EXAMPLE TEST QUESTIONS

1. What is biblical chronology and what fallacy caused it to be discarded as a scientific method for determining ages? Name at least three scientific lines of evidence that finally killed the idea of a 6000-yr old Earth.

2. How do we define a distance of 1 parsec, and how do we use trigonometric parallax to determine distances to celestial objects?

3. What are *apparent* and *absolute* magnitudes? What physical quantity do they measure? Can two stars have the same apparent magnitude at different distances? If so, how?

4. Explain in detail the Hertzsprung-Russell diagram. Mark (approximately) spectral types and luminosity classes on the sketched H-R diagram. Then briefly describe and sketch the life of a star in the H-R diagram: where is it at birth, how does it progress during its lifetime, and where does it die?

5. ^{13}N decays into ^{13}C with a half-life of 9.965 minutes.

   a) Is this an α, β or γ process? Explain why by explaining *only* the chosen process.

   b) How much of ^{13}N remains after 1 hour?

   c) After what time will there be 99% ^{13}C?

   d) Is ^{13}N decay practical for dating artifacts from ancient human history? Why?

6. Stellar spectra can be used to determine a wealth of information. Explain what can be deduced from stellar spectra and how. Do not forget to discuss the continuous (black-body) contribution to the spectrum and the discrete (spectral line) contribution to the spectrum, as well as the significance of the peak and the area under the curve.

7. Name at least five lines of evidence (material or deductive) that led to the abandonment of the 6000 year old Earth idea.

8. How does the Sun produce the bulk of its energy? What process is responsible, and what two quantum laws facilitate that process?

9. How do we define a distance of 1 parsec, and how do we use trigonometric parallax to determine distances to celestial objects?

10. Stellar spectra can be used to determine a wealth of information. Explain what can be deduced from stellar spectra and how. Do not forget to discuss the continuous (black-body) contribution to the spectrum and the discrete (spectral line) contribution to the spectrum.

11. On the back of the test you will find an H-R diagram that connects absolute magnitude and spectral types. First locate the Sun. Then locate Sirius B among the white dwarfs.

    a) What is the luminosity of Sirius B, expressed in solar luminosity?

    b) What is the mass of Sirius B, expressed in solar masses?

    c) Read off the spectral type of Sirius B and estimate its temperature from the lookup table below.

O5:	54,000 K	B0:	29,200 K	B5:	15,200 K
A0:	9600 K	A5:	8310 K	F0:	7350 K

    d) From the temperature and luminosity, compute the radius of Sirius B, expressed in solar radii.

    e) If the distance to Sirius B is 8.6 light years, what is its parallax?

    f) If the distance to Sirius B is 8.6 light years, what is its apparent magnitude?

    Do not forget to convert light years to parsecs, and make sure that your answers agree with common logic. Temperature of the Sun is 6000 K, and its absolute magnitude is 4.85.

12. *Extra credit:* What is the difference between the amount of light (brightness, flux) and the luminosity of a celestial object? Can two objects of different luminosities be equally bright? How?

13. Explain in detail the questions, the available observations, the arguments and the outcome of the Shapley-Curtis debate.

14. White dwarfs play a paramount role in putting a lower limit on the age of the Universe.

    (a) How are white dwarfs created, how prevalent are they and how difficult to observe?

    (b) What is it about white dwarfs that allows us to accurately determine their ages?

    (c) Sketch the cooling tracks of white dwarfs on an H-R diagram. What distinguishes different tracks?

    (d) What is the white dwarf-deduced lower limit on the age of the Universe and how did we determine it?

15. Explain the cosmological principle and Hubble's law. Then apply the cosmological principle to Hubble's law and explain why our Universe can have no edge and no center.

16. One of the most significant discoveries of the 20th Century is dark energy.

(a) What makes SN Ia good standard candles?

(b) What observations led to the claim that dark energy must exist, and what is its consequence on the age of the Universe?

(c) In the absence of dark energy, what would be the inescapable fate of the Universe?

(d) While we do not really know what dark energy might be, what is our best guess?

17. On the back of the test you will find an H-R diagram that connects absolute magnitude and spectral types. First locate the Sun. Then locate Sirius B among the white dwarfs.

    a) What is the luminosity of Sirius B, expressed in solar luminosity?

    b) What is the mass of Sirius B, expressed in solar masses?

    c) Read off the spectral type of Sirius B and estimate its temperature from the lookup table below.

