Name:_____

Date:_____ Period:_____

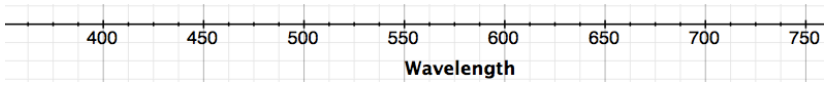
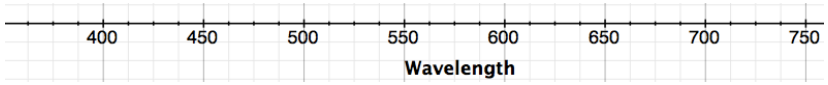
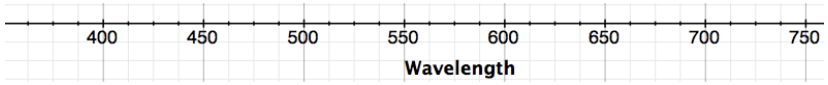
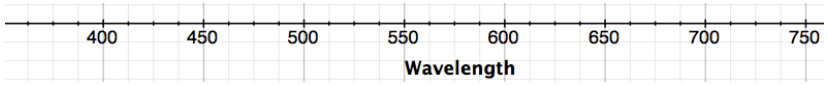
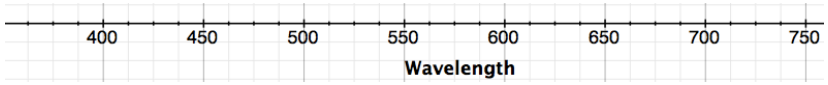
Electromagnetic Spectrum: Introduction to Radiation

1. What is the electromagnetic radiation? *Electromagnetic radiation is a form of energy emitted and absorbed by an object that act as a wave traveling through space.*

2. Fill in the table with information about each type of electromagnetic radiation.

Spectrum	Wave Type	Wavelength	Properties and Uses
	Radio	*10^{3} m*	• *Long wavelength, low energy waves* • *Can be detected on Earth* • *Used in radios, TV and cell phones*
	Microwave	*10^{-2} m*	• *Absorbed in atmosphere* • *Used to heat food*
	Infrared	*10^{-5} m*	• *Mostly absorbed in atmosphere* • *Can see super cool or faint objects in space* • *Used in thermal imaging*
	Visible	*1.5^{-6} m*	• *Not absorbed by atmosphere* • *White light can be separated into rainbow*
	Ultraviolet	*10^{-8} m*	• *Mostly absorbed in atmosphere* • *Causes sunburn and skin cancer*
	X-Ray	*10^{-10} m*	• *High energy waves* • *Absorbed in atmosphere* • *Used in x-rays*
	Gamma	*10^{-12} m*	• *Extremely high energy waves* • *Absorbed in atmosphere* • *Given off by neutron stars, supernovae, black holes, etc.*

3. Describe and draw the observed spectrum of the following forms of radiation.

Type of Radiation	Description of Radiation	Observed Spectrum
Sunlight	*Continuous spectrum of light with all colors blended together*	
Incandescent Lightbulb	*Big yellow/orange emission band with some reds and green*	
Fluorescent Lightbulb	*Big yellow/orange emission band with many more greens, blues and purples than incandescent bulb*	
Black Light	*Single peak in purple range*	
Glow Stick	*Yellow/orange emission bands match color of glow stick*	

