1) Briefly describe about the causes of mining hazard in reference to open pit & underground mining.

Ans.

Improper mining practice is the prime cause of mining hazard.

**Open pit mining**

Open pit mining, where material is excavated from an open pit, is one of the most common forms of mining for strategic minerals. This type of mining is particularly damaging to the environment because strategic minerals are often only available in small concentrations, which increases the amount of ore needed to be mined.

Environmental hazards are present during every step of the open-pit mining process. Hardrock mining exposes rock that has lain unexposed for geological eras. When crushed, these rocks expose radioactive elements, asbestos-like minerals, and metallic dust. During separation, residual rock slurries, which are mixtures of pulverized rock and liquid, are produced as tailings, toxic and radioactive elements from these liquids can leak into bedrock if not properly contained.

**Underground Mining**

Underground mining has the potential for tunnel collapses and land subsidence. It involves large-scale movements of waste rock and vegetation. Additionally, like most traditional forms of mining, underground mining can release toxic compounds into the air and water.

The harmful minerals and heavy metals released during underground mining contaminate water. This contaminated water can pollute the region surrounding the mine and beyond. Mercury is commonly used as an amalgamating agent to facilitate the recovery of some precious ores. Mercury tailings then become a major source of concern, and improper disposal can lead to contamination of the atmosphere and neighbouring bodies of water. Most underground mining operations increase sedimentation in nearby rivers through their use of hydraulic pumps and suction dredges; blasting with hydraulic pumps removes ecologically valuable topsoil containing seed banks, making it difficult for vegetation to recover. Deforestation due to mining leads to the disintegration of biomes and contributes to the effects of erosion.

2) What are the consequences of underground mining on groundwater and atmosphere?

Ans.

**Underground Mining**

- Improper ventilation producing toxic gases mostly in coal mines pollutes atmosphere.
- Mining area intersecting water table causes contamination of groundwater.
- Subsidence of ground due removal of ore from subsurface affects environment.
Open Pit Mining

- Noise produced due to blasting and movement of heavy machineries causes atmospheric pollution.
- Dust produced by mining activities affects nearby area. Finer dust particles because of high surface area affected by chemical changes causing harm to both groundwater and atmosphere.
- Improper solid waste disposal contaminates the soil, ground water and air.
- Landscape changes due to large scale excavation affects groundwater.
- Acid mine drainage due to oxidation of ore also affects groundwater.

3) Briefly describe the impact of Solid waste and liquid waste (result of processing) on environment.

**Ans.** Liquid waste directly released to the nearby water bodies causing its contamination. Ex. Gold occurs in association with sulphide minerals. During recovery of gold by amalgamation or cyanidation process releases harmful chemicals which harshly affect environment. Solid wastes usually produced by beneficiation process which use for the enhancement of primary ore grade. Improper disposal of solid waste contaminates the soil, groundwater and air of the nearby area of disposal.

4) What is acid mine drainage and how is it generated? How would you assess the net impact of acid mine drainage in an area?

**Ans.** Acid mine drainage is caused when water flows over or through sulfur-bearing materials forming solutions of net acidity. Acid mine drainage comes mainly from abandoned coal mines and currently active mining as well.

- Mine drainage is formed when pyrite, an iron sulfide, is exposed and reacts with air and water to form sulfuric acid and dissolved iron.
- Some or all of this iron can precipitate to form the red, orange, or yellow sediments in the bottom of streams containing mine drainage.
- The acid runoff further dissolves heavy metals such as copper, lead, mercury into ground or surface water.
- The rate and degree by which acid-mine drainage proceeds can be increased by the action of certain bacteria.

I. Analysis of pH
II. Analysis of sulphur species and calculation of acid potential (AP)
III. Analysis of neutralization potential (NP)
IV. Calculation of NP/AP (NPR) and NP-AP (NNP)

5) What is the fate of $\text{Fe}^{2+}$ & $\text{Fe}^{3+}$ which released during reaction of pyrite with oxygen &water?

**Ans.** $\text{FeS}_2 + \frac{7}{2}\text{O}_2 + \text{H}_2\text{O} \rightarrow \text{Fe}^{2+} + 2\text{SO}_4^{2-} + 2\text{H}^+$

$\text{Fe}^{2+}$ is produced in the above reaction gets oxidised in presence of hydrogen and further produces $\text{Fe}^{3+}$. The $\text{Fe}^{3+}$ produced in this manner reacts with water producing Iron hydroxide and hydrogenion.
\[
\text{Fe}^{2+} + \frac{1}{4} \text{O}_2 + \text{H}^+ \Leftrightarrow \text{Fe}^{3+} + \frac{1}{2}\text{H}_2\text{O}
\]

\[
\text{Fe}^{3+} + 3\text{H}_2\text{O} \Leftrightarrow \text{Fe(OH)}_3 + 3\text{H}^+
\]

When surface water flow in form of drainage or pumped out of the opencast mine site eventually discharged into local water bodies. Longer the duration for which these ore bodies remain exposed to the atmosphere higher is the chances of acidic water to be produced. This process is accentuated by microorganisms.

6) Briefly discuss about acid neutralization and acid-base accounting.

Ans.

There are situations in nature where acid produced during mine get neutralised. The main neutralizing agents in the decreasing order of their potential are 1) Carbonates 2) Lime (Ca(OH)_2) 3) Metal hydroxide 4) Silicates. Either they act as a sink of hydrogen ion or neutralize the hydrogen ion.

- Acid-Base Accounting (ABA) is the balance between the acid production and acid consumption properties of a mine waste material.
- Minerals in waste material (mostly sulfides; mostly pyrite) react with water and oxygen to produce sulphuric acid.
- This acid is itself detrimental to water quality.
- Acid leaches metals from material and introduces them into the environment.

