Name: _____

1) Scientists infer that the universe began approximately
   A) 13.7 billion years ago
   B) 8.2 billion years ago
   C) 1.0 billion years ago
   D) 3.3 billion years ago

2) Which of the following evidence *best* supports the Big Bang theory?
   A) separation of Earth's interior into different layers
   B) existence of cosmic background radiation
   C) uniform radioactive decay of uranium-238
   D) rate of rotation of the Sun

3) Cosmic background radiation provides direct evidence for the origin of
   A) our solar system
   B) the universe
   C) Earth's earliest atmosphere
   D) Earth's ozone layer

4) Which information *best* supports the inference that the universe began with an explosion?
   A) measurements of cosmic background radiation
   B) calculations of the distance from the Sun to each asteroid in the asteroid belt
   C) measurements of rates of decay using carbon-14
   D) calculations of the temperature and luminosity of stars

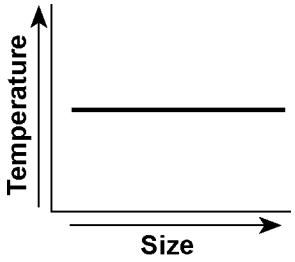
5) Cosmic microwave background radiation is classified as a form of electromagnetic energy because it
   A) is visible to humans
   B) moves due to particle collisions
   C) moves faster than the speed of light
   D) travels in waves through space

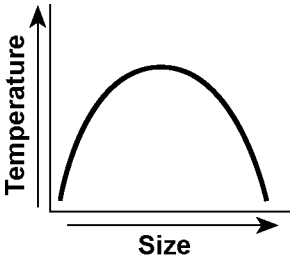
Questions 6 through 8 refer to the following:

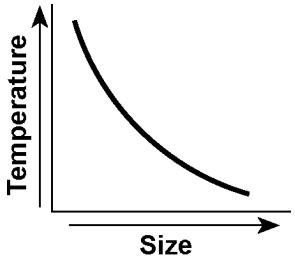
COSMIC MICROWAVE BACKGROUND RADIATION:

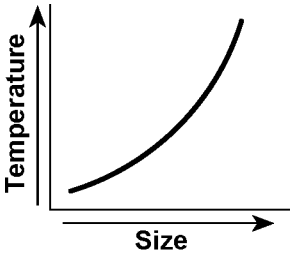
In the 1920s, Edwin Hubble's discovery of a pattern in the red shift of light from galaxies moving away from Earth led to the theory of an expanding universe. This expansion implies that the universe was smaller, denser, and hotter in the past. In the 1940s, scientists predicted that heat (identified as cosmic microwave background radiation) left over from the Big Bang would fill the universe. In the 1960s, satellite probes found that cosmic microwave background radiation fills the universe uniformly in every direction, and indicated a temperature of about 3 kelvins (K). This radiation has been cooling as the universe has been expanding.

6) Which graph best shows the relationship of the size of the universe to the temperature indicated by the cosmic microwave background radiation?

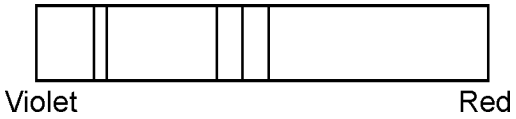
A)


C)


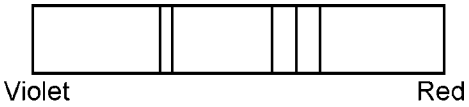
B)


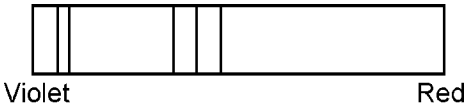
D)


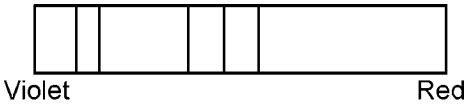
7) The diagram below represents the spectral lines from the light of an element in a laboratory on Earth.

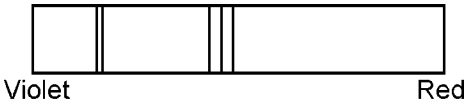


Which diagram below best represents the pattern of spectral lines from the same element when it was observed by Edwin Hubble in the light of one of the distant galaxies?

A)


B)


C)


D)


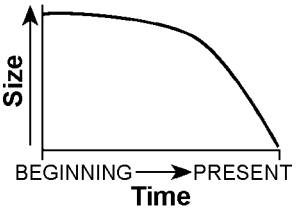
8) The current temperature indicated by the cosmic microwave background radiation is
   A) between room temperature and the temperature at which water freezes
   B) higher than the temperature at which water boils
   C) lower than the temperature at which water freezes
   D) between the temperature at which water boils and room temperature

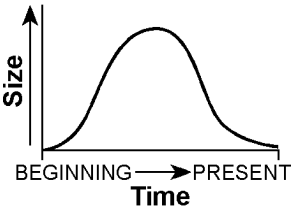
9) The theory that the universe is expanding is supported by the
   A) blue shift of light from distant galaxies
   B) nuclear fusion occurring in the Sun
   C) radioactive decay occurring in the Sun
   D) red shift of light from distant galaxies

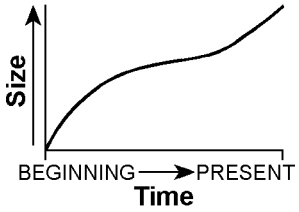
10) The red shift of light from *most* galaxies is evidence that
A) red light travels faster than other colors of light
B) the light slows down as it nears Earth
C) most galaxies are moving away from Earth
D) a majority of stars in most galaxies are red giants

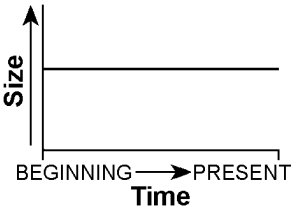
11) A blue shift of the light from a star indicates that the star
A) is moving closer to Earth
B) will soon become a main sequence star
C) is moving away from Earth
D) will soon become a giant star

12) According to the Big Bang theory, which graph *best* represents the relationship between time and the size of the universe from the beginning of the universe to the present?

A) 

C) 

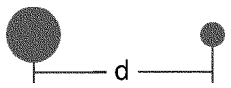
B) 

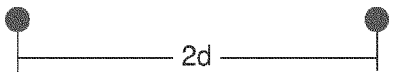
D) 

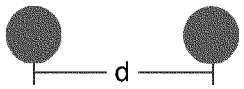
13) The symbols below represent star masses and distances.

