Astronomy 101 Exam 3 Form A

Name: ______________________________

Lab section number: ________________

(In the format "M0**". See back page; if you get this wrong you may not get your exam back!)

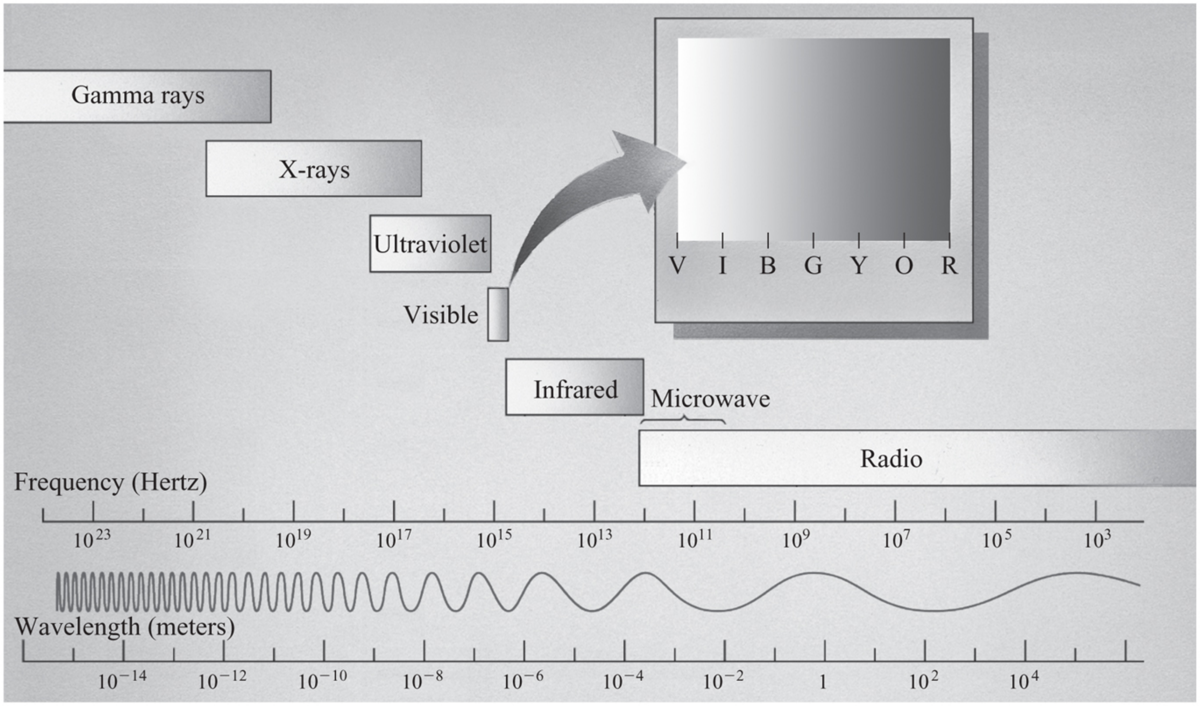
- Exam time: one hour and twenty minutes
- Please put bags under your seats to allow proctors to move around the room.
- Please choose the **best** answer to each question.
- You may use only pencils and pens for this exam; no notes, **or cellphones** are allowed. You do not need a calculator; this exam requires no complicated calculations.
- If you have a question, raise your hand, and a proctor will assist you.
- Do not attempt to communicate with anyone other than teaching staff during the exam.

Good luck!

