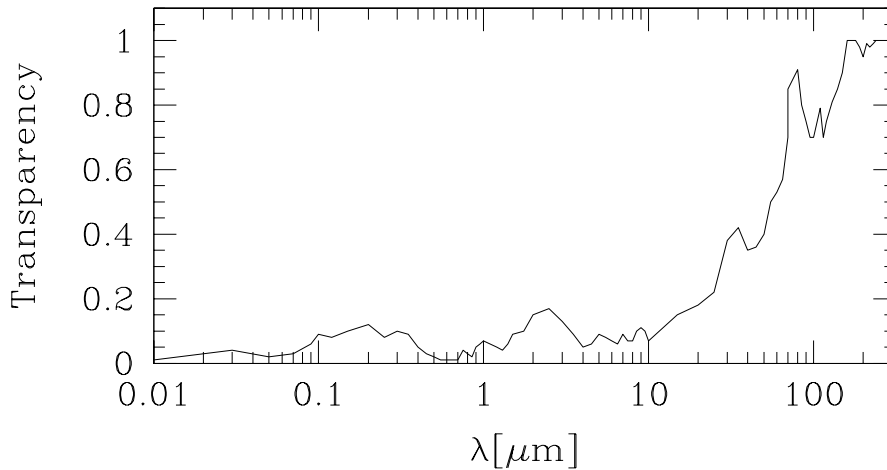


Name: _____

Homework 2 – Ast 281 – Spring 2009
Due Thursday 1/29/09 – 12:00pm, Watanabe 420

The homeworks are not intended to be difficult – if you think about the answers. Please keep the answers brief - but always justify your answer (*i.e.* if the question asks you to choose something, state why you chose it, but fill in the blank questions do not need justifications). Feel free to work with others and use class materials. The point values for each question are shown in the [] following each question. [100 points].

1. While observing, your astrobiology professor discovers a new planet and takes a spectrum of it's atmosphere. Eventually a space probe is sent to the planet, lands on the surface and measures the radiation getting through the atmosphere at each wavelength. The transmitted spectrum as seen from the surface of the planet is shown in the graph below.



- Does this atmosphere have an appreciable greenhouse effect? Why or why not? [5]

- Could we see stars from the surface of this planet at night (*i.e.* is this a romantic spot?) [5]

- Are there any potential health hazards on the surface of the planet (assume that the atmosphere is not poisonous, and that we are dressed warmly)? [5]

2. Differentiation, is a process where as a large body melts, the heavier materials sink to the core and the lighter ones float to the surface, thus separating materials of different composition. This occurred in the early solar system because of heating from short-lived radionuclides. This radioactive material was originally incorporated into planets as they condensed in the early solar nebula, the nebula having received these elements from processing inside stars. Radionuclides release their energy as heat which gets deposited in solar system bodies, which can result in melting inside. When molten (or soft), heavier materials (*i.e.* metals), sink to the core. Would you be more likely to find volatiles on a small undifferentiated asteroid, on a large differentiated asteroid, or in the remnants of an asteroid family and why? [5]

3. Are we likely to be able to mine any one asteroid for both our metal needs and volatiles (extracted from volatile rich minerals by heating)? State reasons. [5]

4. Which of the following radionuclides was most likely responsible for heating leading to differentiation and why? [5]

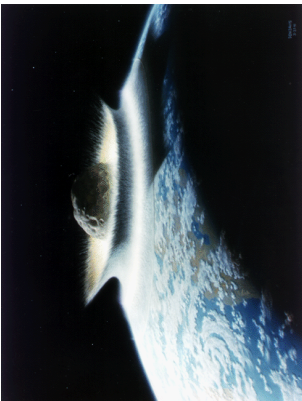
Parent	Daughter	Half-Life
^{238}U	^{206}Pb	4.47×10^9 yr
^{87}Rb	^{87}Sr	48.8×10^9 yr
^{147}Sm	^{143}Nd	105×10^9 yr
^{26}Al	^{26}Mg	0.72×10^6 yr
^{129}I	^{129}Xe	16.0×10^6 yr

5. You are a geologist investigating rock strata corresponding to the Cretaceous/Tertiary epoch of Earth history (~65 My ago). In a thin cm-thick clay layer you find a deposit rich in Iridium (Ir – atomic number 77). Suppose you discover that this layer of Ir is present in geological formations of the same time period throughout the world.

