioxide is used to produce carbonated soft drinks and soda water. Traditionally, the carbonation of beer and sparkling wine came about through natural fermentation, but many manufacturers carbonate these drinks with carbon dioxide recovered from the fermentation process. Carbon dioxide in the form of dry ice is often used during the cold soak phase in wine making to cool clusters of grapes quickly after picking to help prevent spontaneous fermentation by wild yeast. It is one of the most commonly used compressed gases for pneumatic (pressurized gas) systems in portable pressure tools. Carbon dioxide is also used as an atmosphere for welding, although in the welding arc, it reacts to oxidize most metals. Carbon dioxide can be used to extinguish flames by flooding the environment around the flame with the gas. It does not itself react to extinguish the flame, but starves the flame of oxygen by displacing it. Some fire extinguishers, especially those designed for electrical fires; contain liquid carbon dioxide under pressure. Liquid carbon dioxide is a good solvent for many lipophilic organic compounds and is used to remove caffeine from coffee. Plants require carbon dioxide to conduct photosynthesis. The atmospheres of greenhouses may (if of large size, must) be enriched with additional CO_2 to sustain and increase the rate of plant growth. Carbon dioxide is used in enhanced oil recovery where it is injected into or adjacent to producing oil wells, usually under supercritical conditions, when it becomes miscible with the oil. Liquid and solid carbon dioxide are important refrigerants, especially in the food industry, where they are employed during the transportation and storage of ice cream and other frozen foods. Solid carbon dioxide is called "dry ice" and is used for small shipments where refrigeration equipment is not practical. Solid carbon dioxide is always below −78.5 °C at regular atmospheric pressure, regardless of the air temperature. Carbon dioxide is used widely in the food industry for applications such as removing the caffeine from coffee beans to make decafinated coffee and for carbonating beer, soft drinks etc. It is also used for cooling in the food and manufacturing industries.

Applications Carbon monoxide

Carbon monoxide is an industrial gas that has many applications in bulk chemicals manufacturing. Large quantities of aldehydes are produced by the hydroformylation reaction of alkenes, carbon monoxide, and H_2. Hydroformylation is coupled to the Shell higher olefin process to give precursors to detergents. Phosgene, useful for preparing isocyanates, polycarbonates, and polyurethanes, is produced by passing purified carbon monoxide and chlorine gas through a bed of porous activated carbon, which serves as a catalyst. World production of this compound was estimated to be 2.74 million tonnes in 1989. Carbon monoxide is used in modified atmosphere packaging systems in the US, mainly with fresh meat products such as beef, pork, and fish to keep them looking fresh. The carbon monoxide combines with myoglobin to form carboxymyoglobin, a brightcherryred pigment. Carboxymyoglobin is more stable than the oxygenated form of myoglobin, oxymyoglobin, which can become oxidized to the brown pigment metmyoglobin. This stable red color can persist much longer than in normally packaged meat.[82] Typical levels of carbon monoxide used in the facilities that use this process are between 0.4% to 0.5%. In biology, carbon monoxide is naturally produced by the action of heme oxygenase 1 and 2 on the heme from hemoglobin breakdown. This process produces a certain amount of carboxyhemoglobin in normal persons, even if they do not breathe any carbon monoxide.Studies involving carbon monoxide have been conducted in many laboratories throughout the world for its antiinflammatory and cytoprotective properties. These properties have potential to be used to prevent the development of a series of pathological conditions including ischemia reperfusion injury, transplant rejection, atherosclerosis, severe sepsis, severe malaria, or autoimmunity. Clinical tests involving humans have been performed, however the results have not yet been released.[Carbon monoxide is a strong reductive agent, and whilst not known, it has been used in pyrometallurgy to reduce metals from ores since ancient times. Carbon monoxide strips oxygen off metal oxides, reducing them to pure metal in high temperatures, forming carbon dioxide in the process. Carbon monoxide is not usually supplied as is, in gaseous phase, in the reactor, but rather it is formed in high temperature in presence of oxygen carrying ore, carboniferous agent such as coke and high temperature. The blast furnace process is a typical example of a process of reduction of metal from ore with carbon monoxide. Carbon monoxide has also been used as a lasing medium in high powered infrared lasers.

Carbon monoxide has been proposed for use as a fuel on Mars. Carbon monoxide/oxygen engines have been suggested for early surface transportation use as both carbon monoxide and oxygen can be straightforwardly produced from the atmosphere of Mars by zirconia electrolysis, without using any Martian water resources to obtain hydrogen, which would be needed to make methane or any hydrogen based fuel. Likewise, blast furnace gas collected at the top of blast furnace, still contains some 10% to 30% of carbon monoxide, and is used as fuel on Cowper stoves and on Siemens Martin furnaces on open hearth steelmaking.

Applications Chlorine

Chlorine is presently an important chemical for water purification (such as in water treatment plants), in disinfectants,and in bleach. As a disinfectant in water, chlorine is more than three times as effective against Escherichia coli as bromine, and more than six times as effective as iodine. Chlorine is usually used (in the form of hypochlorous acid) to kill bacteria and other microbes in drinking water supplies and public swimming pools. In most private swimming pools, chlorine itself is not used, but rather sodium hypochlorite, formed from chlorine and sodium hydroxide, or solid tablets of chlorinated isocyanurates. The drawback of using chlorine in swimming pools is that the chlorine reacts with the proteins in human hair and skin (see Hypochlorous acid), and becomes chemically bonded. Even small water supplies are now routinely chlorinated. Chlorine gas, also known as bertholite, was first used as a weapon in World War I by Germany on April 22, 1915 in the Second Battle of Ypres. As described by the soldiers, it had the distinctive smell of a mixture of pepper and pineapple. It also tasted metallic and stung the back of the throat and chest. Chlorine reacts with water in the mucosa of the lungs to form hydrochloric acid, destructive to living tissue and potentially lethal. Human respiratory systems can be protected from chlorine gas by gas masks with activated charcoal or other filters, which makes chlorine gas much less lethal than other chemical weapons. Chlorine is a toxic gas that attacks the respiratory system, eyes, and skin.[95] Because it is denser than air, it tends to accumulate at the bottom of poorly ventilated spaces. Chlorine gas is a strong oxidizer, which may react with flammable materials. Chlorine is widely used for purifying water, especially potable water supplies and water used in swimming pools. Several catastrophic collapses of swimming pool ceilings have occurred from chlorine induced stress corrosion cracking of stainless steel suspension rods.

Applications fluorine

Sodium mono fluoro phosphate and sometimes sodium or tin(II) fluoride are often found in fluoride toothpastes, fluoridated mouth washes, gels, foams, and varnishes. Fluorine also finds use in steroids. Fluorine is not essential for humans or other mammals; Small amounts may be beneficial for bone strength, but this has not been definitively established. As there are many environmental sources of trace fluorine, the possibility of a fluorine deficiency could apply only to artificial diets. Hydrofluoric acid is a contact poison with greater hazards than many strong acids like sulfuric acid even though it is weak. Fluoro surfactants are small organofluorine molecules used for repelling water and stains. Fluoro surfactants are a minority in the overall surfactant market, most of which is taken up by much cheaper hydro carbon based products. About 30% of agrichemicals contain fluorine, most of them herbicides and fungicides with a few crop regulators. Fluorine substitution, usually of a single atom or at most a trifluoromethyl group, is a robust modification with effects analogous to fluorinated pharmaceuticals: Increased biological stay time, membrane crossing, and altering of molecular recognition

Oxygen

The majority of the oxygen produced by BOC Gases is used by the Glenbrook steel mill to oxidise unwanted impurities in the steel. The remainder is in the food industry, for medical oxygen for respiration and in oxy-acetylene torches.

Nitrogen

Nitrogen has two main uses: cooling and as an inert atmosphere. As liquid nitrogen it is used for cooling in many industrial processes and in the food industry As gaseous nitrogen it is used to form an inert blanket over substances that would otherwise be oxidised by the air. Nitrogen is used for cooling various mechanical equipment that needs to be kept extremely

cold and for snap-freezing foods such as chicken, hamburger patties and fruit to be eaten out of season. Inert blankets of nitrogen are used over reactive liquids in tankers, in varnish

manufacture and also inside potato chip packets.

Possible Questions

PART-B (Two mark questions)

1. Write any two uses of Nitrogen?
2. Write the uses of acetylene?
3. Write the preparation of potash alum?
4. Write the uses of neon?
5. Write the storage method of Phosgene in industry?
6. Write the preparation of chrome alum?
7. Write the application of caustic soda and common salt?
8. Write the hazards of carbon monoxide and Sulphur dioxide?

PART-C (Eight mark questions)

1. Discuss the production, storage and uses of oxygen?
2. Explain the manufacture, analysis and handling of Sulphuric acid?
3. Discuss the industrial production, storage and uses of chlorine?
4. Explain the manufacture, analysis and handling of nitric acid acid?
5. Discuss the large scale production, storage and handling of hazards in Nitrogen?
6. Explain the manufacture, analysis and applications of caustic soda?
7. Discuss the large scale production, storage and handling of hazards in Noble gases?
8. Explain the manufacture, analysis and applications of potassium dichromate?

S.No	**Questions**	**Option (a)**	**Option (b)**	**Option (c)**	**Option (d)**	**Answer**
1	In the atmosphere oxygen gas constitutes	(a) 18%	(b) 29%	(c) 21%	(d) 70%	**(c) 21%**
2	Oxygen gas produced by water through	(a) Osmosis	(b) electrolysis	(c) Dialysis	(d) Pyrolysis	**(b) electrolysis**
3	Industrially nitrogen gas prepared by	(a) Sublimation	(b) Distillation	(c) Fractional distillation	(d) double distillation	**(c) Fractional distillation**
4	Liquid nitrogen is used in the following technique	(a) Aerated	(b) cryogenics	(c) Supersonics	(d) Vapourized	**(b) cryogenics**
5	The toxicity of chlorine based on	(a) HCl	(b) HClO	(c) PCl_5	(d) None of the Above	**(b) HClO**
6	The commercial name for calcium hypochloride	(a) Caustic soda	(b) Washing soda	(c) baking soda	(d) Bleaching powder	**(d) Bleaching powder**
7	The Chemical Formula for Phosgene is	(a) $COCl_2$	(b) $CaSO_4$	(c) $MgSO_4$	(d) $CaCl_2$	**(a) $COCl_2$**
8	The following compound which are used in Photography	(a) $KMnO_4$	(b) $K_2Cr_2O_7$	(c) K_2CrO_4	(d) H_2S	**(b) K2Cr2O7**
9	$K_2Cr_2O_7$ used to prepare the following compounds	(a) Caustic soda	(b) Potash alum	(c) Chrome alum	(d) Amalgum	**(c) Chrome alum**
10	Industrially best oxidizing agent is	(a) $KMnO_4$	(b) $K_2Cr_2O_7$	(c) K_2CrO_4	(d) H_2S	**(b) $K_2Cr_2O_7$**
11	The best method for preparation of sulphuric acid is	(a) Contact process	(b) Habers process	(c) Lead chamber process	(d) Ostwald’s process	**(a) Contact process**
12	Following compounds which one is more toxic	(a) $KMnO_4$	(b) $K_2Cr_2O_7$	(c) K_2CrO_4	(d) HClO	**(b) $K_2Cr_2O_7$**
13	Which gas is used in welding process?	(a) Methane	(b) Ethane	(c) Acetylene	(d) Nitrogen	**(c) Acetylene**

14	In the production of fluorine _____________ is used as an electrolyte	(a) KF	(b) HF	(c) NaF	(d) Both (a) and (b)	**(d) Both (a) and (b)**
15	The fuel used for the rocket propellant is	(a) Liquid N_2	(b) H_2O_2	(c) Liqid CO2	(d) Ammonia	**(b) H_2O_2**
16	Another name of Borax is known as	(a) Boric acid	(b) Boric oxide	(c) Sodium borate	(d) Potassium borate	**(c) Sodium borate**
17	The following chemical which used to making buffer	(a) Chlorine	(b) Borax	(c) Phosgene	(d) caustic soda	**(b) Borax**
18	Potash alum is commonly known as	(a) Simple salt	(b) Double salt	(c) Complex salt	(d) None of the above	**(b) Double salt**
19	Sodium hydroxide is industrially produced by ___________ process	(a) Electrolytic	(b) Solvey	(c) Chloralkali	(d) Ostwald	**(c) Chloralkali**
20	The main use of chrome alum is	(a) Ink pads	(b) Coloring of papers	(c) Tanning of leather	(d) Lamp materials	**(c) Tanning of leather**
21	The conversion of nitrogen to ammonia is called as	(a) Nitrogen fixation	(b) Nitrogen assimilation	(c) Denitrification	(d) Nitrification	**(a) Nitrogen fixation**
22	Plants absorbs N_2 in the form of	(a) Nitrites	(b) Nitrates	(c) ammonium	(d) All the above	**(d) All the above**
23	Industrial fixation of N_2 is accomplished by	(a) Helmonts process	(b) Haber's process	(c) Reimer - Tiemen	(d) Kolbe's reaction	**(b) Haber's process**
24	The element which is the biggest source of energy in future is	(a) Nitrogen	(b) Oxygen	(c) Halogen	(d) Hydrogen	**(d) Hydrogen**
25	Hydrogen peroxide is	(a) Oxidising agent	(b) Reducing agent	(c) Both (a) and (b)	(d) None of the above	**(c) Both (a) and (b)**
26	Hydrogen peroxide is obtained by electrolysis of	(a) Water	(b) Sulphuric acid	(c) hydrochloric acid	(d) Fused sodium peroxide	**(b) Sulphuric acid**
27	The gas used in welding & cutting of metal is a strong ___________	(a) Reducing agent	(b) Oxidising agent	(c) Redoxing agent	(d) Dehydrating agent	**(a) Reducing agent**

28	Which among the following elements is found in maximum percentage in the Human Body ?	(a) Carbon	(b) Oxygen	(c) Hydrogen	(d) Nitrogen	**(b) Oxygen**
29	The acid used in lead storage cells is	(a) Nitric acid	(b) Sulphuric acid	(c) hydrochloric acid	(d) Phosphoric acid	**(b) Sulphuric acid**
30	What is the chemical name of BAKING SODA?	(a) Sodium bicarbonate	(b) Sodium nitrate	(c) Sodium carboante	(d) Sodium nitrite	**(a) Sodium bicarbonate**
31	The gas used for artificial fruit ripening of green fruit is	(a) Methane	(b) Ethane	(c) Ethylene	(d) Acetylene	**(c) Ethylene**
32	Acidic foods are mostly preserved with help of solution made from	(a) Sulfur dioxide	(b) ammonium nitrate	(c) ammonium phosphate	(d) ammonium sulfate	**(a) Sulfur dioxide**
33	Production of large quantity of ammonia is done by increasing	(a) Temperature	(b) catalyst	(c) pressure	(d) humidity	**(c) pressure**
34	Nitrogen always exists as	(a) Mono atomic	(b) di-atomic molecule	(c) sub-molecule	(d) tertiary molecule	**(b) di-atomic molecule**
35	Raw material required for production of sulfuric acid is	(a) Sulfur	(b) air	(c) water	(d) all of them	**(d) all of them**
36	Nitric acid (HNO_3) is made from	(a) Ammonium	(b) nitrogen	(c) nitrate	(d) ammonia	**(d) ammonia**
37	In first stage in Contact process, sulfur (S_8) is burned to form	(a) Sulfur dioxide gas	(b) sulfur trioxide	(c) sulfur tetraoxide	(d) sulfuric acid	**(a) Sulfur dioxide gas**
38	Explosive such as trinitrotoluene (TNT) is made by	(a) Concentrated nitric acid	(b) ammonia	(c) nitrate	(d) all of them	**(a) Concentrated nitric acid**
39	Noble gas which is least abundant is	(a) Ar	(b) Kr	(c) Xe	(d) Rn	**(d) Rn**
40	Welding of Mg can be done in an atmosphere of	(a) He	(b) Xe	(c) Kr	(d) Oxygen	**(a) He**
41	Which of the following is a superfluid is	(a) Helium I	(b) Argon II	(c) Helium II	(d) Krypton I	**(c) Helium II**

42	Noble gas used in atomic reactors is	(a) Helium	(b) Neon	(c) Krypton	(d) Xenon	**(a) Helium**
43	Which of the following gas mixtures is not used in Gas tungsten arc welding (TIG)?	(a) Argon-Helium	(b) Argon-Nitrogen	(c) Argon-Hydrogen	(d) Argon-Carbon dioxide	**(b) Argon-Nitrogen**
44	Fluorine can be stored in a metal lined with nickel and copper alloy to protect from	(a) Further reaction	(b) outside	(c) water	(d) all of them	**(a) Further reaction**
45	Chlorate ion is the	(a) Oxidizing agents	(b) reducing agents	(c) bleaching agent	(d) all of them	**(c) bleaching agent**
46	Potassium Permanganate is used for purifying drinking water, because	(a) It is a sterilizing agent	(b) it dissolves the impurities of water	(c) It is a reducing agent	(d) it is an oxidising agent	**(d) it is an oxidising agent**
47	If acidified $K_2Cr_2O_7$ acts as oxidizing agent, color changes from	(a) orange to red	(b) orange to green	(c) yellow to green	(d) yellow to red	**(c) yellow to green**
48	Old paintings can be restored through an oxidizing agent	(a) H_2S	(b) H_2O_2	(c) H_2PO_4	(d) H_3O	**(b) H_2O_2**
49	Which of the following is not a use of potash alum?	(a) Arrest bleeding	(b) Pesticide	(c) Mordant in dyeing	(d) coagulant in water	**(b) Pesticide**
50	Percentage of neon in air is	(a) 0.0018%	(b)0.0011%	(c)0.0012%	(d)0.0014%	**0.0018%**
51	Percentage of oxygen in air is	(a)20%	(b)21%	(c)18%	(d)15%	**21%**
52	Percentage of nitrogen in air is	(a)70%	(b)60%	(c) 78%	(d)50%	**78%**
53	Noble gas used in atomic reactors is	(a) Helium	(b) Neon	(c) Krypton	(d) Xenon	**(a) Helium**
54	Percentage of carbon dioxide in air is	(a)0.05%	(b)0.04%	(c) 0.06%	(d)0.08%	**0.04%**
55	Percentage of helium in air is	(a)0.00042%	(b) 0.00044%	(c) 0.00052%	(d) 0.00062%	**0.00052%**

56	Percentage of argon in air is	(a)0.93%	(b)0.83%	(c) 0.74%	(d)0.64%	**0.93%**
57	Process in which metal ions are reduced to free metals is called	A. Smelting	b. Bessemerization	c. Concentration	d. Roasting	**A. Smelting**
58	Ore of iron is called	A. Haematite	b. Chalcopyrite	c. Bauxite	d. Halite	**A. Haematite**
59	Which of following is used in manufacture of fertilizers and explosives?	A. Nitric acid	b. Phosphoric acid	c. Hydrochloric acid	d. Acetic acid	**A. Nitric acid**
60	Which of the following is not a mineral acid?	(a) Nitric acid	(b) Sulphuric acid	(c) hydrochloric acid	(d) Citric acid	**(d) Citric acid**

UNIT II

Industrial Metallurgy:

General Principles of Metallurgy:

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy, methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, Van Arkel-de Boer process and Mond's process. Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

Ellingham Diagrams

A particular case of the free energy change accompanying a chemical reaction is the standard free energy of formation, which is the free energy change accompanying the formation of one mole of a compound from the constituent elements, all being in their standard states. The free energies of formation of the elements in their standard states are, by convention, taken to be zero. As discussed in the previous section, the free energies of formation change with temperature and, without any serious loss of accuracy, this temperature dependence can be taken to be linear.

An Ellingham diagram is a plot of ΔG versus temperature. Since ΔH and ΔS are essentially constant with temperature unless a phase change occurs, the free energy versus temperature plot can be drawn as a series of straight lines, where ΔS is the slope and ΔH is the y-intercept. The slope of the line changes when any of the materials involved melt or vaporize.

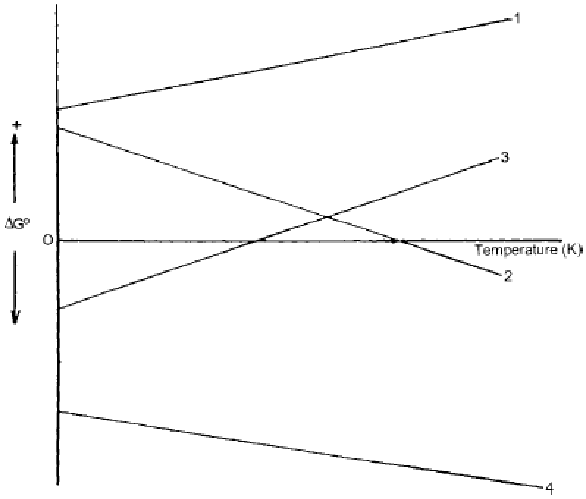
In 1944 Ellingham compiled, for the first time, diagrams depicting the temperature dependence of the standard free energies of formation of numerous oxides and sulphides. In the discussion presented here, attention will be confined to the oxide reaction and the essential features will be brought out in terms of a few illustrative free energy versus temperature lines (Ellingham lines) drawn for this reaction. Figure 3.4 shows one such plot. The plot is a straight line graph because is of the form $y = m x + c$ (with $m = -\Delta S0 = -(S - S)$ where S is the total entropy of the products and S is the total entropy of the reactants, and $c = \Delta H0$).

$M (s) + O_2 (g) \rightarrow MO_2 (s)$

$\Delta G_0 = \Delta H_0 - T\ \Delta S_0$

The intercept of the graph on the y axis is ΔH where ΔH is the standard enthalpy at 0 K. At 0 K, ΔG = ΔH. The slope of the graph is −ΔS0. Thus when the entropy is increasing (DS is positive), the slope of the graph is negative (m = −(+D S) = −D S). This situation is illustrated by lines 2 and 4 in Figure 3.4. Line 2 corresponds to an endothermic reaction with the entropy increasing. Line 4 corresponds to an exothermic reaction with entropy increasing. When the entropy is decreasing (ΔS is negative) the slope will be positive (m = − (−ΔS) = +ΔS). This situation is illustrated by lines 1 and 3 in Figure 3.4 Line 1 corresponds to an endothermic reaction with entropy decreasing (ΔG is always positive), and line 3 shows an exothermic reaction with entropy decreasing. The quantity plotted is free energy per mole of oxygen rather than per mole of the oxide. This facilitates a simple comparison, when data for more than one element are plotted, of the oxygen affinity of the different elements and enables one to obtain the free energy change corresponding to a reaction of the type by simple subtraction of the standard free energy values for the two compounds. Such a diagram allows one to read directly the value of ΔG0 at any temperature T1, and thus has the advantage of combining a great deal of information in a very simple presentation.

