Astronomy 101 Exam 3 Form B

Name: ______________________________

- This exam form is for you to keep. Circle your answers on it for your records; all you will turn in this time is the Scantron.
- If you fill out your Scantron in pen and make a mistake, ask us for a new form. It is better if you use pencil so you can erase.
- Exam time: one hour and twenty minutes
- Please put bags under your seats to allow proctors to move around the room.
- You may use only pencils and pens for this exam; **no cellphones, calculators, or smart-watches** are allowed.
- If you have a question, raise your hand, and a proctor will assist you.
- You may use a single-sided 8.5x11 inch page of notes you wrote yourself
- Do not attempt to communicate with anyone other than teaching staff during the exam

This exam is printed in color. If you have limited color vision, and would like a description of what color things are, please ask us for help.

Good luck!

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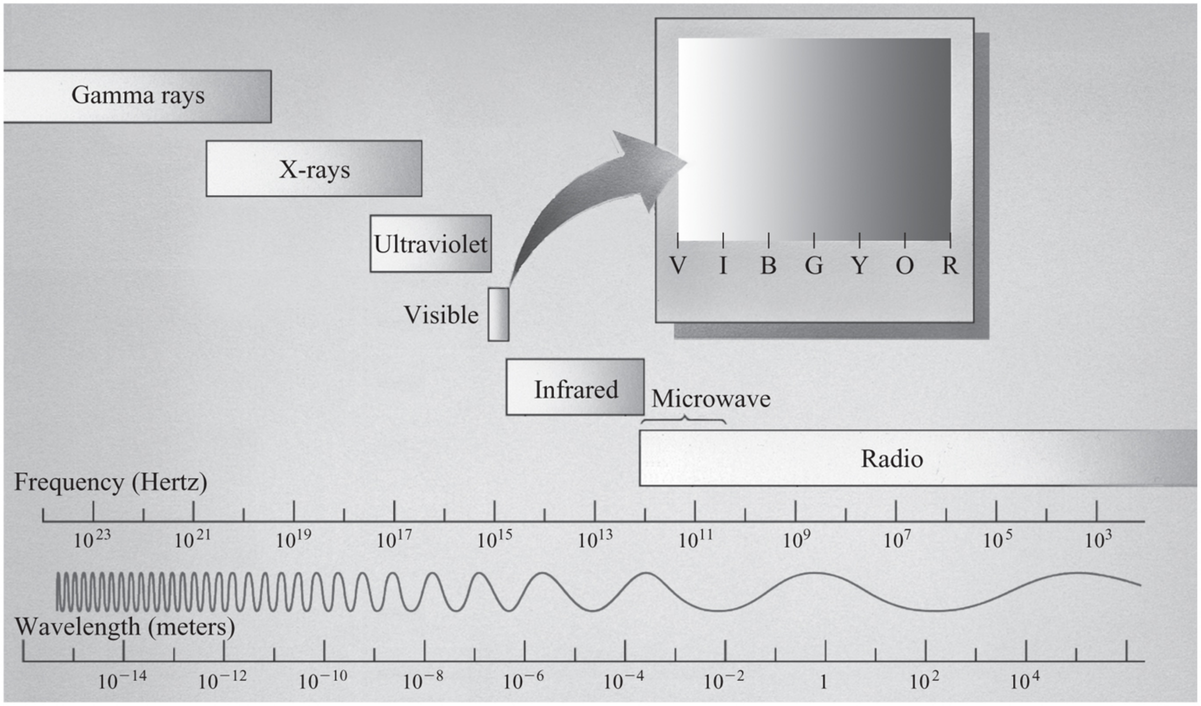
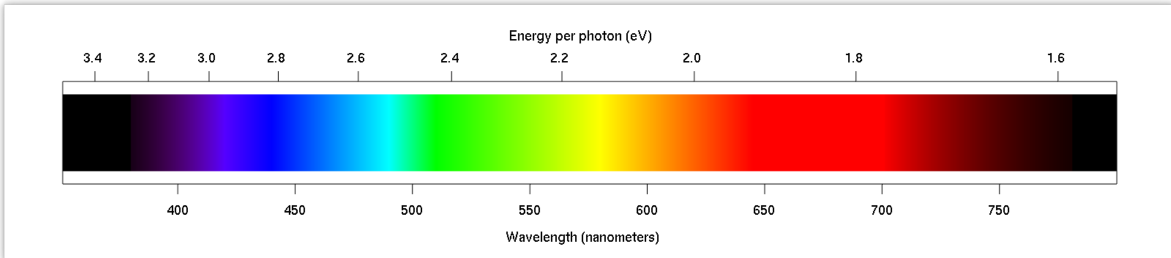
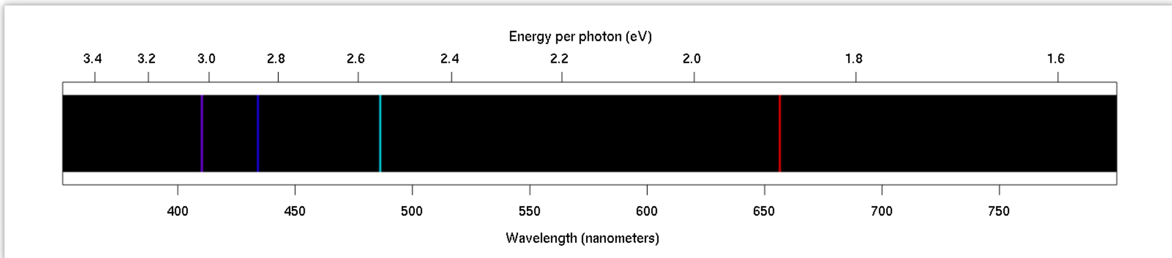
Reference



