SOLAR SYSTEM

ANNOTATED EXAMPLE EXAM

B DIVISION 2017-2018

TEAM NUMBER:_____

TEAM NAME:_____

STUDENT NAMES:_____

_____

Do not open the test packet until instructed by the event supervisor. Ensure that you have all 6 pages of the test, 3 image sheets, and 2 answer sheets. You are encouraged to use the backs of the test sheets as scratch paper. Only answers recorded on the answer sheet will be graded. All questions are of equal value. Good luck!

The cover sheet of the exam should tell the students how many of each sheet in the test they should have (how many answer sheets, image sheets, etc.). Students should be encouraged to check that they have all test pages before beginning the test. Students should also be made aware of any differences in point value for different questions or sections of the test in case they wish to allocate their time proportionately. If students must submit an answer sheet to be graded, they should be made aware of this before beginning the test.

Advice to Event Supervisors and Coaches

The Solar System Event entered the rotation of astronomy-focused National Science Olympiad B Division events in 2006, and had been a test of general solar system knowledge until 2014, when the event rules were revised in the 2013-2014 and 2014-2015 seasons to focus on the search for extraterrestrial water and the study of habitability in and beyond our own solar system. The Solar System event focus for the 2017-2018 season is the geologic characteristics and evolution of the Earth's Moon and other rocky bodies of the solar system.The event rules currently concentrate on specific "rocky" or geologic solar system bodies, as well as their evolutionary histories, and the physics, geology, and remote sensing concepts that help scientists observe and understand these objects. Writing a Solar System test for Science Olympiad Invitationals, Regional competitions, and State competitions requires thorough understand of the event subject matter and the relevance and validity of available information to the students, as well as a strong grasp of the testing level of the students and the length and structure appropriate for the exam.

The Solar System objects and phenomena students will be tested on are outlined in this year's official Science Olympiad Rules. These rules should be available from the competition director for which you are writing and/or proctoring a Solar System test. Note changes made from past years' Solar System event rules, especially the omission of focus on water and habitability in the solar system (the 2014 focus); Although some objects included in the rules were also included in 2013-2014 and 2014-2015, the focus of this year's rules is on the geology of those objects. Not all questions on a given test must pertain to any one concept in the rules, but all should be relevant to the objects and topics outlined in "Part I" and "Part II" of the rules. It is important that tests contain both knowledge-based questions and questions that require interpretive understanding and analysis of hypothetical systems. Solar System tests should never be based on "random" trivia, and while detailed quantitative and qualitative information about the objects from the rules is important for a thorough understanding of object geology and evolution, the point of the event is not to test students on "random" or obscure information about the objects. As this event focuses on emergent data in a relatively new field of science, recent information (for example, the total solar eclipse on August 21st, 2017 visible from many parts of the US) may be pertinent to the event rules. Aim always to draw material from established and substantiated announcements and discoveries.

There are many reputable and extensive resources from which information can be drawn (see annotated event resources document) for writing test questions. It is important to use recent information as the field of extraterrestrial geology is one of active research and discovery. Questions should be clear and of appropriate level for Invitational, Regional, or State level Competitions and teams. The difficulty of invitational level tests may also depend on how late the invitational is in the competition season. To write a thorough test, one should usually begin writing the test at least one month prior to the competition at which the test will be distributed,

allowing several days prior to competition for printing and correlation of all tests, image files, answer sheets, and answer keys. Every test should include some questions that every team should be able to answer even after only cursory review of the rules, as well as some questions that demonstrate both extensive research and conceptual understanding of the event material on the part of the competitors and the test author. Reference the tests from previous years and note the length, format, and difficulty range of questions on the tests and when in the season the tests were given. Keep in mind the available space on the resource sheets the students may bring in with them and the kind of questions that are direct numerical or identification questions versus those that require deeper connections that students must make on the spot based on in depth understanding of the Solar System processes outlined in the rules. This year's rules allow the use of calculators to solve questions, so numerical questions may include real data as opposed to "clean" numbers.