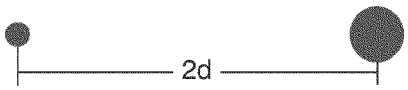
● represents a star with a mass the same as the Sun's mass
● represents a star with a mass greater than the Sun's mass
d represents a certain distance between star centers
2d represents twice the distance between star centers

Which diagram shows two stars that have the *greatest* gravitational force between them?

A) 

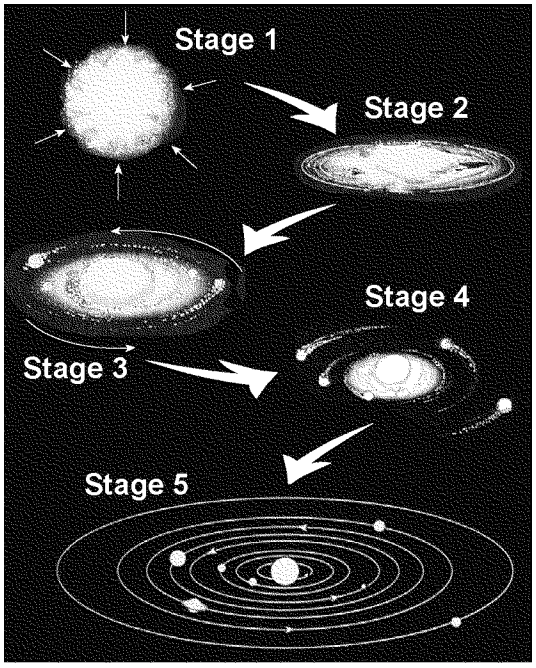
C) 

B) 

D) 

Questions 14 through 17 refer to the following:

The diagram below represents the inferred stages in the formation of our solar system. Stage 1 shows a contracting gas cloud. The remaining stages show the gas cloud flattening into a spinning disk as planets formed around our Sun.



(not drawn to scale)

14) Which force was mostly responsible for the contraction of the gas cloud shown?

A) magnetism
B) friction
C) inertia
D) gravity

15) Which process was occurring during some of the given stages that resulted in the formation of *heavier* elements from *lighter* elements?

A) radioactive decay
B) nuclear fusion
C) conduction
D) radiation

16) Approximately how long ago did stage 4 on the given diagram end and stage 5 begin?

A) 5 billion years
B) 1 billion years
C) 20 billion years
D) 100 billion years

17) Compared to the terrestrial planets, the Jovian planets in stage 5 on the given diagram have

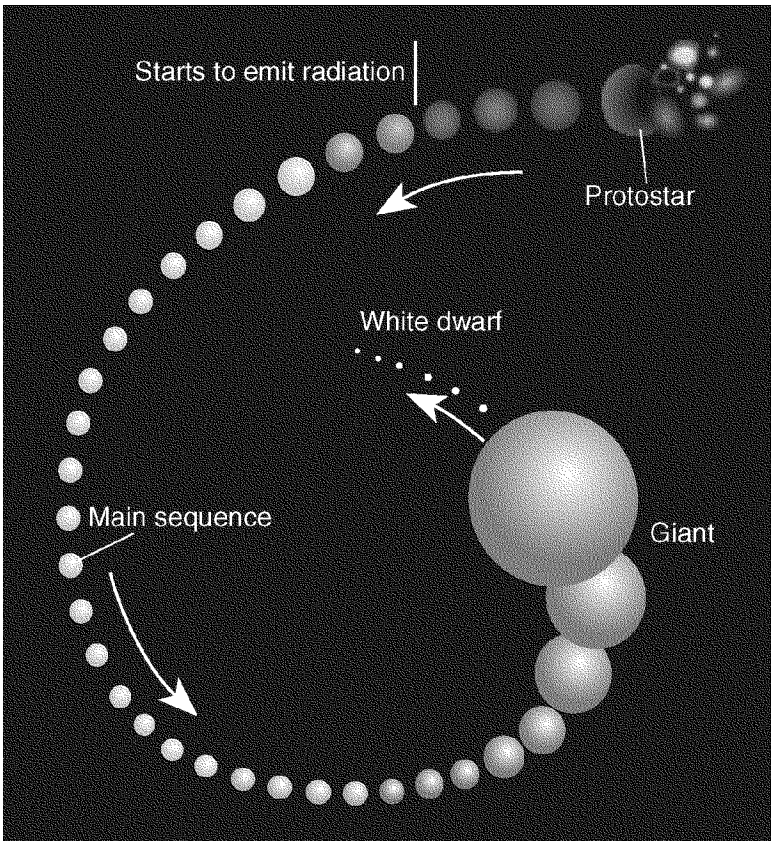
A) shorter periods of revolution
B) longer periods of rotation
C) higher densities
D) larger diameters

18) Compared to the luminosity and surface temperature of red main sequence stars, blue supergiants are

A) less luminous and have a lower surface temperature
B) more luminous and have a lower surface temperature
C) less luminous and have a higher surface temperature
D) more luminous and have a higher surface temperature

Questions 19 and 20 refer to the following:

The diagram below shows the change in the size of a star such as our Sun as it evolves from a protostar to a white dwarf star.



19) During which stage of development does the given star have a cool surface temperature and the *greatest* luminosity?

A) protostar
B) white dwarf
C) giant
D) main sequence

20) Which process produces the energy radiated by the given star when it becomes a main sequence star?

A) conduction
B) radioactive decay
C) convection
D) nuclear fusion

21) Energy is produced within a star's core by the process of

A) radioactive decay
B) nuclear fusion
C) insolation
D) conduction

22) Great amounts of energy are released in the core of a star as lighter elements combine and form heavier elements during the process of

A) nuclear fusion
B) radioactive decay
C) condensation
D) compaction

23) To an observer on Earth, the Sun appears brighter than the star *Rigel* because the Sun is

A) more luminous than *Rigel*
B) larger than *Rigel*
C) closer than *Rigel*
D) hotter than *Rigel*

24) Which star is cooler and *less* luminous than the Sun?

A) *Proxima Centauri*
B) *Rigel*
C) *40 Eridani B*
D) *Pollux*

25) Which one of the following stars has a surface temperature *most* similar to the surface temperature of *Alpha Centauri*?

A) *Sirius*
B) *Polaris*
C) *Procyon B*
D) *Betelgeuse*

26) Which sequence of stars is listed in order of increasing luminosity?

A) *Polaris*, *Deneb*, *40 Eridani B*, *Proxima Centauri*
B) *Spica*, *Rigel*, *Deneb*, *Betelgeuse*
C) *Barnard's Star*, *Alpha Centauri*, *Rigel*, *Spica*
D) *Procyon B*, *Sun*, *Sirius*, *Betelgeuse*

27) The Sun revolves around the center of

A) Earth
B) *Polaris*
C) the Milky Way Galaxy
D) *Aldebaran*

28) Which process combines lighter elements into heavier elements and produces energy within the Sun and other stars?

