Exercise 6 – The Expanding Universe

Past Paper Homework Questions

1. The siren on an ambulance is emitting sound with a constant frequency of 900 Hz. The ambulance is travelling at a constant speed of 25 m s^{-1} as it approaches and passes a stationary observer. The speed of sound in air is 340 m s^{-1}.

Which row in the table shows the frequency of the sound heard by the observer as the ambulance approaches and as it moves away from the observer?

	Frequency as ambulance approaches/Hz	*Frequency as ambulance moves away*/Hz
A	900	900
B	971	838
C	838	900
D	971	900
E	838	971

2. Light from an element in a distant star is observed by an astronomer. Analysis of the line spectrum of this light shows it to be redshifted compared to the line spectrum of the same element on Earth.

Compared to the spectrum observed from this element on Earth

A the frequency of each line in the spectrum from the star is greater

B the wavelength of each line in the spectrum from the star is less

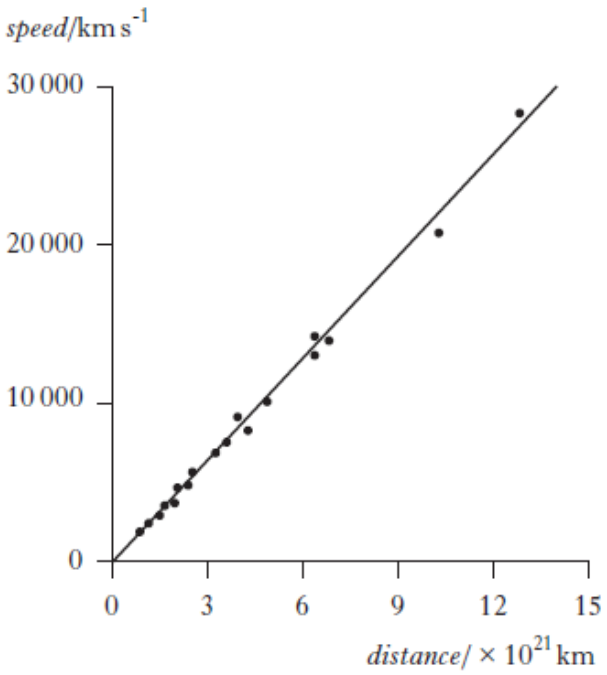
C the frequency of each line in the spectrum from the star is less

D the wavelength of each line in the spectrum from the star is the same

E the frequency of each line in the spectrum from the star is the same.

3. Galaxies at different distances from the Earth have been found to have different speeds.

The graph shows data for some distant galaxies.



A student studies this graph and makes the following statements.

I The speed of distant galaxies varies inversely with their distance from the Earth.

II The gradient of the line gives the value of Hubble's constant.

III The unit for Hubble's constant is s^{-1}.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

4. A galaxy is moving away from the Earth at a velocity of $1{\cdot}20 \times 10^{7}\,\text{m s}^{-1}$.

Light of wavelength 450 nm is emitted from this galaxy.

When detected and measured on Earth this light has a wavelength of

A 425 nm

B 432 nm

C 468 nm

D 475 nm

E 630 nm.

5. An astronomer observes the spectrum of light from a star. The spectrum contains the emission lines for hydrogen.

The astronomer compares this spectrum with the spectrum from a hydrogen lamp. The line which has a wavelength of 656 nm from the lamp is found to be shifted to 663 nm in the spectrum from the star.

The redshift of the light from this star is

A 0·011

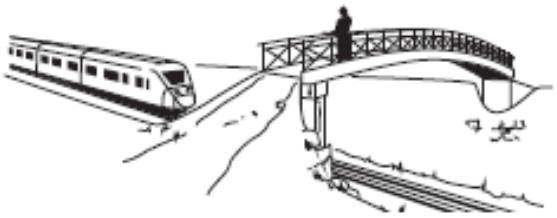
B 0·50

C 0·99

D 2·0

E 94.

6. A train is travelling at a constant speed of $16{\cdot}0\,\text{m s}^{-1}$ as it approaches a bridge.



A horn on the train emits sound of frequency 277 Hz.

The sound is heard by a person standing on the bridge.

The speed of sound in air is $340\,\text{m s}^{-1}$.

The frequency of the sound heard by the person on the bridge is

A 265 Hz

B 277 Hz

C 291 Hz

D 357 Hz

E 361 Hz.

7. By observing the spectrum of light received from galaxy M101, astronomers have determined that the galaxy is moving away from us with a velocity of $5{\cdot}5 \times 10^{5}\,\text{m s}^{-1}$.

(*a*) Calculate the distance of the galaxy from us. **3**

(*b*) The observation that galaxies are moving away from us is evidence for the expanding universe. As the universe expands it cools down.

What property of the Cosmic Microwave Background has been measured by astronomers to determine the present temperature of the universe? **1**

(4)

8. All stars emit radiation with a range of wavelengths. The peak wavelength of radiation, λ_{peak}, emitted from a star is related to the surface temperature, T, of the star.

The table gives the surface temperatures, in kelvin, of four different stars and the peak wavelength radiated from each star.

Surface temperature of star T/K	*Peak wavelength radiated* λ_{peak}/m
4200	$6{\cdot}90 \times 10^{-7}$
5800	$5{\cdot}00 \times 10^{-7}$
7900	$3{\cdot}65 \times 10^{-7}$
12 000	$2{\cdot}42 \times 10^{-7}$

(*a*) Use **all** the data in the table to show that the relationship between the surface temperature, T, of a star and the peak wavelength radiated, λ_{peak}, from the star is

$$T = \frac{2{\cdot}9 \times 10^{-3}}{\lambda_{peak}}$$

2

(*b*) The blue supergiant star Eta Carinae is one of the largest and most luminous stars in our galaxy. It emits radiation with a peak wavelength of 76 nm.

Calculate the surface temperature, in kelvin, of this star. **2**

(*c*) Radiation of peak wavelength 1·06 mm can be detected on Earth coming from all directions in space.

(i) What name is given to this radiation? **1**

(ii) Give a reason why the existence of this radiation supports the Big Bang Theory. **1**

(6)

9. (*a*) Experimental work at CERN has been described as "*recreating the conditions that occurred just after the Big Bang*".

Describe what scientists mean by the *Big Bang theory* and give **one** piece of evidence which supports this theory. **2**

(*b*) During a television programme the presenter states, "*Looking through a telescope at the night sky is like looking back in time*".

Use physics principles to comment on this statement. **3**

(5)

21 marks