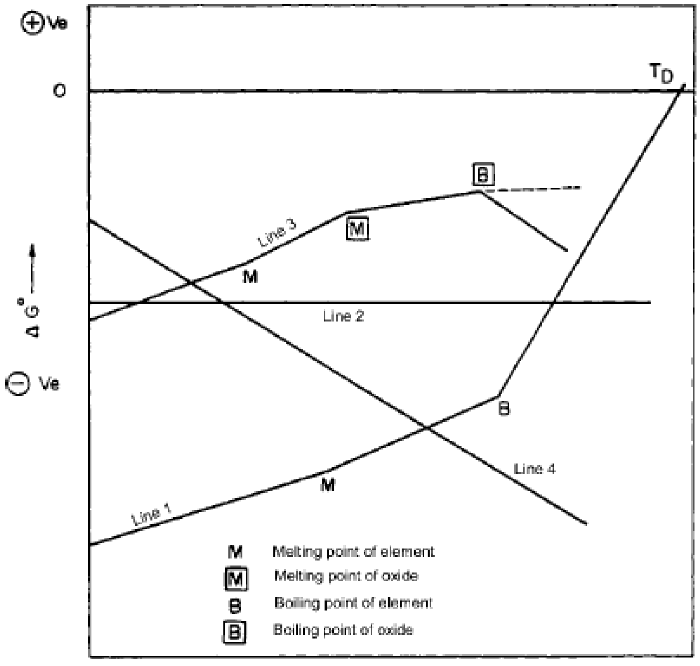
$M + NO \rightarrow MO + N$



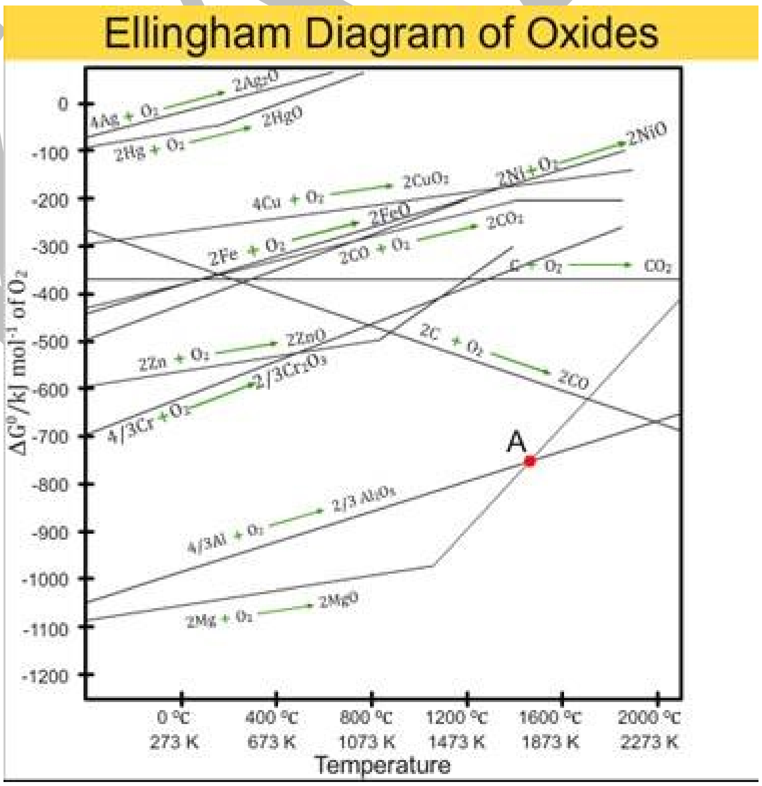
Effect of the sign of ΔH° and ΔS° on Ellingham lines

In an Ellingham diagram covering a wide temperature range, sharp changes in the slope of the line (ΔG0 versus T plot) occur at certain temperatures. At these temperatures phase transformations take place in the reactants or in the products. As the slope of the line corresponds to −ΔS0, where ΔS0 is the entropy change associated with oxide formation, the magnitude of the change in slope is determined by the value of the entropy change for the transformation. Since the entropy changes markedly at the melting and the boiling points of a metal as well as of its oxides, a change in the slope of the line in the Ellingham diagram may be anticipated at these temperatures. The various possibilities are shown in Figure 3.5 and Table 3.2. When the metal undergoes a phase change with rising temperature, its entropy increases by an amount equal to the enthalpy of the phase change divided by the absolute temperature at which the change occurs. When the phase change occurs in the reactants,augmentation of the entropy of the reactants results in the slope 0 0(m = -ΔS = S - Sp) becoming a larger positive value. Line 1 represents a typical case of phase transformation in reactant. If, on the other hand, there is a phase transformation in the product the slope becomes a smaller positive value because here the entropy of the product is augmented (S becomes more and m becomes a smaller positive value or even a negative value). In Figure 3.5, line 3 represents a typical case of phase transformation in the product. As regards the phase change, boiling results in a far greater augmentation of entropy than melting. Thus in the figure, sharper changes in slope occur at points marked B and B than at points marked M and M. Line 2 illustrates the special case where there is almost no entropy

change associated with the oxidation reaction and where no phase transformation of the metal or its oxide occurs in the range of temperatures considered. Line 4 in the diagram pertains to another special situation which arises when oxidation causes an increase in entropy. For such reactions, ΔS0 is positive and the slope of the Ellingham line is negative. The oxide becomes stabler as the temperature is increased. Typical examples of “line 1” behaviour are provided by magnesium, calcium, and zinc. The classic example of “line 2” behaviour is exhibited by carbon dioxide. However, this type of behaviour is not exhibited by any metal. The oxides of metals like lead and cadmium are examples of “line 3” behaviour. “Line 4” behaviour is exhibited by carbon monoxide, and volatile suboxides of several refractory metals.



Slopes of Ellingham lines



Hydrometallurgy

Hydrometallurgy is concerned with the methods of production of metals and compounds, most often from minerals but sometimes also from substances produced by another process. In order to achieve this result, at least some of the reactions occurring during the sequence of process operations are implemented in an aquatic medium. It is a method for obtaining metals from their ores. It is a technique within the field of extractive metallurgy involving the use of aqueous chemistry for the recovery of metals from ores, concentrates, and recycled or residual materials. Metal chemical processing techniques that complement hydrometallurgy are pyrometallurgy, vapour metallurgy and molten salt electrometallurgy. Hydrometallurgy is typically divided into three general areas:

- Leaching
- Solution concentration and purification
- Metal or metal compound recovery

Leaching

Leaching involves the use of aqueous solutions to extract metal from metal bearing materials which is brought into contact with a material containing a valuable metal. The lixiviant solution conditions vary in terms of pH, oxidation-reduction potential, presence of chelating agents and temperature, to optimize the rate, extent and selectivity of dissolution of the desired metal component into the aqueous phase. Through the use of chelating agents, one can selectively extract certain metals. Such chelating agents are typically amines of schiff bases.[3]

Solution concentration and purification

After leaching, the leach liquor must normally undergo concentration of the metal ions that are to be recovered. Additionally, undesirable metal ions sometimes require removal.[1]

- Precipitation is the selective removal of a compound of the targeted metal or removal of a major impurity by precipitation of one of its compounds. Copper is precipitated as its sulfide as a means to purify nickel leachates.

- Cementation is the conversion of the metal ion to the metal by a redox reaction. A typical application involves addition of scrap iron to a solution of copper ions. Iron dissolves and copper metal is deposited.

- Solvent Extraction

- Ion Exchange

- Gas reduction. Treating a solution of nickel and ammonia with hydrogen affords nickel metal as its powder.

- Electrowinning is a particularly selective if expensive electrolysis process applied to the isolation of precious metals. Gold can be electroplated from its solutions.

Solvent extraction

In the solvent extraction is a mixture of an extractant in a diluent is used to extract a metal from one phase to another. In solvent extraction this mixture is often referred to as the "organic" because the main constituent (diluent) is some type of oil.

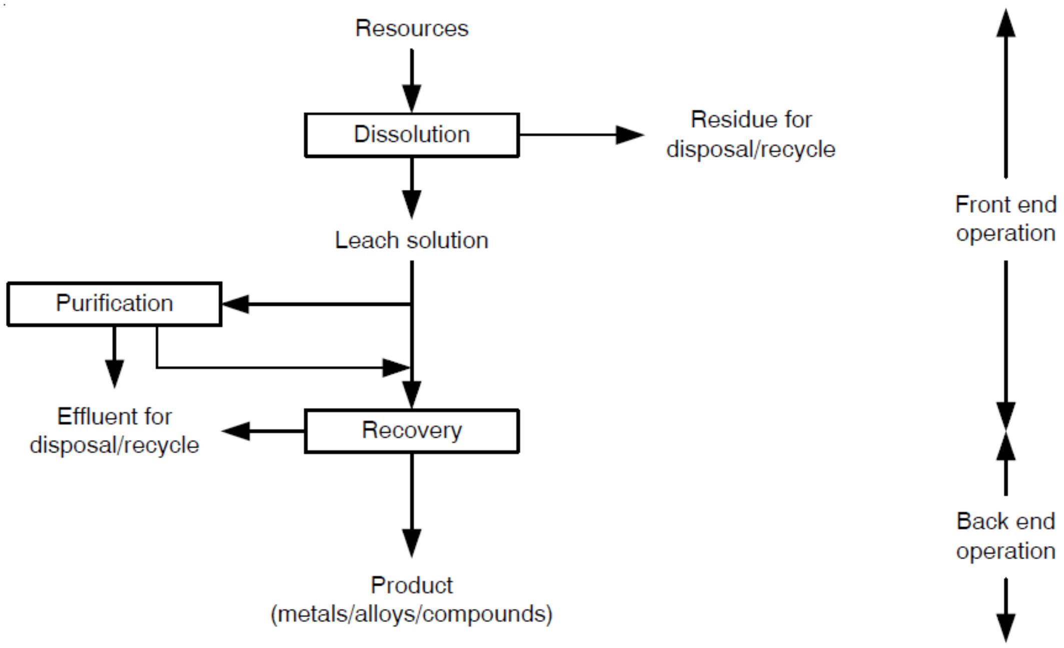
The PLS (pregnant leach solution) is mixed to emulsification with the stripped organic and allowed to separate.[citation needed] The metal will be exchanged from the PLS to the organic they are modified.[clarification needed] The resulting streams will be a loaded organic and a raffinate. When dealing with electrowinning, the loaded organic is then mixed to emulsification with a lean electrolyte and allowed to separate. The metal will be exchanged from the organic to the electrolyte. The resulting streams will be a stripped organic and a rich electrolyte. The organic stream is recycled through the solvent extraction process while the aqueous streams cycle through leaching and electrowinning [clarification needed] processes respectively.[citation needed]

Ion exchange

Chelating agents, natural zeolite, activated carbon, resins, and liquid organics impregnated with chelating agents are all used to exchange cations or anions with the solution.[citation needed] Selectivity and recovery are a function of the reagents used and the contaminants present.

Metal Recovery

Metal recovery is the final step in a hydrometallurgical process. Metals suitable for sale as raw materials are often directly produced in the metal recovery step. Sometimes, however, further refining is required if ultra-high purity metals are to be produced. The primary types of metal recovery processes are electrolysis, gaseous reduction, and precipitation. For example, a major target of hydrometallurgy is copper, which is conveniently obtained by electrolysis. Cu2+ ions reduce at mild potentials, leaving behind other contaminating metals such as Fe2+ and Zn2+.



Basic unit processes in hydrometallurgy

Electrolytic process

In the electrolytic process of dissolution, an electric current is imposed on a solid, and this technique can bring about its dissolution in the liquid with which it is in contact. For example, if nickel sulfide is connected to a direct current source such that it becomes the anode and the cathode is any conducting material, dissolution will occur according to the following overall anodic reaction:

$Ni_3S_2 \rightarrow 3Ni^{2+} + 2S + 6e^-$

The cathodic reaction is:

$Ni^{2+} + 2e^- \rightarrow Ni$

In the case of metal as anode instead of its sulfide the reaction is:

$M \rightarrow M^{n+} + ne^-$

The two electrolytic processes, one with the metallic sulfide and the other with the metal itself, are industrial processes. The first one allows simultaneous recovery of metal and sulfur, and second one allows purification of impure metal.

Electrolysis

Electrowinning and electrorefining respectively involve the recovery and purification of metals using electrodeposition of metals at the cathode, and either metal dissolution or a competing oxidation reaction at the anode.

Precipitation

Precipitation in hydrometallurgy involves the chemical precipitation of either metals and their compounds or of the contaminants from aqueous solutions. Precipitation will proceed when, throughreagent addition, evaporation, pH change or temperature manipulation, any given species exceeds its limit of solubility

Kroll's Process

The Kroll process is a pyrometallurgical industrial process used to produce metallic titanium. It was invented by William J. Kroll in Luxembourg. After moving to the United States, Kroll further developed the method for the production of zirconium. The Kroll process replaced the Hunter process for almost all commercial production.

The reduction reaction in Kroll's process can be written as

$$TiCl_4\ (g) + 2Mg\ (l) \rightarrow Ti\ (s) + 2MgCl_2\ (l)\ [T = 800–850\ °C]$$

The reaction is carried out in a stainless steel container for externally heating by gas or electricity. Exothermic reaction occurs. After reaction is over the Ti sponge is recover either by dissolving MgCl either by dissolving MgCl2 and excess Mg by leaching with cold dilute hydrochloric acid or by distilling of mgcl2 and excess mg by vacuum heating. The residue is pure Ti sponge.

The maximum yield is 96% because of

- Efficient Scavenger with respect to impurity chlorides such as $FeCl_3$ and $AlCl_3$.
- Better conductivity of NaCl compares to $MgCl_2$ and hence, reaction is exothermic.
- NaCl-$MgCl_2$ leads a better separation of metal from slag.

The sponge Ti produces in Kroll's process and ductile Ti produce in Hunter process. Main uses of Ti overally are Jet engine components, Air frames and Missiles and space craft. Area of Extraction: Tuticorin (Tamil Nadu), Kerala

Parting process

Parting is the separating of gold from silver. Gold and silver are often extracted from the same ores and are chemically similar and therefore hard to separate. Over the centuries special means of separation have been invented.

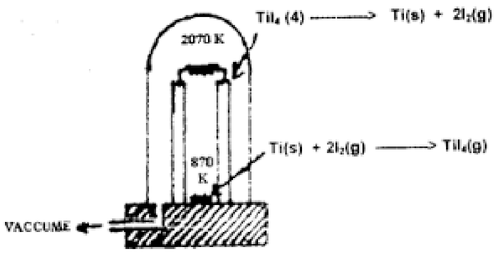
The very earliest precious metals had mixes of gold and silver; gold and silver alloy is called electrum. With the advent of coinage, methods had to be invented to remove impurities from the gold so that gold of specific purities could be made. Cupellation was able to remove gold and silver from mixtures containing lead and other metals, but silver could not be removed.

Gold parting as a process was specifically invented to remove the silver. The main ancient process of gold parting was by salt cementation and there is archaeological evidence of that process from the 6th century BC in Sardis, Lydia. In the post-medieval period parting using antimony, sulfates and mineral acids was also used. In the modern period chlorination using the Miller process, and electrolysis using theWohlwill process are the most widely used methods of refining gold by removing silver and platinum.

Van Arkel-de Boer Method

$$\underset{\text{(Impure)}}{Ti} + 2I_2 \xrightarrow{500K} TiI_4$$

$$TiI_4 \xrightarrow{1700K} \underset{\text{(Pure Metal)}}{Ti} + 2I_2$$



Ultra pure metals are being prepared by the Van Arkel Method. Crude metal is heated with a suitable substance so that the pure metal present in it may be converted into stable volatile compound leaving behind impurities. The compound so formed is then decomposed by heating to get the pure metal. Van Arkels method is used to purify crude titanium metal. It is heated with iodine to about 500K to form volatile compound. Til4leaving behind the impurities .Til4 is further heated to 1700K when it decomposes to give pure titanium.

Mond's process

The Mond process, sometimes known as the carbonyl process, is a technique created by Ludwig Mond in 1890,[1] to extract and purify nickel. The process was used commercially before the end of the 19th century.[2] This process converts nickel oxides into pure nickel.

This process involves the fact that carbon monoxide combines with nickel readily and reversibly to give nickel carbonyl. No other element forms a carbonyl compound under the mild conditions used in the process

This process has three steps:

1. Nickel oxide reacts with Syngas at 200 °C to give nickel, together with impurities including iron and cobalt.

$NiO(s) + H2(g) \rightarrow Ni(s) + H2O(g)$

2. The impure nickel reacts with carbon monoxide at 50–60 °C to form the gas nickel carbonyl, leaving the impurities as solids.

$Ni(s) + 4\ CO(g) \rightarrow Ni(CO)4(g)$

3. The mixture of nickel carbonyl and Syngas is heated to 220–250 °C, resulting in decomposition back to nickel and carbon monoxide:

$Ni(CO)4(g) \rightarrow Ni(s) + 4\ CO(g)$

Steps 2 and 3 illustrate a chemical transport reaction, exploiting the properties that (1) carbon monoxide and nickel readily combine to give a volatile complex and (2) this complex degrades back to nickel and carbon monoxide at higher temperatures. The decomposition may be engineered to produce powder, but more commonly an existing substrate is coated with nickel. For example, nickel pellets are made by dropping small, hot pellets through the carbonyl gas; this deposits a layer of nickel onto the pellets.

This process has also been used for plating nickel onto other metals, where a complex shape or sharp corners have made precise results difficult to achieve by electroplating. Although the results are good, the toxicity makes it impractical as an industrial process. Such parts are now plated by electroless nickel plating instead.

Pyrometallurgical

Some of the newer pyrometallurgical techniques produce slags from various dusts containing hazardous chemicals such as arsenic and lead. These slags, however, are stable and have been classified as nonhazardous. Many uses (and thus methods of disposal) have been developed over the years for both ferrous and nonferrous slags, including mine backfill, aggregate for construction, sand blasting, and ballast for rail lines. In addition to these high-tonnage uses of slags there are some minor (but important) uses, including the production of rockwool insulation, filter media, brake linings, and noise reduction materials.

Ferrous Materials and Non-Ferrous Metals

Introduction

Ferrous materials/metals may be defined as those metals whose main constituent is iron such as pig iron, wrought iron, cast iron, steel and their alloys. The principal raw materials for ferrous metals are pig iron. Ferrous materials are usually stronger and harder and are used in daily life products. Ferrous material possesses a special property that their characteristics can be altered by heat treatment processes or by addition of small quantity of alloying elements. Ferrous metals possess different physical properties according to their carbon content.

IRON AND STEEL

The ferrous metals are iron base metals which include all varieties of iron and steel. Most common engineering materials are ferrous materials which are alloys of iron. Ferrous means iron. Iron is the name given to pure ferrite Fe, as well as to fused mixtures of this ferrite with large amount of carbon (may be 1.8%), these mixtures are known as pig iron and cast iron. Primarily pig iron is produced from the iron ore in the blast furnace from which cast iron, wrought iron and steel can be produced.

WROUGHT IRON

The meaning of “wrought” is that metal which possesses sufficient ductility in order to permit hot and/or cold deformation. Wrought iron is the purest iron with a small amount of slag forged out into fibres. The typical composition indicates 99 per cent of iron and traces of carbon, phosphorus, manganese, silicon, sulphur and slag. During the production process, first all elements in iron (may be C, S, Mn, Si and P) are eliminated leaving almost pure iron molten slag. In order to remove the excess slag, the final mix is then squeezed in a press and reduced to billets by rolling milling. The resulting material would consist of pure iron separated by thin layers of slag material. The slag characteristic of wrought iron is beneficial in blacksmithy/forging operations and provides the material its peculiar fibrous structure. Further, the non-corrosive slag constituent makes wrought iron resistant to progressive corrosion and also helps in reducing effect of fatigue caused by shocks and vibrations. Wrought iron is tough, malleable and ductile and possesses ultimate tensile strength of 350 N/mm2. Its melting point is 1530°C. It can neither be hardened nor tempered like steel. The billets of wrought iron can be reheated to form bars, plates, boiler tubing, forgings, crane hook, railway coupling, bolts and nuts, chains, barbed wire, coal handling equipment and cooling towers, etc.

CAST IRON

It is primarily an alloy of iron and carbon. The carbon content in cast iron varies from 1.5 to 4 per cent. Small amounts of silicon, manganese, sulphur and phosphorus are also present in it. Carbon in cast iron is present either in free State like graphite or in combined state as cementite. Cast iron contains so much carbon or its equivalent that it is not malleable. One characteristic (except white cast iron) is that much of carbon content is present in free form as graphite. Largely the properties of cast iron are determined by this fact. Melting point of cast iron is much lower than that of steel. Most of the castings produced in a cast iron foundry are of grey cast iron. These are cheap and widely used. The characteristics of cast iron which make it a valuable material for engineering applications are:

(1) Very good casting characteristics.

(2) Low cost

(3) High compressive strength

(4) Good wear resistance

(5) Excellent machinability

The main limitation of this metal is brittleness and low tensile strength and thus cannot be used in those components subjected to shocks.

The varieties of cast iron in common uses are:

(1) Grey cast iron

(2) White cast iron

(3) Malleable cast iron

(4) Nodular cast iron

(5) Chilled cast iron

(6) Alloy cast iron

NON-FERROUS METALS

Non-ferrous metals are those which do not contain significant quantity of iron or iron as base metal. These metals possess low strength at high temperatures, generally suffer from hot shortness and have more shrinkage than ferrous metals. They are utilized in industry due to following advantages:

1. High corrosion resistance
2. Easy to fabricate, i.e., machining, casting, welding, forging and rolling
3. Possess very good thermal and electrical conductivity
4. Attractive colour and low density

The various non-metals used in industry are: copper, aluminium, tin, lead, zinc, and nickel, etc., and their alloys.

