**1.Briefly describe the rock cycle, be sure to define each rock type ( igneous, sedimentary and metamorphic) and discuss the processes that lead to the formation of each.**

The rock cycle is a continuous process that describes how rocks are formed, transformed, and recycled over time on Earth. It involves various geological processes and can take millions of years to complete. The rock cycle is driven by forces such as tectonic activity, erosion, weathering, and the movement of materials within the Earth's interior.

The rock cycle consists of three main types of rocks: igneous, sedimentary, and metamorphic. Each type of rock represents a different stage in the cycle, and they can transition from one form to another through different processes.

**Igneous rocks.**

Igneous rocks are a type of rock that forms from the cooling and solidification of molten magma or lava. They are one of the three main types of rocks, along with sedimentary and metamorphic rocks. Igneous rocks are created through the process of crystallization, where molten material transitions from a liquid state to a solid state, resulting in the formation of mineral crystals.

There are two main types of igneous rocks based on their formation:

1.**Intrusive Igneous Rocks**: Intrusive igneous rocks, also known as plutonic rocks, form when magma cools and solidifies slowly beneath the Earth's surface. The slow cooling allows for the growth of large mineral crystals. As a result, intrusive rocks typically have a coarse-grained or phaneritic texture, meaning that individual mineral grains are visible to the naked eye. Examples of intrusive igneous rocks include granite, diorite, and gabbro.

2.**Extrusive Igneous Rocks**: Extrusive igneous rocks, also called volcanic rocks, form when lava erupts onto the Earth's surface and cools quickly. The rapid cooling prevents the formation of large crystals, resulting in a fine-grained or aphanitic texture, where individual mineral grains are too small to be seen without a microscope. Examples of extrusive igneous rocks include basalt, andesite, and rhyolite.

The composition of igneous rocks can vary, but they are primarily made up of minerals such as quartz, feldspar, mica, pyroxene, amphibole, and olivine. The specific minerals present depend on factors such as the chemical composition of the magma or lava and the cooling rate. The relative proportions of these minerals give igneous rocks their unique colors and textures.

Igneous rocks also exhibit a wide range of physical properties. Some igneous rocks, such as pumice and scoria, are lightweight and porous due to the presence of gas bubbles during the cooling process. Others, like granite and basalt, can be quite dense and durable. Igneous rocks are often resistant to weathering and erosion, making them prominent features in many landscapes.

**Sedimentary rocks.**

Sedimentary rocks are one of the three main types of rocks, alongside igneous and metamorphic rocks. They form through the accumulation, compaction, and cementation of sediment particles derived from the erosion and weathering of pre-existing rocks, organic remains, or chemical precipitation. Sedimentary rocks are often found in layers or strata, reflecting the sequential deposition of sediments over time.

The formation of sedimentary rocks involves several processes:

1. Weathering and Erosion: Weathering is the breakdown of rocks into smaller fragments through physical, chemical, or biological processes. Erosion is the transport of these weathered particles by agents such as water, wind, or ice.

2. Deposition: When the transported sediments settle and come to rest, they undergo deposition. This typically occurs in depositional environments such as rivers, lakes, deltas, beaches, or ocean basins.

3. Compaction: Over time, the weight of overlying sediments compresses the deposited layers. Compaction reduces the pore spaces between sediment grains, causing the sediments to become more tightly packed.

4. Cementation: As compaction occurs, minerals dissolved in groundwater can precipitate and fill the remaining pore spaces between sediment grains. This process, known as cementation, helps bind the sediment particles together, forming a solid rock.

Sedimentary rocks can be classified into three main categories based on their origin:

1.**Clastic Sedimentary Rocks**: Clastic rocks form from the accumulation and lithification of weathered rock fragments, known as clasts. The size and shape of the clasts determine the specific type of clastic rock. Examples include sandstone (composed of sand-sized grains), shale (composed of clay-sized particles), and conglomerate (composed of rounded pebbles or larger clasts).

