Astronomy 101 Exam 3 Form A

Name: ____________________ Lab section number: __________

(See back page for lab schedule; if you omit this you may not get your exam back!)

Multiple Choice	Free Response 1	Free Response 2		**Total**
/ 42	/ 20	/ 20		**/ 82**

Instructions:

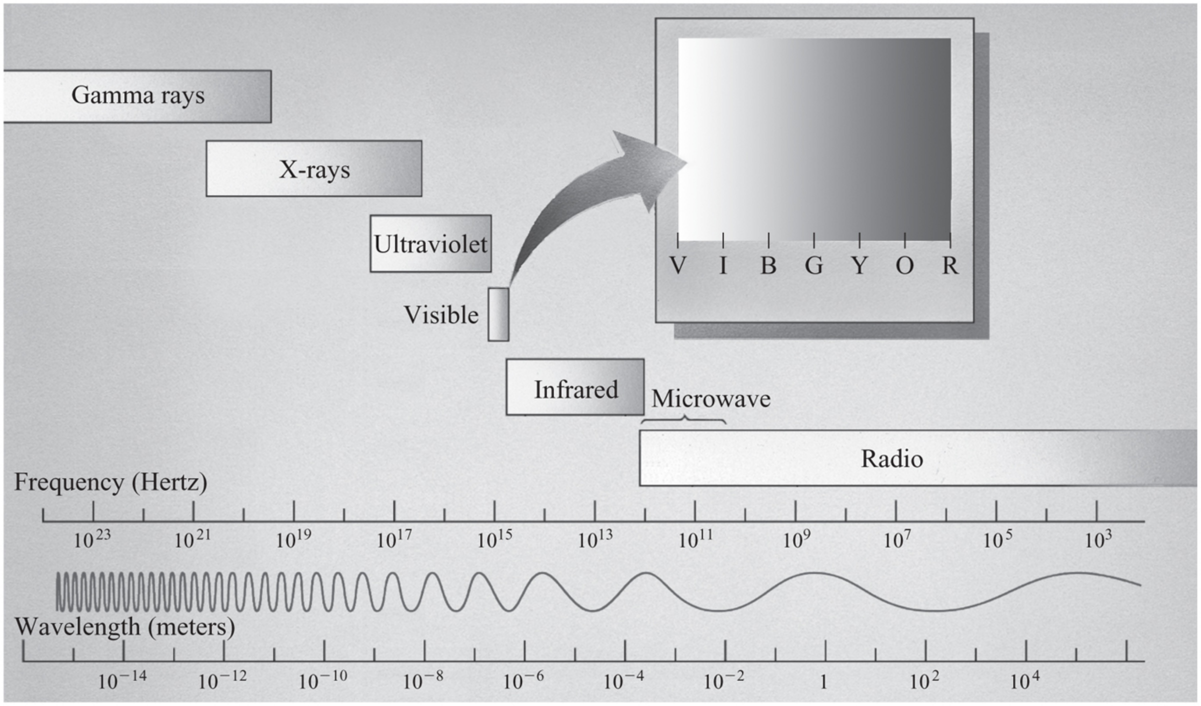
- Exam time: 80 minutes
- Please put bags under your seats to allow proctors to move around the room.
- You may use one page of notes that you handwrote yourself, or wrote with a stylus and printed. No electronic devices or things written by others are allowed.
- This exam has fourteen multiple-choice questions worth three points each, followed by two free-response questions worth 20 points each.
- We will award substantial partial credit for free-response answers if you show valid reasoning or insight, even if your answer is not correct.
- 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!