A) conduction
B) fusion
C) radioactive decay
D) insolation

29) Which event occurred approximately 4.6 billion years ago?

A) evolution of the earliest fish
B) evolution of stromatolites
C) formation of the oldest known Earth rocks
D) formation of Earth and our solar system

30) Why do the planets in our solar system have a layered internal structure?

A) Cosmic dust settled in layers on the planets' surfaces.
B) The Sun exerts a gravitational force on the planets.
C) Each planet is composed of materials of different densities.
D) All planets cooled rapidly after they formed.

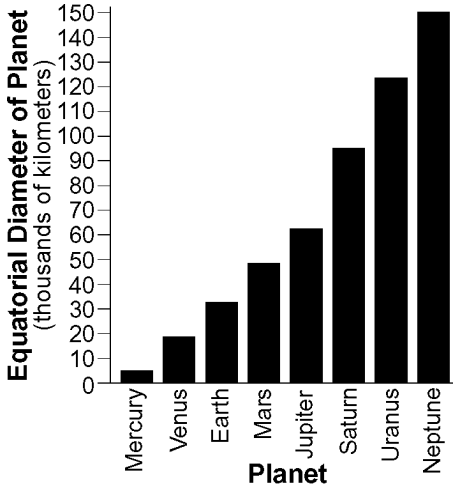
31) The terrestrial planets differ from the Jovian planets because the terrestrial planets are

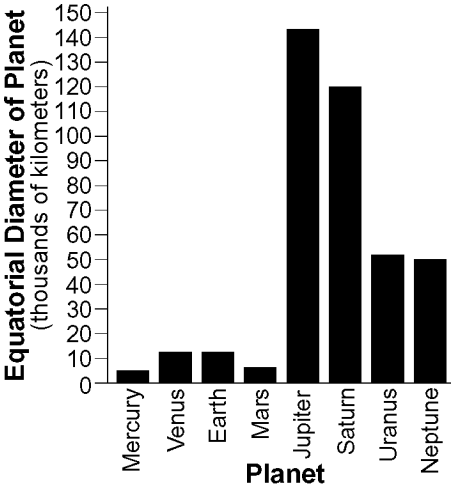
A) more dense and larger
B) less dense and larger
C) less dense and smaller
D) more dense and smaller

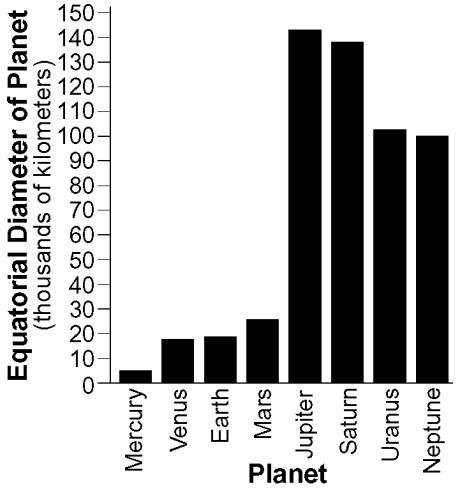
32) Which two characteristics do all Jovian planets have in common?

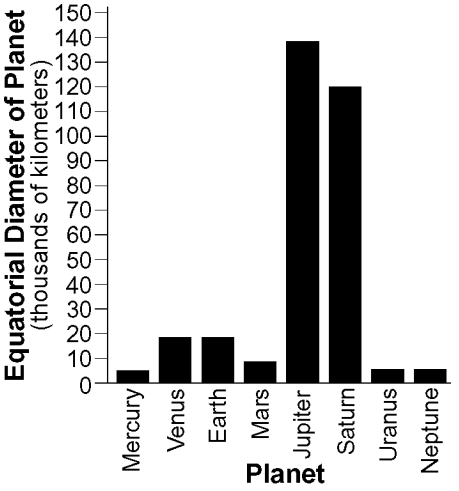
A) large diameters and low densities
B) small diameters and low densities
C) large diameters and high densities
D) small diameters and high densities

33) Which bar graph *best* represents the equatorial diameters of the eight planets of our solar system?

A)


C)


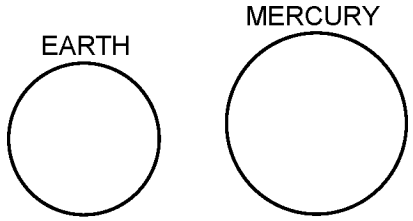
B)


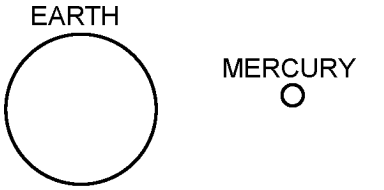
D)


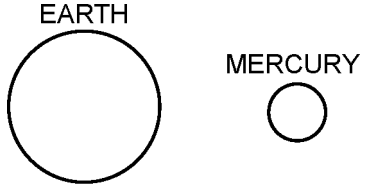
34) Why is the surface of Mercury covered with meteor impact craters, while Earth's surface has relatively few craters?

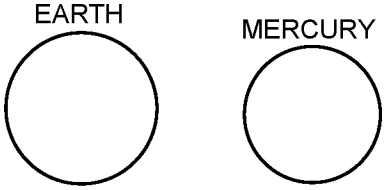
A) Mercury is an older planet, so it has a longer history of meteor impacts.
B) Earth's hydrosphere and atmosphere destroyed or buried most meteor impact sites.
C) Earth's less dense water surface attracts fewer meteors.
D) Mercury is larger than Earth, so it gets hit with more meteors.

35) Which diagram most accurately represents the relative diameters of Earth and Mercury?

A)


C)


B)


D)


36) Ocean tides observed at coastal locations each day are primarily caused by

A) the gravitational attraction between the Moon and Earth
B) seasonal changes in the compass location of sunrise
C) the changing phases of the Moon
D) Earth's revolution around the Sun

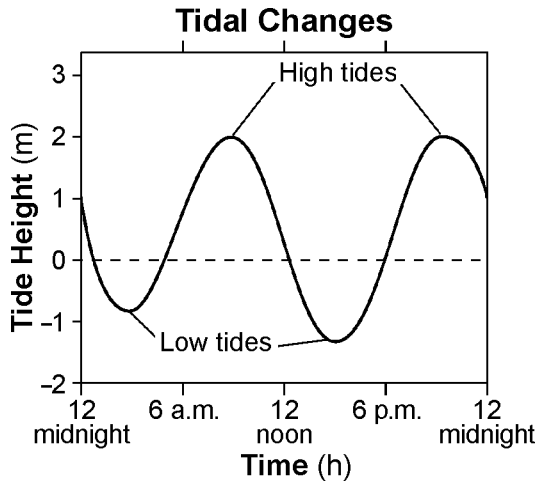
37) Why does the Moon's gravity have a *greater* effect on Earth's ocean tides than the Sun's gravity?