2.**Chemical Sedimentary Rocks**: Chemical rocks form through the precipitation of dissolved minerals from water. This occurs when the concentration of dissolved substances exceeds their solubility limit, leading to the formation of solid minerals. Examples of chemical rocks include limestone (composed mainly of calcium carbonate), evaporites (such as rock salt or gypsum), and travertine (formed from calcium carbonate precipitation in caves or hot springs).

3.**Organic Sedimentary Rocks**: Organic rocks form from the accumulation and compaction of organic matter, such as the remains of plants and animals. Over time, the organic matter undergoes biochemical and physical changes, resulting in the formation of rocks like coal (formed from the remains of plant material) and some types of limestone (containing fossilized shells or coral fragments).

Sedimentary rocks often exhibit distinct features that provide clues about their formation, such as visible layers, fossils, ripple marks, cross-bedding, or mud cracks. They also contain valuable information about Earth's history, including past environments, climate conditions, and the evolution of life.

**Metamorphic rocks.**

Metamorphic rocks are one of the three main types of rocks, along with igneous and sedimentary rocks. They are formed from pre-existing rocks (igneous, sedimentary, or other metamorphic rocks) that have undergone physical and chemical changes in response to high temperature, pressure, and/or chemical activity within the Earth's crust. The term "metamorphism" means "change in form," reflecting the transformation of the original rock into a new rock with different mineral composition, texture, and sometimes even structure.

The process of metamorphism occurs deep within the Earth's crust and is influenced by several factors:

1.Heat: High temperatures, often associated with the presence of magma or deep burial, cause the minerals in the rock to recrystallize. This recrystallization can lead to the growth of new minerals and the rearrangement of existing mineral structures.

2.Pressure: Increased pressure, such as that exerted by the overlying rocks or tectonic forces, can result in the reorientation of minerals and the development of new crystal structures. Pressure can also cause the minerals to become more compact and aligned in specific orientations, resulting in a foliated texture.

3.Chemically Active Fluids: Fluids rich in water and dissolved ions can facilitate chemical reactions between minerals, leading to the formation of new minerals and alteration of the original rock's composition. These fluids can enhance the metamorphic process and introduce new elements into the rock.

Metamorphic rocks can be classified based on their texture and composition:

1.**Foliated Metamorphic Rocks**: Foliation refers to the alignment of minerals in parallel layers or bands. It is a characteristic feature of many metamorphic rocks and is a result of directed pressure during metamorphism. Examples of foliated rocks include slate, schist, and gneiss.

2.**Non-foliated Metamorphic Rocks**: Non-foliated rocks lack the pronounced layering or banding found in foliated rocks. Their minerals are typically equidimensional and lack preferred orientation. Examples of non-foliated rocks include marble and quartzite.

The specific type of metamorphic rock formed depends on the composition of the parent rock, the intensity of metamorphic conditions, and the presence of chemically active fluids. For example:

• Slate is a fine-grained, foliated metamorphic rock that forms from the low-grade metamorphism of shale or mudstone.

• Marble is a non-foliated metamorphic rock that forms from the metamorphism of limestone or dolomite.

• Quartzite is a non-foliated metamorphic rock that forms from the metamorphism of quartz-rich sandstone.

Metamorphic rocks often exhibit unique textures, such as mineral banding, elongated minerals, or recrystallized grains. They can also preserve evidence of the conditions under which they formed, such as mineral reactions, deformation features, and the presence of index minerals indicative of specific temperature and pressure conditions.

Metamorphic rocks provide important insights into the geological history of an area, including the tectonic processes, regional metamorphism, and the temperature-pressure conditions that prevailed during their formation. They also serve as valuable natural resources, with applications in construction, architecture, and decorative purposes.