Extraction of zinc from ore sulphide

Zn is white silver color with melting point of zinc 420^{o}C. Density: 7.13 g/cm^{3}. Used to coat steel to protect it from corrosion at room temperature and for decorative finish. Fast rate of die casting. (ex. toys, car parts…etc.)

Ores:

- Zinc blende or Sphalerite (ZnS)
- Marmatite (ZnFe)S.
- Typical zinc ores generally contain about 5-15 % metal. Zinc ores are mined on alarge scale in many countries including Australia, USA, Canada and Peru.
- Current world production is about 9 million tons each year, including recycled metal.
- In a few cases, samples of native zinc have been found, for example in Australia.This is the pure metal.
- The low concentrations of the zinc sulphide mineral in most zinc ores mean that
- The ore must first be concentrated before extracting the metal.

Zone refining: (ultrapure metals for semiconductor technology)

This refining technique applied only for ultra pure material i.e. low concentration of impurity. If 'A' is solvent and 'B' is solute then addition of A with B caused increase in melting point of B as due to bond formation as A-A, A-B, B-B.

When A at composition of 'P', it get melted and when it is at 'Q' get solidify, whereas the same compositions for B at equilibrium condition is less than A.

The free energy difference is

$$\Delta(s)\text{-}\Delta G_B(l) = RT\ln(a/b) = RT\ln K_0$$

[Where K_0, a= concentration of impurity in liquid = a/b= segregation coefficient

b=concentration of the liquid]

It mainly applicable to semiconductor industry during coal refining of Ge and Si.

Possible Questions

PART-B (Two mark questions)

1. What is parting process?

2. What is meant by hydrometallurgy?

3. How will you purified the Nickel by Mond's process?

4. What is meant by oxidative refining?

5. Write a note on electrolytic refining?

6. Write about oxidative refining?

7. Write a note on Ellingham diagram?

PART-C (Eight mark questions)

1. Sketch and explain the Ellingham diagram of metal oxides?

2. Write a note on Kroll process and Mond's process?

3. State and explain Van Arkel and parting process with examples?

4. Give an account on electrolytic refining of purification of metals?

5. Eplain the preparation of ferrous metals?

6. Explain the preparation of non-ferrous metals?

UNIT – 2

1	The undesired particles which are present in ores are called	(a) Flux	(b) Matrix	(c) Slag	(d) Gangue	**(d) Gangue**
2	The entire scientific and technological process used for isolation of the metal is termed as	(a) Chromatography	(b) osmosis	(c) dialysis	(d) metallurgy	**(d) metallurgy**
3	The chief ore of Aluminum is	(a) Galena	(b) Calamine	(c) Bauxite	(d) Kalonite	**(c) Bauxite**
4	Sulphide ores are separated by ____________ process	(a) Gravity separation	(b) magnetic separation	(c) Froth floatation	(d) Bessimerization	**(c) Froth floatation**
5	Minerals from which the metals can be extracted are called	(a) Metals	(b) minerals	(c) Mining	(d) ores	**(d) ores**
6	Name any one noble metal among the following	(a) Zinc	(b) Iron	(c) Gold	(d) Titanium	**(c) Gold**
7	In alumino thermic process which is used as reducing agent	(a) Ca powder	(b) Mg powder	(c) Al powder	(d) Fe powder	**(c) Al powder**
8	Zone refining method is also known as	(a) Electrolytic refining	(b) Vapour phase	(c) fractional crystalisation	(d) chromatography	**(b) Vapour phase**
9	Removal of rocky impurities from the ore is known as	(a) Concentration	(b) Froath floatation	(c) Magnetic separation	(d) Ore dressing	**(a) Concentration**
10	Which metal is obtained from haematite ore?	(a) Copper	(b) Silver	(c) Iron	(d) Gold	**(c) Iron**

11	Valuable metals are attached to anode, which is known as	(a) Ore	(b) sludge	(c) cryolite	(d) bauxite	**(b) sludge**
12	Cathode production electrolysis of zinc iodide is	(a) Iodine	(b) zinc oxide	(c) zinc	(d) all of them	**(c) zinc**
13	The process of electrolysis used in	(a) Washing	(b) Cleaning	(c) purification	(d) all of them	**(c) purification**
14	In the electrolytic process, pure metal deposited at	(a) Anode	(b) Cathode	(c) Neutral	(d) Electrolyte	**(b) Cathode**
15	In which method high purity of nickel can be obtained	(a) Electrolytic refining	(b) Parting process	(c) Mond's process	(d) Van Arkel method	**(c) Mond's process**
16	Name of the ore which has the formula of Cu(OH)2.CuCO3	(a) Malachite	(b) Dolamite	(c) Monosite	(d) Magnesite	**(a) Malachite**
17	The following cause alkalinity as well hardness in natural water.	(a) Calcium carbonate	(b) Calcium bicarbonate	(c) Magnesium carbonate	(d) All of the above	**(c) Magnesium carbonate**
18	Titanium is purified by the following process	(a) Parting	(b) Kroll	(c) van arkel	(d) Hydrometallurgy	**(b) Kroll**
19	Parting process is used the separate the following metal	(a) Copper	(b) Gold	(c) Aluminium	(d) Platinum	**(b) Gold**
20	Ferrous metallurgy is related to materials like	(a) White	(b) brown	(c) Black	(d) None of the above	**(c) Black**
21	Ellingham diagram is used to separate	(a) Metallic oxides	(b) Metallic sulphates (c) Metallic	(b) Metallic sulphates (c) Metallic	(b) Metallic sulphates (c) Metallic halates	**(a) Metallic oxides**

			halates (d) None of the above	halates (d) None of the above	(d) None of the above	
22	Electromagnetic separation is the process to separate ___________ particles	(a) Non magnetic	(b) Magnetic	(c) Sulphide	(d) Oxide	**(b) Magnetic**
23	Moisture and volatile impurities are removed by	(a) Roasting	(b) Smelting	(c) Calcination	(d) Bessimerization	**(a) Roasting**
24	The method is employed for preparing highly pure metal by	(a) Zone refining	(b) Parting process	(c) Kroll process	(d) Mond's process	**(a) Zone refining**
25	In the electrolytic process, impure material deposited at	(a) Anode	(b) Cathode	(c) Neutral	(d) Electrolyte	**(a) Anode**
26	Chemical formula of lymonite ore is	$Fe_2O_3.H_2O$	$Fe_3O_4.3H_2O$	$Fe_2O_4.H_2O$	$Fe_2O_3.4H_2O$	**$Fe_2O_3.H_2O$**
27	Name of the ore which has the formula of FeS2	magnetite	haematite	iron pyrites	siderite	**iron pyrites**
28	The formula of cementite is	Fe_2C	Fe_3C	FeC	Fe_4C	**Fe_3C**
29	Pure iron melts at	1536°C	1537°C	1436°C	1437°C	**1536°C**
30	Tungsten steel containing	15-20% tungsten	10-20% tungsten	18-20% tungsten	5-20% tungsten	**10-20% tungsten**
31	In open hearth process, dolomite lining is used if present	C	Si	S	P	**P**
32	Name of the ore which has the formula of CoAs2	smaltite	cobalt glance	cobaltite	cobalt bloom	**smaltite**

33	Gold, if present is removed by	smelting	roasting	amalgamation	aluminothermic	**amalgamation**
34	Platinum black is obtained from its solution of tetrachloride by reducing agent like	fructose	glucose	sucrose	starch	**glucose**
35	Oxidation of methyl alcohol to formaldehyde by	Ni	Co	Pt	Fe	**Pt**
36	Alloy of invar containing	36% nickel	25% nickel	20% nickel	40% nickel	**36% nickel**
37	Which of the following one is not true?	lymonite	siderite	iron pyrites	linnacite	**linnacite**
38	%C in medium carbon steels ranges from	0.3-0.4	0.3-0.5	0.3-0.6	0.3-0.7	**0.3-0.6**
39	Stainless steel is so called because of its	high strength	high corrosion	high ductility	brittleness	**high corrosion**
40	In white cast irons, carbon present as	graphite flakes	graphite modules	cementite	carbon does not exist	**cementite**
41	Refractory metal	Ag	w	Pt	Ni	**W**
42	Not a noble metal	Cu	Ag	Au	Pt	**Cu**
43	Noble metal	Al	Pt	Mo	Ni	**Pt**
44	What solid is added to the steel-making furnace to remove acidic impurities?	lime stone	coke	slag	lime	**lime**

45	What is the name of the process used to making steel from iron?	the basic carbon process	the basic oxygen process	the acidic oxygen process	the casting process	**the basic oxygen process**
46	Mild steel belongs to the following category	low carbon steel	medium carbon steel	high carbon steel	alloy steel	**low carbon steel**
47	The correct name for Co2O3 is	cobalt oxide	cobalt (II) oxide	cobalt oxide(III)	cobalt(III) oxide	**cobalt(III) oxide**
48	Which of the following one is used as pigments in glass and porcelain?	nickel	iron	cobalt	platinum	**cobalt**
49	Which colour is obtained when CoO is fused with silica and potassium carbonate?	red	blue	yellow	green	**blue**
50	Which of the following coloured mass is known as smalt?	blue	green	brown	yellow	**blue**
51	Cobalt steel is containing	35% cobalt	10% cobalt	15% cobalt	20% cobalt	**35% cobalt**
52	Which of the following is not an alloy?	steel	copper	brass	bronze	**copper**
53	Which of the metal combination is called monel metal?	Ni-Cu	Fe-Ni	Fe-Zn	Zn-Pt	**Ni-Cu**
54	Monel metal containing	30% Ni	40% Ni	50% Ni	60% Ni	**60% Ni**
55	Which of the following metal is used in making spatulas, crucibles and tongs?	Fe	Ni	Cu	Co	**Ni**

56	Which alloy is used in making bullet sheaths?	cupronickel	german silver	nichrome	invar	**cupronickel**
57	Which of the following one is used in making pendulums?	nichrome	cupronickel	invar	german silver	**invar**
58	Nickel coinage alloy containing	25% Ni-75% Cu	20% Ni-80% Cu	30% Ni-70% Cu	40% Ni-60% Cu	**25% Ni-75% Cu**
59	The following one is not true with others	constantan	nichrome	invar	stellite	**stellite**
60	A base is added to a solution containing Co2+ ion, cobalt (II) hydroxide separates out as	blue precipitate	white precipitate	brown precipitate	yellow precipitate	**blue precipitate**
61	Which of the vitamin containing Co(III) as main constituent?	vitamin A	vitamin D	vitamin B_{12}	vitamin B_6	**vitamin B_{12}**
62	The ore NiAsS, generally called as	pentlandite	nickel slance	garnierite	kupfer nickel	**nickel slance**

UNIT III

Environment and its segments:

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.
Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.
Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates.

Ecosystems:

An ecosystem is a community of living organisms in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system. These biotic and abiotic components are regarded as linked together through nutrient cycles and energy flows. As ecosystems are defined by the network of interactions among organisms, and between organisms and their environment, they can be of any size but usually encompass specific, limited spaces (although some scientists say that the entire planet is an ecosystem).

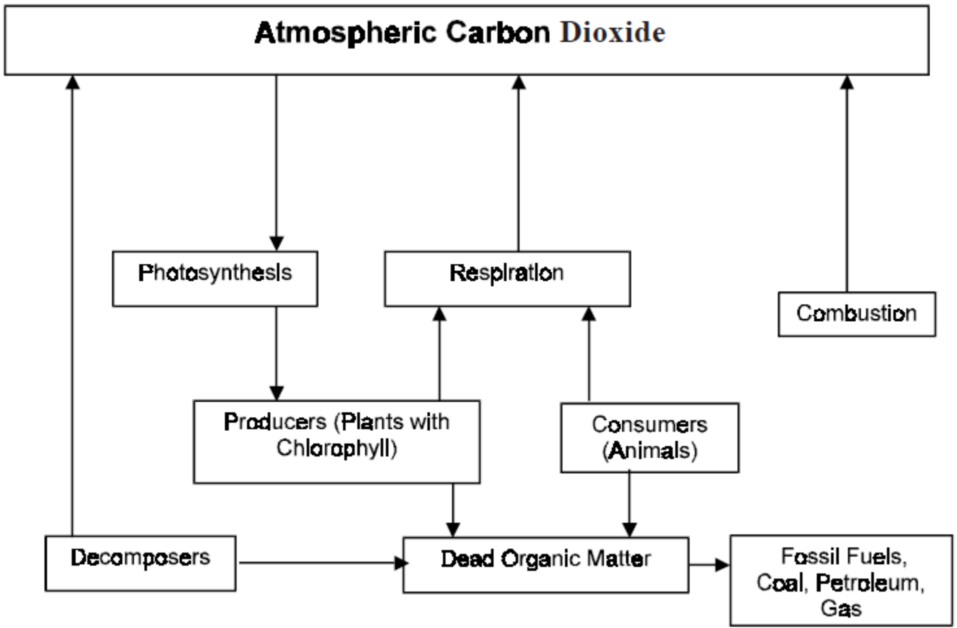
Energy, water, nitrogen and soil minerals are other essential abiotic components of an ecosystem. The energy that flows through ecosystems is obtained primarily from the sun. It generally enters the system through photosynthesis, a process that also captures carbon from the atmosphere. By feeding on plants and on one another, animals play an important role in the movement of matter and energy through the system. They also influence the quantity of plant and microbial biomass present. By breaking down dead organic matter, decomposers release carbon back to the atmosphere and facilitate nutrient cycling by converting nutrients stored in dead biomass back to a form that can be readily used by plants and other microbes.

Ecosystems are controlled both by external and internal factors. External factors such as climate, the parent material that forms the soil, and topography control the overall structure of an ecosystem and the way things work within it, but are not themselves influenced by the ecosystem. Other external factors include time and potential biota. Ecosystems are dynamic entities-invariably; they are subject to periodic disturbances and are in the process of recovering from some past disturbance. Ecosystems in similar environments that are located in different parts of the world can have very different characteristics simply because they contain different species. The introduction of non-native species can cause substantial shifts in ecosystem function. Internal factors not only control ecosystem processes but are also controlled by them and are often subject to feedback loops. While the resource inputs are generally controlled by external processes like climate and parent material, the availability of these resources within the ecosystem is controlled by internal factors like decomposition, root competition or shading. Other internal factors include disturbance, succession and the types of species present. Although humans exist and operate within ecosystems, their cumulative effects are large enough to influence external factors like climate.

Biodiversity affects ecosystem function, as do the processes of disturbance and succession. Ecosystems provide a variety of goods and services upon which people depend; the principles of ecosystem management suggest that rather than managing individual species, natural resources should be managed at the level of the ecosystem itself. Classifying ecosystems into ecologically homogeneous units is an important step towards effective ecosystem management, but there is no single, agreed-upon way to do this.

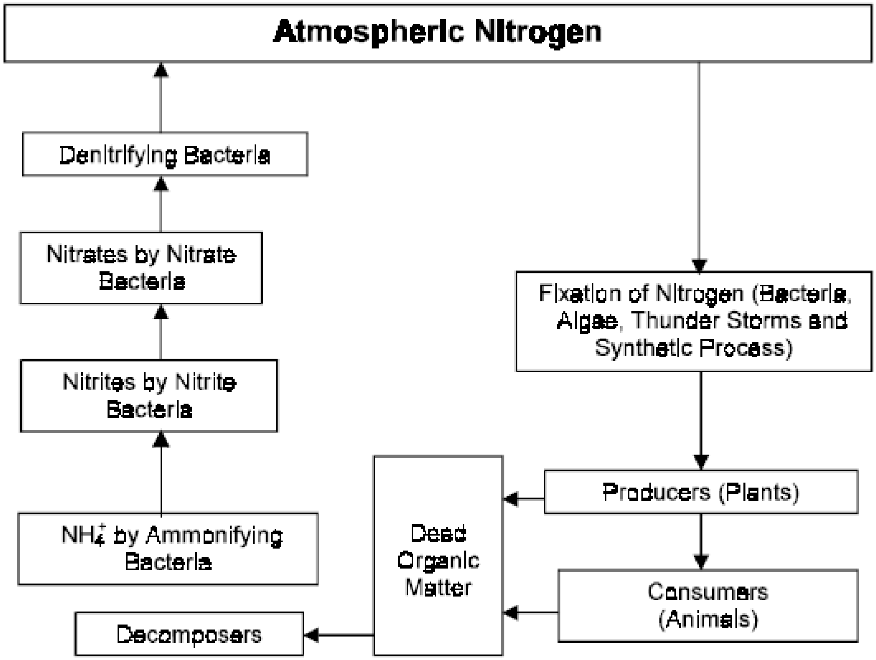
Carbon Cycle

Carbon is an essential component of all plant, animal and organic matter. The atmosphere is an important source of carbon which is present in the form of carbon dioxide which the plants or producers absorb by photosynthesis and generate several organic compounds. These are passed to the consumers (Herbivores and Carnivores) in the form of food. Part of this is returned to the atmosphere by respiration. The dead organic matter from plants and animals are decomposed by microorganisms releasing Carbon dioxide to the atmosphere. Burning of fossil fuels releases large quantities of carbon di oxide. There is a steady buildup of carbon dioxide in the atmosphere due the increased utilization of fossil fuels as well as reduction of green plants (Deforestation). The seas and oceans also serve as sink for carbon oxide by absorbing the same and converting it into bicarbonates and mineral deposits and thus they play a vital role in regulation of carbon cycle.



Nitrogen Cycle

Nitrogen and its compounds form a vital ingredient in all forms of life in the biosphere. Availability of Nitrogen is from the atmosphere as molecular Nitrogen in the gaseous form, which cannot be directly absorbed by the plants or producers. In order to be absorbed by the plants it has to be converted into water-soluble compounds with elements like Hydrogen, Carbon, and oxygen. This process is known as Fixation of Nitrogen. Nitrogen fixation takes place by Bacteria, Algae and electrical storms. Synthetic fixation of Nitrogen is done by the manufacture of nitrogenous fertilizers through ammonia conversion route. The plants absorb the fixed Nitrogen from the soil and convert them into proteins and other compounds during the metabolic process. Decomposers, ammonifying bacteria and Nitrate bacteria also help in the fixing process by converting dead animal and plant parts into absorbable nitrates. The denitrifying bacteria complete the cycle, which helps in releasing gaseous Nitrogen back to the atmosphere from the soil.



Sulphur Cycle

Amino acids and proteins need sulphur compounds for their production. In the atmosphere it is present as Sulphur di oxide and hydrogen sulfide and in the soil as sulfates or sulfides. Volcanic emissions and burning of fossil fuels are the supply of Sulphur dioxide to the atmosphere while hydrogen sulfide is from bacterial emissions. Atmospheric Sulphur dioxide is also oxidized to Sulphur trioxide, which eventually reaches the earth along with rainfall. Anaerobic and aerobic Sulphur bacteria also play a vital role in the interchange and movement of Sulphur compounds in the ecosystem. The Sulphur compounds in the plant and animal parts are absorbed by the soil after their death and decay and converted into sulfides and sulfates by Sulphur bacteria, which are subsequently used up by the plants. As in the case of carbon dioxide the atmosphere is receiving excess quantities of Sulphur dioxide, which is leading to adverse environmental effects.

Air pollution

An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. A pollutant can be of natural origin or man-made. Pollutants are classified as primary or secondary. Primary pollutants are usually produced from a process, such as ash from a volcanic eruption. Other examples include carbon monoxide gas from motor vehicle exhaust, or the sulfur dioxide released from factories. Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. Ground level ozone is a prominent example of a secondary pollutant. Some pollutants may be both primary and secondary: they are both emitted directly and formed from other primary pollutants.

Before flue-gas desulfurization was installed, the emissions from this power plant in New Mexico contained excessive amounts of sulfur dioxide. Nitrogen dioxide diffusion tube for air quality monitoring. Positioned in London City.

Schematic drawing, causes and effects of air pollution: (1) greenhouse effect, (2) particulate contamination, (3) increased UV radiation, (4) acid rain, (5) increased ground level ozone concentration, (6) increased levels of nitrogen oxides.

Thermal oxidizers are air pollution abatement options for hazardous air pollutants (HAPs), volatile organic compounds (VOCs), and odorous emissions.

Major primary pollutants produced by human activity include:

- Sulfur oxides (SO_x) - particularly sulfur dioxide, a chemical compound with the formula SO2. SO2 is produced by volcanoes and in various industrial processes. Coal and petroleum often contain sulfur compounds, and their combustion generates sulfur dioxide. Further oxidation of SO2, usually in the presence of a catalyst such as NO2, forms H2SO4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- Nitrogen oxides (NO_x) - Nitrogen oxides, particularly nitrogen dioxide, are expelled from high temperature combustion, and are also produced duringthunderstorms by electric discharge. They can be seen as a brown haze dome above or a plume downwind of cities. Nitrogen dioxide is a chemical compound with the formula NO_2. It is one of several nitrogen oxides. One of the most prominent air pollutants, this reddish-brown toxic gas has a characteristic sharp, biting odor.
- Carbon monoxide (CO) - CO is a colorless, odorless, toxic yet non-irritating gas. It is a product of incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

- Volatile organic compounds (VOC) - VOCs are a well-known outdoor air pollutant. They are categorized as either methane (CH_4) or non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming. Other hydrocarbon VOCs are also significant greenhouse gases because of their role in creating ozone and prolonging the life of methane in the atmosphere. This effect varies depending on local air quality. The aromatic NMVOCs benzene, toluene and xylene are suspected carcinogens and may lead to leukemia with prolonged exposure. 1,3-butadiene is another dangerous compound often associated with industrial use.
- Particulates, alternatively referred to as particulate matter (PM), atmospheric particulate matter, or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to combined particles and gas. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged worldwide, anthropogenic aerosols-those made by human activities-currently account for approximately 10 percent of our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.
- Persistent free radicals connected to airborne fine particles are linked to cardiopulmonary disease.
- Toxic metals, such as lead and mercury, especially their compounds.
- Chlorofluorocarbons (CFCs) - harmful to the ozone layer; emitted from products are currently banned from use. These are gases which are released from air conditioners, refrigerators, aerosol sprays, etc. On release into the air, CFCs rise to the stratosphere. Here they come in contact with other gases and damage the ozone layer. This allows harmful ultraviolet rays to reach the earth's surface. This can lead to skin cancer, eye disease and can even cause damage to plants.
- Ammonia (NH_3) - emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for

the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous. In the atmosphere, ammonia reacts with oxides of nitrogen and sulfur to form secondary particles.