A) The Sun's gravity influences more planets.
B) The Sun is composed mostly of gases.
C) The Moon is much closer to Earth.
D) The Moon has a greater mass.

38) A high tide occurred at 6:00 a.m. at a beach on Long Island. The next high tide at this same beach would occur at approximately

A) 6:30 p.m. on the same day
B) 12:45 p.m. on the following day
C) 12:15 p.m. on the same day
D) 7:00 a.m. on the following day

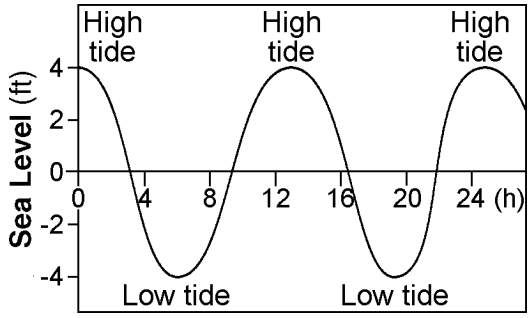
39) The graph below shows the tidal changes in ocean water level, in meters, recorded at a coastal location on a certain day.



Approximately how many hours apart were the two high tides?

A) 24 h
B) 18 h
C) 6 h
D) 12 h

40) A graph of tidal sea-level changes at a coastal city is shown below.

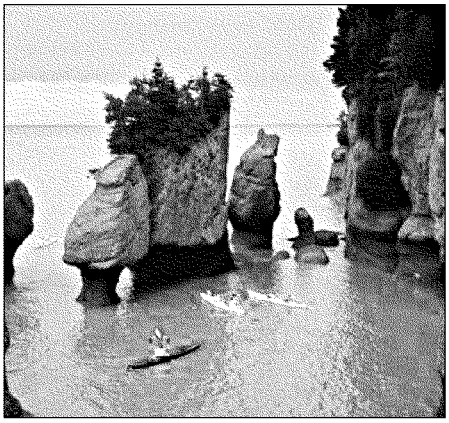


The number of hours from one high tide to the next high tide is approximately

A) 4 h
B) 12 h
C) 24 h
D) 8 h

41) The photographs below show the same coastal location at two different times during the same day.

People on Beach
12:40 p.m.



People Boating
6:52 p.m.

SOURCE: thehopewellrocks.ca (adapted)

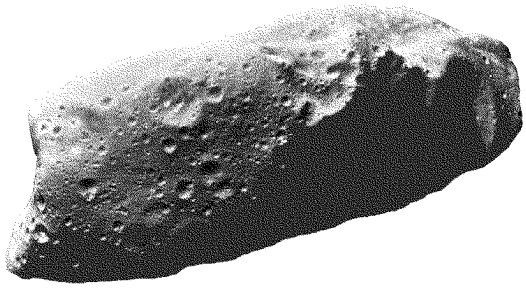
Which statement *best* explains the cause for the higher water level at 6:52 p.m.?

A) Earth's tilted axis causes different amounts of insolation throughout the day.
B) The Moon rotates on its axis at the same rate that it revolves around Earth.
C) Earth's rotation causes a deflection of surface ocean currents.
D) The Moon exerts a gravitational pull on a rotating Earth.

42) Many meteors are believed to be fragments of celestial objects normally found between the orbits of Mars and Jupiter. These objects are classified as

A) asteroids B) stars C) moons D) planets

43) The solar system object in the photograph below is 56 kilometers long.



The object in the photograph is most likely

A) Neptune
B) Mercury
C) an asteroid
D) Earth's Moon

44) The diagrams below represent the events that occur when a large meteor, such as the one believed to have caused the extinction of many organisms, impacts Earth's surface. Diagram *A* shows the meteor just before impact. Diagram *B* represents the crater forming, along with the vapor and ejecta (the fragmented rock and dust) thrown into the atmosphere.

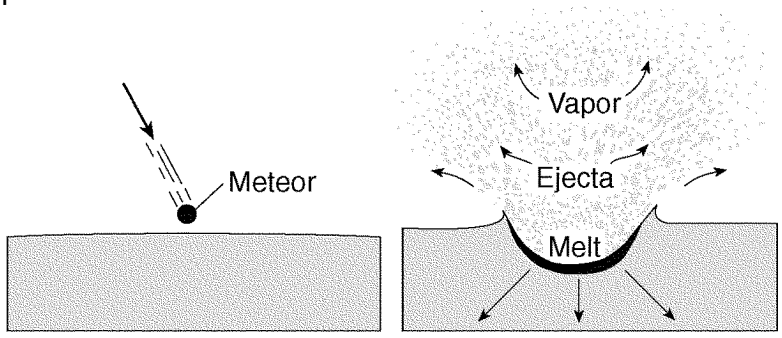


Diagram *A*: Before Impact **Diagram *B*: During Impact**

Which statement *best* explains how global climate would most likely be affected after the large meteor impact shown in the diagram?

A) Large quantities of ejecta in the atmosphere would block insolation and lower global temperatures.
B) An increase in vapor and ejecta would allow radiation to escape Earth's atmosphere and lower global temperatures.
C) Forest fires produced from the vapor and ejecta would raise global temperatures.
D) Ejecta settling in thick layers would increase the absorption of insolation by Earth's surface and raise global temperatures.

45) The modern heliocentric model of planetary motion states that the planets travel around

A) Earth in circular orbits
B) Earth in slightly elliptical orbits
C) the Sun in circular orbits
D) the Sun in slightly elliptical orbits

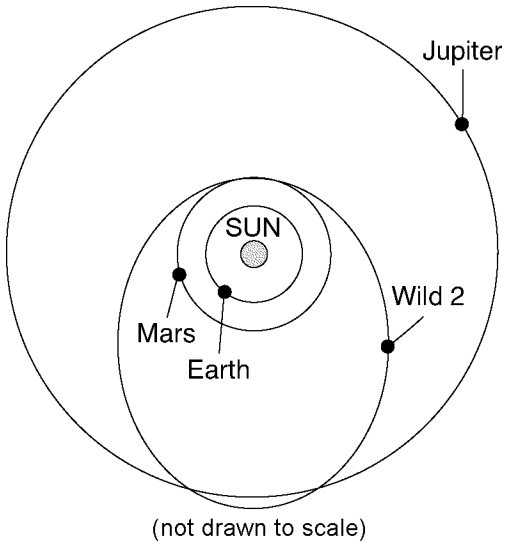
46) As Earth travels in its orbit, Earth's axis

A) is pointing toward the center of the Milky Way
B) remains parallel to itself at all Earth positions
C) is perpendicular to the Moon's axis
D) remains aligned with the Sun's axis

47) Compared to Jovian planets, terrestrial planets have

A) larger masses
B) larger equatorial diameters
C) shorter periods of revolution
D) shorter periods of rotation

48) The diagram below shows the orbital paths of Earth, Mars, Jupiter, and a comet named Wild 2.



