Paper Reference(s) 9PH0/02
Pearson Edexcel Level 3 GCE

Physics
Advanced
Paper 2: Advanced Physics II

Total Marks

Monday 1 June 2020 – Afternoon

Time: 1 hour 45 minutes plus your additional time allowance

In the boxes below, write your name, centre number and candidate number.

Surname						
Other names						
Centre Number						
Candidate Number						

Q61865A

Pearson

YOU MUST HAVE

Ruler

YOU WILL BE GIVEN

Data, Formulae and Relationships Booklet

Diagram Booklet

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided – there may be more space than you need.

INFORMATION

The total mark for this paper is 90.

The marks for EACH question are shown in brackets – use this as a guide as to how much time to spend on each question.

You may use a scientific calculator.

In questions marked with an ASTERISK (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

ADVICE

Read each question carefully before you start to answer it.

Try to answer every question.

Check your answers if you have time at the end.

You are advised to show your working in calculations, including units where appropriate.

Answer ALL questions.

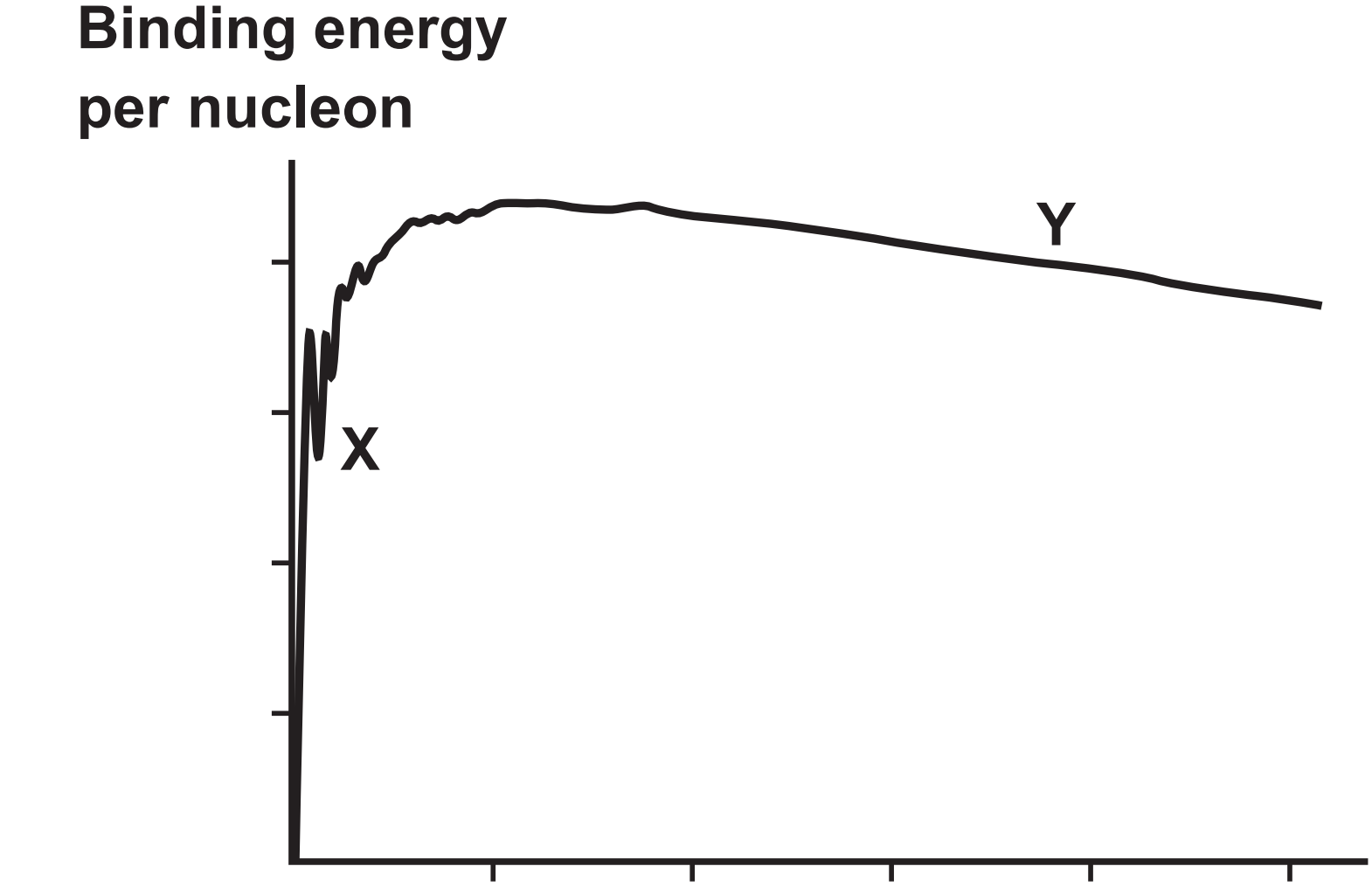
All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which row of the table shows a base quantity and its base SI unit?