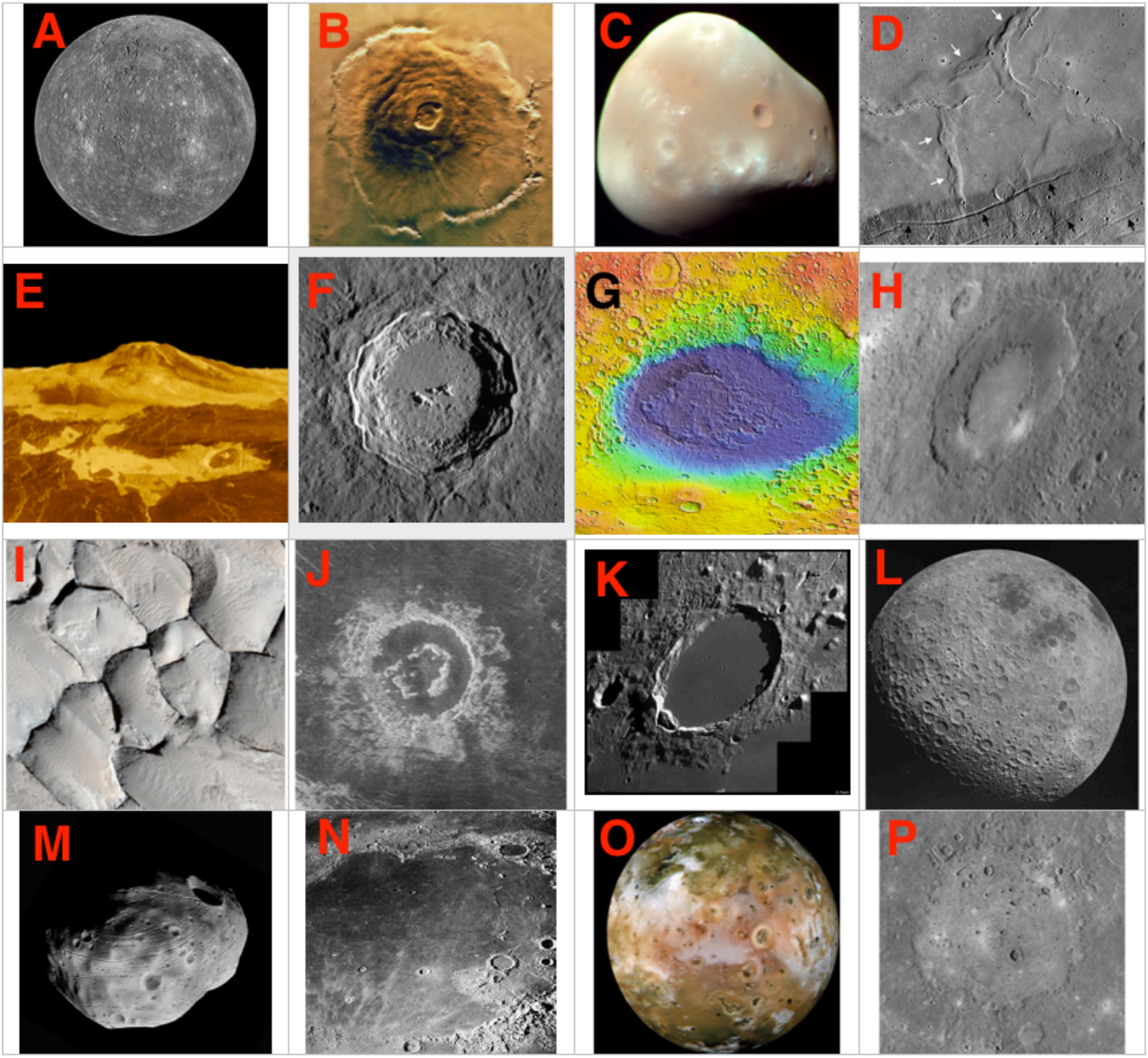
The format and length of the tests is generally at the discretion of the test author, though generally the author must consider the number and experience of teams at the competition as well as the amount of time available to score and rank the tests before the awards ceremony. Will students be taking the test at the beginning, throughout, or at the end of the day? How many teams, and in how many testing blocks, will be taking the test? Will there be volunteers available to distribute and assist in grading tests? If the grading process will be assisted by volunteers, the grading process may be hastened in several ways. Tests should be accompanied by an answer sheet and an answer key of the same format for those grading the tests, and the majority of the test should be in a very short answer or matching format, such that graders have no question as to whether the answer is right or wrong. Occasionally, there may be more than one question on a test with multiple correct answers, or a range of acceptable answers, such as a question about temperature on an object. Sometimes, it may assist both students and graders to include on the answer sheet the intended units for the answer to a question, so students do not have to ask which units to use and graders know immediately if the response is correct or not.

It is often desirable for both the test author and the competitors for Solar System tests to be formatted such that the images referenced in the test are separate from the questions, usually in the form of a powerpoint presentation or image sheets attached to each test. This is how most State and National Solar System tests are formatted. Make sure images are properly labelled to correspond with the questions in which they are referenced, and when distributed or publishing the tests post-competition that all image files for the test are included. Questions style vary, although image analysis and identification questions are part of most Solar System tests. Matching, multiple choice, fill in the blank, and naming questions are usually the easiest to grade and for students to answer, although no test should consist entirely of these kinds of questions. Typically, tests should include some short answer or explanation questions worth multiple points that the author of the test

should grade him or herself. Note that the same person should grade questions of this type on every test, and that if partial points will be awarded for the answer, that the specific elements of the answer worth different amounts of points are allotted prior to grading. A long, well written answer is not necessarily more correct or complete than a more concise one.