**2. Igneous rocks are classified based on their TEXTURE and COMPOSITION. Define TEXTURE and COMPOSITION.**

Texture of Igneous Rocks: The texture of an igneous rock refers to the size, shape, and arrangement of the mineral grains or crystals within the rock. It provides information about the cooling history and conditions under which the rock formed. There are three main textures observed in igneous rocks:

1.**Aphanitic Texture**: In rocks with an aphanitic texture, the mineral grains are too small to be visible with the naked eye. This texture is characteristic of extrusive igneous rocks that cool rapidly on the Earth's surface or in shallow depths. The rapid cooling prevents the growth of large mineral crystals. As a result, aphanitic rocks have a fine-grained texture, similar to the texture of sugar or salt. Examples of aphanitic rocks include basalt and andesite.

2.**Phaneritic Texture**: Phaneritic textures are observed in rocks with visible mineral grains. These rocks have a coarse-grained texture because they cool slowly beneath the Earth's surface, allowing sufficient time for the growth of large mineral crystals. Phaneritic rocks typically have interlocking grains that can be seen with the naked eye or a hand lens. Granite and gabbro are common examples of phaneritic igneous rocks.

3.**Porphyritic Texture**: Porphyritic texture is a combination of both large and small mineral grains within the same rock. It indicates a two-stage cooling history. The larger grains, called phenocrysts, formed earlier when the rock was cooling slowly beneath the Earth's surface. The surrounding matrix or groundmass consists of smaller grains that formed later during rapid cooling at the surface. Porphyritic texture is often observed in rocks that underwent a two-stage cooling process, such as andesite or rhyolite.

Composition of Igneous Rocks: The composition of an igneous rock refers to the types and relative proportions of minerals present in the rock. It provides information about the chemical composition of the original magma or lava from which the rock formed. Igneous rocks can be classified into four main compositional groups:

1.**Felsic (or Silicic) Composition**: Felsic rocks are rich in silica (SiO2) and aluminum (Al) and are composed primarily of light-colored minerals such as quartz, feldspar (orthoclase or plagioclase), and muscovite. These rocks have a high silica content (over 65%) and are usually light in color, ranging from white to pink or light gray. Granite is a common example of a felsic igneous rock.

2.**Intermediate Composition**: Intermediate rocks have a composition that falls between felsic and mafic rocks. They contain moderate amounts of silica, aluminum, and iron-magnesium minerals. Andesite is a typical intermediate rock, characterized by its gray to dark gray color.

3.**Mafic (or Basaltic) Composition**: Mafic rocks are rich in iron (Fe), magnesium (Mg), and calcium (Ca), and have a lower silica content (45-52%) compared to felsic rocks. They are composed of dark-colored minerals such as pyroxene, amphibole, and plagioclase feldspar. Mafic rocks, like basalt, are typically dark in color, ranging from black to dark gray or green.

4.**Ultramafic Composition**: Ultramafic rocks have the highest proportion of iron, magnesium, and calcium among all igneous rocks. They contain very low amounts of silica (less than 45%) and are composed mainly of dark-colored minerals such as olivine and pyroxene. Ultramafic rocks, such as peridotite, are usually dark green and have a higher density compared to other igneous rocks.

It's important to note that the texture and composition of igneous rocks can vary within a single rock formation or even within a single rock sample. This is due to factors such as the cooling rate, presence of volatile components, and the crystallization sequence of minerals from the magma or lava.

**3.Define the following igneous rock textures, aphanitic, phaneritic, porphyritic, vesicular, glassy and pegmatitic.**

**Aphanitic Texture**: The aphanitic texture refers to the fine-grained nature of igneous rocks in which mineral grains are too small to be visible with the naked eye. The individual crystals are typically less than 0.1 millimeters in size. Aphanitic texture is commonly observed in extrusive igneous rocks that cool rapidly on the Earth's surface or in shallow depths, where there is less time for crystal growth. Examples of rocks with an aphanitic texture include basalt, andesite, and rhyolite.