	Quantity	Unit
☐ A	charge	C
☐ B	length	m
☐ C	mass	g
☐ D	temperature	°C

(TOTAL FOR QUESTION 1 = 1 MARK)

2 The diagram shows binding energy per nucleon against nucleon number for atomic nuclei.



Which line of the table correctly identifies the process that would increase stability for nuclei in the positions indicated by X and Y?

		X	Y
☐	A	nuclear fission	nuclear fission
☐	B	nuclear fission	nuclear fusion
☐	C	nuclear fusion	nuclear fission
☐	D	nuclear fusion	nuclear fusion

(TOTAL FOR QUESTION 2 = 1 MARK)

3 When a force F is applied to a spring with stiffness k, the elastic potential energy stored is E.

What is the elastic potential energy stored when a force $2F$ is applied to a spring with stiffness $2k$?

☐ A $\frac{E}{2}$

☐ B E

☐ C $2E$

☐ D $8E$

(TOTAL FOR QUESTION 3 = 1 MARK)

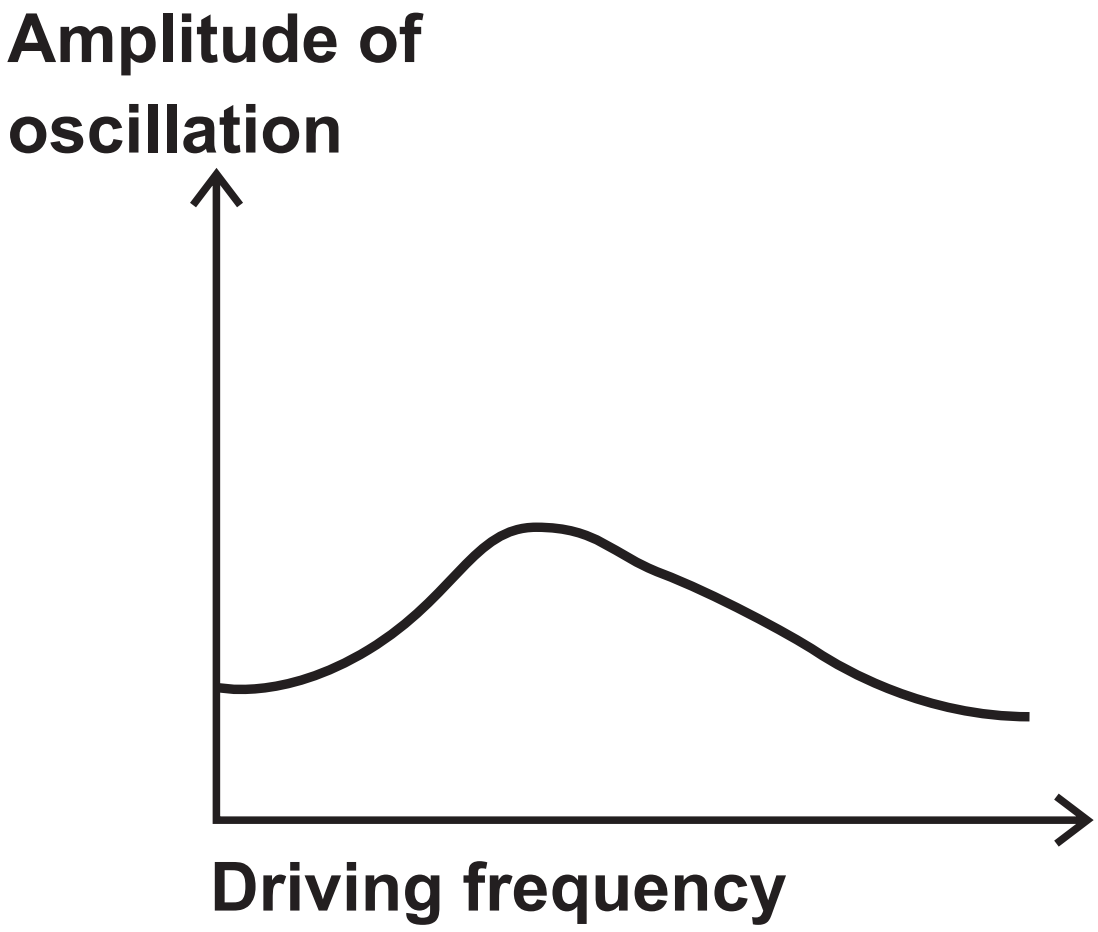
4 There are several different methods that can be used to determine the distance from our solar system to astronomical objects. These include the measurement of red shift, trigonometrical parallax and the use of standard candles.