Authors of Science Olympiad tests also have many options for distributing the tests. Most test proctors choose not to distribute the raw scores on their tests from competitions or return the graded tests to the competitors. However, most teams receive a blank copy of the test and an answer key, either physically or digitally, after invitational competitions. Some proctors choose to publish these tests and keys on the online test exchange of SciOly.org (see Resources & Websites). Generally, tests from Regional and State Competitions are not released due to potential debate over team ranking and corrector acceptable answers.

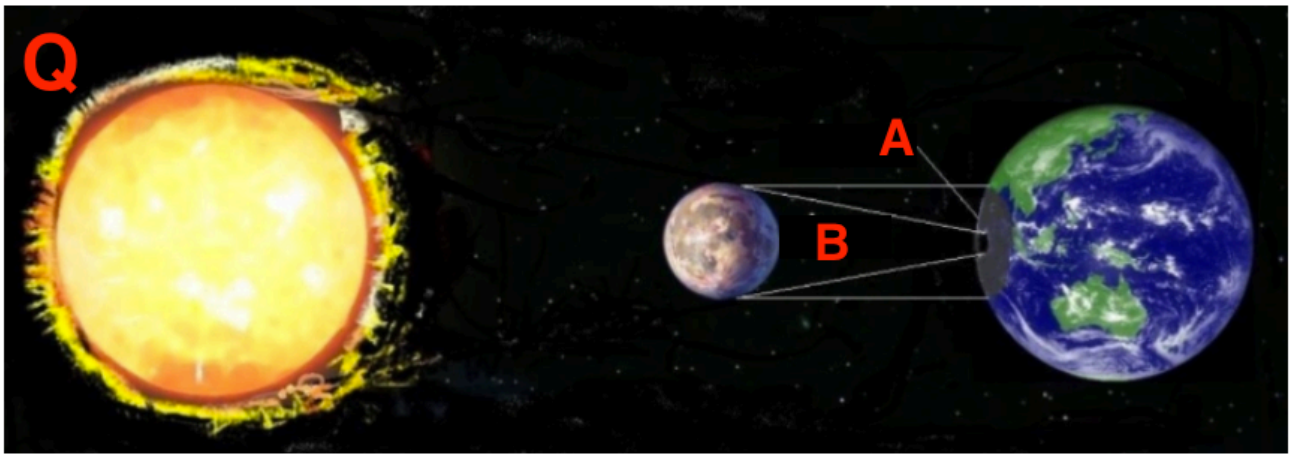
IMAGE SHEET A

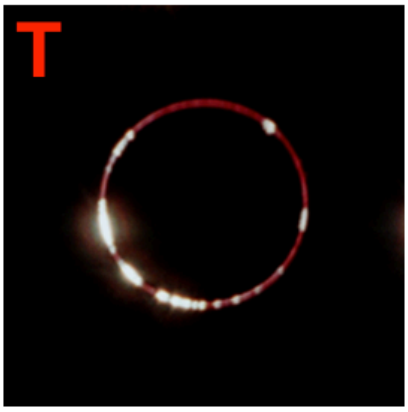


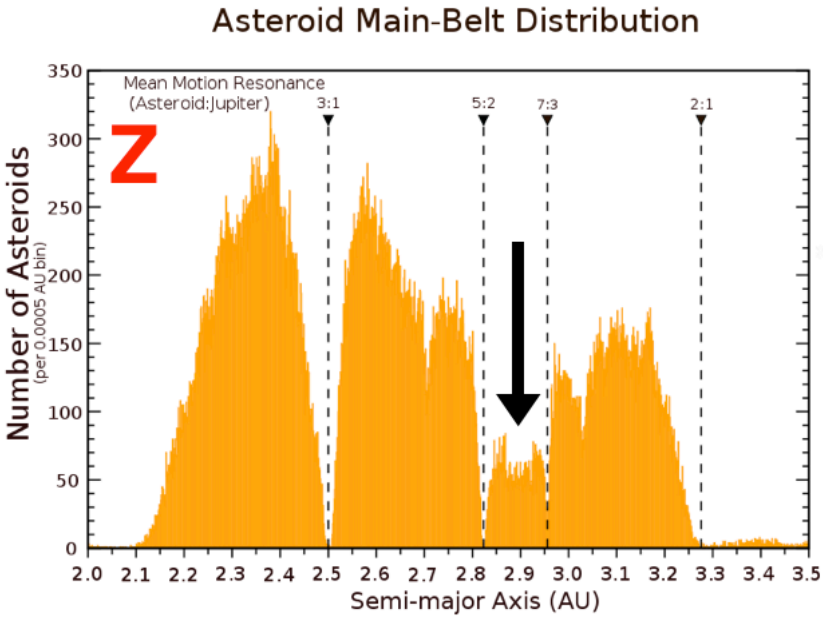
It is best to label image sheets if there are more than one, so that students save time looking for images referenced in the questions. This can aid in sorting the images by question type i.e. images of surface features on one page and images of missions and spectral features on another page. Tests should be long because they have many or more difficult questions, not because test formatting makes answering questions tedious.