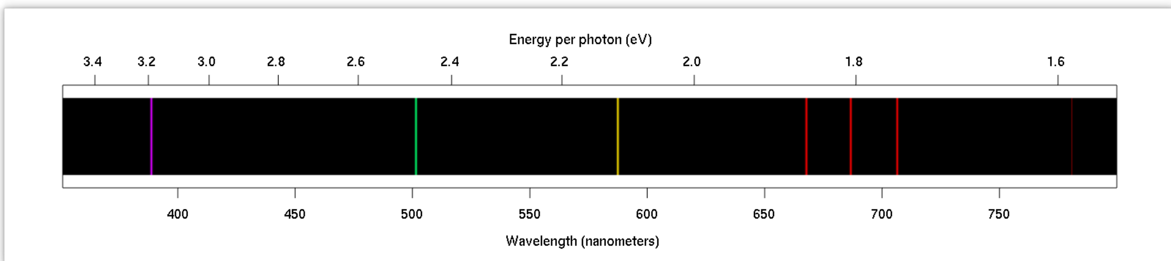
Gamma rays
X-rays
Ultraviolet
Visible
Infrared
Microwave
Radio
V I B G Y O R
Frequency (Hertz)
10^23 10^21 10^19 10^17 10^15 10^13 10^11 10^9 10^7 10^5 10^3
Wavelength (meters)
10^−14 10^−12 10^−10 10^−8 10^−6 10^−4 10^−2 1 10^2 10^4