Lab Schedule

Section	Instructor	Time
M024	Jiaxin Sun	Monday 8:00AM-9:20AM
M003	Pan Dong	Monday 9:30AM-10:50AM
M004	Pan Dong	Monday 11:00AM-12:20PM
M005	Pan Dong	Monday 12:45PM-2:05PM
M006	Pan Dong	Monday 2:15PM-3:35PM
M007	Suman Kundu	Monday 3:45PM-5:05PM
M008	Suman Kundu	Monday 5:15PM-6:35PM
M009	Suman Kundu	Monday 6:45PM-8:05PM
M010	Suman Kundu	Monday 8:15PM-9:35PM
M027	Julian Georg	Tuesday 3:30PM-4:50PM
M028	Julian Georg	Tuesday 5:00PM-6:20PM
M029	Julian Georg	Tuesday 6:30PM-7:50PM
M030	Julian Georg	Tuesday 8:00PM-9:20PM
M025	Ohana Benevides Rodrigues	Wednesday 8:00AM-9:20AM
M011	Ohana Benevides Rodrigues	Wednesday 9:30AM-10:50AM
M012	Ohana Benevides Rodrigues	Wednesday 11:00AM-12:20PM
M013	Scott Bassler	Wednesday 12:45PM-2:05PM
M014	Jiaxin Sun	Wednesday 2:15PM-3:35PM
M015	Sarthak Gupta	Wednesday 3:45PM-5:05PM
M016	Sarthak Gupta	Wednesday 5:15PM-6:35PM
M017	Elizabeth Lawson-Keister	Wednesday 6:45PM-8:05PM
M018	Elizabeth Lawson-Keister	Wednesday 8:15PM-9:35PM
M019	Sarthak Gupta	Thursday 5:00PM-6:20PM
M020	Sarthak Gupta	Thursday 6:30PM-7:50PM
M031	Ohana Benevides Rodrigues	Thursday 8:00PM-9:20PM
M026	Elizabeth Lawson-Keister	Friday 8:00AM-9:20AM
M021	Elizabeth Lawson-Keister	Friday 9:30AM-10:50AM
M022	Jiaxin Sun	Friday 11:00AM-12:20PM
M023	Jiaxin Sun	Friday 12:45PM-2:05PM

Reference



Gamma rays
X-rays
Ultraviolet
Visible
Infrared
Microwave
Radio
V I B G Y O R
Frequency (Hertz)
10^23 10^21 10^19 10^17 10^15 10^13 10^11 10^9 10^7 10^5 10^3
Wavelength (meters)
10^−14 10^−12 10^−10 10^−8 10^−6 10^−4 10^−2 1 10^2 10^4

1. What form is your exam?

    (A) Form A
    (B) Form B
    (C) Form C
    (D) Form D
    (E) Form E

2. Suppose that an atom has energy levels of 0 eV, 2.5 eV, 3.5 eV, and 4 eV. It has one electron which is currently in the $n = 3$ state (with energy 3.5 eV). Which of the following can this atom do?

    (A) It can absorb photons with energy 1 eV or 3.5 eV, or emit a photon of energy 0.5 eV
    (B) It can emit a photon with energy 2.5 eV or absorb a photon of energy 4 eV
    (C) It can absorb a photon with energy 2.5 eV or emit a photon of energy 4 eV
    (D) It can emit photons with energy 1 eV or 3.5 eV, or absorb a photon of energy 0.5 eV

3. Can significant numbers of x-rays be emitted as thermal radiation?

    (A) No, since like x-rays can only be produced in nuclear reactions
    (B) Yes, by a chemical whose energy levels are very far apart
    (C) Yes, by an extremely hot object heated to a temperature of thousands of degrees
    (D) No, since x-rays are ionizing radiation, not thermal radiation
    (E) Yes, by an extremely hot object heated to a temperature of millions of degrees

4. Some astronomers build a strange "telescope" deep underground, half a mile below the surface of the Earth. Even though no light can penetrate that much dirt, they are still able to observe a supernova. How did they do this?

    (A) They observed neutrinos produced in the explosion
    (B) They observed the gamma-ray burst that was produced at the same time
    (C) They observed a change in the Earth's rotation caused by gravitational waves
    (D) They observed fluctuations in the Earth's magnetic field caused by the shock wave
    (E) There are no telescopes deep underground since you can't see anything from down there

5. Which of the following would allow you to most easily determine the temperature of a star, if you have a telescope and a spectrometer?