Which row of the table shows a suitable method for each of the objects named?

	Nearby star	Nearby galaxy	Very distant galaxy
☐ A	parallax	red shift	standard candle
☐ B	red shift	standard candle	parallax
☐ C	parallax	standard candle	red shift
☐ D	red shift	parallax	standard candle

(TOTAL FOR QUESTION 4 = 1 MARK)

5 A damped mass-spring system is driven into oscillation. The graph shows the amplitude of oscillation as the driving frequency is varied.



The damping is decreased.

Which row of the table describes what happens to the maximum amplitude of oscillation and the driving frequency at which this occurs?

	Maximum amplitude	Frequency at which maximum amplitude occurs
☐ A	decreases	decreases
☐ B	decreases	increases
☐ C	increases	decreases
☐ D	increases	increases

(TOTAL FOR QUESTION 5 = 1 MARK)

6 A proton can be considered to be both a point charge and a point mass. There is an electric field and a gravitational field associated with the proton.

Which of the following statements about the fields is NOT correct?

☐ A Field strength is a vector.

☐ B Potential is always less than 0.

☐ C Potential is proportional to $\frac{1}{\text{distance from proton}}$

☐ D Field strength is proportional to $\frac{1}{(\text{distance from proton})^2}$

(TOTAL FOR QUESTION 6 = 1 MARK)

7 A pendulum of length l with a bob of mass m oscillates with frequency f.

What is the frequency of a pendulum of length $4l$ with a bob of mass $2m$?

☐ A $4f$

☐ B $2f$

☐ C f

☐ D $\frac{f}{2}$

(TOTAL FOR QUESTION 7 = 1 MARK)

