Answer THREE questions.

The numbers in square brackets in the right hand margin indicate the provisional allocation of maximum marks per subsection of a question.

Constants and conversions:

$$\begin{aligned} 1\ \text{g cm}^{-3} &= 1000\ \text{kg m}^{-3} \\ 1\ \text{Pa} &= 1\ \text{N m}^{-2} \\ 1\ \text{N} &= 1\ \text{kg m s}^{-2} \\ \text{Earth's atmospheric pressure} = 1\ \text{bar} &= 10^5\ \text{kg m}^{-1}\text{s}^{-2} \\ \text{gravitational acceleration on Earth, } g_E &= 9.8\ \text{m s}^{-2} \\ \text{gravitational acceleration on Venus, } g_V &= 0.91 \times g_E \end{aligned}$$

1. In this question only, assume the following parameters for a basalt:

$$\begin{aligned} \text{density, } \rho &= 3.3\ \text{g cm}^{-3} \\ \text{yield strength, } \tau &= 100\ \text{N m}^{-2} \\ \text{viscosity, } \eta &= 100\ \text{Pa.s} \end{aligned}$$

The most common form of volcanism found on other planets is flood lavas erupted from fissures. Name the four other types of volcanic activity found on Earth and give a brief description of each. [5]

A fissure eruption occurs on Venus. Assuming that the eruption is basaltic and taking the physical parameters given above, what is the mass eruption rate, M, expected for a fissure 10 m wide and 150 m long? Assume the magma is rising at 12 m s^{-1}.

The magma from this event is erupted onto a slope with an angle, α, of 5°. Assuming the lava starts from a stationary position, how thick will the flow have to be before it starts to move?

The flow continues to move at a constant velocity for 300 days. How far has it travelled in that time? Take the constant B to be 3.0. [6]

Describe coronae, large volcanoes and small volcanoes on Venus, concentrating on their morphology and physical parameters. [9]

2. Give a brief overview of the four main theories regarding the origin of the Moon. List the evidence that either does or does not support each theory. Which of these theories is currently the most widely accepted? [9]

Describe briefly the "magma ocean hypothesis", and summarise the current view of lunar magmatic evolution. [6]

Name the five periods in lunar history and briefly describe the main events occurring in each. In which of these periods did the magma ocean occur? [5]

3. Describe how the basic morphology of impact craters changes from small, simple craters to a large basin-sized impact. [7]

A 0.3 km diameter projectile is travelling at 25 km s^{-1} and produces a crater on Mars with a transient crater diameter of 5 km.

a) How long does the compression stage of the impact last?

b) From what depth will the material have been excavated?

c) What final form will the crater take and how will the modification stage have changed the transient crater?

d) If this projectile were to enter Earth's atmosphere at an angle of 45°, would it cause an impact crater on the surface? Show your working assuming that the density of the projectile is that of a stony-iron meteorite. How would this situation change for iron meteorites and stony meteorites (show an example), and for a change in incoming angle? [8]

A meteorite struck an area of fine regolith overlying strong bedrock. The resultant impact crater took on the form shown in Figure 1. What is the minimum thickness of the regolith layer for this form to result if the diameter of the crater, D, was 11 km?

Describe, with the aid of diagrams, the profile the crater would have taken for the same thickness of regolith with progressively smaller crater diameters. [5]

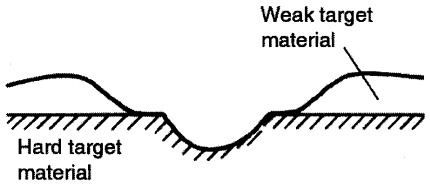

Figure 1

4. Name and describe the various features on Mars which indicate that water once existed on its surface, using diagrams to show their morphology. [10]

Water, at least in ice form, still exists in the outer regions of the Solar System, as evidenced by the remote sensing of the Galilean satellites orbiting Jupiter. Describe the role water ice and perhaps liquid water take in the evolution of the satellites of the outer planets once they have been heated enough for differentiation to occur (Do not discuss the heating mechanisms). Include discussions of the gravitational stability of the satellites at various stages, and which phases of ice may be present in various outer satellites. How could the ice affect the heat loss/retention on these satellites? [10]

5. Briefly describe what reflectance spectroscopy is and the information that it can give. A soil sample and a sample from a fresh crater may have the same composition, but their spectra will be different in important ways. State what these are and describe why this difference occurs. [3]

The Clementine UVVIS camera has filters at 415 nm, 750 nm, 900 nm, 950 nm and 1000 nm. Sketch an appropriate spectrum for each of the following with a short description:

i) high Ca pyroxene

ii) low Ca pyroxene

iii) olivine

iv) plagioclase feldspar [4]

Describe the absorption features that might be seen for each material in the wavelength region 1000 nm-2500 nm (1.0 μm - 2.5 μm). Describe how some band centres may change with the addition of particular elements or minerals. On the Moon, a mare basalt and a gabbro may have an absorption band centre at the same wavelength. What would be the critical difference between the two and what is the mineral component in the gabbro which would cause this difference? [3]

Describe the X-ray fluorescence and gamma-ray spectroscopy techniques, list the main elements they are capable of detecting and give an overview of their use on the Apollo 15 and 16 missions. Describe the main results from the gamma-ray spectrometer flown on the recent Lunar Prospector mission. [10]

END OF PAPER