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Sample Assessment Materials September 2007

GCE Physics

Edexcel Advanced Subsidiary GCE in Physics (8PH01)

First examination 2009

Edexcel Advanced GCE in Physics (9PH01)

First examination 2010

A PEARSON COMPANY

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Contents

A Introduction

These sample assessment materials have been prepared to support the specification.

Their aim is to provide the candidates and centres with a general impression and flavour of the actual question papers and mark schemes in advance of the first operational examinations.

B Sample question papers

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	P	H	0	1	/	1	Signature	

Paper Reference(s)

6PH01/1

Edexcel GCE

Physics

Advanced Subsidiary

Unit 1: Physics on the Go

Sample Assessment Material

Time: 1 hour 20 minutes

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Team Leader's use only

Question Number	Leave Blank
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Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 22 questions in this question paper. The total mark for this paper is 80.
There are 20 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 14, 21 and 22. These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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Answer ALL the questions.

For questions 1–4, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

1. Which of the following quantities is a vector?

☒ **A** density

☒ **B** mass

☒ **C** strain

☒ **D** weight

(Total 1 mark)

Q1

2. Two wires made of the same material but of different lengths and diameters are joined end to end and used to support a vertical load. If the weight of each wire is neglected, each wire must have the same

☒ **A** extension

☒ **B** strain

☒ **C** tensile force

☒ **D** tensile stress

(Total 1 mark)

Q2

3. Newton's third law tells us that

☒ **A** actions usually have a reaction

☒ **B** weight and normal contact force are always equal and opposite

☒ **C** moving with constant velocity is the same as being at rest

☒ **D** forces always arise in pairs

(Total 1 mark)

Q3

4. An athlete throws a javelin. Just as it hits the ground the javelin has a horizontal velocity component of 20 m s^{-1} and a vertical velocity component of 10 m s^{-1}. The magnitude of the javelin's velocity as it hits the ground is

☒ **A** 10 m s^{-1}

☒ **B** 15 m s^{-1}

☒ **C** 22 m s^{-1}

☒ **D** 30 m s^{-1}

(Total 1 mark)

Q4

Leave blank

In questions 5–6, which of the following statements best completes the sentence.

A decreases linearly from zero

B increases from zero to a maximum

C increases linearly from zero

D stays constant at a non-zero value

Choose the appropriate letter to indicate which statement best completes the sentence. Each answer may be used once, more than once or not at all.

5. If air resistance is neglected, the horizontal velocity component of an arrow fired from a bow ..... with distance travelled

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q5

(Total 1 mark)

6. The velocity of a ball bearing falling from rest through syrup ..... with distance fallen

☒ **A**

☒ **B**

☒ **C**

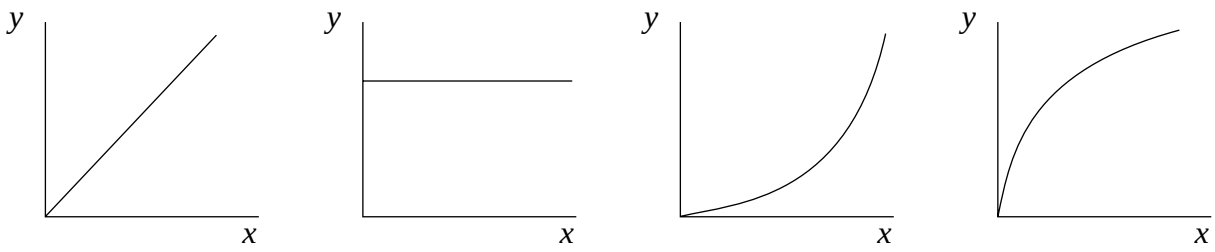
☒ **D**

Q6

(Total 1 mark)

Leave blank

In questions 7–8, which of the following graphs best represents the quantities described when they are plotted on the *y*- and *x*-axes. Each graph may be used once, more than once or not at all.



A **B** **C** **D**

	Variable on *y*-axis	**Variable on *x*-axis**
7. The kinetic energy of a car accelerating uniformly from rest		Displacement from starting position
8. The acceleration of a feather falling near to the Moon's surface		Height above the Moon's surface

7. **A** ☒ **B** ☒ **C** ☒ **D** ☒ **Q7**

(Total 1 mark)

8. **A** ☒ **B** ☒ **C** ☒ **D** ☒ **Q8**

(Total 1 mark)

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For questions 9–10, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

9. A shot putter launches the shot at an angle of 30° to the horizontal. The throw is repeated with the same launch speed, but this time at an angle of 40° to the horizontal. Which of the following is **not** correct?

☐ **A** The horizontal range is greater

☐ **B** The horizontal velocity component is increased

☐ **C** The maximum height reached is greater

☐ **D** The shot is in the air for longer

Q9

(Total 1 mark)

10. Steel can be classified as a strong material. This is because

☐ **A** it is difficult to deform

☐ **B** it has a large ultimate tensile stress value

☐ **C** it has a large Young modulus value

☐ **D** it breaks shortly after its proportional limit

Q10

(Total 1 mark)

11. Complete the gaps in the following paragraph by selecting appropriate words from the following list.

compressive density energy force mass stiff tensile tough

Increasingly, drinks containers are made out of polymers rather than glass. A container made from a polymer such as polythene has several advantages over a glass container. Polythene has low ....., and so the ..... of the container is kept low. Polythene is also ..... and so can absorb a large amount of ..... before breaking. Glass is only strong under ..... forces but polythene is also strong under ..... forces.

Q11

(Total 3 marks)

Leave blank

12. (a) Near schools the speed limit is 20 mph. It is claimed that reducing the speed limit from 30 mph (13.3 m s^{-1}) to 20 mph (8.9 m s^{-1}) halves the risk of serious injury in a car accident.

When a car is involved in a crash, the collision energy depends upon the car's speed just before impact.

(i) Determine $\frac{\text{kinetic energy of car travelling at 20 mph}}{\text{kinetic energy of car travelling at 30 mph}}$.

$\frac{\text{kinetic energy of car travelling at 20 mph}}{\text{kinetic energy of car travelling at 30 mph}}$ = ...

(1)

(ii) To what extent does your answer support the claim?

.....

.....

(2)

(b) A car of mass 1200 kg is in a crash. The front bumper of the car deforms, and the car is brought to rest from an initial speed of 10 m s^{-1} in a distance of 0.12 m.

By considering the work done on the car as it is brought to rest, calculate the average impact force that acts.

Average impact force = ...

(3)

(c) Modern cars include crumple zones to reduce the size of the impact force. Suggest how the crumple zones do this.

.....

.....

.....

(1)

Q12

(Total 7 marks)

Leave blank

13. A skydiver accelerates towards the ground at 9.81 m s^{-2} at the instant that he leaves the aeroplane.

(a) Explain why his acceleration will decrease as he continues to fall.

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(2)

(b) The skydiver opens his parachute. Explain why he reaches a terminal velocity shortly afterwards.

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(2)

(c) The velocity at which he then hits the ground is similar to that achieved when falling freely from a height of 3 m. Calculate this velocity.

Velocity = ...

(2)

Q13

(Total 6 marks)

Leave blank

*14. A sign at a railway station advises passengers to keep back from the platform edge. This is because passing trains may cause turbulence.

Explain what is meant by turbulent flow, and suggest why it is dangerous for passengers to stand near the edge of the platform.

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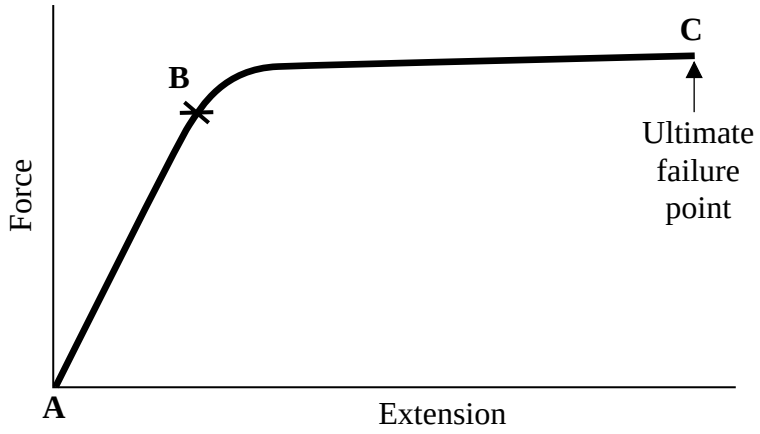
..... Q14

(Total 3 marks)

Leave blank

15. The graph shows how a sample of material behaves when extended by a force.



(a) What does point **B** represent?

.....

(1)

(b) State the physical property represented by the gradient of the section **AB** of the graph.

.....

(1)

(c) Explain the significance of the area underneath the line from **A** to **C**.

.....

.....

(2)

Q15

(Total 4 marks)

Leave blank

16. A raindrop has a radius of 0.70 mm. It is falling at terminal velocity through air.

(a) Show that the mass of the raindrop is approximately 1×10^{-6} kg.
Density of water = 1000 kg m^{-3}.

.....

.....

.....

(2)

(b) Ignoring any upthrust on the raindrop, calculate its terminal velocity.
Viscosity of air = 8.90×10^{-4} kg m^{-1} s^{-1}.

Terminal velocity = ...

(2)

Q16

(Total 4 marks)

Leave blank

17. A student was asked the following question: "Describe the variation in energy of a bungee jumper from the moment that the jumper is released to the lowest point that the jumper reaches." As an answer the student wrote the following:

"Initially the jumper has gravitational potential energy, which is converted into elastic potential energy as the cord stretches. At the lowest point in the jump, all of the gravitational potential energy has been converted to elastic potential energy."

(a) Discuss the student's answer, highlighting any incorrect or missing physics.

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(4)

(b) The bungee jumper has a mass of 80 kg and is in free fall through the air. At a particular instant the force of the air resistance acting on the bungee jumper is 285 N. Calculate the acceleration of the jumper.

Acceleration = ...

(2) **Q17**

(Total 6 marks)

Leave blank

18. An astronaut on the moon drops a hammer. The gravitational acceleration is 1.6 m s^{-2}.

(a) How long does the hammer take to fall 1.0 m from rest?

Time = ...

(2)

(b) Calculate the velocity of the hammer just before it hits the ground.

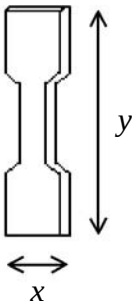
Velocity = ...

(2) **Q18**

(Total 4 marks)

Leave blank

19. A tensile tester connected to a datalogger is used to investigate the effect of applying forces to a range of materials.



The sample has approximate dimensions $x = 1$ cm, $y = 10$ cm. It is fixed into the frame and force applied from a hydraulic system. The datalogger records the extension of the sample and the applied force.

(a) State any measurements, other than the force, that you would need to calculate the stress in the sample and name an appropriate instrument that you could use to make these measurements.

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(2)

(b) Explain why access to a datalogger is useful when tensile testing is carried out.

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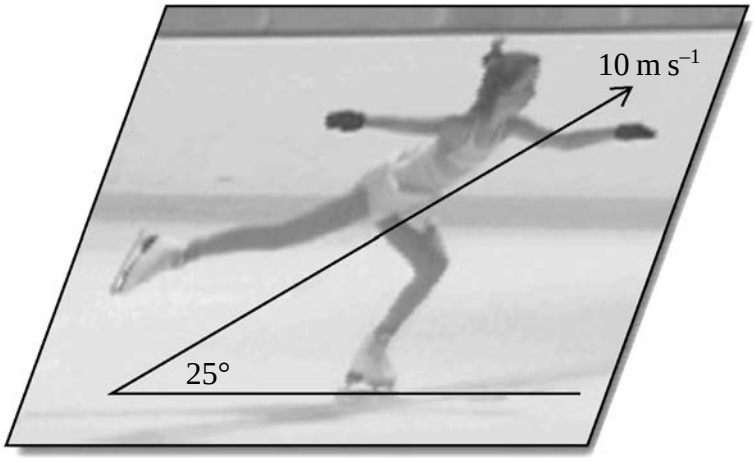
(2) **Q19**

(Total 4 marks)

Leave blank

20. Performing complex jumps is an important aspect of a figure skater's program. Jumps with great heights and jump distances tend to leave a better impression with the judges, resulting in better marks for the skater.

A skater of mass 60 kg leaves the ice with a velocity of 10 m s^{-1} at an angle of 25° to the horizontal.



(a) Show that the vertical component of the skater's velocity is approximately 4 m s^{-1}.

.....

.....

(2)

(b) Calculate the time taken to reach the top of the jump.

Time taken = ...

(2)

(c) Calculate the maximum height reached.

Maximum height = ...

(2)

Q20

(Total 6 marks)

Leave blank

*21. (a) A chest expander is used to build up the chest muscles.

One type of expander consists of five identical springs as shown. A student disconnects one spring and finds that applying a force of 6 N to it causes an extension of 5 cm.

(i) Calculate the force required to stretch a single spring by 50 cm, stating the assumption you have made.

Assumption: .....

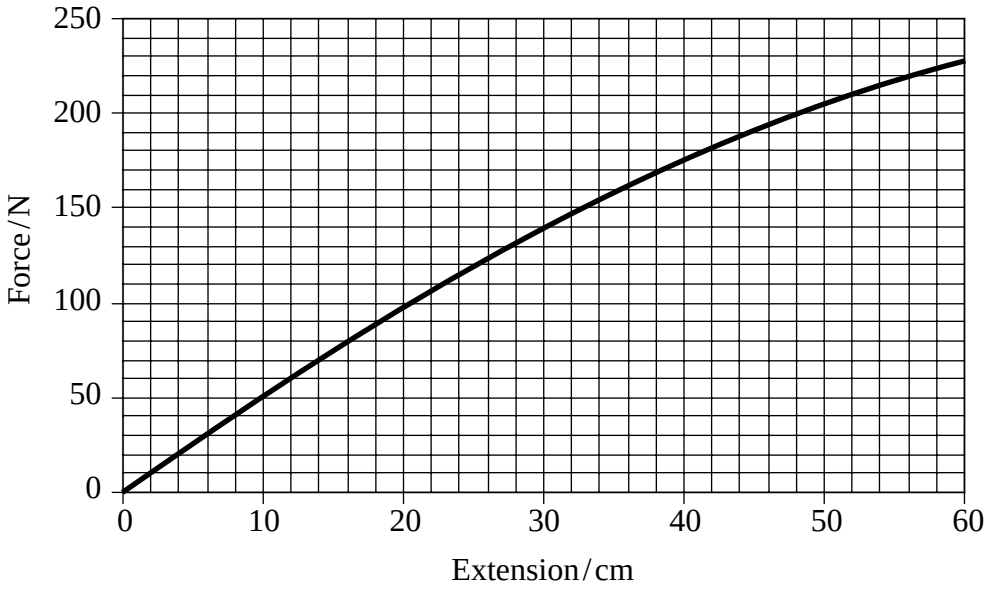
Force = ...
(3)

(ii) Calculate the work done when all five springs are stretched by 50 cm.