O5:	54,000 K	B0:	29,200 K	B5:	15,200 K
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    e) If the distance to Sirius B is 8.6 light years, what is its parallax?

    f) If the distance to Sirius B is 8.6 light years, what is its apparent magnitude?

    Do not forget to convert light years to parsecs, and make sure that your answers agree with common logic. Temperature of the Sun is 6000 K, and its absolute magnitude is 4.85.

18. What is Olbers' paradox? Explain the reasoning behind the paradox, the proposed hypotheses and their counter-arguments, and the only inevitable resolution of the paradox.

19. Parallaxes are used to measure the distances in the Universe.

    a) What is the measured quantity when using the parallax method?

    b) How do we convert that measured quantity to distance?

    c) What are the units of the measured quantity, and of the derived distance?

    d) What would be the parallax of the Andromeda galaxy, if its distance is 2.5 million light years?

    e) Based on your answer above, is the parallax method suitable for measuring the distances to faraway objects? Why?

20. Stars live on the main sequence for the majority of their lifetimes.

    a) How (by what process) do stars on the main sequence produce thermonuclear energy?

    b) What two considerations need to be invoked to overcome the issue with the above process?

    c) How long do stars of different spectral types live on the main sequence?

21. Globular clusters are some of the oldest galaxy formations. They can be used to put a lower limit on the age of the galaxy.

    a) What are globular clusters and where do we find them in a galaxy?

    b) Sketch two HR diagrams: one that corresponds to a young globular cluster and the other that corresponds to an old globular cluster.

    c) Based on your answer in (b), explain how we determine the ages of stars in globular clusters.

22. The existence of dark *matter* has been inferred through a number of observations.

    a) How do rotation curves of galaxies imply the existence of dark matter?

    b) Provide at least 3 proposed sources of conventional dark matter.

    c) What was Franz Zwicky's contribution to our understanding of dark matter? How was he correct and how was he incorrect?

    d) Provide at least 2 proposed sources of exotic dark matter.

23. Radioactive iodine, ^{131}I, decays into ^{131}Xe. It is used predominantly in medicine, for treating thyroid cancer because of the thyroid's affinity to absorb it.

    a) Is this an α, β or γ process? Explain why by explaining *only* the chosen process.

    b) If 10% of ^{131}I decays in 1.219 days, what is the half-life of ^{131}I?

    c) After what time will there be 99% ^{131}Xe?

    d) Is ^{131}I decay practical for modern forensic analysis (i.e. examining teeth or hair of recently deceased victims)? Why?

24. We know today that we live in a universe that expands at an accelerated rate.

a) What is the most definitive observation of the expansion of the Universe?

b) That observation can be explained by both an exploding universe and an expanding Universe. How?

c) Why do we believe that the Universe is expanding rather than exploding?

d) How do we call the agent that causes expansion of the Universe and what is our best guess of its origin?

25. Explain the principle of radioactive dating; what three specimens did we use it to determine (bracket) the age of Earth?

26. What are *apparent* and *absolute* magnitudes? What physical quantity do they measure? Can two stars have the same apparent magnitude at different distances? If so, how?

27. Explain in detail the Hertzsprung-Russell diagram. Briefly describe and sketch the life of a star in the H-R diagram: where is it at birth, how does it progress during its lifetime, and where does it die? Mark (approximately) spectral types on the x-axis of the sketched H-R diagram.

28. Betelgeuse (α Orionis) is the ninth brightest star in the sky: its apparent magnitude is 0.42. The distance to Betelgeuse is 642.5 light years, and its surface temperature is 3500 K.

    a) What is the parallax of Betelgeuse?

    b) What is the absolute magnitude of Betelgeuse?

    c) What is the luminosity of Betelgeuse, expressed in solar luminosity?

    d) What is the radius of Betelgeuse?

    e) What is the mass of Betelgeuse?

    f) Based on your answers above, is Betelgeuse a red dwarf, a red giant or a red supergiant?

    Do not forget to convert light years to parsecs, and make sure that your answers agree with common logic. Temperature of the Sun is 6000 K, and its absolute magnitude is 4.85.

29. *Extra credit:* How do we observationally determine the masses of stars in binary systems?