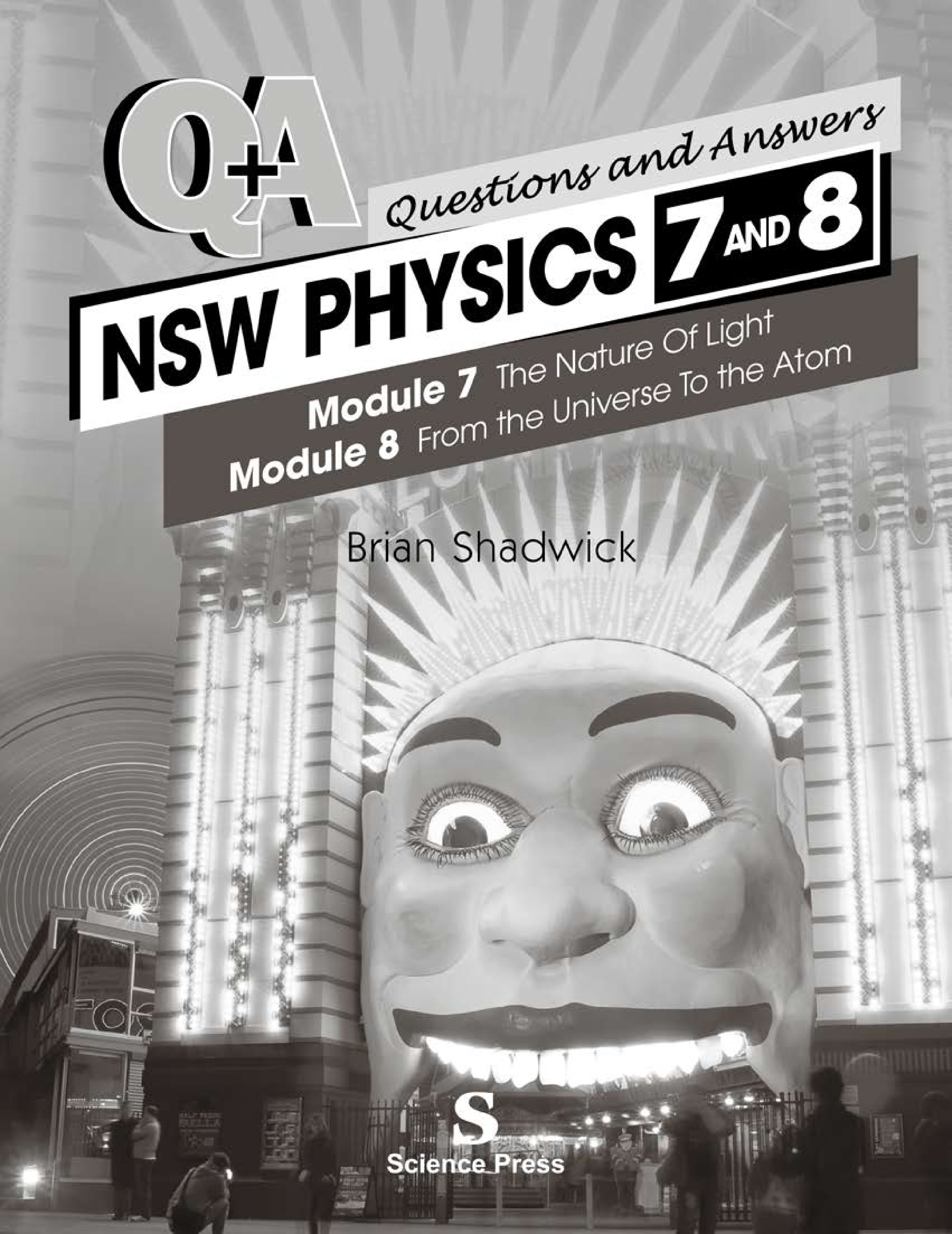

Q+A Questions and Answers

NSW PHYSICS 7 AND 8

Module 7 The Nature Of Light

Module 8 From the Universe To the Atom

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Contents

Analyse the photoelectric effect: $E_k = hf - \phi$ as it occurs in metallic elements by applying the law of conservation of energy and the photon model of light.

Light and Special Relativity

Analyse and evaluate the evidence confirming or denying Einstein's two postulates: the speed of light in a vacuum is an absolute constant and all inertial frames of reference are equivalent.

Investigate the evidence, from Einstein's thought experiments and subsequent experimental validation, for time dilation: $t = \frac{t_o}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ and length contraction: $L = L_o\sqrt{\left(1-\frac{v^2}{c^2}\right)}$.

Analyse experimental validation for special relativity, for example observations of cosmic-origin muons at the Earth's surface, atomic clocks (Hafele-Keating experiment), evidence from particle accelerators and evidence from cosmological studies.

Describe the consequences and applications of relativistic momentum with reference to $p_v = \frac{mv}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ and the limitation on the maximum velocity of a particle imposed by special relativity.

Use Einstein's mass-energy equivalence relationship: $E = mc^2$ to calculate the energy released by processes in which mass is converted to energy. Production of energy in the Sun is coverd in Module 8.

Module 8 From the Universe To the Atom

Origins Of the Elements

Investigate the processes that led to the transformation of radiation into matter that followed the 'Big Bang'.

Investigate the evidence that led to the discovery of the expansion of the Universe by Hubble.

Analyse and apply Einstein's description of the equivalence of energy and mass and relate this to the nuclear reactions that occur in stars.

Account for the production of emission and absorption spectra and compare these with a continuous black body spectrum.

Investigate the key features of stellar spectra and describe how these are used to classify stars.

