

UNIVERSITY OF TORONTO  
Faculty of Arts and Science  
DECEMBER 2011 EXAMINATIONS  
AST101H1F

PLEASE HAND IN

Duration – 3 hours  
No Aids Allowed

NAME: \_\_\_\_\_ UTORID: (e.g.smitha4) \_\_\_\_\_

TUTORIAL: (e.g. 0302) \_\_\_\_\_ STUDENT NUMBER: \_\_\_\_\_

**Instructions:**

1. ON THIS PAGE: Fill in your identifying information above. Make sure you fill in your name AS IT APPEARS ON ROSI.
2. ON THE SCANTRON CARD: Fill in your last name, first initial, and student number in the spaces given and, using pencil, darkly shade in the corresponding bubbles. Then sign the card.
3. For each multiple choice question, mark your answer *in pencil* on the Scantron card by darkly shading the appropriate bubble. All answers to multiple choice questions must be transferred to the Scantron card. **UNDER NO CIRCUMSTANCES WILL ANSWERS TO MULTIPLE CHOICE QUESTIONS WRITTEN ON THIS PAPER BE ACCEPTED FOR MARKS.**
4. Answer short answer questions in the spaces provided.
5. Answers to short-answer questions which are written in pencil will not be re-marked.
6. Mark values are indicated with each question.
7. Make sure that your exam paper has 16 pages.

| Question     | Marks      |
|--------------|------------|
| A1-A50       | /50        |
| B1           | /7         |
| B2           | /4         |
| B3           | /3         |
| B4           | /4         |
| B5           | /7         |
| B6           | /5         |
| <b>Total</b> | <b>/80</b> |

**PART A: Multiple choice questions. Choose the MOST CORRECT answer and TRANSFER YOUR ANSWERS TO THE SCANTRON CARD WHEN YOU ARE DONE (1 mark each)**

1. Earth is made mostly of metal and rocks, consisting of elements like nickel, iron, and silicon. Where did these elements come from?
  - (a) They were produced during the first few instants of the Big Bang.
  - (b) They were created by chemical reactions in interstellar space.
  - (c) They were produced by nuclear fusion in stars.
  - (d) They were made by our Sun.
  - (e) They were made by nuclear fission of uranium and other radioactive materials.
  
2. Why is it summer in the Northern Hemisphere when it is winter in the Southern Hemisphere?
  - (a) The Northern Hemisphere is closer to the Sun than the Southern Hemisphere during northern summer.
  - (b) The Northern Hemisphere is “on top” of Earth and therefore receives more sunlight during northern summer.
  - (c) The Northern Hemisphere is facing the hotter side of the Sun during northern summer.
  - (d) The Northern Hemisphere is tilted toward the Sun and receives more direct sunlight during northern summer.
  - (e) In fact, both hemispheres have the same seasons at the same time.
  
3. Why is the Moon hard to see from Earth when the Moon is in its new phase?
  - (a) The new Moon is obscured by Earth's shadow.
  - (b) The side of the Moon facing Earth is not directly illuminated by the Sun.
  - (c) The new Moon is too close to the Sun to be seen.
  - (d) The new Moon is not above the horizon during the daytime.
  - (e) The Moon is too far from the Earth to be seen when its in its new phase.
  
4. When a rocket blasts off from Earth, how is it propelled into space?
  - (a) The rocket engines push against the launch pad, lifting the rocket upwards.
  - (b) The rocket converts mass into kinetic energy, and so is propelled by conservation of energy.
  - (c) The rocket produces lift using fins, the same way an aeroplane uses its wings.
  - (d) The rocket pushes against the air underneath it, pushing it forward.
  - (e) The rocket expels gasses at high speeds which pushes the rocket upward by conservation of momentum.
  