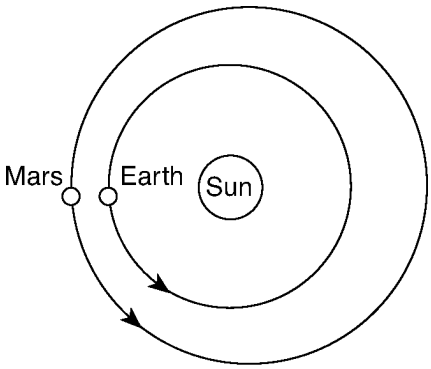
What is the approximate distance between the Sun and Wild 2 when this comet is *closest* to the Sun?

A) 820 million kilometers
B) 778 million kilometers
C) 150 million kilometers
D) 228 million kilometers

49) During which Northern Hemisphere season is Earth *closest* to the Sun?

A) autumn B) winter C) summer D) spring

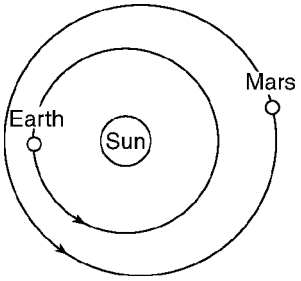
50) The diagram below shows the relative positions of Earth and Mars in their orbits on a particular date during the winter of 2007.



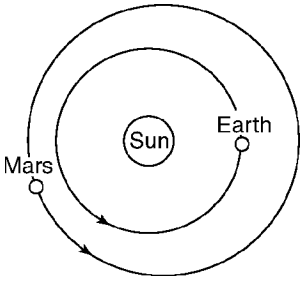
(not drawn to scale)

Which diagram correctly shows the locations of Earth and Mars on the same date during the winter of 2008?

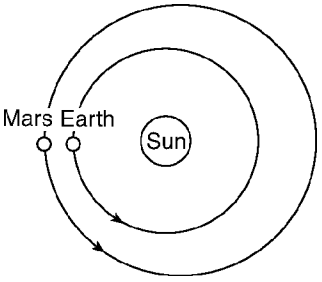
A)



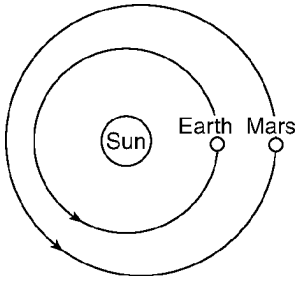
C)



B)

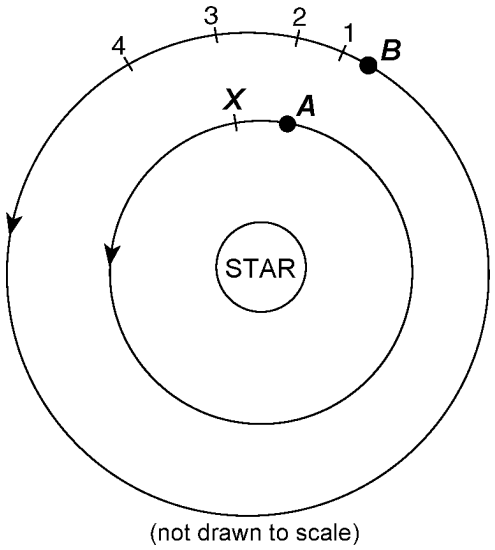


D)



Questions 51 and 52 refer to the following:

The diagram below represents the current locations of two planets, *A* and *B*, orbiting a star. Letter *X* indicates a position in the orbit of planet *A*. Numbers 1 through 4 indicate positions in the orbit of planet *B*.



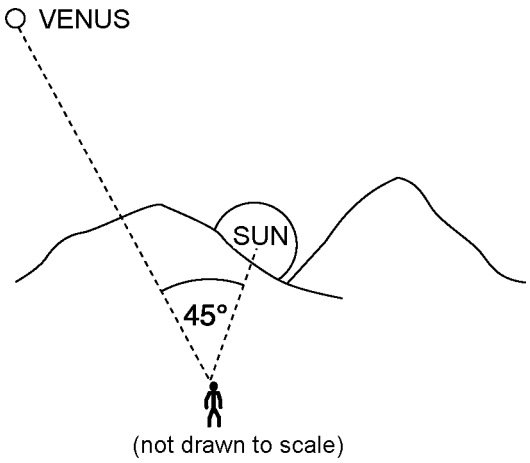
51) As planet *A* moves in orbit from its current location on the given map to position *X*, planet *B* most likely moves in orbit from its current location to position

A) 1 B) 2 C) 3 D) 4

52) If the given diagram represents our solar system and planet *B* is Venus, which planet is represented by planet *A*?

A) Earth B) Mars C) Mercury D) Jupiter

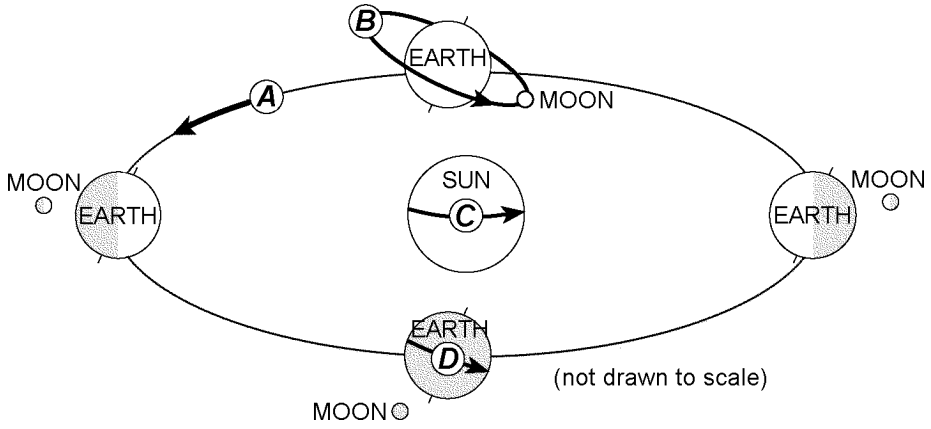
53) An observer on Earth measures the angle of sight between Venus and the setting Sun.



