TEST 1

MINERALS

eight most abundant elements in the Earth's crust:

O, Si, Al, Fe, Ca, Na, K, Mg,

their most common ionic form:

Si^{+4}, Al^{+3}, Fe^{+2}, Mg^{+2}, Ca^{+2}, Na^{+1}, K^{+1}, O^{-2}

relative ionic sizes:

O 1.4, Si 0.26, Al 0.39, Fe 0.63, Ca 1.0, Na 0.99, K 1.37, Mg 0.72

and the most common coordination numbers of these ions:

Si (4), Al (4, or 6), Fe (6), Mg (6), Ca (8), Na (8), K (8, 12)

the distinction between crystalline and non-crystalline solids

The term crystalline refers to the ordered, symetrical, arrangement of the atoms that make up the structure.

the most common silicate minerals

olivine, pyroxenes, amphiboles, biotite, muscovite, plagioclase feldspar,alkali-feldspars, quartz

their structure and composition (note: while exact chemical formulae are not required, knowledge of their relative silica contents, and other major cations present is expected.)

- **olivines - $(Mg,Fe)_2SiO_4$; independent tetrahedra**
- **pyroxenes - $(Mg,Fe)_2Si_2O_6)$; single chain**
- **amphiboles - $(W,X,Al)_{7-8}(Z_4O_{11})_2(OH)_2$; double chains**
- **biotite mica - $K(Mg.Fe)_3(AlSi_3O_{10})(OH)_2$; sheet silicates**
- **muscovite mica - KAl_2(AlSi3O10)(OH)2 ; sheet silicates**
- **alkali feldspars - $KAlSi_3O_8$---$NaAlSi_3O_8$ (solid solution series) ; framework silicates**
- **plagioclase feldspars - $NaAlSi_3O_8$---$CaAl_2Si_2O_8$ (solid solution series) ; framework silicates**
- **quartz - SiO_2 ; framework silicates**

atomic or ionic substitution in silicates : factors controlling substitution, commonly substituting ion pairs, and degree of substitution

Ionic Substitution - variations in composition resulting from a systematic substitution of ions - There are several minerals which display solid solution (solids which act like solutions during crystallization and melting). The olivine group, forsterite (Mg2SiO4) - fayalite (Fe2SiO4) is a good example. Both Mg+2 and Fe+2have the same charge (+2) and about the same ionic size so that either can fit into the olivine crystalline structure.

Coupled Ion Substitution - the plagioclase series - NaAlSi3O8 to CaAl2Si2O8 is an example of a solid solution with coupled ion substitution - The ions don't have the same charge, but are able to substitute for one another when coupled with another ion. Within the plagioclase crystal structure, Ca+2and Al+3 with a combined charge of +5 substitute for Na+1 and Si+4 which also have a combined charge of +5.

Variations in Composition and Crystalline Structure - Most minerals contain impurities and several also display ionic substitution. There are other

minerals which have identical chemical compositions, but different crystalline structures due to the conditions under which they crystallized.
relationship of cleavage to structure in silicate minerals
Cleavage - tendency of minerals to break along parallel planes of weaknesses (cleavage planes) within the crystal forming parallel planar surfaces along broken fragments - Cleavage results from weaker bond strengths along the certain planar directions within the mineral. *The number of cleavage planes and the angles between the cleavage planes are important characteristics used in identifying minerals (example - micas, excellent cleavage in 1 direction; halite, good cleavage in three directions, each at 90o to each other; and sphalerite, 6 good directions not at 90o).
***Difference between cleavage and crystal form - crystal form is only an external reflection of atomic structure which is lost when the crystal is broken. In contrast, cleavage is related to planes of weakness which are found throughout the mineral. Cleavage planes will form no matter how finely the crystal is broken.**
meaning of mafic, felsic
Mafic mineral are relatively rich in Mg, and Fe, and relatively poor in silica and the alkali (K and Na) elements. Felsic minerals have relatively high silica and alkali contents and lower Mg and Fe.

