ESS 100 Name: _____

Ages of Rocks, Part 1: **Relative Dating**

Unit Goals:

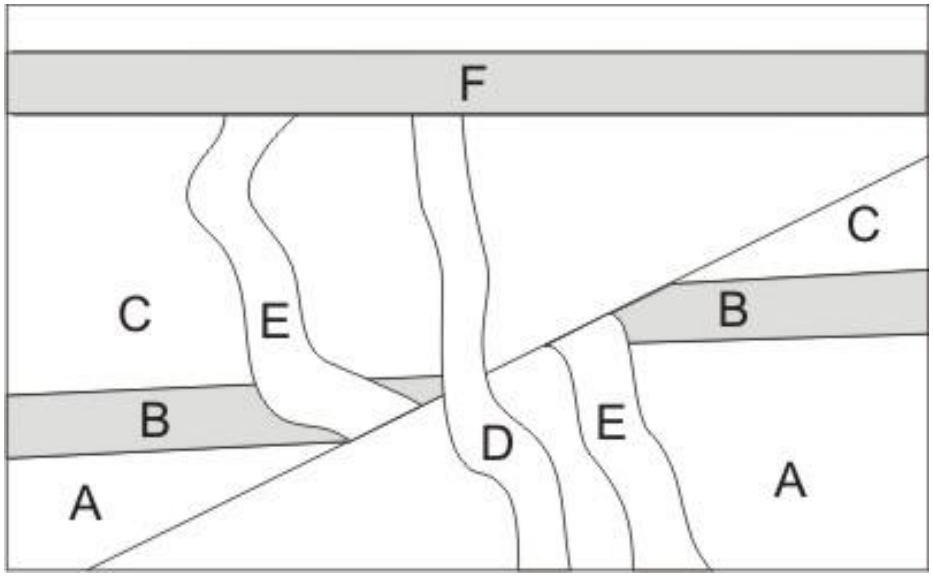
1. Know and apply the four principles of relative dating (box below) to put rocks, fossils, and events in order according to their age.
2. Know and apply the principles of absolute dating to estimate the ages of rocks based on their radioactive isotope content.
3. Define atom, element, electron, proton, neutron, isotope, and radioactive isotope, and understand how these terms relate to absolute dating.

Definitions/Information:
Principle of Original Horizontality: Rock layers are horizontal when they are deposited.
Relative Dating: Comparing or ranking the ages of rocks without actually determining their actual ages. For example, with relative dating we might say that rock A is older than rock B, but we don't know the actual age of either rock.
Absolute Dating: Determining (or approximating) the exact age of a rock.
Principle of Superposition: The closer a rock layer is to the surface of the Earth, the younger it is.
Principle of Cross-Cutting Relationships: If a layer of rock is found cutting through another layer of rock, the layer which is cutting through must be younger.
Principle of Faunal Succession: In the history of the Earth, many species of living things have come and gone. Some animals and plants are not alive today, but their fossils are evidene that they lived in the past. Layers of rokcs with similar types of fossils are probably of similar ages.

HINTS: Questions to ask yourself when you are trying to determine which of two rock layers is older:
1. Which layer reaches highest?
2. Which layer cuts through the other layer?
3. Which layer was broken by the earthquake?

