Name: _____

Expanding Universe

Questions

Date:

Time:

Total marks available:

Total marks achieved: _____

Questions

Q1.

The wavelength of a line in the spectrum produced by a distant star is found to be shorter than the wavelength of the corresponding line in the spectrum produced by the Sun.

This is because the distant star is

☒ **A** cooler than the Sun.

☒ **B** hotter than the Sun.

☒ **C** moving away from the Earth.

☒ **D** moving towards the Earth.

(Total for question = 1 mark)

Q2.

When light from the galaxy in Andromeda is analysed, it is found that the wavelengths are shorter than expected.
This tells us that the galaxy is

☒ **A** moving towards us.

☒ **B** moving away from us.

☒ **C** a very distant galaxy.

☒ **D** rotating on an axis.

(Total for question = 1 mark)

Q3.

A line in the hydrogen spectrum of a star in the Milky Way galaxy is observed to have a wavelength of 656.3 nm. In a laboratory on Earth this line has a wavelength of 654.9 nm.

Which of the following expressions gives the magnitude of the velocity of the star relative to Earth?

☒ **A** $\frac{656.3}{654.9} \times 3 \times 10^8 \text{ms}^{-1}$

☒ **B** $\frac{654.9}{(656.3 - 654.9)} \times 3 \times 10^8 \text{ms}^{-1}$

☒ **C** $\frac{654.9}{656.3} \times 3 \times 10^8 \text{ms}^{-1}$

☒ **D** $\frac{(656.3 - 654.9)}{654.9} \times 3 \times 10^8 \text{ms}^{-1}$

(Total for question = 1 mark)

Q4.

A source of sound of constant frequency is moving towards an observer. Compared to the frequency of the source, the frequency of sound heard by the observer is

☒ **A** higher, because the speed of sound increases.

☒ **B** lower, because the air is compressed.

☒ **C** higher, because the wavelength of the sound decreases.

☒ **D** lower, because the amplitude increases.

(Total for question = 1 mark)

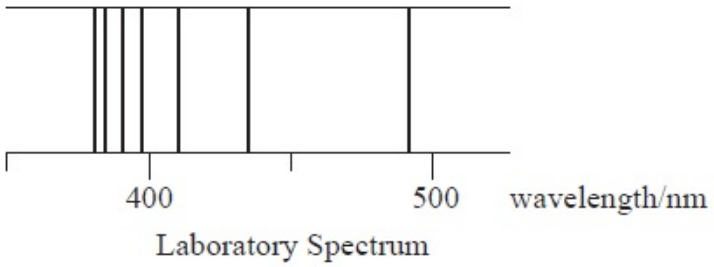
Q5. The diagrams show the motions of a source of sound, S, and an observer, O.

Which line of the table correctly shows the effect this relative motion has on the frequency of the sound heard by the observer.

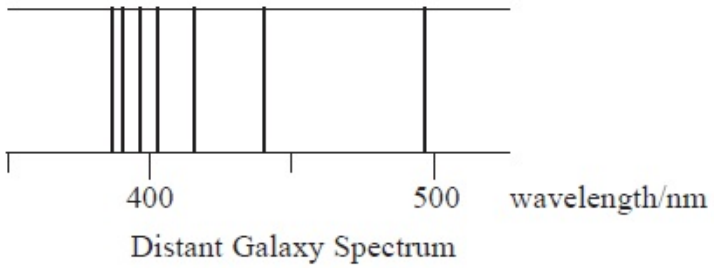
	Motions of S and O	Frequency
☒ A	S ← ● O stationary	increased
☒ B	S → ● ← O	decreased
☒ C	S ← ● O →	decreased
☒ D	S stationary ● O →	increased

(Total for Question = 1 mark)

Q6. The diagram shows part of the hydrogen line spectra obtained for radiation emitted from hydrogen in the laboratory and received from hydrogen in a distant galaxy.



Laboratory Spectrum



Distant Galaxy Spectrum

The lines in the distant galaxy spectrum are all shifted in wavelength compared to the lines in the laboratory spectrum.

State why the lines are shifted and what we can conclude about this distant galaxy.

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(Total for Question = 2 marks)

Q7.

Light from all distant galaxies is found to be shifted towards longer wavelengths. The more distant the galaxy, the greater the shift in wavelength.

State the conclusions that we can draw from this.

