1) During a rainstorm, when is surface runoff least likely to occur?
A) when the rainfall rate exceeds the permeability rate of the soil
B) when the slope of the surface is too great for infiltration to occur
C) when the permeability rate of the soil equals the rainfall rate
D) when the pore spaces of the ground are saturated with water

2) Which graph best represents the relationship between soil permeability rate and infiltration when all other conditions are the same?

Questions 3 and 4 refer to the following:

The diagrams below represent three identical beakers, A, B, and C. Each beaker contains solid plastic spheres. The diameter of the spheres in each beaker is shown.

3) Which beaker contains material with the greatest permeability?
A) A  B) B  C) C

4) A mixture of 0.10-centimeter spheres and 0.70-centimeter spheres is placed in a fourth beaker, D. Beaker D is filled to the same level as beaker C. Compared to the porosity of C, the porosity of D is
A) less  B) greater  C) the same
5) The diagrams below represent two containers, each filled with a sample of nonporous particles of uniform size.

Compared to the sample of larger particles, the sample of smaller particles has
A) higher permeability  C) lower permeability
B) less porosity       D) more porosity

6) Which property of loose earth materials most likely increases as particle size decreases?
A) permeability       C) infiltration
B) capillarity        D) porosity

7) Characteristics such as composition, porosity, permeability, and particle size are used to describe different types of
A) hillslopes         C) soils
B) stream drainage patterns D) landscapes

8) Which graph shows the effect of soil permeability on the amount of runoff in an area?

A) ![Graph A](image)
B) ![Graph B](image)
C) ![Graph C](image)
D) ![Graph D](image)
Questions 9 through 11 refer to the following:

The diagram below represents part of the laboratory setup for an activity to investigate the effects of particle size on permeability, porosity, and water retention. Three separate tubes were used (only one example is shown), each containing 300 milliliters of beads of uniform size. Bead sizes were 4 millimeters, 7 millimeters, and 12 millimeters in diameter, respectively.

The amount of water added to each tube to cover the beads was determined. The clamp was then removed, the flow of the water was timed, and its volume was measured. Data are shown in the table below. (The amount of water retained on the 7-millimeter beads has been omitted.)

![Diagram of laboratory setup]

<table>
<thead>
<tr>
<th>PARTICLE SIZE</th>
<th>Infiltration time (seconds)</th>
<th>Amount of water needed to cover all beads (ml)</th>
<th>Water recovered from tube after clamp was removed (ml)</th>
<th>Water retained on beads (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mm beads</td>
<td>3.7</td>
<td>147</td>
<td>111</td>
<td>36</td>
</tr>
<tr>
<td>7 mm beads</td>
<td>3.0</td>
<td>145</td>
<td>123</td>
<td>12</td>
</tr>
<tr>
<td>12 mm beads</td>
<td>2.4</td>
<td>147</td>
<td>135</td>
<td>12</td>
</tr>
</tbody>
</table>

9) The data table shows that all three tubes of beads had approximately the same
   A) capillarity                     C) porosity
   B) permeability time              D) water retention

10) What was the total amount of water retained on the 7-millimeter beads after the tubing was unclamped and the water flowed out?

   A) 8 mL          B) 12 mL          C) 36 mL          D) 22 mL

11) Which graph best represents the infiltration times for these three particle sizes?

   ![Graph A](image)
   ![Graph B](image)
   ![Graph C](image)
   ![Graph D](image)

12) A student determines that the porosity of a large volume of sand is 40%. The accepted value is 46%. What is the student's approximate percent deviation (percent of error) from the accepted value?

   A) 10%          B) 46%          C) 7%          D) 13%
13) Which condition is most likely to cause surface runoff during a rainstorm?
A) The porosity of the soil is greater than the amount of rainfall.
B) The surface slope allows for maximum infiltration.
C) The surface soil is saturated.
D) The permeability of the soil is greater than the rate of rainfall.

14) The diagrams below represent two identical containers filled with nonporous uniform particles. The containers represent models of two different sizes of soil particles.

Compared to the model containing larger particles, the model containing smaller particles has
A) greater permeability and greater porosity
B) less permeability and greater capillarity
C) less permeability and greater porosity
D) greater porosity and greater capillarity

15) The diagram below represents two identical containers filled with samples of loosely packed sediments. The sediments are composed of the same material, but differ in particle size. Which property is most nearly the same for the two samples?

A) capillarity  
B) water retention  
C) infiltration rate  
D) porosity

16) Soil with the lowest porosity is composed of particles that are all
A) small and rounded  
B) large and rounded  
C) large and angular  
D) different sizes and shapes

17) The flowchart below shows part of Earth's water cycle. The question marks indicate a part of the flowchart that has been deliberately left blank.

Which process should be shown in place of the question marks to best complete the flowchart?
A) deposition  
B) evaporation  
C) infiltration  
D) condensation
18) The upward movement of water through tiny spaces in soil or rock is called
A) capillary action
B) permeability
C) water retention
D) porosity

19) Which graph best represents the general relationship between soil particle size and the permeability rate of infiltrating rainwater?

A) ![Graph A]

B) ![Graph B]

C) ![Graph C]

D) ![Graph D]

20) A diagram of the water cycle is shown below. Letters A through D represent the processes taking place.