- Odours - such as from garbage, sewage, and industrial processes
- Radioactive pollutants - produced by nuclear explosions, nuclear events, war explosives, and natural processes such as the radioactive decay of radon.

Secondary pollutants include:

- Particulates created from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- Ground level ozone (O_3) formed from NO_x and VOCs. Ozone (O_3) is a key constituent of the troposphere. It is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer. Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.
- Peroxyacetyl nitrate (PAN) - similarly formed from NO_x and VOCs.

Minor air pollutants include:

- A large number of minor hazardous air pollutants. Some of these are regulated in USA under the Clean Air Act and in Europe under the Air Framework Directive
- A variety of persistent organic pollutants, which can attach to particulates

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and to have potentially significant impacts on human health and the environment.

Sources

There are various locations, activities or factors which are responsible for releasing pollutants into the atmosphere. These sources can be classified into two major categories.

Anthropogenic (man-made) sources:

These are mostly related to the burning of multiple types of fuel.

- Stationary sources include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices. In developing and poor countries, traditional biomass burning is the major source of air pollutants; traditional biomass includes wood, crop waste and dung.
- Mobile sources include motor vehicles, marine vessels, and aircraft.
- Controlled burn practices in agriculture and forest management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.
- Fumes from paint, hair spray, varnish, aerosol sprays and other solvents
- Waste deposition in landfills, which generate methane. Methane is highly flammable and may form explosive mixtures with air. Methane is also anasphyxiant and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.
- Military resources, such as nuclear weapons, toxic gases, germ warfare and rocketry

Natural sources:

- Dust from natural sources, usually large areas of land with little or no vegetation
- Methane, emitted by the digestion of food by animals, for example cattle
- Radon gas from radioactive decay within the Earth's crust. Radon is a colorless, odorless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.
- Smoke and carbon monoxide from wildfires

- Vegetation, in some regions, emits environmentally significant amounts of Volatile organic compounds (VOCs) on warmer days. These VOCs react with primary anthropogenic pollutants—specifically, NOx, SO2, and anthropogenic organic carbon compounds - to produce a seasonal haze of secondary pollutants.[15] Black gum, poplar, oak and willow are some examples of vegetation that can produce abundant VOCs. The VOC production from these species result in ozone levels up to eight times higher than the low-impact tree species.
- Volcanic activity, which produces sulfur, chlorine, and ash particulates.

Environmental effects of air pollution

Each pollutants emitted to the atmosphere can affect directly or indirectly the human health. Along with harming human health, air pollution can cause a variety of environmental effects, such us acid rain, eutrophication, effects on wildlife, ozone depletion, crop and forest damages, global climate change.

Some pollutants can also play important role in weather situations (e.g. reduction of visibility, forming of clouds and precipitation, modification of radiation budget etc.). At the same time, the state of the atmosphere is also affects the degree of air pollution through several processes (e.g. photochemical activity, transport and deposition processes etc.). Table 13.1 summarizes the possible effects of some important pollutants on the human health and on the environment.

Carbon monoxide (CO)

Carbon monoxide forms, when carbon in fuel is not burned completely (see more about CO emission in Chapter 2). CO is a colourless, tasteless, odourless and non-irritating gas. It can enter the bloodstream through the lungs and forms carboxyhemoglobyn. High concentration of carboxyhemoglobyn could be poisonous. CO poisoning cover a wide range of symptoms, depending on severity of exposure, such as headache, dizziness, weakness, nausea, vomiting, disorientation, confusion, collapse and coma (Raub and Benignus, 2002). Due to the seasonal variation of CO emission and the weather conditions, CO concentration generally higher in winter, and lower in summer period (Figure 13.2). Based on the measurements carried out in Budapest downtown, in 2010, the concentration of carbon monoxide did not reach the occupational exposure limit.

Sulphur dioxide (SO2)

Sulphur can be found as a trace element in coal and oil. During combustion processes, sulphur combines with oxygen to form sulphur dioxide (SO2). As SO2 is relatively inert compound, it can travel long distances from its emission sources. High concentrations of sulphur dioxide can result in breathing problems. Long-term exposure of SO2 can also causes cardiovascular diseases. Sulphur dioxide can react with ozone or hydrogen peroxide in the atmosphere, produced sulphur trioxide, which can dissolve in water, forming a dilute solution of sulphuric acid. When this strong acid reaches the surface by precipitation or dry deposition ("acid rain"), it can be damaging to organisms and objects. Due to the rigid emission reduction strategies in Europe, and in Hungary too, the SO2 emission has decreased significantly in the last decades. Figure 13.3 shows a yearly course of sulphur dioxide concentration in Budapest.

Nitrogen dioxide (NO2)

Nitrogen dioxide emitted to the atmosphere from transport and from power plants (more details about emission can be found in Chapter 2). The short-term exposure may cause increased respiratory symptoms, while long-term exposure can lead to irritation of the lung, susceptibility to respiratory infections, or even stroke (Andersen et al., 2012). Nitrogen dioxide and nitric oxide (NO) too, next to the sulphur dioxide are other precursor compounds of acid rain. NO and NO2 can dissolve in water forming weak solutions of nitric and nitrous acids. Additionally, nitrogen oxides can cause several other environmental problems, such us the decrease of the visibility or eutrophication.

Ozone (O3)

Ozone in the troposphere forms from its precursor compounds during photochemical reactions (see Chapter 8). Near-surface ozone plays an important role in the formation of photochemical air pollution. Ozone has several injurious effects both on human health (Weschler, 2006), and plant functioning (Emberson, 2003). Human exposure to ozone is associated with respiratory and cardiovascular symptoms.

Elevated ozone concentrations can be potentially harmful to agricultural and natural vegetation. Occasional extreme concentrations may cause visible injury to the vegetation while the long-term, growing-season averaged exposure can result in decreased productivity and crop yield. Recently it has also been shown that the indirect radiative forcing of climate change through ozone effecting on the land carbon sink could be an important factor and can induce a positive feedback for global warming.

Control of Air Pollution:

The following items are commonly used as pollution control devices by industry or transportation devices. They can either destroy contaminants or remove them from an exhaust stream before it is emitted into the atmosphere.

i. Particulate Control:

Mechanical collectors (dust cyclones, multi-cyclones)- Cyclonic separation is a method of removing particulates from an air, gas or water stream, without the use of filters, through vortex separation. Rotational effects and gravity are used to separate mixtures of solids and fluids.

A high speed rotating (air) flow is established within a cylindrical or conical container called a cyclone. Air flows in a spiral pattern, beginning at the top (wide end) of the cyclone and ending at the bottom (narrow) end before exiting the cyclone in a straight stream through the centre of the cyclone and out the top.

Larger (denser) particles in the rotating stream have too much inertia to follow the tight curve of the stream and strike the outside wall, falling then to the bottom of the cyclone where they can be removed.

In a conical system, as the rotating flow moves towards the narrow end of the cyclone the rotational radius of the stream is reduced, separating smaller and smaller particles. The cyclone geometry, together with flow rate, defines the cut point of the cyclone. This is the size of particle that will be removed from the stream with 50% efficiency. Particles larger than the cut point will be removed with a greater efficiency and smaller particles with a lower efficiency.

ii. Electrostatic Precipitators:

An electrostatic precipitator (ESP), or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge. Electrostatic precipitators are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulate matter such as dust and smoke from the air stream.

In contrast to wet scrubbers which apply energy directly to the flowing fluid medium, an ESP applies energy only to the particulate matter being collected and therefore is very efficient in its consumption of energy (in the form of electricity).

iii. Particulate Scrubbers:

The term Wet scrubber describes a variety of devices that remove pollutants from a furnace flue gas or from other gas streams. In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, or by some other contact method, so as to remove the pollutants.

The design of wet scrubbers or any air pollution control device depends on the industrial process conditions and the nature of the air pollutants involved. Inlet gas characteristics and dust properties (if particles are present) are of primary importance.

Scrubbers can be designed to collect particulate matter and/or gaseous pollutants. Wet scrubbers remove dust particles by capturing them in liquid droplets. Wet scrubbers remove pollutant gases by dissolving or absorbing them into the liquid.

Any droplets that are in the scrubber inlet gas must be separated from the outlet gas stream by means of another device referred to as a mist eliminator or entrainment separator (these terms are interchangeable). Also, the resultant scrubbing liquid must be treated prior to any ultimate discharge or being reused in the plant:

i. Vehicular pollution can be checked by regular tune-up of engines; replacement of more polluting old vehicles; installing catalytic converters; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions; and slow and cooler burning of fuels to reduce NOx emission.

ii. Using low sulphur coal in industries.

iii. Minimise/modify activities which cause pollution e.g. transportation and energy production.

Greenhouse effect

The greenhouse effect is a natural process that warms the Earth’s surface. When the Sun’s energy reaches the Earth’s atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons

(CFCs). The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist.

Enhanced greenhouse effect

The problem we now face is that human activities – particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing – are increasing the concentrations of greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.

Greenhouse effect

Step 1: Solar radiation reaches the Earth's atmosphere - some of this is reflected back into space.
Step 2: The rest of the sun's energy is absorbed by the land and the oceans, heating the Earth.
Step 3: Heat radiates from Earth towards space.
Step 4: Some of this heat is trapped by greenhouse gases in the atmosphere, keeping the Earth warm enough to sustain life.
Step 5: Human activities such as burning fossil fuels, agriculture and land clearing are increasing the amount of greenhouse gases released into the atmosphere.
Step 6: This is trapping extra heat, and causing the Earth's temperature to rise.

Greenhouse gas measurement

Australia's National Greenhouse Accounts are made up of a series of comprehensive reports and databases that estimate, and account for, Australia's greenhouse gas emissions. These publications fulfil Australia's international and domestic reporting requirements.

The National Greenhouse Accounts are supported by company emissions measurement rules, legislated under the National Greenhouse and Energy Reporting (Measurement) Determination. These reporting rules are reviewed annually. The Department also releases official projections of Australia's greenhouse gas emissions annually. These projections forecast a range of policy environments and scenarios.

Global warming

Global warming and climate change are terms for the observed century-scale rise in the average temperature of the Earth's climate system and its related effects. Multiple lines of scientific evidence show that the climate system is warming. Although the increase of near-surface atmospheric temperature is the measure of global warming often reported in the popular press, most of the additional energy stored in the climate system since 1970 has gone into the oceans. The rest has melted ice and warmed the continents and atmosphere. Many of the observed changes since the 1950s are unprecedented over tens to thousands of years.

Scientific understanding of global warming is increasing. The Intergovernmental Panel on Climate Change (IPCC) reported in 2014 that scientists were more than 95% certain that global warming is mostly being caused by human (anthropogenic) activities, mainly increasing concentrations of greenhouse gases such as methane and carbon dioxide (CO2). Human activities have led to carbon dioxide concentrations above levels not seen in hundreds of thousands of years. Methane and other, often much more potent, greenhouse gases are also rising along with CO2. Currently, about half of the carbon dioxide released from the burning of fossil fuels remains in the atmosphere. The rest is absorbed by vegetation and the oceans.[13] Climate model projections summarized in the report indicated that during the 21st century the global surface temperature is likely to rise a further 0.3 to 1.7 °C (0.5 to 3.1 °F) for their lowest emissions scenario and 2.6 to 4.8 °C (4.7 to 8.6 °F) for the highest emissions scenario. These findings have been recognized by the national science academies of the major industrialized nations and are not disputed by any scientific body of national or international standing.

Future climate change and associated impacts will differ from region to region around the globe. Anticipated effects include warming global temperature, rising sea levels, changing precipitation, and expansion of deserts in the subtropics. Warming is expected to be greater over land than over the oceans and greatest in the Arctic, with the continuing retreat of glaciers, permafrost and sea ice. Other likely changes include more frequent extreme weather events including heat waves, droughts, heavy rainfall with floods and heavy snowfall; ocean acidification; and species extinctions due to shifting temperature regimes. Effects significant to humans include the threat to food security from decreasing crop yields and the abandonment of populated areas due to rising sea levels. Because the climate system has a large "inertia" and greenhouse gases will stay in the atmosphere for a long time, many of these effects will not only exist for decades or centuries, but will persist for tens of thousands of years.

Impacts Global Warming

- Rapid change in climate will be too great that many ecosystems will not be able to adapt, and hence the rate of species extinction will most likely increase.
- In addition impacts on wildlife and species, biodiversity, agriculture, forestry, dry lands, water resources and health will be adverse.
- Melting of polar ice caps and glaciers will result in increased sea levels
- leading to flooding of coastal lines causing damage to life and property.
- Massive soil erosion, contamination of fresh water and water borne diseases.
- In temperate areas summers will be longer and hotter and winters shorter and warmer.
- Sub-tropical regions will become drier and tropical regions wetter.
- Desertification, droughts and famine.
- Altered weather patters will have altered crop patterns and adverse effects on plant and animal life.

Ozone layer depletion

Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about four percent in the total amount of ozone in Earth's stratosphere (the ozone layer), and a much larger springtime decrease in stratospheric ozone around Earth's Polar Regions. The latter phenomenon is referred to as the ozone hole. In addition to these well-known stratospheric phenomena, there are also springtime polar tropospheric ozone depletion events.

The details of polar ozone hole formation differ from that of mid-latitude thinning but the most important process in both is catalytic destruction of ozone by atomic halogens.[2] The main source of these halogen atoms in the stratosphere is photodissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents (chlorofluorocarbon (CFCs), HCFCs, freons, halons). These compounds are transported into the stratosphere by winds after being emitted at the surface. Both types of ozone depletion were observed to increase as emissions of halocarbons increased.

CFCs and other contributory substances are referred to as ozone-depleting substances (ODS). Since the ozone layer prevents most harmful UVB wavelengths (280–315 nm) of ultraviolet light (UV light) from passing through the Earth's atmosphere, observed and projected decreases in ozone generated worldwide concern, leading to adoption of the Montreal Protocol that bans the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane. It is suspected that a variety of biological consequences such as increases in sunburn, skin cancer, cataracts, damage to plants, and reduction of plankton populations in the ocean's photic zone may result from the increased UV exposure due to ozone depletion.

Particulate matter

Aerosol particles have various natural and anthropogenic sources (for more details see Chapter 2 and Chapter 9). Aerosol particles have important role in lower tropospheric air quality. Aerosols, especially ultra-fine particles can cause several severe health effects, including enhanced mortality, respiratory, cardiovascular and allergic diseases (see. e.g. Pöschl, 2005).

Aerosol particles can also affect significantly the cycles of atmospheric contaminants including nitrogen, sulphur, and atmospheric oxidants. Additionally they can reduce the visibility.

Pollution Prevention and Control Planning

The principal methods for controlling the release of particulate matter are summarized here.

- Identify measures for improving operating and management practices.
- Consider alternative fuels such as gas instead of coal.
- Consider fuel-cleaning options such as coal washing, which can reduce ash content by upto 40%.
- Consider alternative production processes and technologies, such as fluidized bed combustion, that result in reduced PM emissions.
- Select optimal particulate removal devices such as ESPs and baghouses.

Possible questions

PART-B (Two mark questions)

1. What are the types of pollutants involved in air pollution?
2. What is acid rain?
3. How will you control air pollution?
4. What is hydrological cycle?
5. Write a note on control of particulates?
6. Define greenhouse effect?
7. Define global warming?
8. What is meant by ozone?

PART-C (Eight mark questions)

1. Mention the sources, effects and control method of air pollution of various air pollutant?
2. Explain carbon, oxygen and nitrogen cycles?
3. Briefly explain the global warming and its effects?
4. Explain the causes, effects & control measures of water pollution?
5. Explain the sources, effects and control measures of air pollution?
6. Write a note on the following
   (i) Greenhouse effect(ii) acid rain

UNIT – 3						
1	Which of the following is an organic gas?	(a) Hydrocarbons	(b) Aldehydes	(c) Ketones	(d) Ammonia	**(d) Ammonia**
2	The major contributor of Carbon monoxide is	(a) Motor vehicle	(b) Industrial processes	(c) Stationary fuel combustion	(d) None of the above	**(a) Motor vehicle**
3	Which of the following is/are inorganic gas (es)?	(a) Carbon monoxide	(b) Hydrogen sulphide	(c) Chlorine	(d) All of the above	**(c) Chlorine**
4	Ozone of found in	(a) Mesosphere	(b) Ionosphere	(c) Stratosphere	(d) Exosphere	**(c) Stratosphere**
5	Ozone is formed in the upper atmosphere by a photochemical reaction with	(a) UV radiation	(b) IR radiation	(c) Visible light	(d) All of the above	**(a) UV radiation**
6	Which of the following is used as antiknock compound in gasoline?	(a) tetramethyl lead	(b) tetraethyl lead	(c) trimethyl lead	(d) triethyl lead	**(b) tetraethyl lead**
7	Which of the following is a fermentation product of molasses?	(a) Methanol	(b) Formaldeyde	(c) Ammonia	(d) Acetone	**(d) Acetone**
8	The boiler flue gas is source of	(a) HCl	(b) NO	(c) HF	(d) Volatile organic compounds	**(b) NO**
9	Which of the following is a secondary air pollutant?	(a) CO_2	(b) CO	(c) O_3	(d) SO_2	**(a) CO_2**
10	The supersonic jets cause damage at by the thinning of	(a) CO2 layer	(b) CO Layer	(c) O_3 Layer	(d) SO_2 layer	**(c) O_3 Layer**
11	The principal source of volatile organics (Hydrocarbons) is	(a) Transportation	(b) Industrial processes	(c) Stationary fuel combustion	(d) Volcanoes	**(b) Industrial processes**

12	Combustion of coal in power plant produces mainly ……………. which is a major pollutant of air.	(a) SO_2	(b) NO_2	(c) CFC	(d) Methane	**(b) NO_2**
13	Which gas is primarily responsible for Green House Effect ?	(a) CO_2	(b) NO_2	(c) SO_2	(d) CFC	**(a) CO_2**
14	Smog is	(a) A natural phenomenon	(b) A combination of smoke and fog	(c) Is colourless	(d) All of the above	**(b) A combination of smoke and fog**
15	Which of the following devices is suitable for the removal of gaseous pollutants?	(a) Cyclone separator	(b) Electrostatic precipitator	(c) Fabric filter	(d) Wet scrubber	**(d) Wet scrubber**
16	Gas leaked in Bhopal tragedy:	(a) Methyl isocyanate	(b) Potassium isothoiocynate	(c) Ethyl isocyanate	(d) Sodium isothiocyanate	**(a) Methyl isocyanate**
17	Excess fluoride in drinking water is likely to cause:	(a) Blue baby syndrome	(b) Fluorosis	(c) Change in taste and odour	(d) Intestinal irritation	**(b) Fluorosis**
18	According to EPA of USA, the following is not one of the six major pollutants?	(a) Ozone	(b) Carbon monoxide	(c) Nitrogen oxides	(d) Carbon di-oxide	**(d) Carbon di-oxide**
19	The Pollution Standard Index (PSI) scale has span from	(a) 0-200	(b) 0-300	(c) 0-400	(d) 0-500	**(d) 0-500**
20	Which of the following is an organic gas?	(a) Hydrocarbons	(b) Aldehydes	(c) Ketones	(d) Ammonia	**(d) Ammonia**
21	Which of the following is/are inorganic gas (es)?	(a) Carbon monoxide	(b) Hydrogen sulphide	(c) Chlorine	(d) All of the above	**(d) All of the above**

22	The major contributor of Carbon monoxide is	(a) Motor vehicle	(b) Industrial processes	(c) Stationary fuel combustion	(d) None	**(a) Motor vehicle**
23	Fugitive emissions consist of	(a) Street dust	(b) Dust from construction	(c) Dust from farm cultivation	(d) All the above	**(b) Dust from construction**
24	Ozone of found in	(a) Mesosphere	(b) Ionosphere	(c) Stratosphere	(d) Exosphere	**(c) Stratosphere**
25	Ozone is formed in the upper atmosphere by a photochemical reaction with	(a) UV solar radiation	(b) Infra red radiation	(c) Visible light	(d) All of the above	**(a) UV solar radiation**
26	The principal source of volatile organics (Hydrocarbons) is	(a) Transportation	(b) Industrial processes	(c) Stationary fuel combustion	(d) Volcanoes	**(b) Industrial processes**
27	The function of automobile catalytic converter is to control emissions of	(a) Carbon dioxide and hydrogen	(b) carbon monoxide and hydrogen	(c) Carbon monoxide and carbon dioxide	(d) carbon monoxide and nitrogen dioxide	**(b) carbon monoxide and hydrogen**
28	The threshold concentration of sulphur dioxide in any industrial activity should not be permitted beyond	(a) 2ppm	(b) 3ppm	(c) 4ppm	(d) 5ppm	**(d) 5ppm**
29	The threshold limit of benzene is	(a) 15ppm	(b) 20ppm	(c) 25ppm	(d) 30ppm	**(c) 25ppm**
30	In an ecosystem, which one shows one way passage?	(a) Nitrogen	(b) Carbon	(c) Potassium	(d) Free energy	**(d) Free energy**
31	The source of energy in an ecosystem is	(a) DNA	(b) RNA	(c) ATP	(d) Sunlight	**(d) Sunlight**