Words to Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

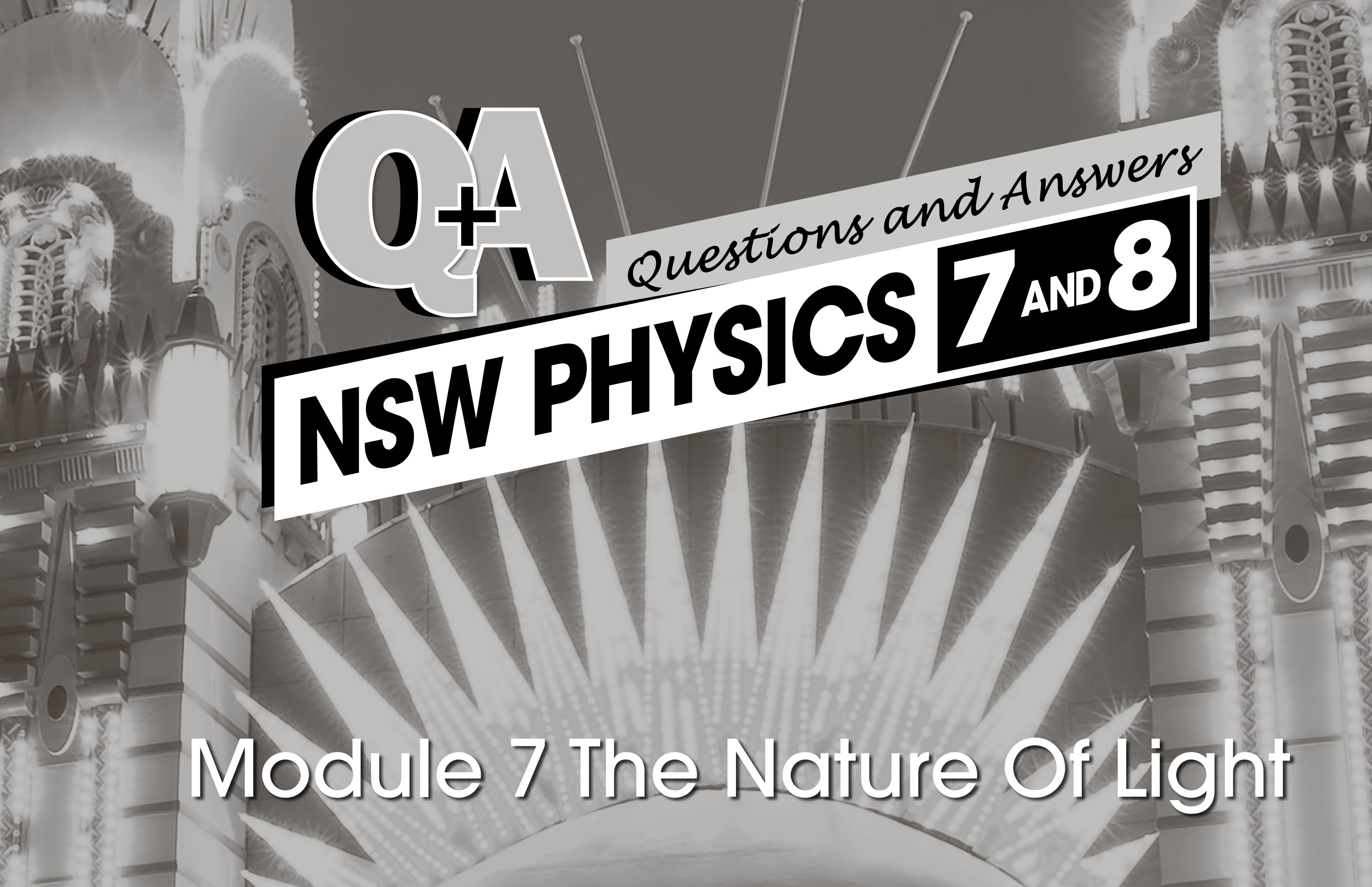
solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.



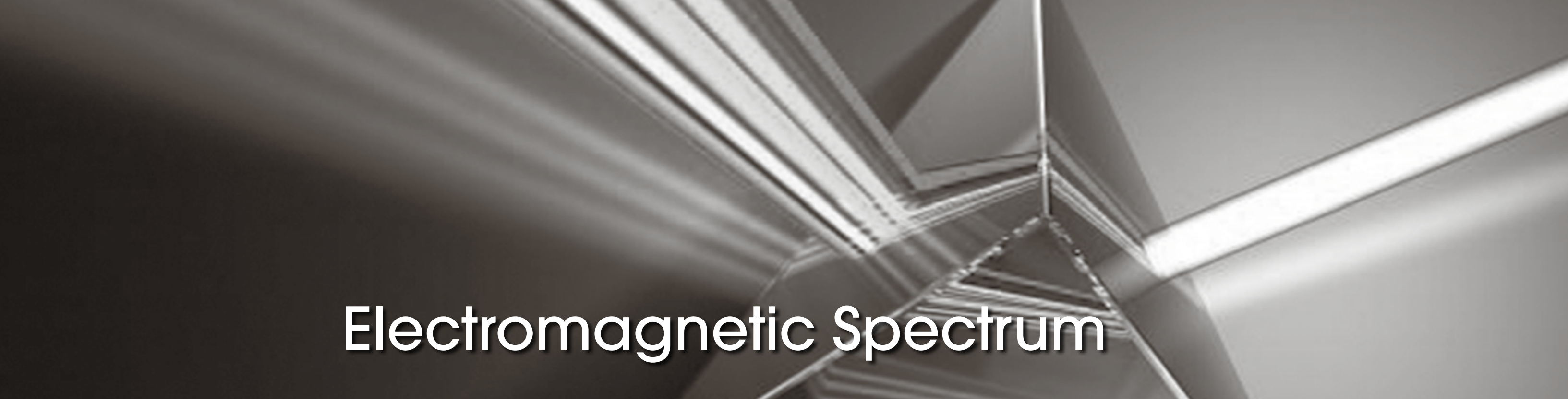
Q+A Questions and Answers NSW PHYSICS 7 AND 8

Module 7 The Nature Of Light

CONTENT FOCUS

In this module you will:

- Examine evidence for the properties of light and evaluate the implications of this evidence for modern theories of physics.
- Study theories and models developed by early physicists, including Newton and Maxwell, about mechanics, electricity and magnetism and the nature of matter.
- Explore how major discoveries in physics in the 20th century challenged existing theories and models and led to the development of quantum theory and the theory of relativity.
- Understand how technologies arising from these new theories have shaped the modern world.
- Engage with all the Working Scientifically skills for practical investigations involving the focus content to examine trends in data and to solve problems and communicate scientific understanding about the nature of light.



Electromagnetic Spectrum

CONTENT FOCUS

Investigate Maxwell's contribution to the classical theory of electromagnetism, including unification of electricity and magnets, prediction of electromagnetic waves and prediction of velocity.

