NEEP 533/Geology 533/Astronomy 533/EMA 601
First Hour Exam
Feb. 26, 1999
(Each of the 10 problems will be given 10 pts.)

1) Why do engineers strive to increase a rocket's exhaust velocity? Answer using the rocket equation (simplest version with constant exhaust velocity and no separate power source). Discuss two cases:

   a.) Getting the maximum payload for a given mission's velocity increment (Δv).
   b.) Fast missions

   The rocket equation is: $$\frac{M_f}{M_o} = \exp\left(\frac{-\Delta \upsilon}{\upsilon_{ex}}\right)$$

   Where: M_f is the rockets' final mass, M_o is the initial mass, Δv is the mission's velocity increment, and V_{ex} is the exhaust velocity

   1. *For a given Δv, increasing V_{ex} gives a larger payload fraction exponentially.*
   2. *Fast missions require a large Δv, so achieving a reasonable payload fraction requires increasing V_{ex}.*

2) What physical properties of the universe determined the on-set of nucleosynthesis of the light elements (H, D, He, and Li) and what determined the end of this epoch of element synthesis?

   Universe is expanding and as it does the T goes down and the density goes down. The Universe had to cool to a temperature where deuterium was stable before the light elements could be synthesized. This occurred about 2-3 minutes after the Big Bang. The synthesis of the elements only lasted a few minutes because of the expansion of the universe, the density rapidly decreased and reached a point that encounters became too rare to support further nucleosynthesis.

3) About a dozen extrasolar planetary systems have been detected. Describe the technique used to detect most of these planets and explain why this method preferentially selects massive planets with small orbits.

   All the planets (with the exception of the ones around the pulsar) have been selected by Doppler shifts, this tends to select the massive planets and small orbits because the smaller the orbit the greater the orbital speeds and the greater the orbit speeds the greater the Doppler shifts which makes these systems easier to detect.

4) List the seven (7) stages of lunar evolution emphasized in class and in one short sentence for each describe the major event or events in each stage. (If you do not remember exact terminology, use you other descriptive terms that convey your understanding of those events.

Beginning – origin by Earth fission or Earth capture
Magma Ocean – at least the outer 500 km were molten
Cratered Highlands – several million years of intense impact activity
Old Large Basins – period of large impacts that resulted in the strengthening of the crust
Young Large Basins – Continuation of large impacts but with the preservation of mass concentrations and deficiencies
Mare Basalt – 800 million years of the eruption of basaltic lavas in lunar basins
Mature Surface – regolith formation, occasional formation of relatively small impact craters (<100km diameter), and creation of light colored swirls.

5) a. Give a physical description of the lunar regolith.

Pulverized lunar crust comprised predominately of <u>the local bedrock,</u> but mixed with debris thrown in from other areas. Contains about 2% meteoritic material. Includes an abundance of impact glass and very fine dust particles. May be mixed with volcanic pyroclastic glass. High bearing strength and slightly cohesive.

b. How would the Martian regolith differ and why?

There would be <u>much less fine material and glass produced by impact processes</u> due to the filtering/protective effect of the Martian atmosphere. Very fine <u>wind-blown dust</u> and possible water-borne material would be mixed with the impact generated fragments of bedrock. Clay minerals may be a significant component. A crust of salt deposits will generally be present.

6) List four volatile resources and two metallic resources we find in the Apollo samples of the lunar regolith that will be important to lunar settlers. For each resource, give one potential use.

Hydrogen (H) – <u>water</u>, fuel cells, propulsion
Oxygen (O) - <u>water</u>, fuel cells, propulsion, life support
Nitrogen (N) <u>- agriculture</u>
Carbon (C) <u>- agriculture</u>
Helium (He) – pressurization, thrust augmentation

Okay answers:
Water
Nitrogen compounds
Carbon compounds

7) List four possible Martian environments to which simple early life forms may have adapted and still be replicating/reproducing today. For each give (very briefly) an Earth analog.