- Given the following table of terrestrial and primitive meteorite (chondrite) relative abundances, what conclusion might you draw from this table concerning the origin of the layer and why? [Note: The number of electrons in an atom gives the atomic number, and the number of electrons and protons in a neutral atom are equal. This is what gives an atom its chemical characteristics. The atomic mass is the sum of the protons and neutrons in an atom. Isotopes are species with the same atomic number, but just a different atomic mass (because of extra neutrons), and are closely related chemically.] Note: ppm = parts per million. [5]

Element	Atomic #	Earth [ppm]	Chondrites [ppm]
O	8	4.66×10^5	4.60×10^5
Fe	26	5.00×10^4	1.82×10^5
Si	14	2.77×10^5	1.05×10^4
Mg	12	2.09×10^4	9.70×10^4
Ni	28	80.0	1.07×10^4
Al	13	8.13×10^4	8.60×10^3
K	19	2.59×10^4	560
Ir	77	0.001	0.46

- Suppose now, that you determine that this layer must be of extraterrestrial origin, and that you estimate the mass of material to be over 1.4×10^{12} kg (by adding up a cm thick shell of material covering the Earth). This would correspond to a meteoroid of at least 10 km diameter. Assuming that the meteoroid would enter the Earth's atmosphere at a typical or "average" velocity, approximately what diameter crater would you expect? (Please describe why you come to this conclusion – don't just put a number down). [5]
6. How might you expect the size distribution of craters to change on a planet without an atmosphere (again assuming that the planets receive the same meteoroid flux)? Would you expect to see the same number of small craters on an airless body and one of the same size with an atmosphere? Why? [10]
7. How might the impact of a very large meteor (several km) effect modern society? [10]



8. While we don't completely understand the full story of star formation and planet formation there are many observed features within our solar system that we have a general understanding of how they came about. Please describe very briefly in a few words or a sentence the basic underlying physical explanation for some of the features in our solar system (if known) for each of the following observed characteristics [15].
- (a) The planets orbits are mostly circular, and lie in the same plane.
 - (b) An explanation of why the planets are placed at the particular distances from the sun that they are at.
 - (c) Why our solar system has rocky terrestrial planets close to the sun, and gas giants farther out.
 - (d) Why do some planetary systems have gas giants close to their star?
 - (e) Why do most planets spin in the same direction (with a few exceptions - and why the exceptions?)

9. In summer 2006 in Prague, at the International Astronomical Union General Assembly, the IAU made a new resolution about the definition of a planet which has caused tremendous controversy: "Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particular, to the designation 'planets'. The word 'planet' originally described 'wanderers' that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information. Resolution 5A:

The IAU therefore resolves that planets and other bodies in our Solar System be defined into three distinct categories in the following way: (1) A planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit. (2) A dwarf planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite. (3) All other objects orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".

footnotes: planet: The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. shape: An IAU process will be established to assign borderline objects into either dwarf planet and other categories. objects(3): These currently include most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs), comets, and other small bodies. Resolution 6A: The IAU further resolves: Pluto is a dwarf planet by the above definition and is recognized as the prototype of a new category of trans-Neptunian objects."

The table below lists various objects in the solar system, their densities and distance from the sun. On the attached graph paper, plot log semi-major axis (log a) versus log diameter, using different symbols for each class of object. On the graph draw a circle around the group of points that are terrestrial planets and a circle around the group of points that are gas giants. What is your opinion about the nature of the other bodies in the solar system based on a physical process that governs planet formation and from the evidence on this graph (state why). Where does Pluto fit in this scheme based on the physical characteristics of the bodies? [10]

Object	Type	density	Diam	a[AU]	log a	logDiam
Ceres	asteroid	2.08	913	4.603	0.663	2.960
Mercury	Terrestr	5.43	4878	0.387	-0.412	3.688
Mars	Terrestr	3.9	6794	1.524	0.183	3.832
Venus	Terrestr	5.24	12104	0.723	-0.141	4.083
Earth	Terrestr	5.52	12756	1.000	0.000	4.106
Neptune	GasGiant	1.5	50450	30.061	1.478	4.703
Uranus	GasGiant	1.3	52400	19.191	1.283	4.719
Saturn	GasGiant	0.7	120000	9.538	0.979	5.079
Jupiter	GasGiant	1.3	142796	5.202	0.716	5.155
Varuna	KBO	2	900	43.218	1.636	2.954
Ixion	KBO	2	1065	39.302	1.594	3.027
Quaoar	KBO	2	1200	43.093	1.634	3.079
2003EL61	KBO	2	1200	43.198	1.635	3.079
2005FY9	KBO	2	1250	45.778	1.661	3.097
Orcus	KBO	2	1500	39.387	1.595	3.176
Sedna	KBO	2	1500	523.286	2.719	3.176
Pluto	KBO	2	2274	39.529	1.597	3.357
Eris	KBO	2	2400	67.750	1.831	3.380
Tethys	Satellite	1.3	1048	9.538	0.979	3.020
Charon	Satellite	2	1270	39.529	1.597	3.104
Iapetus	Satellite	1.2	1435	9.538	0.979	3.157
Rhea	Satellite	1.3	1530	9.538	0.979	3.185
Titania	Satellite	1.6	1610	19.191	1.283	3.207
Europa	Satellite	3	3138	5.202	0.716	3.497
Io	Satellite	3.6	3630	5.202	0.716	3.560
Callisto	Satellite	1.9	4800	5.202	0.716	3.681
Titan	Satellite	1.9	5150	9.538	0.979	3.712
Ganymede	Satellite	1.9	5262	5.202	0.716	3.721