**Phaneritic Texture**: The phaneritic texture refers to the coarse-grained nature of igneous rocks, where mineral grains are visible to the naked eye. The individual crystals are typically larger than 1 millimeter in size. Phaneritic rocks form from slow cooling and solidification of magma beneath the Earth's surface, allowing sufficient time for crystal growth. The minerals within phaneritic rocks are interlocking and can be distinguished with the naked eye or a hand lens. Granite and gabbro are common examples of phaneritic igneous rocks.

**Porphyritic Texture**: The porphyritic texture is characterized by the presence of two distinct crystal sizes within an igneous rock. Larger crystals, called phenocrysts, are embedded in a finer-grained matrix known as the groundmass. The phenocrysts typically have a different mineral composition than the groundmass. Porphyritic texture suggests a two-stage cooling history: initial slow cooling underground (forming phenocrysts) followed by rapid cooling on the surface (forming the groundmass). Andesite and rhyolite are examples of porphyritic rocks.

**Vesicular Texture**: The vesicular texture is characterized by the presence of voids or cavities, known as vesicles, within the igneous rock. These vesicles are formed by the escape of gas bubbles during volcanic eruptions. When lava rapidly cools and solidifies, the gas bubbles get trapped, leaving behind spherical to elongated cavities in the rock. The size and density of vesicles can vary. Rocks with a vesicular texture, such as vesicular basalt or scoria, are often lightweight and porous.

**Glassy Texture**: The glassy texture refers to the complete absence of visible mineral crystals in an igneous rock. It occurs when lava cools extremely quickly, preventing the formation of crystals. The rapid cooling prevents the atoms from arranging into a crystalline structure, resulting in an amorphous solid resembling glass. Obsidian is a common example of an igneous rock with a glassy texture. It is usually black or dark-colored and exhibits conchoidal fracture.

**Pegmatitic Texture**: The pegmatitic texture refers to exceptionally coarse-grained igneous rocks characterized by very large crystals, often exceeding several centimeters or even meters in size. These rocks form in the final stages of the cooling process of magma-rich in water and other volatiles. The slow cooling rate and abundance of water allow for the growth of large crystals. Pegmatites are known for hosting valuable minerals and gemstones due to their unique formation conditions.

**4.List the common igneous rock-forming minerals (there are eight or nine) and give their formulas.**

List the most common forming minerals and its formula

1. Quartz - SiO2

2. Feldspar (Plagioclase and Orthoclase) - Plagioclase feldspar: (Na, Ca) (Si, Al)4O8 and Orthoclase feldspar: KAlSi3O8

3. Olivine - (Mg, Fe)2SiO4

4. Pyroxene - Single chain silicates: (Ca, Na)(Mg,Fe, Al)(Si,Al)2O6

5. Amphibole - Double chain silicates: (Ca, Na)2-3(Mg, Fe, Al)5(Al, Si)8O22(OH, F)2

6. Biotite Mica - K (Fe, Mg, Al)3(AlSi3O10) (OH)2

7. Muscovite Mica - KAl2(AlSi3O10) (OH)2

8. Plagioclase Feldspar - (Na, Ca) (Si, Al)4O8

9. Potassium Feldspar (Orthoclase) - KAlSi3O8

**5. Define ULTRAMAFIC, MAFIC, INTERMEDIATE and FELSIC.**

1.**Ultramafic**: Ultramafic refers to igneous rocks that have a very low silica content (less than 45%) and are rich in iron (Fe), magnesium (Mg), and calcium (Ca). Ultramafic rocks consist predominantly of dark-colored minerals such as olivine and pyroxene. These rocks are typically dark green in color and have a higher density compared to other igneous rocks. Examples of ultramafic rocks include peridotite and dunite.

2.**Mafic**: Mafic describes igneous rocks that have a moderate silica content (45-52%) and are rich in iron, magnesium, and calcium. Mafic rocks are composed primarily of dark-colored minerals such as pyroxene, amphibole, and plagioclase feldspar. Basalt, a common volcanic rock, is a prime example of a mafic igneous rock. Mafic rocks are typically dark in color, ranging from black to dark gray or green.