   (A) Examining the color that the star appears

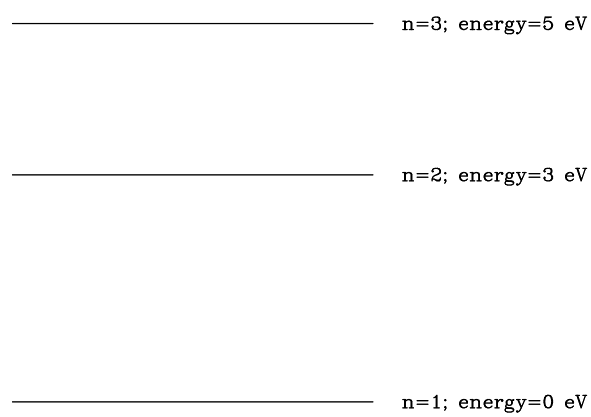
   (B) Examining the location of the emission lines in the star's spectrum

   (C) Examining the amount of infrared radiation emitted by the star

   (D) Examining the location of the absorption lines in the star's spectrum

   (E) We have no way of determining the temperature of stars using this equipment

6. Suppose a particular sort of atom has energy levels as shown below. You shine a beam of 4 eV photons on these atoms. What transition(s) will the atom's electron make? *(Thanks to Amanda for the question!)*



   (A) It will jump to the space between the $n = 2$ and $n = 3$ levels

   (B) It will jump from the $n = 1$ level to the $n = 2$ level, emitting a 1 eV photon to carry the leftover energy

   (C) It will not make any transitions at all

   (D) It will jump to the $n = 2$ level, but not emit any light.

   (E) More than one of the above is possible.

7. Which of the following is *not* produced by the nuclear reactions inside the Sun?

   (A) Helium

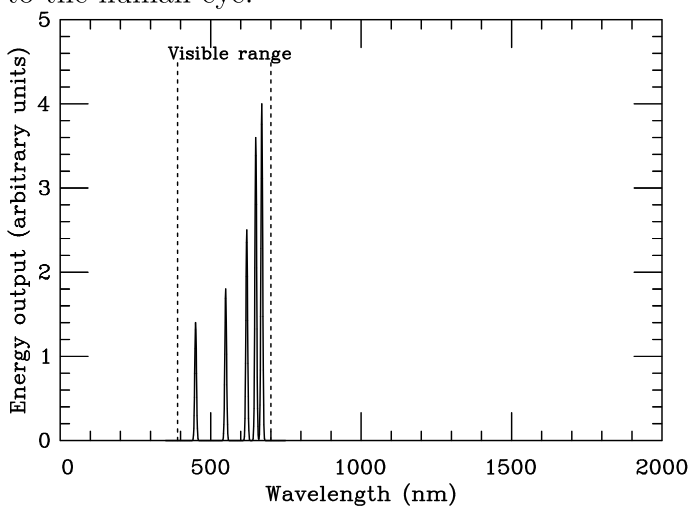
   (B) Neutrinos

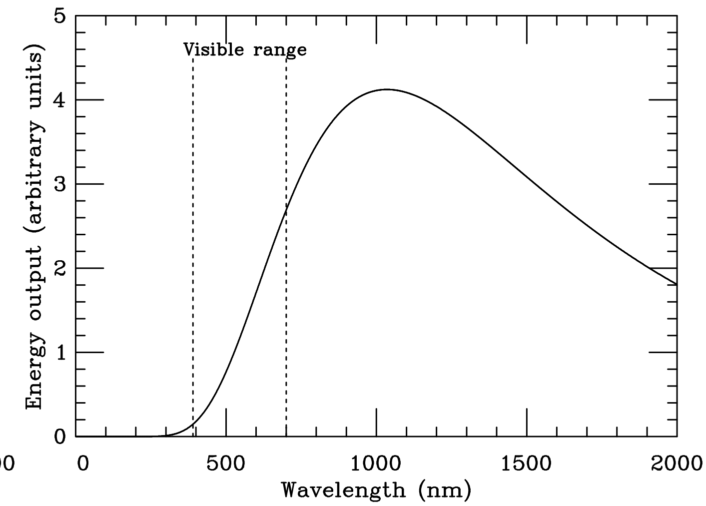
   (C) Hydrogen

   (D) Heat

   (E) All of the above are produced inside the Sun

8. Here are spectra for two types of light bulbs, both of which appear the same yellowish-orange color to the human eye.





What can you conclude about them?