Work done = ...
(2)

Leave blank

(b) A different type of chest expander uses rubber cords instead of springs. The variation of restoring force with extension for this expander is shown.



(i) Use the graph to estimate the work done in extending the expander by 50 cm.

Work done = ...

(3)

(ii) When unloading the expander, it is found that at each extension the restoring force is always less than the loading force. Explain the significance of this, and describe what effect this would have on the rubber cords when performing a large number of repetitions with the expander.

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.....

(3)

Q21

(Total 11 marks)

Leave blank

*22. The photograph shows a climber abseiling down a rock face. At the instant shown the climber is in equilibrium.

(a) Explain what is meant by equilibrium in this context.

.....

.....

(1)

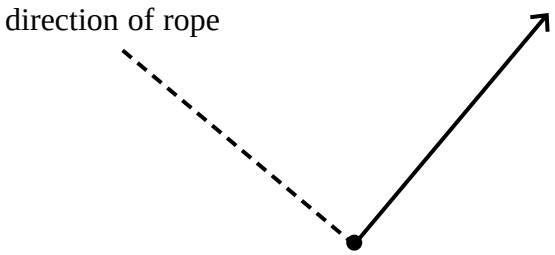
(b) The climber's mass is 65 kg. Calculate his weight.

Weight = ...

(2)

Leave blank

(c) (i) Below is an incomplete free-body force diagram for the climber.



One of the forces, which is assumed to be acting perpendicular to the rope is already shown. Label this force, and add labelled arrows to the diagram to represent the other two forces acting on the climber. Assume that the rope hanging down from the climber exerts a negligible force on him.

(3)

(ii) The rope is at an angle of 40° to the horizontal. Calculate the tension in the rope.

Tension in rope = ...

(2)

(d) The climber is wearing protective headgear in case of an accident. Describe the properties of a material suitable for the headgear, and explain why these properties are desirable.

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(4) **Q22**

(Total 12 marks)

TOTAL FOR PAPER: 80 MARKS

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Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	P	H	0	2	/	1	Signature	

Paper Reference(s)

6PH02/1

Edexcel GCE

Physics

Advanced Subsidiary

Unit 2: Physics at Work

Sample Assessment Material

Time: 1 hour 20 minutes

Materials required for examination
Nil

Items included with question papers
Nil

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Total	

Instructions to Candidates

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Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
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Answer ALL the questions.

For questions 1–9, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

1. Three identical resistors are connected across a potential difference V so that one of them is in parallel with the other two which are connected in series. The power dissipated through the first one, compared to the power dissipated by each of the other two, is approximately

☒ **A** the same

☒ **B** half as much

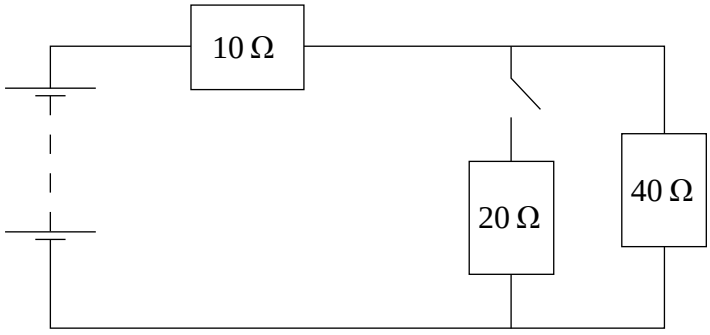
☒ **C** twice as much

☒ **D** four times as much

Q1

(Total 1 mark)

2. A circuit is set up as shown in the diagram.



When the switch is closed, the potential difference across the 20 Ω resistor would

☒ **A** equal the potential difference across the 10 Ω resistor

☒ **B** be twice the potential difference across the 10 Ω resistor

☒ **C** equal the potential difference across the 40 Ω resistor

☒ **D** be half the potential difference across the 40 Ω resistor

Q2

(Total 1 mark)

Leave blank

3. How much electrical energy is required to move 4.00 mC of charge through a potential difference of 36.0 V?

☒ **A** 1.11 × 10-4 J

☒ **B** 0.144 J

☒ **C** 144 J

☒ **D** 9000 J

Q3

(Total 1 mark)

4. A source of light emits a train of waves lasting 0.04 μs. The light has a wavelength of 600 nm and the speed of light is 3 × 108 m s-1. How many complete waves are sent out?

☒ **A** 2.0×10^{7}

☒ **B** 4.5×10^{7}

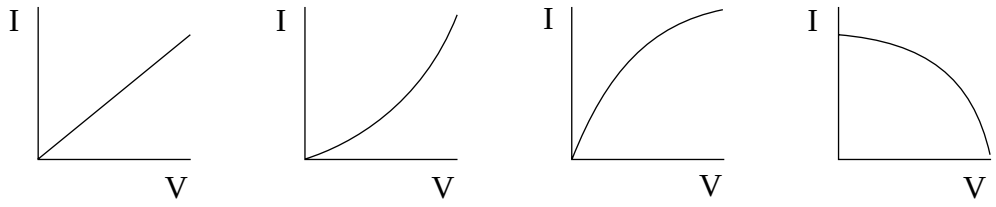
☒ **C** 2.0×10^{10}

☒ **D** 4.5×10^{13}

Q4

(Total 1 mark)

5. Which of the following graphs gives the current-potential difference characteristic of an NTC thermistor?



☒ **A** ☒ **B** ☒ **C** ☒ **D**

Q5

(Total 1 mark)

Leave blank

6. Which of the following statements about standing waves is true?

☒ **A** particles between adjacent nodes all have the same amplitude.

☒ **B** particles undergo no disturbance at an antinode.

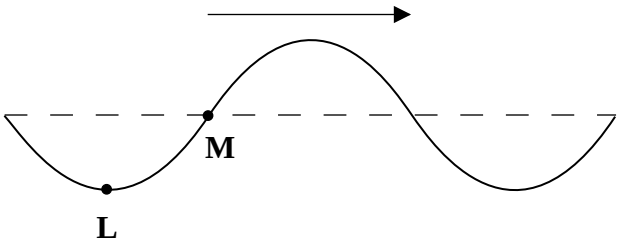
☒ **C** particles immediately either side of a node are moving in opposite directions.

☒ **D** particles between adjacent nodes are out of phase with each other.

Q6

(Total 1 mark)

7. The diagram shows a wave on a rope. The wave is travelling from left to right.



At the instant shown, point **L** is at a maximum displacement and point **M** has zero displacement. Which row in the table correctly describes the motion of points **L** and **M** during the next half cycle of the wave?

		Point L	Point M
☒	**A**	rises	falls
☒	**B**	rises	falls then rises
☒	**C**	rises then falls	rises
☒	**D**	rises then falls	falls then rises

Q7

(Total 1 mark)

Leave blank

8. Electromagnetic waves are produced by oscillating charges. Sound waves are produced by oscillating tuning forks. How are these waves similar?

- ☒ **A** they are both longitudinal waves.
- ☒ **B** they are both transverse waves.
- ☒ **C** they both have the same frequency as their respective sources.
- ☒ **D** they both require a medium to travel through.

Q8

(Total 1 mark)

9. Two points on a progressive wave differ in phase by $\frac{\pi}{4}$ radian. The distance between them is 0.50 m. The frequency of the oscillations is 10 Hz. The maximum speed of the wave is

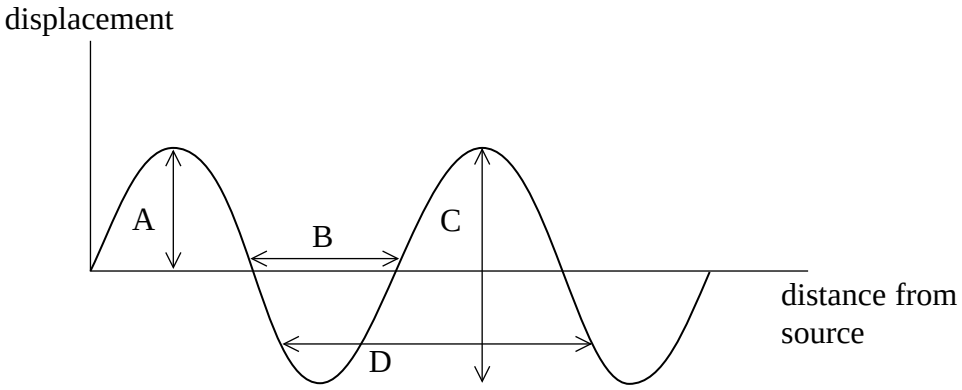
- ☒ **A** 2.50 m s^{-1}
- ☒ **B** 5.00 m s^{-1}
- ☒ **C** 12.5 m s^{-1}
- ☒ **D** 40.0 m s^{-1}

Q9

(Total 1 mark)

Leave blank

10. A loudspeaker emits a sound wave of wavelength 0.66 m. The diagram shows how displacement varies with distance from the loudspeaker at one instant of time.



(a) Which letter indicates the wavelength of the sound wave?

.....

(1)

(b) Sound travels at 330 m s^{-1} in air. Calculate the period of the wave.

.....

.....

Period = ...

(3)

Q10

(Total 4 marks)

11. State **two** conditions necessary for total internal reflection to occur at an interface between air and water.

Condition 1 .....

.....

Condition 2 .....

.....

Q11

(Total 2 marks)

Leave blank

12. (a) Explain with the aid of diagrams why transverse waves can be polarised but longitudinal ones cannot be polarised.

.....

.....

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(3)

(b) Describe with the aid of a diagram how you could demonstrate that light can be polarised.

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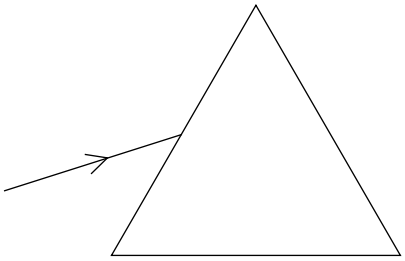
(3) **Q12**

(Total 6 marks)

Leave blank

13. A ray of light travelling in air, strikes the middle of one face of an equilateral glass prism as shown.



State what happens to the following properties as the light goes from the air into the glass.

Frequency.....

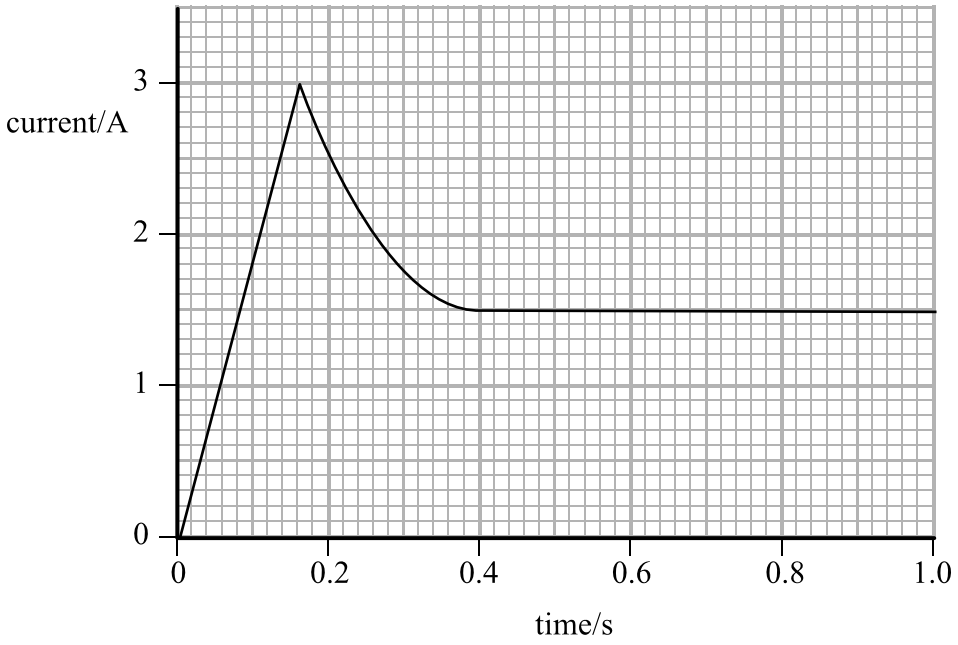
Wavelength .....

Speed..... **Q13**

(Total 3 marks)

Leave blank

14. The graph shows how the current in a 9 V filament lamp varies during one second after it has been turned on.



(a) A student wishes to carry out an experiment to verify these results. Explain why using a sensor and computer is a sensible option and suggest a suitable sampling rate.

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(2)

(b) Explain the shape of the graph and why the filament is more likely to fail when being switched on rather than at other times.

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(4)

Q14

(Total 6 marks)

Leave blank

***15.** About 100 years ago X-rays were first used in hospitals. At that time, many of the doctors who worked with X-rays died young. Explain why this occurred and the implications it has for the use of new technology today.

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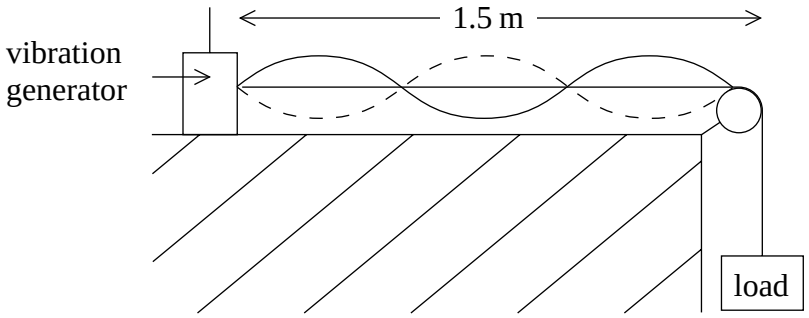
Q15

(Total 4 marks)

16. The following apparatus is set up. When the frequency of the vibrator is 60 Hz, the standing wave shown in the diagram is produced.



(a) What is the wavelength of this standing wave?

Wavelength = ...

(1)

(b) The frequency of the vibrator is altered until the standing wave has two more nodes. Calculate the new frequency.

Frequency =.....

