Name:_____ Student number:_____

**GEO 1111**

**EXAM 1 ANSWER KEY**

**PART 1. Multiple choice questions** (15 points)

Each question in this section has <u>one</u> correct answer. Mark it on the scantron sheet.

1. Which is <u>false</u>?
   **a) Natural systems are at equilibrium with their surroundings.**
   b) Natural systems are composed of a set of interacting parts.
   c) Natural systems are thermodynamically open.
   d) None of the above are false.

2. _____ are the main phenomena that drive the Earth System.
   a) Solar radiation and heat left over from planetary accretion
   b) The greenhouse effect and heat left over from planetary accretion
   c) Tidal forces and heat within the Earth
   **d) Solar radiation and heat within the Earth**

3. Oceanic crust is on average much <u>younger</u> than continental crust because
   a) continental crust was generated first.
   b) oceanic crust is constantly being generated.
   c) continental crust is thicker and more easily deformed.
   **d) None of the above.**

4. Tectonic plates always contain
   a) continental crust.
   **b) oceanic crust.**
   c) continental and oceanic crust.
   d) All of the above.

5. Gravitational collapse of a star is stemmed by
   **a) pressure**
   b) nuclear fusion
   c) nuclear fission
   d) All of the above

6. Which of these is in the <u>correct</u> order?
   a) Big Bang → stars → Earth → Moon → Earth differentiates into core and mantle
   b) hydrogen → iron → stellar nucleosynthesis → elements heavier than iron
   **c) Big Bang → stars → iron → supernovae → Earth**
   d) iron → stars → supernova → planets

7. Chondrites…
   a) …are likely derived from planetesimals that did not differentiate into core and mantle.

b) …are enriched in siderophile elements compared to the Earth's crust.
c) …contain chondrules.
**d) All of the above**

8. Asteroids are to terrestrial planets what _____ are to Jovian planets.
   a) moons
   **b) comets**
   c) meteorites
   d) gases

9. The Jovian planets are more massive than the terrestrial planets because
   a) there was more accretable material in the outer solar system.
   b) there was more ice in the outer solar system.
   c) temperature was too hot close to the Sun.
   **d) All of the above.**

10. The Moon and Mercury have little to no atmospheres likely because
    a) they are small bodies (low mass).
    b) they exert little gravitational pull on their surroundings.
    c) gas molecules need relatively low velocities to escape their gravitational pull.
    **d) All of the above.**

11. The impact hypothesis of the Moon helps explain
    **a) the lower average density of the Moon relative to that of Earth.**
    b) the different oxygen isotope signatures in Moon rocks and Earth rocks.
    c) why the Moon is so small (which would have made it difficult to capture).
    d) All the above

12. Uniformitarianism states that
    a) sedimentary beds are laid down in a uniform, horizontal fashion.
    b) sedimentary beds are laid down in uniform vertical successions.
    **c) the present is the key to the past.**
    d) None of the above

13. The following unconformity is a
    a) angular unconformity.
    b) paraconformity.
    c) disconformity.
    **d) None of the above**

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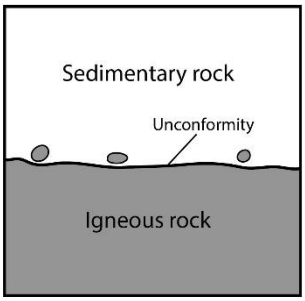
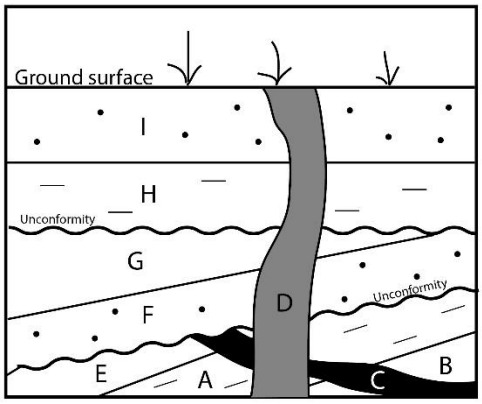



14. From oldest to youngest, the correct sequence for the following figure is
    a) B,C,D,A,F,G,H,I
    **b) B,A,E,C,F,G,H,I,D**
    c) A,B,C,D,E,F,G,H,I
    d) B,A,D,C,E,F,G,H,I




15. The half life of a radioactive isotope refers to
    **a) the time it takes for half of the parent isotopes to decay.**
    b) the time it takes for half the closure temperature to be reached.
    c) the time it takes for half the Curie temperature to be reached.
    d) None of the above.