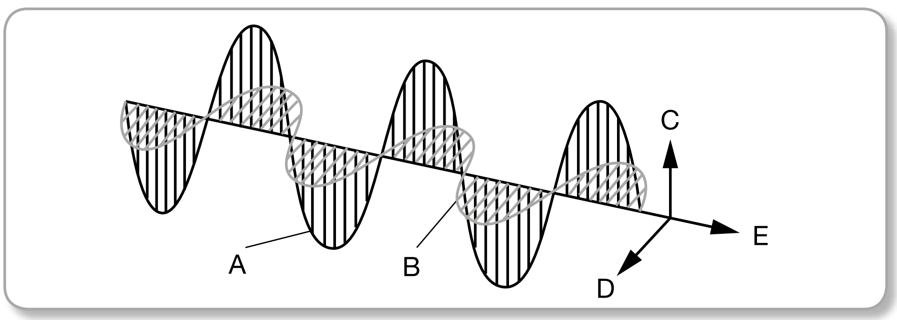
SET 1 James Clerk Maxwell (1831-1879)

1. Copy the first half of each sentence below into your book and then complete them by matching the correct second halves.

(A) Around 1862, Maxwell calculated that the speed of
(B) He proposed that light consists of transverse oscillations of the same
(C) Maxwell proposed that light must be a wave in a medium
(D) In the 1830s Michael Faraday converted electric energy into
(E) Faraday used the results of his experiment to derive electric and magnetic
(F) Maxwell understood the significance of Faraday's work and, in 1864
(G) Maxwell's theory proposed that electricity, magnetism and light
(H) Maxwell's theory also proposed that light was propagated
(I) Maxwell believed that the alternating electric and magnetic
(J) In 1867 Maxwell predicted that there would
(K) This was the first prediction of a

(a) equations to describe electricity and magnetism.
(b) could all be explained using the same theory in physics.
(c) which was the medium carrying electrical and magnetic waves.
(d) be a continuous range of electromagnetic radiations.
(e) proposed a theory connecting light, magnetism and electricity into a single theory.
(f) continuous spectrum of electromagnetic radiation.
(g) fields would vibrate perpendicular to one another.
(h) propagation of an electromagnetic was the same as the speed of light.
(i) magnetic energy using an insulated wire and a galvanometer.
(j) by alternating electric and magnetic fields.
(k) medium which carries electric and magnetic waves.

2. The diagram shows a typical representation of an electromagnetic wave. Identify the labelled parts.



CONTENT FOCUS **Describe the production and propagation of electromagnetic waves and relate these processes qualitatively to the predictions made by Maxwell's electromagnetic theory.**

SET 2 Transverse Electromagnetic Waves

1. (a) What is a transverse electromagnetic wave?

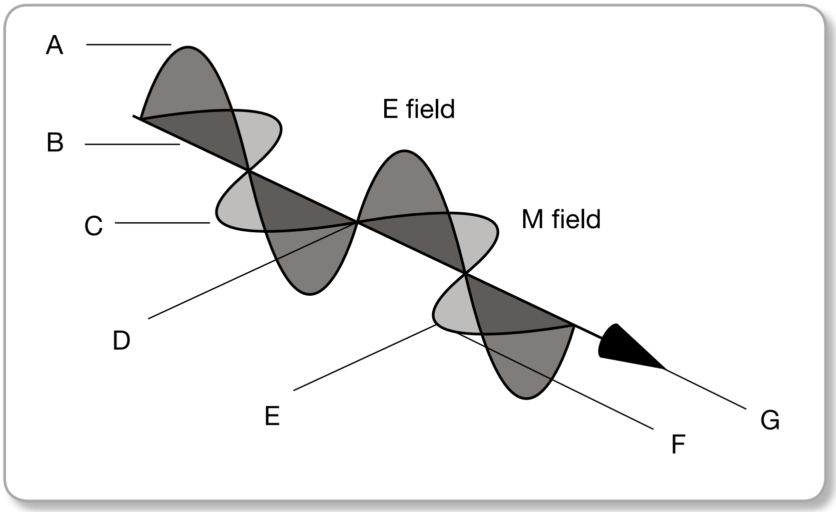
(b) How are they produced?

2. (a) What is an electromagnetic wave?

(b) State three ways in which an electromagnetic wave differs from transverse matter waves.

(c) Given that transverse waves are defined in terms of the relative direction of their particle oscillation, and that electromagnetic waves do not propagate through particle oscillation, why are they referred to as transverse waves?

3. Consider the diagram which represents an electromagnetic wave in the air. The scale of the diagram is 1 cm = 10^{-8} metres.



(a) What is the distance AB on this diagram?

(b) What distance is represented by CD?

(c) What is represented by the distance FG?

(d) What is the wavelength of the wave?

(e) How many wave pulses are shown in the diagram?

(f) How many wavelengths are shown in the diagram?

(g) What is the speed of this wave in air? Justify your answer.

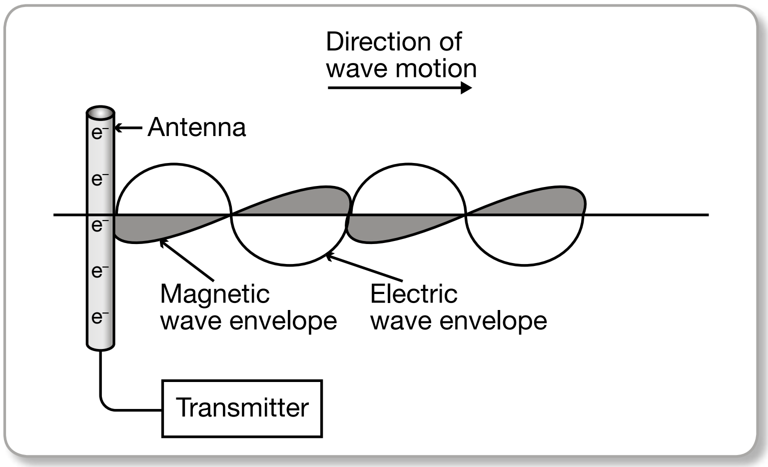
(h) Using the wave equation, $v = f\lambda$, calculate its frequency.