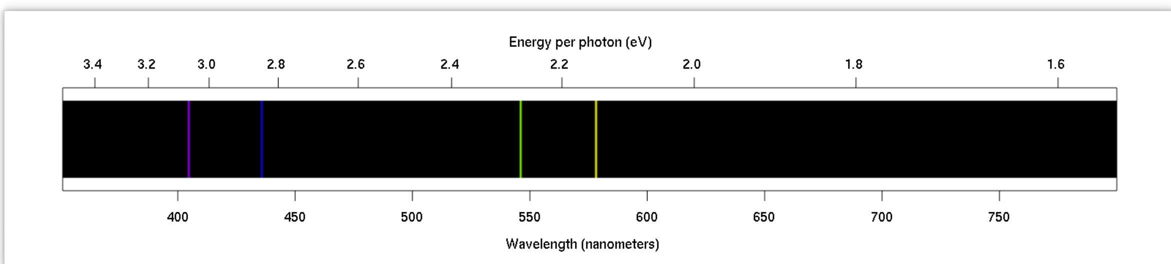
Visible light



Hydrogen



Helium



Mercury

1. What form is your exam?

   (A) Form A

   (B) Form B

   (C) Form C

   (D) Form D

   (E) Form E

2. Why don't humans use nuclear fusion, as in the Sun, as an energy source on Earth? *(Thanks to Ben Rabin for the question!)*

   (A) Because there is nothing on Earth that is suitable fuel for nuclear fusion; only stars have the needed raw materials

   (B) Because it requires temperatures of millions of degrees to produce, and containing these temperatures is a difficult engineering challenge

   (C) Because nuclear fusion is an inefficient energy source and doesn't produce much energy per ton of fuel

   (D) Because nuclear fusion produces highly radioactive byproducts that are difficult to store safely

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

   (A) It is unable to absorb light via electron transitions to another energy level

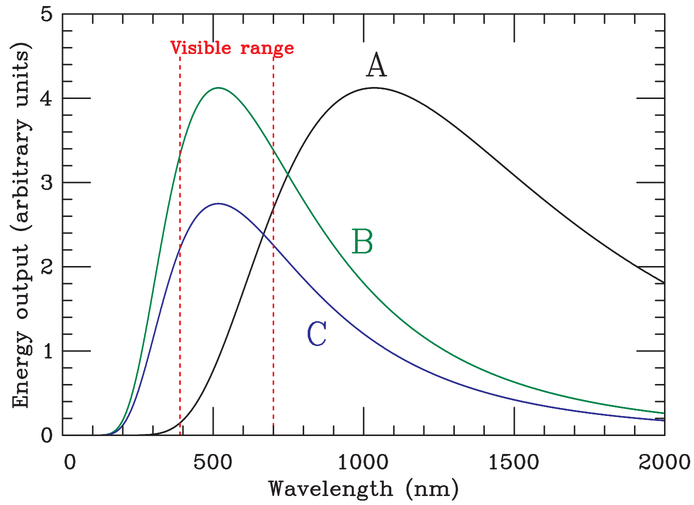
   (B) It is unable to gain energy by absorbing light

   (C) It is unable to emit light via electron transitions to another energy level

   (D) It is unable to emit thermal radiation

   (E) An atom in its ground state can do all four of the above

4. You observe three stars (A, B, and C) that are all the same distance away. The shapes of spectra are shown in the following graph:



The next three questions will all reference this graph.

Of these three stars, what can you conclude about their *temperatures*?

(A) Star A and B are the same temperature; star C is cooler

(B) Star B and C are the same temperature; star A is warmer

(C) Star B and C are the same temperature; star A is cooler

(D) Star A and B are the same temperature; star C is warmer

(E) You can't determine their temperatures from only this information

5. In the previous question, you saw spectral curves for three stars. Which statement is true about their *color*, as viewed by a human observer?

(A) Stars B and C would look white; star A would not be visible since we cannot see infrared light

(B) Stars A and B would look red; star C would look blue

(C) Stars B and C would look white; star A would look red

(D) Star A would look red; star B would look blue; star C would look white

6. Referencing again the spectral curves of these three stars, what can you conclude about their *sizes*?

   (A) Star A is larger than stars B and C, which are the same size
   (B) Star A is larger than star B, and both are larger than star C
   (C) Stars A and B are the same size; both are larger than star C
   (D) Star B is larger than stars A and C; you can't tell whether star A is larger than star C from these data
   (E) You can't conclude anything about their sizes from these data

7. Amateur radio ("ham") signals can have very long wavelengths around a hundred meters. Which of the following is true about these radio signals?

