Science Olympiad 2017 Fairfax Division C Invitational Tournament

Astronomy Event Test

TEAM NAME:_____

TEAM NUMBER:_____

TEAM MEMBER NAMES:_____

TOTAL POINTS=_____/75

TEAM RANKING=_____

Answer each of the following questions as completely as possible. Show work for all calculations.

**Points on each question are stated. There will be a one point deduction for each incorrect unit or a missing unit on answers requiring numeric calculation.**

**1.** This question is about the evolution of stars.

(a) Outline the process that provides the source of energy for stars while on the main sequence.

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**(2)**

(b)

(i) Fill in the missing particles in the first step in the primary proton-proton chain.

$${}_1^1p + {}_1^1p \rightarrow {}_1^2H + \_\_\_\_\_ + \_\_\_\_\_$$ **(2)**

(c) State the conditions required for the above process to take place.

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**(1)**

(c) State the reason why stars leave the main sequence.

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**(1)**

(d) Main sequence stars eventually evolve to form red giants. With reference to the Chandrasekhar limit, describe and distinguish between the **subsequent** evolutionary paths of **red giant** stars that have evolved from main sequence stars of mass about two times that of the Sun.

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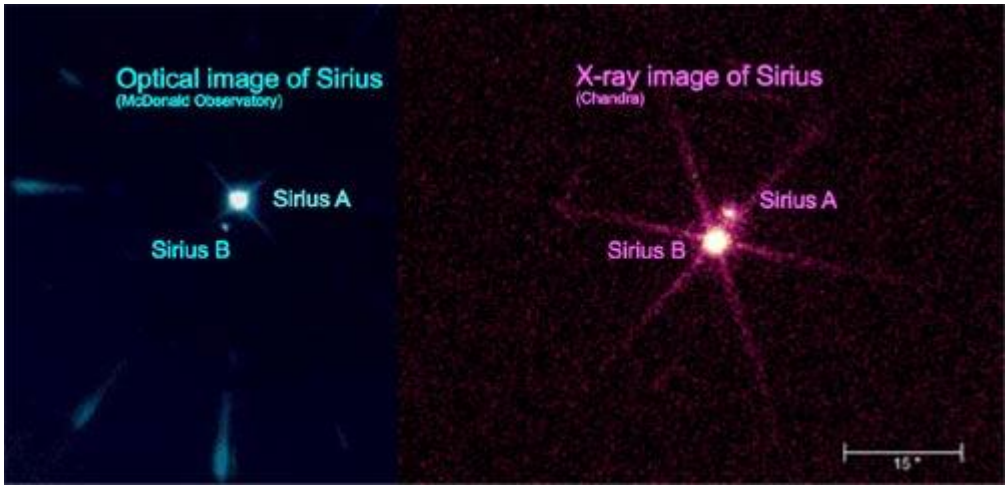
..... (3)

**_____/9 pts**

**2.** This question is about binary stars.

(a) On the lines below, identify which star (A or B) is the main sequence star and which is the white dwarf.




(i) Sirius A:_____Reason:_____ (2)

(ii) Sirius B:_____Reason:_____(2)

(b) Explain the difference between visual binaries and eclipsing binary stars.

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..... (2)

(c) In a particular binary star system, star A has apparent brightness $8.0 \times 10^{-13}$ W m$^{-2}$ and star B has apparent brightness $2.0 \times 10^{-14}$ W m$^{-2}$.

(i) Explain how it is possible to deduce that star A has a higher luminosity than star B.