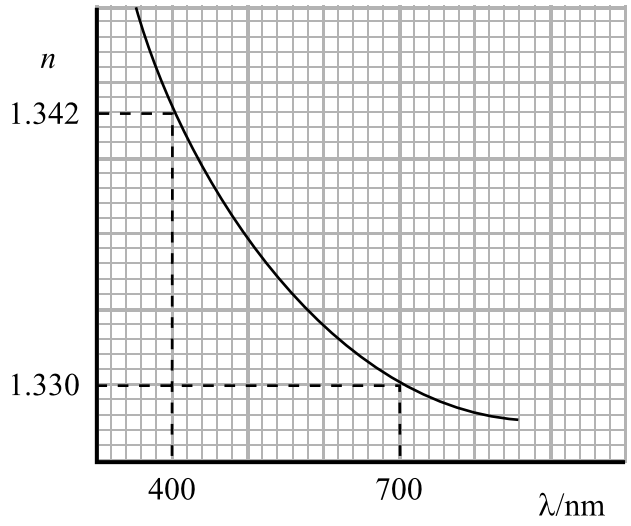
(2)

Q16

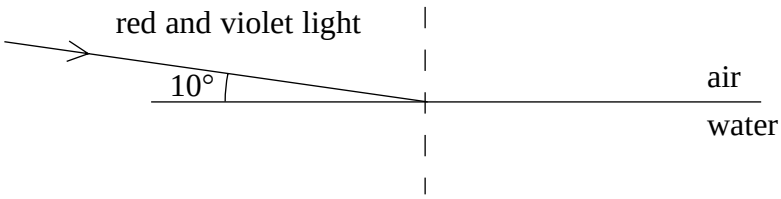
(Total 3 marks)

Leave blank

17. The graph shows how the refractive index of water, *n* varies with wavelength λ of the light in a vacuum. The values for red and violet light are indicated.



The diagram shows a mixture of red and violet light incident on an air/water interface.



Calculate the angle of refraction for the red light.

Angle of refraction = ...

(3)

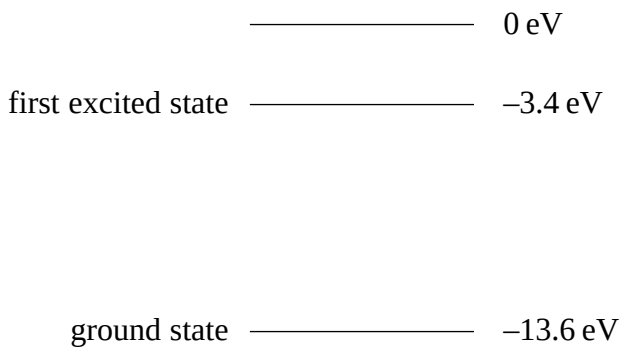
On the diagram draw the approximate paths of the refracted rays.

(2) **Q17**

(Total 5 marks)

Leave blank

18. Below is a simplified energy level diagram for atomic hydrogen.



(a) A free electron with 12 eV of kinetic energy collides with an atom of hydrogen. As a result the atom is raised to its first excited state. Calculate the kinetic energy of the free electron, in eV, after the collision.

Kinetic energy =..... eV

(2)

(b) Calculate the wavelength of the photon emitted when the atom returns to its ground state.

Wavelength =.....

(3)

Q18

(Total 5 marks)

Leave blank

*19. A group of students is discussing why the resistance of the metal filament of a lamp and the resistance of an NTC thermistor respond differently to changes in temperature.

One student says that the increased vibrations of the atoms affect the conduction process. Another student says that as the temperature increases more electrons can break free of the atoms and take part in conduction.

Both students are correct. Explain how these **two** effects apply to the lamp and the thermistor.

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Q19

(Total 5 marks)

Leave blank

20. Until the early 20th century, the wave theory of light was successful at explaining different properties of light such as reflection, refraction and diffraction. With the discovery of the photoelectric effect, scientists had a problem. The wave theory of light assumes that the energy of the wave is spread over the whole wavefront. Using the wave theory, scientists calculated that, if light of very low intensity is shone onto the metal, it should take a very long time for an electron to gain sufficient energy to break free from a metal. It was discovered that, providing the light was above a certain frequency, electrons could escape from a metal surface instantly. The new model that was introduced treated light as being made of particles called photons.

(a) What is meant by diffraction?

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(2)

(b) How did considering light as photons enable scientists to explain why electrons could be emitted instantly from a metal surface?

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(2)

(c) Explain why this effect only happens when the light is above a certain frequency.

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(2) **Q20**

(Total 6 marks)

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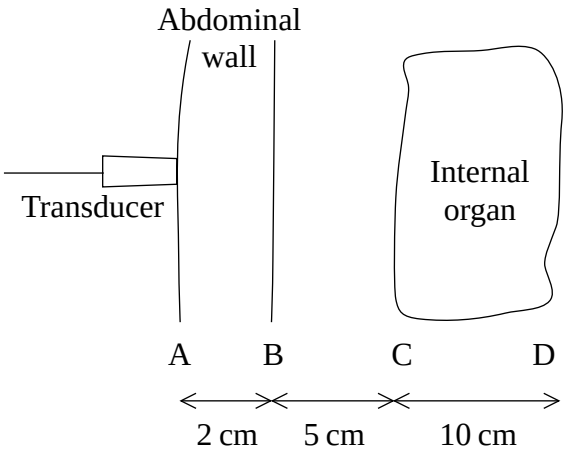
***21.** (a) Ultrasound images of the body are a useful diagnostic tool for doctors. A single transducer can be used both to send and receive pulses of ultrasound.

The diagram shows a lateral cross-section through part of the abdomen. The diagram is not to scale.



(i) Calculate the time interval between sending out a single pulse and receiving its echo from interface B. The speed of ultrasound in the abdominal wall is 1500 m s^{-1}.

Time interval = ...

(3)

(ii) The time between pulses being emitted by the transducer is 200 μs. At what frequency are the pulses emitted?

Frequency = ...

(2)

Leave blank

(iii) The time interval before the echo returns from interface D is 250 μs. Suggest why this time interval will make reflections from D difficult to interpret and what could be done to overcome this problem.

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(3)

(iv) State **one** reason why ultrasound rather than X-rays is now used to scan expectant mothers.

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(1)

(b) Ultrasound is also used to measure blood flow in the body. It uses the Doppler shift of the reflected pulse to measure the speed of blood through the arteries of the body.

Describe the principle of this method and how it can be used to determine the speed of blood.

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(4)

Q21

(Total 13 marks)

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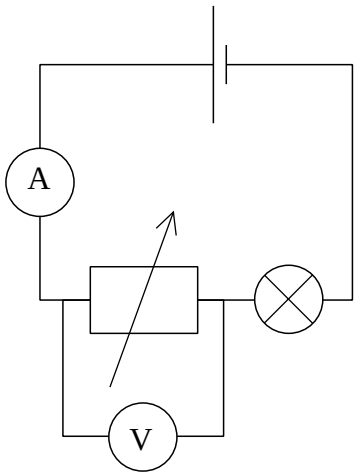
22. A student sets up the following circuit to measure the internal resistance of a cell.



(a) What is wrong with his circuit diagram?

.....

.....

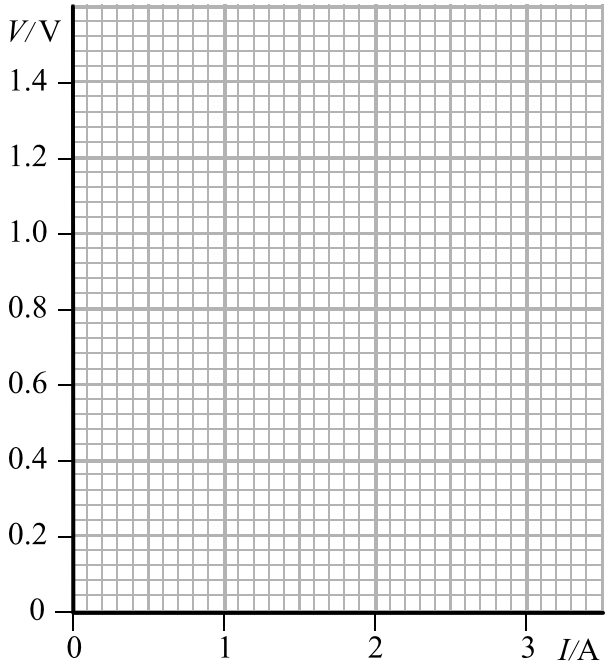
(1)

(b) Using the correct circuit the student obtains the following results.

Current in the cell *I*/A	**Terminal potential difference across the cell *V*/V**
0.5	1.2
0.9	1.0
1.5	0.8
1.9	0.6
2.5	0.4
2.9	0.2

Leave blank

(i) On the grid below, plot these results and draw the line of best fit through your points.



(3)

(ii) Use your graph to determine the e.m.f. of the cell.

e.m.f. = ...

(1)

(iii) Use your graph to determine the internal resistance of the cell.

Internal resistance = ...

(2)

(c) The experiment is repeated with two such cells connected in series. How does the graph differ?

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(2) **Q22**

(Total 9 marks)

TOTAL FOR PAPER: 80 MARKS

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Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	P	H	0	4	/	1	Signature	

Paper Reference(s)

6PH04/1

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Sample Assessment Material

Time: 1 hour 35 minutes

Examiner's use only		

Team Leader's use only		

Question Number	Leave Blank
1	
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18	
Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper.
Answer ALL the questions. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 18 questions in this question paper. The total mark for this paper is 80.
There are 20 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 14, 17, and 18. These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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Answer ALL the questions.

For some questions, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

1. Which of the following is the same unit as the farad?

☒ **A** Ω s

☒ **B** Ω s^{-1}

☒ **C** Ω^{-1} s

☒ **D** Ω^{-1} s^{-1}

Q1

(Total 1 mark)

2. An emf will only be induced across the wing tips of an aircraft if it is flying horizontally in

☒ **A** a north-south direction

☒ **B** an east-west direction

☒ **C** a region where there is a horizontal component of the earth's magnetic field

☒ **D** a region where there is a vertical component of the earth's magnetic field.

Q2

(Total 1 mark)

3. A top quark has a mass of 171 $\frac{\text{GeV}}{c^2}$. Its mass in kilograms is about

☒ **A** 3×10^{-31}

☒ **B** 3×10^{-28}

☒ **C** 3×10^{-25}

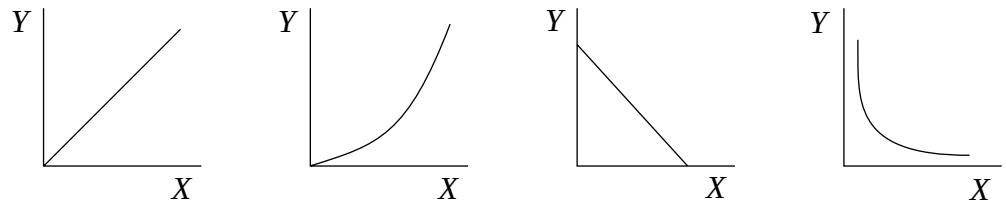
☒ **D** 3×10^{-19}

Q3

(Total 1 mark)

Leave blank

The following are four possible graphs of a quantity *Y* plotted against another quantity *X*. Refer to these graphs when answering questions 4, 5 and 6.



A **B** **C** **D**

4. Which graph **best** represents *Y* when it is the kinetic energy of an electron and *X* is its momentum?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

Q4

(Total 1 mark)

5. Which graph **best** represents *Y* when it is the electric field strength between two parallel plates with a constant potential difference across them and *X* is the distance apart of the plates?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

Q5

(Total 1 mark)

6. Which graph **best** represents *Y* when it is the radius of the circle described by an electron in a constant magnetic field at right angles to the path of the electron and *X* is the momentum of the electron?

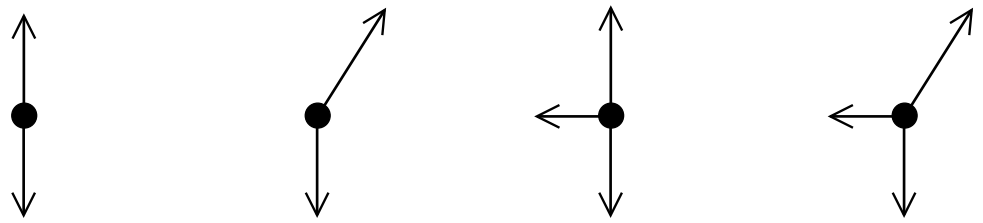
- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

Q6

(Total 1 mark)

Leave blank

7. Each of the diagrams below is a free-body force diagram representing the forces acting on a body.



A **B** **C** **D**

Which diagram best illustrates the forces acting on a charged sphere, supported on a nylon thread, in equilibrium alongside a second similarly charged sphere?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

Q7

(Total 1 mark)

8. A π^+ pion is composed of which combination of quarks?

- ☒ **A** ud
- ☒ **B** $\bar{u}d$
- ☒ **C** $u\bar{d}$
- ☒ **D** $\bar{u}\bar{d}$

Q8

(Total 1 mark)

Leave blank

The diagram shows two charged spheres X and Y, of masses 2*m* and *m* respectively, which are just prevented from falling under gravity by the uniform electric field between the two parallel plates. Use the diagram when answering questions 9 and 10.

9. Which of the following is a property of a **uniform** electric field?

- ☒ **A** The field strength is the same at all points.
- ☒ **B** The field acts equally in all directions.
- ☒ **C** The field produces no force on a stationary charged particle.
- ☒ **D** The field produces a force on a moving charged particle which is always perpendicular to its direction of travel.

Q9

(Total 1 mark)

10. If the plates are moved closer together

- ☒ **A** X and Y will both remain stationary.
- ☒ **B** X and Y will both move upwards with the same acceleration.
- ☒ **C** X will have a greater upward acceleration than Y.
- ☒ **D** Y will have a greater upward acceleration than X.

Q10

(Total 1 mark)

Leave blank

11. Figure 1 shows the London Eye, a tourist attraction in the form of a very large wheel. Passengers ride in capsules, describing a vertical circle at constant speed. Figure 2 is a free-body force diagram showing the forces acting on a passenger in one of the capsules at point X of the circle.

Figure 1

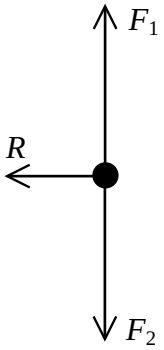


Figure 2

A teacher asks the class why the forces F_1 and F_2 are equal and opposite. A student suggests that this is because of Newton's third law.

(a) State **two** reasons why the forces F_1 and F_2 cannot be a Newton's third law pair.

Reason 1 .....

.....

Reason 2 .....

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(2)

(b) Explain why the forces F_1 and F_2 must be equal and opposite.

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(2)

(c) State what causes the force R.

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(1)

Q11

(Total 5 marks)

Leave blank

12. (a) State what is meant by the term **baryon**.

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(1)

(b) In β^- decay a neutron decays into a proton.

Explain how the quark structure of the baryon changes in this process.