   (A) They are generated by producing energy-level transitions in molecules between energy levels that are about 0.1 eV apart
   (B) They pose a significant danger to human health because their wavelengths are so long
   (C) They are transmitted at very low power
   (D) They have very low frequencies
   (E) They have large amounts of energy per photon

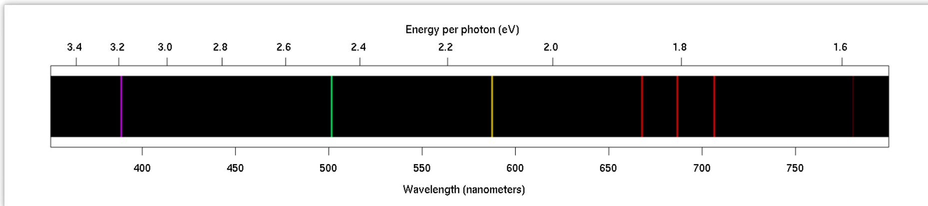
8. How can astronomers best determine the temperature of stars near us in the Milky Way?

   (A) By examining them with a thermal camera similar to the ones we used in class/lab
   (B) By looking at the peak wavelength at which they emit light (or, equivalently, their color)
   (C) By looking at the location of the thin bright lines that appear in their spectra
   (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

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

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

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



(A) A hot object heated to thousands of degrees

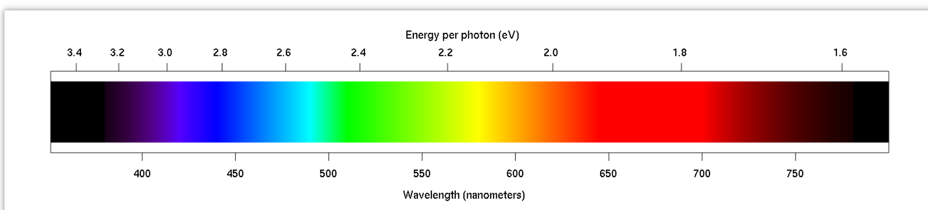
(B) Reflected light from the wall of a room that was lit by a mixture of incandescent and fluorescent lamps

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

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

(E) None of the above

11. 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

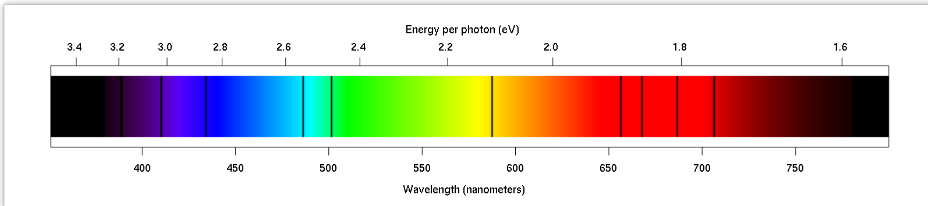
(B) A hot object heated to thousands of degrees

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

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

(E) None of the above

12. 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

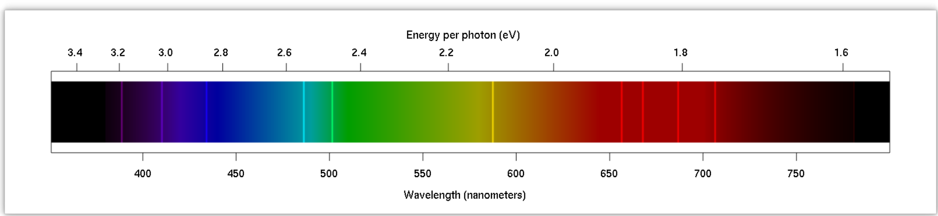
(B) A hot object heated to thousands of degrees, seen through the atmosphere of a planet or star