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**(2)**

_____/8pts

(ii) The surface area of star B is 10 000 times smaller than that of star A. Calculate the ratio

$$\frac{\text{surface temperature of star B}}{\text{surface temperature of star A}}$$

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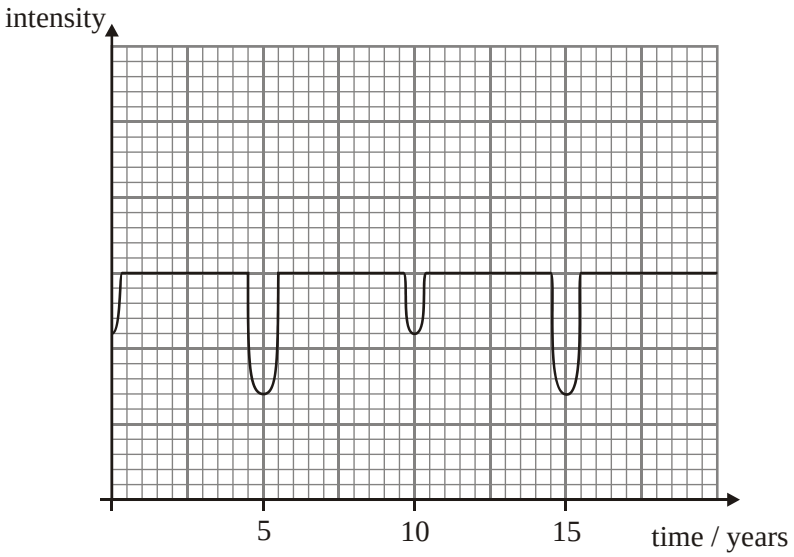
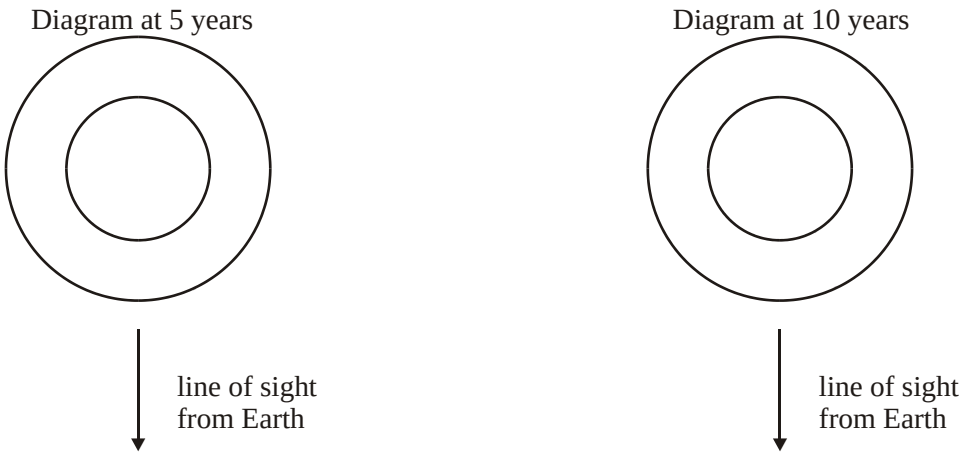
**(4)**

(d) The graph below shows the variation with time of the intensity of light received on Earth from the two eclipsing binary stars.




_____/4 pts

(i) The diagrams below each show the orbits of the two stars. Star A is in the inner orbit. Annotate the diagrams to show the relative positions of stars A and B as seen from Earth, that correspond to the intensity-time graph above at time of 5 and 10 years.




**(2)**

(ii) State the period of this binary star system.

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**(1)**

(iii) State what can be deduced from knowing the period of the binary and the separation of the stars.

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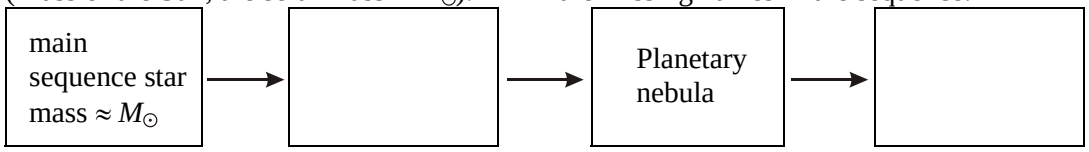
**(1)**

**3.** The diagram below is a flow chart that shows the stages of evolution of a main sequence star such as the Sun. (Mass of the Sun, the solar mass = $M_{\odot}$). Fill in the missing names in the sequence.