32	An ecosystem must have continuous external source of	(a) Minerals	(b) energy	(c) Food	(d) None	**(b) energy**
33	All are particulate pollutants except	(a) Dust	(b) ozone	(c) soot	(d) smoke	**(b) ozone**
34	Fine inorganic and organic particles suspended in air is called	(a) Aerosol	(b) Sol	(c) Sponge	(d) None of the above	**(a) Aerosol**
35	Which of the following is secondary air pollutant?	(a) CO_2	(b) CO	(c) O_3	(c) NO	**(c) O_3**
36	Air pollution can be of	(a) Natural origin	(b) Manmade origin	(c) Both (a) and (b)	(d) (b) only	**(c) Both (a) and (b)**
37	Mobile combustion accounts	(a) 10 – 20%	(b) 40 – 50%	(c) 50 – 60%	(d) 5 – 10%	**(c) 50 – 60%**
38	Carbon mono oxide is a pollutant because	(a)It reacts with O_2	(b) it inhibits glycolysis	(c) reacts with haemoglobin	(d) none	**(b) it inhibits glycolysis**
39	The unfavorable alteration of environment due to human activities	(a) Pollution	(b) degradation	(c) catastrophe	(d) Disturbance	**(a) Pollution**
40	Which of the following is the indicator to reduce SO_2 pollution?	(a) Algae	(b) Linchen	(c) bryophyte	(d) teridophyte	**(b) Linchen**
41	Heavy dust can cause	(a) Leaf blights	(b) opening of stomata	(c) Closure of stromata	(d) browning of leaves	**(c) Closure of stromata**
42	Minamata disease is caused by	(a) Mercury	(b) Tin	(c) Lead	(d) methyl iso cyanate	**(a) Mercury**
43	The type of pollution is likely to affect Taj mahal	(a) Air	(b) water	(c) Soil	(d) noise	**(b) water**
44	The phenomenon of marble cancer is due to	(a) Soot particles	(b) CFCs	(c) Fog	(d) acid rain	**(d) acid rain**

45	Which of the following is not a green house gas?	(a) Nitrogen gas	(b) water vapour	(c) methane gas	(d) carbon dioxide	**(b) water vapour**
46	Upset caused in natural balance of concentration of greenhouse gases is called	(a) Pollution	(b) global warming	(c) atmospheric poisoning	(d) earth heating	**(b) global warming**
47	Solvents used for cleaning electronic circuit boards are	(a) Chlorofluorocarbons	(b) carbons	(c) fluorides	(d) grease	**(a) Chlorofluorocarbons**
48	Gas responsible for global warming is	(a) Oxygen	(b) carbon dioxide	(c) carbon monoxide	(d) Nitrogen	**(b) carbon dioxide**
49	Global atmospheric temperatures are likely to be increased due to:	(a) Burning of fossil fuel	(b) Water pollution	(c) Soil erosion	(d) None of the above	**(a) Burning of fossil fuel**
50	What country emits the most carbon dioxide?	(a) India	(b) China	(c) USA	(d) Japan	**(b) China**
51	The term environment literally means……………..	The surroundings	The structures	The system	The climate	**The surroundings**
52	The Primary consumer are also called as	herbivores	carnivores	omnivores	detrivores	**herbivores**
53	Valuable, practical services that help to preserve ecosystem performed by nature are called__________	ecosystem service	biological control	the green house effect	biosphere balancing	**ecosystem service**
54	The surrounding physical and biological factor with which organisms closely interact and remain adapted is known as ___________________	nature	ecology	forest	environment	**environment**

55	The organic matter produced by the Photosynthetic activity of green plants is called as ____________	light energy	cellular process	energy flow	primary productivity	**primary productivity**
56	____________ is diffused into the ground by gravitational force	Rain water	Ocean	River water	sea	**Rain water**
57	Solar energy stored in material such as wood, grain, sugar, and municipal waste is called ___________	fossil fuels	biomass	geothermal energy	natural gas	**biomass**
58	Decomposers are otherwise called as _________	detritivores	primary consumers	organic matter	secondary consumers	**detritivores**
59	Light energy is transformed into chemical energy by ___________	photosynthesis	respiration	recycling	productivity	**photosynthesis**
60	All food chains starts with ___________ and ends with decay	environment	organisms	photosynthesis	fungi	**photosynthesis**

Unit IV

Water Pollution:

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods: Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

The hydrological cycle

The preceding chapter has dealt with the input to the hydrological cycle - rainfall - and its variation in time and space in response to various climatic factors. This chapter attempts to explain what happens to the rainfall once it reaches the ground. The science of hydrology is concerned with quantifying the various components into which rainfall is partitioned, and understanding the physical processes by which water is eventually returned to the atmosphere.

Water Resources

Water resources are sources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and environmental activities. The majority of human uses require fresh water. 97% of the water on the Earth is salt water and only three percent is fresh water; slightly over two thirds of this is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is found mainly as groundwater, with only a small fraction present above ground or in the air.

Fresh water is a renewable resource, yet the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia, South America and North America, although it is still unclear how much natural renewal balances this usage, and whether ecosystems are threatened. The framework for allocating water resources to water users (where such a framework exists) is known as water rights.

Sources of fresh water

Surface water

Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge.

Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water loss.

Human activities can have a large and sometimes devastating impact on these factors. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing stream flow.

The total quantity of water available at any given time is an important consideration. Some human water users have an intermittent need for water. For example, many farms require large quantities of water in the spring, and no water at all in the winter. To supply such a farm with water, a surface water system may require a large storage capacity to collect water throughout the year and release it in a short period of time. Other users have a continuous need for water, such as a power plant that requires water for cooling. To supply such a power plant with water, a surface water system only needs enough storage capacity to fill in when average stream flow is below the power plant's need.

Nevertheless, over the long term the average rate of precipitation within a watershed is the upper bound for average consumption of natural surface water from that watershed.

Natural surface water can be augmented by importing surface water from another watershed through a canal or pipeline. It can also be artificially augmented from any of the other sources listed here, however in practice the quantities are negligible. Humans can also cause surface water to be "lost" (i.e. become unusable) through pollution.

Brazil is the country estimated to have the largest supply of fresh water in the world, followed by Russia and Canada.

Under river flow

Throughout the course of a river, the total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through rocks and sediments that underlie the river and its floodplain called the hyporheic zone. For many rivers in large valleys, this unseen component of flow may greatly exceed the visible flow. The hyporheic zone often forms a dynamic interface between surface water and groundwater from aquifers, exchanging flow between rivers and aquifers that may be fully charged or depleted. This is especially significant in karst areas where pot-holes and underground rivers are common.

Groundwater

Groundwater is fresh water located in the subsurface pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between groundwater that is closely associated with surface water and deep groundwater in an aquifer (sometimes called "fossil water").

Groundwater can be thought of in the same terms as surface water: inputs, outputs and storage. The critical difference is that due to its slow rate of turnover, groundwater storage is generally much larger (in volume) compared to inputs than it is for surface water. This difference makes it easy for humans to use groundwater unsustainably for a long time without severe consequences. Nevertheless, over the long term the average rate of seepage above a groundwater source is the upper bound for average consumption of water from that source.

The natural input to groundwater is seepage from surface water. The natural outputs from groundwater are springs and seepage to the oceans.

If the surface water source is also subject to substantial evaporation, a groundwater source may become saline. This situation can occur naturally under endorheic bodies of water, or artificially under irrigated farmland. In coastal areas, human use of a groundwater source may cause the direction of seepage to ocean to reverse which can also cause soil salinization. Humans can also cause groundwater to be "lost" (i.e. become unusable) through pollution. Humans can increase the input to a groundwater source by building reservoirs or detention ponds.

Frozen water

Several schemes have been proposed to make use of icebergs as a water source, however to date this has only been done for research purposes. Glacier runoff is considered to be surface water.

The Himalayas, which are often called "The Roof of the World", contain some of the most extensive and rough high altitude areas on Earth as well as the greatest area of glaciers and permafrost outside of the poles. Ten of Asia's largest rivers flow from there, and more than a billion people's livelihoods depend on them. To complicate matters, temperatures there are rising more rapidly than the global average. In Nepal, the temperature has risen by 0.6 degrees Celsius over the last decade, whereas globally, the Earth has warmed approximately 0.7 degrees Celsius over the last hundred years.

Desalination

Desalination is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination. It is only economically practical for high-valued uses (such as household and industrial uses) in arid areas. The most extensive use is in the Persian Gulf.

Water uses

Agricultural

It is estimated that 70% of worldwide water is used for irrigation, with 15-35% of irrigation withdrawals being unsustainable.It takes around 2,000 - 3,000 litres of water to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is between two and five litres. To produce food for the now over 7 billion people who inhabit the planet today requires the water that would fill a canal ten metres deep, 100 metres wide and 2100 kilometres long.

As global populations grow, and as demand for food increases in a world with a fixed water supply, there are efforts under way to learn how to produce more food with less water, through improvements in irrigation methods and technologies, agricultural water management, crop types, and water monitoring. Aquaculture is a small but growing agricultural use of water.

Freshwater commercial fisheries may also be considered as agricultural uses of water, but have generally been assigned a lower priority than irrigation (see Aral Sea and Pyramid Lake).

Industrial

It is estimated that 22% of worldwide water is used in industry. Major industrial users include hydroelectric dams, thermoelectric power plants, which use water for cooling, ore and oil refineries, which use water in chemical processes, and manufacturing plants, which use water as a solvent. Water withdrawal can be very high for certain industries, but consumption is generally much lower than that of agriculture.

Water is used in renewable power generation. Hydroelectric power derives energy from the force of water flowing downhill, driving a turbine connected to a generator. This hydroelectricity is a low-cost, non-polluting, renewable energy source. Significantly, hydroelectric power can also be used for load following unlike most renewable energy sources which are intermittent. Ultimately, the energy in a hydroelectric powerplant is supplied by the sun. Heat from the sun evaporates water, which condenses as rain in higher altitudes and flows downhill. Pumped-storage hydroelectric plants also exist, which use grid electricity to pump water uphill when demand is low, and use the stored water to produce electricity when demand is high.

Hydroelectric power plants generally require the creation of a large artificial lake. Evaporation from this lake is higher than evaporation from a river due to the larger surface area exposed to the elements, resulting in much higher water consumption. The process of driving water through the turbine and tunnels or pipes also briefly removes this water from the natural environment, creating water withdrawal. The impact of this withdrawal on wildlife varies greatly depending on the design of the powerplant.

Pressurized water is used in water blasting and water jet cutters. Also, very high pressure water guns are used for precise cutting. It works very well, is relatively safe, and is not harmful to the environment. It is also used in the cooling of machinery to prevent overheating, or prevent saw blades from overheating. This is generally a very small source of water consumption relative to other uses.

Water is also used in many large scale industrial processes, such as thermoelectric power production, oil refining, fertilizer production and other chemical plant use, and natural gas extraction from shale rock. Discharge of untreated water from industrial uses is pollution. Pollution includes discharged solutes (chemical pollution) and increased water temperature (thermal pollution). Industry requires pure water for many applications and utilizes a variety of purification techniques both in water supply and discharge. Most of this pure water is generated on site, either from natural freshwater or from municipal grey water. Industrial consumption of water is generally much lower than withdrawal, due to laws requiring industrial grey water to be treated and returned to the environment. Thermoelectric powerplants using cooling towers have high consumption, nearly equal to their withdrawal, as most of the withdrawn water is evaporated as part of the cooling process. The withdrawal, however, is lower than in once-through cooling systems.

Domestic

It is estimated that 8% of worldwide water use is for domestic purposes.[6] These include drinking water, bathing, cooking, toilet flushing, cleaning, laundry and gardening. Basic domestic water requirements have been estimated by Peter Gleick at around 50 liters per person per day, excluding water for gardens. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Such water is commonly called potable water. In most developed countries, the water supplied to domestic, commerce and industry is all of drinking water standard even though only a very small proportion is actually consumed or used in food preparation.

Environmental

Explicit environment water use is also a very small but growing percentage of total water use. Environmental water may include water stored in impoundments and released for environmental purposes (held environmental water), but more often is water retained in waterways through regulatory limits of abstraction.Environmental water usage includes watering of natural or artificial wetlands, artificial lakes intended to create wildlife habitat, fish ladders, and water releases from reservoirs timed to help fish spawn, or to restore more natural flow regimes.

Like recreational usage, environmental usage is non-consumptive but may reduce the availability of water for other users at specific times and places. For example, water release from a reservoir to help fish spawn may not be available to farms upstream, and water retained in a river to maintain waterway health would not be available to water abstractors downstream.

Water stress

Estimate of the share of people in developing countries with access to drinking water 1970–2000

Water crisis and Water stress

The concept of water stress is relatively simple: According to the World Business Council for Sustainable Development, it applies to situations where there is not enough water for all uses, whether agricultural, industrial or domestic. Defining thresholds for stress in terms of available water per capita is more complex, however, entailing assumptions about water use and its efficiency. Nevertheless, it has been proposed that when annual per capita renewable freshwater availability is less than 1,700 cubic meters, countries begin to experience periodic or regular water stress. Below 1,000 cubic meters, water scarcity begins to hamper economic development and human health and well-being.

Population growth

In 2000, the world population was 6.2 billion. The UN estimates that by 2050 there will be an additional 3.5 billion people with most of the growth in developing countries that already suffer water stress. Thus, water demand will increase unless there are corresponding increases in water conservation and recycling of this vital resource. In building on the data presented here by the UN, the World Bank goes on to explain that access to water for producing food will be one of the main challenges in the decades to come. Access to water will need to be balanced with the importance of managing water itself in a sustainable way while taking into account the impact of climate change, and other environmental and social variables.

Expansion of business activity

Business activity ranging from industrialization to services such as tourism and entertainment continues to expand rapidly. This expansion requires increased water services including both supply and sanitation, which can lead to more pressure on water resources and natural ecosystem.

Rapid urbanization

The trend towards urbanization is accelerating. Small private wells and septic tanks that work well in low-density communities are not feasible within high-density urban areas. Urbanization requires significant investment in water infrastructure in order to deliver water to individuals and to process the concentrations of wastewater – both from individuals and from business. These polluted and contaminated waters must be treated or they pose unacceptable public health risks.

In 60% of European cities with more than 100,000 people, groundwater is being used at a faster rate than it can be replenished.Even if some water remains available, it costs increasingly more to capture it.

Climate change

Climate change could have significant impacts on water resources around the world because of the close connections between the climate and hydrological cycle. Rising temperatures will increase evaporation and lead to increases in precipitation, though there will be regional variations in rainfall. Both droughts and floods may become more frequent in different regions at different times, and dramatic changes in snowfall and snow melt are expected in mountainous areas. Higher temperatures will also affect water quality in ways that are not well understood. Possible impacts include increased eutrophication. Climate change could also mean an increase in demand for farm irrigation, garden sprinklers, and perhaps even swimming pools. There is now ample evidence that increased hydrologic variability and change in climate has and will continue have a profound impact on the water sector through the hydrologic cycle, water availability, water demand, and water allocation at the global, regional, basin, and local levels.

Depletion of aquifers

Due to the expanding human population, competition for water is growing such that many of the world's major aquifers are becoming depleted. This is due both for direct human consumption as well as agricultural irrigation by groundwater. Millions of pumps of all sizes are currently extracting groundwater throughout the world. Irrigation in dry areas such as northern China, Nepal and India is supplied by groundwater, and is being extracted at an unsustainable rate. Cities that have experienced aquifer drops between 10 and 50 meters include Mexico City, Bangkok, Beijing, Madras and Shanghai.

Pollution and water protection

Water pollution is one of the main concerns of the world today. The governments of numerous countries have striven to find solutions to reduce this problem. Many pollutants threaten water supplies, but the most widespread, especially in developing countries, is the discharge of raw sewage into natural waters; this method of sewage disposal is the most common method in underdeveloped countries, but also is prevalent in quasi-developed countries such as China, India, Nepal and Iran. Sewage, sludge, garbage, and even toxic pollutants are all dumped into the water. Even if sewage is treated, problems still arise. Treated sewage forms sludge, which may be placed in landfills, spread out on land, incinerated or dumped at sea.[21] In addition to sewage, nonpoint source pollution such as agricultural runoff is a significant source of pollution in some parts of the world, along with urban stormwater runoff and chemical wastes dumped by industries and governments.

Water and conflicts

Competition for water has widely increased, and it has become more difficult to conciliate the necessities for water supply for human consumption, food production, ecosystems and other uses. Water administration is frequently involved in contradictory and complex problems. Approximately 10% of the worldwide annual runoff is used for human necessities. Several areas of the world are flooded, while others have such low precipitations that human life is almost impossible. As population and development increase, raising water demand, the possibility of problems inside a certain country or region increases, as it happens with others outside the region.

Over the past 25 years, politicians, academics and journalists have frequently predicted that disputes over water would be a source of future wars. Commonly cited quotes include: that of former Egyptian Foreign Minister and former Secretary-General of the United Nations Boutrous Ghali, who forecast, “The next war in the Middle East will be fought over water, not politics”; his successor at the UN, Kofi Annan, who in 2001 said, “Fierce competition for fresh water may well become a source of conflict and wars in the future,” and the former Vice President of the World Bank, Ismail Serageldin, who said the wars of the next century will be over water unless significant changes in governance occurred. The water wars hypothesis had its roots in earlier research carried out on a small number of transboundary rivers such as the Indus, Jordan and Nile. These particular rivers became the focus because they had experienced water-related disputes. Specific events cited as evidence include Israel's bombing of Syria's attempts to divert the Jordan's headwaters, and military threats by Egypt against any country building dams in the upstream waters of the Nile. However, while some links made between conflict and water were valid, they did not necessarily represent the norm.

The only known example of an actual inter-state conflict over water took place between 2500 and 2350 BC between the Sumerian states of Lagash and Umma. Water stress has most often led to conflicts at local and regional levels. Tensions arise most often within national borders, in the downstream areas of distressed river basins. Areas such as the lower regions of China's Yellow River or the Chao Phraya River in Thailand, for example, have already been experiencing water stress for several years. Water stress can also exacerbate conflicts and political tensions which are not directly caused by water. Gradual reductions over time in the quality and/or quantity of fresh water can add to the instability of a region by depleting the health of a population, obstructing economic development, and exacerbating larger conflicts.

Water shortage

In 2025, water shortages will be more prevalent among poorer countries where resources are limited and population growth is rapid, such as the Middle East, Africa, and parts of Asia.By 2025, large urban and peri-urban areas will require new infrastructure to provide safe water and adequate sanitation. This suggests growing conflicts with agricultural water users, who currently consume the majority of the water used by humans.

Generally speaking the more developed countries of North America, Europe and Russia will not see a serious threat to water supply by the year 2025, not only because of their relative wealth, but more importantly their populations will be better aligned with available water resources. North Africa, the Middle East, South Africa and northern China will face very severe water shortages due to physical scarcity and a condition of overpopulation relative to their carrying capacity with respect to water supply.Most of South America, Sub-Saharan Africa, Southern China and India will face water supply shortages by 2025; for these latter regions the causes of scarcity will be economic constraints to developing safe drinking water, as well as excessive population growth.

Water pollution

It is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells). It has been suggested that water pollution is the leading worldwide cause of deaths and diseases,[1] and that it accounts for the deaths of more than 14,000 people daily. An estimated 580 people in India die of water pollution related illness every day. About 90 percent of the water in the cities of China is polluted. As of 2007, half a billion Chinese had no access to safe drinking water. In addition to the acute problems of water pollution indeveloping countries, developed countries also continue to struggle with pollution problems. For example, in the most recent national report on water quality in the United States, 44 percent of assessed stream miles, 64 percent of assessed lake acres, and 30 percent of assessed bays and estuarine square miles were classified as polluted. The head of China's national development agency said in 2007 that one quarter the length of China's seven main rivers were so poisoned the water harmed the skin.

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water, or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish. Natural phenomena such as volcanoes, algae blooms, storms, and earthquakes also cause major changes in water quality and the ecological status of water.

Categories

Although interrelated, surface water and groundwater have often been studied and managed as separate resources. Surface water seeps through the soil and becomes groundwater. Conversely, groundwater can also feed surface water sources. Sources of surface water pollution are generally grouped into two categories based on their origin.

Point source water pollution refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. The U.S. Clean Water Act (CWA) defines point source forregulatory enforcement purposes.[9] The CWA definition of point source was amended in 1987 to include municipal storm sewer systems, as well as industrial storm water, such as from construction sites.

Non-point sources

Nonpoint source pollution refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common example is the leaching out of nitrogen compounds from fertilized agricultural lands. Nutrient runoffs in storm water from "sheet flow" over an agricultural field or a forest are also cited as examples of NPS pollution.

Contaminated storm water washed off of parking lots, roads and highways, called urban runoff, is sometimes included under the category of NPS pollution. However, because this runoff is typically channeled into storm drain systems and discharged through pipes to local surface waters, it becomes a point source.

Groundwater pollution

Interactions between groundwater and surface water are complex. Consequently, groundwater pollution, also referred to as groundwater contamination, is not as easily classified as surface water pollution.[8] By its very nature, groundwater aquifers are susceptible to contamination from sources that may not directly affect surface water bodies, and the distinction of point vs. non-point source may be irrelevant. A spill or ongoing release of chemical or radionuclide contaminants into soil (located away from a surface water body) may not create point or non-point source pollution but can contaminate the aquifer below, creating a toxic plume. The movement of the plume, called a plume front, may be analyzed through a hydrological transport model or groundwater model. Analysis of groundwater contamination may focus on soil characteristics and site geology, hydrogeology, hydrology, and the nature of the contaminants.

Causes

The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical changes such as elevated temperature and discoloration. While many of the chemicals and substances that are regulated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration is often the key in determining what is a natural component of water and what is a contaminant. High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna.

Oxygen-depleting substances may be natural materials such as plant matter (e.g. leaves and grass) as well as man-made chemicals. Other natural and anthropogenic substances may causeturbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species.

Many of the chemical substances are toxic. Pathogens can produce waterborne diseases in either human or animal hosts. Alteration of water's physical chemistry includes acidity (change in pH),electrical conductivity, temperature, and eutrophication. Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases in the primary productivityof the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia (oxygen depletion) and severe reductions in water quality may occur, affecting fish and other animal populations.

Pathogens

Disease-causing microorganisms are referred to as pathogens. Although the vast majority of bacteria are either harmless or beneficial, a few pathogenic bacteria can cause disease. Coliform bacteria, which are not an actual cause of disease, are commonly used as a bacterial indicator of water pollution. Other microorganisms sometimes found in surface waters that have caused human health problems include:

- Burkholderia pseudomallei
- Cryptosporidium parvum
- Giardia lamblia
- Salmonella
- Norovirus and other viruses

High levels of pathogens may result from on-site sanitation systems (septic tanks, pit latrines) or inadequately treated sewage discharges. This can be caused by a sewage plant designed with less than secondary treatment (more typical in less-developed countries). In developed countries, older cities with aging infrastructure may have leaky sewage collection systems (pipes, pumps, valves), which can cause sanitary sewer overflows. Some cities also havecombined sewers, which may discharge untreated sewage during rain storms.