4. Why do you think incandescent bulbs have a different emission spectrum than fluorescent bulbs?_____

5. What is the main difference you saw in the absorption spectrum between sunlight and the other types of light?

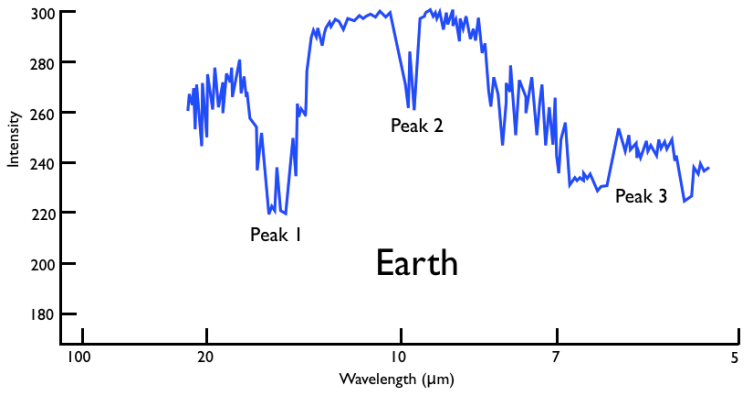
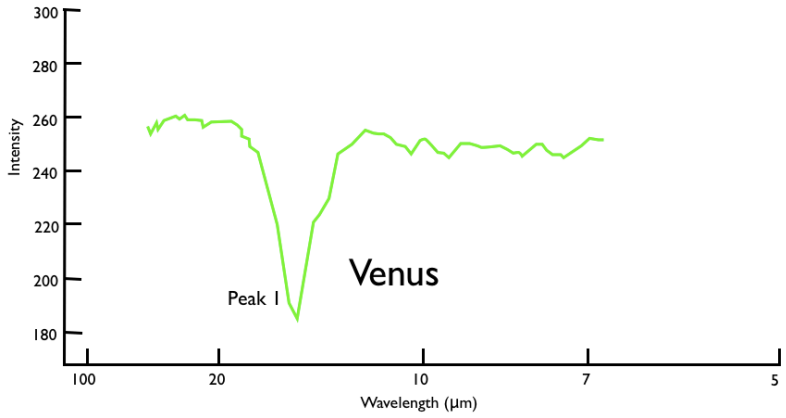
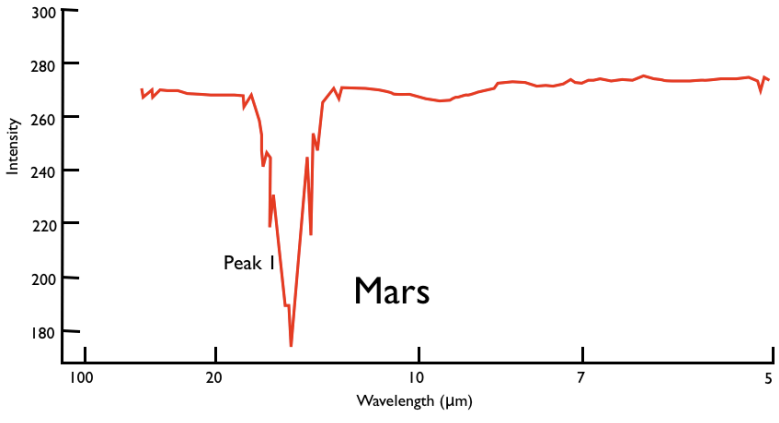
The main difference between sunlight and all the other types of light is that sun gives off a continuous spectrum of light. As the light blends together it appears white, however, it contains the full rainbow. Each of the other forms of light had specific emission peaks depending on what they were made of. Incandescent bulbs have sodium which creates a strong yellow signal, while fluorescent bulbs are made of mercury and have brighter signals in the greens, blues and purples.