(2)

(b) Outline

(i) why white dwarf stars cannot have a greater mass than $1.4M_{\odot}$;

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**(2)**

_____/8 pts

(ii) how a white dwarf is thought to, under special circumstances, undergo a type 1a supernova

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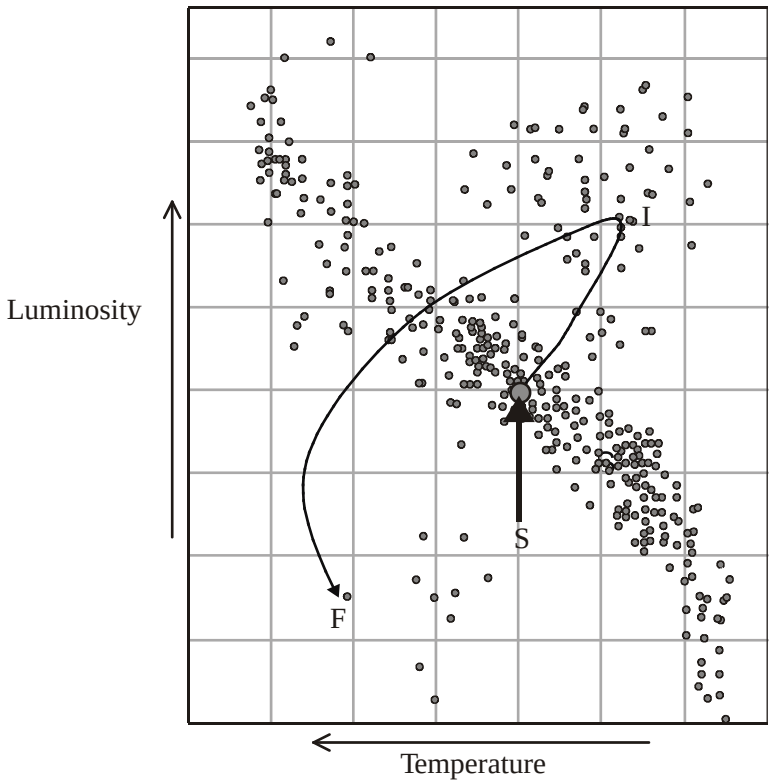
**(3)**

**4.** This question is about stellar evolution.

A partially completed Hertsprung-Russel (H-R) diagram is shown below.




The line indicates the evolutionary path of the Sun from its present position, S, to its final position, F. An intermediate stage in the Sun's evolution is labelled by I.

_____/3 pts

(a) State the condition for the Sun to move from position S.

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**(1)**

(b) State and explain the change in the luminosity of the Sun that occurs between positions S and I.

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**(2)**

(c) Explain, by reference to the Chandrasekhar limit, why the final stage of the evolutionary path of the Sun is at F.

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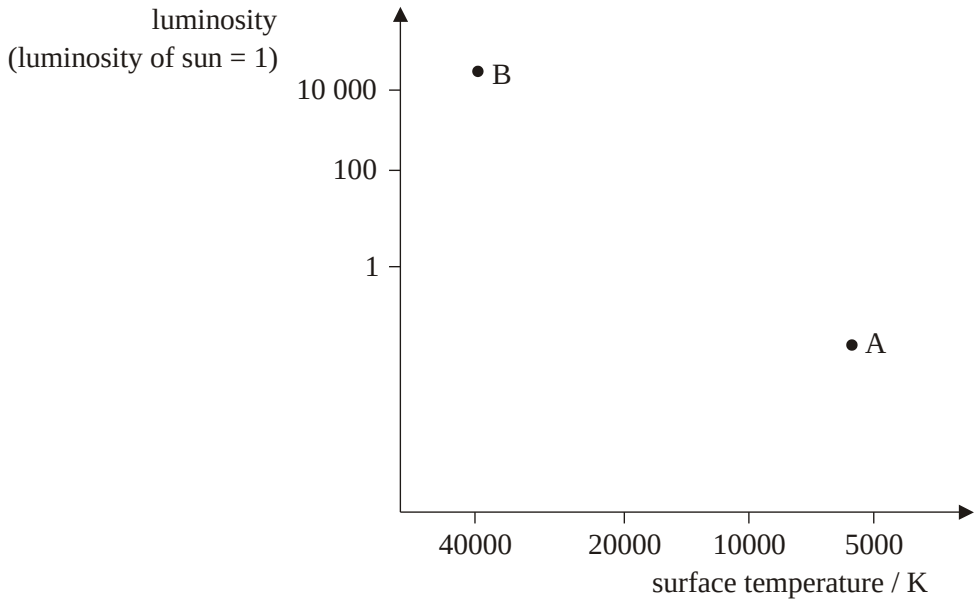
**(2)**