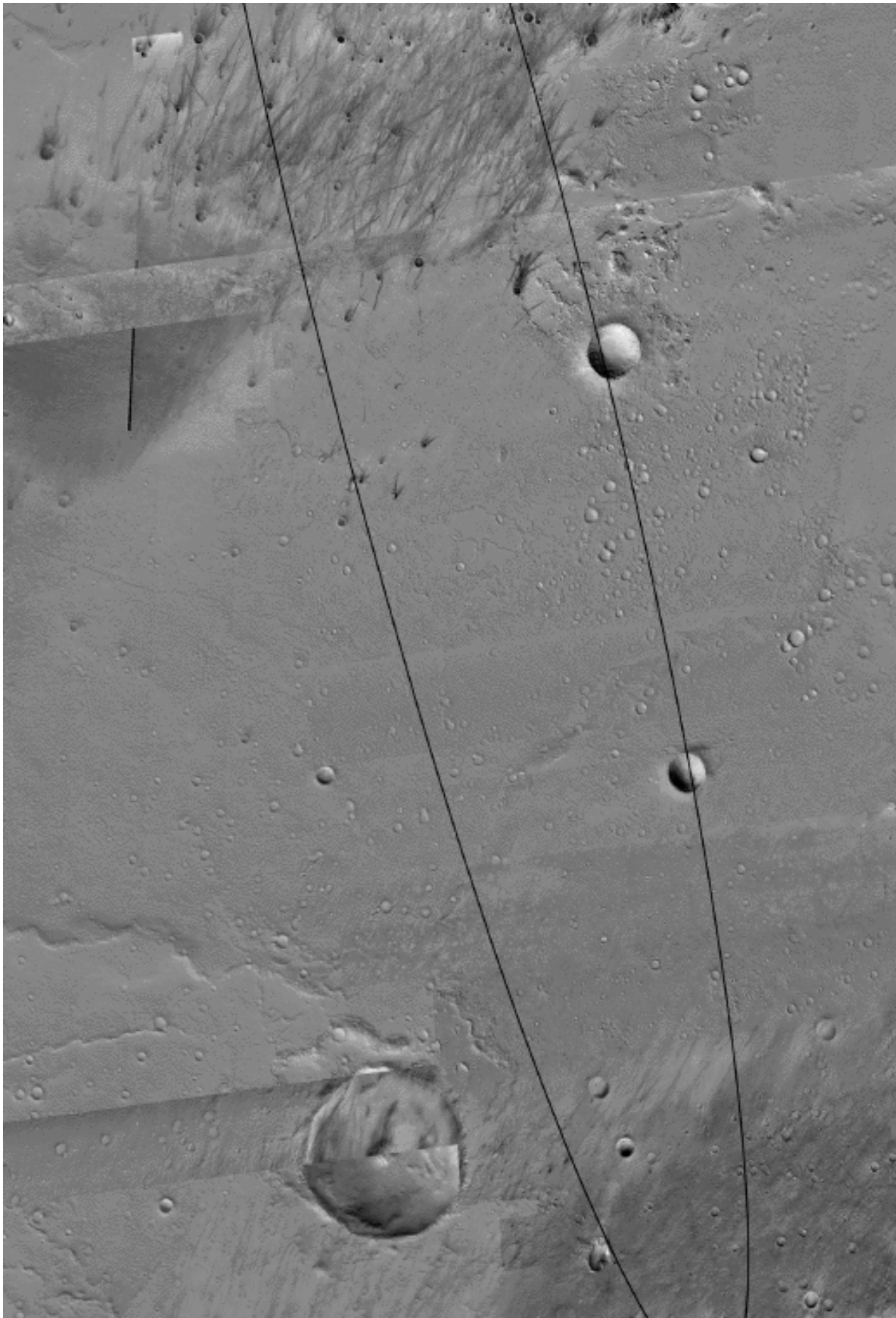


Figure 1: 83×10 km ellipse on the floor of Gusev crater which was the target landing site for the Spirit Mars Exploration Rover.