8 Which of the following lenses would produce a real image of an object placed 15 cm away from the lens?

☐ A converging, focal length = 10 cm

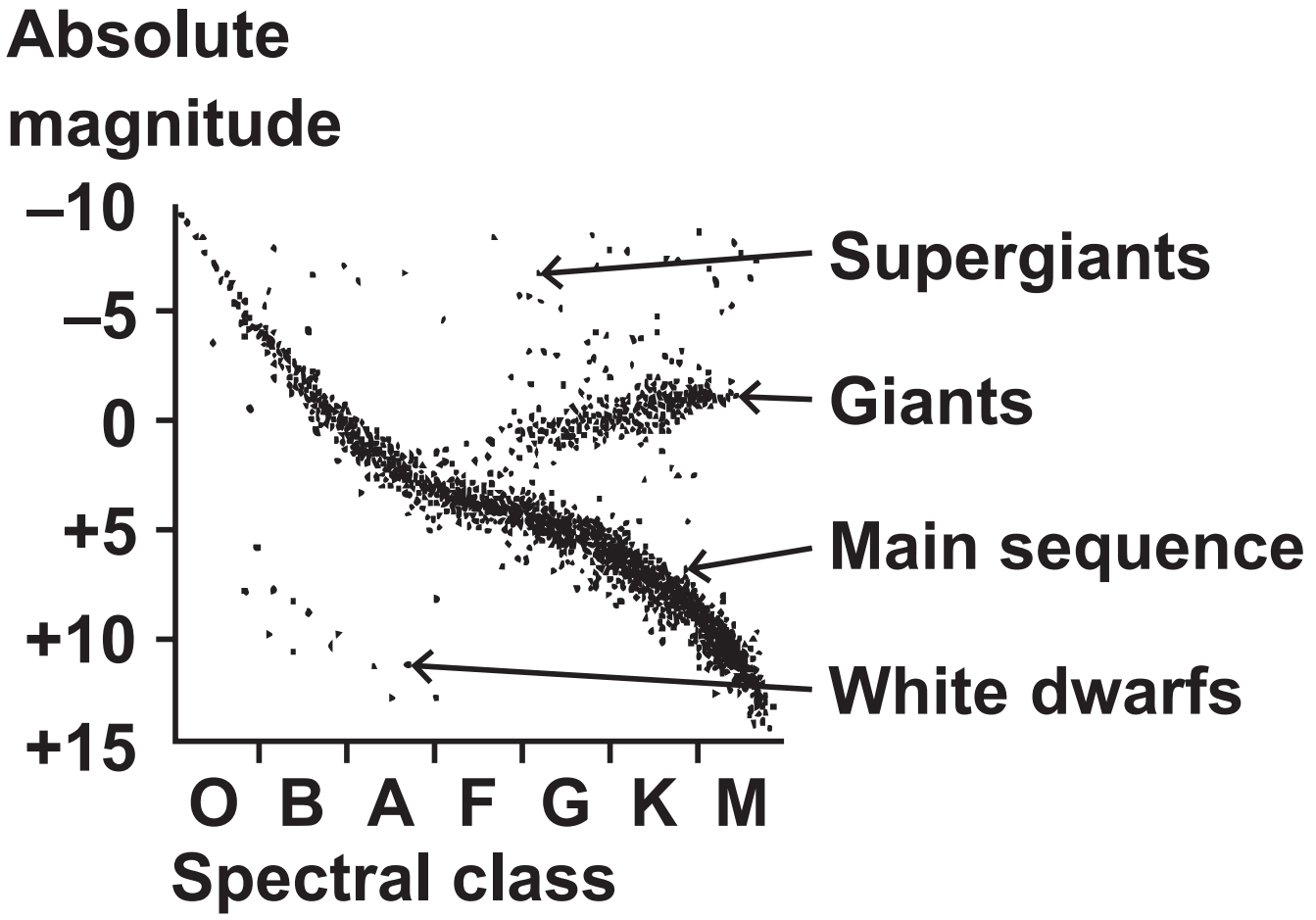
☐ B converging, focal length = 20 cm

☐ C diverging, focal length = 10 cm

☐ D diverging, focal length = 20 cm

(TOTAL FOR QUESTION 8 = 1 MARK)

9 A student finds a Hertzsprung-Russell diagram in an old astronomy book and notices that the axes aren't the same as in her current textbook.



Look at the graphs for Question 9 in the Diagram Booklet.

Which of the graphs shows a correct alternative way to label the axes?

☐ A

☐ B

☐ C

☐ D

(TOTAL FOR QUESTION 9 = 1 MARK)

10 A detector is placed 30 cm from a gamma source, the count rate is 64 counts per minute.

The detector is then placed 60 cm from the source. The background rate is presumed to be a constant 24 counts per minute.

Which of the following gives the expected counts per minute?

- ☐ A 16
- ☐ B 32
- ☐ C 34
- ☐ D 44

(TOTAL FOR QUESTION 10 = 1 MARK)

11 A cup contains 180 g of black coffee at a temperature of 82 °C. 68 g of milk at a temperature of 2·7 °C is added to the coffee. An ideal temperature range for drinking coffee is said to be 50 °C to 60 °C.

Deduce whether the coffee will be within the ideal temperature range when the milk is added. (3 marks)

initial temperature of milk = 2·7 °C

specific heat capacity of black coffee = $4{\cdot}2 \times 10^3\,J\,kg^{-1}\,K^{-1}$

specific heat capacity of milk = $3{\cdot}9 \times 10^3\,J\,kg^{-1}\,K^{-1}$

(continued on the next page)

11 continued.

(TOTAL FOR QUESTION 11 = 3 MARKS)

12 Look at the diagram for Question 12 in the Diagram Booklet. The diagram shows a transparent tank, with thin plastic sides, that can be used to determine the refractive index of a transparent liquid.

A rectangle of opaque card is stuck on the side of the tank containing the liquid. A light source is placed in front of the tank and the width **S** of the shadow of the card, which is formed on the back of the tank, is measured. The width **t** of the card and the width **w** of the tank are also measured.

(a) The angle of incidence of the light as it enters the tank is 7·2°

Show that the refractive index of the liquid is about 1·4 (3 marks)

w = 35·0 cm

t = 4·0 cm

S = 10·2 cm

(continued on the next page)

12 continued.