(A fluorescent light bulb contains a diffuse gas with an electric current running through it; an incandescent light bulb consists of a thin filament heated to a high temperature.)

(A) Both bulbs are fluorescent light bulbs, but they contain different types of gas

(B) The bulb on the left is a fluorescent light bulb, and the bulb on the right is an incandescent light bulb

(C) Both bulbs are incandescent light bulbs, but they are heated to different temperatures

(D) The bulb on the left is a incandescent light bulb, and the bulb on the right is a fluorescent light bulb

(E) You cannot conclude any of the above

9. In a famous experiment, a neutrino detector measured only 1/3 as many neutrinos coming from the core of the Sun as expected. Why was this?

(A) Because the detector was sensitive only to one out of the three flavors of neutrinos; the Sun produces only electron neutrinos, but while traveling to the Earth they become a mix of all three flavors

(B) Neutrino detection is very challenging; our detectors only catch one-third of the neutrinos that pass through them. In order to measure the other 2/3, we'd need a bigger detector.

(C) Nuclear reactions in the heart of the Sun proceed slower than expected, because it is now fusing helium into heavier elements in addition to fusing hydrogen into helium.

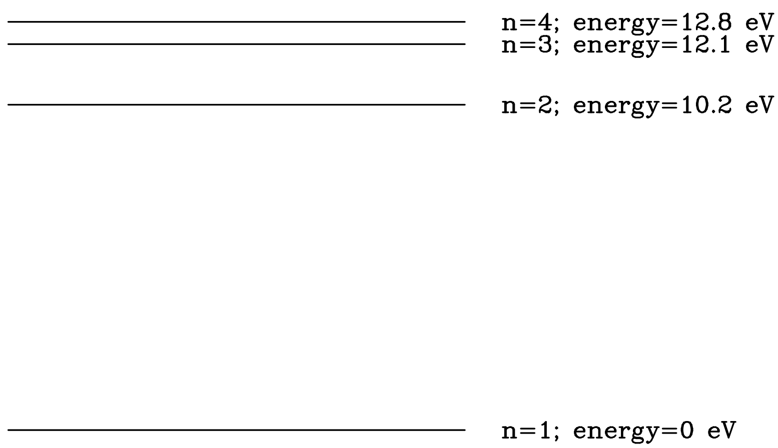
(D) Because neutrinos are unstable particles which decay; their half-life is about 5 minutes, so about 2/3 of them decay during the 8-minute trip from the Sun to the Earth. (This is why we don't detect neutrinos from other stars.)

(E) None of the above are plausible explanations.

10. Here is an energy-level diagram showing the first four energy levels of hydrogen.

    Suppose that you run an electric current through hydrogen gas in a discharge tube (like you used in lab) and looked at it through one of the handheld spectrometers you used in lab. What would you see?

    (Visible light photons have energies from 1.6-3.2 eV. Note that I'm only asking you to think about the first four energy levels, shown here. There is an additional piece of the spectrum resulting from energy levels above $n = 4$, but don't worry about that for this problem.)



    (A) One red, one orange, one yellow, one green, one blue, and one purple line
    (B) A continous band of color ranging from red to blue
    (C) One red line and one blue-green line
    (D) One red line
    (E) Three ultraviolet lines

11. As you slowly increase the temperature of your stove, at some point (perhaps around 1500 K) you will see it start to glow. What makes the stove start to emit light at that point?

    (A) Only at that temperature do the atoms have enough energy to transition to higher energy levels
    (B) Only at that temperature do the atoms in the stove begin to transition back down to the ground state, emitting light
    (C) Only at that temperature do the atoms have enough energy to undergo nuclear fusion
    (D) It's actually been emitting light the whole time, but of wavelengths we can't see

12. Suppose you work for a shop on Marshall Street, and the store owner tells you that they've bought a new blue neon sign: "Everyone else's neon signs are red, but I have a fancy blue one!"

    What would you say to the shop owner?