Macroscopic pollution – large visible items polluting the water – may be termed "floatables" in an urban storm water context, or marine debris when found on the open seas, and can include such items as:

- Trash or garbage (e.g. paper, plastic, or food waste) discarded by people on the ground, along with accidental or intentional dumping of rubbish, that are washed by rainfall into storm drains and eventually discharged into surface waters
- Nurdles, small ubiquitous waterborne plastic pellets
- Shipwrecks, large derelict ships.

Control of pollution

Decisions on the type and degree of treatment and control of wastes, and the disposal and use of adequately treated wastewater, must be based on a consideration all the technical factors of each drainage basin, in order to prevent any further contamination or harm to the environment.

Sewage treatment

In urban areas of developed countries, domestic sewage is typically treated by centralized sewage treatment plants. Well-designed and operated systems (i.e., secondary treatment or better) can remove 90 percent or more of the pollutant load in sewage. Some plants have additional systems to remove nutrients and pathogens.

Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including:

- utilizing a green infrastructure approach to improve storm water management capacity throughout the system, and reduce the hydraulic overloading of the treatment plant
- repair and replacement of leaking and malfunctioning equipment
- increasing overall hydraulic capacity of the sewage collection system (often a very expensive option).

A household or business not served by a municipal treatment plant may have an individual septic tank, which pre-treats the wastewater on site and infiltrates it into the soil.

Industrial wastewater treatment

Some industrial facilities generate ordinary domestic sewage that can be treated by municipal facilities. Industries that generate wastewater with high concentrations of conventional pollutants (e.g. oil and grease), toxic pollutants (e.g. heavy metals, volatile organic compounds) or other non-conventional pollutants such as ammonia, need specialized treatment systems. Some of these facilities can install a pre-treatment system to remove the toxic components, and then send the partially treated wastewater to the municipal system. Industries generating large volumes of wastewater typically operate their own complete on-site treatment systems. Some industries have been successful at redesigning their manufacturing processes to reduce or eliminate pollutants, through a process called pollution prevention.

Heated water generated by power plants or manufacturing plants may be controlled with:

- Cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation
- cooling towers, which transfer waste heat to the atmosphere through evaporation and/or heat transfer
- Cogeneration, a process where waste heat is recycled for domestic and/or industrial heating purposes.

Agricultural wastewater treatment

Non point source controls Sediment (loose soil) washed off fields is the largest source of agricultural pollution in the United States. Farmers may utilize erosion controls to reduce runoff flows and retain soil on their fields. Common techniques include contour plowing, crop mulching, crop rotation, planting perennial crops and installing riparian buffers.

Nutrients (nitrogen and phosphorus) are typically applied to farmland as commercial fertilizer, animal manure, or spraying of municipal or industrial wastewater (effluent) or sludge. Nutrients may also enter runoff from crop residues, irrigation water, wildlife, and atmospheric deposition. Farmers can develop and implementnutrient management plans to reduce excess application of nutrients and reduce the potential for nutrient pollution.

To minimize pesticide impacts, farmers may use Integrated Pest Management (IPM) techniques (which can include biological pest control) to maintain control over pests, reduce reliance on chemical pesticides, and protect water quality.

Point source wastewater treatment Farms with large livestock and poultry operations, such as factory farms, are called concentrated animal feeding operations or feedlots in the US and are being subject to increasing government regulation. Animal slurries are usually treated by containment in anaerobic lagoons before disposal by spray or trickle application to grassland. Constructed wetlands are sometimes used to facilitate treatment of animal wastes. Some animal slurries are treated by mixing withstraw and composted at high temperature to produce a bacteriologically sterile and friable manure for soil improvement.

Urban runoff

Effective control of urban runoff involves reducing the velocity and flow of storm water, as well as reducing pollutant discharges. Local governments use a variety of storm water management techniques to reduce the effects of urban runoff. These techniques, called best management practices (BMPs) in the U.S., may focus on water quantity control, while others focus on improving water quality, and some perform both functions.

Pollution prevention practices include low-impact development techniques, installation of green roofs and improved chemical handling (e.g. management of motor fuels & oil, fertilizers and pesticides). Runoff mitigation systems include infiltration basins, bioretention systems, constructed wetlands, retention basins and similar devices

Thermal pollution from runoff can be controlled by storm water management facilities that absorb the runoff or direct it into groundwater, such as bioretention systems and infiltration basins. Retention basins tend to be less effective at reducing temperature, as the water may be heated by the sun before being discharged to a receiving stream.

Water purification methods:

Effluent treatment plants (primary, secondary and tertiary treatment).

The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. Irrigation with wastewater is both disposal and utilization and indeed is an effective form of wastewater disposal (as in slow-rate land treatment). However, some degree of treatment must normally be provided to raw municipal wastewater before it can be used for agricultural or landscape irrigation or for aquaculture. The quality of treated effluent used in agriculture has a great influence on the operation and performance of the wastewater-soil-plant or aquaculture system. In the case of irrigation, the required quality of effluent will depend on the crop or crops to be irrigated, the soil conditions and the system of effluent distribution adopted. Through crop restriction and selection of irrigation systems which minimize health risk, the degree of pre-application wastewater treatment can be reduced. A similar approach is not feasible in aquaculture systems and more reliance will have to be placed on control through wastewater treatment.

Primary Wastewater Treatment

Primary treatment of wastewater involves sedimentation of solid waste within the water. This is done after filtering out larger contaminants within the water. Wastewater is passed through several tanks and filters that separate water from contaminants. The resulting “sludge” is then fed into a digester, in which further processing takes place. This primary batch of sludge contains nearly 50% of suspended solids within wastewater.

Secondary Wastewater Treatment

Secondary treatment of wastewater makes use of oxidation to further purify wastewater. This can be done in one of three ways:

Biofiltration

This method of secondary treatment of wastewater employs sand filters, contact filters, or trickling filters to ensure that additional sediment is removed from wastewater. Of the three filters, trickling filters are typically the most effective for small-batch wastewater treatment.

Aeration

Aeration is a long, but effective process that entails mixing wastewater with a solution of microorganisms. The resulting mixture is then aerated for up to 30 hours at a time to ensure results.

Oxidation Ponds

Oxidation ponds are typically used in warmer places. In addition, this method utilizes natural bodies of water like lagoons. Wastewater is allowed to pass through this body for a period of time and is then retained for two to three weeks.

Tertiary Wastewater Treatment

This third and last step in the basic wastewater management system is mostly comprised of removing phosphates and nitrates from the water supply. Substances like activates carbon and sand are among the most commonly used materials that assist in this process.

Wastewater treatment may entail a bit more than these three steps, but they are the basis of how traditional wastewater treatment facilities operate. The more you know about the process, the more ideas you’ll be able to cultivate in order to make a positive change and enhance it.

Reverse osmosis:

Reverse osmosis is the process of water solution separation by means of their filtration through semipermeable membranes at pressure exceeding osmotic one. This method has significant advantages in comparison with other demineralization methods: lower power consumption, simple design, assembly and operation, small dimensions, etc.

As the result of reverse osmosis, water and dissolved substances are separated at molecular level, thus almost demineralized water is accumulated on one side of membrane and all impurities are on the other side thereof. Therefore, water with initial salt content of 3000 mg/l and more may be demineralized at reverse osmosis stage one to 10–200 mg/l.

High-selective membranes with working pressure 40-60 bars are used for sea water demineralization. Reverse osmosis membrane performance and permeate output are lower and, hence, they require more power consumption.

Composite roll-type polyamide membranes and acetate-cellulose membranes have been widely used in reverse osmosis processes.

Nanofiltration is used for brackish water demineralization with the use of membrane elements characterized be lower selective ability (50-80%).

Membrane element bodies are made of epoxy resin and fiberglass and stainless steel.

Electrodialysis:

Electrodialysis represents a process of demineralization of water and other fluids containing ionic form impurities using a constant electric field and selective ion-exchange membranes. Salt ions move along field orientation in constant electric field. Thus the principle of solution electroneutrality is met at any field point. Ion-exchange membranes represent polymer films, have fixed ionogenic groups trapping and exchanging ions (counter ions). Membranes in electrolytic solutions are electron conduction-free, i.e. they act as electrolytic conductors, not bipolar electrodes.

The principle of multi chamber electrodialysis is concluded in placement of a set of separated alternating cation-exchange and anion exchange membranes between two electrodes. So, demineralized and concentrated solutions flow in the formed chambers. The transfer process in such a system is repeated for many times that allows to reduce dramatically relative losses of energy on electrodes. Appplication of the principle of multichamber electrodialysis made it possible to design compact electro dialyzers with a big surface of membrances.

Efficiency and quality of used membranes is of utmost priority in electrodialysis process. In addition to chemical stability, mechanical strength and stable size ion-exchange membrane shall have a high selective ability, good current conductivity, revers diffusion small rate and low osmotic permeability within the working range of compositions and solution concentrations. Electrodialysis represents a process of demineralization of water and other fluids containing ionic form impurities using a constant electric field and selective ion-exchange membranes. Salt ions move along field orientation in constant electric field. Thus the principle of solution electro neutrality is met at any field point. Ion-exchange membranes represent polymer films, have fixed ionogenic groups trapping and exchanging ions (counter ions). Membranes in electrolytic solutions are electron conduction-free, i.e. they act as electrolytic conductors, not bipolar electrodes.

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Ion Exchange Softening

Ion exchange softening, also known as zeolite softening, passes water through a filter containing resin granules. In the filter, known as a softener, calcium and magnesium in the water are exchanged for sodium from the resin granules. The resulting water has a hardness of 0 mg/L and must be mixed with hard water to prevent softness problems in the distributed water.

Ion exchange softening does not require the flash mixer, flocculation basin, and sedimentation basin required for lime-soda ash softening. In addition, the process does not require as much operator time. Ion exchange softening is effective at removing both carbonate and noncarbonate hardness and is often used for waters high in noncarbonate hardness and with a total hardness less than 350 mg/L. However, ion exchange softening has its disadvantages as well. The calcium and magnesium in the hard water are replaced by sodium ions, which may cause problems for people with health problems who are not supposed to eat any salt. Softeners have to be backwashed in a manner similar to a filter, and the recharge water, known as brine, can cause disposal problems.

Ion exchange

- ➢ reversible chemical reaction.
- • insoluble solid (resin) and a solution (wastewater)
- • ions are interchanged
- ➢ Used only on dilute solutions.

Ion exchange is an effective, versatile means of conditioning boiler feed water. The term “ion exchange” describes the process: as water flows through a bed of ion exchange material, undesirable ions are removed and replaced with less objectionable ones.

For example, in softening processes, calcium and magnesium ions (hardness) are exchanged for sodium ions. In dealkalization, the ions contributing to alkalinity (carbonate, bicarbonate, etc.) are removed and replaced with chloride ions. Other dealkalization processes utilizing weak acid cation resin or strong acid cation resin in a split stream process, exchange cations with hydrogen. This forms carbonic acid which can be removed in a decarbonator tower. Demineralization is simply replacing all cations with hydrogen ions (H^+) and all anions with hydroxide ions (OH^-). Ion exchange materials are like storage batteries; they must be recharged (regenerated) periodically to restore their exchange capacity. With proper design and operation, ion exchange processes are capable of removing selected ions almost completely.

Cation exchangers

Cation exchange materials are classified as either weak acid or strong acid depending on the type of exchange group. Strong acid cation exchanger contain SO3-functional, weak acid cation exchanger contain –COO functional groups. There has been constant improvement in ion exchange materials since the first use of natural and synthetic inorganic products.

Anion exchangers

Anion exchange materials are classified as either weak base or strong base depending on the type of exchange group. Weak base resins act as acid adsorbers, efficiently removing strong acids such as sulfuric and hydrochloric. However, they will not remove carbon dioxide or silica. They are used in systems where strong acids predominate, where silica reduction is not required, and where carbon dioxide is removed in degasifiers.

Possible questions
PART-B (Two mark questions)

1. Define eco-system with an example?
2. Define aquatic eco-system?
3. Write a note on water resources?
4. How will water purify by osmosis method?
5. Write about purification method of electro dialysis?
6. Write a short note on ion exchange?

PART-C (Eight mark questions)
1. Discuss the aquatic ecosystems in detail?
2. Briefly explain the ozone layer depletion?

3. Explain the sources and nature of water pollutants on water pollution?
4. Briefly explain the effluent treatment plants and its methods?
5. Give an account on Reverse osmosis and electro dialysis processes?
6. Write any two methods are involved in water treatment?
7. Give the components & functions of eco system?
8. Mention the methods of disposal of radioactive wastages?

UNIT-4

1	A technique used to determine the concentration of odor compounds in a sample is known as	(a) Stripping	(b) Settling	(c) Flushing	(d) Chlorination	**(a) Stripping**
2	The Total dissolved solids (TDS) can be reduced by the following method	(a) Distillation	(b) Reverse osmosis	(c) Ion exchange	(d) All of the above	**(c) Ion exchange**
3	The following cause alkalinity in natural water.	(a) Potassium carbonate	(b) Potassium bicarbonate	(c) Sodium carbonate	(d) All of the above	**(b) Potassium bicarbonate**
4	Permanent hardness is caused due to	(a) Magnesium carbonate	(b) Magnesium bicarbonate	(c) Magnesium sulphate	(d) All the above	**(b) Magnesium bicarbonate**
5	Fluorides can be removed by	(a) Reverse osmosis	(b) Lime softening	(c) Ion exchange	(d) All of the above	**(a) Reverse osmosis**
6	The process of nutrient enrichment is termed as	(a) Eutrophication	(b) Limiting nutrients	(c) Enrichment	(d) Schistosomiasis	**(a) Eutrophication**
7	Which of the following is not a water borne disease?	(a) Typhoid	(b) Scabies	(c) Cholera	(d) Hepatitis	**(d) Hepatitis**
8	Temporary hardness is caused due to	(a) Magnesium carbonate	(b) Calcium sulphate	(c) Magnesium sulphate	(d) Magnesium chloride	**(a) Magnesium carbonate**
9	The water temperature should preferably be less than __ degree Celsius.	(a) 10	(b) 15	(c) 25	(d) 30	**(c) 25**
10	Harmful radiation emitted by the sun is ______.	(a) Visible	(b) Ultra violet	(c) Infra red	(d) Gamma rays	**(b) Ultra violet**
11	Which of the following causes the least pollution when burnt?	(a) Petrol	(b) Natural gas	(c) Diesel	(d) Coal	**(b) Natural gas**

12	Which of the following is not a water hygiene disease?	(a) Leprosy	(b) Conjunctivitis	(c) Trachoma	(d) Diarrhoea	**(d) Diarrhoea**
13	A likely pH of acid rain could be	(a) 4.7	(b) 5.8	(c) 7.2	(d) 8.8	**(a) 4.7**
14	Secondary treatment uses __________ to consume wastes.	(a) Micro organisms	(b) chemicals	(c) Filtration	(d) None of the above	**(a) Micro organisms**
15	The common methods used for disinfection in waste water treatment plants are	(a) Fermentation	(b) UV light	(c) Filtration	(d) Phenolic solvent	**(b) UV light**
16	The maximum permissible limit (BIS) of turbidity in drinking water is	(a) 5 NTU	(b) 10 NTU	(c) 15 NTU	(d) 20 NTU	**(b) 10 NTU**
17	The source of Arsenic in water is	(a) Industrial waste	(b) Fertilizers	(c) Phosphate rocks	(d) All of the above	**(d) All of the above**
18	Natural source of pollution is	(a) Rain forest	(b) mining for minerals	(c) forest fire	(d) falling of meteoroids	**(c) forest fire**
19	Global warming' leads to	(a) Low level of oxygen	(b) high level of oxygen	(c) floods and droughts	(d) rain forests	**(c) floods and droughts**
20	Sediments in water blocks the	(a) Sunlight	(b) carbon dioxide	(c) ethane	(d) methane	**(a) Sunlight**
21	Upper part of aquatic ecosystem contains	(a) Plankton	(b) Nekton	(c) Benthos	(d) Plankton and Nekton	**(a) Plankton**
22	BOD stands for	(a) Biotic oxygen demand	(b) biological oxidation demand	(c) biological oxygen demand	(d) biochemical oxygen demand	**(c) biological oxygen demand**
23	Global atmospheric temperatures are likely to be increased due to:	(a) Burning of fossil fuel	(b) Water pollution	(c) Soil erosion	(d) None of the above	**(a) Burning of fossil fuel**
24	Problem of solid waste disposal can be reduced through	(a) Recycling	(b) lesser pollution	(c) more timber	(d) population control	**(a) Recycling**

25	Metal is a/an	(a) Renewable resource	(b) non-renewable resource	(c) artificial resource	(d) element	**(b) non-renewable resource**
26	Central heating systems can be run through	(a) More deforestation	(b) burning of garbage	(c) lesser incinerators	(d) cooling water pipelines	**(b) burning of garbage**
27	Metals is produced as waste in industries like	(a) Skiing	(b) mining	(c) electroplating	(d) digging	**(c) electroplating**
28	Making new containers from crushed glass helps to	(a) Save materials	(b) save fuel	(c) increase pollution	(d) both A and B	**(d) both A and B**
29	Sublimation, dissolving and filtration can only be carried out in	(a) soluble-substances in solution	(b) insoluble substances in liquids	(c) liquid-liquid mixtures	(d) solid-solid mixtures	**(d) solid-solid mixtures**
30	Process quicker than filtration but not so effective is	(a) Decanting	(b) centrifuging	(c) crystallization	(d) fractional distillation	**(a) Decanting**
31	Crystallization is used to	(a) Purify sugar	(b) purify fertilizers	(c) separate salt from solution	(d) Both (a) and (b)	**(d) Both (a) and (b)**
32	Anhydrous agent used to remove water from ethanol distillate may be	(a) Iodine	(b) hydrocarbon	(c) calcium chloride	(c) calcium Iodide	**(c) calcium chloride**
33	Only one type of atom is found in	(a) Organic compounds	(b) inorganic compounds	(c) pure substances	(d) radioactive substances	**(c) pure substances**
34	The maximum desirable limit BIS of lead in the drinking water is ___________	(a) 0.05 mg/l	(b) 0.09 mg/l	(c) 0.5 mg/l	(d) 0.1 mg/l	**(a) 0.05 mg/l**
35	Sewage is mainly a	(a) Liquid waste	(b) solid waste	(c) gaseous waste	(d) mixture of solid and gas.	**(b) solid waste**
36	Which of the following is/are products of wastewater treatment?	(a) Biogas	(b) Sludge	(c) Both biogas and sludge	(d) Aerator	**(c) Both biogas and sludge**
37	Open drain system is a breeding place for which of	(a) Flies	(b) Mosquitoes	(c) Organisms which cause	(d) All of these	**(b) Mosquitoes**

	the following.			diseases		
38	Pick from the following one chemical used to disinfect water.	(a) Chlorine	(b) Washing soda	(c) Silica	(d) Coal	**(a) Chlorine**
39	The system of a network of pipes used for taking away wastewater from homes or public buildings to the treatment plant is known as	(a) Sewers	(b) Sewerage	(c) Transport system	(d) Treatment plant	**(d) Treatment plant**
40	Which of the following is a part of inorganic impurities of the sewage?	(a) Pesticides	(b) Urea	(c) Phosphates	(d) Vegetable waste	**(c) Phosphates**
41	In a filtration plant water is filtered using layers of	(a) Sand and clay	(b) Clay and fine gravel	(c) Sand and fine gravel	(d) Sand and medium gravel	**(b) Clay and fine gravel**
42	Which of the following is not a source of waste water?	(a) Sewers	(b) Homes	(c) Industries	(d) Hospitals	**(d) Hospitals**
43	Which of the following is the best example of a point source of water pollution?	(a) Storm water	(b) Acid rain	(c) Agricultural Runoff	(d) Factory effluent	**(d) Factory effluent**
44	Which of the following are other names for estuaries?	(a) Bays	(b) Lagoons	(c) Inlets	(d) Sloughs	**(b) Lagoons**
45	Which of the following is decreased by the breakdown of organic waste?	(a) Salinity	(b) Total Suspended Solids	(c) Acidity	(d) Dissolved Oxygen	**(d) Dissolved Oxygen**
46	The water cycle is driven by the:	(a) Sun	(b) moon	(c) clouds	(d) oceans	**(a) Sun**
47	What causes puddles to get smaller and smaller?	(a) Evaporation	(b) Condensation	(c) Precipitation	(d) The sun	**(a) Evaporation**
48	Snow and hail are examples of _________________	(a) Runoff	(b) Precipitation	(c) Condensation	(d) Water vapor	**(b) Precipitation**

49	What can we do to reduce water pollution?	(a) Pour chemicals into drains	(b) Use lots of fertilizer	(c) Dump trash into lakes	(d) Clean up oil spills properly	**(d) Clean up oil spills properly**
50	Which of these warms most of the air, water, and land on Earth?	(a) Coal	(b) Electricity	(c) Sunlight	(d) Wind	**(c) Sunlight**
51	Which part of plant evaporates water ?	Stomata	Fruit	Branch	Root	**Stomata**
52	A fossil fuel is best described as_______	a flammable solid or gas	a fuel that contains carbon.	fossilised rock that will burn in a power station.	a flammable substance formed from ancient biological material.	**a flammable substance formed from ancient biological material.**
53	An example of a non-renewable, non-fossil energy resource is_______	oil.	coal.	tidal	uranium.	**tidal**
54	Which of the following is not a renewable energy source?	wind	solar	biomass	natural gas	**biomass**
55	The term ‘exothermic’ refers to a chemical reaction ______	in which heat is absorbed.	in which heat is given out.	that proceeds very rapidly.	that requires high temperatures to begin the reaction.	**that requires high temperatures to begin the reaction.**
56	What percentage of the coal’s energy reaches the city?	approximately 30%	approximately 50%	approximately 60%	approximately 90%	**approximately 90%**
57	How much of the energy contained in the diesel-oil fuel is not converted to electricity when burnt in the power station?	4800 kJ	3200 kJ	2400 kJ	1200 kj	**2400 kJ**

58	Mercury is particularly hazardous to human health because________	it bioaccumulates high up the food chain.	as a heavy metal, it can cause serious impact injury.	as a pure metal it is very soluble in water, hence easily absorbed through drinking water.	it is light and volatile, and so is widely dispersed through the environment by wind	**as a heavy metal, it can cause serious impact injury.**
59	Which of the following is the best description of sulphur dioxide?	a gas less dense than air	a gas more dense than air	a gas insoluble in water	an acidic liquid at ordinary room temperature	**an acidic liquid at ordinary room temperature**
60	The dosage of sulphur dioxide is best described as__________	a measure of the harm sulfur dioxide does to a person.	the amount of sulfur dioxide a person experiences in a given time.	the amount of sulfur dioxide absorbed by a person in a given time.	the amount of sulfur dioxide entering the environment in a given time	**the amount of sulfur dioxide absorbed by a person in a given time.**

Unit V

Energy & Environment:

Sources of energy: Coal, petrol and natural gas. Nuclear fusion / fission, solar energy, hydrogen, geothermal, tidal and hydel, etc. Nuclear pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis:

Introduction to biocatalysis: Importance in "Green chemistry" and chemical industry.