(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

13. 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

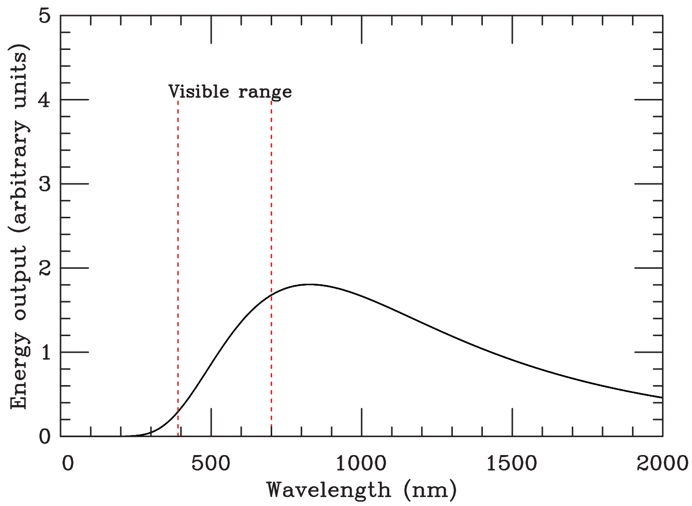
(B) A diffuse gas in an electrified tube, such as the ones you used in lab

(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

14. Consider the spectral curve below, showing the light given off by a chunk of carbon heated to 3500 K.



What type of light does this object primarily emit?

(A) Gamma rays
(B) Visible light
(C) Ultraviolet light
(D) X-rays
(E) Infrared light

15. Suppose that a particular element has its first four energy levels of 0 eV, 3 eV, 5.2 eV, and 7 eV. You have a sample of this element at room temperature, so almost all of its atoms are initially in their ground state.

If you illuminate it with ultraviolet light whose photons have 5.2 eV of energy while looking at it with a handheld spectroscope, what will you see? *(Reference the mapping of photon energy to color included with your exam.)*

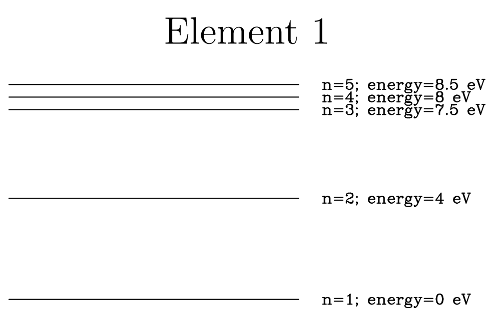
(A) One bright blue/violet line, one bright yellow/green line, and one bright red line
(B) Nothing, because you can't see ultraviolet light of that energy
(C) A continuous band of color, like a rainbow
(D) One bright blue/violet line and one bright yellow/green line
(E) One bright blue/violet line

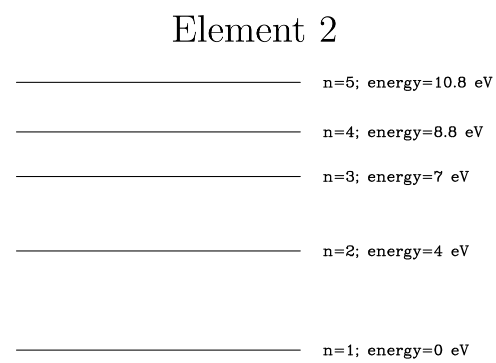
16. You take this same element with energy levels of 0 eV, 3 eV, 5.2 eV, and 7 eV, vaporize it and make a diffuse gas, and put it in an electrified emission tube that tears the electrons completely away from the nucleus.

    As they transition back down to the ground state, they will emit light. If you examine this light using a computer spectrometer that can see wavelengths of light outside the visible range, what will you see? *(The visible range is from 1.6-3.2 eV.)*

    (A) Three lines in the ultraviolet and three lines in the visible range
    (B) A continuous band of wavelengths extending from the ultraviolet to the visible range
    (C) Three lines in the visible range
    (D) One line in the visible range and two lines in the ultraviolet
    (E) Three lines in the ultraviolet, one line in the visible range, and two lines in the infrared

17. You are put in charge of designing a new sort of fluorescent light bulb, and have to choose what sort of gas to put inside. A chemist presents you with two options.