    (A) "Uh, I don't think that's neon..."
    (B) "That's beautifully-colored glass"
    (C) "The stuff inside must be really hot; I hope it doesn't melt the glass"
    (D) "Be careful with the ultraviolet coming from that thing; you don't want to get a sunburn"
    (E) "The energy levels in that type of neon must be very far apart"

13. Blacksmiths use the visible appearance of the thermal radiation of hot metal to judge its temperature.

    Suppose a metal is heated to the point where its glow is barely visible to the human eye, around 1000 Kelvin. What type of light is it mostly emitting?

    (A) Red light
    (B) Infrared light
    (C) Ultraviolet light
    (D) White light
    (E) Blue light

14. Two stars, Star X and Star Y, are the same color and size. However, Star X has more dark lines in its spectrum. Which star has the higher temperature? *(Thanks to Danielle for the question!)*

    (A) We don't know, since the dark lines contain colors the human eye can't see
    (B) Star X is hotter
    (C) They are both the same temperature
    (D) Star Y is hotter
    (E) There is not enough information to figure out the answer

15. Which type of electromagnetic radiation travels the fastest?

    (A) Radio waves
    (B) Infrared
    (C) X-rays
    (D) Visible light
    (E) All travel at the same speed

16. Which statement is correct?

    (A) Light of longer wavelengths has lower energy per photon and a lower frequency
    (B) Light of longer wavelengths has lower energy per photon but its frequency depends on its color
    (C) Light of longer wavelengths has higher energy per photon and a lower frequency
    (D) Light of longer wavelengths has higher energy per photon and a higher frequency
    (E) Light of longer wavelengths has lower energy per photon and a higher frequency

17. Suppose that a fictitious element Examium has atomic energy levels of 0 eV, 2.5 eV, 3.5 eV, and 4 eV.

    If a tube of diffuse examium gas is excited with an electric current and its spectrum examined, what sorts of light will it generate?

    Note that the visible range is 1.6 eV - 3.2 eV. Imagine that you are examining the spectrum both with your eye and with instruments, so that you can detect light outside the visible range.

    (A) Two bright lines in the infrared and one line in the visible
    (B) A continuous band of light, but with three dark lines, one in the visible and two in the ultraviolet
    (C) Three bright lines in the infrared, one line in the visible, and two in the ultraviolet
    (D) One bright line in the visible and two in the ultraviolet

18. How can we most readily measure what chemical elements are in stars?

    (A) By examining the slight motions they make in the sky
    (B) By examining the positions of the dark lines in their spectra
    (C) By examining the peak wavelengths of the continuous spectra that they emit
    (D) By examining the positions of the bright lines in their spectra
    (E) We have no way to measure the composition of stars

19. Most stars in the universe are red dwarf stars which are cooler than the Sun, perhaps around 2500 K (similar to the temperature of an incandescent light bulb). It is possible that a star of this type might host a planet whose environmental conditions are favorable for the evolution of life.

    Which of the following would be most plausibly true regarding the eyes of creatures that had evolved on such a planet to make use of the light from their host star?

    (A) Their eyes would be unable to see red light, but would be able to see near-infrared light.
    (B) They would be unable to see blue light, but would be able to see near-infrared light.
    (C) They would be unable to see in the light of their star
    (D) Their eyes would be particularly good at seeing ultraviolet light
    (E) Their eyes would evolve to see the spectral lines of hydrogen distinctly

20. The *Pioneer* spacecraft contain golden plaques referencing a certain atomic transition in hydrogen. The hope is that alien life somewhere will discover these plaques and use the information on them to learn about humans.

    Why did we refer to this atomic transition when writing a message for exterrestrial beings?