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(2)

Q12

(Total 3 marks)

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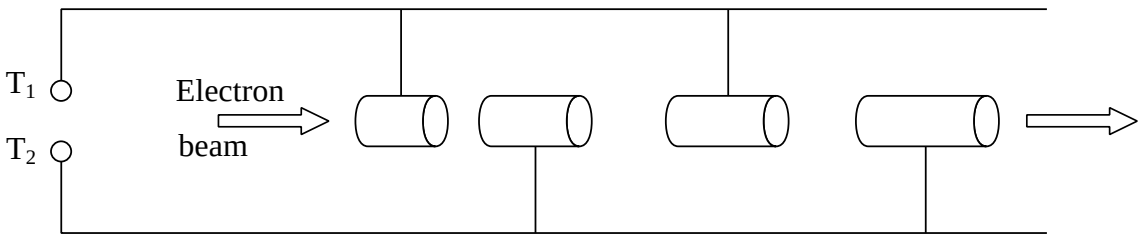
13. Quarks were discovered using the Stanford Linear Accelerator (SLAC). The diagram below shows the principle of a linear accelerator (LINAC).



(a) State what is connected between terminals T_1 and T_2.

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(2)

(b) Explain why the electrons travel with constant velocity whilst in the cylinders.

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(2)

(c) Explain why the cylinders gradually increase in length along the accelerator.

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(2) **Q13**

(Total 6 marks)

Leave blank

*14. At the start of the 20th century it was thought that the atom contained an even distribution of positive charge with electrons embedded in it. Rutherford directed a series of experiments using α-particles to investigate the structure of the atom.

In 1913 Rutherford wrote that "the observations on the scattering of α-particles by matter afford strong experimental evidence for the theory that the atom consists of a positively charged nucleus of minute dimensions surrounded by a compensating distribution of negative electrons".

Outline the experimental observations to which Rutherford is referring and explain how they led him to this deduction.

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Q14

(Total 5 marks)

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15. (a) A 2200 μF capacitor is charged to a potential difference of 12 V and then discharged through an electric motor. The motor lifts a 50 g mass through a height of 24 cm.

(i) Show that the energy stored in the capacitor is approximately 0.16 J.

Energy = ...

(2)

(ii) What is the efficiency of the electric motor in this situation?

Efficiency = ...

(2)

(b) The capacitor is charged to 12 V again and then discharged through a 16 Ω resistor.

(i) Show that the time constant for this discharge is approximately 35 ms.

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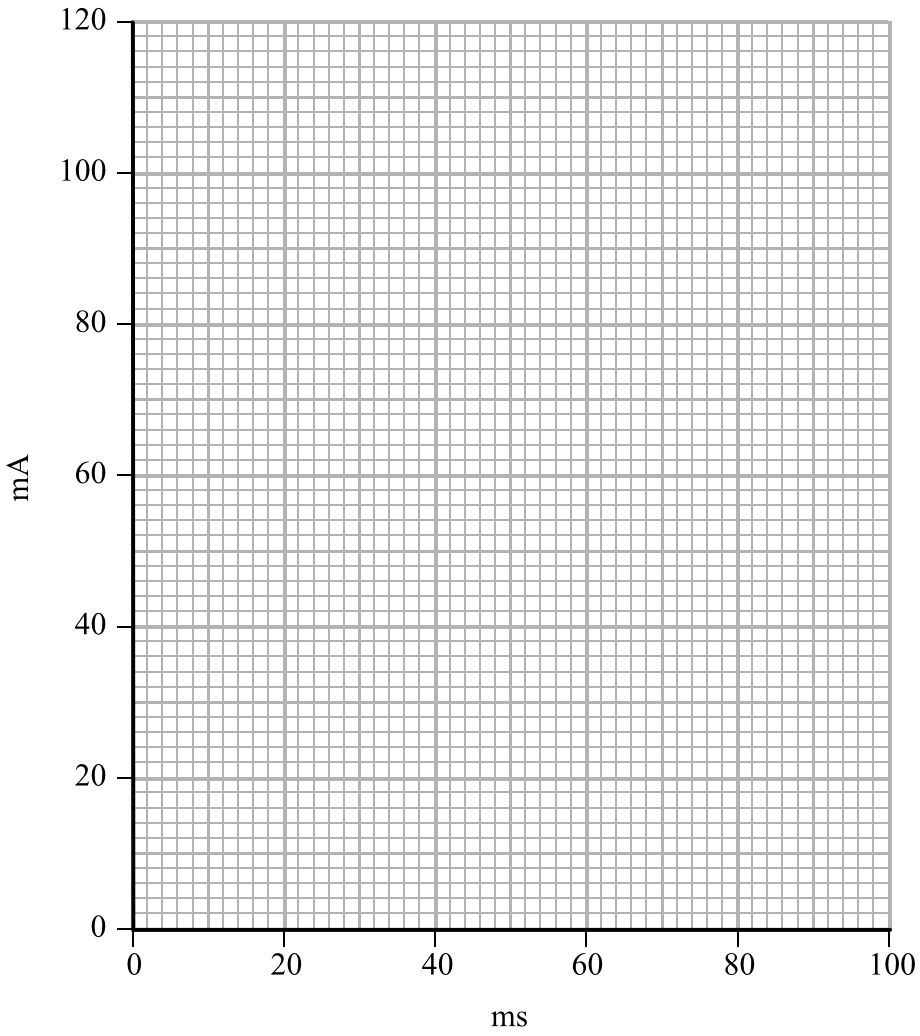
(1)

(ii) Sketch a graph of current against time for this discharge on the grid below. You should indicate the current at $t = 0$ and $t = 35$ ms.



(3)

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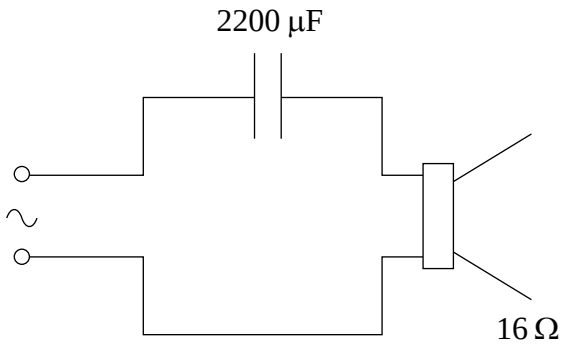
(c) Capacitors are used in audio systems when connecting the amplifier to the loudspeaker. In one such circuit the capacitor has a value of 2200 μF and the loudspeaker has a resistance of 16 Ω.



(i) The loudspeaker produces longitudinal waves. What is meant by longitudinal in this context?

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(2)

(ii) Ideally, the time constant for such a circuit should be much greater than the time period of the lowest frequency note. Discuss the extent to which this circuit would be effective if the lowest frequency note is 20 Hz.

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(2)

Q15

(Total 12 marks)

Leave blank

16. (a) In their famous experiment conducted in 1932, Cockcroft and Walton accelerated protons through a potential difference of 300 kV and used them to bombard a lithium ($^{7}_{3}\text{Li}$) target. They found that two alpha particles were produced. The energy of the alpha particles was subsequently calculated from the tracks they made in a cloud chamber.

Complete the nuclear equation for this event.

$$^{7}_{3}\text{Li} + \longrightarrow$$

(2)

(b) Cockcroft and Walton reported to the Royal Society that "if momentum is conserved in the process, then each of the α-particles must take up equal amounts of energy, and from the observed range of the α-particles we conclude that an energy of 17.2 million electron-volts [MeV] would be liberated in this disintegration process".

(i) State **two** other properties, in addition to momentum, that are conserved in such a process.

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(2)

(ii) Use the data below to show that the energy released in this process is approximately 2.8×10^{-12} J.

Mass of lithium nucleus = 7.0143 u
Mass of proton = 1.0073 u
Mass of α-particle = 4.0015 u

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(4)

Leave blank

(iii) Hence discuss the extent to which Cockcroft and Walton's results confirm Einstein's prediction that E is equal to mc^2.

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(5) **Q16**

(Total 13 marks)

Leave blank

***17.** (a) State the principle of conservation of linear momentum.

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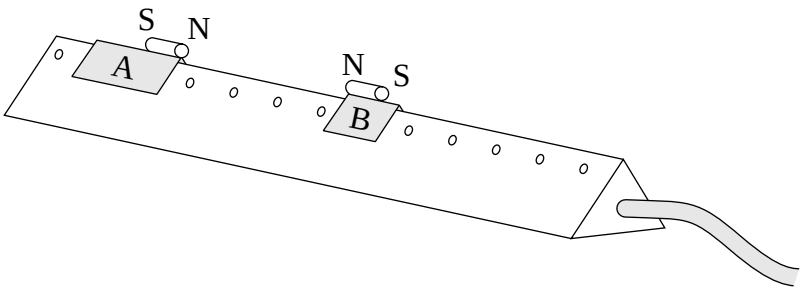
(2)

(b) The diagram shows two gliders on an air track. The magnets on the top of the gliders repel each other. The mass of glider A is 300 g and that of glider B is 100 g.



Glider A is given a push to start it moving towards glider B which is initially at rest.

Describe how you could determine the velocity of A before the gliders interact and the velocities of both A and B after the interaction. You may add to the diagram to show any additional apparatus required.

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(6)

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(c) A student obtains the following velocities:

velocity of A before interaction = 5.2 cm s^{-1}

velocity of A after interaction = 2.7 cm s^{-1}

velocity of B after interaction = 7.5 cm s^{-1}

Show if these results confirm that momentum is conserved in the interaction.

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(2) **Q17**

(Total 10 marks)

Leave blank

*18. A do-it-yourself company is advertising a wind turbine that they state can deliver a power of 1 kW.

Their specification provides the following data:

- area swept out by the blades in one revolution = 2.4 m^2
- power output = 1 kW at a wind speed of 12.5 m s^{-1}
- typical operating speed of blades = 600 revolutions per minute

(a) (i) Show that the length of each blade is approximately 0.9 m.

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(1)

(ii) Show that the angular velocity of the blades at the typical operating speed is approximately 63 rad s^{-1}.

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(1)

(iii) Calculate the speed at which the tips of the blades will then be travelling.

Speed = ...

(1)

(b) The theoretical power available from a wind turbine is given by

$$p = \tfrac{1}{2} \rho A v^3$$

where ρ = density of air = 1.3 kg m^{-3}
A = area swept out by blades per revolution
v = wind speed

(i) Show that when the wind speed is 12.5 m s^{-1}, the theoretical power from the advertised turbine is about 3 kW.

Power = ...

(2)

Leave blank

(ii) Suggest two reasons why the actual power is less than the theoretical power.

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(2)

(c) The manufacturer has to ensure that when the turbine is attached to a chimney stack, the force exerted on the chimney does not cause it to collapse. The turbine is designed to cut out at a wind speed of 14 m s^{-1}.

(i) Calculate the mass of air hitting the blades each second when the wind speed is 14 m s^{-1}.

Mass of air = ...

(2)

(ii) Hence calculate the maximum force that the wind could exert on the blades.

Maximum force .....

(2)

Leave blank

(d) The average wind speed in the UK is 5.8 m s^{-1}, which results in an actual average power output of 100 W. Discuss whether it would be better for the environment to replace some filament light bulbs with low energy bulbs than to use this turbine. Assume each filament light bulb is rated at 100 W and each low energy bulb is rated at 11 W.

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(5) **Q18**

(Total 16 marks)

TOTAL FOR PAPER: 80 MARKS

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Candidate No.						6	P	H	0	5	/	1	Signature	

Paper Reference(s)

6PH05/1

Edexcel GCE

Physics

Unit 5: Physics from Creation to Collapse

Sample Assessment Material

Time: 1 hour 35 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
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Total	

Materials required for examination
Nil

Items included with question papers
Nil

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature. Check that you have the correct question paper.
Answer ALL the questions in Section A and Section B. Write your answers in the spaces provided in this question paper.
Some questions must be answered with a cross in a box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(4)**.
The total mark for this paper is 80. There are 19 questions in this paper.
There are 20 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

Quality of written communication will be taken into account in the marking of your responses to Questions 18 and 19. These questions are indicated with an asterisk. Quality of written communication includes clarity of expression, the structure and presentation of ideas and grammar, punctuation and spelling.

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SECTION A

Answer ALL the questions in this section.

For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).

1. A valid set of units for specific heat capacity is

- ☒ **A** $\text{kg J}^{-1}\text{K}^{-1}$
- ☒ **B** kg J K^{-1}
- ☒ **C** $\text{kg}^{-1}\text{ J K}^{-1}$
- ☒ **D** $\text{kg J}^{-1}\text{K}$

Q1

(Total 1 mark)

2. The gravitational field strength on the surface of the Earth is g. The gravitational field strength on the surface of a planet of twice the radius and the same density is

- ☒ **A** $4g$
- ☒ **B** $2g$
- ☒ **C** g
- ☒ **D** $g/4$

Q2

(Total 1 mark)

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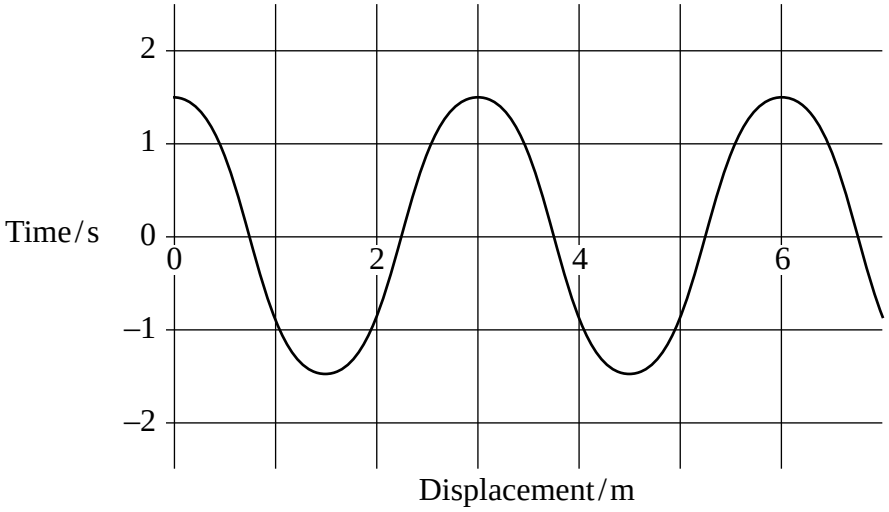
3. A child is playing on a swing. The graph shows how the displacement of the child varies with time.