Sources of energy:

The different sources of energy they list natural gas, coal and oil as the options – these are all considered to be just one source of energy from fossil fuels.

Oil and natural gas together make petroleum. Petroleum, which is Latin for rock oil, is a fossil fuel, meaning it was made naturally from decaying prehistoric plant and animal remains. It is a mixture of hundreds of different hydrocarbons molecules containing hydrogen and carbon that exist sometimes as a liquid (crude oil) and sometimes as a vapor (natural gas). Not only does petroleum provides fuel to run our vehicles, cook our food, heat our homes and generate electricity, it is also used in plastics, medicines, food items, and countless other products, from aspirin. Transportation needs use 66% of all available petroleum to fuel cars, buses, trucks and jets. That means 34% of oil is used for all the other items that make our daily lives easier. Most people have no idea how often they come in contact with things made from oil or natural gas. Petroleum is another resource and fossil fuel found in close proximity to and with natural gas. Most natural gas was created over time by two mechanisms: biogenic and thermogenic. Biogenic gas is created by methanogenic organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, thermogenic gas is created from buried organic material.

In petroleum production gas is often burnt as flare gas. The World Bank estimates that over 150 cubic kilometers of natural gas are flared or vented annually. Before natural gas can be used as a fuel, most, but not all, must be processed to remove impurities, including water, to meet the specifications of marketable natural gas. The by-products of this processing include: ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, hydrogen sulfide (which may be converted into pure sulfur), carbon dioxide, water vapor, and sometimes helium and nitrogen.

Natural gas is often informally referred to simply as "gas", especially when compared to other energy sources such as oil or coal. However, it is not to be confused with gasoline, especially in North America, where the term gasoline is often shortened in colloquial usage to gas. Petroleum and natural gas are nonrenewable sources of energy. Petroleum is a liquid mixture found underground that can be used to make gasoline, diesel fuel, and many other products.
Petroleum is also called crude oil or oil.

- Natural gas is a mixture of gases – mostly methane. Natural gas is sometimes just called gas.
- Natural gas is found underground with petroleum.
- Natural gas is flammable (burns with a flame).
- Petroleum and natural gas are fossil fuels.
- Fossil fuels were formed millions of years ago from the remains of plants and animals.
- The fossil fuels are petroleum, natural gas, and coal.
- Natural gas is the cleanest-burning fossil fuel.

Coal

Coal is the most abundant and burned fossil fuel. This was the fuel that launched the industrial revolution and has continued to grow in use; China, which already has many of the world's most polluted cities, was in 2007 building about two coal-fired power plants every week. Coal is the fastest growing fossil fuel and its large reserves would make it a popular candidate to meet the energy demand of the global community, short of global warming concerns and other pollutants. According to the International Energy Agency the proven reserves of coal are around 909 billion tones, which could sustain the current production rate for 155 years, although at a 5% growth per annum this would be reduced to 45 years, or until 2051. With the Fischer- Tropsch process it is possible to make liquid fuels such as diesel and jet fuel from coal. In the United States, 49% of electricity generation comes from burning coal.

Oil

It is estimated that there may be 57 ZJ of oil reserves on Earth (although estimates vary from a low of 8 ZJ, consisting of currently proven and recoverable reserves, to a maximum of 110 ZJ consisting of available, but not necessarily recoverable reserves, and including optimistic estimates for unconventional sources such as tar sands and oil shale. Current consensus among the 18 recognized estimates of supply profiles is that the peak of extraction will occur in 2020 at the rate of 93-million barrels per day (mbd). Current oil consumption is at the rate of 0.18 ZJ per year (31.1 billion barrels) or 85-mbd.

There is growing concern that peak oil production may be reached in the near future, resulting in severe oil price increases. A 2005 French Economics, Industry and Finance Ministry report suggested a worst-case scenario that could occur as early as 2013. There are also theories that peak of the global oil production may occur in as little as 2-3 years. The ASPO predicts peak year to be in 2010. Some other theories present the view that it has already taken place in 2005. World crude oil production (including lease condensates) according to US EIA data decreased from a peak of 73.720 mbd in 2005 to 73.437 in 2006, 72.981 in 2007, and 73.697 in 2008.According to peak oil theory, increasing production will lead to a more rapid collapse of production in the future, while decreasing production will lead to a slower decrease, as the bell-shaped curve will be spread out over more years.

In a stated goal of increasing oil prices to $75/barrel, which had fallen from a high of $147 to a low of $40, OPEC announced decreasing production by 2.2 mbd beginning 1 January 2009.

Sustainability

Political considerations over the security of supplies, environmental concerns related to global warming and sustainability are expected to move the world's energy consumption away from fossil fuels. The concept of peak oil shows that about half of the available petroleum resources have been produced, and predicts a decrease of production.

A government move away from fossil fuels would most likely create economic pressure through carbon emissions and green taxation. Some countries are taking action as a result of the Kyoto Protocol, and further steps in this direction are proposed. For example, the European Commission has proposed that the energy policy of the European Union should set a binding target of increasing the level of renewable energy in the EU's overall mix from less than 7% in 2007 to 20% by 2020.

The antithesis of sustainability is a disregard for limits, commonly referred to as the Easter Island Effect, which is the concept of being unable to develop sustainability, resulting in the depletion of natural resources. Some estimate, assuming current consumption rates, current oil reserves could be completely depleted by the year 2050.

Nuclear fuel

The International Atomic Energy Agency estimates the remaining uranium resources to be equal to 2500 ZJ. This assumes the use of breeder reactors, which are able to create more fissile material than they consume. IPCC estimated currently proved economically recoverable uranium deposits for once-through fuel cycles reactors to be only 2 ZJ. The ultimately recoverable uranium is estimated to be 17 ZJ for once-through reactors and 1000 ZJ with reprocessing and fast breeder reactors.

Resources and technology do not constrain the capacity of nuclear power to contribute to meeting the energy demand for the 21st century. However, political and environmental concerns about nuclear safety and radioactive waste started to limit the growth of this energy supply at the end of last century, particularly due to a number of nuclear accidents. Concerns about nuclear proliferation (especially with plutonium produced by breeder reactors) mean that the development of nuclear power by countries such as Iran and Syria is being actively discouraged by the international community.

Although at the beginning of the 21st century uranium is the primary nuclear fuel worldwide, others such as thorium and hydrogen had been under investigation since the middle of the 20th century.

Thorium reserves significantly exceed those of uranium, and of course hydrogen is abundant. It is also considered by many to be easier to obtain than uranium. While uranium mines are enclosed underground and thus very dangerous for the miners, thorium is taken from open pits, and is estimated to be roughly three times as abundant as uranium in the Earth's crust.

Since the 1960s, numerous facilities throughout the world have burned Thorium.

Nuclear fusion

Alternatives for energy production through fusion of hydrogen have been under investigation since the 1950s. No materials can withstand the temperatures required to ignite the fuel, so it must be confined by methods which use no materials. Magnetic and inertial confinement are the main alternatives (Cadarache, Inertial confinement fusion) both of which are hot research topics in the early years of the 21st century.

Fusion power is the process driving the sun and other stars. It generates large quantities of heat by fusing the nuclei of hydrogen or helium isotopes, which may be derived from seawater. The heat can theoretically be harnessed to generate electricity. The temperatures and pressures needed to sustain fusion make it a very difficult process to control. Fusion is theoretically able to supply vast quantities of energy, with relatively little pollution. Although both the United States and the European Union, along with other countries, are supporting fusion research (such as investing in the ITER facility), according to one report, inadequate research has stalled progress in fusion research for the past 20 years.

Renewable resources

Renewable resources are available each year, unlike non-renewable resources, which are eventually depleted. A simple comparison is a coal mine and a forest. While the forest could be depleted, if it is managed it represents a continuous supply of energy, vs. the coal mine, which once has been exhausted is gone. Most of earth's available energy resources are renewable resources. Renewable resources account for more than 93 percent of total U.S. energy reserves. Annual renewable resources were multiplied times thirty years for comparison with non-renewable resources. In other words, if all non-renewable resources were uniformly exhausted in 30 years, they would only account for 7 percent of available resources each year, if all available renewable resources were developed.

Solar energy

Renewable energy sources are even larger than the traditional fossil fuels and in theory can easily supply the world's energy needs. 89 PWof solar power falls on the planet's surface. While it is not possible to capture all, or even most, of this energy, capturing less than 0.02% would be enough to meet the current energy needs. Barriers to further solar generation include the high price of making solar cells and reliance on weather patterns to generate electricity. Also, current solar generation does not produce electricity at night, which is a particular problem in high northern and southern latitude countries; energy demand is highest in winter, while availability of solar energy is lowest. This could be overcome by buying power from countries closer to the equator during winter months, and may also be addressed with technological developments such as the development of inexpensive energy storage. Globally, solar generation is the fastest growing source of energy, seeing an annual average growth of 35% over the past few years. Japan, Europe, China, U.S. and India are the major growing investors in solar energy. Solar power's share of worldwide electricity usage at the end of 2014 was 1%.

Wind power

The available wind energy estimates range from 300 TW to 870 TW.[26][28] Using the lower estimate, just 5% of the available wind energy would supply the current worldwide energy needs. Most of this wind energy is available over the open ocean. The oceans cover 71% of the planet and wind tends to blow more strongly over open water because there are fewer obstructions.

Wave and tidal power

At the end of 2005, 0.3 GW of electricity was produced by tidal power.[29] Due to the tidal forces created by the Moon (68%) and the Sun (32%), and the Earth's relative rotation with respect to Moon and Sun, there are fluctuating tides. These tidal fluctuations result in dissipation at an average rate of about 3.7 TW.

Another physical limitation is the energy available in the tidal fluctuations of the oceans, which is about 0.6 EJ (exajoule). Note this is only a tiny fraction of the total rotational energy of the Earth. Without forcing, this energy would be dissipated (at a dissipation rate of 3.7 TW) in about four semi-diurnal tide periods. So, dissipation plays a significant role in the tidal dynamics of the oceans. Therefore, this limits the available tidal energy to around 0.8 TW (20% of the dissipation rate) in order not to disturb the tidal dynamics too much.

Waves are derived from wind, which is in turn derived from solar energy, and at each conversion there is a drop of about two orders of magnitude in available energy. The total power of waves that wash against our shores add up to 3 TW.

Geothermal

Estimates of exploitable worldwide geothermal energy resources vary considerably, depending on assumed investments in technology and exploration and guesses about geological formations. According to a 1999 study, it was thought that this might amount to between 65 and 138 GW of electrical generation capacity 'using enhanced technology'. Other estimates range from 35 to 2000 GW of electrical generation capacity, with a further potential for 140 EJ/year of direct use.

A 2006 report by MIT that took into account the use of Enhanced Geothermal Systems (EGS) concluded that it would be affordable to generate 100 GWe (gigawatts of electricity) or more by 2050, just in the United States, for a maximum investment of 1 billion US dollars in research and development over 15 years. The MIT report calculated the world's total EGS resources to be over 13 YJ, of which over 200 ZJ would be extractable, with the potential to increase this to over 2 YJ with technology improvements - sufficient to provide all the world's energy needs for several millennia. The total heat content of the Earth is 13,000,000 YJ.

Biomass

Production of biomass and biofuels are growing industries as interest in sustainable fuel sources is growing. Utilizing waste products avoids a food vs fuel trade-off, and burning methane gas reduces greenhouse gas emissions, because even though it releases carbon dioxide, carbon dioxide is 23 times less of a greenhouse gas than is methane. Biofuels represent a sustainable partial replacement for fossil fuels, but their net impact on greenhouse gas emissions depends on the agricultural practices used to grow the plants used as feedstock to create the fuels. While it is widely believed that biofuels can be carbon-neutral, there is evidence that biofuels produced by current farming methods are substantial net carbon emitters.[36][37][38] Geothermal and biomass are the only two renewable energy sources that require careful management to avoid local depletion.

Nuclear hazards

Radioactive (nuclear) pollution is a special form of physical pollution related to all major life-supporting systems - air, water and soil. It is always convenient to discuss radioactive pollution separately because its nature of contamination is different from other types of pollution. Its effects are also of special kinds.

Radioactivity is the phenomenon of emission of energy from radioactive isotopes (i.e., unstable isotopes), such as Carbon-14, Uranium-235, Uranium-238, Uranium-239, Radium-226, etc. The emission of energy from radioactive substances in the environment is often called as 'Radioactive Pollution'.

Sources/causes of nuclear hazards

The sources of radioactivity are both natural and man-made. The natural sources include:

1) Cosmic rays from outer space. The quantity depends on altitude and latitude; it is more at higher latitudes and high altitudes.

2) Emissions from radioactive materials from the Earth's crust.

People have been exposed to low levels of radiation from these natural sources for several millennia. But it is the man-made sources which are posing a threat to mankind. The man-made sources of radioactivity are nuclear wastes (i.e., waste material that contains radioactive nuclei) produced during the:

1) Mining and processing of radioactive ores;

2) Use of radioactive material in nuclear power plants;

3) Use of radioactive isotopes in medical, industrial and research applications; and

4) Use of radioactive materials in nuclear weapons.

The greatest exposure to human beings comes from the diagnostic use of X-rays, radioactive isotopes used as tracers and treatment of cancer and other ailments.

Effects of nuclear hazards

The effects of radioactive pollutants depend upon half-life, energy releasing capacity, rate of diffusion and rate of deposition of the contaminant. Various atmospheric conditions and climatic conditions such as wind, temperature and rainfall also determine their effects.

All organisms are affected from radiation pollution, and the effects are extremely dangerous. The effects may be somatic (individual exposed is affected) or genetic (future generations) damage. The effects are cancer, shortening of life span and genetic effects or mutations. Some of the possible effects are listed as under:

1) Radiations may break chemical bonds, such as DNA in cells. This affects the genetic make-up and control mechanisms. The effects can be instantaneous, prolonged or delayed types. Even it could be carried to future generations.

2) Exposure at low doses of radiations (100-250 rads), men do not die but begin to suffer from fatigue, nausea, vomiting and loss of hair. But recovery is possible.

3) Exposure at higher doses (400-500 rads), the bone marrow is affected, blood cells are reduced, natural resistance and fighting capacity against germs is reduced, blood fails to clot, and the irradiated person soon dies of infection and bleeding.

4) Higher irradiation doses (10,000 rads) kill the organisms by damaging the tissues of heart, brain, etc.

5) Workers handling radioactive wastes get slow but continuous irradiation and in course of time develop cancer of different types.

6) Through food chain also, radioactivity effects are experienced by man.

But the most significant effect of radioactivity is that it causes long range effects, affecting the future of man and hence the future of our civilization.

Control of nuclear hazards

On one hand, the peaceful uses of radioactive materials are so wide and effective that modern civilization cannot go without them; on the other hand, there is no cure for radiation damage. Thus the only option against nuclear hazards is to check and prevent radioactive pollution. For this:

1) Leakages from nuclear reactors, careless handling, transport and use of radioactive fuels, fission products and radioactive isotopes have to be totally stopped;

2) Safety measures should be enforced strictly;

3) Waste disposal must be careful, efficient and effective;

4) There should be regular monitoring and quantitative analysis through frequent sampling in the risk areas;

5) Preventive measures should be followed so that background radiation levels do not exceed the permissible limits;

6) Appropriate steps should be taken against occupational exposure; and

7) Safety measures should be strengthened against nuclear accidents.

Disposal of nuclear wastes

Since nuclear waste can be extremely dangerous and, therefore, the way in which they are to be disposed of is strictly controlled by international agreement. Since 1983, by international agreement, the disposal in the Atlantic Ocean and into the atmosphere has been banned.

After processing, to recover usable material and reducing the radioactivity of the waste, disposal is made in solid form where possible. The nuclear wastes are usually classified into three categories:

1) High Level Wastes (HLW): High level wastes have a very high-radioactivity per unit volume. For example, spent nuclear fuel. HLWs have to be cooled and are, therefore, stored for several decades by its producer before disposal. Since these wastes are too dangerous to be released anywhere in the biosphere, therefore, they must be contained either by converting them into inert solids (ceramics) and then buried deep into earth or are stored in deep salt mines.

2) Medium level wastes (MLW): Medium level wastes (e.g., filters, reactor components, etc.,) are solidified and are mixed with concrete in steel drums before being buried in deep mines or below the sea bed in concrete chambers.

3) Low liquid wastes (LLW): Low liquid wastes (e.g., solids or liquids contaminated with traces of radioactivity) are disposed of in steel drums in concrete-lined trenches in designated sites.

In India, a Waste Immobilization Plant (WIP) was commissioned in 1985 at Tarapore. It verifies HLWs.

Nuclear Fission and Fusion

Nuclear fission is the splitting of a heavy nucleus into two lighter ones. Fission was discovered in 1938 by the German scientists Otto Hahn, Lise Meitner, and Fritz Strassmann, who bombarded a sample of uranium with neutrons in an attempt to produce new elements with Z > 92. They observed that lighter elements such as barium (Z = 56) were formed during the reaction, and they realized that such products had to originate from the neutron-induced fission of uranium-235:

$$^{235}{}_{92}U+^{1}{}_{0}n \rightarrow ^{141}{}_{56}Ba + ^{92}{}_{36}Kr + 3^{1}{}_{0}n$$

$$_{92}{}^{235}U+_{0}{}^{1}n\rightarrow_{56}{}^{141}Ba+_{36}{}^{92}Kr+3_{0}{}^{1}n$$

This hypothesis was confirmed by detecting the krypton-92 fission product. The nucleus usually divides asymmetrically rather than into two equal parts, and the fission of a given nuclide does not give the same products every time.

In a typical nuclear fission reaction, more than one neutron is released by each dividing nucleus. When these neutrons collide with and induce fission in other neighboring nuclei, a selfsustaining series of nuclear fission reactions known as a nuclear chain reaction can result. For example, the fission of 235U releases two to three neutrons per fission event. If absorbed by other 235U nuclei, those neutrons induce additional fission events, and the rate of the fission reaction increases geometrically. Each series of events is called a generation. Experimentally, it is found that some minimum mass of a fissile isotope is required to sustain a nuclear chain reaction; if the mass is too low, too many neutrons are able to escape without being captured and inducing a fission reaction. The minimum mass capable of supporting sustained fission is called the critical mass. This amount depends on the purity of the material and the shape of the mass, which corresponds to the amount of surface area available from which neutrons can escape, and on the identity of the isotope. If the mass of the fissile isotope is greater than the critical mass, then under the right conditions, the resulting supercritical mass can release energy explosively. The enormous energy released from nuclear chain reactions is responsible for the massive destruction caused by the detonation of nuclear weapons such as fission bombs, but it also forms the basis of the nuclear power industry.

Nuclear fusion, in which two light nuclei combine to produce a heavier, more stable nucleus, is the opposite of nuclear fission. As in the nuclear transmutation reactions discussed in Section 20.2, the positive charge on both nuclei results in a large electrostatic energy barrier to fusion. This barrier can be overcome if one or both particles have sufficient kinetic energy to overcome the electrostatic repulsions, allowing the two nuclei to approach close enough for a fusion reaction to occur. The principle is similar to adding heat to increase the rate of a chemical reaction. As shown in the plot of nuclear binding energy per nucleon versus atomic number in equation. Fusion reactions are most exothermic for the lightest element. For example, in a typical fusion reaction, two deuterium atoms combine to produce helium-3, a process known as deuterium–deuterium fusion (D–D fusion).

$$2{}_2{}^1H \rightarrow {}^3{}_2He + {}^1{}_0n$$

$${}^2{}_1H + {}^3{}_1H \rightarrow {}^4{}_2He + {}^1{}_0n$$

Disposal of nuclear waste, nuclear disaster and its management:

The emergence of nuclear energy offers promising opportunity for low cost and highly efficient energy sources. However, the proper disposal of nuclear waste is still highly challenging. Nuclear waste is one of the most difficult kinds of waste to manage because it is highly hazardous. According to the U.S. Environmental Protection Agency (EPA), nuclear waste is sorted into six general categories. These include (1) spent nuclear fuel from nuclear reactors, (2) uranium mill tailings from mining and milling of uranium ore, (3) high-level waste from spent nuclear fuel reprocessing, (4) low-level waste, (5) transuranic waste from defense programs, and (6) naturally occurring and accelerator-produced radioactive materials.

The health concerns and safety issues associated with nuclear waste present important constraints on the widespread use of nuclear energy. Due to its radioactivity and highly hazardous properties, nuclear waste is required to be very carefully stored or reprocessed. The storing and reprocessing are further complicated by the long half-life of the radioactive materials in the nuclear waste. For example, some of the components can remain half of their dangerous levels even one million years later after production. This makes the nuclear waste extremely difficult to be controlled and stored. Even if the waste is well stored, it is difficult to guarantee that the storages can be maintained properly for a long time period. Therefore, in order to reduce the amount of nuclear waste produced, the use of nuclear power is limited. In this work the current methods of nuclear waste disposal and issue associated with them are reviewed.

