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Planetary Temperatures

Part 1. Terrestrial Planet Temperature Experiment

In this experiment, you will investigate the relationship between the heating of an object and its distance from the source of heat. The cans represent the terrestrial planets and the distances of the cans from the light are proportional to the distances of the terrestrial planets from the Sun. The light represents the Sun.

Pre-Activity Questions

1. Read through the experimental procedure below and make a prediction about the relationship between the temperature of the black cans and their distances from the light/heat source.

Many students will correctly predict that the can closest to the light source will be hotter.

2. Make a prediction about the relationship between the temperature of a planet and its distance from the Sun.

Many students will correctly predict that planets closer to the Sun will be warmer than planets further away from the Sun. Venus is an anomaly due to greenhouse warming.

Experimental Procedure

1. Obtain the following materials:
   - 4 black cans with lids
   - 4 thermometers (°C)
   - 4 ring stands
   - 4 high intensity lamps
   - 1 timer
   - 1 meter stick
2. Working in groups, you will be running four experiments simultaneously. Attach each light to a stand so that they are oriented horizontally.
3. Position one can 20 cm from a light, another can 35 cm from a different light, another can 50 cm from another light and the final can at 75 cm from a light. Be sure that each can is positioned in the same way for all 4 experiments. These distances are proportional to the distances of the terrestrial planets from the Sun.
4. Insert a thermometer in each can and record the temperatures for each can in Table 2 (they should all be approximately the same).
5. Simultaneously turn on the light for each experiment and record the temperature after 10 minutes in the data table below.
6. Plot the temperature of each can after being heated for 10 minutes and the distance of the can from the light on the plot below. Connect the points and label.

Distance from Light (cm)	Starting Temp. (°C)	Temp. after 10 min. (°C)
20		
35		
50		
75		

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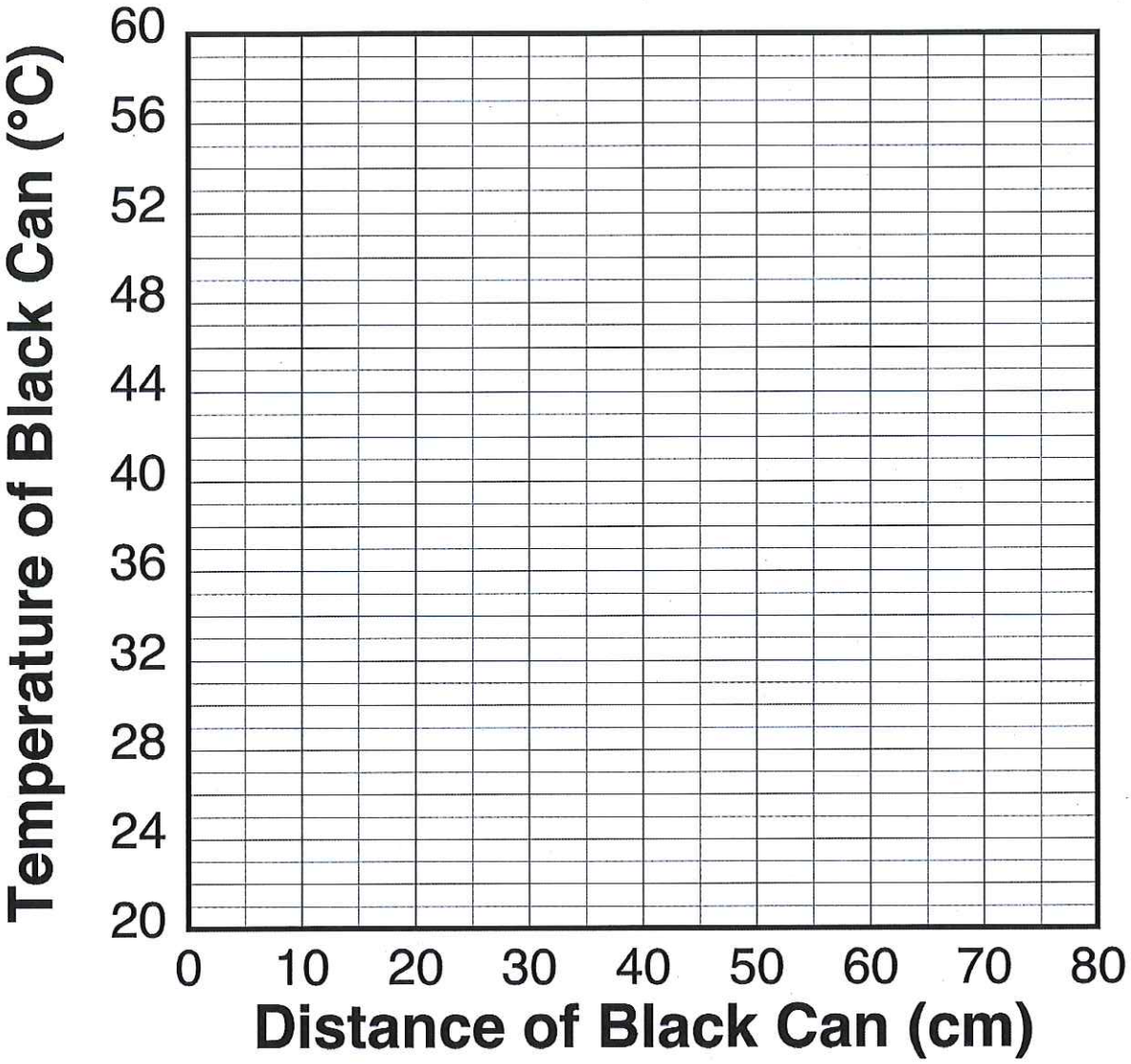

