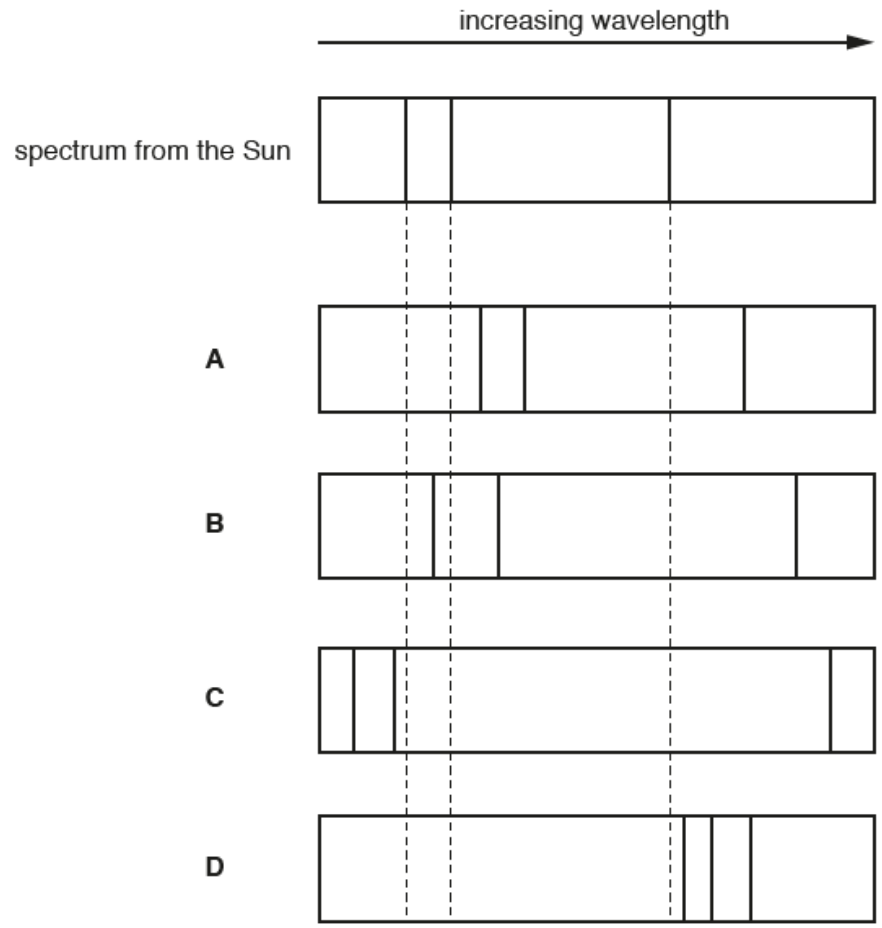
Astrophysics 1

1.

Part of the line spectrum for light from the Sun is shown below.

Which spectrum best shows light from a similar star to the Sun?



Your answer ☐ **[1]**

2.

Which two quantities are related in Hubble's law?

A Distance and mass of galaxies.

B Velocity and intensity of galaxies.

C Distance and velocity of galaxies.

D Distance and red shift of stars in our galaxy.

Your answer ☐ **[1]**

3.

(a) Fig. 21.1 shows some of the energy levels of electrons in hydrogen gas atoms. The energy levels are labelled **A**, **B**, **C** and **D**.

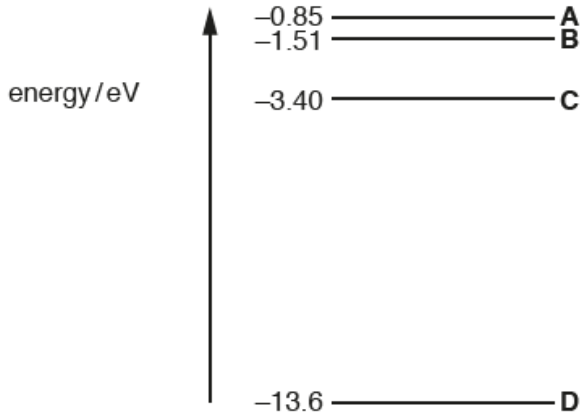


Fig. 21.1 (not to scale)

(i) Explain why the energy levels are negative.

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..... **[1]**

(ii) An electron makes a transition (jump) from level **C** to level **A**.

1 Calculate the energy gained by this electron.

energy = ... eV **[1]**

2 Calculate the wavelength in nm of the photon absorbed by this electron.

wavelength = ... nm **[3]**

(b) Light from a distant galaxy is passed through a diffraction grating. Fig. 21.2 shows the part of the spectrum of light that shows a strong hydrogen-alpha emission line.

