Name_____

Homework-4 Mars 2024

Name_____

1. One-word answers for how the environment on Mars today differs from Noachian Mars (>3.8 billion years ago) (5 pts)
   a. The atmosphere is __less dense
   b. The sun is ___more intense
   c. The magnetosphere is ___not active
   d. The cryosphere is __thicker
   e. The impact rate is _lower

2. The first successful robotic mission to Mars (Mariner 4) discovered: (3 pts)
   a. Martian canals are _nonexistant
   b. The atmospheric pressure is less than __1_% that of Earth
   c. The southern hemisphere has lots of this landform: _impact craters

3. How long does it take a solar flare, traveling at the speed of light, to reach Mars when it is closest to the Sun in its orbit? (3 pts)
   1.38 AU * ($1.496*10^{11}$ m/AU) / ($3*10^{8}$ m/s) = 688 s ~ 11.5 minutes

4. Which times of day on equatorial Mars have the highest relative humidities: (2 pts)
   Midnight to sunrise

5. Compare and briefly explain the mean bulk densities of Earth and Mars (3 pts)

Earth has a much higher bulk density (~5500 kg/m^3) than Mars (~3900 kg/m^3) because of a greater proportion of heavier elements and because it is larger, with more self-compression. (Very recent results from InSight indicate that Mars' core is larger and less dense than previously believed, but that doesn't change the bulk density very much.)

6. Describe the hemispheric dichotomy of Mars in term of: (3 pts)
   a. Elevations N hemisphere lower
   b. Crustal thickness N hemisphere thinner
   c. Terrain (surface) ages based on crater counts: Fewer on surface of N hemisphere

7. List 3 hypotheses for how the hemispheric dichotomy might have formed: (3 pts)
   1. Single giant impact
   2. Multiple very large impacts
   3. Degree-1 mantle convection
   4. Early form of plate tectonics

   (Any 3 of these is fine)

8. List at least 2 sources of energy for melting and differentiation of early Mars: (2 pts)

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Radioactive decay (e.g. U, Al, K) and accretional heating from the kinetic energy of impacts.

9. Fill out this table about the major geologic time periods on Mars (5 pts)

Characteristic	Noachian	Hesperian	Amazonian
Ages in years	4.1-3.7 Ga	3.7-3.0 Ga	<3 Ga
Impact cratering rate	High	declining rapidly	Low
Fluvial/water activity	widespread valley networks	localized outflow channels	more limited
Flood lava volcanism	Probably extensive, but largely covered	Extensive flood lavas	Continued at lower/ less frequent rate
Altered minerals according to Bibring et al. 2006	clay minerals	sulfates	anhydrous ferric oxides

10. Describe the active gullies on Mars in terms of (3 pts)

    a. Seasonal activity: winter, especially late winter when the most CO_2 frost is present
    b. Surface temperatures: Buffered to the CO_2 frost point temperature (~-130 C or ~140 K)
    c. Latitudinal distribution: mostly mid-latitude

11. The hydrostatic equation is $dP = -\rho g dZ$ where dP is the difference in pressure between 2 depths (dZ), ρ is density of the crustal section, and g is the acceleration of gravity (Mars or Earth). Ignoring atmospheric pressure and assuming the same crustal density, the pressure would change _ 3.7/9.8=0.38 _ times faster or 2.64 times slower (circle one) with depth in Mars than in Earth. What are the implications for porosity with depth? (4 pts)
    Slower increase in pressure with depth will lead to a slower decrease in porosity with depth on Mars compared to Earth.

12. How does Mars' eccentric orbit around the sun affect (4 pts)
    a. Lengths (durations) of the 4 seasons: Perihelion (closest to sun) is near southern summer which causes shorter S summers and N winters. Northern summer is near aphelion (farthest from sun) which causes longer N summers and S winters. Thus, unlike Earth, the seasons have different lengths.

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b. Abundance of CO_2 on the ground and in the atmosphere: CO_2 condenses on the winter hemisphere, especially the southern winter which is longer. Up to 25% of the atmosphere may condense.

c. Dust devil and dust storm activity
More activity when surface is warmest, near perihelion, but some activity all year in the warmest hemisphere.

d. Sand ripple and dunes migration rates: Greatest near perihelion, with greatest atmospheric pressure (least CO_2 on the ground as frost/ice.)

13. List 2 theories for the origin of Phobos and Deimos: (2 pts)
1.) Phobos and Deimos may be captured asteroids.
2.) Phobos and Deimos may have coalesced after a major impact event on Mats

14. Briefly summarize the evidence from Perseverance rover that Jezero Crater contained an ancient lake. (3 pts)
There is stratigraphy consistent with a delta, that formed in standing water
The delta contains sand and silt, consistent with deposition expected in a delta
There are minerals that form in the presence of water, such as carbonates

(Also, from orbit rather than the rover: Crater is a closed depression with inlet and outlet channels.)

15. The diameter of impact craters is proportional to kinetic energy (mv^2, mass x velocity squared). Calculate the kinetic energy of: (3 pts)
a. A water ice sphere 2 km in diameter and velocity of 25 km/s
KE = ½ mv^2
= ½*(1000 kg/m^3)*(4/3*pi*(1000 m)^3) * (25,000 m/s)^2 = 1.28 * 10^{21} Joules (J)

b. An iron sphere 2 km in diameter and velocity 8 km/s
½*(7870 kg/m^3)*(4/3*pi*(1000 m)^3) * (8,000 m/s)^2 = 1.04 * 10^{21} J

c. Which one should make a smaller crater?

Iron sphere

16. Describe 2 ways to explain the bright basal radar reflector in the south pole region (interpreted as subsurface water by some) without invoking water. (4 pts)
1. Interference effects with closely spaced interfaces (either dust or CO_2 layers)
2. Geologic materials with higher reflectivity such as clays

52 pts total, so grade based on score/52 x 100