Earth Systems 3209 (___/76) Name:
Radioactive Decay Assignment #2 Slot:

Part 1: Fill ins (1 mark each)

1. What percentage of the C-14 in a sample would be left after 18 000 years?

2. If three half-lives pass for an isotope, what percentage of its original amount remains?

3. If 25 % of a radioactive isotope remains, how many half-lives have passed?

4. If X decays to Y, and you find that the there is 1X : 7 Y , how many half-lives have passed?

5. How many half-lives have passed when 1/64th of the original isotope remains?

6. If X has a half-life of 20, 000 years, how much of the original amount of X remains after 2 half lives?

Part 2: Show workings. Place answers on your own paper. (5 marks each)

7. A rock has a radioactive isotope of X that has a half-life of 47,000 years. There is 1/16th of the original material remaining. How old is the rock?

8. A rock has a radioactive isotope of Y that has a half-life of 23,000 years. There is a ratio of 1 : 7 of the parent to daughter product. How old is the sample?

9. A rock has a radioactive isotope of Z that has a half-life of 35,000 years. There is a 12.5 g of parent product in a 100 g sample. How old is the sample?

10. A rock is found to have a radioactive isotope with a half-life of 64,000 years. It is found to be 320,000 years old. How much of the sample has not decayed?

11. Calculate the age of a rock using K - 40 → Ar - 40 (half - life 1.3 billion years) if you know that 12.5% of the parent material now remains in the sample. (Show your workings.)

12. A stone arrowhead was found embedded in a thighbone of a wooly mammoth. Would you select the arrowhead or the thighbone for testing if only carbon-14 dating technology was available? Explain.

13. Given the half-life of U-235 is 0.7 billion years, determine the age of a sample of U-235 if 1/16 of the starting material remains. (SHOW YOUR WORKINGS)

14. 1200 g of a radioactive element has decayed to produce 75 g of the element. If the half-life of the mineral is 0.40 billion years, what is the age of the sample? Show calculations.

15. Uranium-235 decays to form lead-207 and has a half-life of 713 million years. Determine the age of a sample of uranium-235 if the original mass was 256 grams and after radioactive decay the mass is 32 grams. Show your workings.

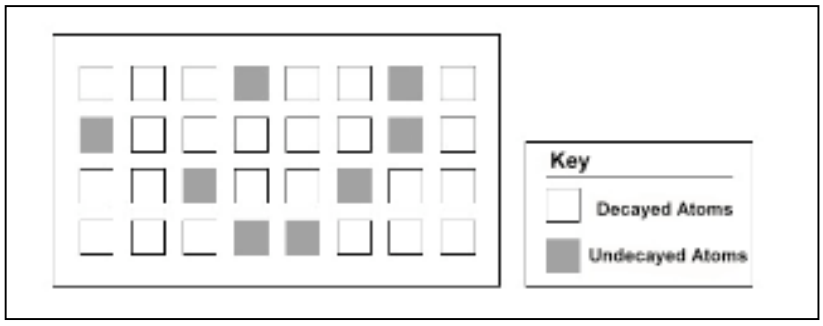
16. A sample of carbon-14 has a half-life of 5730 years. If the parent isotope was 512 g, how many grams of parent isotope will remain after 34 380 years? Show all calculations.

17. The half life of uranium-235 is 713 million years. If a sample had 256 g of uranium-235 originally, how many grams of the parent material would remain after 2139 million years have passed? Show all workings.

18. An organism contained 28 kg of carbon-14. If the half life of carbon-14 is 5730 years, what mass of carbon-14 remains in a fossil of this organism that is approximately 22 920 years old? Show all workings.

19. The diagram below represents the decay pattern of a radioactive isotope in an igneous rock sample. The half-life of the radioactive isotope is 2.3 million years.

Use the pattern to determine the age of the rock and show your working in the space below.



20. The information below was collected from radioactive isotopes found in two different rock samples from a volcanic island

Rock sample	Half-life (million years)	Amount of parent material remaining
A	2.5	$\frac{1}{128}$
B	4.3	$\frac{1}{16}$

a) Determine the number of half-lives that has passed for each sample. Show your workings. (3 marks)

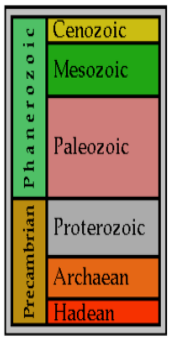
b) State which of the rock samples is older. Show workings to justify your answer. (2 marks)

Earth Systems 3209 - Unit 2 Lesson 7 – Events and Geologic Time

4.6 billion years ago the earth and the remainder of the solar system have formed. Earths atmosphere, lithosphere and oceans now exist. Reference: 236 - 239 in text

Geologic Time Scale

What do the divisions of the geologic time scale signify?