**5.** This question is about two different stars.

The diagram below shows the position of two main-sequence stars A and B with respect to the labeled axes of a Hertzsprung-Russell diagram.




_____/5 pts

(a) Suggest which of the stars has the larger mass.

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**(2)**

(b) State **one** difference between the changes in nucleosynthesis that take place in star B compared to star A after both stars leave the main sequence.

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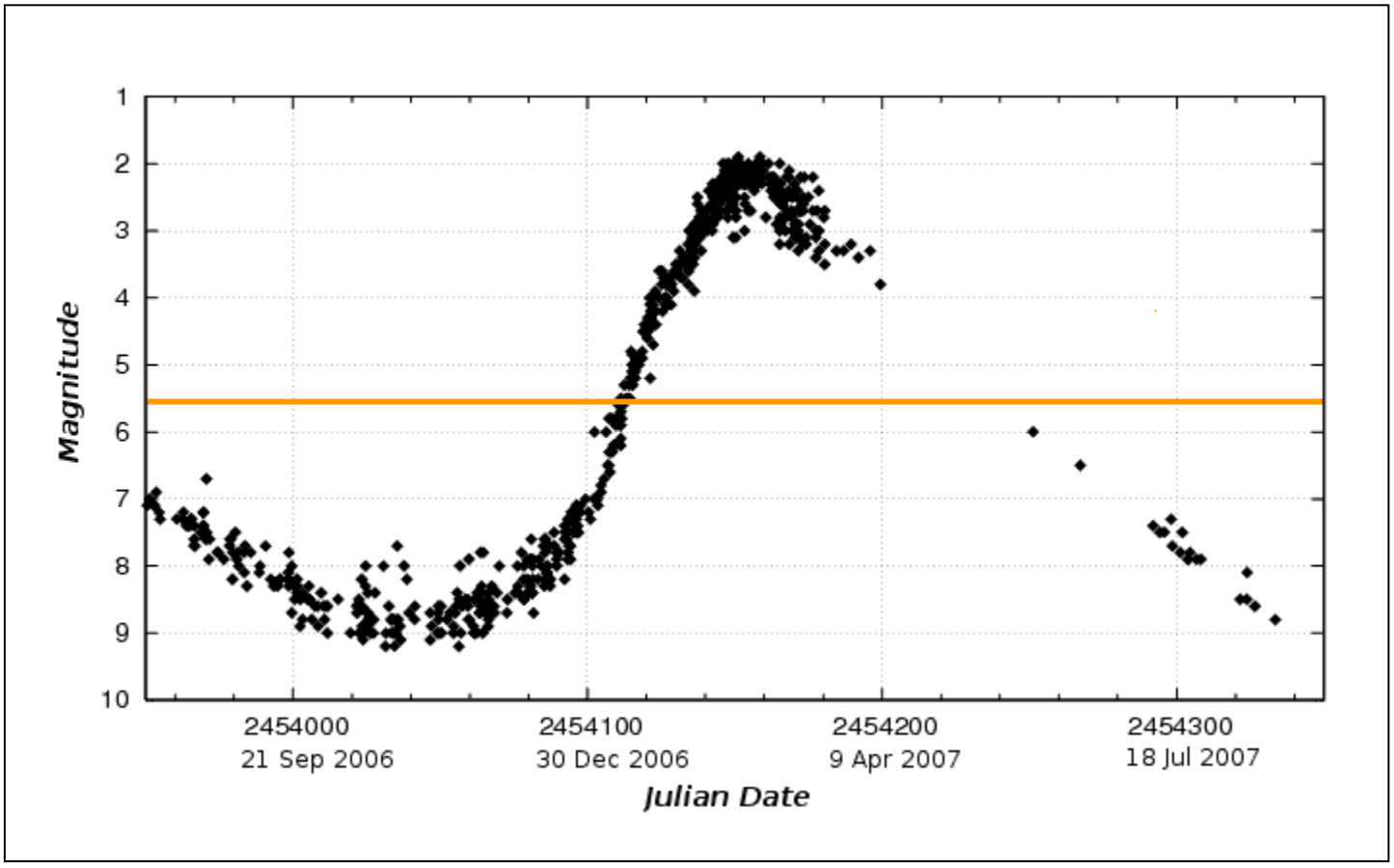
**(1)**