(continued on the next page)

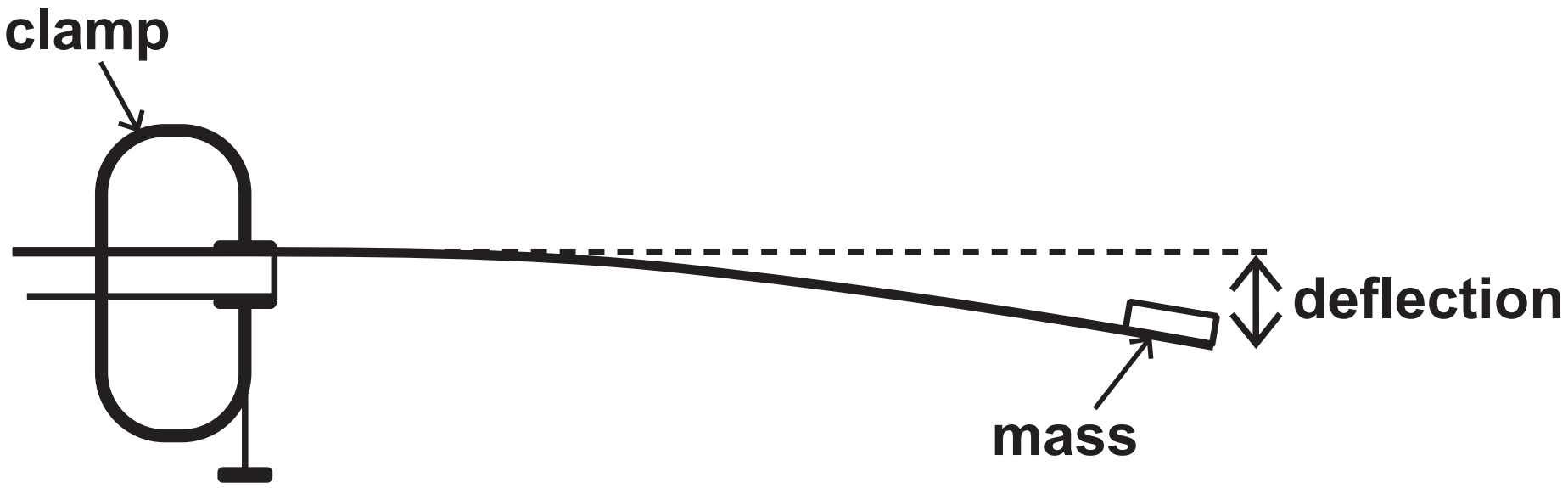
12 continued.

(b) Determine the speed of light in the liquid.
(2 marks)

Speed of light = _____

(TOTAL FOR QUESTION 12 = 5 MARKS)

13 A student measured the deflection of a mass attached to the end of a thin strip of metal. The strip was clamped to a bench at one end as shown.



The student varied the force on the end of the strip by changing the mass attached.

The deflection was measured each time when the mass was in its equilibrium position.

Look at the graph for Question 13 in the Diagram Booklet. The student obtained the graph of deflection against force.

(continued on the next page)

13 continued.

(a) State why the mass will oscillate with simple harmonic motion when it is displaced slightly from its equilibrium position and released. (2 marks)

(continued on the next page)

13 continued.

(b) The student then investigated the oscillations of the mass on the metal strip. The student fixed different numbers of 10 g masses to the end of the metal strip.

The student noticed that the smaller the mass the higher the frequency of the oscillations. He estimated that the maximum number of oscillations he could count was two per second. He decided that the smallest mass he should use was 50 g.

Determine whether 50 g is the smallest mass he should use.

You may assume that the system acts in the same way as a mass on a spring. (5 marks)

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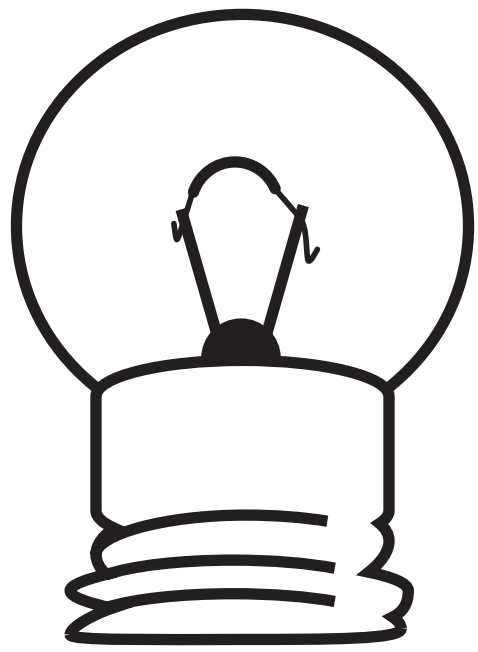
13 continued.