Name:_____

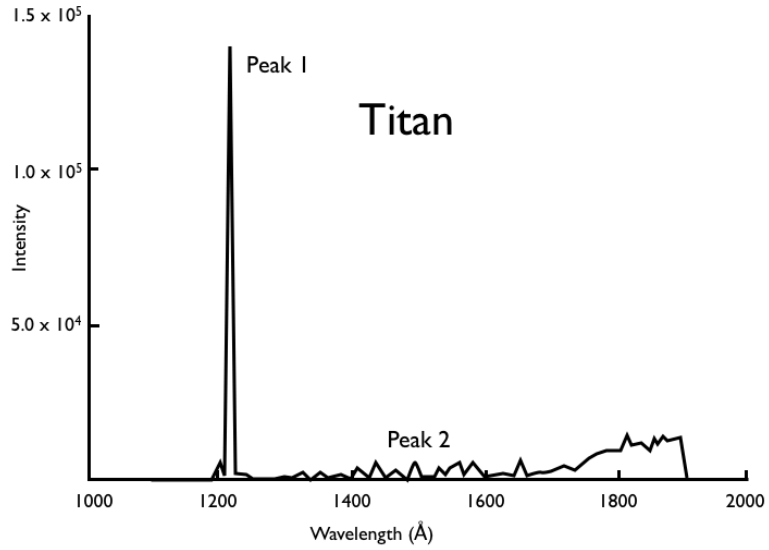
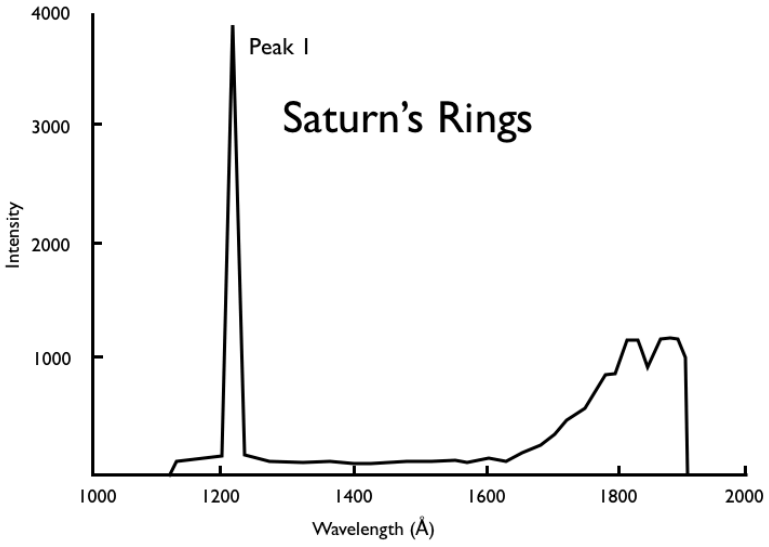
Date:_____ Period:_____

Exploring Planets with Absorption Spectroscopy

Objective: Identify the wavelength of each peak and the chemical responsible for each of the labeled peaks using the INFRARED absorption spectrum on the Earth, Venus and Mars Reference Card.

	Wavelength	Chemical
	Peak 1 *17 µm* Peak 2 *10 µm* Peak 3 *6 µm*	Peak 1 CO_2 Peak 2 O_3 Peak 3 H_2O
	Peak 1 *17 µm*	Peak 1 CO_2
	Peak 1 *17 µm*	Peak 1 CO_2

Objective: Identify the wavelength of each peak and the chemical responsible for each of the labeled peaks using the ULTRAVIOLET absorption spectrum on the Saturn and Titan Reference Card.

	Wavelength	Chemical
	Peak 1 *1200* Å Peak 2 *1500* Å	Peak 1 *H* Peak 2 N_2
	Peak 1 *1200* Å	Peak 1 *H*

Analysis:

Why is Peak 2 so small on Titan and Saturn's spectra compared to the reference card peak for that chemical?

Peak 2 on Titan is considerable smaller because it is much less abundant than hydrogen. On the reference card the y-axis scale for hydrogen is up to 1.5 x 10^5 while nitrogens y-axis intensity only goes up to 8000.

Name:_____

Date:_____ Period:_____

Searching for Life in the Universe Using Spectroscopy

Questions: Use your notes to answer each question thoroughly and in complete sentences.

