How to Make Mars Jars

How to build mini-Mars environments

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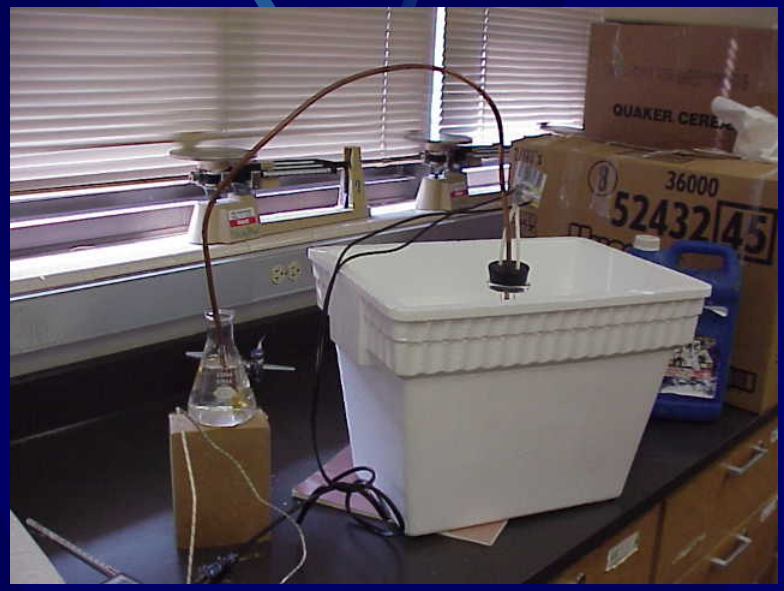
What is a Mars Jar?

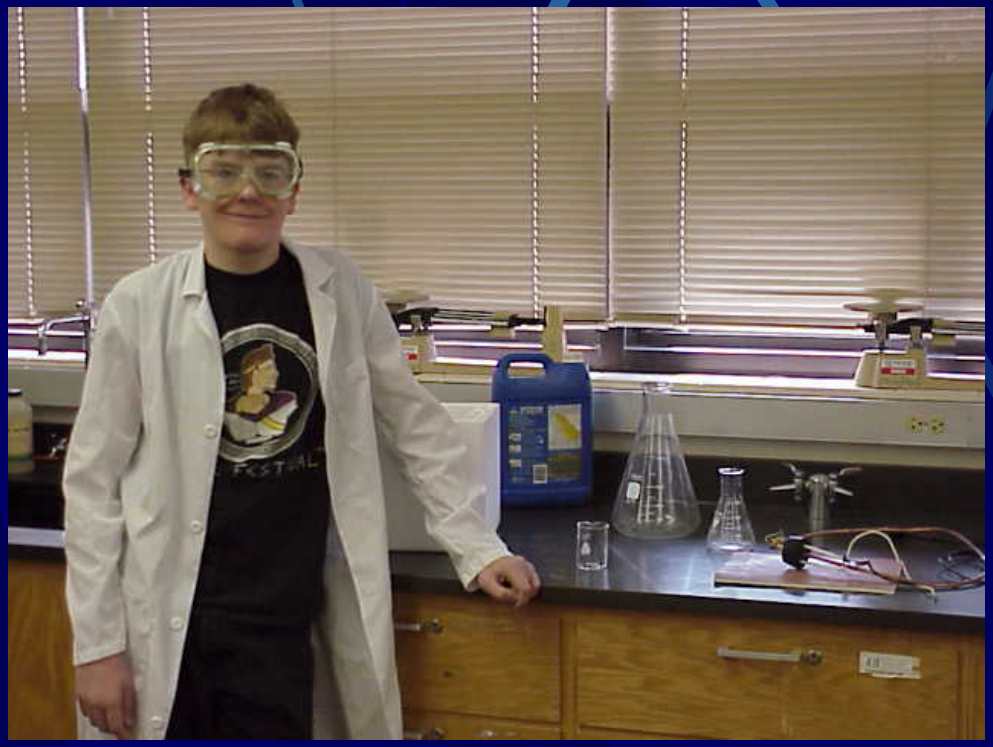
A container in which we have created a pseudo-Martian environment in terms of:

- Atmosphere
  - 95% Carbon Dioxide
  - 3% Nitrogen
  - 2% Argon
- Air Pressure
  - 5-8 millibar or 4-6 Torr
- Temperature
  - -55^{o} Celsius on average



Making the Mars Jar

1. Get a Student



2. Get a jar and a stopper to fit it

Make sure the stopper seals all the way round in the jar

Here is what you must not see:

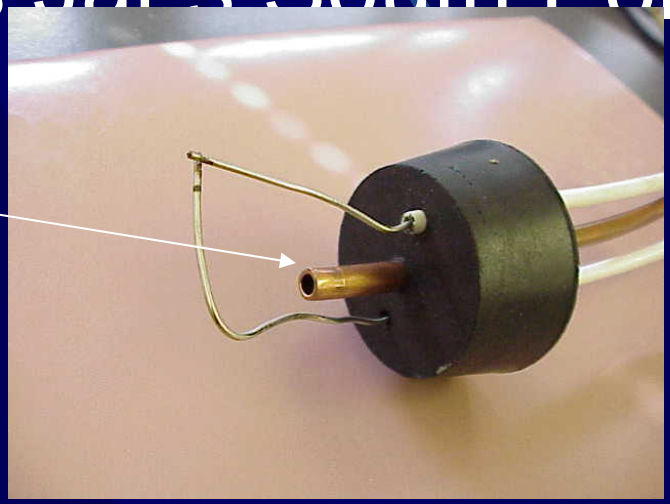
gap

3. Add Mars' South Pole

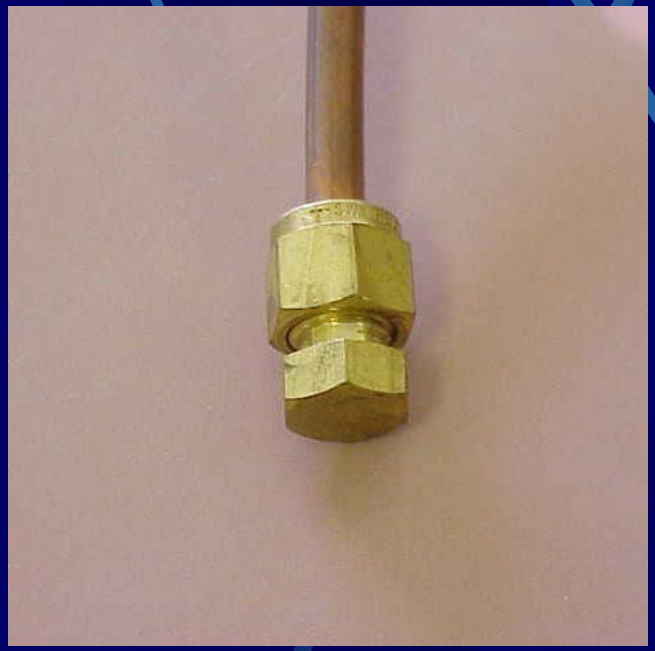
The stopper should have a hole in it for copper tubing –This particular stopper has two extra holes for electical feed-throughs. Yours may not need that.

This will be the Mars Jar's South Pole

Copper tubing in hole



The other end of the copper tube is sealed*



This end will be put in a slurry which melts at about –123^{o} C. *This kind of bendable Cu tubing and end caps can be obtained at refrigeration and air conditioning supplies stores.

Why do we need a South Pole? So we don't have to have a vacuum pump.

- The atmospheric pressure on Mars varies by season. When it is winter in the Southern Hemisphere the pressure is lowest.
- This is because carbon dioxide is freezing out of the atmosphere near the South Pole.
- So Mars' atmospheric pressure is set by how cold the South Pole gets in its winter. And how cold the North pole gets half a year later.