5. You can read this exam paper because it:
  - (a) emits visible light
  - (b) converts thermal radiation to visible light
  - (c) reflects visible light
  - (d) absorbs infrared light and converts it to visible light
  - (e) produces a continuous spectrum of light

6. Which of the following can be deduced from the knowledge that Venus orbits the Sun at about twice the distance that Mercury does?
- (a) Venus is more massive than Mercury.
  - (b) Venus takes longer to rotate on its axis than Mercury does.
  - (c) Venus has a thicker atmosphere than Mercury does.
  - (d) Venus orbits the Sun at a slower average speed than Mercury does.
  - (e) Venus is more geologically active than Mercury is.
7. Imagine a space probe which is orbiting a planet in a circular orbit. If the probe fired its engines so that its orbital speed suddenly increased by 5%, what would the new shape of the probe's orbit be?
- (a) a circle
  - (b) an ellipse
  - (c) a parabola
  - (d) a hyperbola
  - (e) a straight line, in whatever direction the moon was moving in when the engines were fired
8. We can learn a lot about a star by studying its spectrum. Which of the following statements about what we learn from spectra is **FALSE**?
- (a) We can identify chemical elements present in the star by recognizing patterns of spectral lines that correspond to particular chemicals.
  - (b) The peak of the star's thermal emission tells us its temperature: hotter stars peak at shorter (bluer) wavelengths.
  - (c) Shifts in the wavelengths of spectral lines compared to the wavelengths of those same lines measured in a laboratory on Earth can tell us the star's speed toward or away from us.
  - (d) The total amount of light in the spectrum tells us the star's radius.
  - (e) We can tell how fast the star is rotating by measuring the width of its spectral lines.
9. Compared to the set of wavelengths at which an atom can emit light, the set of wavelengths at which another atom of the same element can absorb light is:
- (a) shifted toward the red end of the spectrum
  - (b) shifted toward higher frequencies
  - (c) shifted toward the blue end of the spectrum
  - (d) Doppler shifted
  - (e) the same
10. What atmospheric constituent is responsible for the blue colour of Neptune and Uranus?
- (a) methane
  - (b) hydrogen
  - (c) water
  - (d) ammonia
  - (e) chlorine

11. How do the interiors of the Jovian planets differ from one another?

- (a) All have cores of about the same mass, but they differ in the amount of surrounding hydrogen and helium.
- (b) The core mass decreases with the mass of the planet.
- (c) The composition changes from mostly ammonia in Jupiter and Saturn to mostly methane in Uranus and Neptune.
- (d) The composition changes from mostly hydrogen in Jupiter and Saturn to mostly helium in Uranus and Neptune.
- (e) All have about the same amount of hydrogen and helium but the proportion of rocks is greater in those planets closer to the Sun.

12. What kind of surface did the Huygens probe find when it landed on Saturn's moon Titan?

- (a) dry, featureless plains
- (b) a water world of frozen ice sheets
- (c) a surface covered with volcanoes
- (d) hills, valleys, and rivers
- (e) nothing; there was zero visibility due to the methane smog

13. Why are the rings of Saturn so thin?

- (a) Saturn's gravity prevents particles from migrating up out of the rings.
- (b) The shepherd moons in the gaps maintain the thin profile of the rings.
- (c) Any particle in the ring with a tilted orbit would collide with another ring particle, flattening its orbit.
- (d) The solar wind strips away any particles which rise up out of the rings.
- (e) The rings only stay thin for a short period of time and it is thought that they will 'fluff up' again soon.

14. What is a 'shooting star'?

- (a) A star which is moving at a high velocity across the sky.
- (b) A star which is falling through the atmosphere toward the ground.
- (c) The flash that occurs when a speeding rock from space is deflected by Earth's magnetic field.
- (d) The glow of a small piece of interplanetary debris burning up in Earth's atmosphere.
- (e) A fragment of molten rock spewed high into Earth's atmosphere by an erupting volcano, often mistaken for an actual star.

15. If you were to stand at the South Pole at the summer solstice, you could see:

- (a) all of the stars on the celestial sphere.
- (b) about three-quarters of the stars on the celestial sphere.
- (c) about half of the stars on the celestial sphere.
- (d) about a quarter of the stars on the celestial sphere.
- (e) none of the stars on the celestial sphere (except the Sun) because it would be day time.