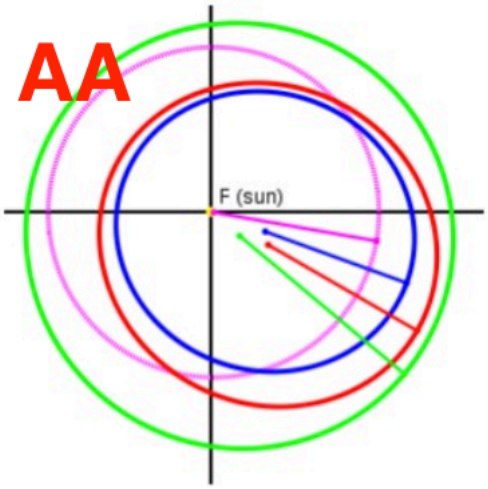
When creating image sheets for a test, it is usually easier to prepare sets of images, along with any labels or lettering/numbering, in a separate document and then screenshot or export the set of images for use in your test, to avoid formatting problems. Keep in mind when preparing image sheets that the images most easily accessible to you (usually from the internet) are also those most accessible to students preparing for the event. The object of image identification is to test both understanding and preparation; Test authors are discouraged from including too many obscure images that only reward rote memorization rather than holistic preparation.

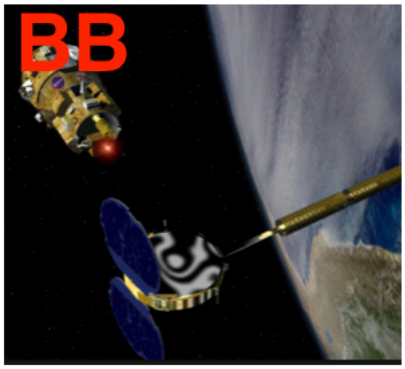
IMAGE SHEET B

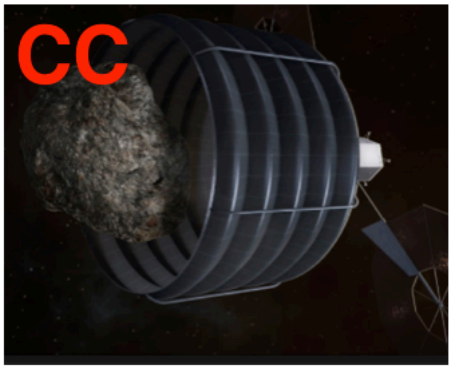












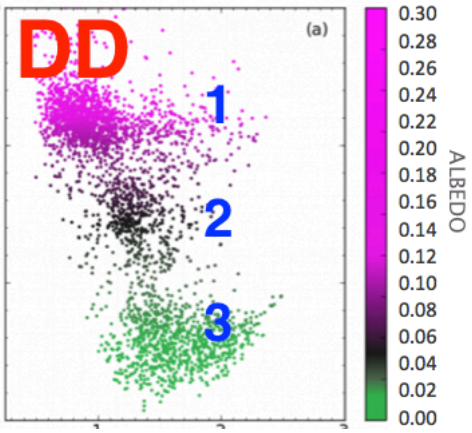
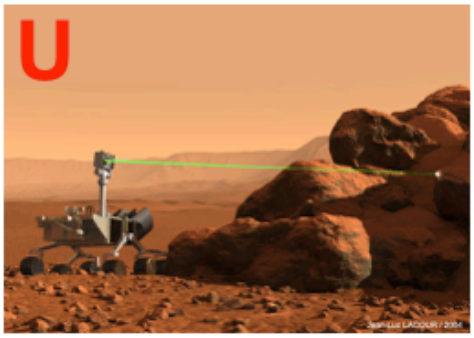