(c) On the H-R diagram on the previous page, mark with the letter X, the approximate final position of star A after it has left the main sequence.

**(1)**

6. The image below shows a light curve from a particular star showing the apparent magnitude on the vertical axis and time on the horizontal axes (given as the Julian date).




_____/4 pts

(a) Which DSO is this light curve most likely from?

…… (1)

(b) The image below is from the star whose light curve is depicted above.

Explain the most likely origins of the "tail" shown in this image.

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…… (3)

(c) Is the object visible to the naked eye? If so, when? Explain.

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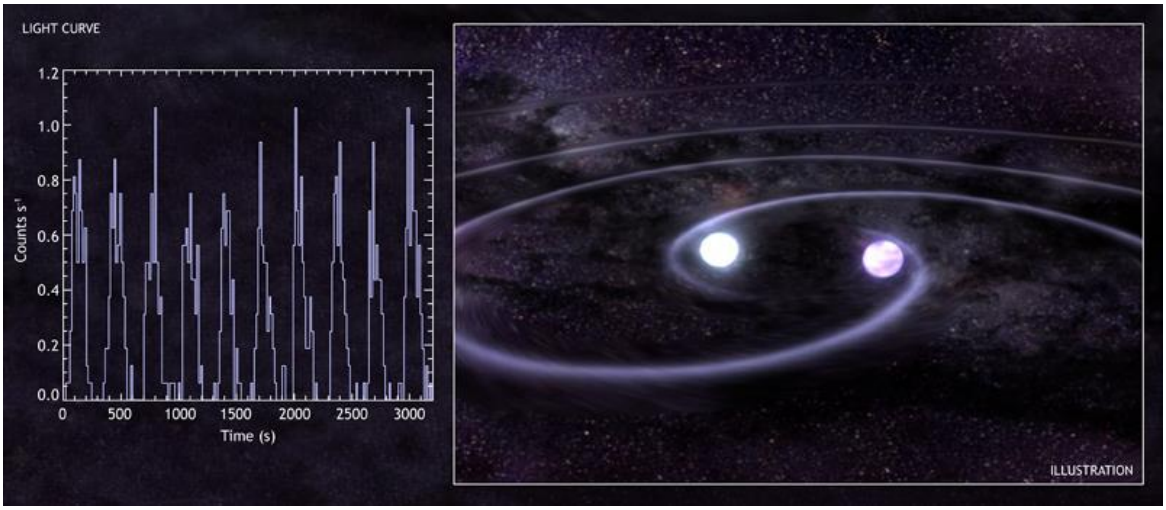
…… (3)

7. The image below shows the light curve from and an illustration of one of this year's DSOs.




_____/7pts

(a) Which DSO is this most likely?