(TOTAL FOR QUESTION 13 = 7 MARKS)

14 The diagram shows a filament bulb.



The filament is an emitter with 35% of the power output of a black body radiator of the same temperature.

(a) When a potential difference (p.d.) of 2·0 V is applied across the bulb, there is a current of 0·37 A in the filament. (3 marks)

Calculate the temperature of the filament.

surface area of filament = $3{\cdot}9 \times 10^{-6}\,m^2$

(continued on the next page)

14 continued.

Temperature = _____

(continued on the next page)

14 continued.

(b) In an experiment to investigate the efficiency of a filament light bulb a p.d. was applied. The p.d. and current were measured and the light bulb was observed. The p.d. was then increased and new measurements taken.

When a small p.d. is applied to the bulb, no light is visible. If the p.d. is gradually increased, the filament starts to glow and eventually appears white.

(i) On the graph for Question 14(b) in the Diagram Booklet, add to the graph to show the distribution of radiation from a black body at a temperature of 2026 K.

Your answer should include a calculation.
(5 marks)

(continued on the next page)

14 continued.

(ii) Use your graph to explain why filament light bulbs are considered inefficient. (2 marks)

(TOTAL FOR QUESTION 14 = 10 MARKS)

15 The photograph shows a guitar.

When a guitar string is plucked, a standing wave is created.

(a) Explain how a standing wave is created on the string. (3 marks)

(continued on the next page)

15 continued.

(b) Look at the diagram for Question 15(b) in the Diagram Booklet, it shows a standing wave on a guitar string.

The oscillating length of the guitar string is 66 cm.

(i) State the wavelength for this standing wave. (1 mark)

Wavelength = _____

(continued on the next page)

15 continued.

(ii) Calculate the frequency of vibration for this standing wave. (3 marks)

tension in guitar string = 88·6 N

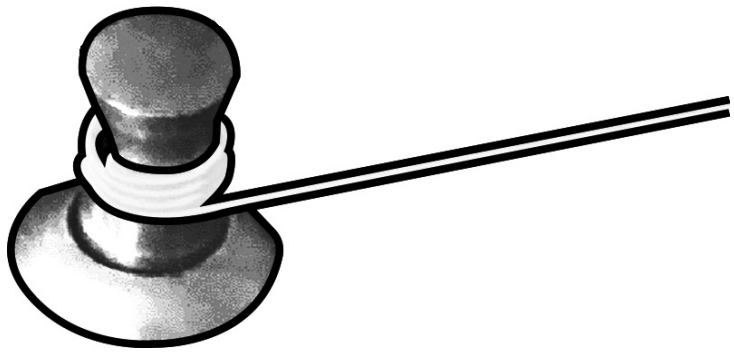
mass per unit length of guitar string = $4{\cdot}47 \times 10^{-3}\,\text{kg}\,\text{m}^{-1}$

Frequency = _____

(continued on the next page)

15 continued.

(c) One end of the guitar string is wrapped around a cylindrical tuning peg. Turning the peg changes the total length of the string and hence changes the tension in the string. This changes the frequency of vibration of the string.



(i) The length of one string is 68 cm.

Calculate the extension required to produce a tension of 93·4 N in the string. (4 marks)

Young modulus of string material = $1{\cdot}8 \times 10^{9}\,\mathrm{N\,m^{-2}}$

cross-sectional area of string = $6{\cdot}6 \times 10^{-7}\,\mathrm{m^{2}}$

(continued on the next page)

15 continued.

Extension =

(continued on the next page)

15 continued.

(ii) The vibrating length of string is unchanged by turning the tuning peg.

Explain the effect that tightening the string has on the frequency of the sound produced.
(2 marks)

(TOTAL FOR QUESTION 15 = 13 MARKS)

16 Astronauts on the 1971 Apollo 14 mission to the Moon brought back many rock samples. It is now believed that one of these contains a piece of rock that originated on Earth about 4 billion years (4×10^9 years) ago.

The piece of rock is believed to have been launched into space when an asteroid struck the Earth.

(a) The rock sample contains uranium. The radioactive decay of uranium allows it to be used to determine the time since the rock was formed on the Earth.

(continued on the next page)

16 continued.

(i) The uranium isotope $^{238}_{92}U$ becomes the lead isotope $^{206}_{82}Pb$ through a series of radioactive decays.