Which one of the following statements *best* describes and explains the apparent motion of Venus over the next few hours?

A) Venus will set 2 hours after the Sun because Venus orbits Earth faster than the Sun orbits Earth.
B) Venus will set 4 hours after the Sun because Venus orbits Earth slower than the Sun orbits Earth.
C) Venus will set 3 hours after the Sun because Earth rotates at 15D per hour.
D) Venus will set 1 hour after the Sun because Earth rotates at 45D per hour.

54) The diagram below shows Earth and the Moon in four locations during their orbits. Arrows *A* through *D* represent different motions of Earth, the Moon, and the Sun.



Which arrow represents a rate of movement of approximately 1D per day?

A) *A* B) *B* C) *C* D) *D*

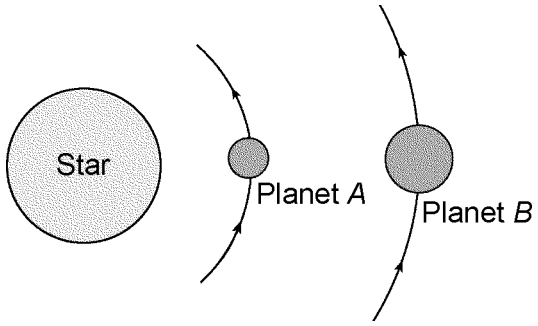
55) If Earth's rate of rotation increases, the length of one Earth day will be

A) shorter than 24 hours
B) 24 hours, with a longer nighttime period
C) 24 hours, with a shorter nighttime period
D) longer than 24 hours

56) Which planet's day (period of rotation) is *longer* than its year (period of revolution)?

A) Saturn B) Venus C) Jupiter D) Mercury

57) The diagram below represents planets *A* and *B*, of equal mass, revolving around a star.



Compared to planet *A*, planet *B* has a

A) weaker gravitational attraction to the star and a shorter period of revolution
B) stronger gravitational attraction to the star and a longer period of revolution
C) weaker gravitational attraction to the star and a longer period of revolution
D) stronger gravitational attraction to the star and a shorter period of revolution

58) What is the eccentricity of the Moon's orbit?

A) 0.386 B) 0.055 C) 0.723 D) 0.017

Questions 59 through 63 refer to the following:

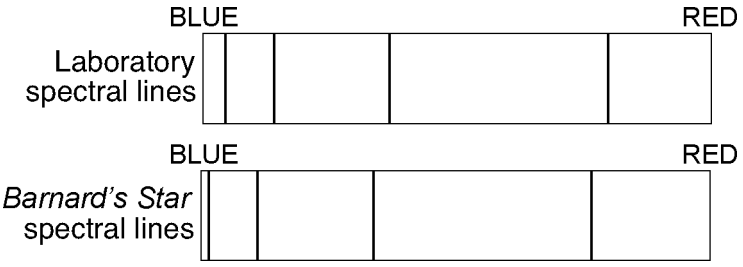
The table below lists some information about *Barnard's Star*.

Barnard's Star

Distance from Sun	• 6.0 light-years* • currently moving toward the Sun (and Earth) and will get as close as 3.8 light-years in approximately 11,000 years
Characteristics of *Barnard's Star*	• less than 17 percent of the Sun's mass • approximately 20 percent of the Sun's diameter • age thought to be between 11 and 12 billion years old and may last another 40 billion years • no planets observed orbiting *Barnard's Star*

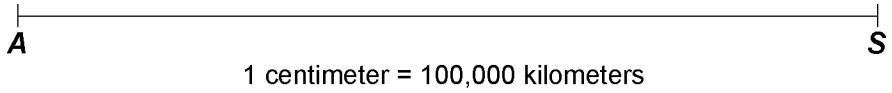
* A light-year is the distance light travels in one year.

59) The diagram below shows four spectral lines produced by glowing hydrogen gas in a laboratory and four spectral lines produced by hydrogen gas as seen in the light from *Barnard's Star*.



Explain why the positions of the spectral lines of *Barnard's Star* are all shifted toward the blue end of the spectrum.

60) The distance from point *A* to point *S* on the line below represents the equatorial diameter of the Sun.



On this line, place a point labeled *B* at the correct scale distance from point *A* to represent the equatorial diameter of *Barnard's Star*.

61) Compared to the surface temperature and luminosity of the Sun, describe the relative surface temperature and the relative luminosity of *Barnard's Star*.

62) Use the information given to list *Barnard's Star*, the Sun, and the universe in order by age from *oldest* to *youngest*.

63) If a planet with the same mass as Earth were discovered orbiting *Barnard's Star* at the same distance that Earth is orbiting the Sun, why would there be less gravitational attraction between this new planet and *Barnard's Star* than there is between Earth and the Sun?

64) What is the estimated age, in years, of Earth and our solar system?

65) Compared to Jupiter, state how Earth's equatorial diameter and density are different.

66) Other than Jupiter, identify *one* Jovian planet in our solar system.

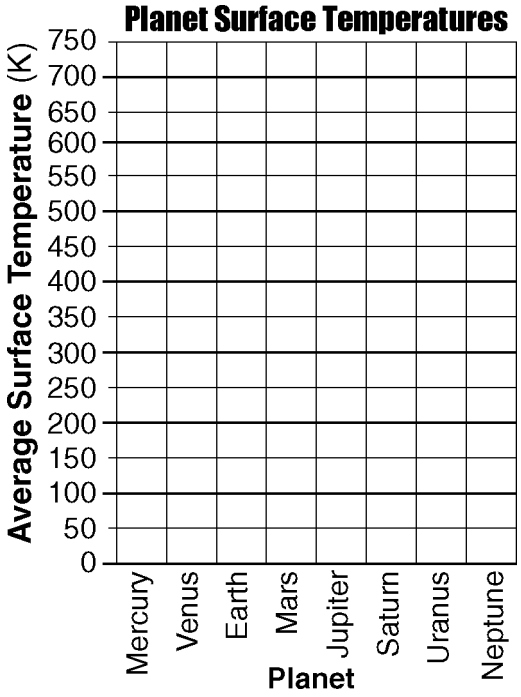
Questions 67 through 70 refer to the following:

The table below lists the average surface temperature, in kelvins, and the average orbital velocity, in kilometers per second, of each planet of our solar system.