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**PART 2. Short-answer questions** (25 points)

Answer the questions below in the spaces provided.

1. What is the main evidence that suggests the universe is expanding? (1 point)

The key word here is **red shift**.

From Lecture 4, slide 10
"Within two years, however, Edwin Hubble, an American astronomer, provided evidence that the

universe was indeed expanding. From his telescope in California, he observed a shift toward the red spectra (**red shift**) of the light from stars in distant galaxies (red shift is a type of Doppler shift). The simplest explanation for this shift was that distant galaxies were speeding away from our galaxy (the Milky Way) at great speeds."

2. Provide <u>two reasons</u> why Darwinian evolution likely occurred. (2 points)

The key words here are **fossils** and **DNA**.

From Lecture 2, slides 76 and 77
"How do we know that Darwinian evolution occurred? 1. The **fossil record**. It suggests life not only has evolved over Earth history, but that is has diversified with time: the Tree of Life branches outward. 2. **DNA**. We share less DNA in common with the organisms that branched off the Tree of Life at early stages."

3. Scientists commonly argue that the surface of the Earth has likely changed colour over time, passing from <u>grey to red (with periods of white) to green</u>. What likely caused these colour changes? Explain. (4 points)

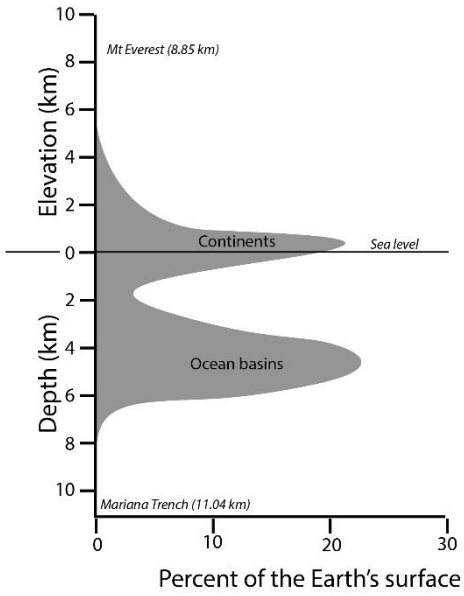
From Questions (Lecture 2)
"Grey → **No free oxygen** in atmosphere or ocean.
Red → Great Oxidation Event → The hypothesis is as follows. Lifeforms evolved and started to **photosynthesize**. This produced oxygen, a waste product of photosynthesis. Oxygen reacted with fresh mineral surfaces (especially iron), generating "mass rusting" (red colour). Once the majority of fresh mineral surfaces on Earth surface became oxidized, **free oxygen** started to build up in ocean and atmosphere.
White → Several **significant glaciations** occurred during this time (possibly Snowball Earth events).
Green → **Plants colonized land**."

4. The first stars likely consisted almost exclusively of hydrogen and helium. Why? (1 point)

| | |
|---|---|
| 0.5/1 for something like "Big Bang created the H and He in the universe"<br><br>1/1 for something like "Big Bang created the H and He in the universe, but not much else, because temperatures fell too rapidly following the Big Bang to generate heavier elements". | |

5. The elevation of the Earth's surface has a bimodal distribution (see figure below): the continents are associated with one peak, the ocean basins with the other. What <u>two things</u> cause this bimodal distribution? (2 points)

Name:_____ Student number:_____




Difference in **density** and **thickness** of continental vs oceanic crust.

6. The mantle is ultramafic, the oceanic crust is mafic, and the continental crust is felsic. Explain why. (1 point)

**Partial melting**

7. What is the iron limit and why does it exist? (2 points)

Give full marks for something like "Elements heavier than Fe do not constitute "fuel" for stars. The nuclear fusion assembly line therefore stops at Fe—stellar nucleosynthesis has an iron limit."

From Lecture 4, slide 40
"Generation of elements heavier than iron (Fe) by nuclear fusion does not result in mass loss and does therefore not generate heat; rather, fusion actually requires heat input. These reactions are heat sinks, not heat sources, and cannot stem gravitational collapse of the star. For this reason, nuclear fires within stars tend to primarily produce elements ranging from He to Fe. This is referred to as the **iron limit**."