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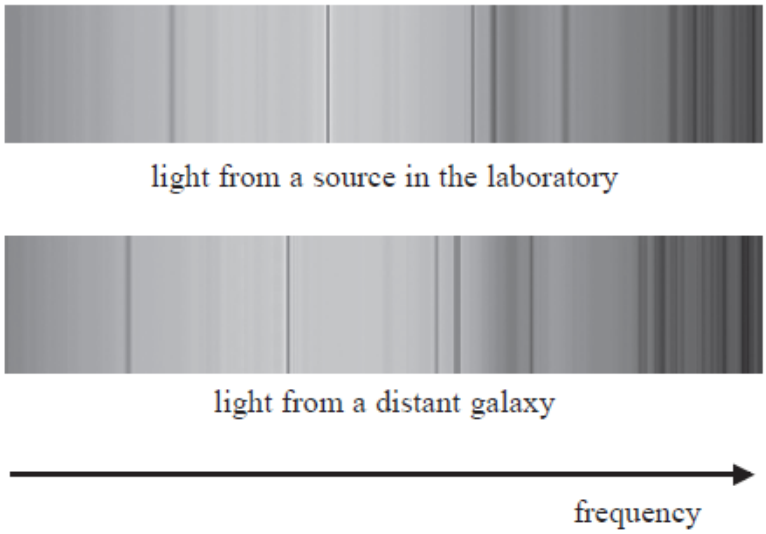
(Total for Question = 3 marks)

Q8.

The spectra below show dark absorption lines against a continuous visible spectrum.



A particular line in the spectrum of light from a source in the laboratory has a frequency of 4.570×10^{14} Hz.
The same line in the spectrum of light from a distant galaxy has a frequency of 4.547×10^{14} Hz.

With the aid of a calculation state what should be concluded about the distant galaxy.

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(Total for question = 3 marks)

Q9.

Barnard's star is a red dwarf star in the vicinity of the Sun. The wavelength of a line in the spectrum of light emitted from Barnard's star is measured to be 656.0 nm. The same light produced by a source in a laboratory has a wavelength of 656.2 nm.

Calculate the velocity of Barnard's star relative to the Earth.

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Velocity = ...

(Total for question = 3 marks)

Q10.

The distance to astronomical objects relatively close to the Sun is determined using trigonometric parallax. For objects beyond a certain distance standard candles are used.

(a) State what is meant by a standard candle.

(1)

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(b) Explain why trigonometric parallax is not used beyond a certain distance.

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(c) Describe how distances too large for the use of standard candles can be determined.

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(Total for question = 6 marks)

Q11. Analysing the light from a star allows elements present in its outer atmosphere to be identified because each element produces a distinctive set of spectral lines.

*(a) Describe how a spectral line is produced by a hot gas, explaining why a particular element can only give rise to particular frequencies.

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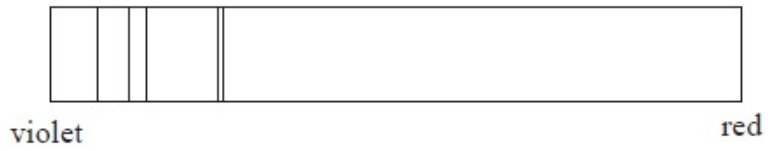
(b) The diagram shows the spectral lines produced by a particular element when observed in a laboratory.

The diagram below shows the spectral lines obtained by analysing the light from a star. This shows the same pattern of lines, but in a different part of the spectrum.



Name this effect and explain what may be deduced about the motion of this star relative to the Earth.

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(c) Suggest what the phenomena in parts (a) and (b) imply about the nature of light.

(1)

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(Total for Question = 10 marks)

Q12.

According to astronomers in Denmark and Australia a common type of active galactic nucleus (AGN) could be used as an accurate "standard candle" for measuring cosmic distances. The technique has been used to measure distances corresponding to redshifts significantly larger than was previously possible.

(a) (i) State what is meant by a standard candle.

(1)

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(ii) Explain how a standard candle is used to measure cosmic distances.

(2)

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(b) (i) State what is meant by redshift.

(1)

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(ii) Calculate the distance to a galaxy with a redshift $z = 0.12$

$H_0 = 2.1 \times 10^{-18}\ s^{-1}$

(2)

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Distance to galaxy = ...

*(c) Discuss how astronomers were led to propose the existence of dark matter and the consequences of its existence for the ultimate fate of the universe.

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(d) Explain why the observable universe has a finite size.