DATA TABLE:

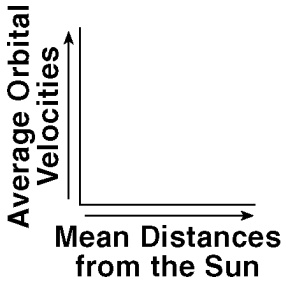
Planet	**Average Surface Temperature** (K)	**Average Orbital Velocity** (km/s)
Mercury	440	47.87
Venus	737	35.00
Earth	288	29.78
Mars	208	24.13
Jupiter	163	13.07
Saturn	133	9.69
Uranus	78	6.81
Neptune	73	5.43

67) On the grid below, construct a bar graph to represent the average surface temperature for *each* planet.



68) Approximately 97% of Venus's atmosphere is carbon dioxide. Describe how carbon dioxide contributes to the unusually high average surface temperature of Venus.

69) Use the set of axes below to draw a line that represents the general relationship between the mean distances of planets from the Sun and the average orbital velocities of the planets.



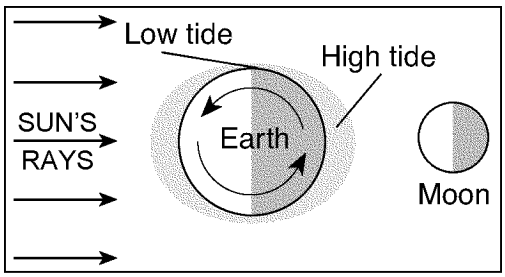
70) The orbital velocity of Earth is sometimes faster and sometimes slower than its average orbital velocity. Explain why the orbital velocity of Earth varies in a cyclic pattern.

71) **EXTRASOLAR PLANETS**:
Astronomers have discovered more than 400 planets outside of our solar system. The first extrasolar planet was detected in 1995 orbiting a star known as *51 Pegasi*, which is similar in color and luminosity to our Sun. Astronomers can detect planets by identifying stars that move in response to the gravitational pull of planets revolving around them. Other planets have been discovered by finding stars whose luminosity varies as orbiting planets block outgoing starlight. Nearly all of these discovered planets are thought to be Jovian-like planets similar to Jupiter.

Based on the information given, state the color and luminosity of *51 Pegasi*.

72) Identify the force that causes ocean tides on Earth.

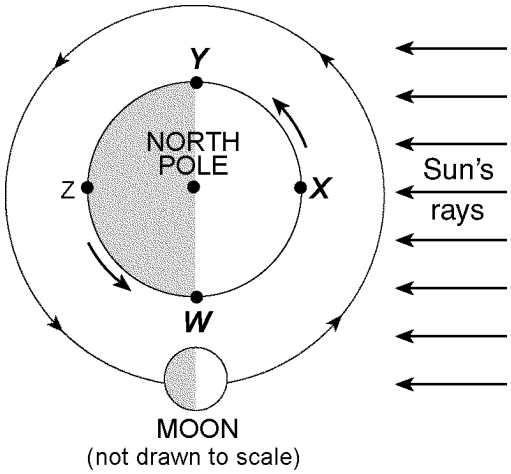
73) The diagram below shows the locations of high and low tides on Earth at a particular time.



(not drawn to scale)

Approximately how many hours will pass between high tide and the following low tide?

74) The diagram below shows one position of the Moon in its orbit around Earth. Letters *W*, *X*, *Y*, and *Z* are locations on Earth's surface.



On the lines below, write "high" or "low" to indicate whether a high ocean tide or low ocean tide is occurring at locations *W*, *X*, *Y*, and *Z*.

Location *W*: _____ tide

Location *X*: _____ tide

Location *Y*: _____ tide

Location *Z*: _____ tide

Questions 75 through 77 refer to the following:

The passage and data table below describe the exploration and characteristics of one of Saturn's moons, Titan.

HUYGENS PROBE LANDS ON TITAN:
The Huygens probe was carried to Saturn by the Cassini spacecraft and parachuted to the surface of Saturn's giant moon, Titan. The Huygens probe's landing site was littered with smooth, rounded, rocklike objects. Photographs taken of Titan's surface show drainage channels leading to an apparent shoreline. The question is, what are they draining? One of the photographs seems to show ground fog consisting not of water, but perhaps of ethane or methane.

Titan Data

Distance from Saturn	1.22 million km
Diameter	5,150 km
Average Density	1.881 g/cm^3
Atmospheric Pressure at Surface	1,500 mb
Mass (Earth = 1)	0.022
Air Temperature at Landing Site	–291°F

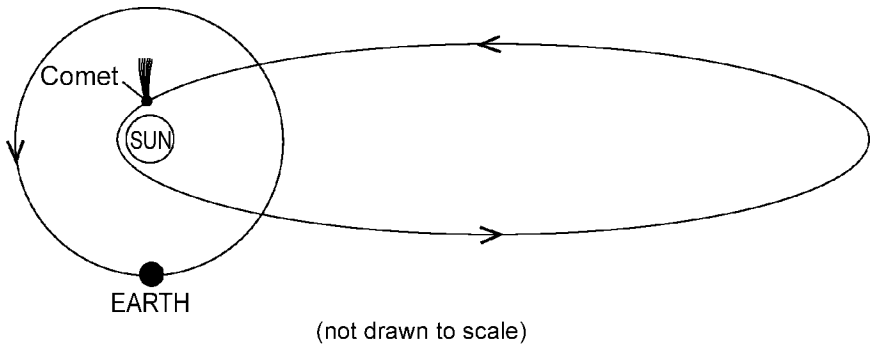
75) What natural process occurring on Earth produces smooth, rounded rocks similar to those found at the probe's landing site on Titan?

76) Based on the given information, approximately how many times farther is Titan from Saturn than Earth's Moon is from Earth?

77) Based on the given information, identify the planet with a density *closest* to the density of Titan.

Questions 78 and 79 refer to the following:

The diagram below shows Earth's orbit and the orbit of a comet within our solar system.



(not drawn to scale)

78) Explain how the given comet's orbit illustrates the heliocentric model of our solar system.

79) Explain why the time required for one revolution of the given comet is *more* than the time required for one revolution of Earth.

Questions 80 and 81 refer to the following:

METEORITE COMPOSITION:

Meteors that strike Earth's surface are called meteorites. Analysis of meteorite composition has provided scientists with information regarding the formation of Earth and our solar system, and possibly the development and evolution of life on Earth.

Two types of meteorites are iron meteorites and chondrites. Iron meteorites consist mostly of iron and nickel, and are inferred to be from core materials of early planetary bodies in our solar system. More than 60% of meteorites studied have been identified as chondrites. Chondrites are made of millimeter-sized spheres of olivine and pyroxene crystals embedded in a mass of mineral and metal grains. The chondrites are thought to represent fragments of the earliest solid materials in our solar system. One type of chondrite, the carbonaceous chondrite, contains water, organic compounds, and minerals that represent the chemical composition necessary for life to form.