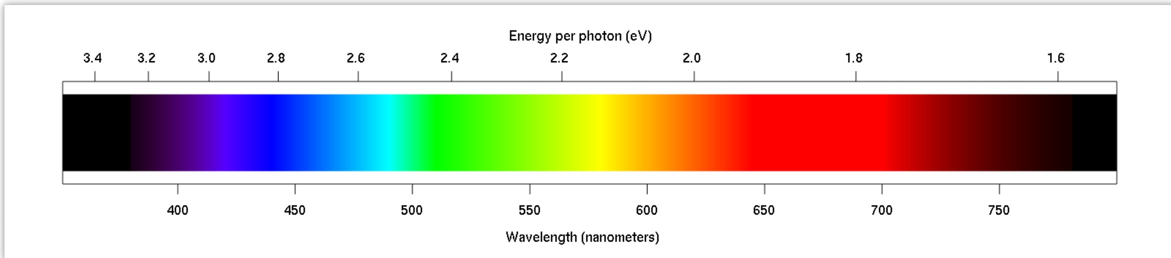
Lab Schedule

Section	Time	Instructor
M024	Monday 8:00-9:20	Sierra
M003	Monday 9:30-10:50	Keisi
M004	Monday 11:00-12:20	Keisi
M005	Monday 12:45-2:05	Nada
M006	Monday 2:15-3:35	Sierra
M007	Monday 3:45-5:05	Sierra
M008	Monday 5:15-6:35	Nada
M009	Monday 6:45-8:05	Sierra
M010	Monday 8:15-9:35 pm	Dylan
M027	Tuesday 3:30-4:50	Byron
M028	Tuesday 5:00-6:20	Byron
M029	Tuesday 6:30-7:50	Chad
M030	Tuesday 8:00-9:20 pm	Chad
M025	Wednesday 8:00-9:20	Nada
M011	Wednesday 9:30-10:50	Keisi
M012	Wednesday 11:00-12:20	Keisi
M013	Wednesday 12:45-2:05	Byron
M014	Wednesday 2:15-3:35	Byron
M015	Wednesday 3:45-5:05	Lindsay
M016	Wednesday 5:15-6:35	Lindsay
M017	Wednesday 6:45-8:05	Dylan
M018	Wednesday 8:15-9:35 pm	Dylan
M019	Thursday 5:00-6:20	Chandler
M020	Thursday 6:30-7:50	Chad
M031	Thursday 8:00-9:20 pm	Chad
M026	Friday 8:00-9:20	Chandler
M021	Friday 9:30-10:50	Lindsay
M022	Friday 11:00-12:20	Chandler
M023	Friday 12:45-2:05	Chandler

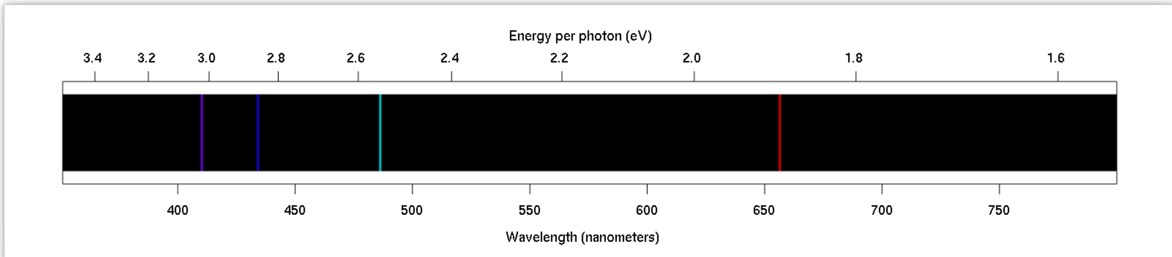
Reference



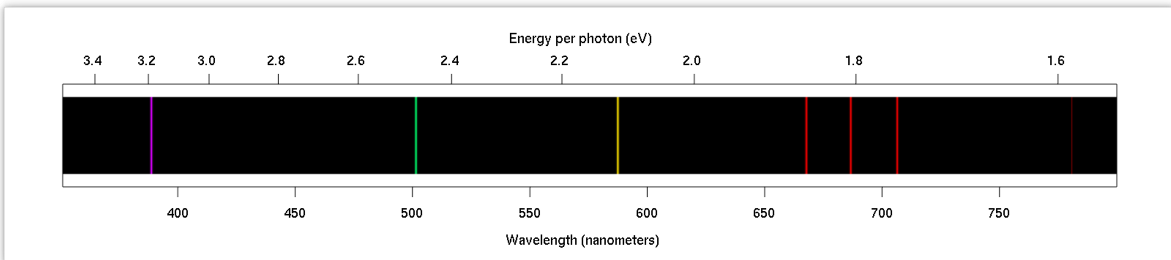
Gamma rays
X-rays
Ultraviolet
Visible
Infrared
Microwave
Radio
V I B G Y O R
Frequency (Hertz)
10^{23} 10^{21} 10^{19} 10^{17} 10^{15} 10^{13} 10^{11} 10^{9} 10^{7} 10^{5} 10^{3}
Wavelength (meters)
10^{-14} 10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 1 10^{2} 10^{4}