Divisions of Geologic Time
Eon, Era, Period, Epoch

Eon - Largest span of time

Epoch - Smallest

MESOZOIC →

PROTEROZOIC →

Time Units of the Geologic Time Scale				Development of Plants and Animals
Eon	Era	Period	Epoch	
PHANEROZOIC	CENOZOIC	Quaternary	Holocene 0.01	Humans develop
			Pleistocene 1.6	
		Tertiary	Pliocene 5.3	"Age of Mammals"
			Miocene 23.7	
			Oligocene 36.6	
			Eocene 57.8	
			Paleocene 66.4	Extinction of dinosaurs and many other species
	MESOZOIC	Cretaceous 144	"Age of Reptiles"	First flowering plants
		Jurassic 208		First birds
		Triassic 251		Dinosaurs dominant
	PALEOZOIC	Permian 286	"Age of Amphibians"	Extinction of trilobites and many other marine animals
		Pennsylvanian 320		First reptiles
		Mississippian 360		Large coal swamps
				Amphibians abundant
		Devonian 408	"Age of Fishes"	First insect fossils
		Silurian 438		Fishes dominant
				First land plants
		Ordovician 505	"Age of Invertebrates"	First fishes
		Cambrian 543		Trilobites dominant
				First organisms with shells
PROTEROZOIC	Collectively called Precambrian, comprises about 87% of the geologic time scale			First multicelled organisms
Archean 2500				First one-celled organisms
Hadean 3800				Age of oldest rocks
4600				Origin of the Earth

Adapted from: illustration by Dennis Tasa, 1993, Macmillan Publishing Company.

As you can see, the Geologic Time Scale is split into specific parts. Each part is associated with a different sub-division of time with Eons (being the largest), Eras, Periods and Epochs (being the smallest).

If you were to find us (modern day people) on the Geologic Time Scale, we would be in the Phanerozoic Eon, Cenezoic Era, Quaternary Period and Holocene Epoch. Please note that it is not necessary for you to memorize the specific names of each period or epoch, but simply realize the relation of each time period to the other. However, you should be able to distinguish between Precambrian time and the Paleozoic, Mesozoic, and Cenozoic eras.

In these instances, dating or aging is not required but you can match the periods with the life forms in order of when they arrived "on the scene" (you did this in an earlier lesson with a multiple choice question, where you showed what life form came first). It should be noted that the Phanerozoic eon is divided into three eras: the Paleozoic, Mesozoic, and Cenozoic.

You should be very careful not to confuse the Phanerozoic eon with the Paleozoic era.

Other things you should note as you study the time scale are:

a) Precambrian time represents the longest part of Earths history. It also has the least amount of life forms due to pre-existing physical and chemical environmental conditions at that time (e.g. low levels of free oxygen in atmosphere, extreme temperatures, extreme UV levels, and metamorphism of rocks).

b) The Phanerozoic eon represents the emergence of complex life forms and is often referred to as the ***time of visible life***. It represents the emergence of more complex life, like multi-celled organisms, as life evolved.

c) There were two major extinctions in Earths history. These are sometimes referred to as K-T extinctions (*this actually isn't true. The K-T is actually the German equivalent of "Cretaceous –Tertiary" which is the last great dinosaur extinction. Essentially, if you ever hear of a K-T boundary, it means Massive extinction*). These are represented on the Geologic Time Scale by a line drawn straight across forming a new era. At these points, the interrelation of a changing hydrosphere, atmosphere and geosphere in climate, continental positions, and the Earth's crust changing over time, show an effect on the biosphere.

The two extinctions are located at the:

(i) Permian-Triassic boundary - extinction occurred approximately 245 million years ago with 96% of marine species disappearing. Trilobites are a perfect example of a species that went extinct during this time.