16. How do we know that Mercury's surface is the oldest planetary surface in the solar system?
- (a) It is covered in craters to the maximum extent possible.
  - (b) Radiocarbon dating of the rocks on Mercury has revealed it is about 4.7 billion years old—slightly older than Earth.
  - (c) We can see from satellite imagery that, although Mercury has many volcanoes, they have not erupted in a very long time.
  - (d) The fossil record on Mercury goes much further back in history than the fossil record on Earth.
  - (e) The surface of Mercury has been extensively eroded away, so it looks very old.
17. According to the nebular theory, how did the Kuiper Belt form?
- (a) It is material left over from the interstellar cloud that never contracted with the rest of the gases to form the solar nebula.
  - (b) It is made of planetesimals that formed beyond Neptune's orbit and never accreted to form a planet.
  - (c) It consists of objects that fragmented from the protosun during a catastrophic collision early in the formation of the solar system.
  - (d) It is made of planetesimals between the orbits of Mars and Jupiter that never formed into a planet.
  - (e) It is made of planetesimals formed in the outer solar system that were flung into distant orbits by encounters with the Jovian planets.
18. Which of the following best describes the composition of a Kuiper Belt object?
- (a) 20 percent oxygen, 20 percent carbon dioxide, and 60 percent nitrogen
  - (b) 80 percent nitrogen, 20 percent oxygen
  - (c) 95 percent carbon dioxide
  - (d) mostly hydrogen and helium
  - (e) water, carbon dioxide, organic compounds, and dust
19. Which of the following best describes the composition of Mars' atmosphere?
- (a) 20 percent oxygen, 20 percent carbon dioxide, and 60 percent nitrogen
  - (b) 80 percent nitrogen, 20 percent oxygen
  - (c) 95 percent carbon dioxide
  - (d) mostly hydrogen and helium
  - (e) water, carbon dioxide, organic compounds, and dust
20. Which of the following best describes the composition of Earth's atmosphere?
- (a) 20 percent oxygen, 20 percent carbon dioxide, and 60 percent nitrogen
  - (b) 80 percent nitrogen, 20 percent oxygen
  - (c) 95 percent carbon dioxide
  - (d) mostly hydrogen and helium
  - (e) water, carbon dioxide, organic compounds, and dust

21. Which of the following best explains why nuclear fusion requires nuclei to be brought extremely close together?
- (a) Nuclei have to be very hot in order to fuse, and the only way to get them hot is to bring them close together.
  - (b) Nuclei are attracted to each other by the electromagnetic force, but this force is only strong enough to make nuclei stick when they are very close together.
  - (c) Nuclei can only get very close together when they are raised to a very high temperature and begin to melt and stick.
  - (d) Nuclei normally repel because they are all positively charged and can be made to stick only when brought close enough for the strong force to take hold.
  - (e) Fusion can proceed only by the proton-proton chain, and therefore requires that protons come close enough together to be linked up into a chain.
22. An evil genius corners you in a dark alley, pointing her Neutrino Blaster at you and demanding the contents of your pockets. If you don't act fast, she says, she'll fire the Neutrino Blaster and you'll be hit with quadrillions of neutrinos moving at 90% of the speed of light. What should you do and why?
- (a) Take your time. Neutrinos actually travel much, much slower than she claimed.
  - (b) Laugh at her. Neutrinos have been proven not to exist.
  - (c) Grab a trash can lid. You can use it to block the neutrinos.
  - (d) Ignore her. The neutrinos will pass right through you.
  - (e) Duck! You're about to be vaporized!
23. When was the light currently reaching Earth from the Sun released **from the Sun's core**?
- (a) 8 minutes ago
  - (b) 11 years ago
  - (c) several hundred years ago
  - (d) a few thousand years ago
  - (e) hundreds of thousands of years ago
24. As the Sun converts hydrogen into helium, the Sun:
- (a) loses mass
  - (b) gets dimmer and dimmer as it runs out of fuel
  - (c) produces more gravity
  - (d) uses up its supply of carbon, nitrogen, and oxygen
  - (e) gains mass, because helium atoms are heavier than hydrogen atoms

