Science Challenge

Sample Question

The Science Challenge forms 70% of the competition component. The Challenge will consist of a multi-disciplinary science problem that requires the participants to adapt their existing knowledge to novel situations.

The theme and scenario of the novel problem will be sent to the teacher-in-charge one month before the actual Challenge via email. It will also be uploaded onto our website.

The actual Challenge question will be released to participants on the second day of SISC 2007. Time and resources (e.g. access to internet) will be set aside for participants to engage in creative problem solving. Participants will present their solutions on the final day of competition.

Part 1: Physics Question

You are part of a pioneering mission to send humans to Mars. Your primary job is to choose and recommend a location on Mars that is most favourable for setting up and sustaining a colony. Recall that conditions on Mars are harsh, and the choice of a good location is important to the success of this mission. In choosing this location, you should take into account the following factors, based on the most up-to-date information you can find:

A) Climate

- The seasons of Mars
- The temperatures at different latitudes and longitudes of Mars
- The average temperature variations in a typical Martian day and night
- The frequencies of dust storms on Mars and the locations of occurrences

B) Terrain

- The terrain of Mars, which ranges from plains and craters to canyons and mountains
- Possible plate tectonics and volcanism

C) Natural Resources

- Location of nearby water sources
- Availability of other natural resources

Website Resources:

1. http://seds.lpl.arizona.edu/nineplanets/nineplanets/mars.html
2. http://www.ucls.uchicago.edu/MartianSunTimes/index.html
3. http://www.windows.ucar.edu/tour/link=/cool_stuff/tour_mars_water_1.html

*Source: *Gifted Education Branch, Ministry of Education, Singapore*

Part 2: Life Science Questions

There are limited pay-loads that scientists can put into a cosmic exploring vehicle (CEV) for travelling to Mars. Hence, the National Aeronautics and Space Administration (NASA) of USA has to make decisions to install miniaturized scientific instruments on-board the CEV to carry out experiments with its test settings. Consider what **the definition of life is** and answer the following questions.

1. If scientists in NASA had used the CEV to collect a piece of rock on Mars and decided to send it back to the Earth to test whether there is any sign of life in the rock, what experiments would you propose to do if you are a microbiologist and want to determine if there are any microorganisms existing in the rock. Further,

    a. If the microorganism is still alive, what would you do to confirm, and later decipher; the hereditary make-ups of the organism? What would you do to determine whether the organism is alien (e.g. different from anything on earth)
    b. What would you do to answer a) if the organism is dead?

2. How would you carry out experiments to answer Q1 if NASA decides to carry out all experiments on Mars using miniaturized instruments needed?

3. What would you do if in Q1 & 2 that instead of a rock, an alien was found on Mars, how would you

    a. Carry out experiments back on earth to examine whether the alien is human-like (based on his/her genetic make-ups) by comparing it with human?
    b. What if the experiments were to be carried out on Mars using miniaturized instruments?

Part 3: Mathematics Questions

What time is it on Mars? Imagine that you are a Martian colonist living in a small camp in a rather flat region of Mars and must keep track of the Martian time of day and time of year without communicating with Earth. You have an Earth watch that is accurate to a fraction of a second, you have a sexton for measuring the angular position of the Sun, and you know

a. the length of a Martian day in seconds,
b. the length of a Martian year in seconds,
c. the Earth date/time of the Martian equinoxes and solstices from an almanac,
d. your latitude on Mars.

Answer the following questions:

1. What time do you go to work and what time do you go home?
2. How do you tell what season it is?
3. What is noon on Mars?
4. Where is the Sun at noon?
5. How do you tell what longitude it is? (14 year old sailors could do this in 17^{th} century)
6. What time is it relative to the time at the prime meridian?
7. How do you define a year so that you can celebrate a holiday at the same apparent time every year?

You do not need to use calculus or Keplerian dynamics - basic algebra and trigonometry will suffice to answer these questions. You may also need to study some basic geometry and Solar calendar concepts and use these concepts to derive and explain your answers.

References:

1. Skywatchers of Ancient Mexico, by Anthony F. Aveni, University of Texas Press, 1980. pages 48-67 provide a description of the apparent motion of the Earth's Sun
2. The Millenium Mars Calendar, http://pweb.jps.net/~tgangale/mars/other/millenn.htm

Part 4: Chemistry Questions

We have 20.00 hrs on 20/02/2020 (Earth date). A research colony has been established on the planet Mars. Since the Atmosphere on Mars is not suitable for human life the colony is contained in a semispherical dome covering 2020 m^2. All legends about little green man living on Mars have by now been put in the dustbin of history. No life at the present time was ever found. Your task (or so you still think) is to determine whether there was life on Mars in earlier times.

1. Describe which class of molecules you would look for, where you would look for them and why you would look for these molecules (how and from which organisms did the molecules originate)? Give a list of molecules with explanations.

2. Choose one of the molecules and describe how you would go about to find and identify this molecule with modern instruments.

While you are sitting in your office and sipping a cup of green tea thinking about this problem, a security officer storms into your lab. He is all excited and tells you that the security systems have found that the pressure in the dome is dropping. That must mean there is a leak somewhere. You, as the only scientist, have to find the leak before the pressure drops too much otherwise you will have to evacuate the dome. Assume that the pressure in the dome is normally 1 atmosphere (22 °C, temperature does not change since life support systems keep working) and neglect the pressure outside on Mars (it is less than $1/100^{th}$ of one atmosphere). Assume also that all air in the dome is made up of nitrogen molecules (in air nitrogen constitutes almost 80% of all gases). When the pressure has dropped to less than 0.8 atmosphere you have to start evacuating the dome, and you have to inform Earth of the exact date of the start of a possible evacuation so that they can prepare all necessary requirements.

3. If there is a hole of 0.5 cm^2 which date and time will you have to tell Earth for the beginning of a possible evacuation? Show how you arrive at your results.