The maximum velocity, in m s^{-1}, of the child is

☒ **A** $\pi/2$

☒ **B** π

☒ **C** 2π

☒ **D** 3π

Q3

(Total 1 mark)

4. Cosmic background radiation is a remnant of the big bang and appears to pervade the universe. It has a maximum wavelength in the microwave region of the electromagnetic spectrum. This can be calculated to correspond to a temperature of about 3 K. This calculation is based on the assumption that

☒ **A** the universe is spherical

☒ **B** the universe is expanding

☒ **C** space can be regarded as a black body

☒ **D** space is a vacuum

Q4

(Total 1 mark)

Leave blank

5. A student is asked: "What is meant by background radiation?"
She writes: "It is the radiation produced by the rocks in the ground."
This answer is

- ☒ **A** correct
- ☒ **B** incorrect – rocks do not produce radiation
- ☒ **C** incomplete
- ☒ **D** incorrect – this radiation would not be ionising

Q5

(Total 1 mark)

6. A car driver notices that her rear view mirror shakes a lot at a particular speed. To try to stop it she sticks a big lump of chewing gum on the back of the mirror.

Which one of the following statements is correct?

- ☒ **A** The mirror no longer shakes a lot because it is heavily damped.
- ☒ **B** The mirror stills shakes a lot at the same speed as before because the chewing gum does not change the damping.
- ☒ **C** The mirror shakes a lot at a different speed because the chewing gum changes the damping.
- ☒ **D** The mirror shakes a lot at a different speed because the chewing gum has changed the resonant frequency of the mirror.

Q6

(Total 1 mark)

7. The *x*-axis of a Hertzsprung-Russell diagram is log *T*. This is because

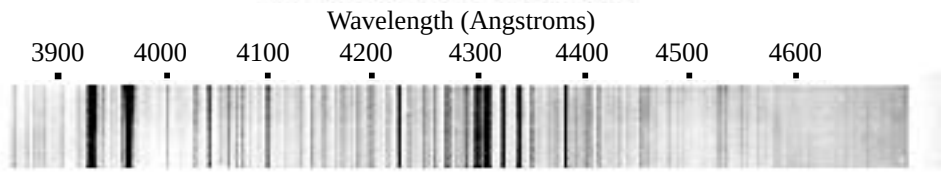
- ☒ **A** the range of temperatures of the surfaces of stars is large
- ☒ **B** the temperatures of the surfaces of stars are all very large numbers
- ☒ **C** the scale has to start with the hottest stars
- ☒ **D** the diagram would be impossible to interpret if log *T* was the *y*-axis

Q7

(Total 1 mark)

Leave blank

8. The spectrum of visible light from the Sun contains a number of dark lines known as Fraunhofer lines.



This is due to

☒ **A** polarisation caused by the atmosphere

☒ **B** absorption of light by atoms

☒ **C** refraction of light by telescopic lenses

☒ **D** the Doppler effect because atoms are moving very fast

Q8

(Total 1 mark)

9. All quasars show large red shifts in the light received from them. This shows that they

☒ **A** have large diameters

☒ **B** are moving towards us at very high speeds

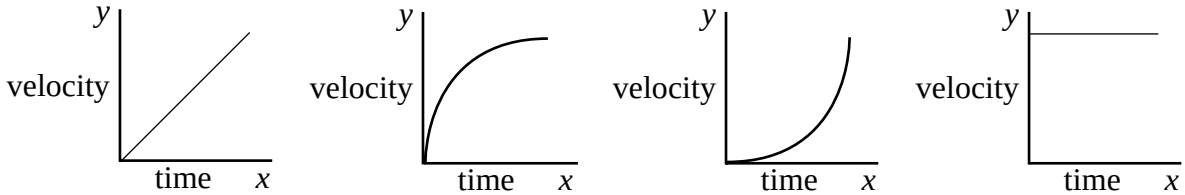
☒ **C** have a low temperature

☒ **D** are far away from earth

Q9

(Total 1 mark)

10. A space rocket takes off vertically from the surface of the Earth. Assuming the thrust remains constant which graph best represents the variation of velocity of the rocket with time f the universe expands forever it can be described as



☒ **A**

☒ **B**

☒ **C**

☒ **D**

Q10

(Total 1 mark)

TOTAL FOR SECTION A: 10 MARKS

Leave blank

SECTION B

Answer ALL the questions in this section.

11. An ideal gas is contained in a volume of $2.0 \times 10^{-3}\,m^3$.

(a) Explain why the internal energy of an ideal gas is only kinetic.

.....

.....

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.....

(2)

(b) The pressure of the gas is $1.2 \times 10^5\,Pa$ and its temperature is 27 °C. Calculate the number of molecules of gas within this container.

Number of molecules = ...

(2) **Q11**

(Total 4 marks)

Leave blank

12. Smoke detectors contain an alpha emitting source.

(a) Describe how you would determine whether this radioactive source emits alpha particles only.

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(4)

(b) State why smoke detectors do not provide a radiation risk in normal use.

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(1) **Q12**

(Total 5 marks)

13. Two stars in the night sky appear equally bright to an observer. The Ancient Greeks thought that all stars were the same distance from the Earth. State and explain **two** reasons why these two stars do not need to be the same distance from the observer.

Reason One

.....

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(2)

Reason Two

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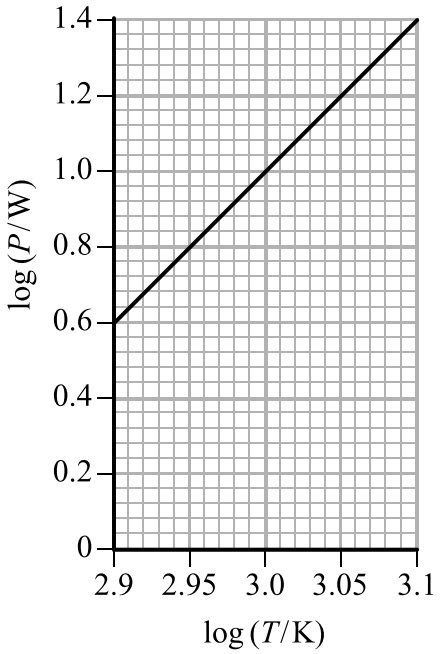
(2) **Q13**

(Total 4 marks)

Leave blank

14. The graph shows how the logarithm of the electrical power P supplied to a filament lamp varies with the logarithm of the temperature T of the filament.



(a) P is related to T by a power law: $P = k\,T^{n}$

Use the graph to determine n.

n = ...

(2)

(b) A student suggests that this relationship is predicted by the Stefan-Boltzmann law.

Comment on this statement.

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(2)

Q14

(Total 4 marks)

Leave blank

15. The Hubble constant is thought to be about 70 000 m s^{-1} Mpc^{-1}.

(a) Give one reason why the value of this constant is uncertain.

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(1)

(b) State how an estimate of the age of the Universe can be calculated from the Hubble constant.

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(1)

(c) Explain how the ultimate fate of the Universe is associated with the Hubble constant.

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(3) **Q15**

(Total 5 marks)

Leave blank

16. Potassium-40 ($_{19}$K) is unstable.

(a) Calculate the binding energy per nucleon for potassium-40.
Nuclear mass of potassium-40 = 39.953548 u
Mass of one neutron = 1.008 665 u
Mass of one proton = 1.007 276 u

Binding energy per nucleon = ...

(6)

(b) Explain what is meant by the random nature of nuclear decay.

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.....

.....

.....

(1)

Leave blank

(c) Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium-40 to argon-40. The half-life of potassium-40 is 1.3×10^9 years.

(i) Show that the decay constant of potassium-40 is about $5 \times 10^{-10}\,y^{-1}$.

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(1)

(ii) In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40.

Calculate the age of the rock sample in years.

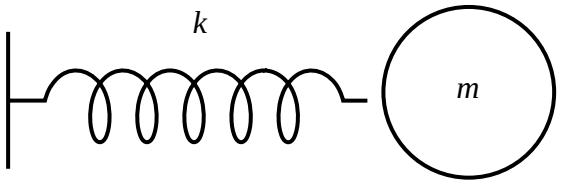
Age of rock = ...

(4) **Q16**

(Total 12 marks)

Leave blank

17. Certain molecules such as hydrogen chloride (HCl) can vibrate by compressing and extending the bond between atoms. A simplified model ignores the vibration of the chlorine atom and just considers the hydrogen atom as a mass *m* on a spring of stiffness *k* which is fixed at the other end.



(a) (i) Show that the acceleration of the hydrogen atom, *a*, is given by $a = -\frac{kx}{m}$ where *x* is the displacement of the hydrogen atom.

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(2)

(ii) Hence derive the equation $T = 2\pi\sqrt{\frac{m}{k}}$ for the period of natural oscillations of the hydrogen atom.

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(2)

Leave blank

(b) Infrared radiation is used in chemical analysis.

Compared to other radiations, infrared radiation of wavelength 3.3 μm is strongly absorbed by hydrogen chloride gas. As a result of this absorption, the amplitude of oscillations of the hydrogen atoms significantly increases.

(i) What name is given to this phenomenon?

.....

.....

(1)

(ii) State the condition for it to occur.

.....

.....

(1)

(iii) Calculate the frequency of infrared radiation of wavelength 3.3 μm.

Frequency = ...

(2)

(iv) Hence calculate the stiffness of the hydrogen chloride bond.

Mass of hydrogen atom = 1.67×10^{-27} kg

Stiffness = ...

(3)

Q17

(Total 11 marks)

Leave blank

*18. (a) A planet of mass m orbits a star of mass M. The radius of orbit is r. By considering the force required for circular motion in this situation, show that the period T of the orbit is given by $T^2 = \frac{4\pi^2 r^3}{GM}$.

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(3)

(b) Measurements have shown that star HD70642 has a planet which orbits the star with a period of about 6 years. The radius of the orbit is about 3× the radius of the Earth's orbit around the Sun.

(i) Use the formula in (a) to determine a value for the ratio $\frac{\text{mass of star HD70642}}{\text{mass of Sun}}$.

$\frac{\text{mass of star HD70642}}{\text{mass of Sun}}$ = ...

(3)

Leave blank

(ii) Because of the presence of the planet, the star HD70642 does not remain at rest. Instead, the planet and star both orbit around their common centre of mass. Explain why the orbiting speed of the star is very small in comparison to the speed of the planet.

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(2)

(c) Astronomers discovered the planet by observing the "Doppler Wobble" effect. As the planet orbits the star, light from the star undergoes a Doppler shift in its frequency. Explain why this method is likely to only detect **very large** planets.

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(3)

Q18

(Total 11 marks)

Leave blank

***19.** Read the following passage and answer the questions that follow.

A nova is a sudden brightening of a star. Novae are thought to occur on the surface of a white dwarf star which is paired with another star in a binary system. If these two stars are close enough to each other, hydrogen can be pulled from the surface of the star onto the white dwarf. Occasionally, the temperature of this new material on the surface of the white dwarf may become hot enough for the hydrogen to fuse to helium. This causes the white dwarf to suddenly become very bright. In a nova, this hydrogen fusion occurs by the "CNO" process, where helium-4 is produced by a series of steps in which protons react with various isotopes of Carbon, Nitrogen and Oxygen. Novae are used by astronomers as standard candles.

(a) Complete the equation which shows a typical part of the CNO process.

$$\text{.....}_{8}\text{O} + \text{.....}_{\text{.....}}\text{H} \rightarrow {}^{14}_{\text{.....}}\text{N} + \text{.....}_{\text{.....}}\text{.....}$$

(3)

(b) What is a white dwarf? Suggest why hydrogen fusion in the white dwarf is likely to be the CNO process.

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(3)

Leave blank

(c) The temperature required for these processes is 10^7 K.

(i) Calculate the mean kinetic energy, in keV, of the particles involved.

energy of particles = ... keV
(3)

(ii) Explain how this temperature arises.

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.....

.....
(2)

(d) Astronomers use novae as standard candles. Explain what a standard candle is, and suggest what this implies about the processes occurring in a nova.

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(3)

Q19

(Total 14 marks)

TOTAL FOR SECTION B: 70 MARKS
TOTAL FOR PAPER: 80 MARKS

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C Sample mark schemes

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Physics Specific Marking Guidance

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

> Horizontal force of hinge on table top
>
> 66.3 (N) or 66 (N) **and** correct indication of direction [no ue]
> [Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

Mark scheme format

- Bold lower case will be used for emphasis.
- Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
- Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

Unit error penalties

- A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
- Incorrect use of case e.g. 'Watt' or 'w' will not be penalised.
- There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given.
- The same missing or incorrect unit will not be penalised more than once within one question but may be penalised again in another question.
- Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
- The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

Significant figures

- Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
- Use of an inappropriate number of significant figures will normally be penalised in the practical examinations or coursework.
- Using $g = 10\ m\ s^{-2}$ will **not** be penalised.

Calculations

- Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
- If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
- use of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.
- recall of the correct formula will be awarded when the formula is seen or implied by substitution.
- The mark scheme will show a correctly worked answer for illustration only.

- Example of mark scheme for a calculation:

  'Show that' calculation of weight

  Use of L × W × H

  Substitution into density equation with a volume and density

  Correct answer [49.4 (N)] to at least 3 sig fig. [No ue]
  [Allow 50.4(N) for answer if 10 N/kg used for g.]
  [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
  [Bald answer scores 0, reverse calculation 2/3]

  Example of answer:

  80 cm × 50 cm × 1.8 cm = 7200 cm^3

  7200 cm^3 × 0.70 g cm^{-3} = 5040 g

  5040 × 10^{-3} kg × 9.81 N/kg

  = 49.4 N

Quality of Written Communication

- Indicated by QoWC in mark scheme, placed as first mark.
- Usually it is part of a max mark.

Graphs

- A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
- Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
- A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.
- Points should be plotted to within 1 mm.