25. If the Sun's core suddenly shrank a little bit, what would happen inside the Sun?
- (a) The density of the core would decrease, causing the core to cool down and expand.
  - (b) The core would heat up, causing it to release so much energy that it would shrink even more.
  - (c) The core would heat up, fusion rates would increase, the core would expand.
  - (d) The core would cool down and continue to shrink as its density increased.
  - (e) The core would become more dense, which would "quench" fusion reactions and cause the Sun to cool down.
26. If we set a new icy moon with a diameter of 20 km orbiting in some dense outer part of the rings of Saturn, what would happen?
- (a) The moon would be rapidly destroyed, breaking apart into particles which would become part of the rings.
  - (b) Nothing much would happen. Lots of moons already orbit within the rings of Saturn.
  - (c) The moon would collide with ring particles and grow rapidly in size, forming something like a planetesimal.
  - (d) The moon would open a gap in the rings by repelling ring particles both interior and exterior to its orbit.
  - (e) The moon's gravity would pull material toward it and make that part of the rings even denser.
27. One AU is closest to:
- (a) the distance between the Earth and the Moon
  - (b) the diameter of the solar system
  - (c) half of a light year
  - (d) the distance around Earth's equator
  - (e) the distance between Mars and Jupiter
28. The highest of the high tides occurs when the phase of the Moon is:
- (a) first quarter
  - (b) waxing gibbous
  - (c) crescent
  - (d) third quarter
  - (e) new
29. If the Sun appears in the center of the constellation of Aries at noon on April 21, where will it appear on August 25 of the same year?
- (a) four constellations to the west, in Sagittarius
  - (b) one constellation to the west, in Pisces
  - (c) still in Aries
  - (d) one constellation to the east, in Taurus
  - (e) four constellations to the east, in Leo

30. If the Sun appears in the center of the constellation of Aries at noon on April 21, where will it appear at 4:00 p.m. later that same day?
- (a) four constellations to the west, in Sagittarius
  - (b) one constellation to the west, in Pisces
  - (c) still in Aries
  - (d) one constellation to the east, in Taurus
  - (e) four constellations to the east, in Leo
31. All Jovian planets have:
- (a) liquid metallic hydrogen interiors
  - (b) moons the size of Mercury or larger
  - (c) retrograde orbits around the Sun
  - (d) rings
  - (e) helium rain
32. What do the Kuiper belt and the main asteroid belt have in common?
- (a) Both consist of material left over from the formation of the solar system.
  - (b) Both orbit the Sun beyond the orbit of Neptune.
  - (c) Both contain many dwarf planets.
  - (d) Both consist mainly of very small ice particles, each a few centimeters in diameter.
  - (e) Both are very dense and difficult for space probes to cross.
33. The Doppler method for locating exoplanets has a strong bias in favour of finding:
- (a) Jupiter-sized planets orbiting within 1 AU from their parent stars
  - (b) Neptune-sized planets orbiting at about 5 AU from their parent stars
  - (c) Earth-sized planets orbiting at about 1 AU from their parent stars
  - (d) Jupiter-sized planets orbiting at about 5 AU from their parent stars
  - (e) Mars-sized planets orbiting within 0.5 AU from their parent stars
34. The number of confirmed habitable exoplanets discovered to date is:
- (a) zero
  - (b) about 10
  - (c) about 100
  - (d) about 1,000
  - (e) about 1,000,000