(i) If the frequency of this wave was doubled, what would happen to its speed? Explain your answer.

(j) If the frequency of this wave was doubled, what else would change? Explain your answer.

4. Sheldon Cooper and his friends reflected a laser beam with speed 3×10^8 m s^{-1} off the Moon and received the reflected signal back on Earth 2.5 s later. Despite Kurt's fears, the Moon did not explode during this event. According to this information, what is the distance between the Moon and the Earth?

5. The diagram shows an antenna emitting an electromagnetic wave.



In what way do the electrons in the antenna produce the electromagentic wave?

(A) By remaining stationary.

(B) By moving at constant speed upwards only.

(C) By moving at constant speed downwards only.

(D) By accelerating alternately upwards and downwards.

6. The electromagnetic waves with the highest frequencies are called:

(A) Radio waves.

(B) Gamma rays.

(C) X-rays.

(D) Visible light.

7. Which electromagnetic radiation has the shortest wavelength?

(A) Radio waves.

(B) Gamma rays.

(C) Infra-red waves.

(D) Ultraviolet waves.

8. The range of electromagnetic waves placed in a certain order is called the:

(A) Electromagnetic spectrum.

(B) Electromagnetic wavelength.

(C) Electromagnetic frequency.

(D) Electromagnetic field.

9. What is the same for all emr in a vacuum?

(A) Wavelength.

(B) Frequency.

(C) Speed.

(D) Amplitude.

10. Two types of electromagnetic waves are infra-red waves and ultraviolet waves. Which of these statements describes a property that is shared by infra-red waves and ultraviolet waves?

(A) Both have the same energy.

(B) Both have the same frequency.

(C) Both have the same wavelength.

(D) Both have the same speed in a vacuum.

11. An electromagnetic wave from the Sun travels through space:

(A) At half the speed of light.

(B) At the speed of sound.

(C) At twice the speed of sound.

(D) At the speed of light.

12. How does visible emr from the Sun differ from the non-visible emr from the Sun?

(A) It has different amplitudes.

(B) It travels a different distance.

(C) It travels at a different speed.

(D) It has different wavelengths.

13. Visible light has a higher frequency than:

(A) X-rays.

(B) Ultraviolet rays.

(C) Infra-red rays.

(D) Gamma rays.

14. What is the relationship between the wavelength (λ) and frequency (f) of an emr?

(A) If λ increases, f increases.

(B) If f decreases, λ increases.

(C) If f remains constant, λ increases.

(D) If λ remains constant, f increases.

15. Which statement is true regarding mechanical and electromagnetic waves?

(A) Both types of waves require a medium.

(B) Neither type requires a medium.

(C) A mechanical wave requires a medium, but an electromagnetic wave does not.

(D) Emr speed is affected by a medium, but the speed of a mechanical wave is not.

16. Which has the highest frequency?

(A) Red light.

(B) Yellow light.

(C) Blue light.

(D) Violet light.

17. Which has the shortest wavelength?

(A) Red light.

(B) Yellow light.

(C) Blue light.

(D) Violet light.

CONTENT FOCUS **Conduct investigations of historical and contemporary methods used to determine the speed of light and its current relationship to the measurement of time and distance.**

SET 3 Historical Measurements Of the Speed Of Light

Some of the more notable attempts to measure the speed of light were made by the scientists listed below. Your task here is to research the efforts of *two* of these scientists and compare the reliability and validity of their work.

(Note that the values calculated by these scientists vary from resource to resource, so it is difficult to obtain reliable figures. The values used here must, despite the degree of accuracy they sometimes state, therefore be taken as indicative rather than accurate.)

- 1638 Galileo at least 10 times faster than sound.
- 1675 Ole Roemer 301 000 000 m s^{-1}.
- 1577 Christiaan Huygens 201 168 000 m s^{-1}.
- 1728 James Bradley 301 000 000 m s^{-1}.
- 1848 Hippolyte Louis Fizeau 315 000 000 m s^{-1}.
- 1848 Marie Alfred Cornu 300 400 000 m s^{-1}.
- 1862 Leon Foucault 298 000 000 m s^{-1}.
- 1879 Albert Michelson 299 310 000 m s^{-1}.
- 1926 Albert Michelson 299 798 000 m s^{-1}.
- 1958 Keith Davy Froome 299 792 050 m s^{-1}.

Ole Roemer (1644-1710).

Galileo Galilei (1564-1642).

CONTENT FOCUS

Conduct an investigation to examine a variety of spectra produced by discharge tubes, reflected sunlight or incandescent filaments.

SET 4 Comparing Spectra From Lighting Sources

1. Copy the first part of each sentence into your book, then match the correct second half to it.

(A) The spectrum of any source of radiation depends not only on the

(B) This relationship was found by Max

(C) The hotter the body, the more its Planck

(D) The Planck curves of cooler objects peak

(E) The radiation given out by sources of light will be

(F) Light sources which have filaments that get very

(G) Low temperature vapour light sources such as mercury or sodium vapour

(H) So, sodium vapour lamps will tend to

(I) Modern technology enables low temperature LED globes with a

(J) Note that incandescent light globes have

(K) This is because they produce

(L) Because of this they are no longer allowed

(M) If you still have incandescent lighting fixtures at home, when they 'blow'

(a) more to the red end of the spectrum.

(b) wide variety of colour characteristics to be manufactured.

(c) hot will all usually produce continuous spectra.

(d) to be manufactured in Australia.

(e) be yellow in colour and mercury vapour lamps will be purple.

(f) they will have to be replaced with more energy efficient globes.

(g) different if their composition is not identical.

(h) so much useless heat energy.

(i) composition of the source, but also its temperature.

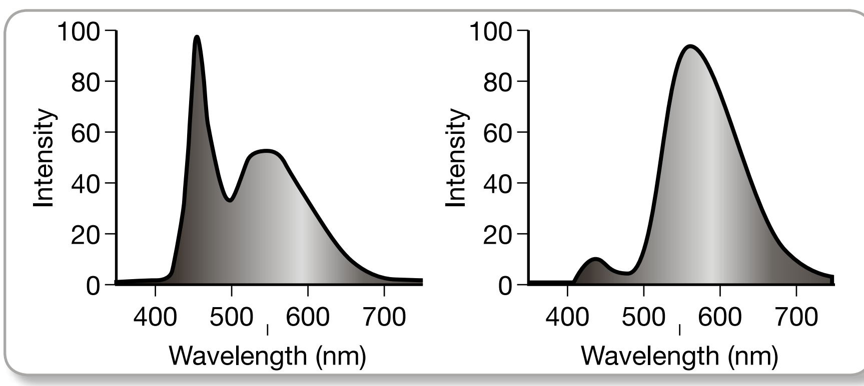
(j) lamps will produce light more consistent with their composition.