Which arrow represents the process of transpiration?
A) D
B) C
C) B
D) A

21) The amount of surface runoff increases as
A) the slope of the land decreases
B) the infiltration rate decreases
C) porosity increases
D) permeability increases

22) Which is most important in determining the amount of ground water that can be stored within a rock?
A) the rock's hardness
B) the rock's color
C) the rock's porosity
D) the rock's geologic age
Questions 23 through 27 refer to the following:

The diagrams below which describe an investigation with soils.

Three similar tubes, each containing a specific soil of uniform particle size and shape were used to study the effect that different particle size has on porosity, capillarity, and permeability. A fourth tube containing soil which was a mixture of the same sizes found in the other tubes was also studied and its data are recorded in the table. [Assume that the soils were perfectly dry between each part of the investigation.]

<table>
<thead>
<tr>
<th>Tube</th>
<th>Particle Size (diameter in cm)</th>
<th>Porosity (%)</th>
<th>Capillarity (mm)</th>
<th>Permeability (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fine (0.025 cm)</td>
<td>40</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>B</td>
<td>Medium (0.1 cm)</td>
<td>40</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>C</td>
<td>Coarse (0.3 cm)</td>
<td>40</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>Mixed (0.025 to 0.3 cm)</td>
<td>20</td>
<td>12</td>
<td>20</td>
</tr>
</tbody>
</table>

23) When water was poured into the top of each tube at the same time, which tube allowed the water to pass through most quickly?
   A) A                   B) C                   C) B                   D) D

24) A handful of material from tube D was dropped into a fifth tube filled with water only. In which order would the particle sizes of this soil probably settle in the tube from the bottom of the tube upward?
   A) coarse on the bottom, then medium, then fine
   B) fine on the bottom, then medium, then coarse
   C) coarse on the bottom, then fine, then medium
   D) fine on the bottom, then coarse, then medium

25) The bottom of each tube was closed and water was slowly poured into each tube until the water level reached the dotted line. Which statement best describes the amount of water held by the tubes?
   A) Tube C held more water than any other tube and tube D the least.
   B) Tube A and D held the same amount of water and twice as much as tubes B and C.
   C) Tube D held more water than any other tube and tube A the least.
   D) Tube A, B and C held the same amount of water and tube D half as much.
26) According to the *Earth Science Reference Tables*, the soil in tube C would be classified as
A) cobbles     B) pebbles     C) silt     D) sand

27) Each tube was placed in a shallow pan of water. In which tube did the water rise the highest?
A) C     B) B     C) D     D) A

28) When rainfall exceeds the rate of permeability for saturated soil, the most likely result will be
A) infiltration     C) surface runoff
B) soil moisture utilization     D) soil moisture deficit

29) Columns A, B, C, and D are partially filled with different sediments. Within each column, the sediment is uniform in size. A fine wire mesh screen covers the bottom of each column to prevent the sediment from falling out. The lower part of each column has just been placed in a beaker of water. Sediment sizes are not drawn to scale.

In an experiment, the beakers of water were removed and replaced with empty beakers. The sediments were allowed to dry. Then water was poured into each column to compare the permeability of the sediments. The permeability rate of the medium sand sample was shown to be
A) greater than the silt sample but less than the pebble sample
B) less than the silt sample but more than the pebble sample
C) less than the silt and pebble samples
D) greater than the silt and pebble samples
30) The bedrock cross section below represents part of Earth's crust where natural gas, oil, and water have moved upward through a layer of folded sandstone and filled the pore spaces at the top of the sandstone layer.

In the diagram shown, the natural gas, oil, and water are trapped within the top of the sandstone and do not move upward through the shale because, compared to the sandstone, the shale has
A) larger pore spaces  C) less foliation
B) lower permeability  D) larger particles

31) Surface runoff is most likely to occur when
A) rainfall exceeds the permeability rate
B) the land is flat
C) little capillary action occurs
D) the soil is unsaturated

Questions 32 and 33 refer to the following:

The diagrams below represent cross sections of four samples of loosely packed, uniformly sorted soil particles. The diameter of the particles is given below each diagram. All soil samples consist of solid spherical particles.

32) Which sample has the greatest permeability?
A) A  B) B  C) C  D) D

33) Some particles from sample D are mixed with particles from sample A. Compared to the original porosity of sample A, the porosity of the resulting mixture will be
A) less  B) greater  C) the same
Questions 34 and 35 refer to the following:

The diagram below represents the water cycle.

34) Precipitation is most likely occurring at the time represented in the diagram because
   A) the water droplets are heavy enough to fall
   B) the relative humidity of the air is low
   C) no condensation nuclei are present in the air
   D) the air has been warmed due to expansion

35) The small arrows drawn near the rivers represent the direction of
   A) runoff       B) infiltration       C) capillarity       D) absorption

36) Which diagram represents the soil with the greatest permeability?

   KEY: Soil particles  Pore space (air)

   A)       B)       C)       D)
37) Which graph best represents the relationship between porosity and particle size for soil samples of uniform size, shape, and packing?

A)  

B)  

C)  

D)  

38) During a heavy rainfall, runoff will be greatest on a soil that has an infiltration (permeability) rate of

A) 0.2 cm/sec  
B) 0.3 cm/sec  
C) 0.1 cm/sec  
D) 1.2 cm/sec