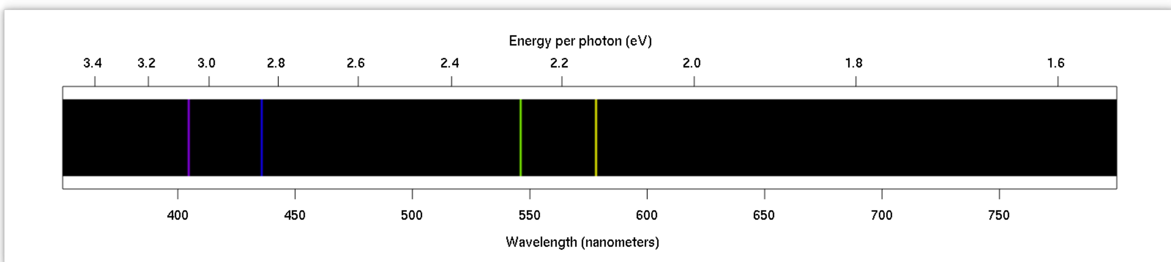
Visible light



Hydrogen



Helium



Mercury

1. Suppose astronomers see a star whose spectrum does not have very many dark lines in it.

   What can they conclude about it?

   (A) It does not have that many different chemical elements in its atmosphere
   (B) It is a young star that has recently been formed
   (C) It is cooler than the Sun
   (D) It is much hotter than the Sun
   (E) They couldn't conclude any of the above

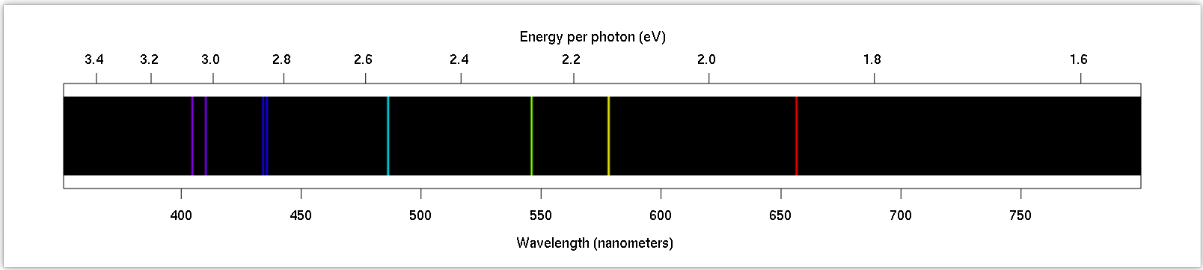
2. You decide to make the best of the Syracuse weather, and build a snowman in the Quad that is about the same size as you and stand next to it. (The air temperature is $-3°$ Celsius.

   Which statement is true?

   (A) Both you and the snowman are emitting infrared light; the light coming from you is more intense and has longer wavelength than the light coming from the snowman.
   (B) Neither of you is emitting light
   (C) Both you and the snowman are emitting infrared light; the light coming from you is more intense and has shorter wavelength than the light coming from the snowman.
   (D) You are emitting infrared light, and the snowman is emitting ultraviolet light
   (E) You are emitting infrared light, but the snowman is not emitting light

3. A mixup has happened in a fluorescent light factory with the gas supply. They now have lots of unlabeled gas discharge tubes. Even worse, some of them may contain mixtures of several different gases.

   You are sent in with a spectrometer and a set of reference spectra (included with your exam) to figure out which is which. You see the following spectrum from the first tube you look at:



   What is in this tube? Consult the reference spectra provided with your exam.