1. What gases does life require? What does does life product? *On Earth, planets require carbon dioxide to photosynthesize while animals use oxygen to respire. However, primitive bacteria and microbes have been found to metabolize methane.*

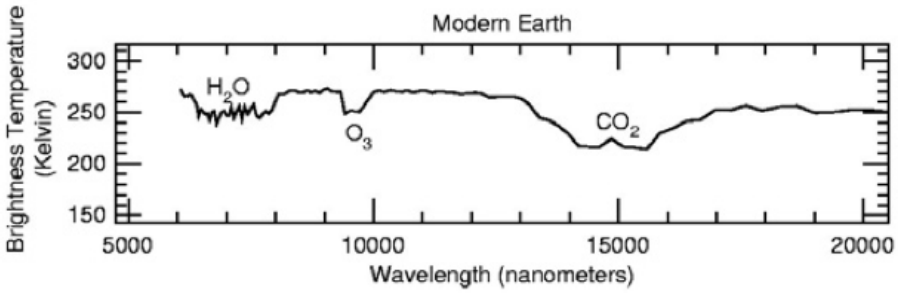
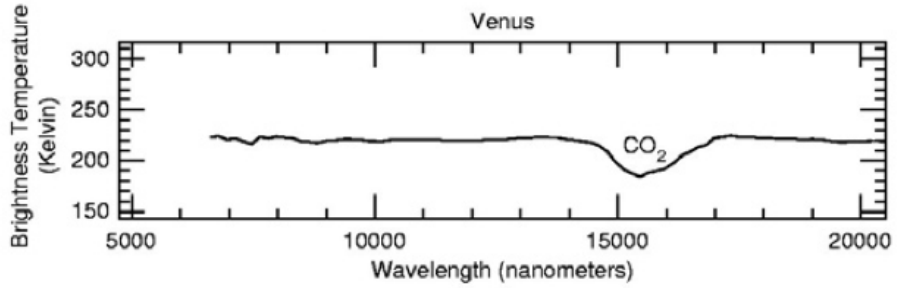
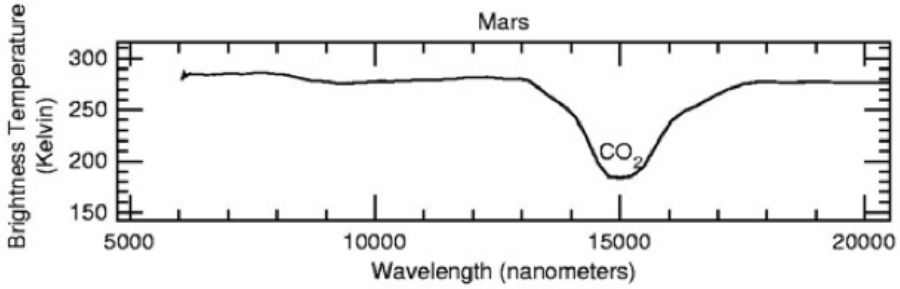
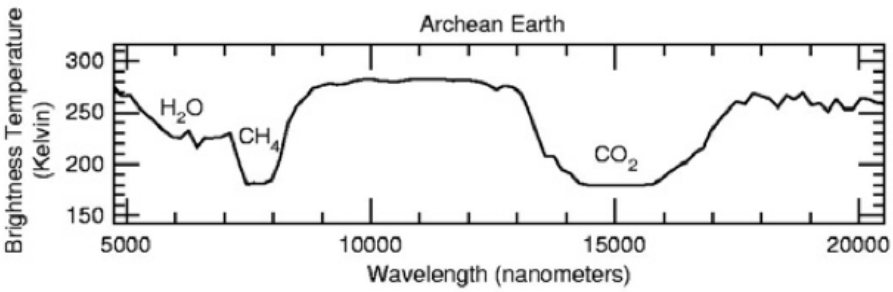
2. What is the difference between a terrestrial and gaseous planet? *Mercury, Venus, Earth and Mars are referred to as the terrestrial planets of our solar system because they are all small and rocky. On the other hand, Jupiter, Saturn, Neptune and Uranus are massive and are made of gas and ice. These outer planets are called Jovian planets.*

3. What does it mean for a planet to be in the "habitable zone"? What planets are in the habitable zone? *The habitable zone refers to a region in our solar system that is able to support liquid water since is not too close to the sun to evaporate off and not too far away to freeze. Venus and Earth are considered to be in the habitable zone, however, whatever water Venus may have once had is now gone due to the planet's geology.*