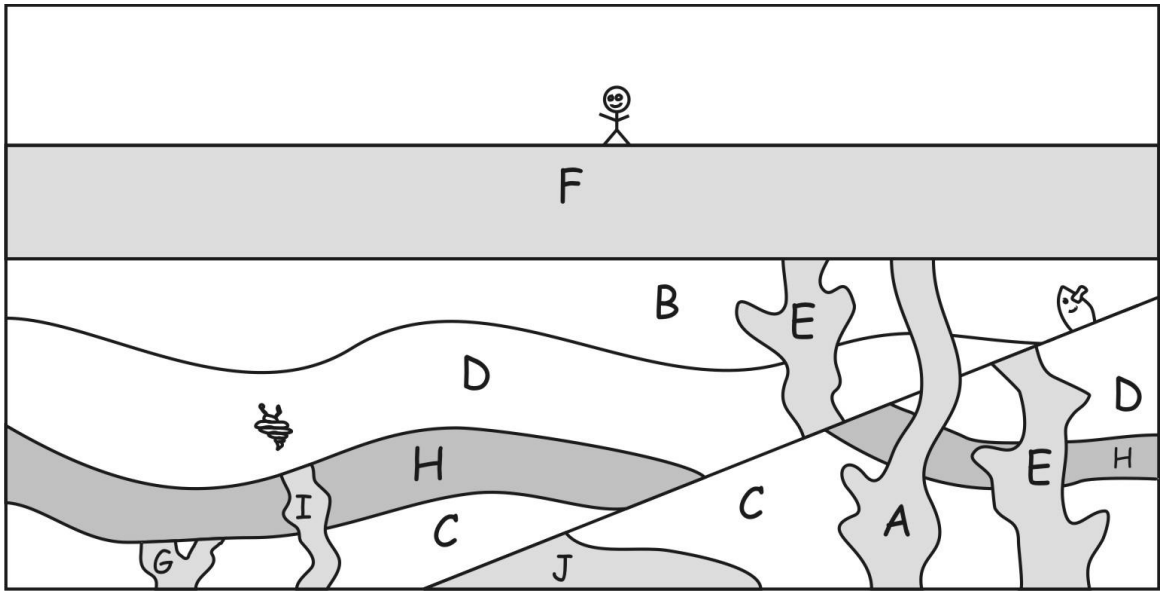
Practice #1. Rank the rocks in the diagram from oldest to youngest.

Oldest Youngest					



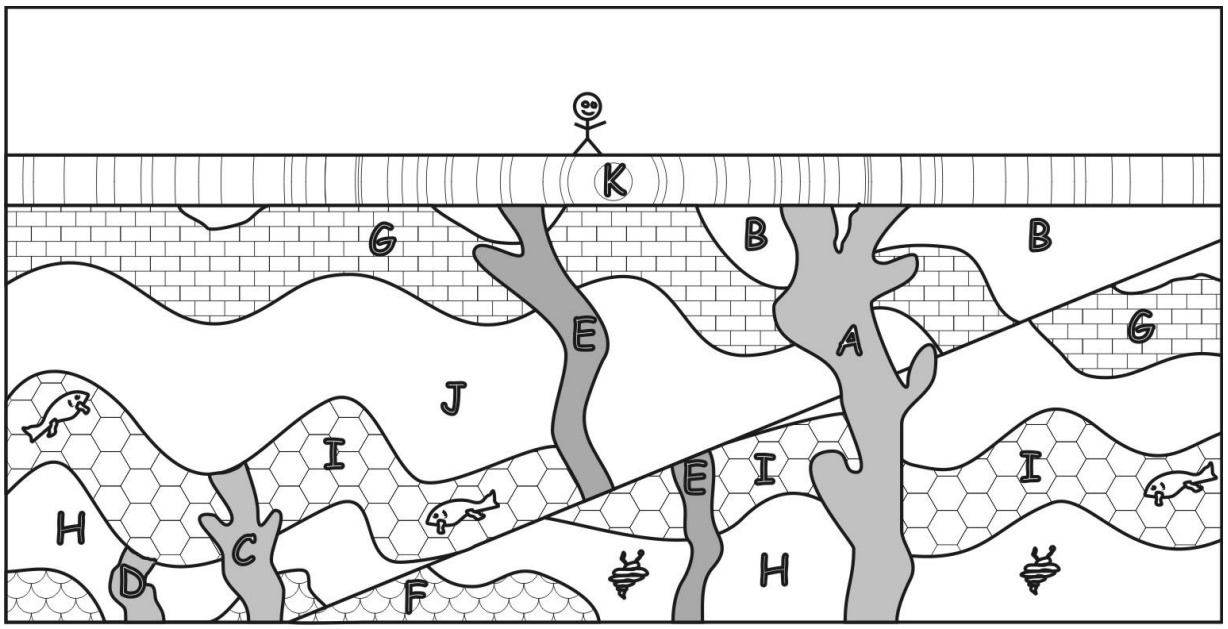
Practice #2. Rank the rocks in the diagram from oldest to youngest.