We can use this fact to control the pressure in our Mars Jar as well. We will fill our Mars Jar with carbon dioxide and then cool the "South Pole" to the temperature where enough CO_2 condenses to create a pressure of 4-6 torr.

temp	Kelvin	1/t	pressure	log pres
-134.3	138.85	7.202017	1	0
-127	146.15	6.842285	3.5	0.544068
-123	150.15	6.660007	6	0.778151
-119.5	153.65	6.508298	10	1
-108.6	164.55	6.07718	40	1.60206
-100.2	172.95	5.782018	100	2
-85.7	187.45	5.334756	400	2.60206
-78.2	194.95	5.12952	760	2.880814

The Pressure/Temperature Tables show that this temperature is between –127 and –123^{o} C. Small changes in temperature make large changes in atmospheric pressure.

How do we get a refrigerator that is that cold and that precise?

- If we wanted to get 0^{o} C, we could use a ice bath.- Ice can be very cold but it cannot be over 0 C. As it is warmed up it will start to melt at zero Celsius. Then the temperature of the ice + water does not increase. It stays at zero C until all the ice is melted, as long as the ice bath is stirred to keep it well mixed.

But we want –123 to -127^{o} C. What can we use? What can we freeze which melts at about - 125^{o} C?

	Melting point (°C)
Methanol	-93.9
Ethanol	-117.3
Isopropyl alcohol	-85.8
Acetone	-94.6
1-propanol	-127
Gasoline	-56
N-pentane	-130
Hexane	-95.3
Toluene	-95
Diethyl ether	-116.3

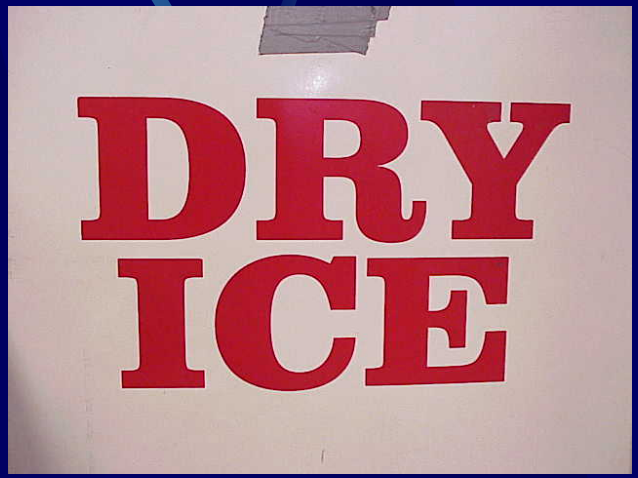
1-propanol and n-pentane can be found in most university chemistry stock rooms.

What to choose:

- We used n-propanol because its melting temperature. We found that it mostly gels.
- Prof. Bevan Ott (Emeritus BYU) suggests mixing some hex and getting the right temperature thusly. It will be crystalline better than the alcohol.
- Absolute (100%) ethanol is very close. It may be adequate for many purposes.

4. Cryogenics

- Get liquid nitrogen to freeze the 1-propanol
- Get dry ice to create the Martian atmosphere and temperature