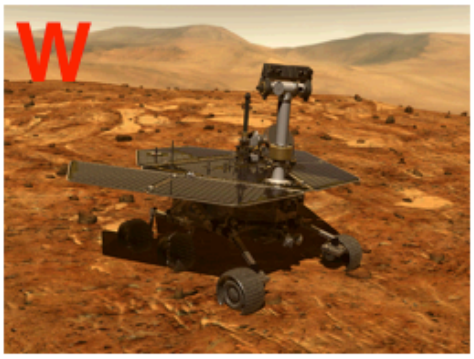
IMAGE SHEET C

U

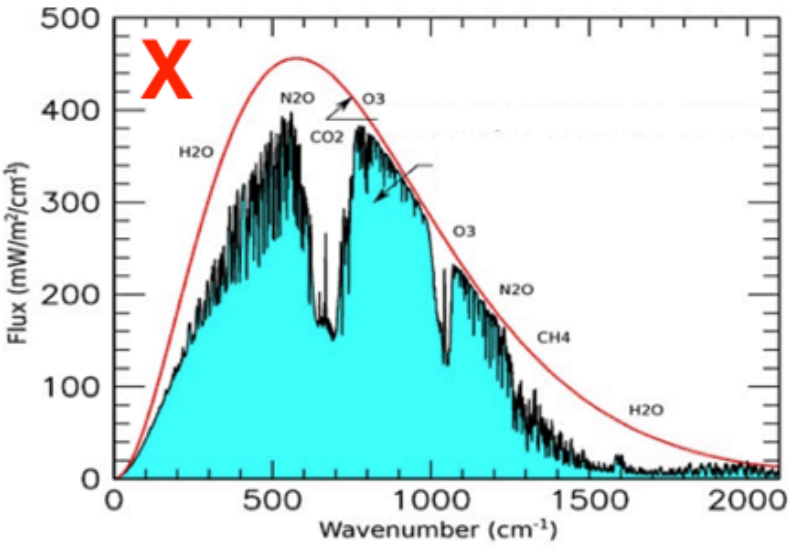


V

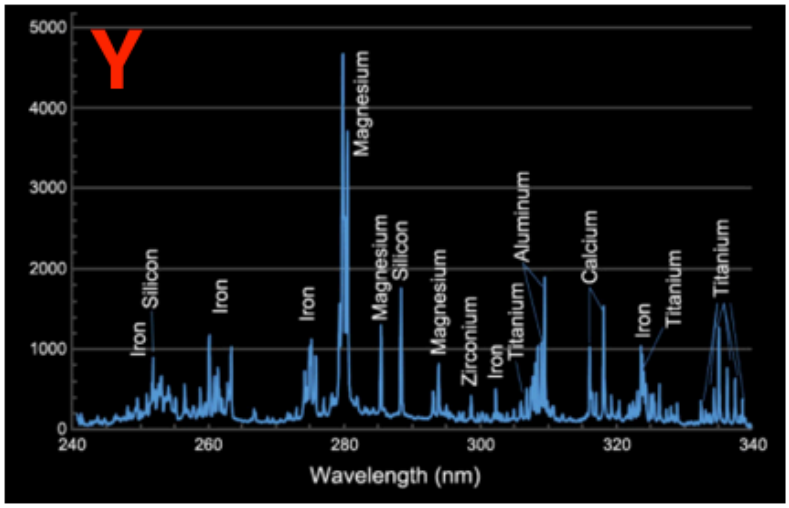
W



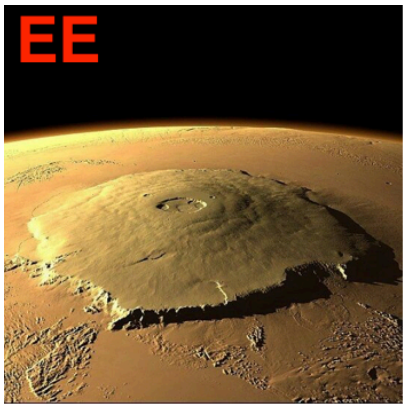
X



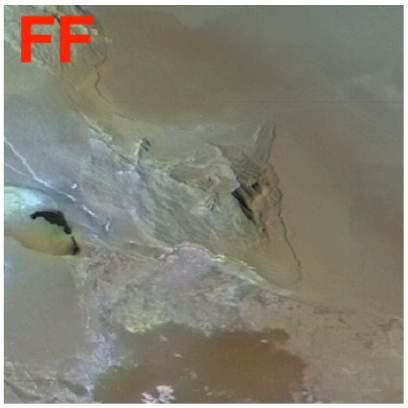
Y



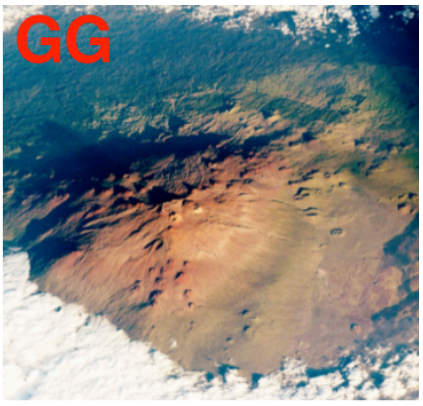
EE



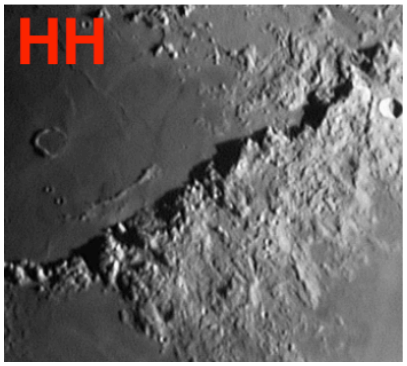
FF



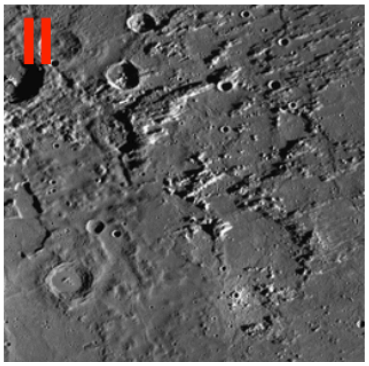
GG



HH



II



JJ

SECTION A

Questions 1-34 in Section A refer to Image Sheet A.