(ii) Cretaceous-Tertiary boundary - The Cretaceous-Tertiary boundary extinction occurred approximately 65 million years ago with over 50% of all species going

extinct. This time ended the reign of the “dinosaurs” or large reptiles.

d) List the dominant life forms present at each era like:

(i) Single-celled and other simple life forms (Precambrian)
(ii) Invertebrates (early Paleozoic)
(iii) Fish (middle Paleozoic)
(iv) First land plants (between early and middle Paleozoic)
(v) Amphibians (late Paleozoic)
(vi) Reptiles (Mesozoic)
(vii) Birds (Mesozoic)
(viii) Flowering plants (Mesozoic)
(ix) Mammals (Cenozoic)

Use the following mnemonic device to remember the dominant life forms present at each Era:

Since
I
Found
Flying
Angels
Riding
Brooms
Forget
Medicine

e) Match the time frame with the dominant life form on Earth at that time, like:

(i) Cenozoic - Age of Mammals
(ii) Mesozoic - Age of Reptiles
(iii) Paleozoic (late) - Age of Amphibians
(iv) Paleozoic (middle) - Age of Fishes
(v) Paleozoic (early) - Age of Invertebrates

Special note: The reason why the Paleozoic has three (middle, late, and early) is that there was an explosion of life at end of the Precambrian (start of the Phanerozoic eon, Paleozoic era, Cambrian period)

**Along with this Lesson, you will be given a detailed Geologic Time Scale found here: http://www.enchantedlearning.com/subjects/Geologictime.html

As you scan this Time Scale, some major events are as follows:

Archean
✧Approx. 3.2 billion years ago. The first known life now exists on earth. This includes Bacteria and Algae

Proterozoic
✧No life is on land it is in the oceans.
✧Includes: simple marine plants, algae, fungi, etc.
✧In North America there is a great deal of Volcanic Activity. Lava flows and metamorphism occurs.
✧Also, formation of large copper, iron and nickle deposits.

Paleozoic - Age of invertebrates

Cambrian
✧570-505 Ma (Millions of years Ago)
✧Marine invertebrates are very common.
✧Includes: trilobites, brachiopods, snails, sponges, etc.
✧Late cambrian we see the evolution of the first vertebrate organisms… the early fish
Ordovician
✧505 - 438 Ma
✧Marine invertebrates continue to thrive.
✧North America sees the start of the formation of the Appalachian Mountain Chain.
✧Half of present North America is submerged.

Silurian
✧438 - 408 Ma
✧The first land animals now exist.
✧Includes: Spiders, scorpions, etc
✧Fish continue to develop.

Devonian
✧408 - 360 Ma
✧First amphibians appear in the fossil record.
✧First land plants, forests, etc now exist.
✧In North America the Mountain Building Process continues.

Mississippian
✧360 - 320 Ma
✧Amphibians flourish
✧Ferns and conifers are abundant

Pennsylvanian
✧320 - 280 Ma
✧First reptiles appear in fossil record.
✧Many species of giant insects exist now.
✧Spore bearing plants and amphibians flourish.
✧In North America large coal swamps form.

Permian
✧286 - 245 Ma
✧A mass extinction of most species occurs at the end of the Permian.
✧Trilobites, seed ferns, scale trees, etc all die.
✧Corals become abundant.

Mesozoic Era - Age of the Reptiles

Triassic
✧245 - 208 Ma
✧Reptiles start to evolve.
✧Forests of cycads and conifers now exist.
✧In North America: volcanism, faulting and earthquakes occur along the west coast.
Jurassic
✧208 - 144 Ma
✧Giant Dinosaurs have now evolved.
✧First birds and mammals appear in the fossil record.
✧Conifers and cycads are now abundant.
✧West Central North America is under a huge sea. The Gulf of Mexico and the Atlantic Ocean start to form.

Cretaceous
✧144 - 66.4 Ma.
✧Dinosaurs and amniotes die out as part of a mass extinction that kill most species
✧Mammals and birds start to evolve.
✧Flowering plants and hardwood trees evolve.
✧North America: Rockies start to form.
✧Coal swamps form.

Cenezoic Era - Age of the Mammals

Paleocene
✧66.4 - 57.8 Ma
✧Evolution of mammals starts after extinction of dinosaurs.
✧Uplift of Mountains in Western North America continues.

