1. The inner core of the Earth is composed of:
   a) solid silicate  b) liquid silicate magma  c) liquid metal  d) solid metal  e) olivine.

2. The upper mantle of the Earth is composed of:
   a) solid silicate  b) liquid silicate magma  c) liquid metal  d) solid metal  e) green cheese.

3. The water of the Earth’s oceans covers more than 70 percent of the surface but composes only what fraction of the mass?
   a) 50%  b) 10%  c) 1%  d) 0.5%  e) 0.025%

4. What is the most likely geologic setting in which to find basaltic volcanism?
   a) continent-continent convergent boundary (e.g. Himalayas)
   b) ocean-continent convergent boundary (e.g. Andes Mountains)
   c) ocean-ocean convergent boundary (e.g. Fiji-Tonga)
   d) ocean-ocean divergent plate boundary (mid-ocean ridge), and oceanic islands
   e) transform plate boundary (e.g. San Andreas Fault zone)

5. The earliest fossils of complex multi-celled organisms like trilobites are of about what age?
   a) 4.55 billion years (Hadean)  b) 3.8 billion years (Archean)  c) 1.8 billion years (Proterozoic)
   d) 550 million years (Cambrian)  e) 66 million years (Tertiary or Cenozoic)

6. An external heat engine drives most of the surface processes on the Earth. The source of energy for this engine is:
   a) radioactive decay of U, Th, and K.  b) thermonuclear fusion in the sun.
   c) burning of fossil fuels  d) gravitational collapse of the solar nebula  e) tides driven by lunar gravitation.

7. Plate motion is believed to be driven by solid state convection of the silicate mantle. This convection is driven by the Earth's internal heat engine, which is powered by:
   a) radioactive decay of uranium, thorium, and potassium  b) thermonuclear fusion in the sun
   c) burning of fossil fuels  d) fission reactions in the Earth's core  e) radioactive decay of 14C.

8. The age of the Earth, as indicated by radiometric dating of meteorite, lunar, and terrestrial rocks, generally believed to be:
   a) 10 billion years  b) 4.5 billion years  c) 545 million years  d) 40 million years
   e) 7000 years.

9. In the scientific method, an observation in the laboratory or field is considered fact if it is:
   a) consistent with previous hypotheses  b) consistent with prevailing theory
   c) repeatable  d) made by a reputable scientist  e) cited by a reputable scientist

10. The atomic number of an element is:
    a) the number of protons in the nucleus  b) the neutron in the nucleus  c) the number of electrons
     d) protons plus neutrons in the nucleus  e) the average number of protons plus neutrons

11. Oxygen has 8 protons in the nucleus. $^{16}$O is:
    a) an oxygen atom with 8 protons and 8 neutrons  b) an oxygen ion with a charge of sixteen
    c) a molecule composed of sixteen atoms of oxygen  d) an oxygen atom with sixteen neutrons
    e) an atom of sixteenium.
12. MgSiO₃ is
   a) a chemical formula with one atom of magnesium, one atom of silicon, and three atoms of oxygen
   b) a polymer
   c) a compound with 60 weight percent oxygen and 20 weight percent silicon, and 20 weight percent magnesium
   d) a pyroxene
   e) a feldspar

13. The most abundant element in the Earth's crust and mantle is:
   a) aluminum   b) boron   c) silicon   d) magnesium   e) oxygen.

14. For a given element, the average mass number (number of protons plus neutrons in the nucleus) is known as the:
   a) atomic number   b) atomic weight   c) mass number   d) ionic charge   e) ionic weight.

15. The number of electrons lost by an element in chemical reactions is its common ionic charge. This is also known as its:
   a) atomic number   b) atomic weight   c) mass number   d) valence   e) ionic weight.

16. Those elements of the periodic table that form metallic bonds with iron and are enriched in the core of the Earth and in iron meteorites are termed:
   a) atmophile   b) siderophile   c) chalcophile   d) lithophile   e) thermophile

17. A naturally occurring, homogeneous solid of definite chemical composition and ordered atomic arrangement that is usually formed by inorganic processes is known as a(n)
   a) element   b) mineral   c) rock   d) crystal   e) planet.

18. Forsterite (Mg₂SiO₄) and fayalite (Fe₂SiO₄) are different chemical end-members of olivine and have the same crystal structure. They are known as
   a) isomorphs   b) pseudomorphs   c) polymorphs   d) mightymorphs   e) tetrahedra.