35. Which of the following statements about the solar wind is **FALSE**?
- (a) It consists of a stream of charged particles flowing outward from the Sun in all directions.
  - (b) It shapes the ion tails of comets.
  - (c) It can strip away the atmospheres of planets slowly over time.
  - (d) It consists mainly of energetic particles ejected from nuclear reactions in the Sun's core.
  - (e) It is responsible for creating planetary auroras.
36. Earth's moon was probably formed by:
- (a) Direct capture of the Moon by the Earth's gravity.
  - (b) A catastrophic collision of the early Earth with a planet-sized object.
  - (c) Fission of a spinning body condensing from the early protosolar nebula.
  - (d) Accretion of comets onto a small captured asteroid.
  - (e) Fission of the young Earth, which split because it was spinning so quickly.
37. Which types of light does the Earth's atmosphere mainly screen out?
- (a) x-rays, radio waves, and gamma rays
  - (b) x-rays, gamma rays, and ultraviolet light
  - (c) gamma rays, ultraviolet light, and visible light
  - (d) radio waves, x-rays, and ultraviolet light
  - (e) ultraviolet light, microwaves, and radio waves
38. Why do astronomers believe that the surface of Venus is relatively young?
- (a) It is still very hot, due to the heat of accretion.
  - (b) It hasn't lost its thick atmosphere yet.
  - (c) It has relatively few craters.
  - (d) Radioactive dating of rocks from Venus shows them to be very young.
  - (e) Astronauts who have been there say that it looks a lot like the youngest parts of Earth.
39. Which main source of heat keeps the interiors of the terrestrial planets warm today?
- (a) accretion
  - (b) differentiation
  - (c) radiation
  - (d) radioactivity
  - (e) convection
40. When astronomers look for potentially habitable worlds, they mainly look for signs of:
- (a) Rocky planets which could have liquid water on their surfaces.
  - (b) Oxygen in a planet's atmosphere.
  - (c) Sufficient greenhouse gases to keep a planet warm.
  - (d) Signs of fusion reactions in the planet's parent star.
  - (e) Ultraviolet light from plants.

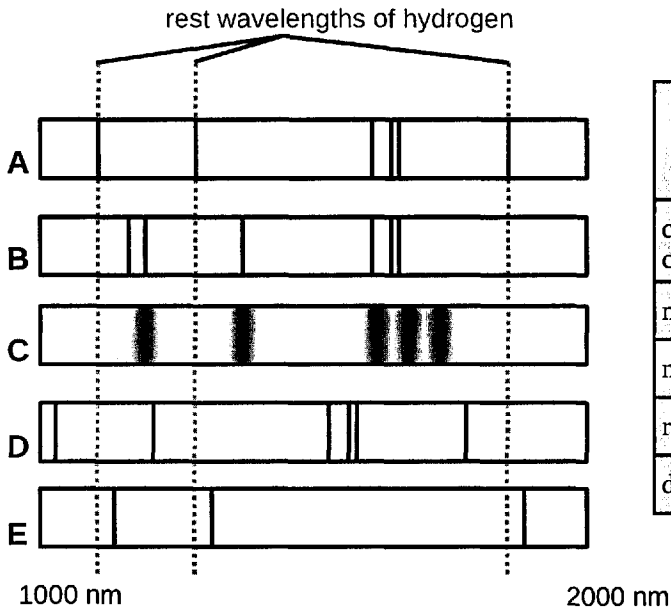
41. In which one of the following scenarios would we see a continuous spectrum with some extra bright bands?
- (a) A warm planetary surface is viewed through the hot upper layers of its atmosphere.
  - (b) The surface of a cold planet with no atmosphere is observed directly.
  - (c) A cool nebula of pure gas is observed through a hot nebula of pure gas.
  - (d) A hot nebula is observed directly.
  - (e) A hot nebula of pure gas is observed through a cool nebula of pure gas.
42. If we observe an average star 10 light years away, which of the following factors will **most strongly** determine the colour of the star?
- (a) The star's chemical composition.
  - (b) The star's age.
  - (c) The star's surface temperature.
  - (d) The star's motion toward or away from us.
  - (e) The star's distance from us.
43. Why are Jovian planets made mostly of light elements, while terrestrial planets are made mostly of heavy elements?
- (a) Because Jovian planets formed first, before the Sun used up all of the light elements.
  - (b) Because Jovian planets formed outside the frost line.
  - (c) Because Jovian planets have accreted a lot of comets, which contain large amounts of volatile chemicals, which are mainly made of light elements.
  - (d) Because Jovian planets are much younger than terrestrial planets and haven't yet had their atmospheres removed by the solar wind.
  - (e) Because Jovian planets are much warmer than terrestrial planets, so their lighter elements boil up to their surfaces, making them appear to be made mainly of these elements.
44. Fermi's paradox states that, even if extraterrestrial life is fairly rare:
- (a) it doesn't matter because the Galaxy is infinitely large, so there must be life somewhere within it.
  - (b) intelligent life ought to have evolved long before us and should have colonized the Galaxy already.
  - (c) intelligent species would be too smart to talk to a backward species like ours.
  - (d) intelligent aliens have obviously already visited Earth.
  - (e) Captain Kirk would probably find a way to insult it, kill it, or reproduce with it.
45. Direct imaging of exoplanets is very difficult because:
- (a) exoplanets are very dim compared to the stars they orbit.
  - (b) exoplanets tend to be very bright, which makes them dangerous to point telescopes at.
  - (c) we can only see exoplanets by building telescopes in space, which is very expensive.
  - (d) exoplanets are too small for the magnification of our telescopes to be able to pick them up.
  - (e) exoplanets move quickly, making them difficult to catch with a telescope.