1. Which image shows one full hemisphere of the planet closest to the Sun?
2. Which image shows this planet's largest crater?
3. What is the name of the crater indicated in Question #2?

4. Which image shows Phobos?
5. Phobos has one large crater, named for the wife of the astronomer who discovered Phobos. What is the name of this crater?
6. What is the name of Mars's other moon?
7. Does Phobos orbit closer to Mars or further from Mars than Mars's other moon?
8. Scientists have long believed that Mars's moons are gravitationally captured asteroids, but recent evidence suggests that they may be another type of solar system object that originated beyond the Asteroid Belt. What kind of objects may Mars's moons be?

9. Which images show the object closest to Earth?
10. Which image shows the object furthest from Earth?
11. Who discovered the object indicated in Question #10?

12. Which image shows a crater on the surface of Venus?
13. What kind of imaging was used to generate the image indicated in Question #12?
14. What mission generated the image indicated in Question #12?
15. Venus has a thin crust compared to Earth and an extremely active tectonic cycle, resulting in relatively rapid surface recycling. What is the name for the highly deformed oldest regions of Venus's crust?

16. Which image shows the lunar crater Plato?
17. Plato's basin is relatively flat compared to other lunar craters, with very few secondary craters within it. Does this indicate that it is relatively old or young?
18. What lunar feature is shown in image D?
19. What is the name for the large plains on the moon (shown in image N) that are darker and smoother than their surrounding terrain?
20. What kind of rock is present in the plains indicated in Question #19?
21. What was the first mission to return lunar samples to Earth?
22. During what period of solar system evolution did most lunar cratering occur?
23. How long ago did this extensive period of cratering indicated in Question #22 take place?

24. Which planet is nicknamed "The Red Planet"?
25. The presence of what element in the surface material of this planet is responsible for its red color?
26. Which image shows this planet's largest crater?
27. What is the name for this crater?

28. On which planet is the crater in image H found?
29. Craters on this planet are named after famous individuals who held what profession?

30. The majority of observations of this planet were performed by which mission, which orbited this planet from 2011 to 2015?

31. Which lunar crater is shown on the cover of this test?
32. How many years after the formation of the Earth was the moon formed?
33. What is the name for the leading formation hypothesis of the moon? In this scenario, a large protoplanet collided with the Earth early in its history and broke off a large amount of material that then fell into orbit around Earth and coalesced into the Moon.
34. What is the name for the large protoplanet included in the above theory?

Section A of this test is an example of common style of B Division astronomy event exams. Some questions are very easy, and some are very difficult - either because they require critical thinking and understanding about the concepts in the rules, or because they require more complete preparation and knowledge of the objects. Many of the questions require image recognition and secondary questions build off correct identification of an image, but not all.

Relevant information about past, current, and future missions is often the most challenging for both students and proctors to distinguish from irrelevant information, as there is no clear line that dictates which missions or which instruments comprising those missions are directly relevant to studies of geology in the solar system as outlined in the rules. Be careful with questions about timelines for progress of future missions because timescales for these missions tend to change frequently. When used on a test, answers should reflect the most recent official statement made on the date of launch.

SECTION B

Questions 35-48 reference in Section B refer to Image Sheet B.

35. What kind of eclipse is shown in Image Q?
36. What part of the moon's shadow is indicated by the letter A in Image Q?
37. What part of the moon's shadow is indicated by the letter B in Image Q?
38. On what date was the last eclipse of this kind?
39. What step in this eclipse is shown in Image T?
40. What feature of the Sun and/or Moon is responsible for the irregular brightness shown in Image T?
41. What kind of eclipse is shown in Image S?

42. What kind of tides would be experienced during an eclipse such as shown in Image Q?
43. The moon orbits such that the same side is always facing Earth. What is the name for the gravitational phenomenon that causes this?
44. Over time, greater than 50% of the Moon's surface is actually visible from Earth as it wobbles in its orbit. To the nearest percent, how much of the Moon's surface can be seen from Earth?
45. What specific type of libration is caused by the inclination between the Moon's orbital plan and its rotational axis? This effect is the same that causes season's for Earth in its orbit around the Sun.

46. What phase of the Moon is shown in Image R?
47. If this moon is observed from the Northern Hemisphere (right-side-up), how many hours before or after midnight does it reach its highest position in the night sky?
48. If a new moon occurred on January 1st, on what day could a Northern Hemisphere observer see the moon in Image R?

Consider the following solar system objects:

A. Io
B. Mercury
C. Venus
D. Mars
E. The Moon

49. Rank the five objects (A-F) from highest to lowest surface atmospheric pressure.
50. Which of the five objects (A-F) have measurable intrinsic magnetic fields?
51. Which of the five objects (A-F) are satellites of solar system planets?
52. Successful surface landing missions have studied which of the five objects (A-F)?