   (A) Only mercury
   (B) Hydrogen and helium
   (C) Helium and mercury
   (D) Hydrogen and mercury
   (E) Another element not listed here

4. What feature of the James Webb Space Telescope allows it to capture images at longer wavelengths (in the mid-infrared) than the Hubble Telescope can?

   (A) It has a larger primary mirror and can thus capture larger wavelengths
   (B) It has a more modern electronic detector that can measure photons of lower energy
   (C) It is kept cold so that it is not "blinded" by its own thermal radiation
   (D) It uses an adaptive optics system, invented since the launch of Hubble, that compensates for the twinkling of stars
   (E) It is located further from Earth and thus is subject to less interference from Earth's gravity

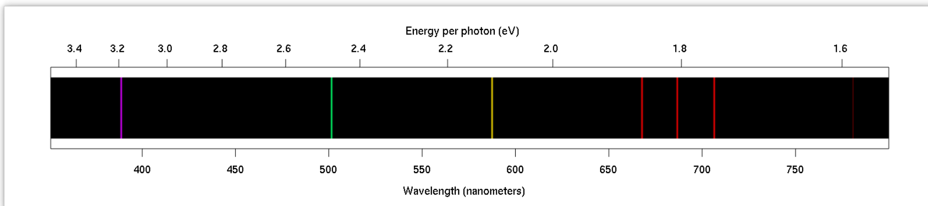
5. How can astronomers best determine the temperature of stars near us in the Milky Way?

   (A) By looking at the peak wavelength at which they emit light (or, equivalently, their color)
   (B) By looking at the location of the thin bright lines that appear in their spectra
   (C) By examining them with a thermal camera similar to the ones we used in class/lab
   (D) By looking at the location of the thin dark lines that appear in their spectra
   (E) None of the above would allow us to measure the temperature of a star

6. How can astronomers best determine what chemical elements are present in the outer layer of stars?

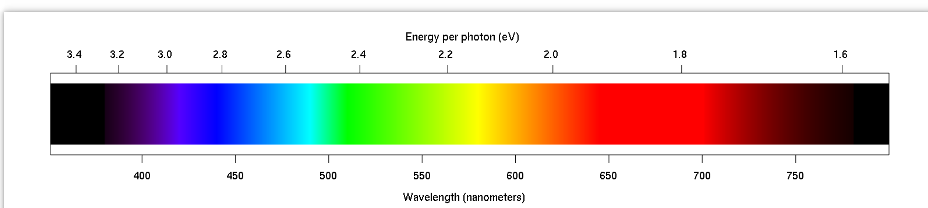
    (A) By examining the peak wavelength at which they emit light (equivalently, their color)
    (B) By examining the energies of the neutrinos produced in nuclear reactions in their core
    (C) By determining their age, and thus the elements they are producing with nuclear fusion
    (D) By examining the amount of light they produce in total
    (E) By examining the locations of the thin dark lines that appear in their spectra

7. What sort of object would produce a spectrum that looks like this?



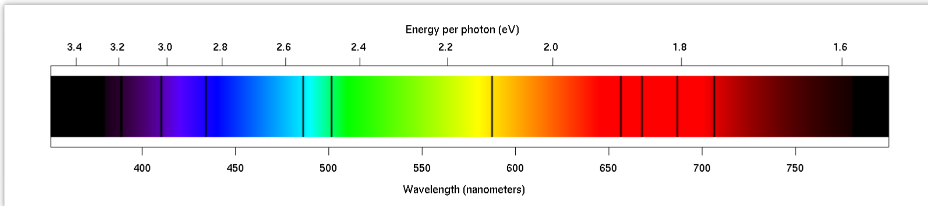
    (A) A hot object heated to thousands of degrees, seen through the atmosphere of a planet or star
    (B) A diffuse gas in an electrified tube, such as the ones you used in lab
    (C) Reflected light from the wall of a room that was lit by a mixture of incandescent and fluorescent lamps
    (D) A hot object heated to thousands of degrees
    (E) None of the above