Eocene
✧57.8 - 36.8 Ma.
✧Pygmy ancestors of the horse and other mammals now exist.
✧First whales now appear in the fossil record.
✧Diatoms and flowering plants thrive.
✧Coal forms in Western North America

Oligocene
✧36.6 - 23.7 Ma
✧Mammals continue to evolve.
✧Elephants exist in Africa
✧Monkeys die out in North America
✧The Alps and Himalayas start to form

Miocene
✧23.7 - 5.3 Ma
✧The horse migrates to Asia.
✧Elephants migrate to North America
✧Grasses and grazing animals thrive.
✧North America was still joined to Asia.
✧Volcanic Activity and Mountain building still continue in Western North America.

Quaternary Period

Pleistocene
✧1.6 - 0.01 Ma
✧Hominids continue to evolve.
✧Elephants flourish in North America and then die out.
✧There are a series of ice ages.
✧Mountains and Plateaus form in Western North America.

Holocene
✧0.01 Ma - Present
✧Humans are now the dominant species on the planet.
✧Domestic animal species are developed
✧The last of the Pleistocene Ice ages ends.
✧West Coast of North America continue to uplift and the Great Lakes form
✧And so on…

Questions to Answer:

1. Which geological time span is referred to as the “Age of Reptiles”? _____

2. Which time span would least likely contain fossil evidence? _____

3. Rocks from which era would contain fossils of trilobites? _____

4. What does the Phanerozoic Eon represent? _____

_____

_____

5. a) Describe the two major extinctions in Earth history. _____

_____

_____

_____

b) Do you think there will be a third? Why? _____

_____

_____

Earth Systems 3209 Unit 2 Test Review

Please answer the following completely and on your own paper. You may type them, or handwrite them legibly.

Definitions (Terms to know)

Uniformitarianism	Catastrophism	absolute (dating) time
relative (dating) time	principle	law
Superposition	Cross-cutting relations	Horizontality
Inclusions	Fossil succession (index fossils)	Unconformities
Varves	Growth rings	Radioactive dating
half-life	isotope	parent elements
daughter elements	radiometric data	sources of error
geologic time scale	fossil	petrifaction by replacement
carbonization	mould and cast	preserved intact (frozen, amber)
imprints (soft tissue)	trace fossils	eons
eras	periods	epochs
Precambrian	Phanerozoic	Palaeozoic
Mesozoic		

Review Questions

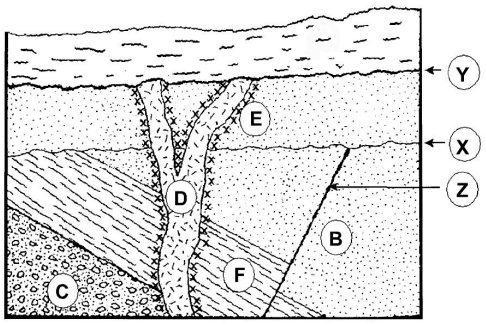
1. Explain how the ideas of catastrophism and uniformitarianism are different. In your answer include what these two philosophies would have believed about geologic time.

2. Using examples, explain the difference between relative time, and absolute time.

3. a) How are half-lives in radioactive isotopes used to determine the age of something?
b) Is there any time when these can't be used, or will give false dates for rocks? Explain using examples.

4. a)You have a rock with a half-life of 200,000 years and there is 40 grams of a 160-gram sample that is parent. How old is the sample?
b) The half-life of element X is 200 000 years. If a sample originally held 256 g of parent isotope and the rock sample has been determined to be 1 million years old, what mass of parent now remains? Show calculations.
c) An organism contained 28 kg of carbon-14. If the half life of carbon-14 is 5730 years, what mass of carbon-14 remains in a fossil of this organism that is approximately 22 920 years old? Show all workings.

5. Use the following diagram to answer some questions about relative age and the ages of layers.



a) Label the ages of the identified letters from the oldest event to the youngest.
Oldest _____ _____ _____ _____ _____ _____ _____ _____ Youngest
b) Accurately name the feature that is identified by the Letter X
c) What Principle helps to tell us how old Z may be?
d) Is letter D a buried lava flow or an intrusion? How did you determine that?

6. Describe the three conditions necessary for fossilization, and explain why you would never find fossils of a worm.

7. List and explain three types of fossil formation.

8. Using the two largest mass extinctions as examples, explain why the dominant life on earth has changed over geologic time.