Habitable Conditions Answer Key

1. Earth is about 4.5 billion years old. The first microfossil evidence of life on Earth dates to about 3.4 billion years ago. Scientists think that it takes millions of years for life to evolve. Which star type is least likely to have a planet on which life could have evolved?
   A-class star

2. Explain your answer.
   A-class stars are hotter than both G-class and M-class stars. Hotter stars burn their fuel more quickly, so they have shorter lifespans than cooler stars. If it takes a long time to evolve life, then the longer-lived stars would provide the greatest opportunity. In this case, the M-class star would be most likely to have a planet on which life could have evolved, and the G-class star would be next most likely. A-class stars would be the least likely of the three provided star types to have a planet on which life could have evolved.

3. Which star type is the hottest?
   A-type star

4. If a planet’s orbit is close to a star, what would happen to any water on the surface?
   The water would evaporate.

5. Explain your answer.
   If the planet orbits the star very closely, the planet's surface will be very hot. When it is hot, water evaporates.
   If the planet orbited far from the star (outside of the zone of liquid possibility), the water would be perpetually frozen. Liquid water is possible on the surface only when the planet orbits within the zone of liquid water possibility.
   Of course, this assumes that the star is not the coolest type of star, where the planet needs to be very close to the star to have liquid water.

6. How certain are you about your answer based on your explanation?
   Student answers will vary.

7. Explain what influenced your certainty rating.
   Student answers will vary. Scientific evidence includes statements about water's physical state at different temperatures. Students may be uncertain about the star type and the need to be close to the star to have liquid water, focusing on whether or not the planet is in the star's zone of liquid water possibility. Students may also be uncertain about the shape of the planet's orbit. If the orbit is elliptical, the planet can be close to the star at some points and farther from the star at others. Again, students may question whether the planet's entire orbit leaves it within the zone of liquid water possibility.
8. Why is the M-class star’s zone of liquid water possibility so close to the star?
   M-class stars are the coolest stars. The heat from the star is not great, so liquid water is possible only very close to the star.

9. Our Sun is a G-class star. The Earth orbits the Sun within the zone of liquid water possibility. A scientist finds an Earth-sized planet orbiting a K-class star at the same distance as the Earth orbits the Sun. Is it likely that the newly discovered planet has liquid water on its surface? no

10. Explain your answer.
   The K-class star is much cooler than the G-class star. The zone of liquid water possibility, which is shown by the blue halo in the model, is much closer to the K-class star than the G-class star (ending at 0.50 AU vs. ending at 1.25 AU). This means that a planet orbiting at an Earth distance (1 AU) from a K-class star will be outside of the habitable zone and therefore have frozen water on its surface.

11. How certain are you about your claim based on your explanation?
   Student answers will vary.

12. Explain what influenced your certainty rating.
   Student answers will vary. Scientific evidence includes specific information from the model about the extent of the zone of liquid water possibility around each star type. Students may be uncertain about the possibility of water beneath the surface of the planet. Depending on the internal heat of the planet, liquid water may exist beneath the surface.

13. Which star types are favorable to the development of life? Choose all that apply.
   - M-type star
   - K-type star
   - G-type star
   - F-type star

14. Which characteristics are favorable to habitability? Check all that apply.
   - rocky planet
   - medium planet (Earth-sized)
   - huge planet
   - an orbit entirely in the liquid water zone

15. Scientists find an Earth-sized planet orbiting an F-class star, slightly outside the zone in which liquid water can exist on the surface. Is it possible that this planet can support living things? Student answers will vary.

16. Explain your answer.
   The planet orbits slightly outside of the zone of liquid water possibility on the surface. This doesn't mean that there is no possibility for liquid water on the planet. The water can exist under the ice (if it's closer to the star than the liquid water zone) or under the ground (if it's farther from the star than the liquid water zone).
It's also possible that this planet has an elliptical orbit which takes it outside of the habitable zone for a short period of time. That would mean that liquid water could exist on the surface for a portion of its orbit. That would make it habitable (according to what we know about habitability) for a portion of the orbit. As on Earth, organisms could go into a dormant state during the periods when the water would freeze.

17. How certain are you about your claim based on your explanation?
   Student answers will vary.

18. Explain what influenced your certainty rating.
   Student answers will vary. Scientific evidence includes specific references to experiments with the model. Students may be uncertain about the bounds of the habitable zone, as defined by the model. If it is possible for life to exist under the surface (either ice or rock), then the habitable zone could be extended beyond where liquid water is possible on the surface (what is shown by the blue halo in the model). Students may also be uncertain about the shape of the planet's orbit. If the planet has an elliptical orbit, most of the time can be spent within the zone of liquid water possibility with only a short time outside of this habitable zone.

19. Which planet is most likely to have conditions that would be favorable to life?
   Planet B

20. Explain your answer.
   Two of the planets orbit completely within the zone of liquid water possibility: Planet A and Planet D.

   Planet A is a gaseous planet, which makes it unfavorable to life. Rocky planets are more favorable for life.

   Planet D is a rocky planet that orbits a blue star, which is least likely to have had life evolve since blue stars burn out so quickly. However, it is possible for life to have reached the planet from another source rather than having had to evolve there. That would make Planet D the best choice of Planets A and D.

   Planet B is a rocky planet that orbits a white star partly in the zone of liquid water possibility. The orbit goes outside the zone of liquid water possibility on the cold side. This would mean that the surface water periodically freezes. But it is within the zone of liquid water possibility enough during the rest of the orbit that the water should be able to melt. I think that some organisms that live in icy conditions (as those in the Arctic and Antarctic on Earth) could live on Planet B.

   Planet C is a rocky planet that orbits a yellow star partly in the zone of liquid water possibility. The orbit goes outside the zone of liquid water possibility on the hot side. This would mean that the water would gradually evaporate away as it went into the hot zone.
Planet B is the best choice, since it is a rocky planet (good for supporting life) orbiting a long-lived star (red, orange, yellow, or white). The water on the surface isn't always liquid throughout the orbit, but at least it is not being evaporated away as the planet leaves the zone of liquid water possibility.

21. How certain are you about your claim based on your explanation?
Student answers will vary.

22. Explain what influenced your certainty rating.
Student answers will vary. Scientific evidence includes specific reference to star type and planet type, and the relationship of these factors to habitability. Other scientific evidence includes specific reference to the planets' orbits and reasoning about what happens to liquid water on either side of the zone of liquid water possibility. Students may be uncertain about which factors are most important in determining habitability and favorability to life.