7) Describe how the environment is affected by mining and quarrying and through processing and smelting of ores. What is acid rain?

Ans.

Mining and quarrying can be very destructive to the environment. They have a direct impact on the countryside by leaving pits and heaps of waste material. This waste material when mixes with surrounding environment causes loss of biodiversity, erosion, contamination of surface water, ground water, and soil. The formation of sinkholes is also possible.

Slag is a stony waste matter separated from metals during the smelting or refining of ore. This slag is emitted into the air, causing pollution. The vast majority of pollution is caused from the air emissions from smelting. Some air pollutants include sulfur dioxide and nitrogen oxide. When sulfur dioxide reacts with the atmosphere, forms a sulfuric acid mist. As the acid rain falls to the earth, the acidity of soils, streams, rivers, and lakes, harming the vegetation and living organisms in the area. Material containing sulphide sulphur more than 9% produces acid which cannot be neutralized by CaCO_3 as well.

Acid rain refers to a mixture of deposited material, both wet and dry, coming from the atmosphere containing more than normal amounts of nitric and sulfuric acids. Acid rain usually has a pH between 4.2 and 4.4.
8) **Describe in brief about the spontaneous combustion of Coal.**

**Ans.**

The process of self-heating of coal due to auto oxidation resulting eventually in its ignition is termed as spontaneous combustion of coal. It is the most important cause of fires in coal mines across the world.

The following general factors have been mentioned as contributing causes:

I. Coal handling procedures allowed for long-time retention of coal, which increases the possibility of heating.

II. New coal added on top of old coal created segregation of particle sizes, which is a major cause of heating.

III. Too few temperature probes installed in the coal bunker resulted in an excessive period of time before the fire was detected.

IV. Failure of equipment needed to fight the fire (drag chain conveyer).

V. Ineffective capability and use of carbon dioxide fire suppression system.

VI. Delay in the application of water.

VII. Inadequate policies, procedures, and training of personnel prevented proper decision making, including the required knowledge to immediately attack the fire.

9) **Describe in brief about the nuclear fuel cycle.**

**Ans.**

- The nuclear fuel cycle is the series of industrial processes which involve the production of electricity from uranium in nuclear power reactors.
- Uranium is a relatively common element that is found throughout the world. It is mined in a number of countries and must be processed before it can be used as fuel for a nuclear reactor.
- Fuel removed from a reactor, after it has reached the end of its useful life, can be reprocessed so that most is recycled for new fuel.

The process is done as follows:

Mining of uranium ore → Milling(Tailing removed) → Conversion(Process of extraction) → Enrichment (Increase the proportion of U235) → Fuel Fabrication → Power Plant (Energy generated) → Reprocessing → Final Disposal
10) Write down about the different types of radioactive waste. Add a note on the process followed for their disposal.

Ans.

Low level waste – Low-level waste (LLW) has a radioactive content not exceeding four gigabequerels per tonne (GBq/t) of alpha activity or 12 GBq/t beta-gamma activity. LLW does not require shielding during handling and transport, and is suitable for disposal in near surface facilities. Ex: – Uranium mine tailings – Potentially dangerous as land fill, source of contamination of ground water; Large volumes of wastes from nuclear power plant, Laboratories and Hospitals – contaminated lab equipment, protective clothing, animal parts.

Disposal: – Put in trenches, put in solid concrete and put into the sea. To reduce its volume, LLW is often compacted or incinerated before disposal. LLW comprises some 90% of the volume but only 1% of the radioactivity of all radioactive waste.

Intermediate level waste – Intermediate-level waste (ILW) is more radioactive than LLW, but the heat it generates (<2 kW/m³) is not sufficient to be taken into account in the design or selection of storage and disposal facilities. Due to its higher levels of radioactivity, ILW requires some shielding. Material used in Nuclear power plants, flasks used to transport fuel, various liquids used in the plant, contaminated rags, tools, clothing, etc. Spent filter cartridges, Spent demineralizer resins.

Disposal: – Smaller items and any non-solids may be solidified in concrete or bitumen for disposal.

High level waste – High-level waste (HLW) is sufficiently radioactive for its decay heat (>2kW/m³) to increase its temperature, and the temperature of its surroundings, significantly.

Disposal: – High-level nuclear waste, simply put, is spent fuel that is still present after it has been used inside of nuclear reactors. This radioactive waste has to cool off for several years and is considered to be very dangerous. The cooling process of this waste usually takes place inside of deep pools of water that are several hundred feet deep. These pools can be located on-site of off-site of the nuclear facility although the off-site facilities are limited and must be approved by the EPA.

11) Briefly discuss about the composition of spent fuel rods from a light water reactor.

Ans. The spent fuel rods from light water reactor is labelled as a high level radioactive waste and is enriched with respect to transuranic elements up to 650 ppm. There is rise in concentration of 236U and plutonium (up to about 1%) and other fission products (0.35%). The radionuclides in spent fuels are 60Co, 90Sr, 137Cs, 226Ra, 14C and 239Pu other than isotopes of Iodine, Uranium. These have half-lives from 5.2 years to 4.4 giga years.
12) Describe in brief about the disposal sites of radioactive waste.

Ans.

- **Ocean floor**: Buried in oceanfloor sediments.
- **Deep geologic burial sites**:  
  i. **Salt domes**: Dry, not much fluid in them. Fluid free place is better for disposal as these wastes can be dissolved in fluid and contaminate groundwater by dispersion.
  ii. **Crystalline rocks**: Granitic terrain