(k) curve will be shifted to the blue end of the spectrum.

(l) Planck in his experiments with hot body radiation.

(m) very low energy inefficiency.

2. Consider the two spectra right. One has been produce by a 'cool' white LED and the other by a 'warm' white LED.

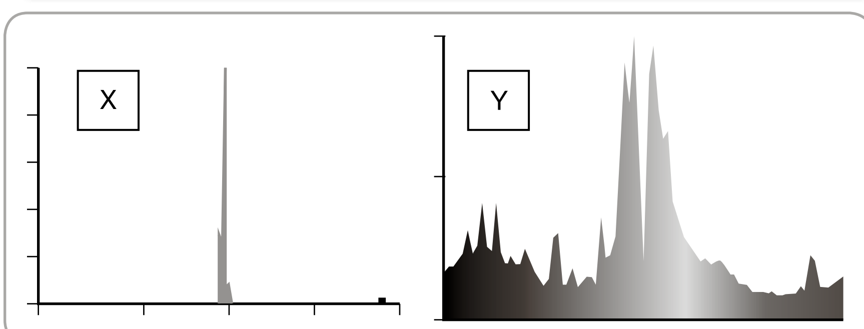


(a) If these spectral curves were Planck curves, which source would be the hotter, the one on the left or the one on the right? Justify your answer.

(b) Account then for their descriptions as 'cool' or 'warm' LEDs.

3. The diagrams show spectra for high and low pressure sodium vapour lamps.

Which is which and justify your answer.



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CONTENT FOCUS

Investigate how spectroscopy can be used to provide information about the identification of elements.

SET 5 Spectroscopy and Elements

1. (a) What is a spectrum?

(b) How can a spectrum be produced in your school laboratory using a glass prism?

(c) Why does a spectrum form using this simple apparatus?

(d) How does this spectrum differ from that of an element?

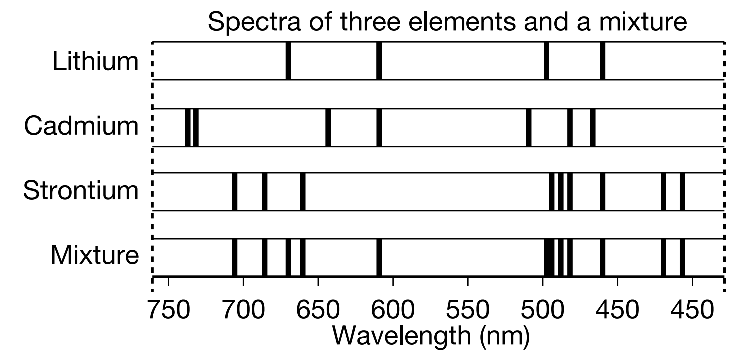
(e) How does the spectrum of an element form?

(f) Why does the spectrum of an element have many lines?

(g) Why are the spectra of elements sometimes likened to fingerprints?

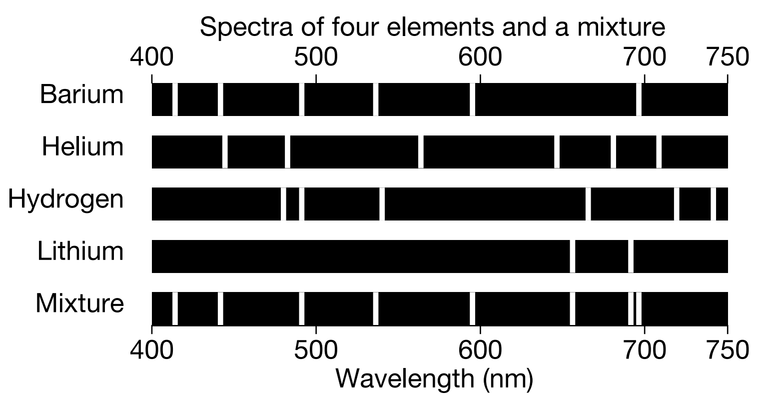
2. The diagram shows the line spectra of three different elements and the line spectrum for a mixture which contains some of these elements.

Which elements are present in the mixture?



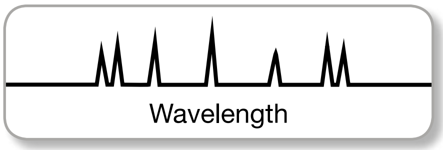
3. The diagram shows the line spectra of four different elements and the line spectrum for a mixture which contains some of these elements.

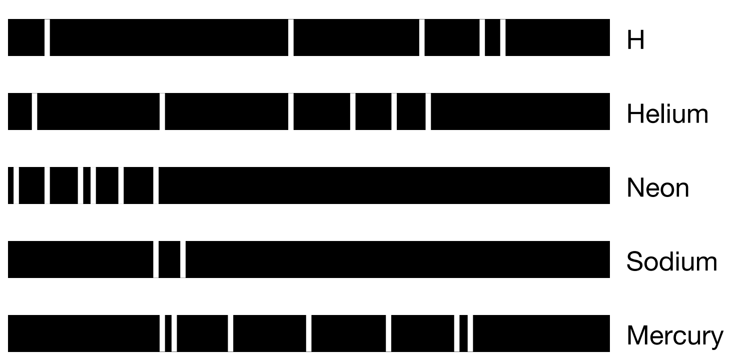
Which elements are present in the mixture?



4. The diagram shows the line spectra of five different elements and the line spectrum for a mixture which contains some of these elements.

Use these spectra to identify the element represented by this line spectrum below.





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5. Classify each of the following statements as true or false. If it is false, write down the true statement.

(a) Emission spectra are characterised by narrow bight lines of specific frequency.

(b) Changing the amount of hydrogen in a container of hydrogen will change the colours of the spectral lines formed from this hydrogen.