Section B of this exam differs from Section A primarily in that it tests concepts related more closely to Part II of the event rules than Part I. It is not necessary to separate the concepts in these two sections, as some concepts lend themselves more readily to applications to the objects outlined in Part I (as seen in Section A and in the next section, Section C.

It is not necessary to split the test into "Sections" but it is a good idea to employ some organizational structure spanning the pages of the test in case students elect to split the test apart.

SECTION C

Questions 53-65 in Section C refer to Image Sheet C.

53. Which Mars exploration mission is shown in Image U?
54. What is the name of the specific instrument shown at work in Image U?
55. Which Mars exploration mission is shown in Image V?
56. Which Mars exploration mission is shown in Image W?
57. Does the spectrum in Image X or Image Y show the composition of Mars's atmosphere?
58. Which Image (U,V,W) shows the mission that generated the spectrum in Image X?
59. Which Image (U,V,W) shows the mission that generated the spectrum in Image Y?
60. A rover on Mars samples surface regolith and finds the concentration of Potassium-40 in this material is 120 ppm (parts per million). This rover drives into a crater on Mars and samples the regolith there, finding the concentration of Potassium-40 to be only 12 parts per million. If the half-life of Potassium-40 is 1.2 billion years, how long ago was this crater formed?

A	A line that connects a planet to the sun sweeps out equal areas in equal times.
B	All planets move in elliptical orbits, with the sun at one focus.
C	The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit.

61. Which of the above statements is known as Kepler's 1st law?
62. Which of the above statements is known as Kepler's 2nd law?
63. A planet orbits the sun with a semi major axis of 3 Astronomical Units. What is its orbital period, in years?
64. A planet orbiting the sun reaches perihelion at 4 Astronomical Units and aphelion at 7 Astronomical Units. What is the semi major axis of this planet's orbit, in Astronomical Units?
65. One Astronomical Unit is defined as the average distance between which two objects in the solar system?

SECTION D

Questions 66-81 in Section D refer to Image Sheet B.

66. Image Z shows the distribution of asteroids in distance from the Sun. The gravitational disturbance of which two planets causes the breaks seen in this distribution?
67. What is the name of these breaks?
68. Image DD shows a distribution of main-belt asteroids color-coded by albedo. What class of asteroids is indicated by the letter 1?
69. What class of asteroids is indicated by the letter 2?
70. What class of asteroids is indicated by the letter 3?
71. What number (1,2,3) indicates the class of asteroids orbiting closest to the Sun?
72. What number (1,2,3) indicates the class of the majority (75%) of asteroids in the asteroid belt?
73. Groups of asteroids with similar orbital elements are usually named for their largest member. What is the name of the relatively small family of asteroids orbiting between 2.8 and 3.0 Astronomical Units from the Sun? This family is indicated by the black arrow in Image Z.

Approximate orbital paths of several families of Near Earth Asteroids are shown in Image AA. The orbital path of the Earth is shown in pink.
74. Which family of Near Earth Asteroids is shown in green, with orbital paths that never intersect Earth's and perihelion distances greater than 1 AU?
75. Which family of Near Earth Asteroids is shown in red, with orbital paths that intersect Earth's with semimajor axes greater than 1 AU?
76. Which family of Near Earth Asteroids is shown in blue, with orbital paths that intersect Earth's with semimajor axes less than 1 AU?
77. Do the asteroids shown in blue or red take longer to orbit the Sun?
78. What is the name for the Near Earth Asteroid detection program run by the United States and Europe that scans specifically for objects that pose collision risk to the Earth?
79. The objects indicated in the previous question are considered to pose collision risk to Earth based on their size and the distance between their orbit and Earth's. What is the name for these objects?

NASA is in the design phases of its first Near Earth Asteroid deflection mission. The craft, which would be used to strike the asteroid at a speed 9 times greater than a bullet, would deliver enough impulse to change the asteroid's path and prevent it from colliding with Earth.
80. Which image shows this spacecraft?
81. What is the name for this method of Near Earth Asteroid redirection?

Some questions in Section D, as well as Section C, are math questions that require the use of the calculator. The mathematical components of the concepts being tested are reasonable for middle schoolers, and questions using these concepts that use "clean" numbers that do not require the use of a calculator could be written.

SECTION E

Questions 82-100 in Section D refer to Image Sheet C. Images EE-JJ show the highest peak on each of the objects of which the images were taken. Match the following 6 Images to the object in the solar system they show.

82. Image EE
83. Image FF
84. Image GG
85. Image HH
86. Image II
87. Image JJ

A. Mercury
B. Earth
C. Venus
D. Moon
E. Io
F. Mars

Match the following 6 Images to the name of the peak shown.