Calculate the number of α particles and the number of β particles emitted for one nucleus of $^{238}_{92}U$ to decay to become a nucleus of $^{206}_{82}Pb$. (2 marks)

Number of α particles = _____

Number of β particles = _____

(continued on the next page)

16 continued.

(ii) The half-life of $^{238}_{92}U$ is $4{\cdot}47 \times 10^{9}$ years.

The half-lives of the other stages in the decay to $^{206}_{82}Pb$ are relatively so short that they can be ignored.

There was no lead in the rock when it formed, so all the $^{206}_{82}Pb$ in the sample is a product of $^{238}_{92}U$ decay. In the sample, for every 103 uranium nuclei present at the start, 50 are now lead nuclei.

Show that the age of the sample is about 4×10^{9} years. (3 marks)

(continued on the next page)

16 continued.

(continued on the next page)

16 continued.

(b) The gravitational potential between the Earth and the Moon due to the combined effect of their gravitational fields increases to a maximum value of $-1{\cdot}28\,\text{MJ}\,\text{kg}^{-1}$ at a point between them.

Calculate the minimum speed at which a rock would have to leave the Earth in order to reach the Moon.

In your calculation, you may assume the rock has zero kinetic energy when it has maximum potential energy. (4 marks)

mass of Earth = $5{\cdot}97 \times 10^{24}\,\text{kg}$
radius of Earth = $6370\,\text{km}$

(continued on the next page)

16 continued.

Minimum speed = _____

(continued on the next page)

16 continued.

(c) Four billion years ago, the Moon had a different orbital period, because it was closer to the Earth than it is today.

Calculate the period of the Moon's orbit four billion years ago, when the radius of its orbit was $1{\cdot}34 \times 10^8$ m. (3 marks)

mass of Earth = $5{\cdot}97 \times 10^{24}$ kg

(continued on the next page)

16 continued.

Period = _____

(TOTAL FOR QUESTION 16 = 12 MARKS)

17 In 1905 Einstein published his equation for the photoelectric effect.

In 1916 Millikan demonstrated that the maximum kinetic energy of photoelectrons is consistent with Einstein's equation.

*(a) Discuss the extent to which our current understanding of observations of the photoelectric effect supports the idea that light behaves as photons rather than as waves. (6 marks)

(continued on the next page)

17 continued.

(continued on the next page)

17 continued.

(b) Millikan used his data to obtain a value of the Planck constant.

Look at the graph for Question 17(b) in the Diagram Booklet. The graph of maximum kinetic energy of photoelectrons against frequency was produced from his data for the photoelectric effect using lithium.

Millikan suggested that the uncertainty from his results for lithium was as little as 1%.

Determine whether the value of the Planck constant obtained from this graph is within 1% of the value stated on the data sheet for this examination paper. (3 marks)

(continued on the next page)

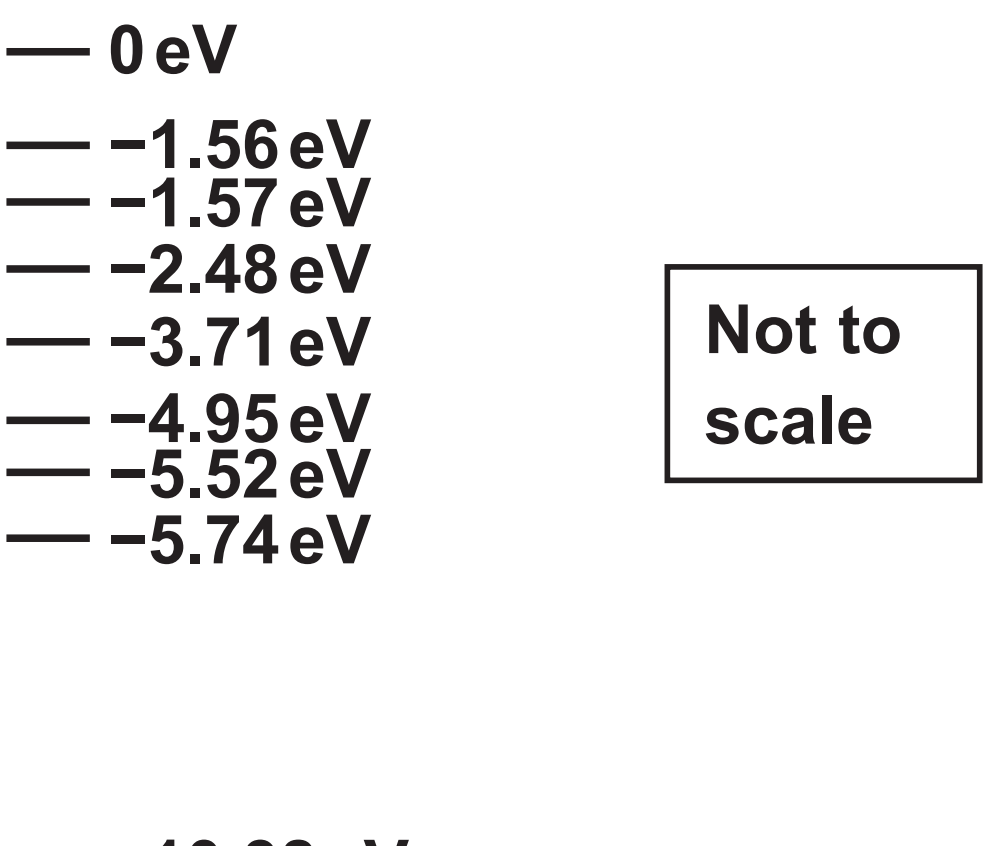
17 continued.