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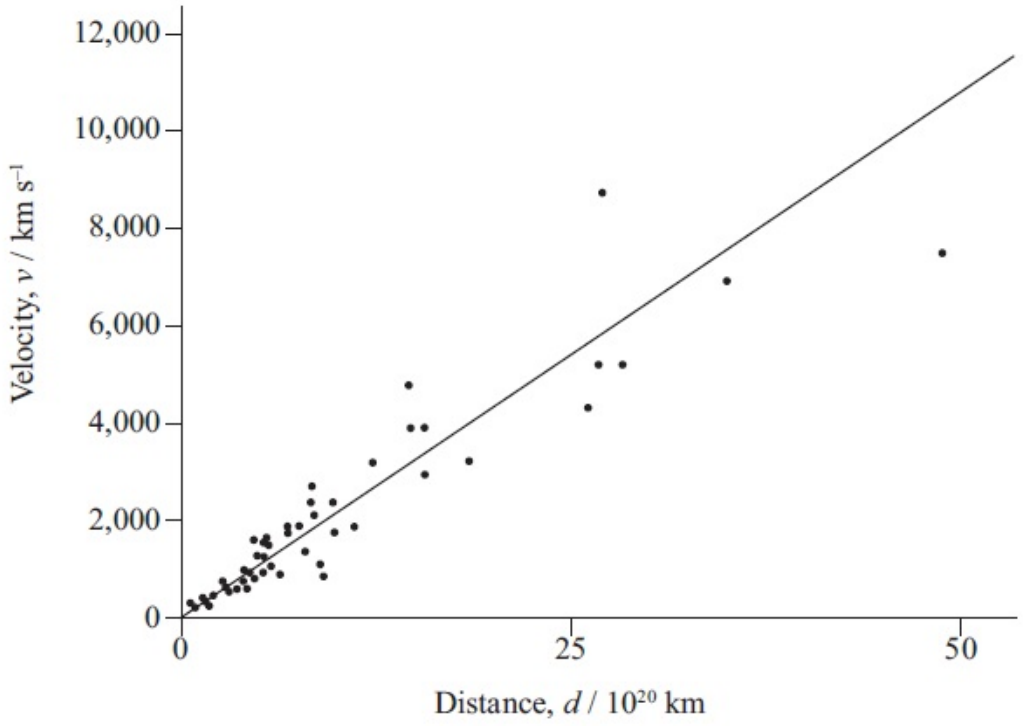
(Total for Question = 11 marks)

Q13.

The graph shows how the velocity varies with distance for a number of distant galaxies. All the galaxies are receding from Earth, and there appears to be a linear relationship between the velocity of recession and the distance to the galaxy.



(a) Use the graph to estimate an age for the Universe

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Age of the Universe = ...

*(b) Describe how astronomers would have determined the velocity of each galaxy.

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*(c) Scientists are uncertain about the ultimate fate of the Universe.

Explain why.

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(Total for question = 12 marks)

Q14.

Almost a century ago Edwin Hubble was investigating the light spectra emitted from a large number of galaxies. He used redshift values obtained from these spectra to determine the velocity of the galaxies relative to the Earth. He also measured the distances to each galaxy using Cepheid variable stars, which are a type of standard candle. From these measurements Hubble was able to formulate a law linking the velocity of distant galaxies to their distance from the Earth.

(a) (i) Explain what is meant by redshift.

(2)

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*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

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(b) State what is meant by a standard candle.

(1)

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(c) Explain how Hubble's law can be used to find a value for the age of the universe.

(2)

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(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

(3)

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(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

(2)

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(Total for question = 13 marks)

Q15.

Helium was first discovered because of dark lines observed in the continuous spectrum of light from the Sun. The lines were caused by a few specific frequencies of light in the spectrum being present at very much lower intensity than the rest.

Scientists deduced that this was due to an unknown element in the Sun's atmosphere.

(a) Explain how helium in the Sun's atmosphere caused this set of dark lines.

(5)

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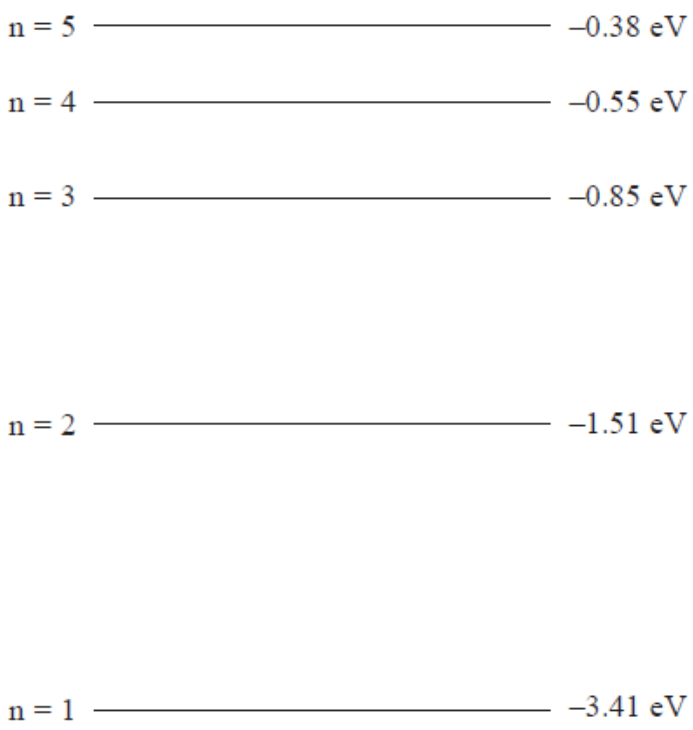
(b) The diagram shows some of the energy levels for an atom of another element.



(i) Determine which energy levels are associated with photons of frequency 4.6×10^{14} Hz.

(4)

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(ii) Suggest why the energy levels all have a negative value.

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(c) Lines such as those described in (a) can be used to determine the motion of stars relative to the Earth.

Suggest how these lines may be used to determine the motion of stars.

(3)

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(Total for question = 14 marks)