5. Getting the Mars Jars to Mars' temperature

Insulated box

Making a "south pole" slurry

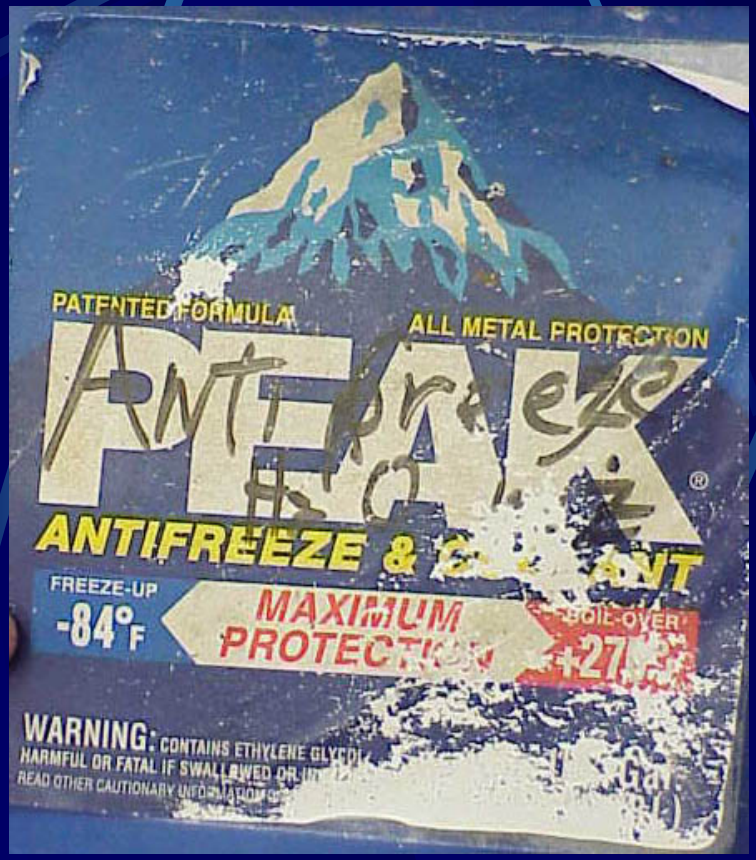
- Pour the liquid to be frozen into a mixing container.
- Pour LN2 (BP= -196^{o} C) on top of the liquid and stir the liquids together. Use a spoon, being careful to minimize splashing. Add more LN2 until the liquid is mostly frozen.
- There should be some liquid left.

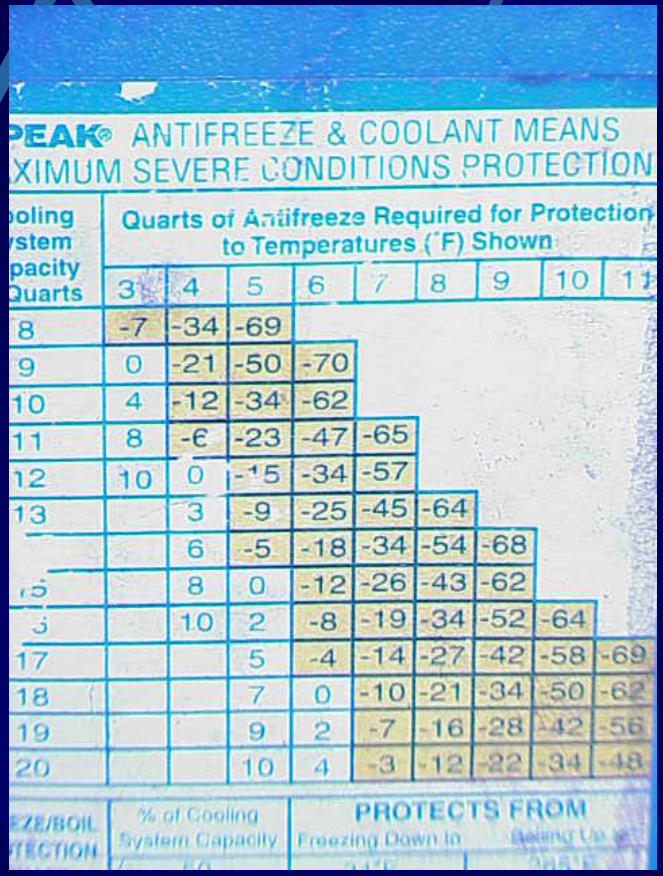
Making the "Mars Temperature" slurry.

- Pick the temperature you want for the Mars Jar.
- I recommend using an ethylene glycol- water mixture for this. We used commercially available antifreeze. It is primarily ethylene glycol and we mixed it one to one with water.
- Mixtures, unlike pure substances, usually do NOT melt at one temperature. Usually they melt over a temperature range. There is an exception. This is for a eutectic mixture. This mixture melts at a single, low temperature. The ratio of liquids varies for each material pair. For glycol and water this is about a two-one solution by volume.