  Check the two points furthest from the best line. If both OK award mark.
  If either is 2 mm out do not award mark.
  If both are 1 mm out do not award mark.
  If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.
- For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Unit 1: Physics on the Go

Question Number	Question	
1	Which of the following quantities is a vector?	
	Answer	Mark
	D	**1**

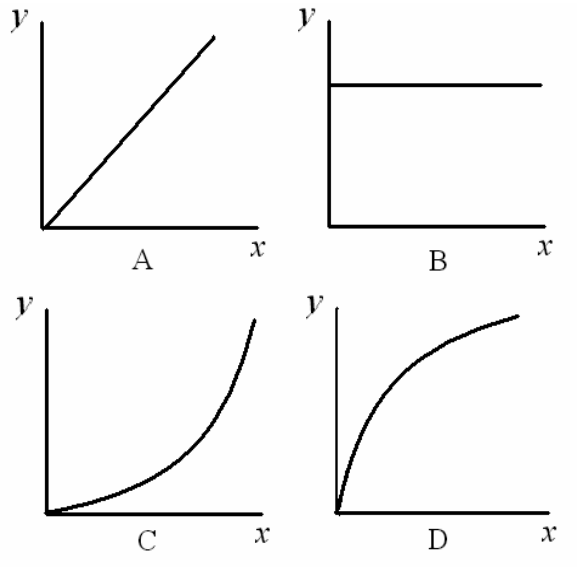
Question Number	Question	
2	Two wires made of the same material but of different lengths and diameters are joined end to end and used to support a vertical load. If the weight of each wire is neglected, each wire must have the same	
	Answer	Mark
	C	**1**

Question Number	Question	
3	Newton's third law tells us that	
	Answer	Mark
	D	**1**

Question Number	Question	
4	An athlete throws a javelin. Just as it hits the ground the javelin has a horizontal velocity component of 20 m s^{-1} and a vertical velocity component of 10 m s^{-1}. The magnitude of the javelin's velocity as it hits the ground is	
	Answer	Mark
	C	**1**

Question Number	Question	
5	In questions 5 – 6, which of the following statements best completes the sentence. A decreases linearly from zero B increases from zero to a maximum C increases linearly from zero D stays constant at a non-zero value If air resistance is neglected, the horizontal velocity component of an arrow fired from a bow…….with distance travelled	
	Answer	Mark
	D	**1**

Question Number	Question	
6	The velocity of a ball bearing falling from rest through syrup……. with distance fallen	
	Answer	Mark
	B	**1**

Question Number	Question	
7	In questions 7 – 8, which of the following graphs best represents the quantities described when they are plotted on the *y*- and *x*-axes. Each graph may be used once, more than once or not at all.  	

Variable on *y*-axis	**Variable on *x*-axis**
The kinetic energy of a car accelerating uniformly from rest	Displacement from starting position

	Answer	Mark
	A	**1**

Question Number	Question	
8		

Variable on *y*-axis	**Variable on *x*-axis**
The acceleration of a feather falling near to the Moon's surface	Height above the Moon's surface

	Answer	Mark
	B	**1**

Question Number	Question	
9	A shot putter launches the shot at an angle of 30^{o} to the horizontal. The throw is repeated with the same launch speed, but this time at an angle of 40^{o} to the horizontal. Which of the following is **not** correct?	
	Answer	Mark
	B	**1**

Question Number	Question	
10	Steel can be classified as a strong material. This is because	
	Answer	Mark
	B	**1**

Question Number	Question	
11	Complete the gaps in the following paragraph by selecting appropriate words from the following list. compressive density energy force mass stiff tensile tough Increasingly, drinks containers are made out of polymers rather than glass. A container made from a polymer such as polythene has several advantages over a glass container. Polythene has low …... and so the …….…….of the container is kept low. Polythene is also ……..…..and so can absorb a large amount of …….…….before breaking. Glass is only strong under …… forces but polythene is also strong under ……..….. forces.	
	Answer	Mark
	density, mass (1) tough, energy (1) compressive, tensile (1)	**3**

Question Number	Question	
12(a)(i)	(a) (i) Determine $\frac{\text{kinetic energy of car travelling at 20 mph}}{\text{kinetic energy of car travelling at 30 mph}}$.	
	Answer	Mark
	Use of $E_k = \frac{1}{2}mv^2$ Correct answer [0.44] (1) Example of calculation: $\frac{E_{20}}{E_{30}} = \frac{(20)^2}{(30)^2} = 0.44$	**1**

Question Number	Question	
12(a)(ii)	(ii) To what extent does your answer support the claim?	
	Answer	Mark
	Collision energy is more than halved (1), so claim is justified (1)	**2**

Question Number	Question	
12(b)	A car of mass 1200 kg is in a crash. The front bumper of the car deforms, and the car is brought to rest from an initial speed of 10 m s^{-1} in a distance of 0.12 m. By considering the work done on the car as it is brought to rest, calculate the average impact force that acts. Average impact force =……	
	Answer	Mark
	Calculation of collision energy [60 kJ] (1) Use of $W = Fx$ (1) Correct answer [500 kN] (1) Example of calculation: $E_k = \frac{1}{2}mv^2 = 0.5 \times 1200 \times (10)^2 = 60{,}000\text{J}$ $W = Fx$ so $F = \frac{W}{x} = \frac{60{,}000}{0.12m} = 500kN$	**3**

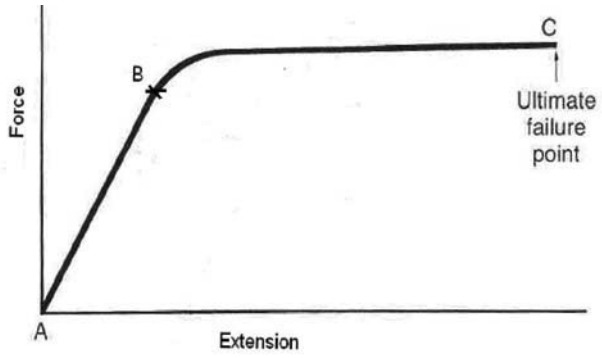
Question Number	Question	
12(c)	Modern cars include crumple zones to reduce the size of the impact force. Suggest how the crumple zones do this.	
	Answer	Mark
	Crumple zone increases displacement of car during crash so collision force is reduced **or** crumple zone increases collision time and so decreases the acceleration (and force) (1)	**1**

Question Number	Question	
13(a)	A skydiver accelerates towards the ground at 9.81 m s^{-2} at the instant that he leaves the aeroplane. Explain why his acceleration will decrease as he continues to fall.	
	Answer	Mark
	As skydiver speeds up, air resistance will increase (1) Net force on skydiver will decrease, reducing acceleration (1)	**2**

Question Number	Question	
13(b)	The skydiver opens his parachute. Explain why he reaches a terminal velocity shortly afterwards.	
	Answer	Mark
	Parachute greatly increases the size of the air resistance (1) When air resistance = weight of skydiver, skydiver is in equilibrium (1)	**2**

Question Number	Question	
13(c)	The velocity at which he then hits the ground is similar to that achieved when falling freely from a height of 3 m. Calculate this velocity.	
	Answer	Mark
	Use of $v^2 = u^2 + 2as$ **or** $\frac{1}{2}mv^2 = mg\Delta h$ (1) Correct answer [7.7 ms^{-1}] (1) Example of calculation: $v = \sqrt{2 \times 9.81 \times 3} = 7.7 ms^{-1}$	**2**

Question Number	Question	
14	A sign at a railway station advises passengers to keep back from the platform edge. This is because passing trains may cause turbulence.  Explain what is meant by turbulent flow, and suggest why it is dangerous for passengers to stand near the edge of the platform. You may be awarded a mark for the clarity of your answer.	
	Answer	Mark
QWC(i, iii)	Spelling of technical terms must be correct and the answer must be organised in a logical sequence Mixing of layers leading to eddies/whorls (1) Air circulates around at edge of platform (1) Passenger may be pushed over due to eddies/whorls (1)	**3**

Question Number	Question	
15(a)	The graph shows how a sample of material behaves when extended by a force.  What does point **B** represent?	
	Answer	Mark
	Proportional / Hooke's law limit (1)	**1**

Question Number	Question	
(b)	State the physical property represented by the gradient of the section **AB** of the graph.	
	Answer	Mark
	Stiffness of sample (1)	**1**

Question Number	Question	
(c)	Explain the significance of the area underneath the line from **A** to **C**.	
	Answer	Mark
	Work done / strain energy (1) To stretch (OR strain) wire to fracture (1)	**2**

Question Number	Question	
16(a)	A raindrop has a radius of 0.70 mm. It is falling at terminal velocity through air. (a) Show that the mass of the raindrop is approximately 1×10^{-6} kg. Density of water = 1000 kg m^{-3}.	
	Answer	Mark
	Use of $\frac{4}{3}\pi r^3 \rho$ (1) Correct answer [1.44 x 10^{-6} kg] (1) Example of calculation: $m = \frac{4}{3}\pi r^3 \rho = \frac{4}{3}\pi\left(0.7\times10^{-3}\right)^3 \times 1000 = 1.44\times10^{-6}\,kg$	**2**

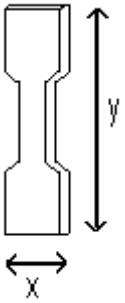
Question Number	Question	
16(b)	Ignoring any upthrust on the raindrop, calculate its terminal velocity.Viscosity of air = 8.90×10^{-4} kg m^{-1} s^{-1}	
	Answer	Mark
	Use of $mg = 6\pi\eta rv$ (1) Correct answer [1.2 ms^{-1}] (1) Example of calculation: $v = \frac{mg}{6\pi\eta r} = \frac{1.44\times10^{-6}\times9.81}{6\pi\times8.90\times10^{-4}\times0.7\times10^{-3}} = 1.2\,ms^{-1}$ (2)	**2**

Question Number	Question	
17(a)	Discuss the student's answer, highlighting any incorrect or missing physics.	
	Answer	Mark
	Reference to free fall whilst bungee is slack Idea of KE increasing as GPE is transformed Idea of work being done against frictional forces GPE converted into EPE (and KE) once bungee stretches KE (and GPE) converted into EPE beyond equilibrium point At lowest point all of the KE has been converted into EPE	**Max 4**

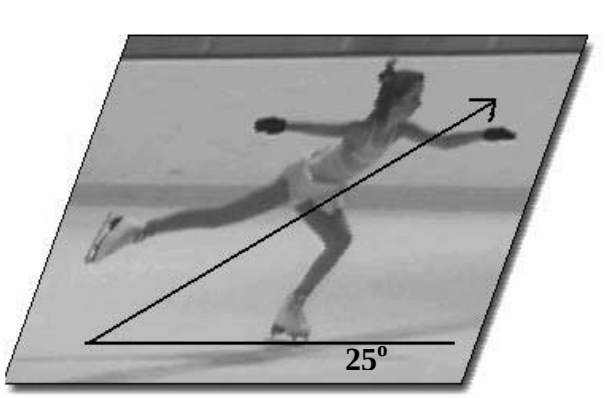
Question Number	Question	
17(b)	Calculate the acceleration of the jumper.	
	Answer	Mark
	Use of F=ma Correct answer [6.25 ms^{-2}] Example of calculation: $a = \frac{F}{m} = \frac{785-285}{80} = 6.25\,ms^{-2}$	**1** **1**

Question Number	Question	
18(a)	How long does the hammer take to fall 1.0 m from rest?	
	Answer	Mark
	Use of $s = ut + \frac{1}{2}at^2$ Correct answer [1.1 s] Example of calculation: $t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2\times 1}{1.6}} = 1.1s$	**1** **1**

Question Number	Question	
18(b)	Calculate the velocity of the hammer just before it hits the ground.	
	Answer	Mark
	Use of $v = u + at$ Correct answer [1.8 ms^{-1}] Example of calculation: $v = u + at = 1.6 \times 1.1 = 1.8\ ms^{-1}$	**1** **1**

Question Number	Question	
19(a)	A tensile tester connected to a datalogger is used to investigate the effect of applying forces to a range of materials.   The sample has approximate dimensions ***x*** = 1 cm, ***y*** = 10 cm. It is fixed into the frame and force applied from a hydraulic system. The datalogger records the extension of the sample and the applied force. State any measurements, other than the force, that you would need to calculate the stress in the sample and name an appropriate instrument that you could use to make these measurements.	
	Answer	Mark
	Length and breadth of the thin cross section to calculate area (1) Digital callipers / micrometer (1)	**2**

Question Number	Question	
19(b)	Explain why access to a datalogger is useful when tensile testing is carried out	
	Answer	Mark
	• Small extensions can be measured accurately (1) • Large data set / easy processing of data (1)	**2**

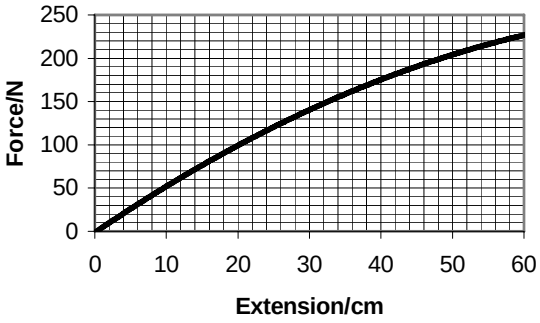
Question Number	Question	
20(a)	Performing complex jumps is an important aspect of a figure skater's program. Jumps with great heights and jump distances tend to leave a better impression with the judges, resulting in better marks for the skater. A skater of mass 60 kg leaves the ice with a velocity of 10 m s^{-1} at an angle of 25° to the horizontal.  Show that the vertical component of the skater's velocity is approximately 4 m s^{-1}.	
	Answer	Mark
	Use of $v \sin\theta$ (1) Correct answer [4.2 ms^{-1}] (1) Example of calculation: $v \sin\theta = 10 \sin 25 = 4.2\ ms^{-1}$	**2**

Question Number	Question	
20(b)	Calculate the time taken to reach the top of the jump Time taken =	
	Answer	Mark
	Use of $v = u + at$ (1) Correct answer [0.43 s] (1) Example of calculation: $v = u + at \quad 0 = 4.2 - 9.81 \times t$ $t = \frac{4.2}{9.81} = 0.43\ s$	**2**

Question Number	Question	
20(c)	Calculate the maximum height reached. Maximum height =	
	Answer	Mark
	Use of $s = ut + \frac{1}{2}at^2$ **or** $s = \frac{(u+v)}{2}.t$ (1) Correct answer [0.90 m] (1) Example of calculation: $s = ut + \frac{1}{2}at^2 = 4.2 \times 0.43 - 0.5 \times 9.81 \times (0.43)^2 = 1.81 - 0.91 = 0.90\ m$ **or** $s = \frac{(u+v)}{2}.t = \left(\frac{4.2+0}{2}\right) \times 0.43 = 0.90\ m$	**2**

Question Number	Question	
21(a)(i)	A chest expander is used to build up the chest muscles.  One type of expander consists of five identical springs as shown. A student disconnects one spring and finds that applying a force of 6 N to it causes an extension of 5 cm. Calculate the force required to stretch a single spring by 50 cm, stating the assumption you have made. Assumption: Force =…….	
	Answer	Mark
	Assumption: spring obeys Hooke's Law (1) Use of $F = kx$ (1) Correct answer [60N] (1) Example of calculation: $\frac{F_2}{F_1} = \frac{x_2}{x_1}$ $F_2 = \frac{50}{5} \times 6 = 60N$	**3**

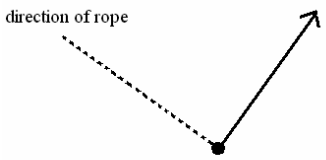
Question Number	Question	
21(a)(ii)	Calculate the work done when all 5 springs are stretched by 50 cm. Work done =……	
	Answer	Mark
	Use of $W = F_{av}.x$ (1) Correct answer [75J] (1) Example of calculation: $W = F_{av}.x$ $W = 5 \times \frac{60}{2} \times 0.5 = 75J$	**2**