46. The next peak in the Sun's cycle of activity is likely to occur in late 2012 or early 2013. This is likely to result in:
- (a) longer summers in the southern hemisphere
  - (b) winters which are a few weeks shorter
  - (c) the extinction of most species of life on Earth
  - (d) more and brighter auroras on Earth
  - (e) more earthquakes
47. Sensitive observatories to detect neutrinos from the Sun must be built:
- (a) underground, where they are shielded from cosmic rays
  - (b) in space, where they can pick up the most neutrinos
  - (c) on the surface of the Earth, where they can be built large enough to detect a sufficient number of neutrinos to study
  - (d) in refrigeration chambers, so that they do not detect the neutrinos produced by the machines themselves
  - (e) at one of Earth's poles, where they can observe in complete darkness for months at a time
48. Which of the following statements does **NOT** follow from Kepler's laws?
- (a) The Earth should move fastest in its orbit when it is closest to the Sun.
  - (b) Two isolated stars of equal masses bound to each other by their mutual gravity will orbit a point in space between them in elliptical orbits.
  - (c) As Earth orbits the Sun, the area of the triangle it sweeps out in September should be the same as the area it sweeps out in April.
  - (d) Two particles orbiting Saturn in two adjacent rings should orbit at nearly the same speed.
  - (e) Comets in highly elliptical orbits take longer to orbit the Sun than those in circular orbits.
49. If Jupiter's rotation period were to increase to about twice its present value over a period of a few days, what would happen?
- (a) The banded structure of its atmosphere would become less complex.
  - (b) Some of its moons would escape Jupiter's gravity.
  - (c) Its rings would dissipate.
  - (d) Io's volcanoes would shut off.
  - (e) Jupiter would move outward, away from the Sun.
50. Compared to the Earth, the Sun is:
- (a) About ten times older
  - (b) About five times older
  - (c) About two times older
  - (d) About the same age
  - (e) About half as old

**PART B: Short answer questions. Answer ALL of the following questions in the spaces provided. Point form is acceptable where appropriate. Marks may be deducted for lack of clarity or concision.**

1. Spectroscopy.

(a) [5 marks] The following diagram shows emission spectra between 1000 nm and 2000 nm of several clouds of gas. The vertical dashed lines show the **rest wavelengths** of hydrogen in this part of the electromagnetic spectrum. Each spectrum is labelled with a letter. Fill in the table below with the letter of the spectrum (or spectra) which match each description. You can use letters more than once, if needed.

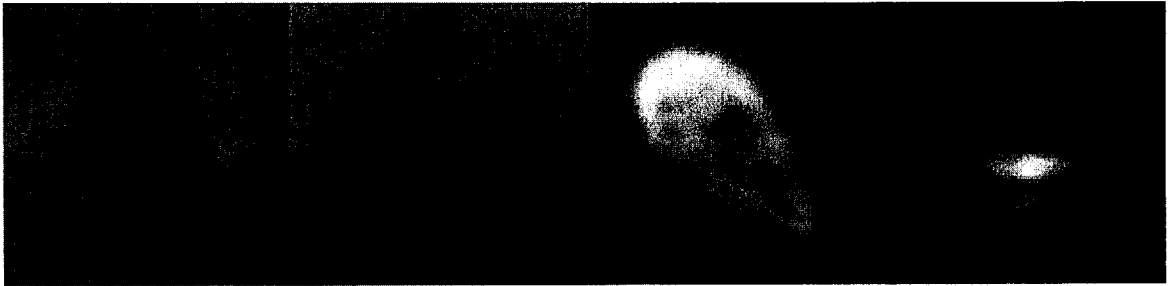


| Description   | Letter(s) of corresponding spectrum/spectra |
|---|---|
| clouds with <b>exactly</b> the same chemical composition as one another |   |
| moving toward us  |   |
| moving away from us   |   |
| rotating more quickly than the others                                   |   |
| does not obviously fit any other pattern                                |   |

(b) [1 mark] What do we mean when we say that electron energy levels are “quantized”?