8. What sort of object would produce a spectrum that looks like this?



    (A) A diffuse gas in an electrified tube, such as the ones you used in lab
    (B) A hot object heated to thousands of degrees, seen through the atmosphere of a planet or star
    (C) A hot object heated to thousands of degrees
    (D) Reflected light from the wall of a room that was lit by a mixture of incandescent and fluorescent lamps
    (E) None of the above

9. What sort of object would produce a spectrum that looks like this?



(A) Reflected light from the wall of a room that was lit by a mixture of incandescent and fluorescent lamps

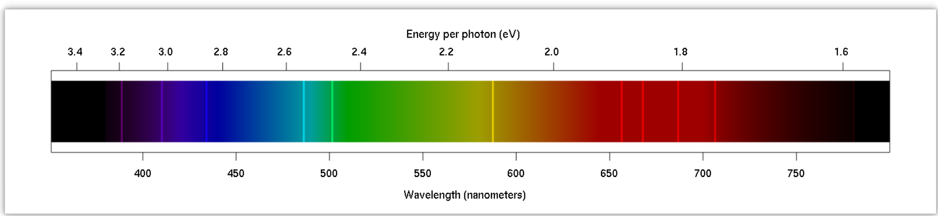
(B) A hot object heated to thousands of degrees, seen through the atmosphere of a planet or star

(C) A hot object heated to thousands of degrees

(D) A diffuse gas in an electrified tube, such as the ones you used in lab

(E) None of the above

10. What sort of object would produce a spectrum that looks like this?



(A) A hot object heated to thousands of degrees

(B) A hot object heated to thousands of degrees, seen through the atmosphere of a planet or star

(C) A diffuse gas in an electrified tube, such as the ones you used in lab

(D) Reflected light from the wall of a room that was lit by a mixture of incandescent and fluorescent lamps

(E) None of the above

11. Atomic nuclei have energy levels just like electrons do.
In particular, the isotope technetium-99 has the following as its first two energy levels:

- $n = 1$: 0 eV
- $n = 2$: 140,000 eV

If nuclear physicists want to study the light associated with this transition, they need to look for...

(A) Ultraviolet light
(B) Gamma rays
(C) Infrared
(D) Visible light
(E) Radio waves

12. An atom in its ground state is unable to do which of the following?

(A) It is unable to emit light via electron transitions to another energy level
(B) It is unable to absorb light via electron transitions to another energy level
(C) It is unable to emit thermal radiation
(D) It is unable to gain energy by absorbing light
(E) An atom in its ground state can do all four of the above

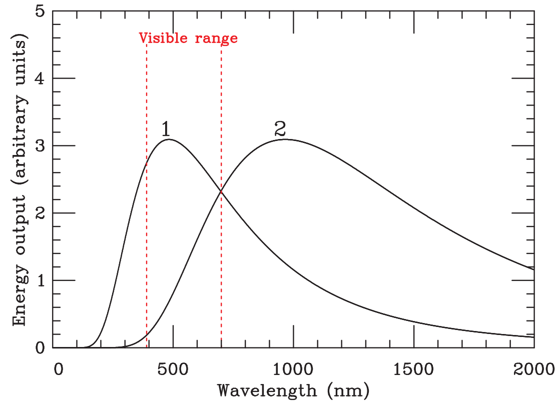
13. Telescopes have gotten larger over the years. Galileo's first telescope was about 2.5 cm across; astronomers now are contemplating building a telescope thirty meters across.

What benefits do larger telescopes have?

- I. Larger telescopes can see fainter objects.
- II. Larger telescopes can see more detail and see smaller objects.
- III. Larger telescopes can measure higher energy photons such as x-rays.