8. How are Fraunhofer lines generated? (1 point)

Absorption of different frequencies of sunlight by elements in the Sun's atmosphere.

From Lecture 4, slide 45
"Astronomers have long been using prisms* in telescopes to analyze the color composition of light coming from stars, including our Sun. Rather than producing a continuous smooth spectrum, dark bands are present. The dark bands **(Fraunhofer lines)** are believed to be

produced by partial absorption of light by different elements present in the gaseous atmosphere surrounding the star. As determined experimentally, the wavelength of each dark band is diagnostic of a specific element, such as sodium pictured below. The resultant "bar code" is diagnostic of the composition of a star's halo of gas and, by extension, the star itself."

9. Explain the difference between refractory and volatile substances. (1 point)

From Lecture 4, slides 52 to 55
"Substances with high melting and boiling points are said to be **refractory**, whereas those with low melting and boiling points are said to be **volatile**."

10. The average chemical composition of the Earth is best ascertained by analyzing chondrites, not rocks from the Earth's crust. Explain. (2 points)

From Questions (Lecture 4)
"Chondrites are thought to have come from planetesimals that did not differentiate into a metallic core and silicate mantle. Chondrites are therefore believed more representative of the average composition of terrestrial planets than, say, (1) meteorites from planetesimals that did differentiate (e.g., iron achondrites, basaltic achondrites), (2) the Earth's crust (the Earth is also a differentiated body—its crust is empoverished in metal and not indicative of bulk composition) and (3) the Sun (Fraunhofer lines show that the Sun is rich in volatiles, whereas the terrestrial planets are not)."

11. The Moon is heavily cratered whereas the Earth is not. Why? (1 point)

From Lecture 5, slides 83 to 86
"From about 2.5 Ga onward, the Moon has effectively been **"dead"**. Little volcanism has occurred, no convection cells have churned in its mantle, no plate tectonic processes have operated, and, due to the lack of an atmosphere, there has been little weathering or erosion. The billions-of-years-old impact craters therefore remain largely pristine; there has been **no surface renewal processes** on the Moon (e.g., plate tectonics, volcanism, sedimentation, erosion) since 2.5 Ga that could have "wiped the board clean"…. The **Earth** must also have suffered similar heavy bombardment until the start of the Archean. However, the Earth bears little evidence of this; it is not pockmarked like the Moon. Why? The reason for this is that Earth is **not a "dead" planet**. Surface renewal is ongoing. Surface renewal continues to this day on Earth thanks to plate tectonics, volcanism, sedimentation, and erosion. These processes "wipe the slate clean" over time, erasing the visible signs of many impact craters soon after they form."

12. Define the term *unconformity*. (1 point)

Answer needs to contain "erosion or non-deposition" and "hiatus" (or similar term/phrase) for full marks.

From Lecture 6, slide 49
"…if a contact between two rock units is unconformable (i.e., it is an **unconformity**), a significant break (**hiatus**) in sedimentation has occurred due to non-deposition or erosion."

13. The geological time scale was established using which two types of dating? (2 points)

**Relative** dating (1 point) and **absolute** (or numerical)* dating (1 point)

*Give 0.5 points for radiometric or radioactive dating

14. How is the age of the Earth determined? (1 point)

Lecture 7, slides 41 to 43
"The oldest radiometric date obtained from an object on Earth is 4.4 Ga, from a detrital zircon from the Jack Hills meta-sediment unit in Australia. The oldest in-situ minerals are about 4.3 Ga; they come from Northern Quebec. So where does the age of 4.6 Ga come from for the age of the Earth? Radiometric ages obtained from **meteorites** tend to cluster around 4.6 Ga (actually, 4.55 Ga). This is thought to be the age at which Earth formed."

15. Explain three differences between P-waves and S-waves. (3 points)

From Lecture 7, slides 59 and 60

"P-wave
-Body wave
-The "P" has a dual meaning: "pressure wave" (it's a compressional wave) or "primary wave" (it's fast→ it arrives first)
-Lower energy than other seismic wave types (subtle shaking…felt by cats, dogs)
-Propagates through solids, liquids or gas

S-wave
-Body wave
-The "S" has a dual meaning: "shear wave" (it's a transverse wave) or "secondary wave" (it travels a bit slower, and arrives second, after Pwave)
-A bit slower (arrives second)
-Higher energy (subtle shaking…felt by cats, dogs, possibly humans)
-Propages through solids only"