(c) [1 mark] How does the quantization of electron energy levels help us determine the chemical composition of stars?

2. Examine the images below. Similar images were shown in class in colour. All four images show the **same type of object**, but they each show different examples of this type of object, photographed from different perspectives and against different backgrounds. In all of the images, dark areas represent less light received and lighter areas represent more light received.



- (a) [1 mark] Name the type of object shown in these images.

\_\_\_\_\_

- (b) [2 marks] These objects were all photographed using light from the same part of the electromagnetic spectrum. **Which part** of the electromagnetic spectrum do you think this was and **why do you think so?**

- (c) [1 mark] How will these objects have changed 500 million years after these images were taken?

3. Orbits.

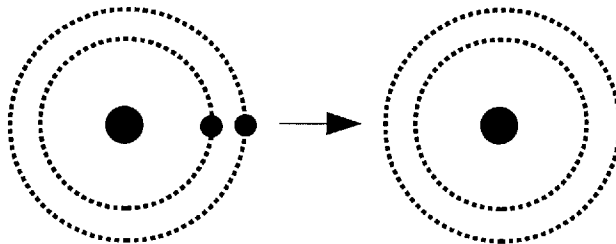
(a) [1 mark] The moons Amalthea and Mimas both orbit their parent planets at distances (measured from the centers of the planets) of about 180,000 km. Yet Amalthea takes about 0.5 days to orbit Jupiter while Mimas takes about 0.94 days to orbit Saturn. Why do these two moons have such different orbital periods?

(b) [1 mark] Since Jupiter and Saturn differ only slightly in their size (radius), what else can you deduce about Jupiter and Saturn from the information given in part (a)?

(c) [1 mark] How would the orbital period of Mimas change if it were to orbit the planet Neptune at the same distance at which it currently orbits Saturn?

4. Resonances.

(a) [1 mark] The diagram on the left below shows a pair of moons which are in a 2:3 resonance. On the diagram on the right, draw the positions of the same two moons after the **outer** one has completed 0.5 orbits since the time of the first diagram.



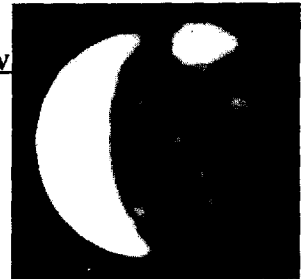
(b) [2 marks] Resonances occur when two objects move in such a way that the periods of their motion are whole number multiples of one another. Describe the main resonance in the Earth-Moon system, being careful to state which two periods of motion define the resonance.

(c) [1 mark] What consequence does the resonance you described in part (b) have for the appearance of the Moon in our sky?

5. Geological activity.

(a) [2 marks] Explain why Mars is less geologically active than the Earth.

(b) [2 marks] The image to the right shows Io as seen in the **infrared**. **What** are the spots on the night side of Io seen in this image and **how** do you know?



(c) [1 mark] Where does Io get the energy to produce the features shown in the image from part (b)?

- (d) [2 marks] Io and the other large moons of Jupiter have a special relationship to one another which helps ensure that the interior of Io stays warm. What is this relationship and how does it help keep Io's interior warm?

6. Exoplanets.

- (a) [4 marks] Draw a **CLEARLY LABELED** diagram illustrating a method of exoplanet detection. You may choose **EITHER** the transit method or the radial velocity method. Indicate your choice clearly by circling the appropriate term below.

**CIRCLE ONE:**

**radial velocity method**

**transit method**

- (b) [1 mark] Which method of finding exoplanets is likely to be the most successful at finding Earth-mass planets?

**THE END**