    Are either of these gases suitable for use by humans? *(The visible range is 1.6 eV - 3.2 eV.)*

    (A) Element 2 is suitable, but Element 1 is not
    (B) Element 1 is suitable, but Element 2 is not
    (C) Both elements are suitable to use in a fluorescent light bulb
    (D) Neither element is suitable to use in a fluorescent light bulb
    (E) Either element could be suitable, depending on the temperature that they are heated to

18. You observe a star that is slightly smaller than the Sun. However, when looking at it through a spectroscope, you see far fewer dark lines than in the Sun's spectrum.

    What can you conclude about this star?

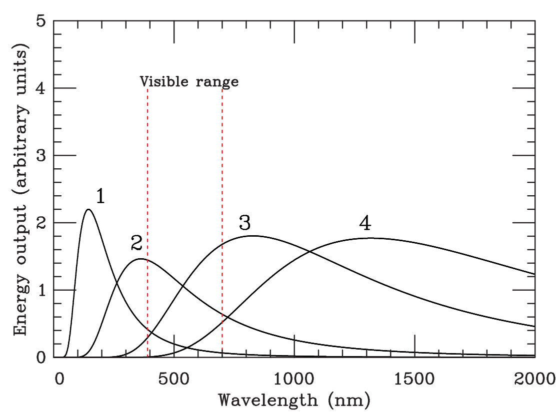
    (A) This star does not have planets orbiting it
    (B) This star is much hotter than the Sun
    (C) This star does not have many different elements in its atmosphere
    (D) This star is fusing helium into carbon in its core
    (E) This star is much cooler than the Sun

19. 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.

    Which statement is true?

    (A) You are emitting infrared light, and the snowman is emitting ultraviolet light
    (B) 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.
    (C) You are emitting infrared light, but the snowman is not emitting light
    (D) Neither of you is emitting light
    (E) 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.

20. Here are spectral curves from four different objects.



    Which one of the spectra shown to the right would come from an object with the highest temperature?

    (A) Spectrum 1
    (B) Spectrum 2
    (C) Spectrum 3
    (D) Spectrum 4
    (E) You can't tell temperature from these, only wavelength

21. Look back at the four spectral curves shown in the previous question.

Which of these corresponds to the thermal radiation emitted by a person?

(A) Spectrum 1

(B) Spectrum 2

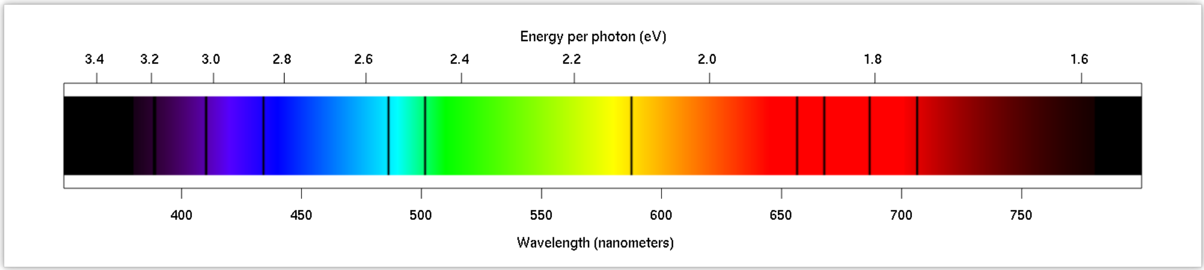
(C) Spectrum 3

(D) Spectrum 4

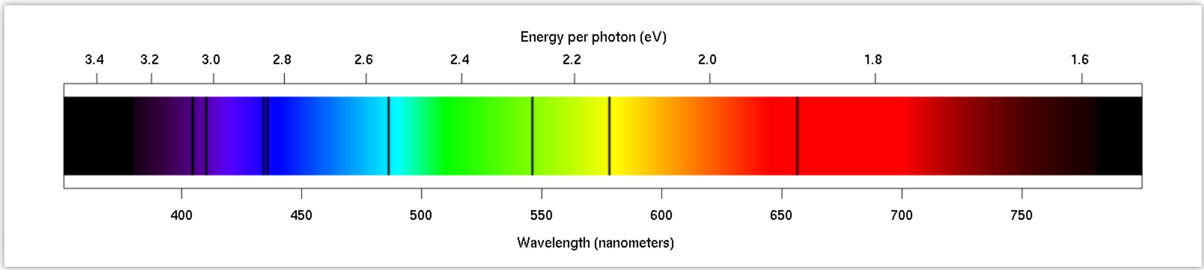
(E) None of these correspond to the spectrum that a person produces