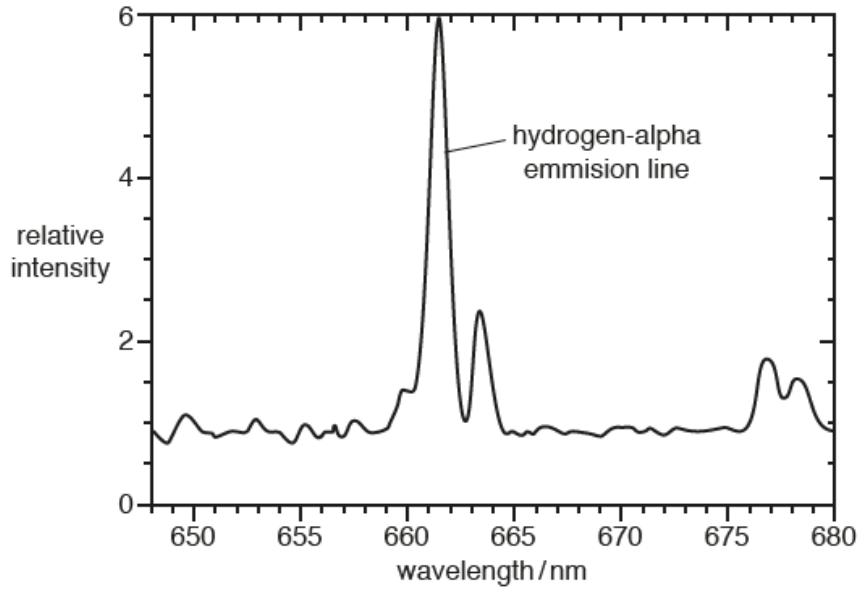

Fig. 21.2

(i) State how an emission line is produced.

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..... **[1]**

(ii) State an adjustment that could be made to the experimental arrangement that would space the emission lines more widely.

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..... **[1]**

(iii) In the laboratory, the wavelength of the hydrogen-alpha emission line is 656.3 nm. Use Fig. 21.2 to determine the recession velocity of the galaxy.

recession velocity = ... $m\,s^{-1}$ **[3]**

(iv) Suggest why hydrogen spectral lines play an important role in determining red shift of galaxies.

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..... **[1]**

(c) Light from a similar star is viewed in a galaxy **further** away. The star is part of a pair of stars which orbit a common centre of mass.
Describe and explain how the equivalent spectrum might appear.

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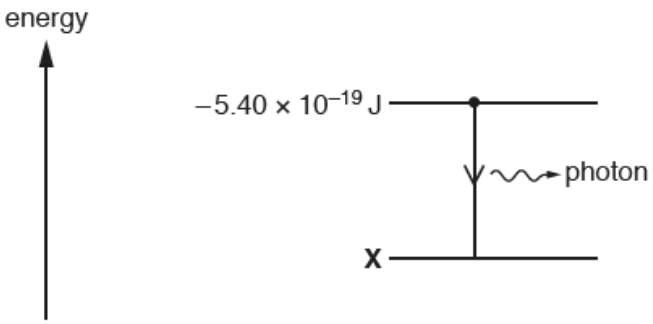
..... **[3]**

4.

An electron makes a transition between the two energy levels shown below.



This transition produces a photon of frequency 4.10×10^{14} Hz.

What is the value of the energy level **X**?

A -2.68×10^{-19} J

B -2.72×10^{-19} J

C -5.40×10^{-19} J

D -8.12×10^{-19} J

Your answer ☐ **[1]**

5.

Fig. 19 is an incomplete Hertzsprung-Russell (HR) diagram of stars in our galaxy.

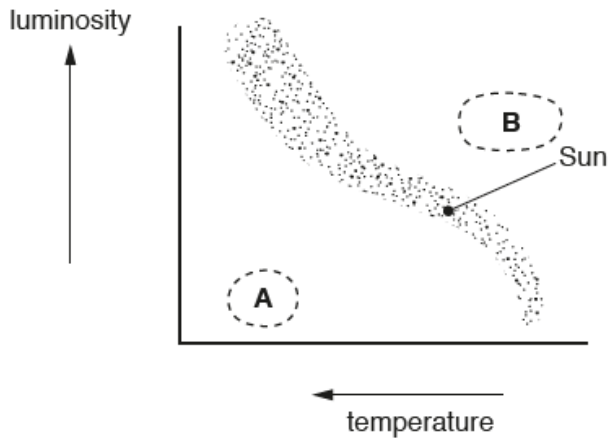


Fig. 19

The position of the Sun on the HR diagram is shown in Fig. 19.