Add a slurry which melts at about –55 C (-67F):

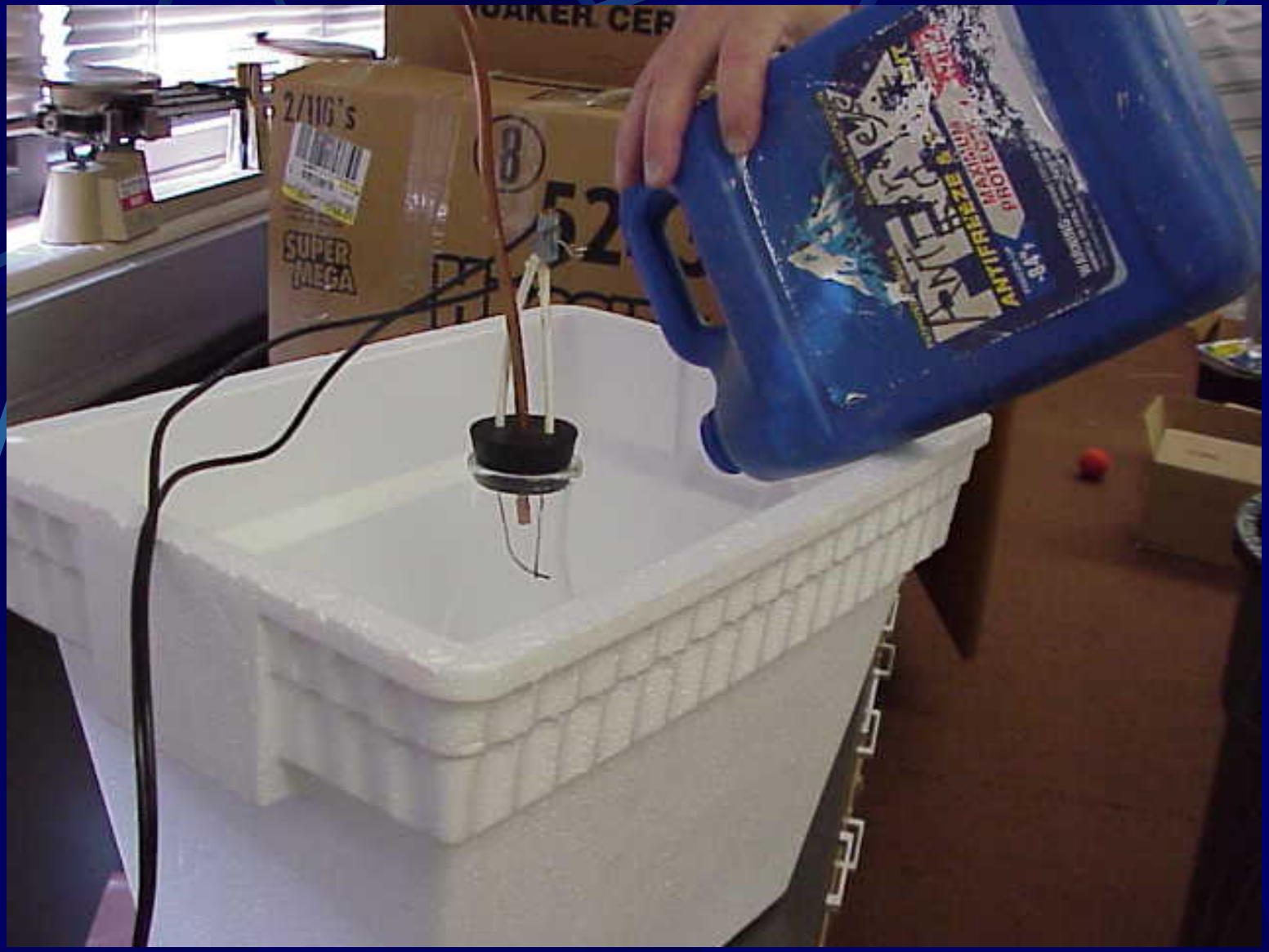
Antifreeze/water (~2:3) + Dry ice to freeze it





Calibrating the thermometer

Many thermometers used in high schools do not have markings below – 20° C. But there is space below the markings for marks to be added. Using a thermocouple etc. marks can be added for Mars-type temperatures.