    (A) Because we needed to demonstrate to the extraterrestrials that there was hydrogen gas in the Sun
    (B) Because the Earth emits a great deal of light at the wavelength of this transition, and if the extraterrestrials know to look for it then they can find Earth
    (C) Because the wavelength of the light emitted by these atomic transitions is the same everywhere in the universe, and this provides a "yardstick" for us to use in describing how big things are
    (D) Because we needed to teach the extraterrestrials something about physics in order for them to understand how the spacecraft worked

21. Consider a very bright red light and a dim blue light. Which is true?

    (A) The total power emitted by the red light is higher, but photons from both lights have the same energy
    (B) The total power emitted by the red light is higher, but one photon from the blue light carries more energy
    (C) The total power emitted by both lights in the same, but photons from the red light carry more energy
    (D) The total power emitted by the blue light is higher, but photons from the red light carry more energy
    (E) None of the above are correct.

22. Which of the following is not a type of light?

    (A) Radio waves
    (B) Neutrinos
    (C) X-rays
    (D) Gamma rays
    (E) None of the above are types of light

23. In lab, you estimated the temperature of the planets by equating the incoming power of the sun's thermal radiation to the outgoing power of the planet's thermal radiation.

    When the temperature of the planets is estimated in this way, which of the following planets has the *least* accurate estimate for its temperature?

    (A) Earth – its actual temperature is much warmer than the estimate
    (B) Mars – its actual temperature is much colder than the estimate
    (C) Pluto – its actual temperature is much colder than the estimate
    (D) Venus – its actual temperature is much warmer than the estimate
    (E) The method provides an accurate estimate of the temperature of all of the planets.

24. You're searching for life on other planets, and are trying to find planets that are the same temperature as Earth.

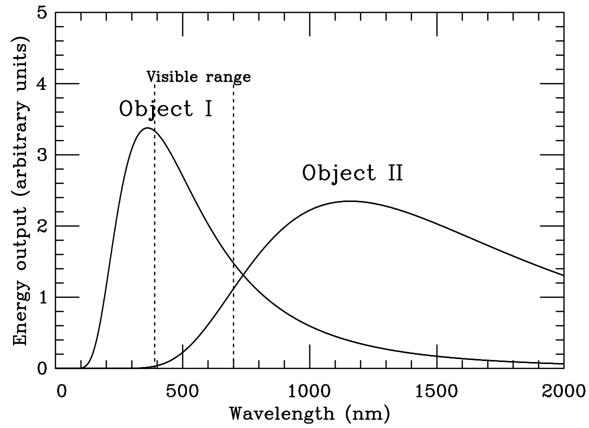
    Suppose that you find a star that is the same temperature as the Sun, but is twice as large. If this star has a planet that is the same temperature as the Earth, how far away from its star would it have to be?

    Recall that, in Lab 8, you found that the intensity I_2 of sunlight at a distance d away from a star of temperature T and radius r is

$$I_2 = \frac{kT^4 r^2}{d^2}.$$

    (A) The planet would need to be more than 1 AU away from its host star.
    (B) The planet would need to be less than 1 AU away from its host star.
    (C) The planet would need to be about 1 AU away from its host star.
    (D) This star is too big to support planets that are the same temperature as Earth.

25. Which is true about these two objects?



(A) Object II is a higher temperature than Object I

(B) Object II emits only infrared light and could not be seen by a human observer

(C) Object I is larger than Object II

(D) Object I appears blue to a human observer

(E) None of the above are true

26. Which of the following is true about a candle (temperature around 1800 K)? *(Inspired by a question submitted by Sam; thanks!)*

(A) It emits mostly ultraviolet light, but also emits a little bit of red and orange light

(B) It emits red and orange light only

(C) It emits mostly infrared light, but also emits a little bit of red and orange light

(D) It emits mostly red and orange light, but also emits a little bit of ultraviolet

(E) It emits mostly red and orange light, but also emits a little bit of infrared light

27. In the 1800's, astronomers noticed spectral lines in the Sun that did not correspond to any of the known chemical elements. They concluded that this was a new element; a few decades later, it was first isolated on Earth. Which element is this?

(A) Sodium

(B) Helium

(C) Uranium

(D) Argon

(E) Solarium

28. An old lighthouse consists of a hot fire and a mirror to focus its light toward approaching ships. Suppose you see the light from this lighthouse from fifty miles away. What will its spectrum look like? *(Adapted from a question suggested by Weiya; thanks!)*

   (A) A continuous band of color, with dark lines on top of it

   (B) A few thin, bright lines

   (C) Many thin, bright lines

   (D) A continuous band of color

29. Consider a collapsing nebula, such as the one that formed our Solar System. *(Thanks to James for the question!)*

   At what point will it be rotating faster?