(a) State the type of stars found in regions **A** and **B**.

A ..... **B** ..... **[1]**

(b) The Sun is a main sequence star. Its surface temperature is 5800 K. The wavelength of the emitted light at maximum intensity is 550 nm.

Beta Pictoris is also a main sequence star. The wavelength of the emitted light at maximum intensity from this star is 370 nm.

(i) Calculate the surface temperature of Beta Pictoris.

temperature = ... K **[2]**

(ii) On Fig. 19, mark the likely position of Beta Pictoris with a letter **P**. **[1]**

6.

(a) According to the Cosmological principle, the Universe is isotropic, homogeneous and the laws of physics are universal.

State what is meant by the term *homogeneous*.

.....

..... **[1]**

(b) Astronomers often use absorption spectral lines to determine the relative velocity of distant galaxies. The wavelength of a specific absorption spectral line observed in the laboratory is 280 nm.

The galaxy RXJ1242-11 is 200 Mpc away from the Earth and it has a massive black hole at its centre.

(i) Calculate in nm the wavelength λ of the same spectral line from RXJ1242-11 when **observed** from the Earth. Assume the Hubble constant is 68 $km\,s^{-1}\,Mpc^{-1}$.

λ = ... nm **[3]**

(ii) State one of the characteristics of a black hole.

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..... **[1]**

(c) The Universe evolved from the Big Bang.

Describe the evolution of the Universe up to the formation of the first nuclei.

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..... **[4]**

7.

Which column **A**, **B**, **C** or **D**, shows the correct sequence for the evolution of the Universe between the Big Bang and the formation of stars?

A	B	C	D
Universe starts to expand ↓ quarks and leptons form ↓ hadrons form ↓ nuclei form ↓ atoms form	Universe starts to expand ↓ hadrons form ↓ quarks and leptons form ↓ nuclei form ↓ atoms form	quarks and leptons form ↓ nuclei form ↓ Universe starts to expand ↓ atoms form ↓ hadrons form	quarks and leptons form ↓ hadrons form ↓ Universe starts to expand ↓ nuclei form ↓ atoms form

Your answer ☐ **[1]**

8.

Some stars will evolve into white dwarfs.
The mass of the Sun is 2.0×10^{30} kg.

Which of the following **cannot** be the mass of a white dwarf?

A 1.2×10^{30} kg

B 2.0×10^{30} kg

C 2.7×10^{30} kg

D 3.2×10^{30} kg

Your answer ☐ **[1]**

9.

An astronomer analyses the light from a distant galaxy.
One of the spectral lines in the spectrum observed from the galaxy has wavelength 610 nm.
The same spectral line has a wavelength of 590 nm when measured in the laboratory.

What is the speed of this galaxy?

A $9.8 \times 10^{6}\,\text{m s}^{-1}$

B $1.0 \times 10^{7}\,\text{m s}^{-1}$

C $2.9 \times 10^{8}\,\text{m s}^{-1}$

D $3.0 \times 10^{8}\,\text{m s}^{-1}$

Your answer ☐ **[1]**

10.

(a)* In 2017, an ultra-cool star TRAPPIST-1 was discovered with at least five of its own orbiting planets. Astronomers are interested about the possibility of finding life on some of the planets orbiting TRAPPIST-1.

The table below shows some data.

	TRAPPIST-1	**Sun**
Luminosity *L*/W	2.0×10^{23}	3.8×10^{26}
Surface temperature *T*/K	2500	5800
Radius of star/m	*R*	7.0×10^{8}
Distance between Earth and Sun/m		1.5×10^{11}
Distance between planets and TRAPPIST-1/m	1.6×10^{9} to 9.0×10^{9}	

The temperature *T* in kelvin of a planet, its distance *d* from the star and the luminosity *L* of the star are related by the expression

$$\frac{T^4 d^2}{L} = \text{constant.}$$

- The average temperature of the Earth is about 290 K. Explain how life may be possible on some of the planets orbiting TRAPPIST-1.
- Use your knowledge of luminosity to show that the radius *R* of TRAPPIST-1 is smaller than the Sun.
- Support your answers by calculations. **[6]**

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Additional answer space if required.

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(b) Kepler's third law can be applied to a satellite in a geostationary orbit around the Earth.

(i) Complete the equation for Kepler's third law below.
You do not need to define any of the terms.

$$\text{.....} = \frac{4\pi^2}{GM} \text{.....}$$

[1]

(ii) The mass of Earth is 6.0×10^{24} kg.
Calculate the radius of the circular path of a satellite in a geostationary orbit around the Earth.

radius = ... m **[2]**