22. Which of the following spectra would you expect to see if you were looking at a star with only hydrogen and helium in its atmosphere? *(Consult the reference spectra provided to you with your exam.)*

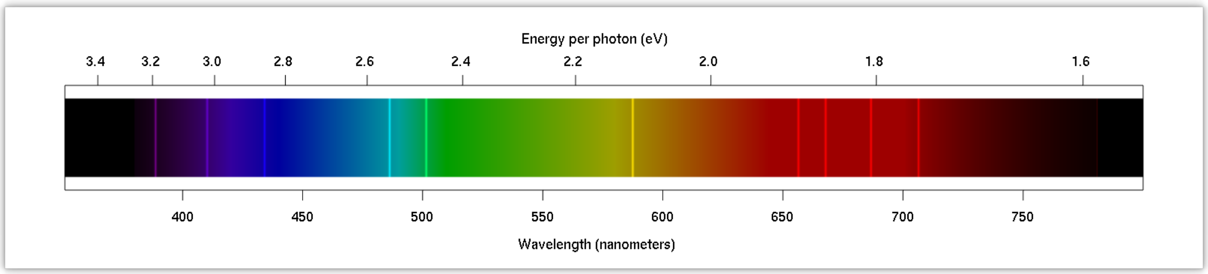
(A)



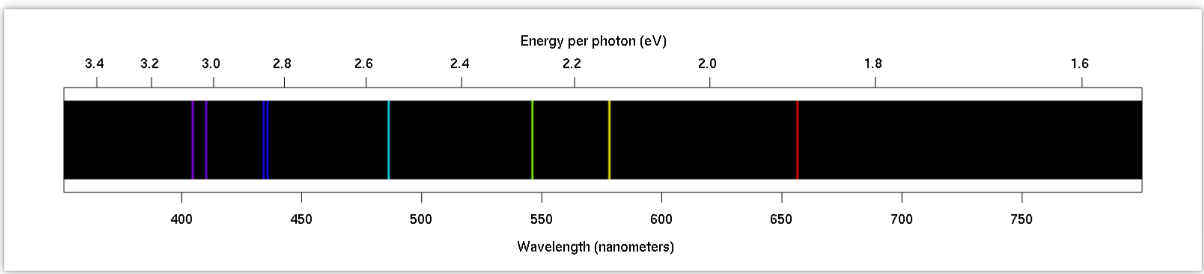
(B)



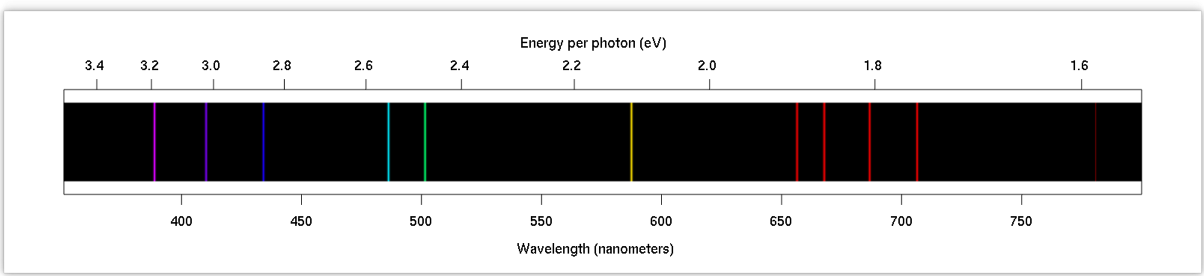
(C)



(D)



(E)



23. A hypothetical element Syracusium has energy levels of 0 eV, 5 eV, 7 eV, and 7.5 eV. If you put a diffuse gas of this element in a tube and run electric current through it, what sort of light will come out?