Oldest									Newest



Practice #3. Rank the rocks in the diagram from oldest to youngest.

Oldest										Newest



Ages of Rocks, Part 2: **Absolute Dating**
(a.k.a. radiometric dating)

PURPOSE: to be able to determine the age of a rock by measuring the number of radioactive atoms in it.

Helpful Information:

Radioactive Element: An element whose atoms turn into other types of atoms over time. As these atoms turn into other atoms, they lose mass. That lost mass turns into a form of energy called radiation. [Example: Uranium-238 is a radioactive element which gives off energy when it turns into Lead-206, a smaller element.]

Radioactive Decay: The process of large radioactive atoms losing mass and becoming smaller atoms.

Half-life: The amount of time it takes for half of something to die or to turn into something else. [Example: If you have 50 U-238 atoms, one half-life is the amount of time it takes for 25 of those atoms to turn into Pb-206 (Pb is the symbol for lead.)]

Parent Atom: A larger atom which can turn into a smaller atom by radioactive decay.

Daughter Atom: What the parent atom turns into when it decays.

How to tell if a rock is old: If there are many daughter atoms and few parent atoms, the parent atoms have been decaying for a long time, so the rock is old. If there are many parent atoms and few daughter atoms, the parent atoms have not been decaying for very long, so the rock is new.

Resetting the Clock: When lava hardens and becomes rock, parent atoms and daughter atoms become separated. They form different types of minerals. When rock is melted, its atoms are re-set.

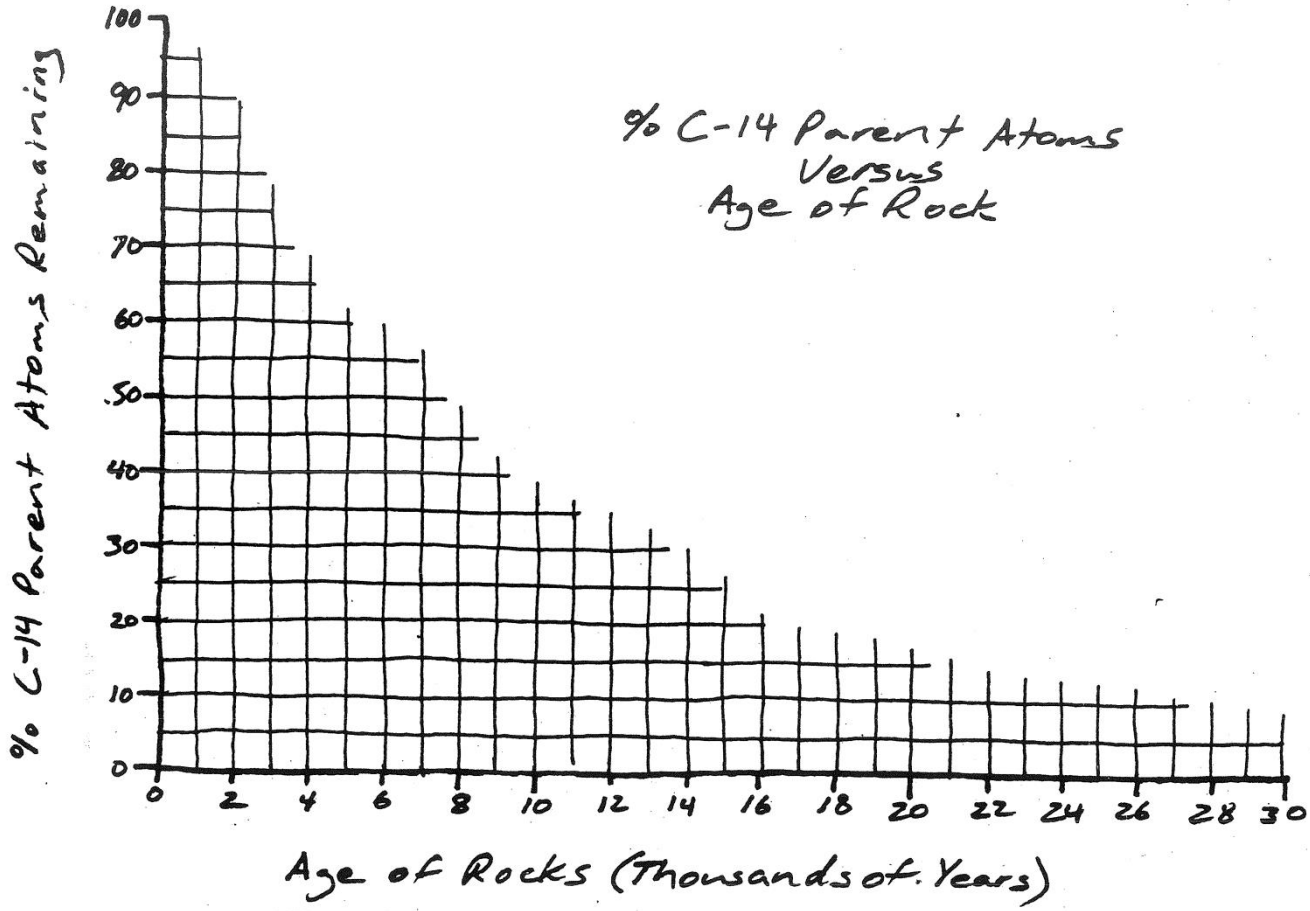
Sedimentary Rock Cannot Be Dated: Its atoms are not "re-set" by melting.