…… (1)

(b) From the light curve, estimate the period of orbit of the binary stars.

…… (1)

(c) Using an estimated mass of each star to be the same as the Sun and the period estimated in (b), estimate the distance separating the two stars. Convert your answer to miles (1 mi≈1600m).

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…… (3)

(d) Measurements show that the period of orbit of the two stars is decreasing by 1.2ms every year. Explain the reason that the stars losing kinetic energy in their orbit.

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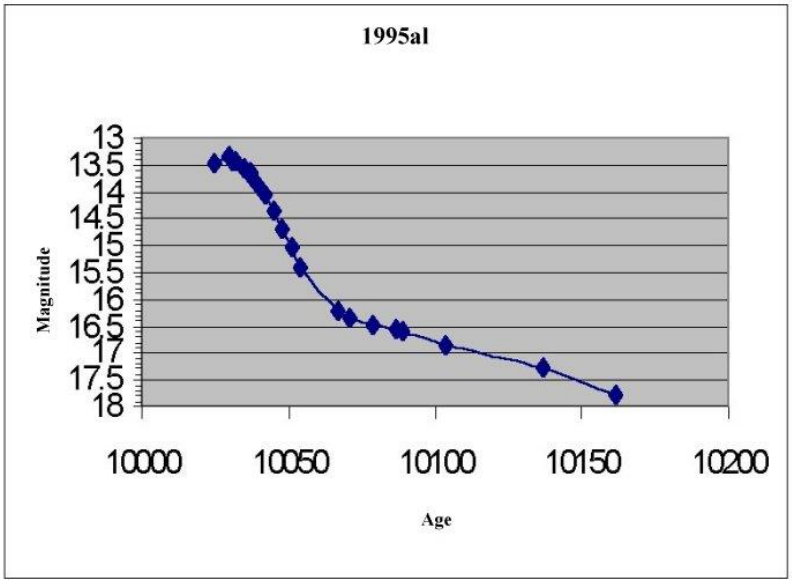
(3)

8. This question is about Type Ia supernova and atomic spectra.




_____/8 pts

The graph on the previous page shows a Type 1a supernova light curve,

(a) Explain how scientist can distinguish whether a supernova is Type I or Type II.

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**(2)**

**(b)** Using information from the graph, calculate the distance to this supernova in light years.

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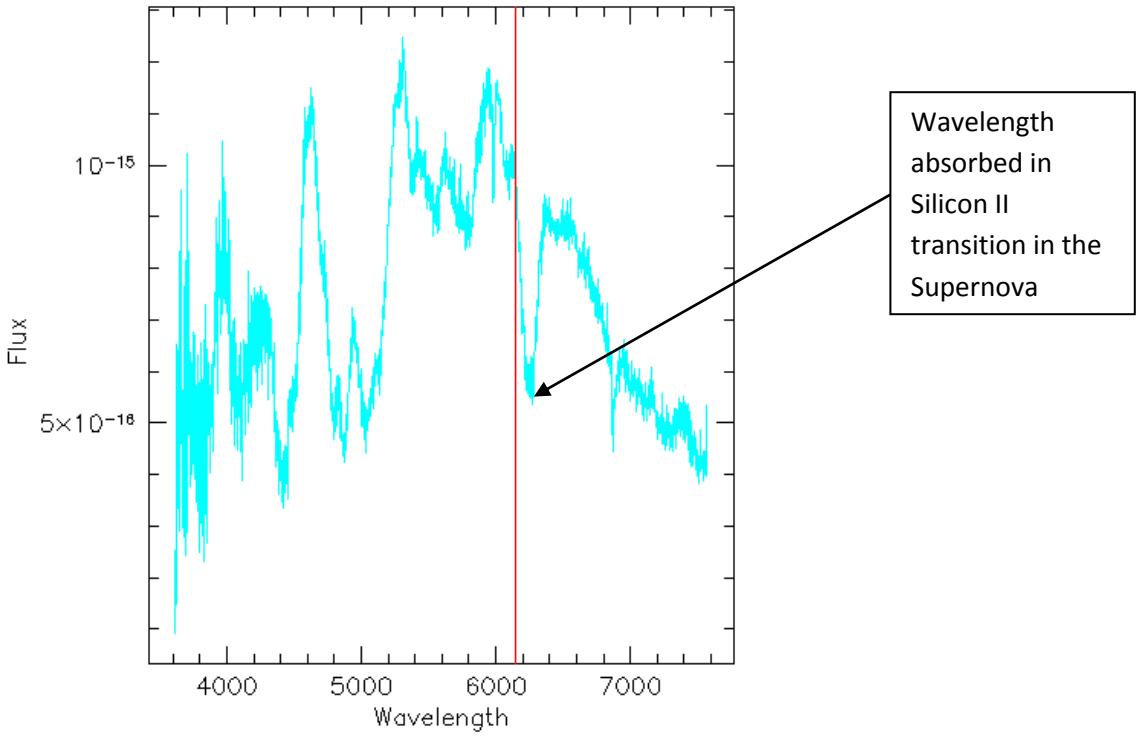
The graph below shows the absorption spectra of the 1995al supernova. The red line indicates the wavelength of light absorbed for one energy transition of Silicon II. This is measured on Earth in the lab at 6150 Angstroms.