(A) I only
(B) I, II, and III
(C) II only
(D) I and II
(E) III only

14. Here are the spectral curves of two stars. What can you conclude about their sizes and temperatures?



(A) Star 2 is hotter, but Star 1 is larger

(B) Star 1 is hotter, but Star 2 is larger

(C) Star 2 is hotter; the two stars are the same size

(D) Star 2 is hotter and larger

(E) Star 1 is hotter; the two stars are the same size

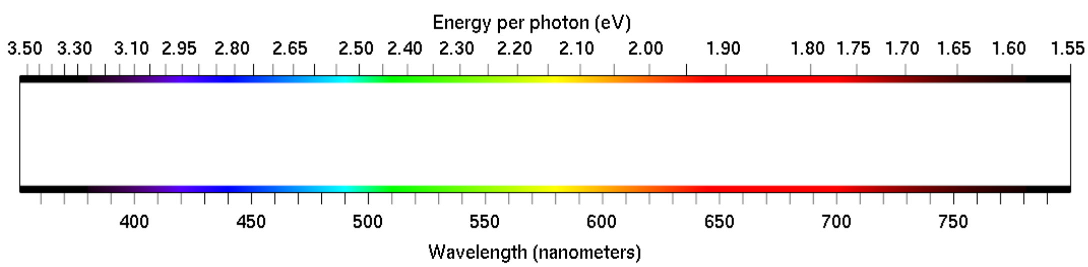
(F) Star 1 is hotter and larger

Free-Response Question 1

1. Draw an energy level diagram for this element in the space below if its first five energy levels are 0 eV, 4 eV, 5.7 eV, 6.5 eV, and 7.0 eV.

2. Suppose that you run an electric current through a diffuse gas of this element to make one of the glowing discharge tubes that you used in lab. Draw arrows on your energy level diagram showing all possible transitions that produce visible light. *(The visible range is 1.6 - 3.2 eV.)*

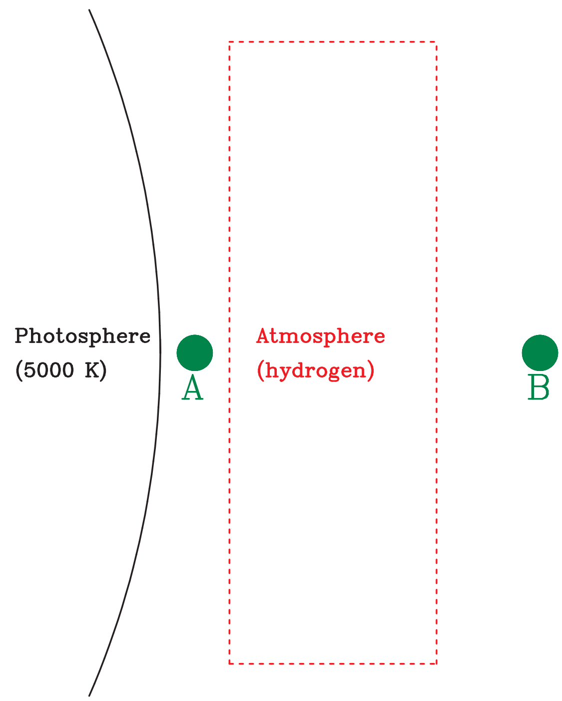
3. Suppose you then look at the glowing tube with a spectroscope. Draw the spectrum you would see below, and indicate whether you would see bright lines on a dark background or dark lines on a bright background.



4. Would this tube also produce infrared or ultraviolet light (or both of them)? How do you know?

Free-Response Question 2

Consider a simplified model of a star consisting of a hot inner layer with a temperature of around 5500 K and an outer atmosphere. This star is like the Sun, but it contains only hydrogen in its atmosphere. You know, from experiments in lab, that the visible spectrum of hydrogen has lines at 1.9 eV, 2.6 eV, and 2.9 eV.



1. Suppose someone were to measure the spectrum at point A, right outside the hot inner layer but below the atmosphere. What sort of spectrum would they observe? Describe whether you would see a continuous band of color, whether you would see bright or dark lines, etc., and describe why you see each of these features.

2. Suppose someone were to measure the spectrum at point B, after the light has passed through the atmosphere. Describe whether you would see a continuous band of color, whether you would see bright or dark lines, etc., and describe why you see each of these features.

(This question continues on the next page.)

3. Suppose the star was altered by reducing its core temperature to 3000 K. Describe how the spectrum at point B, outside the star, would change and why. (Would this alter the location of any lines in the spectrum? If so, why? If not, how would it change other features in the spectrum?)