88. Image EE
89. Image FF
90. Image GG
91. Image HH
92. Image II
93. Image JJ

U. Maat Mons
V. Caloris Montes
W. Boösaule Montes
X. Mauna Kea
Y. Olympus Mons
Z. Mons Huygens

94. Which image (EE-JJ) shows an active volcano?
95. Which images (EE-JJ) show dormant volcanoes?
96. Which images (EE-JJ) do not show volcanoes?

Io is the most volcanically active object in the solar system. It has an especially strong magnetic field, which helps to drive its active magnetosphere and distribute volcanic ejecta.

97. Io's crust is recycled so frequently that it has a notable lack of what surface feature common to all the other geologic bodies in the solar system?
98. To the nearest 100, how many active volcanoes are present on Io?
99. What is the name of the donut-shaped cloud of gas magnetically trapped around Io by its interactions with Jupiter's magnetic field?
100. Allotropes (different physical forms of elements) of what element are responsible for the brightly colored regions of Io's surface?

With regards to Answer Sheets and Answer Keys (following pages):
It is typically a good idea to include space for team number and name on all answer sheets, in case tests become disorganized, and in case there is some confusion with team numbers. A key should usually be printed and recorded in the same format as the test answer sheets to speed the grading process and assist any volunteer graders who may be working with you grading tests. Efficiency is especially important when a large number of tests must be graded and ranked in time for the awards ceremony. Note that a different amount of space is allotted for different questions to assist students in keeping track of answers. It is important to provide answer spaces large enough for larger handwriting. It is **highly** recommended that a test author take his or her own tests several times throughout its development to check for inconsistencies in numbering, oddly phrased questions, and inconveniences like answer spaces that are not large enough for adequate answers to be comfortably provided.

SOLAR SYSTEM EXAMPLE EXAM 2017-2018 ANSWER KEY PAGE 1

Team #:_____Team Name:_____Score: 50/50

1	A	26	G
2	P	27	Hellas (Impact Basin)
3	Caloris (Planitia/Basin)	28	Mercury
4	M	29	artists/authors/composers
5	Stickney	30	MESSENGER
6	Deimos	31	Tycho
7	closer	32	20-100 million years
8	comets	33	Giant Impact Hypothesis (Big Splash)
9	D F K L N (any order)	34	Theia
10	O	35	Solar Eclipse
11	Galileo	36	penumbra
12	J	37	umbra
13	radar	38	August 21st, 2017
14	Magellan	39	Bailey's Beads
15	tessera	40	Lunar Craters
16	K	41	Lunar Eclipse
17	young	42	Spring Tides
18	wrinkle ridges	43	tidal locking
19	maria	44	59%
20	basalt	45	latitudinal libration
21	Apollo 11	46	third quarter
22	Late Heavy Bombardment	47	6 hours after midnight (6 AM)
23	3.8-4.1 billion years ago	48	January 20-22nd
24	Mars	49	C D A E B (correct order)
25	Iron	50	B E (any order)

SOLAR SYSTEM EXAMPLE EXAM 2017-2018 ANSWER KEY PAGE 2

Team #:_____Team Name:_____Score: 50/50

51	A E (any order)	76	Atens
52	C D E (any order)	77	red
53	Curiosity (Rover)	78	Spaceguard
54	ChemCam	79	PHO (Potentially Hazardous Objects)
55	MRO (Mars Reconnaissance Orbiter)	80	BB
56	Opportunity	81	Kinetic Impactor
57	X	82	F
58	V	83	E
59	U	84	B
60	4 billion years	85	D
61	B	86	A
62	A	87	C
63	5.0-5.3 years	88	Y
64	5-6 AU	89	W
65	Sun and Earth	90	X
66	Mars and Jupiter	91	Z
67	Kirkwood Gaps	92	V
68	S (Stony)	93	U
69	M (Metallic) or X (X-Group)	94	JJ
70	C (Carbonaceous)	95	EE, HH, GG (any order)
71	1	96	II, FF (any order)
72	3	97	craters
73	Koronis Family	98	400
74	Amors	99	plasma torus
75	Apollos	100	sulfur

SOLAR SYSTEM EXAMPLE EXAM 2017-2018 ANSWER SHEET PAGE 1

Team #:_____Team Name:_____Score:_____/50

1		26	
2		27	
3		28	
4		29	
5		30	
6		31	
7		32	
8		33	
9		34	
10		35	
11		36	
12		37	
13		38	
14		39	
15		40	
16		41	
17		42	
18		43	
19		44	
20		45	
21		46	
22		47	
23		48	
24		49	
25		50	

SOLAR SYSTEM EXAMPLE EXAM 2017-2018 ANSWER SHEET PAGE 2

Team #:_____Team Name:_____Score:_____/50

51		76	
52		77	
53		78	
54		79	
55		80	
56		81	
57		82	
58		83	
59		84	
60		85	
61		86	
62		87	
63		88	
64		89	
65		90	
66		91	
67		92	
68		93	
69		94	
70		95	
71		96	
72		97	
73		98	
74		99	
75		100	