_____/5 pts

(c) The wavelength corresponding to the same energy transition in Silicon II however is shifted in the spectra of the supernova explosion. Explain why the wavelength absorbed is *longer* for the same transition in the light coming from the Supernova. What does this indicate about the star's motion?

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(d)(i) A student estimates the shifted wavelength at 6200 Angtroms. Use this estimate to find the recessional velocity of the supernova in km/s.

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(ii) Use the recessional velocity found in (d)(i) to estimate the distance to the supernova in Megaparsecs. .
Use $H_0 \approx 70$ km/s/Mpc.

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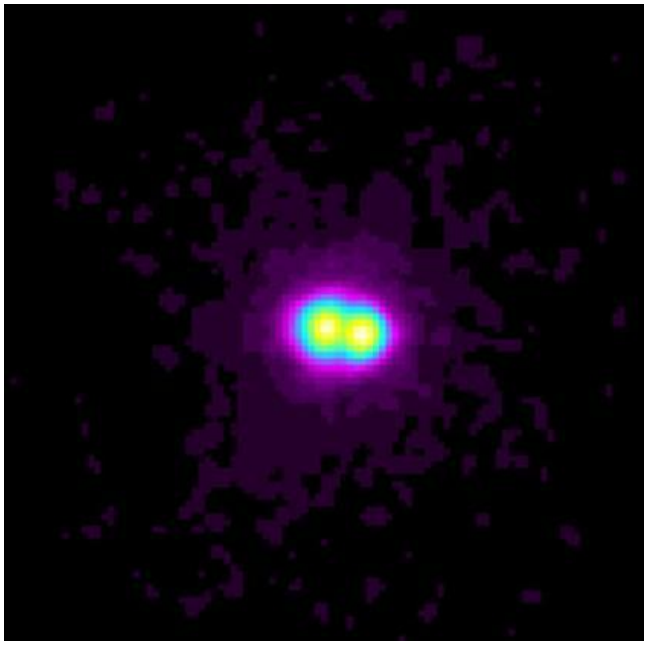
7. This question is about binary stars. The image below is a false-color image of x-ray radiation coming from the M15 cluster.



_____/9 pts

As you can tell, scientists found two intense x-ray signals coming from the cluster. They believe the source of the x-rays are two neutron star X-ray binary systems: 2U2127 and M15 X-2.

(a) Suggest a process by which the neutron binaries would radiate such intense x-ray emission flares.

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…… (2)

(b) The period of the X-2 binary system is 22.58 minutes. Estimating the neutron star as 2 solar masses and its binary companion as 1 solar mass, calculate the distance (in meters) separating this binary pair.

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_____/5 pts