Question Number	Question	
21(b)(i)	A different type of chest expander uses rubber cords instead of springs. The variation of restoring force with extension for this expander is shown.  Use the graph to estimate the work done in extending the expander by 50 cm. Work done = …….	
	Answer	Mark
	Attempt at estimation of area under graph / average force (1) 0.5 m extension used (1) Correct answer [53 → 57J] (1) Example of calculation: Energy represented by 1 square =10 × 0.02 = 0.2 J 280 squares × 0.2J = 56J Treating the area as a large triangle $W = 0.5 \times 205 \times 0.5 = 51J$	**3**

Question Number	Question	
21(b)(ii)	When unloading the expander, it is found that at each extension the restoring force is always less than the loading force. Explain the significance of this, and describe what effect this would have on the rubber cords when performing a large number of repetitions with the expander.	
	Answer	Mark
QWC (i, iii)	Spelling of technical terms must be correct and the answer must be organised in a logical sequence Energy returned is less than the work done in stretching the cords (1) Energy must be conserved, so internal energy of cords must increase (1) Rubber cords will get warmer (1)	**3**

Question Number	Question	
22(a)	The photograph shows a climber abseiling down a rock face. At the instant shown the climber is in equilibrium.  Explain what is meant by equilibrium in this context. Weight =……..	
	Answer	Mark
	Idea that no resultant force acts (e.g. forces are balanced / cancel)(1)	**1**

Question Number	Question	
22(b)	The climber's mass is 65 kg. Calculate his weight.	
	Answer	Mark
	Use of w = mg (1) Correct answer [640 N] (1) <u>Example of calculation:</u> w = mg = 65 × 9.81 = 638 N	**2**

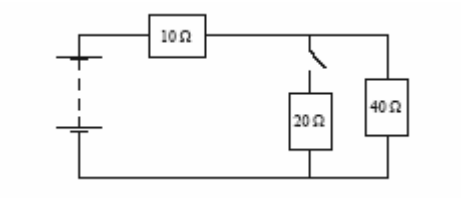
Question Number	Question	
22(c)(i)	Below is an incomplete free-body force diagram for the climber.  One of the forces, which is assumed to be acting perpendicular to the rope is already shown. Label this force, and add labelled arrows to the diagram to represent the other two forces acting on the climber. Assume that the rope hanging down from the climber exerts a negligible force on him.	
	Answer	Mark
	Tension in rope marked (1) Push from rock face marked (1) Weight marked (1)	**3**

Question Number	Question	
22(c)(ii)	The rope is at an angle of 40^{o} to the horizontal. Calculate the tension in the rope.	
	Answer	Mark
	Use of T = w.sin40 (1) Correct answer [410 N] (1) Example of calculation: T = w.sin40 = 640 ×sin40 = 410 N	**2**

Question Number	Question	
22(d)	The climber is wearing protective headgear in case of an accident. Describe the properties of a material suitable for the headgear, and explain why these properties are desirable.	
	Answer	Mark
QWC (i, iii)	Spelling of technical terms must be correct and the answer must be organised in a logical sequence Rigid/stiff exterior to resist deformation under small forces (1) Must undergo plastic deformation under large forces (1) so that collision energy can be absorbed (1) Low density so that helmet is not uncomfortably heavy (1)	**4**

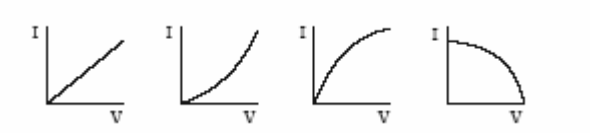
Unit 2: Physics at Work

Question Number	Question	
1	Three identical resistors are connected across a potential difference *V* so that one of them is in parallel with the other two which are connected in series. The power dissipated through the first one, compared to the power dissipated by each of the other two, is approximately	
	Answer	Mark
	D	**1**

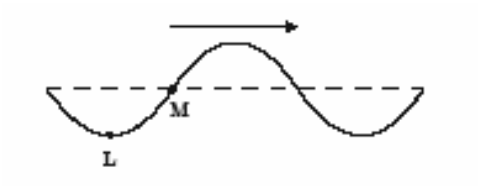
Question Number	Question	
2	A circuit is set up as shown in the diagram.  When the switch is closed, the potential difference across the 20 Ω resistor would	
	Answer	Mark
	C	**1**

Question Number	Question	
3	How much electrical energy is required to move 4.00 mC of charge through a potential difference of 36.0 V?	
	Answer	Mark
	B	**1**

Question Number	Question	
4	A source of light emits a train of waves lasting 0.04 μs. The light has a wavelength of 600 nm and the speed of light is 3×10^8 m s^{-1}. How many complete waves are sent out?	
	Answer	Mark
	A	**1**

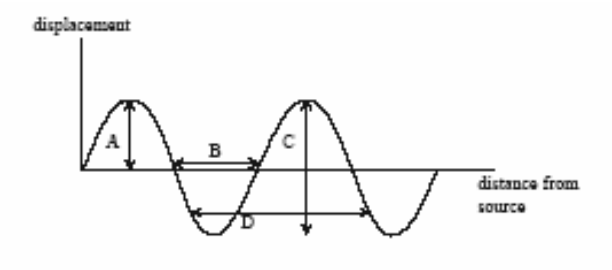
Question Number	Question	
5	Which of the following graphs gives the current-potential difference characteristic of an NTC thermistor. 	
	Answer	Mark
	B	**1**

Question Number	Question	
6	Which of the following statements about standing waves is true?	
	Answer	Mark
	C	**1**

Question Number	Question	
7	The diagram shows a wave on a rope. The wave is travelling from left to right.  At the instant shown, point **L** is at a maximum displacement and point **M** has zero displacement. Which row in the table correctly describes the motion of points **L** and **M** during the next half cycle of the wave?	
	Answer	Mark
	B	**1**

Question Number	Question	
8	Electromagnetic waves are produced by oscillating charges. Sound waves are produced by oscillating tuning forks. How are these waves similar?	
	Answer	Mark
	C	**1**

Question Number	Question	
9	Two points on a progressive wave differ in phase by $\frac{\pi}{4}$ radian. The distance between them is 0.50 m. The frequency of the oscillations is 10 Hz. The maximum speed of the wave is	
	Answer	Mark
	D	**1**

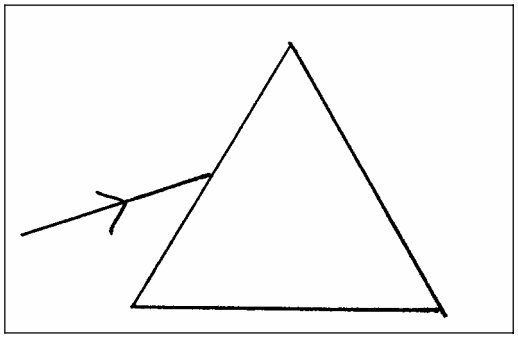
Question Number	Question	
10 (a)	A loudspeaker emits a sound wave of wavelength of 0.66 m. The diagram shows how displacement varies with distance from the loudspeaker at one instant of time.  Which letter indicates the wavelength of the sound wave?	
	Answer	Mark
	D	**1**

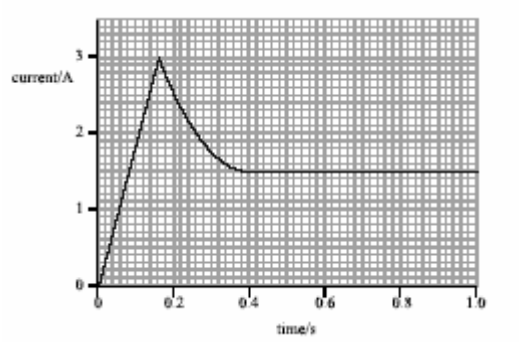
Question Number	Question	
10(b)	Sound travels at 330 m s^{-1} in air. Calculate the period of the wave. Period =	
	Wavelength Use of $v = f\lambda$ (1) Use of $f = 1/T$ (1) Answer T = [0.002 s] (1) [give full credit for candidates who do this in 1 stage $T = \lambda/v$] Example of answer $v = f\lambda$ f = 330 / 0.66 $T = 1/f$ = 0.66 / 330 T = 0. 002 s	**3**

Question Number	Question	
11	State **two** conditions necessary for total internal reflection to occur at an interface between air and water. Condition 1 Condition 2	
	Answer	Mark
	Direction of travel of light is water → air (1) Angle of incidence is greater than the critical angle (1)	**2**

Question Number	Question	
12(a)	Explain with the aid of diagrams why transverse waves can be polarised but longitudinal ones cannot be polarized.	
	Answer	Mark
	Transverse waves oscillate in any direction perpendicular to wave direction Longitudinal waves oscillate in one direction only OR parallel to wave direction. Polarisation reduces wave intensity by limiting oscillations and wave direction to only one plane OR limiting oscillations to one direction only. (accept vibrations and answers in terms of an example such as a rope passing through slits)	**1** **1** **1**

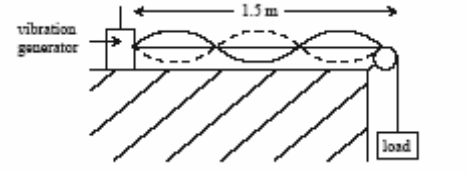
Question Number	Question	
12(b)	Describe with the aid of a diagram how you could demonstrate that light can be polarised.	
	Answer	Mark
	Light source, 2 pieces of polaroid and detector e.g. eye, screen, LED OR laser, 1 polaroid and detector Rotate one polaroid Intensity of light varies	**1** **1** **1**

Question Number	Question	
13	A ray of light travelling, in air, strikes the middle of one face of an equilateral glass prism as shown.  State what happens to the following properties as the light goes from the air into the glass. • Frequency • Wavelength • Speed	
	Answer	Mark
	Frequency unaltered (1) Wavelength decreases (1) Speed decreases (1)	**3**

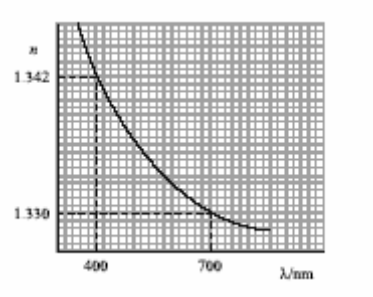
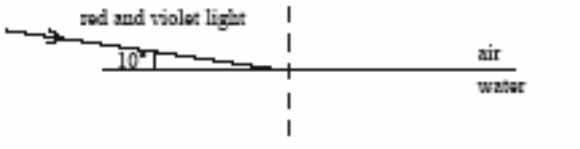
Question Number	Question	
14(a)	The graph shows how the current in a 9V filament lamp varies during one second after it has been turned on.  A student wishes to carry out an experiment to verify these results. Explain why using a sensor and computer is a sensible option and suggest a suitable sampling rate.	
	Answer	Mark
	Use of sensor Event happens very quickly OR cannot take readings fast enough Sampling rate: 50+ samples per second	 **1** **1**

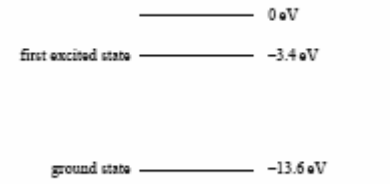
Question Number	Question	
14(b)	Explain the shape of the graph and why the filament is more likely to fail when being switched on rather than at other times.	
	Answer	Mark
	Initially the temperature is low so current is high Resistance of filament increases as temperature increases Current falls to steady value when temperature is constant Maximum heating is when lamp is switched on / when current is highest Filament breaks due to melting caused by temperature rise	**Max 4**

Question Number	Question	
15	About 100 years ago X-rays were first used in hospitals. At that time, many of the doctors who worked with X-rays died young. Explain why this occurred and the implications it has for the use of new technology today.	
	Answer	Mark
QWC(i, iii)	The answer must be clear and the answer must be organised in a logical sequence • It was known that X penetrated (1) • It was not known that X rays were harmful (1) • Doctors died because of too much exposure (1) • Lack of shielding (1) • New treatments may have unknown side effects (1) • Treatments need to be tested / time allowed for side effects to appear (1)	**Max 4**

Question Number	Question	
16	The following apparatus is set up. When the frequency of the vibrator is 60 Hz, the standing wave shown in the diagram is produced.  What is the wavelength of this standing wave? Wavelength = ……..	
	Answer	Mark
	[1.0 m] (1)	1

Question Number	Question	
16(b)	The frequency of the vibrator is altered until the standing wave has 2 more nodes. Calculate the new frequency. Frequency =	
	Answer	Mark
	Ratio of (5 or 6 / 3) × 60 (1) Answer [f = 100 Hz] (1)	**2**

Question Number	Question	
17	The graph shows how the refractive index of water, *n* varies with wavelength λ of the light in a vacuum. The values for red and violet light are indicated.  The diagram shows a mixture of red and violet light incident on an air/water interface.  Calculate the angle of refraction for the red light. Angle of refraction =… On the diagram draw the approximate paths of the refracted rays.	
	Answer	Mark
	Use of sin i / sin r = μ (1) Use of either 80 ^{o} or 1.33 (1) [r = 48^{o}] (1) <u>Example of answer</u> sin 80 / sin r = 1.33 [r = 48^{o}] Both rays refracted towards the normal Violet refracted more than red	**3** **2**

Question Number	Question	
18(a)	Below is a simplified energy level diagram for atomic hydrogen.  A free electron with 12 eV of kinetic energy collides with an atom of hydrogen. As a result the atom is raised to its first excited state. Calculate the kinetic energy of the free electron, in eV, after the collision. Kinetic energy = eV	
	Answer	Mark
	Calculation of energy required by atom (1) Answer [1.8 (eV)] (1) Example of answer: Energy gained by atom = 13.6 eV – 3.4 eV = 10.2 eV KE of electron after collision = 12 eV – 10.2 eV = 1.8 eV	**2**

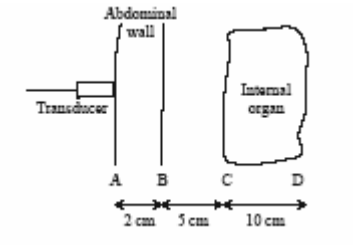
Question Number	Question	
18(b)	Calculate the wavelength of the photon emitted when the atom returns to its ground state. Wavelength =	
	Answer	Mark
	Use of $E = hf$ and $c = f\lambda$ (1) Conversion of eV to Joules (1) Answer = [1.22×10^{-7} m] (1) Example of answer $E = hf$ and $c = f\lambda$ $E = hc/\lambda$ $\lambda = (6.63 \times 10^{-34}\ \text{J s} \times 3 \times 10^{8}\ \text{m s}^{-2}) \div (10.2\ \text{eV} \times 1.6 \times 10^{-19}\text{C})$ $\lambda = 1.21 \times 10^{-7}$ m	**3**