(continued on the next page)

17 continued.

(c) Millikan's experiments involved using different frequencies of light. These were obtained using a mercury vapour lamp which produced an emission spectrum with a specific number of known frequencies.

The diagram shows some energy levels for a mercury atom.



Determine which transition from the −3·71 eV energy level would produce light of wavelength $6{\cdot}1 \times 10^{-7}$ m. (4 marks)

(continued on the next page)

17 continued.

Transition from −3·71 eV to _____

(continued on the next page)

17 continued.

(d) Millikan used a device known as a monochromator to ensure that a single wavelength of light was used to illuminate the surface of the lithium.

A monochromator separates wavelengths using a diffraction grating.

Calculate the angle at which a diffraction grating would produce the most intense line at a single wavelength of $6{\cdot}1 \times 10^{-7}$ m. (3 marks)

number of lines per mm for grating = 600 mm^{-1}

(continued on the next page)

17 continued.

Angle = _____

(TOTAL FOR QUESTION 17 = 16 MARKS)

18 At the Culham Centre for Fusion Energy (CCFE) experiments are carried out to investigate nuclear fusion and the properties of plasmas. A plasma consists of ionised gas, containing positive ions and electrons.

(a) In a fusion experiment at CCFE, ions of two isotopes of hydrogen fuse to produce helium ions and fast-moving neutrons.

$$^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \longrightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

Show that a single fusion reaction releases about 3×10^{-12} J of energy. (4 marks)

mass of $^{2}_{1}\mathrm{H}$ = 2·013553 u

mass of $^{3}_{1}\mathrm{H}$ = 3·015501 u

mass of $^{4}_{2}\mathrm{He}$ = 4·001506 u

mass of $^{1}_{0}\mathrm{n}$ = 1·008665 u

(continued on the next page)

18 continued.

(continued on the next page)

18 continued.

(b) Fusion occurs naturally in the core of stars.

Explain why very high densities of matter and very high temperatures are needed to bring about and maintain nuclear fusion in stars. (2 marks)

(continued on the next page)

18 continued.

(c) In a plasma experiment 5·0 mg of deuterium, an isotope of hydrogen, occupies a volume of 98 m^3. The temperature of deuterium is raised to $1{\cdot}3 \times 10^8$ K. In this experiment, the deuterium behaves as an ideal gas.

(i) Calculate the pressure due to the deuterium ions. (3 marks)

mass of deuterium ion = $3{\cdot}3 \times 10^{-27}$ kg

Pressure = _____

18 continued.

(ii) Calculate the root mean square speed of the deuterium ions at this temperature. (2 marks)

Root mean square speed = _____

(continued on the next page)

(continued on the next page)

18 continued.

(iii) The temperature of the plasma is monitored using the Doppler effect. Light from a laser is directed into the plasma and the wavelength of the light reflected is measured.

The Doppler shift observed when light is reflected by a deuterium ion is twice the Doppler shift that would be observed for a source of light moving at the same speed as the deuterium ion.

Calculate the maximum wavelength of light that would be detected after reflection from a deuterium ion moving at $1{\cdot}5 \times 10^{6}\,\mathrm{m\,s^{-1}}$. (3 marks)

wavelength of laser light = 1064 nm

(continued on the next page)

18 continued.

Maximum wavelength detected = _____

(TOTAL FOR QUESTION 18 = 14 MARKS)

TOTAL FOR PAPER = 90 MARKS

END