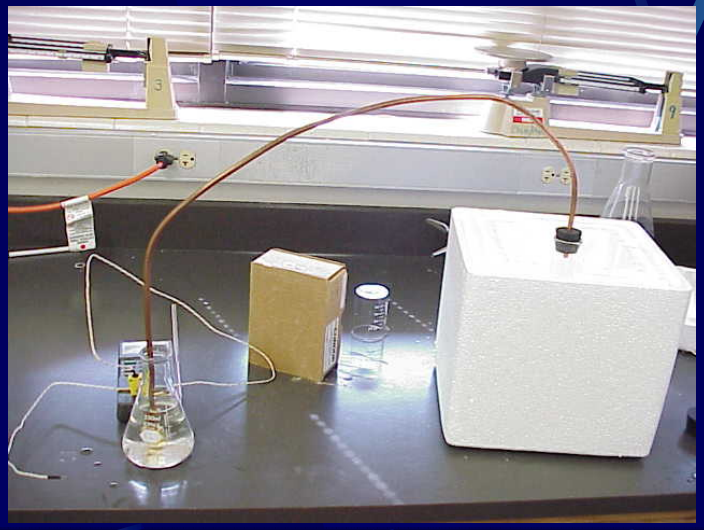

2/11G's
SUPER
MEGA
ANTIFREEZE

6. Producing the Mars Atmosphere

- Push dry ice pellets down the copper tube to displace air with CO_2.
- Put dry ice in the jar as well.
- When all the air has been displaced, cork the lid.

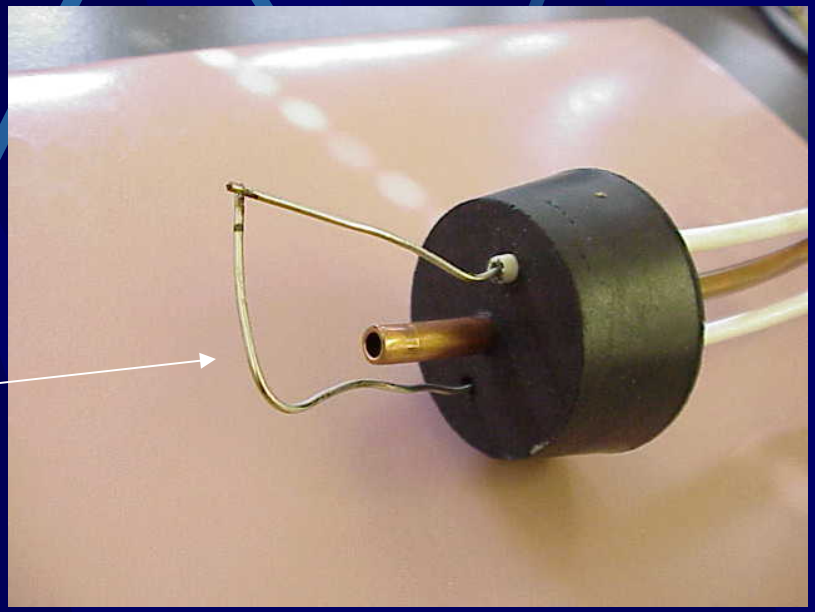
7. Producing the Right Pressure

- Take frozen 1-propanol and put it in a flask
- Put the Mars South Pole (the sealed end of the copper tubing) into the flask.



Choosing an Experiment

- Lightning in a jar
- Ice cream
- Bacteria
- Extremophiles
- And what else?



Surface characteristics of Mars

- A moderately low surface temperature.
- Less sunlight than earth but more UV in the 300 nm range.
- Low atmospheric pressure composed mostly of carbon dioxide.
- Rock and/or fine powder in many places.
- Low surface gravity.

How to Make Sunlight for your Mars Jar

- You need a very blue source of light such as a xenon lamp (these are now being used for some headlights)
- The Mars Jar needs to be made of quartz or to have a quartz window to let UV light in.
- More work needs to be done to help students to find a inexpensive way to make the total amount of light to match the light which reaches Mars's surface

Still to be done

- 1. Check jars' pressure (capacitance monometer)
- 2. Check jars' composition (mini mass spectrometer)
- 3. Find recipe for making Mars surface dust
- 4. Discussion with teachers-Ty of Provo High
- I will post links at Xuv.byu.edu-

Acknowledgements

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