QUESTIONS

1. Examine your plot. Do your experimental data support your predictions above?

2. Based on your experimental data, what is the major factor that determines a planet's mean temperature? What other factors may affect a planet's temperature?

Students should predict that planets closer to the Sun will be warmer. Other factors that might affect a planet's temperature include its reflectivity (albedo) and the presence of an atmosphere.

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NAME _____

Part 2. Planetary Temperature Data

Examination of the data in Table 1 and Figure 2 indicate, generally, the further a planet is from the Sun, the lower the surface temperature.

Table 1. Planetary data

Planet	Distance from Sun (AU)	Diameter (km)	Mass (relative to Earth)	Density ($g \cdot cm^3$)	Mean Temp. (°C)	Irradiance W/m^2
Mercury	0.4	4,854	0.06	5.4	167	9149
Venus	0.7	12,112	0.82	5.2	464	2620
Earth	1.0	12,751	1.0	5.5	15	1371
Mars	1.5	6,788	0.11	3.	-65	591
Jupiter	5.2	143,000	317.9	1.3	-110	51
Saturn	9.5	121,000	95.1	0.7	-140	15
Uranus	19.2	47,000	14.6	1.2	-195	3.7
Neptune	30.1	46,529	17.2	1.7	-200	1.5

In the graphs below, use the data in Table 1 to plot the temperature for each planet as a function of its distance from the Sun. There are two different types of plots. The first is a linear-linear plot where the x- and y-axes have linear scales. The second plot is a logarithmic-linear plot where the x-axis has a logarithmic scale and the y-axis is linear. This type of plot permits a different type of analysis where data may be bunched together if plotted on a regular linear-linear plot.

After you complete the plots below. Consider the following questions:

1. Describe any differences between your prediction of terrestrial planet temperatures from the experiment and actual planetary temperatures in Table 1.

Venus is much hotter than predicted from the model experiment.

2. The irradiance data (last column) indicate the amount of solar energy at the surface of each planet (W/m2). Does the temperature anomaly appear to be related to irradiance? Why?

No. The amount of sunlight that Venus receives is intermediate to that of Mercury and Earth.

3. What other factors may affect planetary temperatures?

Students may need some guidance in understanding that Venus is much hotter due to greenhouse forcing by its atmosphere. It has a very dense atmosphere composed predominantly of the greenhouse gas CO_2. Therefore, its high temperature is due to the greenhouse effect.

4. Write a brief summary of your experiment and explain your results.

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