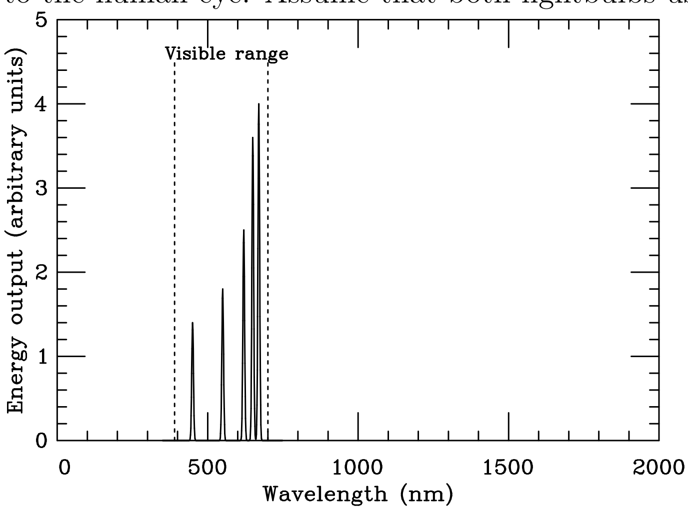
   (A) Later in time, when its size is smaller

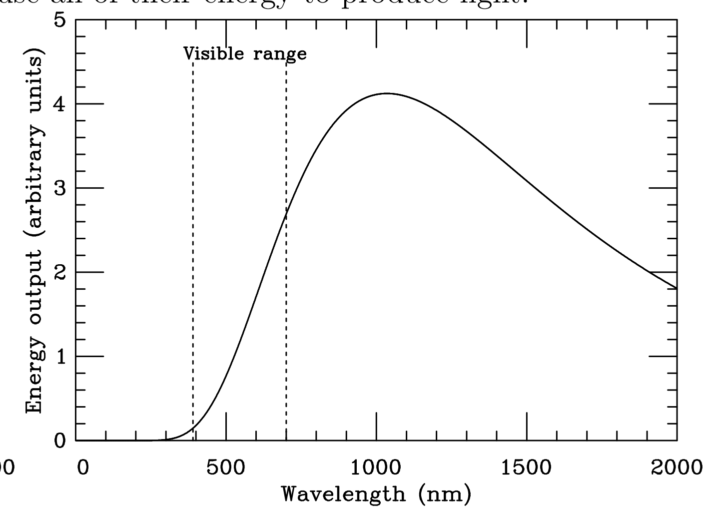
   (B) Earlier in time, when its size is larger

   (C) It will rotate at the same speed at all points in its history, up until the point when it forms a star

   (D) It will rotate at the same speed until it falls out of the sky and clonks a physicist in the head

30. Here are spectra for two types of light bulbs, both of which appear the same yellowish-orange color to the human eye. Assume that both lightbulbs use all of their energy to produce light.





What can you conclude about them?

(A) It is more efficient to light a house with lightbulbs of the type on the right than with the type on the left

(B) The lightbulb on the right would appear white, while the lightbulb on the left would appear blue

(C) It is more efficient to light a house with lightbulbs of the type on the left than with the type on the right

(D) The glowing part of the lightbulb on the left is made out of only one kind of element, while the glowing part of the lightbulb on the right is made out of many different kinds of elements

(E) You cannot conclude any of the above

31. How does a thermal camera, like the ones we used in lab and lecture, work? *(Thanks to Scott Bassler for the question!)*

(A) It examines spectral lines in the emission spectrum of the object

(B) It measures the ambient air temperature in the direction of the object

(C) It measures the wavelength of the infrared photons coming frmo the object

(D) It uses spectral filters to examine the visible photons coming from the object in detail

(E) It reads the psychic aura of the object

Scratch Paper

Scratch Paper