HALF-LIVES OF COMMONLY USED RADIOACTIVE ELEMENTS		
Parent Element	**Daughter Element**	**Approximate Half-life**
Uranium-238 (U-238)	Lead-206 (Pb-206)	4.5 Billion Years
Potassium-40 (K-40)	Argon-40 (Ar-40)	1.5 Billion Years
Carbon-14 (C-14)	Nitrogen-14 (N-14)	6,000 Years

AN EXAMPLE OF THE DECAY OF **U-238** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years					
Number Of Parent Atoms In Rock	400				
Number Of Daughter Atoms In Rock					
Total Number Of Atoms In Rock					
What % Of The Atoms Are Parent Atoms?					

AN EXAMPLE OF THE DECAY OF **K-40** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years					
Number Of Parent Atoms In Rock	64				
Number Of Daughter Atoms In Rock					
Total Number Of Atoms In Rock					
What % Of The Atoms Are Parent Atoms?					

AN EXAMPLE OF THE DECAY OF **C-14** ATOMS					
Number Of Half-lives Which Have Passed	0	1	2	3	4
Age Of The Rock In Years					
Number Of Parent Atoms In Rock	240				
Number Of Daughter Atoms In Rock					
Total Number Of Atoms In Rock					
What % Of The Atoms Are Parent Atoms?					