• *In or below the Polar Caps – in or below Antarctic Ice caps*
• *Volcanic Hot springs – terrestrial hot springs*
• *In or below the Martian permafrost – terrestrial permafrost*
• *In subsurface weathering rocks – many examples of deep rock biological communities*

Okay answers:
"black smokers" in the Martian subsurface hydrosphere – deep ocean black smokers

8) In 1984 the published global Reserve Base (RB) for tin was 3.3 million tons. The annual global Production (P) was 272,000 tons. Thus the RB/P Index was about 12 - all tin mines should have closed by 1996. And yet production last year was still 216,000 tons and the reserve base was still several million tons. Identify and briefly explain 3 variables or factors that help us understand why tin continues to be mined around the world and why these kinds of calculations (for any element) need to be interpreted carefully.

Possible Answers:

reserves and reserve base numbers are based on announced data released by mining companies, lots of reasons (tax, financial, political) why this might be underestimated at any point in time

further exploration has discovered more deposits, reserves, resources in known tin mining areas

entirely new types of deposits may have been discovered

- *new technologies may have been developed that allow tin to be recovered from sources not previously considered to be ore*

- *Prices may have gone up, thus moving tin concentrations from the 'resource' category to the 'reserve' or 'reserve base' category*

9) All the countries in the World got together and decided that, between 1995 and 2050, the annual energy use per capita will be allowed to double for all the developing nations and stay the same for all the developed nations (excluding the U. S.). They further decided that because of the threat of global warming, the total annual World energy use will be limited to 50% higher that the 1995 rate. How much would the U. S. have to drop

its annual per capita energy use rate in order to comply with the World's decision? Is that feasible? Use the table below to develop your answer.

	1995			2050		
Region	**Annual boe/cap**	**Population-billions**	**Energy Prod.-1995,bboe**	**Annual boe/capita**	**Population-billions**	**Energy Prod.-2050, bboe**
U. S.	59	0.26		?????	0.4	????
Non-US OECD	26	0.74			1.1	
Eastern Europe/Former Soviet. Union	22	0.40			0.5	
Middle East	16	0.10			0.2	
Central/South America	8	0.40			0.7	
Non-OECD Asia	4	3.00			5.8	
Africa	3	0.70			1.3	
Total		5.60			10.0	

Answer

	1995			*2050*		
Region	***Annual boe/cap***	***Population-billions***	***Energy Prod.-1995,bboe***	***Annual boe/capita***	***Population-billions***	***Energy Prod.-2050, bboe***
U. S.	*59*	*0.26*	*15.3*	*<0*	*0.4*	*<0*
Non-US OECD	*26*	*0.74*	*19.2*	*26*	*1.1*	*28.6*
Eastern Europe/Former Soviet. Union	*22*	*0.40*	*8.8*	*22*	*0.5*	*11.0*
Middle East	*16*	*0.10*	*1.6*	*16*	*0.2*	*3.2*
Central/South America	*8*	*0.40*	*3.2*	*16*	*0.7*	*11.2*
Non-OECD Asia	*4*	*3.00*	*12.0*	*8*	*5.8*	*46.4*
Africa	*3*	*0.70*	*2.1*	*6*	*1.3*	*7.8*
Total		*5.60*	*62.3*		*10.0*	*108.2*

No, this is not possible

10) a) List the possible ways that you can generate energy (thermal and or electrical) in space to enable the operation of your mining company.

Solar
Nuclear
Beamed
Chemical

b) Where might these energy sources be used to the greatest advantage?

Solar---------------orbit, near the sun, on the Moon, Mars
Nuclear------------orbit, propulsion, on the Moon, mars and outer planets, away from the Sun
Beamed------------Orbit, close to the Earth, maybe Mars
Chemical----------Escape from the Earth, short missions to the Moon, Mars

Not Used

11) What are the physical reasons why these properties played the determining role in element synthesis in the early universe?

12) Describe three other techniques that one could use to detect planets orbiting other stars and tell why they have not been successfully applied to the present time.