19. The minerals, calcite and aragonite, both have the formula (CaCO₃), but have different crystal structures. These minerals are known as:
   a) isomorphs   b) pseudomorphs   c) polymorphs   d) mightymorphs   e) tetrahedra.

20. Which of the following is a native-element mineral (a pure element that occurs naturally):
   a) quartz   b) beryl   c) calcite   d) graphite   e) pyrite

21. An example of a natural solid that is not a mineral is
   a) diamond   b) ice   c) obsidian   d) gold   e) graphite

22. In the crystal structures of the common silicate minerals, each silicon atom is surrounded by four oxygens in the form of a:
   a) triangle   b) tetrahedron   c) hexahedron   d) octahedron   e) dodecahedron

23. Each of the oxygens in quartz is bonded to two silicon atoms, whereas in olivine each oxygen is bonded to only one Si atom. The degree to which the oxygens are shared between to Si atoms is the degree of:
   a) allocation   b) bifurcation   c) polymerization   d) differentiation   e) elongation

24. The compositions of rocks composed almost entirely of quartz, alkali feldspar and mica are said to be:
   a) felsic or silicic   b) intermediate   c) mafic   d) ultramafic   e) basaltic.

25. A small igneous body of rock that has intruded into a sedimentary rocks and has an outcrop area of less than about 100 km² is known as a:
   a) aa   b) sill   c) stock   d) dike   e) pluton.
26. Which of the following is an ultramafic rock:
   a) granite    b) basalt    c) gabbro    d) diorite    e) peridotite

27. Ultramafic rocks are primarily found in the
   a) oceanic crust  b) continental crust  c) mantle  d) core  e) ocean islands

28. Although silica (SiO₂) composes 40 to 70% by weight of most igneous rocks, the mineral quartz (SiO₂)
    is only abundant in the rock
   a) lherzolite or peridotite (ultramafic)  b) gabbro  c) diorite  d) basalt  e) granite.

29. A rock formed by the processes of solid-state recrystallization of pre-existing rock is called:
   a) igneous    b) metamorphic    c) hydrothermal    d) sedimentary    e) limestone.

30. A rock formed by the processes of melting followed by cooling and crystallization is called:
   a) igneous    b) metamorphic    c) hydrothermal    d) sedimentary    e) limestone.

31. The most abundant mineral in ultramafic rocks is typically:
   a) quartz    b) feldspar    c) mica    d) olivine    e) epidote

32. A gabbro is the coarse-grained compositional equivalent of a:
   a) rhyolite    b) basalt    c) andesite    d) granite    e) peridotite.

33. A well-sorted, fine-grained quartz sandstone exhibiting large and extensive cross-bedding was probably
    deposited in a:
   a) alluvial fan  b) lagoon  c) abyssal plain  d) desert  e) shallow sea.

34. A sedimentary rock composed of rounded sand-, pebble-, and cobble-sized particles is a:
   a) sandstone    b) breccia    c) conglomerate    d) cobblestone    e) shale.

35. The most abundant mineral in most shale is:
   a) calcite    b) clay    c) quartz    d) gypsum    e) feldspar.

36. Which of the following minerals would not occur in an evaporite?
   a) halite    b) gypsum    c) calcite    d) sylvite    e) quartz.

37. The polymerization of SiO₄ tetrahedra in a magma:
   a) increases with increasing silica content    b) causes a change of color
      c) causes an electrical discharge    d) is a major cause of earthquakes
      e) causes a rise in pressure.

38. Partial melting and fractional crystallization, together contribute to the process of:
   a) assimilation    b) igneous fractionation    c) subduction    d) xenolith formation
      e) explosive eruption
Essay

How does the degree of polymerization of silicate tetrahedra at the atomic scale account for the different styles and processes of basaltic versus rhyolitic volcanism?

The silicon-oxygen tetrahedral bonds are among the strongest chemical bonds in rocks and minerals. The degree to which they form connected networks by sharing of oxygen atoms between silica tetrahedra is the degree of polymerization. The degree of polymerization is high in quartz and alkali feldspar minerals and also in silicic (granitic) magmas and low in ferromagnesian minerals and in basaltic melts. Highly polymerized (silicic) melts are generally cooler and much more viscous so that volcanism is commonly explosive. Melts with a low degree of polymerization (basaltic) are more fluid, and volcanism is typically quiescent lava flows.