(c) Changing the hydrogen in a container to helium will result in a change in the colours of the spectral lines formed.

(d) An absorption spectrum is a continuous spectrum interrupted by black lines.

(e) The wavelengths of the spectral lines formed in an emission spectrum of an element are different to the lines in the absorption spectrum of this element.

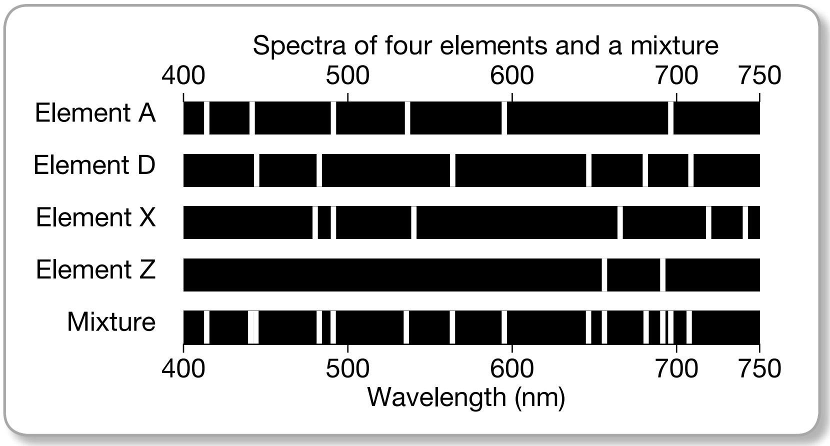
(f) The ground state of hydrogen is that when its electron is in its lowest energy level.

(g) An electron excited above the ground state can have any energy level dependent on the energy used to excite it.

(h) Atoms can remain in excited states indefinitely.

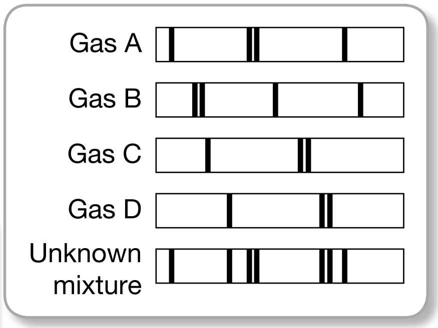
6. The diagram shows the line spectra of four different elements and the line spectrum for a mixture which contains some of these elements.

Which elements are present in each mixture?

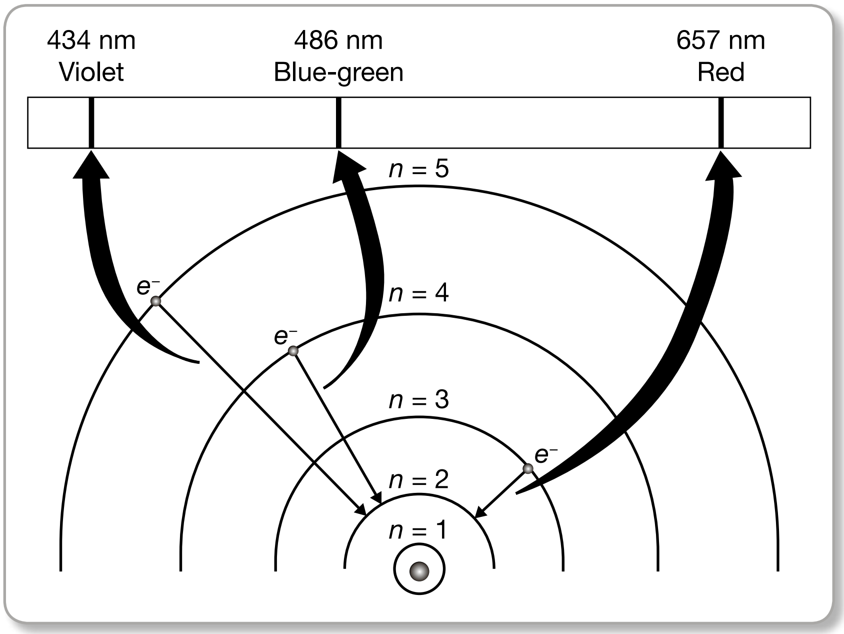


7. The diagram shows the line spectra of four different elements and the line spectrum for a mixture which contains some of these elements.

Which elements are present in each mixture?



8. Consider the diagram below. Explain what this diagram is trying to communicate to students who look at it.



CONTENT FOCUS

Investigate how the spectra of stars can provide information on their surface temperature, rotational and translational velocity, density and chemical composition.

SET 6 Spectra Of Stars

Note that in the following SIX questions there may be more than one answer. Choose all correct answers for each question.

1. An astronomer has observed two nebulae in space that are stationary relative to Earth. Nebula X emits high intensity infra-red light. Nebula Y emits strongly intense ultraviolet light. Which choice(s) best explain this observation?

(A) X has the same average temperature as Y because temperature does not depend on the light emitted.

(B) X has the same average temperature as Y, but Nebula X is farther away, shifting the light emitted.

(C) X has a greater average temperature than Y because hotter objects will emit strongly in infra-red light.

(D) X has a lower average temperature than Y because cooler objects will emit strongly in infra-red light.

2. What use are the electromagnetic spectra of stars to astronomers?

(A) To identify the surface temperatures of stars.

(B) To identify elements of stars and galaxies.

(C) To calculate the rate at which other galaxies are moving either away from or toward us.

(D) To help identify the speed of rotation of distant galaxies.

3. The linear velocity of a star can be determined from its:

(A) Spectral class.

(B) Spectral line Doppler shift.

(C) Its surface temperature.

(D) Its position on the Hertzsprung-Russell diagram.

4. In what way will the spectrum of a hot star differ from that of a cooler star?

(A) There will be more spectral lines in the high frequency region of the spectrum.

(B) There will be more lines in the low wavelength region of the spectrum.

(C) Each spectral line will be of greater intensity.

(D) The spectrum width will be greater.

5. What evidence do we have that quasars are stars that are far away?

(A) The large red shifts in their spectrum.

(B) The strong intensity of X-rays they emit.

(C) The intensity of the ultraviolet lines in their spectrum.

(D) The high intensity of the emission lines in their spectra.