EARTH'S HEAT

how heat is transfered (radiation, conduction, convection)
radiation - heat moves as electromagnetic radiation, such as heat transfered from the Sun to Earth
conduction - enhanced vibrational motion of atoms in materials is induced in neighboring atoms and this motion diffuses through the material (*if you could actually see the atoms, a very crude analogy might be a crowd in a football stadium doing "the Wave"*)
convection - heat is carried by matter which is flowing. Warmer and less dense matter rises, while cooler and more dense matter sinks.
sources or origin of the Earth's heat
During the early history of the solar system, the Earth and other planets grew in size and mass as comets, asteroids, and other smaller masses fell into them. This process continues today, albeit at a much slower rate.
Under the intense bombardment of the Earth during its earliest history, the planet's temperature must have risen significantly, perhaps to the point where some part of the planet melted. Since that early history, the Earth has been cooling, but some of that original heat remains.
the geothermal gradient and geobarometric gradient
The rate at which the temperature increases with depth in the Earth is the geothermal gradient, and it varies from place to place. The geobarometric gradient is the change in pressure with depth.

MAGMAS

melting of silicate rocks- effects of temperature, pressure and water

in general, the temperature required to melt minerals increases with increasing pressure, so that minerals which are heated to temperatures sufficient to melt them at atmospheric pressure can remain solid under the high pressure in the Earth. It follows that some rocks in the Earth's interior that are solid, are so hot that, if the pressure on these were released, or they are convected into a lower pressure zone, they could begin to melt.
Another important factor in the melting and crystallization of magma is the presence of volatiles, especially water. The melting (crystallization) temperatures of minerals are reduced under high water pressure. Consequently "wet" rocks (those containg water) melt at lower temperatures that do dry rock containing identical mineral assemblages.

how composition of magmas are influenced by the degree of partial melting of source rock

Partial melting of rocks produce magmas that are more felsic than the rocks that are melted.

factors influencing the viscosity of magmas

The viscosity (a measure of a fluid's resistance to flowing) of magmas is due to the polymerization of silicon and oxygen in the magma - that is to the chemical bonding of Si-O-Si-O--Si- ect. into unordered chains and fragments of various shapes. The higher the silica content , the higher the viscosity. Recall that mafic magmas such as those that crystallize basalts have a significantly lower silica content than do the more silica rich felsic magmas (such as those that crystallize rhyolites and granites). Another factor is temperature. The viscosity of magmas decreases as the temperature increases. A third important factor is water. Water dissolved in magmas has the affect of lowering the viscosity.

crystallization of magmas mineral sequence with decreasing temperature

Cooling magmas crystallize assemblages of minerals referred to as igneous rocks. With very rare exceptions, the dominate minerals are silicates. Igneous rocks have been classified on the basis of their mineral content and also on the amount of silica in the rock: obviously the two are not unrelated. Textures of the rocks have also been used as a basis of these classifications. A simple and important textural element is the size of individual mineral crystals in the rock. An important (although not unique) factor in crystal or grain size is the rate at which magmas cool. Slow cooling rates provides the time and high mobility of ions to grow large crystals; rapid cooling does not. Magmas that crystallize at depth in the Earth cool slowly, because of the difficulty with loosing heat. Magmas in small bodies crystallizing very close to the surface or enclosed in cool rocks cool much faster and produce small crystals. Magmas erupting onto the surface of the Earth might even cool so quickly, that they solidify before any crystals can form - producing a natural glass, or they might contain only microscopic crystals. Plutonic igneous rocks crystallize at depth and possess individual mineral crystals that can readily be seen with out the aid of magnification. Volcanicigneous rocks form at the Earth's surface and contain very small, usually microscopic, size crystals, and or glass.

equilibrium vs fractional crystallization- mechanisms and effects on the composition