% C-14 Parent Atoms Versus Age of Rock

Assume here that 1 Half-Life = _____

O = Parent Atom (P)
o = Daughter (D) Atom

%P = ___ Half-lives = ___
%D = ___ Age = ___

% Par. = ___ Half-lives = ___
% D. = ___ Age = ___

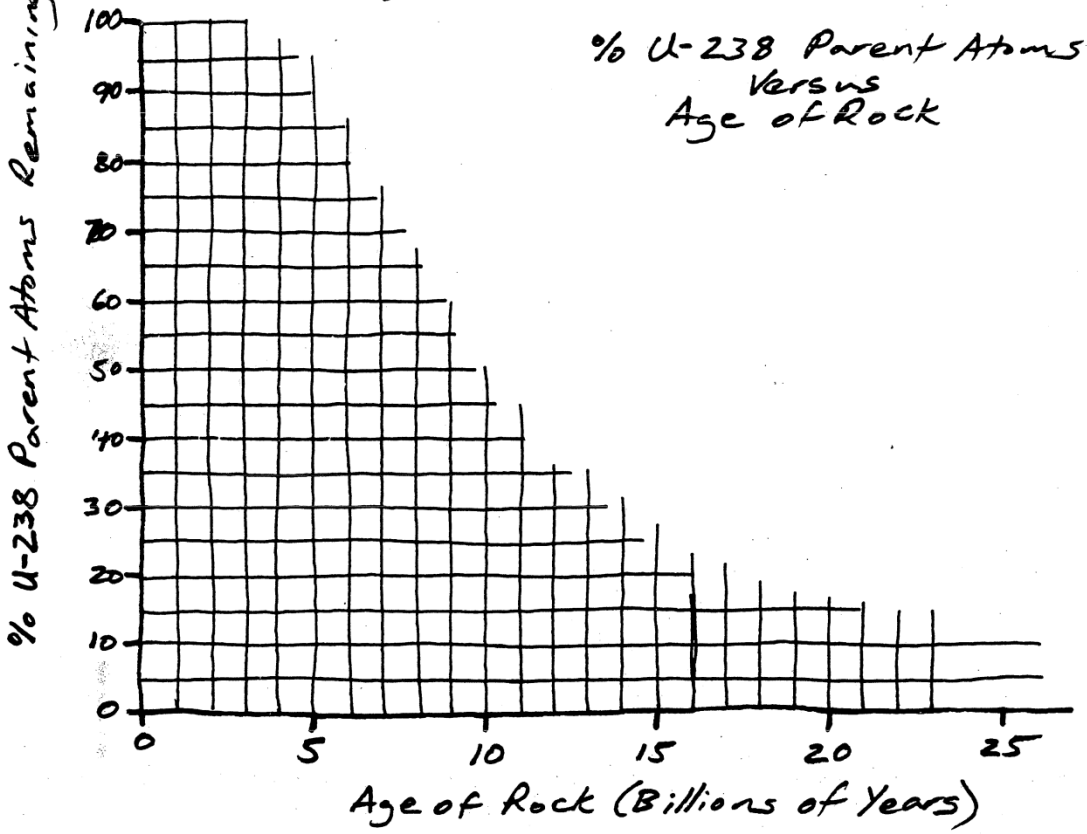
% Parent = ___ Half-Lives = ___
% Daughter = ___ Age = ___

% P = ___ Half-lives = ___
% D = ___ Age = ___

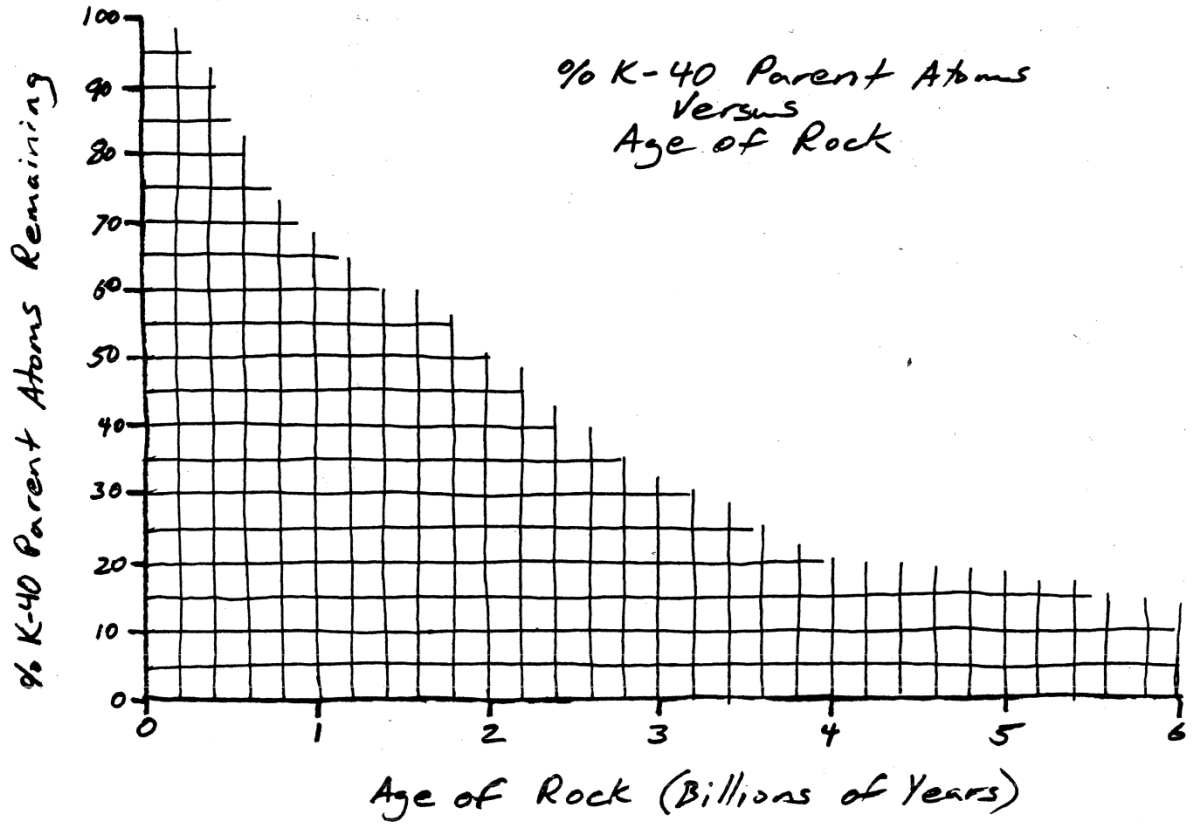
% P = ___ Half-lives = ___
% D = ___ Age = ___