80) Based on the reading passage, identify the type of meteorite that is inferred to have a composition similar to the composition of Earth's core.

81) Explain why there is little evidence of meteorite impact craters on Earth.

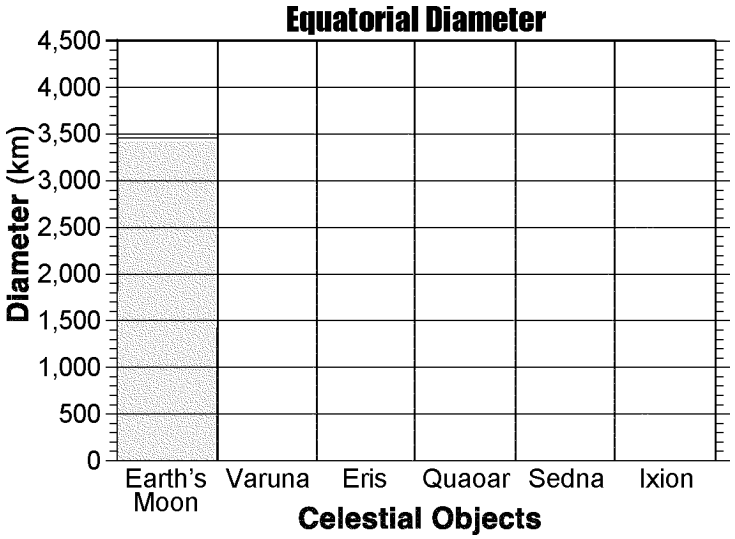
Questions 82 through 84 refer to the following:

The table below shows information about five large objects in the Kuiper Belt. The Kuiper Belt is located approximately 30 to 1,000 astronomical units (AU) from the Sun. An astronomical unit is the average distance between Earth and the Sun, 149.6 million kilometers.

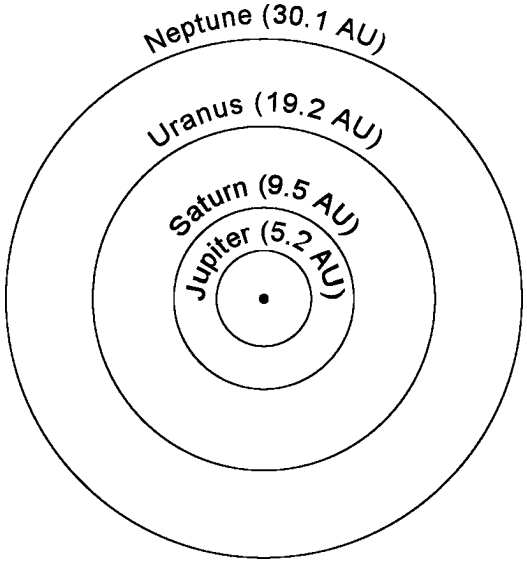
Kuiper Belt Data

	Orbit Characteristics			
Kuiper Belt Objects	**Closest Distance to the Sun** (AU)	**Farthest Distance from the Sun** (AU)	**Eccentricity**	**Approximate Equatorial Diameter** (km)
Varuna	40.47	45.13	0.053	900
Eris	37.77	97.56	0.442	2,400
Quaoar	41.92	45.28	0.039	1,260
Sedna	76.15	975.05	0.855	1,500
Ixion	30.04	49.36	0.243	1,065

82) On the graph provided, construct a bar graph of the equatorial diameter of each of the Kuiper Belt objects listed in the table. The diameter of Earth's Moon has been graphed for comparison.



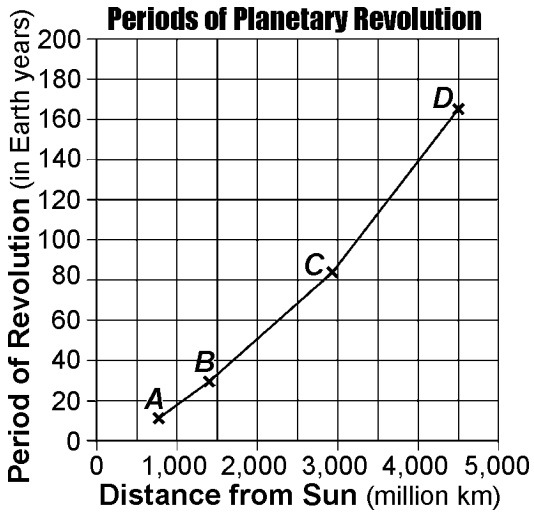
83) The diagram provided shows the orbits of some of the planets in our solar system. The approximate average distances from the Sun, in astronomical units, are indicated. On the diagram, place an **X** to show the *closest* distance of Ixion to the Sun.



84) Identify the Kuiper Belt object with the *longest* period of revolution and state the evidence that supports that conclusion.

Questions 85 and 86 refer to the following:

The graph below shows the distance from the Sun and the period of revolution for four planets in our solar system labeled *A*, *B*, *C*, and *D*.

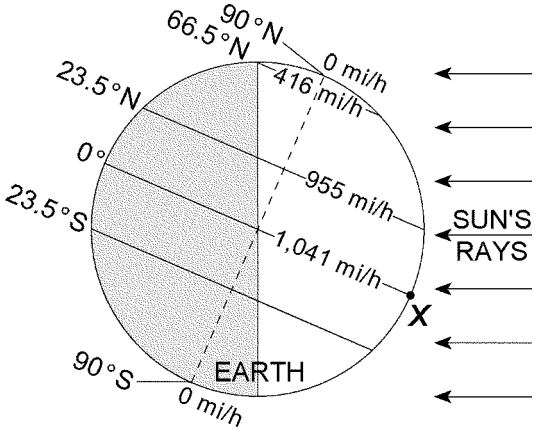


85) State the name of each of the planets represented by *A*, *B*, *C*, and *D* in the given graph.

86) Describe the relationship between the distance from the Sun and the period of revolution for the four planets shown.

Questions 87 and 88 refer to the following:

The diagram below represents daytime and nighttime on Earth. Point *X* is a location on Earth's surface. Earth's rotational surface velocity is shown in miles per hour (mi/h) at specific latitudes.



87) Based on the given diagram, what is Earth's rotational surface velocity, in miles per hour, at 23.5D south latitude?

88) On the grid below, draw a line to show the general relationship between distance from the equator and Earth's rotational surface velocity.