6. What characteristics of the spectrum of a rotating star would tell astronomers that is was rotating?

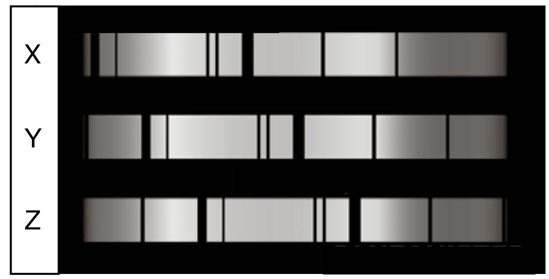
(A) Its spectrum will show a blue shift sometimes and a red shift other times.

(B) Light from one side will show a red shift, and light from the opposite side will show a red shift.

(C) It will show a Doppler effect because it is moving.

(D) The spectrum cannot be used to determine this because the red and blue shifts would cancel each other.

7. Consider the spectra of three stars X, Y and Z.



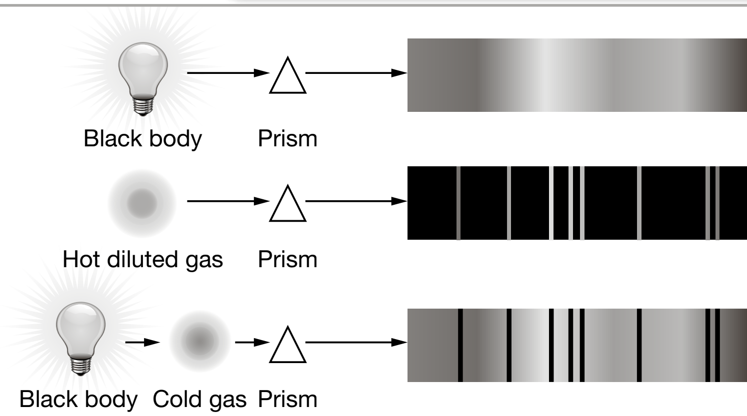
(a) Which one of these stars is stationary relative to Earth?

(b) Which one of these stars is moving towards Earth?

(c) Which one of these stars is moving away from Earth?

(d) Justify your answers.

8. The diagram shows the formation of the three different types of spectra.



(a) Identify each type of spectrum.

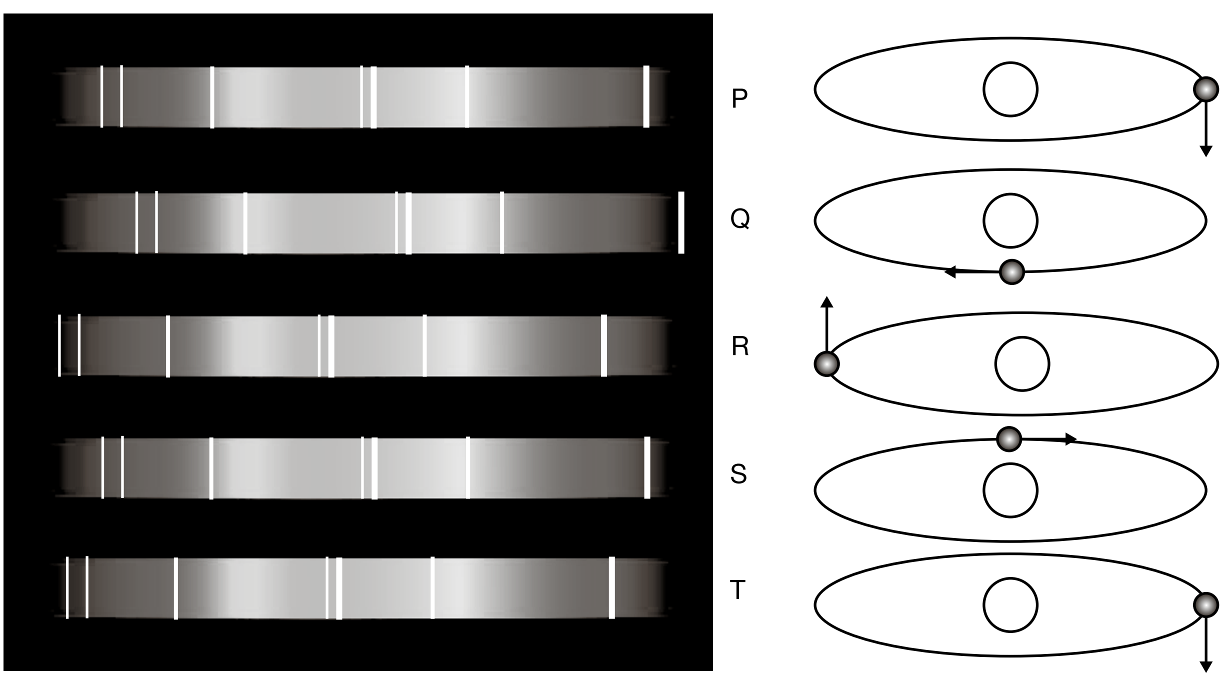
(b) Which of these three types is the one we most commonly view from stars?

(c) Why don't stars emit spectra which show only the elements hydrogen and helium which is what they are composed of?

(d) If all stars emit a continuous spectrum, how can these spectra be used to determine their elemental composition?

(e) What (answer (c)) does this result in in terms of what we see?

9. The five spectra below refer to the binary star system to their right. In this system the smaller star is orbiting the large star. The spectra relate to each position of the smaller star in its obit, but they are not in the correct order. What is their correct order so that they match the diagrams of the stars from top to bottom?