Rock Dating Notes Science

% U-238 Parent Atoms Versus Age of Rock



% K-40 Parent Atoms Versus Age of Rock



Use the formula below to answer these questions. A calculator would be helpful.

8. A rock contains 8 Ar-40 atoms and 17 K-40 atoms. What percentage of the atoms in the rock are parent atoms?
9. A rock contains 24 C-14 atoms and 47 N-14 atoms. What percentage of the atoms in the rock are parent atoms?
10. A rock contains 43 U-238 atoms and 35 Pb-206 atoms. What percentage of the atoms in the rock are parent atoms?

How to determine the percentage (%) of atoms in a rock which are parent atoms:
USE THIS FORMULA.
% Which Are Parent Atoms = Number Of Parent Atoms Remaining ÷ Total Number Of Atoms In Rock
*****You will need to move the decimal point in your answer 2 places to the right.*****

Example Question: A rock contains 14 U-238 atoms and 9 Pb-206 atoms. What percentage of the atoms in this rock are parent atoms?

# of Parent Atoms = 14
Total # of Atoms = 14 + 9 = 23
(% which are parent atoms) = 14 ÷ 23

14 ÷ 23 = .608 ⇒ .608 Move decimal two spaces to get 60.8%

```
23 | 14.0
   13 8
      200
      184
       16
```

Use your graphs to answer the following questions.

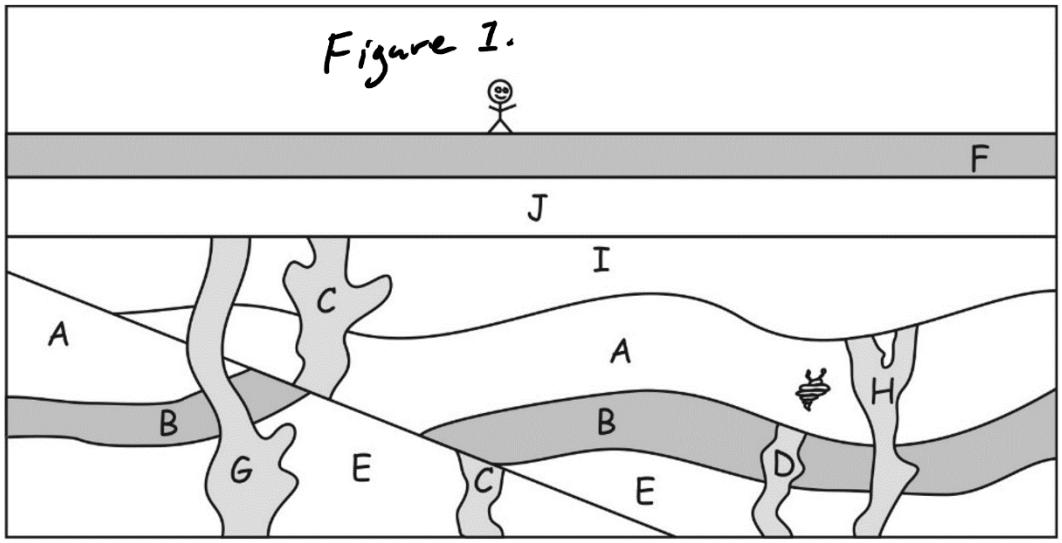
11. If a rock containing U-238 and Pb-206 contains 80% parent atoms, how old is the rock?
12. If a rock containing C-14 and N-14 contains 25% parent atoms, how old is the rock?
13. If a rock containing K-40 and Ar-40 contains 65% parent atoms, how old is the rock?
14. How old was the rock in question number 8?
15. How old was the rock in question number 9?
16. How old was the rock in question number 10?
17. A rock contains 90 atoms of U-238 and 7 atoms of Pb-206. How old is it?
18. A rock contains 17 atoms of K-40 and 3 atoms of Ar-40. How old is it?