Disposal and Management of Nuclear Waste

The disposal methods for nuclear waste most used are simple storage. For example, dry cask storage uses steel cylinders along with inert gas or water to seal and store radioactive waste from spent fuel pool. The steel cylinder is usually further placed in a concrete cylinder. These cylinders serve as radiation shield for the nuclear waste, stopping the radiation from reach in the outside. This is a relatively inexpensive way for storing radioactive waste. It doesn't require special location and transportation. The radioactive waste can be easily stored at a on-site reactor facility or adjacent to the source reactor. In addition, it is convenient to retrieve the waste from those storage cylinders for future reprocessing.

The other storage methods involve the selection of appropriate geologic location for the storage of high level radioactive waste. In this method, deep and stable geologic formations were selected to store the nuclear waste for long term. In this process, large and stable geologic locations are first located and then excavated to form long tunnels (~kilometers) under the surface using conventional mining technology. The spent fuel and radioactive waste are then placed in the tunnels. Since the geologic formations chosen in this method are far from human population centers, the nuclear wastes are expected to be stably isolated from human living environment for the long term. This technique is still under investigation and development. Several countries in the world (e.g. England and France) were on the way of using this geologic disposal technique. However, there are still many concerns about this geologic disposal technique, because the stored nuclear waste has potential to leak into the environment if any huge geologic changing occurs (e.g. an earthquake). Moreover, even very low leakage or migration of nuclear waste may result in a huge disaster because the half-lives of the nuclear waste are so long. In this case, the nuclear waste would become a human catastrophe. Therefore, many countries in the world still don't agree with the using of this deep geologic disposal technique.

A similar technique is storaging the nuclear waste under then ocean. Essentially this is a kind of geologic disposal. However, considering that the nuclear waste would leak and migrate more easily in the ocean, this technique has the higher risk for nuclear waste spreading. Moreover, this ocean disposal may be more difficult to monitor for leakage of the nuclear waste, making the control and management of the nuclear waste further challenging.

The proper disposal of nuclear waste is still a challenging issue that constrains the growth of nuclear power. The main issue is that the half-lives of the radioisotopes produced are very long. Some of them are greater than a million years. This makes control and management of the nuclear waste extremely difficult. The most currently-used method for nuclear waste disposal is storage, either using steel cylinders as radioactive shield or using deep and stable geologic formations. However, the disposal of nuclear waste by storage still has many concern, since the leakage of the nuclear waste may cause huge environmental disaster. These techniques are still under development.

Introduction to biocatalysis:

Biocatalysis have many advantages over chemocatalysis in the context of green chemistry, which include mild reaction conditions (physiological pH and temperature), the use of environmentally compatible catalysts (enzymes) and solvents (usually water), high catalytic activity and good regio- and chemo-selectivities for multifunctional molecules. As a result, the use of enzymes can avoid the need for functional group activation, or unnecessary protection/deprotection steps.

Some of the major themes in biocatalysis are as follows:

- Biocatalysts (enzymes/whole cells) can replace chemo-catalysts in synthetic routes.
- Biocatalysts can enable new synthetic pathways which may be shorter, more efficient and more sustainable.
- Combining chemo- and bio-catalysis generates opportunities for the design of synthetic routes.
- Biocatalysts with a broad substrate scope that are active and stable under the conditions of a chemical process are needed.

There are a range of emerging technologies for biocatalyst development (directed evolution/pathway engineering).

Green chemistry:

Green chemistry deals with designing chemical products and processes that generate anduse fewer (or preferably no) hazardous substances. By applying the principles of green chemistry, companies embrace cleaner and more efficient technologies, with an a priori commitment to a cleaner and healthier environment. Prevent waste instead of treating it.

Anastas and Warner formulated the following 12 principles of green chemistry

– Design atom-efficient synthetic methods.
– Choose synthetic routes using nontoxic compounds where possible.
– Design new products that preserve functionality while reducing toxicity.
– Minimize the use of auxiliary reagents and solvents.
– Design processes with minimal energy requirements.
– Preferably use renewable raw materials.
– Avoid unnecessary derivatization.
– Replace stoichiometric reagents with catalytic cycles.
– Design new products with biodegradable capabilities.
– Develop real-time and on-line process analysis and monitoring methods.
– Choose feedstocks and design processes that minimize the chance of accidents

Three important developments for Green Chemistry:

- The detection and use of supercritical carbon dioxide as a green solvent dissolved in water.
- Hydrogen peroxide for green oxidations and
- The use of hydrogen for stereo-selective syntheses.

An example of the implementation of Green Chemistry is the oxidation reaction with supercritical water (supercritical water oxidation), and solvent-free reactions (Dry media reaction).

Importance of green chemistry:

Academic Chemists

Academic Chemists work in the growing number of universities that offer green chemistry coursework or programs. There are more opportunities for curriculum development in green chemistry programs than with conventional academic chemistry positions.106 A growing number of businesses are collaborating with academic programs, creating more opportunities for green chemists.

Biofuels Plant Engineers

Biofuels Plant Engineers are involved in the large-scale production of alternative, bio-based fuels, such as ethanol-added gasolines, biodiesel, and other new biofuels at biofuel production facilities.

Biomolecular Engineers

Biomolecular Engineers can be an important part of any green research team. Although the traditional role of chemical and biomolecular engineers has been to develop processes to efficiently produce chemical products on an industrial scale, modern biomolecular engineers tend to be much more involved in all phases of research and development. Green chemistry engineers work on projects such as cleaner smelting and refining processes, and how to turn crops or trees into sustainable fuels as well as biodegradable plastics and fabrics.

Pharmaceutical Chemists

Pharmaceutical Chemists aid the drug industry in its ongoing efforts to develop medicines with less harmful side-effects, using processes that produce less toxic waste. The chemical production of drug molecules for commercial use is vastly different from conventional bulk manufacture of, for instance, commodity chemicals. More than half the mass constituting a process stream in the chemical manufacture of active pharmaceutical ingredients generally stems from the solvent(s) utilized; 80-90% if water is included. This means that the potential for production improvements is huge. At some companies, environmental specialists, pharmaceutical development chemists, chemical engineers and medicinal chemists all work together to improve drug manufacturing.

Recycling Specialists

Recycling Specialists work with businesses and municipalities to aid in reusing and recycling chemicals and other wastes produced by industrial processes and by everyday household activities. These specialists develop and run their recycling programs.

Regulatory Specialists

Regulatory Specialists work with governmental organizations and policymakers to implement and maintain mechanisms in place to foster green chemistry research and education. At the local, state, and federal levels, these programs can play a key role in prioritizing and promoting green chemistry and sustainable technologies.

Research Chemists

Research Chemists undertake research to discover more benign alternatives to the many thousands of hazardous chemicals used in modern refining and manufacturing processes. Hundreds of research chemists are employed in green chemistry. They conduct research in many areas, including safer and less-polluting industrial solvents and plant-based substitutes for petrochemical products.

Possible questions

PART-B (Two mark questions)

1. What is the geothermal energy?
2. Define Tidal energy?
3. Write a note on sources of energy?
4. Define hydel?
5. What is nuclear fission?
6. Define hazardous wastes?
7. What is nuclear fusion?

PART-C (Eight mark questions)

1. What are all the water quality parameters?
2. Explain the nuclear disaster and its management?
3. Write the importance of green chemistry in chemical industry?
4. Write any two methods are involved in water treatment?
5. Explain the various types of radio-active radiations. Write notes on disposal of radio-active wastes?
6. Explain the solar energy and its applications?
7. what is nuclear pollution. Explain its effects on environment ?
8. Discuss the following
   (i) Biocatalysis (ii) Green chemistry
9. Explain the various types of radio-active radiations. Write notes on disposal of radio-active wastes?
10. Explain the following (i) Geothermal energy (ii) Tidal energy

UNIT -5						
1	Which of the following is a non-renewable resource?	(a) Coal	(b) Forests	(c) Water	(d) Wildlife	**(c) Water**
2	Which among the following is not a renewable source of energy?	(a) Solar energy	(b) Biomass energy	(c) Hydro-power	(d) Geothermal energy	**(b) Biomass energy**
3	Which of the following is a disadvantage of most of the renewable energy sources?	(a) Highly polluting	(b) High waste disposal cost	(c) Unreliable supply	(d) High running cost	**(c) Unreliable supply**
4	Photovoltaic energy is the conversion of sunlight into:	(a) Chemical energy	(b) Biogas	(c) Electricity	(d) Geothermal energy	**(c) Electricity**
5	Lignite, bituminous and anthracite are different ranks of:	(a) Nuclear fuel	(b) Coal	(c) Natural gas	(d) Biogas	**(b) Coal**
6	Boiling water reactor and pressurised water reactors are:	(a) Nuclear reactor	(b) Solar reactor	(c) OTEC	(d) Biogas reactor	**(a) Nuclear reactor**
7	Cruid oil is:	(a) Colourless	(b) Odourless	(c) Smelly yellow to black liquid	(d) Odourless yellow to black liquid	**(c) Smelly yellow to black liquid**
8	The outermost layer of the earth is:	(a) Magma	(b) Mantle	(c) Crust	(d) Solid iron core	**(c) Crust**
9	9. Which of the following is a disadvantage of most of the renewable energy sources?	(a) Highly polluting	(b) High waste disposal cost	(c) Unreliable supply	(d) High running cost	**(c) Unreliable supply**
10	Horizontal axis and vertical axis are the types of:	(a) Nuclear reactor	(b) Wind mills	(c) Biogas reactor	(d) Solar cell	**(a) Nuclear reactor**
11	Both power and manure is provided by:	(a) Nuclear plants	(b) Thermal plants	(c) Biogas plants	(d) Hydroelectric plant	**(a) Nuclear plants**
12	The one thing that is common to all fossil fuels is that they:	(a) Were originally formed in marine	(b) Contain carbon	(c) Have undergone the	(d) Represent the remains of	**(b) Contain carbon**

		environment		same set of geological processes	one living organisms	
13	The following type of energy is stored as latent heat	(a) Thermal energy	(b) Chemical energy	(c) Electrical energy	(d) Mechanical energy	**(a) Thermal energy**
14	One tonne of uranium contains an equivalent amount coal of energy as	(a) 1000 tonnes	(b) 10000 tonnes	(c) 20000 tonnes	(d) 50000 tonnes	**(c) 20000 tonnes**
15	The energy release in the fission of a ^{235}U nucleus is about	(a) 200 MeV	(b) 100 MeV	(c) 500 MeV	(d) 250 MeV	**(a) 200 MeV**
16	What is the leading source of energy used in the United States today?	(a) Coal	(b) Oil resources	(c) Nuclear	(d) natural gas	**(b) Oil resources**
17	Which of the following energy sources does not produce carbon dioxide?	(a) Coal	(b) Uranium	(c) Oil	(d) natural gas	**(b) Uranium**
18	A major problem with nuclear energy is that	(a) Initial cost is high	(b) Produces acid rain	(c) production is limited	(d) All of the above	**(a) Initial cost is high**
19	“Geothermal” means:	(a) “Geo” means “Fossil” and “Thermal” means “Fuel”	(b) “Geo” means “Plants” and “Thermal” means “Oil”	(c) “Geo” means “Earth” and “Thermal” means “Heat”	(d) “Geo” means “Oil” and “Thermal” means “Drill”	**(c) “Geo” means “Earth” and “Thermal” means “Heat”**
20	What is the main disadvantage of solar energy?	(a) It may suddenly run out	(b) It is not concentrated	(c) Creates a variety of pollutants	(d)None of the above	**(a) It may suddenly run out**
21	The following is indirect method of solar energy utilization	(a) Wind energy	(b) Biomass energy	(c) Wave energy	(d) All of the above	**(d) All of the above**
22	Green chemistry aims to?	(a) Design chemical products and process that	(b) Design safer chemical	(c) Design chemical products and	(d) Utilize non-renewable energy	**(b) Design safer chemical products and processes that**

		maximize profits	products and processes that reduce or eliminate the use and generation of hazardous substances	processes that work most efficiently		**reduce or eliminate the use and generation of hazardous substances**
23	Which of the following are among the 12 Principles of Green Chemistry?	(a) Design commercially viable products	(b) Use only new solvents	(c) Use catalysts, not stoichiometric reagents	(d) Re-use waste	**(d) Re-use waste**
24	Green chemists reduce risk by?	(a) Reducing the hazard inherent in a chemical product or process	(b) Minimizing the use of all chemicals	(c) Inventing technologies that will clean up toxic sites	(d) Developing recycled products	**(b) Minimizing the use of all chemicals**
25	The first listed of the 12 Principles of Green Chemistry is?	(a) Prevent waste	(b) Catalysis	(c) Atom economy	(d) Benign solvents	**(a) Prevent waste**
26	Which of the following is the greenest solvent?	(a) Formaldehyde	(b) Benzene	(c) Ethanol	(d) Water	**(d) Water**
27	________ is an excellent 'green' solvent as well as a greenhouse gas?	(a) Methanol	(b) CFCs	(c) Carbon monoxide	(d) Carbon Dioxide	**(d) Carbon Dioxide**
28	An example of green chemistry is?	(a) Recycled carpet	(b) A product made on Earth Day	(c) A sublimation reaction	(d) Bio-plastics	**(c) A sublimation reaction**
29	Which of the following is the best definition for the term *radionuclide*?	(a) The nucleus of any atom	(b) the nucleus of an atom that contains more than 75 neutrons	(c) An atom whose nucleus absorbs radiation	(d) an atom whose nucleus is unstable	**(d) an atom whose nucleus is unstable**

30	The loss of an alpha particle by a radioactive nuclide causes	(a) no change in mass number	(b) the atomic number to decrease by 4	(c) the mass number to decrease by 2	(d) the atomic number to decrease by 2	**(d) the atomic number to decrease by 2**
31	Radioisotopes used in diagnostic medical procedures are usually	(a) Alpha emitters	(b) beta emitters	(c) gamma emitters	(d) radionuclides with long half-lives.	**(c) gamma emitters**
32	The term *nuclear energy* is most closely associated with which one of the following processes?	(a) Nuclear fusion	(b) nuclear fission	(c) radioactive decay	(d) bombardment reactions	**(b) nuclear fission**
33	Which of the following fuel material occurred naturally?	(a) U^{235}	(b) Pu^{239}	(c) Pu^{241}	(d) U^{-233}	**(a) U^{235}**
34	The function of a moderator is to	(a) Absorb the part of the Kinetic energy of the neutrons	(b) extract the heat	(c) Reflect back some of the neutrons	(d) start the reactor	**(a) Absorb the part of the Kinetic energy of the neutrons**
35	Which of the following is not used as moderator?	(a) Water	(b) heavy water	(c) graphite	(d) boron	**(d) boron**
36	The function of coolant is to	(a) Extract heat from reactor	(b) slow down neutrons	(c) control the reaction	(d) reflect the neutrons	**(a) Extract heat from reactor**
37	Which of the following has highest moderating ratio?	(a) D_2O	(b) H_2O	(c) Carbon	(d) Helium	**(a) D_2O**
38	Direct Solar energy is used for	(a) Water heating	(b) Distillation	(c) Drying	(d) All of the above	**(d) All of the above**
39	The power from the sun intercepted by the earth is approximately	(a) 1.8×10^8 MW		(c) 1.8×10^{14} MW	(d) 1.8×10^{17} MW	**(b) 1.8×10^{11} MW**
40	The following is indirect method of solar energy	(a) Wind energy	(b) Biomass energy	(c) Wave energy	(d) All of the above	**(d) All of the above**

	utilization					
41	A liquid flat plate collector is usually held tilted in a fixed position, facing _____ if located in the northern hemisphere.	(a) North	(b) South	(c) East	(d) West	**(b) South**
42	42. Maximum efficiency is obtained in	(a) Flat plate collector	(b) Evacuated tube collector	(c) Line focussing collector	(d) Paraboloid dish collector	**(d) Paraboloid dish collector**
43	The following type of energy is stored as latent heat	(a) Thermal energy	(b) Chemical energy (c) Electrical energy	(c) Electrical energy	(d) Mechanical energy	**(a) Thermal energy**
44	Absorption of Solar radiations at earth's surface occur due to presence of	(a) Ozone	(b) Water vapours	(c) Carbon di-oxide	(d) All of the above	**(d) All of the above**
45	Which of the following is not a bio-mass source?	(a) Gobar gas	(b) Coal	(c) Wood	(d) Nuclear energy	**(d) Nuclear energy**
46	The energy which is not derived from the sun is ______	(a) Fossil fuel	(b) geothermal energy	(c) Biomass	(d) Nuclear energy	**(d) Nuclear energy**
47	Harmful radiation emitted by the sun is ______	(a) IR	(b) UV	(c) X ray	(d) gamma ray	**(b) UV**
48	A substance which produces a lot of heat on burning is called ______.	(a) Fuel	(b) biogas	(c) biomass	(d) oxidizing agent	**(a) Fuel**
49	The main constituent of LPG is ______	(a) Butane	(b) Propane	(c) methane	(d) hydrogen	**(a) Butane**
50	A solar cell is made up of ______	(a) Titanium	(b) Silicon	(c) Magnesium	(d) Plastic	**(b) Silicon**

51	Atomic energy is obtained by using the ores of ________	copper	uranium	lithium	radium	**uranium**
52	The death of last individual of a species is called _________	extinction	clay	vanishe	climax	**extinction**
53	Red data books provide a list of ___________	advanced plants	rare, endangered or endemic species	disease resistant animals	minerals	**rare, endangered or endemic species**
54	The resources that can be replaced by natural ecological cycle is called……….	Natural Resources	Exhaustible Resources	Non renewable resources	Renewable Resources	**Renewable Resources**
55	___________ is the major raw material for biogas	Plant leaves	Cow dung	Mu	Grass	**Cow dung**
56	Bio gas generation is mainly based on the principle of ____________	fermentation	degradation	purification	sedimentation	**fermentation**
57	The movement of soil compounds is called…….	Soil Nutrition	Soil erosion	Flooding	Sedimentation	**Soil erosion**
58	Blue revolution is associated with _______	agriculture	iron and steel	irrigation	fishing	**fishing**
59	A form of energy or matter that is essential for the functioning and sustained survival of living organism within a specific population or ecosystem is called ________________	resources	natural resource	environment	forest	**resources**
60	Water which is an universal solvent for most of the biochemical and biological process,constitutes about the	15	20	25	30	**15**

	total volume of _____________ billion kilometers					

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KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed University Established Under Section 3 of UGC Act 1956)

M.Sc., DEGREE EXAMINATION, FEBRUARY-2018
(For the candidates admitted from 2017 onwards)

DEPARTMENT OF CHEMISTRY
EVEN SEMESTER

INTERNAL EXAM-I
INDUSTRIAL CHEMICALS AND ENVIRONMENT

Time: 2 hours
Maximum: 50 marks
Date : 1-2-2018

PART- A

ANSWER ALL QUESTIONS **(20 x 1=20 Marks)**

1. Industrially nitrogen gas was prepared by

(a) Sublimation (b) Distillation (c) Fractional distillation (d) Double distillation

2. The toxicity of chlorine based on

(a) HCl (b) HClO (c) PCl_5 (d) PCl_3

3. If acidified $K_2Cr_2O_7$ acts as oxidizing agent, on oxidation color changes from

(a) orange to red (b) orange to green (c) yellow to green (d) yellow to red

4. Which of the following is not a use of potash alum?

(a) Arrest bleeding (b) Pesticide (c) Mordant in dyeing (d) coagulant in water

5. Potassium Permanganate is used for purifying drinking water, because

(a) It is a sterilizing agent (b) it dissolves the impurities of water (c) It is a reducing agent (d) it is an oxidising agent

6. Welding of Mg can be done in an atmosphere of

(a) He(b) Xe(c) Kr (d) Oxygen

7. Raw material required for production of sulfuric acid is

(a) Sulfur with water (b) chlorine with air (c) oxygen (d) hydrogen gas

8. Explosive such as trinitrotoluene (TNT) is made by

(a) Concentrated nitric acid (b) ammonia (c) nitrate (d) Sulphuric acid

9. Production of large quantity of ammonia is done by increasing

(a) Temperature (b) catalyst (c) pressure (d) humidity

10. The acid used in lead storage cells is

(a) Nitric acid (b) Sulphuric acid (c) hydrochloric acid (d) Phosphoric acid

11. Zone refining method is also known as

(a) Electrolytic refining(b) Vapour phase(c) fractional crystalisation (d) chromatography

12. The Chemical formula for Phosgene is

(a) $COCl_2$ (b) $CaSO_4$ (c) $MgSO_4$ (d) $CaCl_2$

13. The process of electrolysis is used in

(a) Washing (b) Cleaning (c) purification (d) wetting

14 In which method high purity of nickel can be obtained

(a) Electrolytic refining (b) Parting process (c) Mond's process (d) Van Arkel method

15. Titanium is purified by the following process

(a) Parting (b) Kroll (c) Van arkel (d) Hydrometallurgy

16. Ellingham diagram is used to separate

(a) Metallic oxides (b) Metallic sulphates (c) Metal halides (d) Metals

17. Moisture and volatile impurities are removed by

(a) Calcination (b) Smelting (c) Roasting (d) Bessimerization

18. In the electrolytic process, impure material deposited at

(a) Anode (b) Cathode (c) Neutral (d) Electrolyte

19. Pure iron melts at

(a)1536°C (b)1537°C (c)1436°C (d)1437°C

20. Which of the following is a secondary air pollutant?

(a) CS_2 (b) CO (c) O_3 (d) SO_2 (d) CO_2

PART-B (3X 2 = 6)

ANSWER ALL THE QUESTIONS

21. Write any two uses of Nitrogen?

22. What is parting process?

23. What are the types of pollutants involved in air pollution?

PART-C (3 X 8 = 24)

ANSWER ALL THE QUESTIONS

24. (a) Discuss the production, storage and uses of hydrogen?

(OR)

(b) Explain the manufacture, analysis and handling of Sulphuric acid?

25. (a) Sketch and explain the Ellingham diagram of metal oxides?

(OR)

(b) Write a note on Van Arkel-de Boer and Mond's process?

26. (a) Mention the sources, effects and control method of air pollution of various air pollutants?

(OR)

(b) Briefly explain the global warming and its effects?