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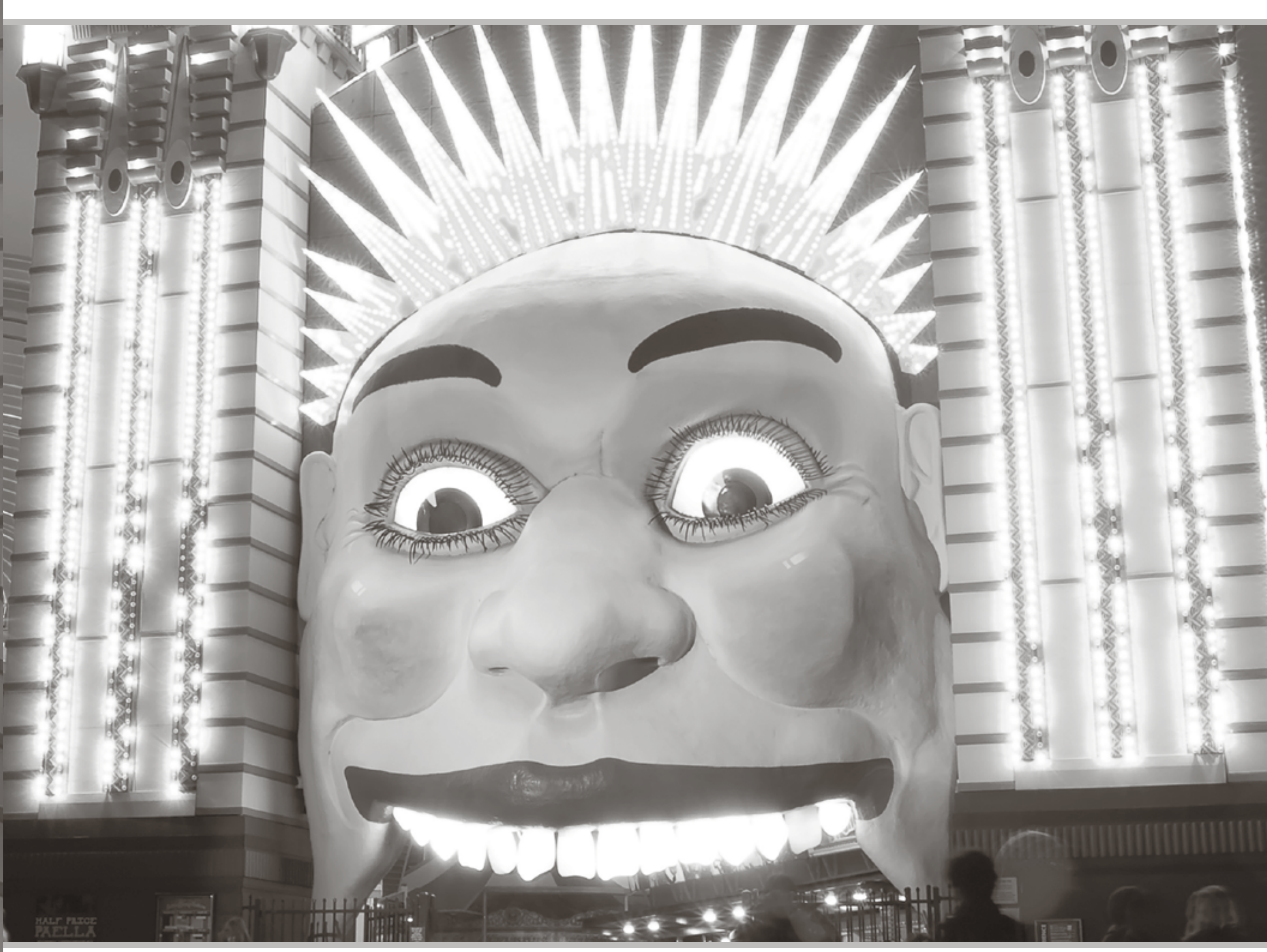
Q+A Questions and Answers

NSW PHYSICS 7 AND 8

Answers



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Set 1 James Clerk Maxwell (1831-1879)

1. (A) Around 1862, Maxwell calculated that the speed of propagation of an electromagnetic was the same as the speed of light.

(B) He propsed that light consists of transverse oscillations of the same medium which carries electric and magnetic waves.

(C) Maxwell proposed that light must be a wave in a medium which was the medium carrying electrical and magnetic waves.

(D) In the 1830s Michael Faraday converted electric energy into magnetic energy using an insulated wire and a galvanometer.

(E) Faraday used the results of his experiment to derive electric and magnetic equations to describe electricity and magnetism.

(F) Maxwell understood the significance of Faraday's work and, in 1864 proposed a theory connecting light, magnetism and electricity into a single theory.

(G) Maxwell's theory proposed that electricity, magnetism, and light could all be explained using the same theory in physics.

(H) Maxwell's theory also proposed that light was propagated by alternating electric and magnetic fields.

(I) Maxwell believed that the alternating electric and magnetic fields would vibrate perpendicular to one another.

(J) In 1867 Maxwell predicted that there would be a continuous range of electromagnetic radiations.

(K) This was the first prediction of a continuous spectrum of electromagnetic radiation.

2. A Electric field (or magnetic field)

B Magnetic field (or electric field)

C Direction of electric field (or magnetic field)

D Direction of magnetic field (or electric field)

E Direction of propagation of the electromagnetic wave

Set 2 Transverse Electromagnetic Waves

1. (a) Transverse electromagnetic waves consist of alternating, self-induced electric and magnetic fields which propagate at the speed of light.

(b) Electromagnetic waves are produced by accelerating charges.

2. (a) An electromagnetic wave consists of self-induced alternating electric and magnetic fields which carry energy from one place to another.

(b) The can travel through a vacuum, they do not involve the oscillation of particles, the energy they carry depends on their frequency rather than the amplitude of the oscillation of the particles.

(c) The self-induced electric and magnetic fields oscillate at right angles to the direction in which the energy is carried and the graphed magnitudes of these fields form a sinusoidal curve. Both of these are properties of transverse waves.

3. (a) Amplitude

(b) $\frac{\lambda}{4}$

(c) Amplitude

(d) CE = 2.4×10^{-8} cm (2.4×10^{-10} m)

(e) 2

(f) 2

(g) 3×10^{8} m s^{-1} (this is the speed of all electromagnetic radiation in a vacuum (and close enough to air)

(h) $3 \times 10^{8} = f \times 2.4 \times 10^{-10}$
Therefore $f = 1.25 \times 10^{18}$ Hz

(i) Nothing. The speed of electromagnetic radiation (or any wave for that matter) in a particular medium is constant. If the frequency doubles, the wavelength will halve to maintain the constant speed.

(j) Its wavelength would halve. Explanation as in (i).

4. From distance = (velocity × time) ÷ 2
$= 3 \times 10^{8} \times 1.25 \div 2$
$= 3.75 \times 10^{8}$ m = 375 000 km

5. D

6. B

7. B

8. A

9. C

10. D

11. D

12. D