Practice Test – Ages of Rock

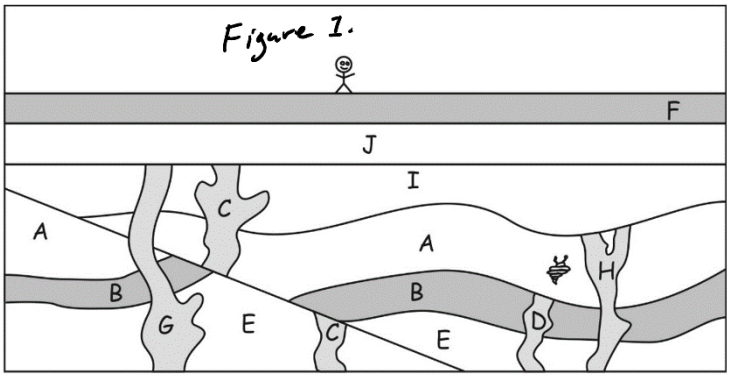
Part 1: Organize the lettered rock samples in **Figure 1** from oldest to youngest. Then make a mark where the earthquake occurred in the sequence.

Oldest									Newest

1. Which letter is barely older than layer B? ____
2. Which letter is barely younger than layer B? _____
3. Which letter is barely older than layer J? ____
4. Which letter is barely younger than layer J? _____
5. Which letter is barely older than letter H? ____
6. Which letter is barely younger than letter H? _____
7. Which letter is barely older than letter C? ____
8. Which letter is barely younger than letter C? _____
9. Which letter is barely older than layer A? ____
10. Which letter is barely younger than layer A? _____
11. The earthquake occurred between the appearance of letters _____ and _____.



Part 2:



12. Sample C contains 50 K-40 parent atoms and 150 Ar-40 daughter atoms.
    a. What is the total number of parent + daughter atoms?

    b. What percentage of those atoms are parent atoms?

    c. Which of the following is closest to the age of Sample C?
    0by 1by 2by 3by 4by 5by 6by 7by 8by

13. Sample G contains 150 K-40 parent atoms and 228 Ar-40 daughter atoms.
    a. What percentage of those atoms are parent atoms?

    b. Which of the following is closest to the age of Sample G?
    0by 1by 2by 3by 4by 5by 6by 7by 8by

14. Which of the following is closest to the age of the fault created by the earthquake?
    0-1by 1-2by 2-3by 3-4by 4-5by 5-6by 6-7by 7-8by

15. Sample D contains 90 K-40 parent atoms and 820 Ar-40 daughter atoms.
    a. What percentage of those atoms are parent atoms?

    b. Which of the following is closest to the age of Sample D?
    0by 1by 2by 3by 4by 5by 6by 7by 8by

16. Sample H contains 50 K-40 parent atoms and 215 Ar-40 daughter atoms.
    a. What percentage of those atoms are parent atoms?

    b. Which of the following is closest to the age of Sample H?
    0by 1by 2by 3by 4by
    5by 6by 7by 8by

17. The diagram on the right shows rock samples from another location on Earth. Choose the most likely age range for layer M, in that diagram.
    0-1by 1-2by 2-3by 3-4by 4-5by 5-6by
    6-7by 7-8by