    (A) Photons of energies 5 eV, 2 eV, and 2.5 eV
    (B) Visible and infrared photons of a wide range of energies, depending on its temperature
    (C) Photons of all energies up to 7.5 eV
    (D) Photons of energies 0.5 eV, 2 eV, 2.5 eV, 5 eV, 7 eV, and 7.5 eV
    (E) Photons of energies 0.5 eV, 5 eV, 7 eV, and 7.5 eV

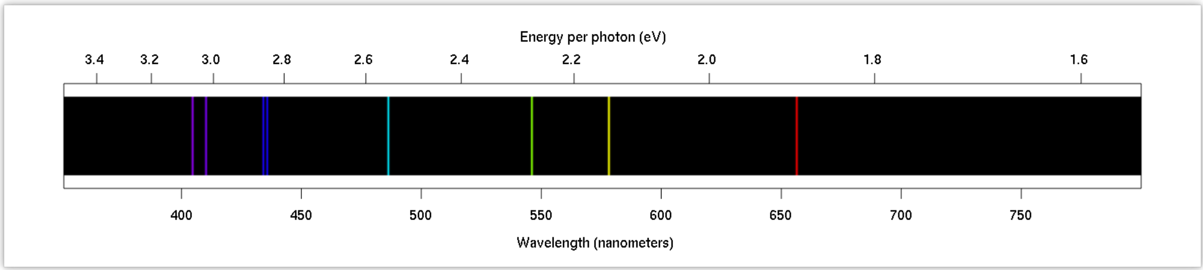
24. How could you determine the temperature of the Moon by measuring the spectrum of moonlight? Imagine that you are using the Hubble Space Telescope, so there is no interference from Earth's atmosphere. *(Inspired by a question suggested by Mingkun; thanks!)*

    Hint: the temperature of the part of the Moon facing Earth is a few hundred Kelvin.

    (A) By examining the thin bright lines that occur in its spectrum
    (B) By examining much longer wavelengths that it emits, around ten times the wavelength of visible light. (This could be done regardless of the Moon's phase.)
    (C) By waiting for a full moon, and examining the wavelengths of visible light that constitute moonlight
    (D) By examining the thin dark lines that occur in its spectrum
    (E) There's no way to measure the temperature of the Moon since it doesn't produce its own light, only reflects the Sun's light

25. 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. *(I wrote this question first and then saw that Andrew wrote a very similar one, so he gets credit!)*

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

26. The leftover radiation from the Big Bang looks like the thermal radiation coming from an object with a temperature of around 3 K. (For reference, room temperature is around 300 K, incandescent light bulbs are around 3000 K, and the Sun is around 5700 K.)

What type of light is this radiation?

(A) Gravitational waves
(B) Microwaves
(C) Ultraviolet
(D) Infrared
(E) Visible light

27. Where do the elements like carbon, oxygen, iron, and silicon around us come from?

(A) They were created in the core of a star which has since exploded in a supernova
(B) They were created in the Big Bang
(C) They are created in the core of the Sun
(D) They are created when the solar wind interacts with Earth's atmosphere
(E) None of the above

28. What property of x-rays makes them more dangerous to human health than microwaves?

(A) X-rays have longer wavelength than microwaves
(B) X-ray photons have much more energy than microwave photons
(C) X-rays cause atoms that they interact with to become radioactive and to decay later
(D) X-ray sources (like an x-ray imaging machine) produce much more total energy than microwave sources (like a microwave oven)
(E) X-rays travel much faster than microwaves

29. Atomic nuclei have energy levels just like electrons do.
In particular, the isotope technetium-99 has its 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) Radio waves
(B) Infrared
(C) Visible light
(D) Gamma rays
(E) Ultraviolet light

Scratch Paper

Scratch Paper