4. Why is it important to look at Archean Earth when trying to understanding life on our planet? *Earth's environment has changed considerably since the Archean eon. While forming, ancient Earth had much higher levels of methane and little to no atmospheric oxygen. This environment worked for the organisms at the time, however, as conditions changed, organisms adapted to use oxygen to respire. By looking at this change in climate, scientists may be able to find a planet that could EVENTUALLY support life.*

Planetary Spectral Analysis: The planet spectra data shown below represents the infrared portion of the electromagnetic spectrum, where planets re-emit the energy absorbed from their parent star. The dips in the curve result when gases in the planet's atmosphere absorb certain wavelengths of energy. Because every element and compound has a characteristic pattern of absorption, the location of these absorption bands allow scientists to identify different the element or compound in the atmosphere that is absorbing the energy.

Instructions: Identify the wavelength and brightness for each peak.

	Wavelength	Brightness
	H_2O *6000 nm* CH_4 *9500 nm* CO_2 *15000 nm*	H_2O *250 K* CH_4 *250 K* CO_2 *225 K*
	CO_2 *15000 nm*	CO_2 *200 K*
	CO_2 *15000 nm*	CO_2 *175 K*
	H_2O *6000 nm* O_3 *7500 nm* CO_2 *15000 nm*	H_2O *210 K* O_3 *200 K* CO_2 *175 K*

Planetary Spectral Analysis Questions: Use the absorption spectrum to answer the following questions.

1. What gases, if any, are common to all four planet spectra? *Carbon dioxide is present on Earth, Venus, Mars and Archean Earth*

2. How does your answer from Question 1 impact where scientists should be looking in order to find life on other planets? *Although life on Earth relies on carbon, no life has been found on Venus or Mars. So while carbon dioxide is a good thing to look for while searching for life, it doesn't necessarily mean a planet could support life.*

3. What gases are likely to be present in the atmosphere of a planet with life? Would your answer be different if it were primitive or complex life? *A planet suitable for life would most likely contain carbon dioxide, ozone and water, and possible small amounts of methane. For a planet with only primitive life, methane may be more abundant, however a planet with complex life would most likely show oxygen and ozone.*

4. Can the infrared portion of the spectrum be used to look for molecules important for life? What absorption peaks (USE NUMBERS) should scientists be looking for? *Scientists searching for life should be looking for planets with absorption peaks around 6000 nm for water, 9500 nm for ozone and 15000 nm for carbon dioxide. However, a peak at 6500 nm (methane) may also be worth investigating.*

Instructions: Read *Chemical Fingerprints*, then answer the following questions using complete sentences.

1. What is it difficult to study a planet using visible light? *Visible light only represents a tiny fraction of the entire electromagnetic spectrum. Using other types of electromagnetic radiation to study planets, moons, stars and galaxies allows scientists to see objects too far away to see with visible light. Objects can also emit low an high energy such as radio waves and x-rays that would not be detected by the human eye.*

2. Explain the two methods will Terrestrial Planet Finder missions use to search for other planets? *The Terrestrial Planet Finder missions will search for other planets by blocking out neighboring stars light to detected faint planets and measuring infrared radiation. These two methods will make planet detection much easier to find distant exoplanets.*

3. How does studying starlight tell you the chemical composition of an object? *Scientists can study how starlight is absorbed and reflected by an atmosphere to identify chemicals in an exoplanets atmosphere. Dark regions appear where wavelengths are absorbed and specifically match different elements in the atmosphere.*

4. What chemicals are the Terrestrial Planet Finder missions looking for? What absorption peaks are scientists looking for? Why these chemicals? *The Terrestrial Planet Finder missions are specifically looking for water (6000 nm), ozone (9500 nm), carbon dioxide (15000 nm) and methane (7500 nm).*

5. Since oxygen does not absorb in infrared, how can scientists test for atmospheres with oxygen? *Even though oxygen does not appear on the spectrum, scientists can detect ozone around 9500 nm. While the presence of ozone does not necessarily mean a planet is inhabited, it does indicate that there is a normal oxygen (O_2) is also present.*

6. What is a greenhouse gas? *A greenhouse gas is a gas that increases a planets temperature. Carbon dioxide and water are both greenhouse gases and keep Earth warm. This also takes place on Venus because of a huge buildup of carbon dioxide.*

7. Why are scientists looking for methane, even though there is very little methane in Earth's atmosphere today? *Scientists thinks that for the first billion years of Earth's history, methane was the main food source for organisms because there was no oxygen in the atmosphere. It was only when oxygen levels increased due to photosynthesis that oxygen breathing organisms evolved.*

Mystery Atmosphere: Now its time to apply what you learned...