3.**Intermediate**: Intermediate refers to igneous rocks that have a silica content ranging from 52% to 65%. Intermediate rocks contain a balance of both light and dark minerals, representing a mix between felsic and mafic compositions. These rocks are composed of minerals such as plagioclase feldspar, amphibole, and biotite mica. Andesite, a volcanic rock commonly associated with volcanic arcs, is an example of an intermediate igneous rock.

4.**Felsic**: Felsic (short for "feldspar" and "silica") describes igneous rocks that have a high silica content (over 65%) and are rich in aluminum (Al). Felsic rocks consist primarily of light-colored minerals such as quartz, feldspar (orthoclase or plagioclase), and muscovite mica. Granite, a common intrusive rock, is an example of a felsic igneous rock. Felsic rocks are typically light in color, ranging from white to pink or light gray.

**6:For each of the following igneous rocks, state if it is extrusive or intrusive and whether it is ultramafic, mafic, intermediate or felsic.**

The classification as intrusive or extrusive indicates whether the rock formed from magma that solidified beneath the Earth's surface (intrusive) or from lava that erupted onto the Earth's surface and solidified quickly (extrusive). The composition as ultramafic, mafic, intermediate, or felsic describes the relative proportion of silica and other elements in the rock, providing information about its mineralogy and color.

Here is a list of common igneous rocks, along with their classification as intrusive (I) or extrusive (E), and their composition as ultramafic (UM), mafic (M), intermediate (I), or felsic (F):

1. Basalt: Extrusive (E), Mafic (M)

2. Granite: Intrusive (I), Felsic (F)

3. Andesite: Extrusive (E), Intermediate (I)

4. Gabbro: Intrusive (I), Mafic (M)

5. Rhyolite: Extrusive (E), Felsic (F)

6. Diorite: Intrusive (I), Intermediate (I)

7. Peridotite: Intrusive (I), Ultramafic (UM)

**7. List and briefly define the three types of volcanoes.**

**1.Shield Volcanoes**: Shield volcanoes are broad, gently sloping volcanoes characterized by their broad, shield-like shape. They are formed by the accumulation of successive lava flows with low viscosity, which allows the lava to spread out in thin layers over large distances. Shield volcanoes are typically built by non-explosive eruptions of basaltic lava, which is low in silica content and has a low gas content. The lava flows from shield volcanoes tend to be fluid and can travel long distances. Examples of shield volcanoes include Mauna Loa and Kilauea in Hawaii. Shield volcanoes generally have relatively gentle eruptions and are not associated with violent explosive activity.

**2.Composite Volcanoes (Stratovolcanoes)**: Composite volcanoes, or stratovolcanoes, are tall, conical volcanoes with steep slopes. They are characterized by their alternating layers of lava flows and pyroclastic deposits, including ash, pumice, and volcanic debris. These layers are built up over time from repeated explosive eruptions and more viscous lava flows. Composite volcanoes are typically formed by intermediate to felsic magma, which has a higher silica content and is more viscous. The high viscosity of the magma causes gas and pressure to build up, resulting in explosive eruptions. Examples of composite volcanoes include Mount St. Helens in the United States, Mount Fuji in Japan, and Mount Vesuvius in Italy. Composite volcanoes can have both explosive and effusive eruptions, and their eruptions can be highly dangerous and destructive.

**3.Cinder Cone Volcanoes**: Cinder cone volcanoes are small, steep-sided volcanoes with a conical shape. They are built from pyroclastic materials, such as volcanic ash, lapilli (small rock fragments), and cinders (pea-sized volcanic bombs). Cinder cones typically form from single, explosive eruptions that eject fragmented lava into the air. The fragmented material falls back to the ground and accumulates around the vent, forming the characteristic cone shape. Cinder cone volcanoes are often found in volcanic fields and are usually associated with basaltic lava. They tend to have short, relatively brief eruptions. Examples of cinder cone volcanoes include Paricutin in Mexico and Sunset Crater in the United States