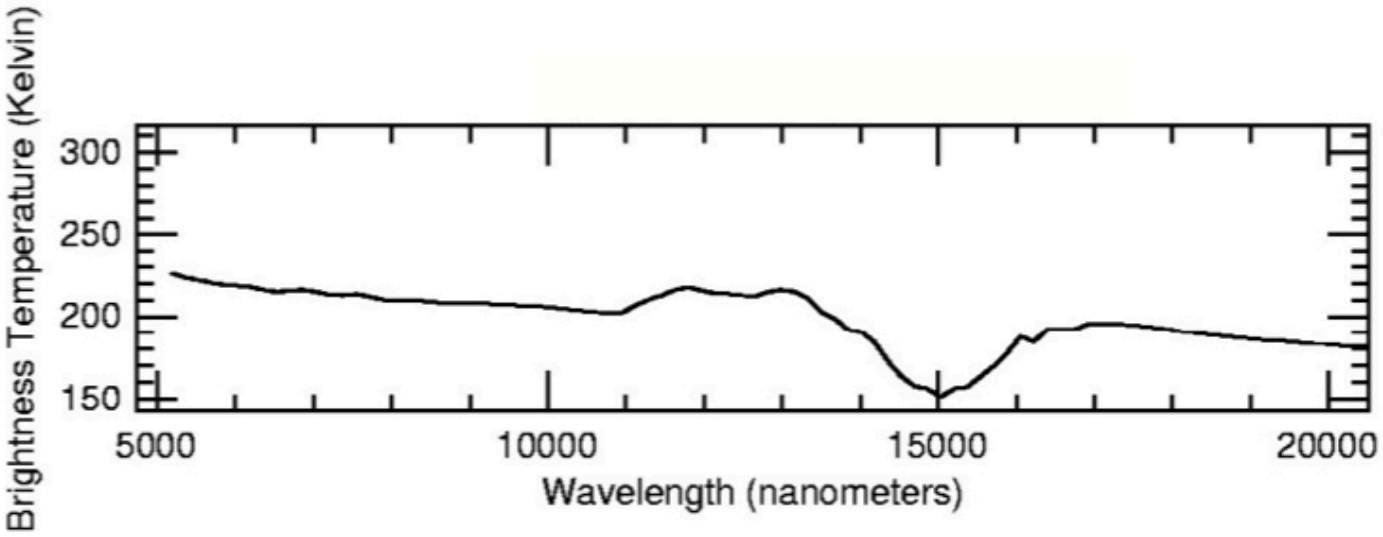
1. What four chemicals are scientists looking for on terrestrial planets?

   Water *Methane* *Carbon Dioxide* *Ozone*

2. Identify the molecule responsible for each absorption peak using *Chemical Fingerprints*

3. Label each absorption peak

4. What do you think about the mystery atmosphere? Can this planet support life? Compare and contrast this spectrum to Earth, Venus, Mars and Archean Earth. Explain your answer using data from the absorption data.



This planet has a strong peak at 15000 nm which indicates the presence of carbon dioxide. Water is also present around 6000 nm even though it doesn't show the characteristic peak. Even without the peak, the brightness is much lower on the y-axis, almost a blend between Earth and Archean Earth spectra. This planet lacks ozone because there is no sharp peak at 9500 nm or methane at 7500 nm. Since the mystery planet has carbon dioxide and water is might indicate life, there is no methane or oxygen to be used a food source for organisms, such as current Earth or Archean Earth.