Question Number	Question	
19	A group of students is discussing why the resistance of the metal filament of a lamp and the resistance of an NTC thermistor respond differently to changesin temperature. One student says that the increased vibrations of the atoms affect the conduction process. Another student says that as the temperature increases more electrons can break free of the atoms and take part in conduction. Both students are correct. Explain how these **two** effects apply to the lamp and the thermistor.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence. Reference to $I = nqvA$ (1) **For the lamp** Increased atomic vibrations reduce the movement of electrons (1) Resistance of lamp increases with temperature (1) **For the thermistor** Increased atomic vibrations again reduce movement of electrons (1) But increase in temperature leads to a large increase in n (1) Overall the resistance of the thermistor decreased with increase in temperature. (1)	**Max 5**

Question Number	Question	
20(a)	What is meant by diffraction?	
	Answer	Mark
	Diffraction is the change in direction of wave or shape or wavefront (1) when the wave passes an obstacle or gap (1)	**2**

Question Number	Question	
20(b)	How did considering light as photons enable scientists to explain why electrons could be emitted instantly from a metal surface?	
	Answer	Mark
	The energy of the wave is concentrated into a photon (1) One photon gives all its energy to one electron (1)	**2**

Question Number	Question	
20(c)	Explain why this effect only happens when the light is above a certain frequency.	
	Answer	Mark
	Energy of photon increases as frequency increases OR reference to $E = hf$ (1) Electrons require a certain amount of energy to break free and this corresponds to a minimum frequency (1)	**2**

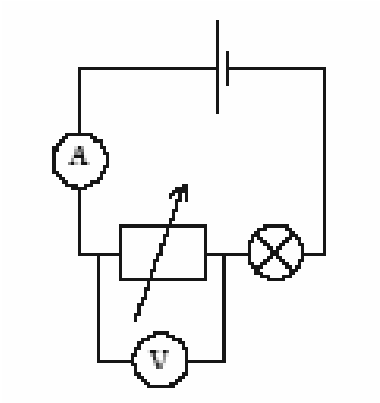
Question Number	Question	
21(a)(i)	Ultrasound images of the body are a useful diagnostic tool for doctors. A single transducer can be used both to send and receive pulses of ultrasound. The diagram shows a lateral cross-section through part of the abdomen. The diagram is not to scale.  Calculate the time interval between sending out a single pulse and receiving its echo from interface B. The speed of ultrasound in the abdominal wall is 1500 m s^{-1}. Time interval =	
	Answer	Mark
	Use of speed = distance over time (1) Distance = 4 cm (1) Answer = [2.7 × 10 $^{-5}$ s] (1) Example of answer t = 4 cm ÷ 1500 m s^{-1} t = 2.7 × 10 $^{-5}$ s	**3**

Question Number	Question	
21(a)(ii)	The time between pulses being emitted by the transducer is 200 μs. At what frequency are the pulses emitted?	
	Answer	Mark
	Use of $f = 1/T$ (1) Answer = [5000 Hz] (1)	**2**

Question Number	Question	
21(a)(iii)	The time interval before the echo returns from interface D is 250 μs. Suggest why this time interval will make reflections from D difficult to interpret and what could be done to overcome this problem.	
	Answer	Mark
	Time for pulse to return greater than pulse interval (1) All reflections need to reach transducer before next pulse sent. (1) Will result in an inaccurate image. (1) (Max 2) Need to decrease the frequency of the ultrasound. (1) (Max 3)	**Max 3**

Question Number	Question	
21(a)(iv)	State one reason why ultrasound rather than X-rays is now used to scan expectant mothers.	
	Answer	Mark
	X-rays damage cells/tissue/foetus/baby but ultrasound does not (need reference to both X-rays and ultrasound) (1)	**1**

Question Number	Question	
21(b)	Ultrasound is also used to measure blood flow in the body. It uses the Doppler shift of the reflected pulse to measure the speed of blood through the arteries of the body. Describe the principle of this method and how it can be used to determine the speed of blood. You may be awarded a mark for the clarity of your answer.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence Doppler shift is the change in frequency of a wave when the source or the receiver is moving (1) Requirement for a continuous set of waves (1) Two transducers required (one to transmit and one to receive) (1) Change in frequency is directly related to the speed of the blood (1)	**4**

Question Number	Question	
22(a)	A student sets up the following circuit to measure the internal resistance of a cell.  What is wrong with his circuit diagram?	
	Answer	Mark
	Voltmeter is across resistor should be across cell (1)	**1**

Question Number	Question	
22(b)	Using the correct circuit the student obtains the following results. Current in the cell *I*/A: 0.5, 0.9, 1.5, 1.9, 2.5, 2.9 Terminal potential difference across the cell *V* /V: 1.2, 1.0, 0.8, 0.6, 0.4, 0.2 On the grid below, plot these results and draw the line of best fit through your points.	
	Answer	Mark
22(b)(i)	**Plot of graph** Check any three points (award mark if these are correct) (3) Line of best fit	**3**
Question Number	Question	
22(b)(ii)	Use your graph to determine the e.m.f. of the cell. e.m.f. = ...	
	Answer	Mark
	e.m.f. = [1.36 – 1.44 V] (1)	**1**

Question Number	Question	
22(b)(iii)	Use your graph to determine the internal resistance of the cell. Internal resistance =	
	Answer	Mark
	Attempt to find gradient (1) Answer [0.38 – 0.42 Ω] (1)	**2**

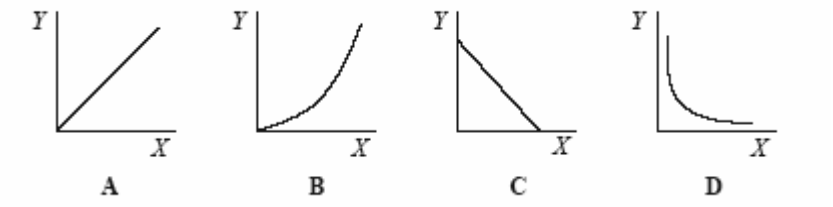
Question Number	Question	
22(c)	The experiment is repeated with two such cells connected in series. How does the graph differ?	
	Answer	Mark
	Intercept would twice value above (1) (accept numerical value 2× value (b)(ii)) Gradient would be twice value above (1) (accept numerical value 2× value (b)(iii))	**2**

Unit 4: Physics on the Move

Question Number	Question	
1	Which of the following is the same unit as the farad?	
	Answer	Mark
	C	**1**

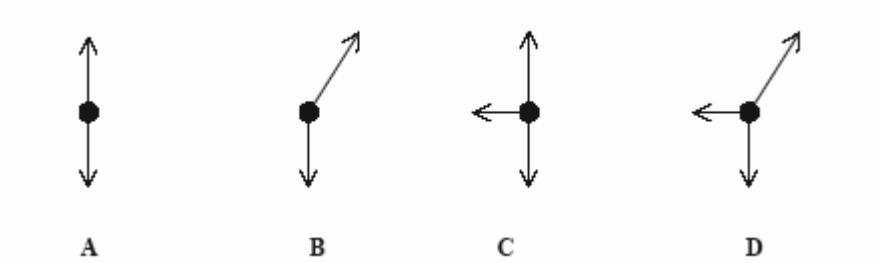
Question Number	Question	
2	An emf will only be induced across the wing tips of an aircraft if it is flying horizontally in	
	Answer	Mark
	D	**1**

Question Number	Question	
3	A top quark has a mass of 171 $\frac{\text{GeV}}{c^2}$. Its mass in kilograms is about	
	Answer	Mark
	C	**1**

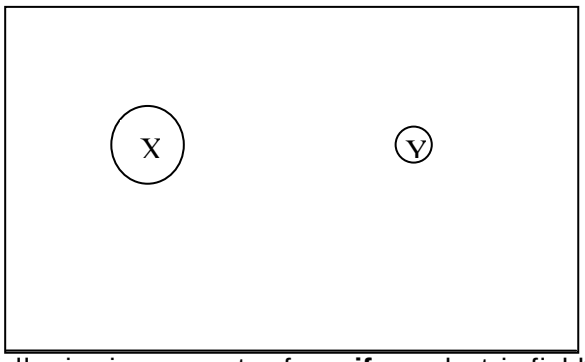
Question Number	Question	
4	The following are four possible graphs of a quantity *Y* plotted against another quantity *X*.  Which graph best represents Y when it is the kinetic energy of an electron and *X* is its momentum?	
	Answer	Mark
	B	**1**

Question Number	Question	
5	Which graph best represents *Y* when it is the electric field strength between two parallel plates with a constant potential difference across them and *X* is the distance apart of the plates?	
	Answer	Mark
	D	**1**

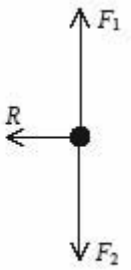
Question Number	Question	
6	Which graph best represents Y when it is the radius of the circle described by an electron in a constant magnetic field at right angles to the path of the electron and *X* is the momentum of the electron?	
	Answer	Mark
	A	**1**

Question Number	Question	
7	Each of the diagrams below is a free-body force diagram representing the forces acting on a body.  A B C D Which diagram best illustrates the forces acting on a charged sphere, supported on a nylon thread, in equilibrium alongside a second similarly charged sphere?	
	Answer	Mark
	D	**1**

Question Number	Question	
8	A π^+ pion is composed of which combination of quarks?	
	Answer	Mark
	C	**1**

Question Number	Question	
9	The diagram shows two charged spheres X and Y, of masses 2*m* and *m* respectively, which are just prevented from falling under gravity by the uniform electric field between the two parallel plates. Use the diagram when answer in questions 9 and 10.  Which of the following is a property of a **uniform** electric field?	
	Answer	Mark
	A	**1**

Question Number	Question	
10	If the plates are moved closer together	
	Answer	Mark
	B	**1**

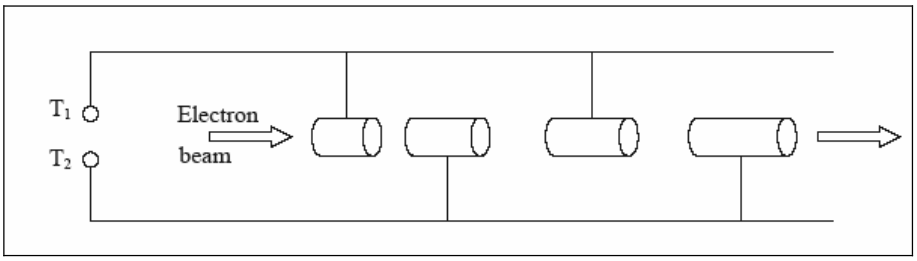
Question Number	Question	
11(a)	Figure 1 shows the London Eye, a tourist attraction in the form of a very large wheel. Passengers ride in capsules, describing a vertical circle at constant speed. Figure 2 is a free-body force diagram showing the forces acting on a passenger in one of the capsules at point X of the circle.  Figure 1  Figure 2 A teacher asks the class why the forces F_1 and F_2 are equal and opposite. A student suggests that this is because of Newton's third law.	
	Answer	Mark
	They act on the same body **or** do not act on different bodies (1) They are different types of, **or** they are not the same type of, force(1)	**2**

Question Number	Question	
11(b)	Explain why the forces F_1 and F_2 must be equal and opposite.	
	Answer	Mark
	As the passenger **or** capsule **or** wheel has constant speed (1) there is No resultant tangential force (acting on the passenger) (1)	**2**

Question Number	Question	
11(c)	State what causes the force R.	
	Answer	Mark
	Friction between seat & person or push of capsule wall on person	**1**

Question Number	Question	
12(a)	State what is meant by the term **baryon**.	
	Answer	Mark
	A baryon is a (sub-atomic) particle made up of 3 quarks(1)	**1**

Question Number	Question	
12(b)	In β^- decay a neutron decays into a proton. Explain how the quark structure of the baryon changes in this process.	
	Answer	Mark
	n (ddu) $\rightarrow$(1) p (duu) (1)	**2**

Question Number	Question	
13(a)	Quarks were discovered using the Stanford Linear Accelerator (SLAC). The diagram below shows the principle of a linear accelerator (LINAC).  State what is connected between terminals T_1 and T_2.	
	Answer	Mark
	High frequency or high voltage(1) Alternating **or** square wave voltage(1)	**2**

Question Number	Question	
13(b)	Explain why the electrons travel with constant velocity whilst in the cylinders.	
	Answer	Mark
	No electric field inside cylinders (due to shielding) (1) so no force (on electrons) (1)	**2**

Question Number	Question	
13(c)	Explain why the cylinders gradually increase in length along the accelerator.	
	Answer	Mark
	As speed increases (along the accelerator), (1) cylinders are made longer so that time in each stays the same(1)	**2**

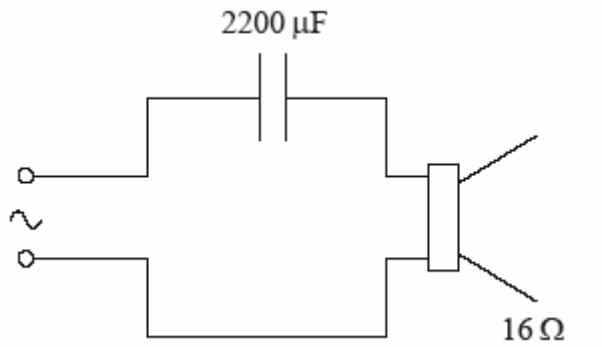
Question Number	Question	
14	Outline the experimental observations to which Rutherford is referring and explain how they led him to this deduction.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence α-particles fired at (named) metal (film) (1) in a vacuum (1) Most went straight through **or** suffered small deflections. (1) A few were reflected through large angles **or** some were reflected along their original path (1) suggesting the mass **or** charge of the atom was concentrated in a very small volume(1)	**5**

Question Number	Question	
15 (a)(i)	Show that the energy stored in a 2200 μF capacitor is of approximately 0.16J. Energy = ……...	
	Answer	Mark
	Use of $E = ½ CV^2$ (1) Answer [0.158 J] (1) $E = ½ CV^2 = 0.5 \times 2200 \times 10^{-6}$ F × $(12 \text{ V})^2$ $E = 0.158$ J	**2**

Question Number	Question	
15 (a)(ii)	What is the efficiency of the electric motor in this situation? Efficiency = …….	
	Answer	Mark
	Correct substitution into $\Delta E_p = \Delta mgh$ (1) Answer 0.75 [75%] (1) ΔE_p = 0.05 kg x 9.8 N kg^{-1} x 0.24 m [= 0.12 J] Efficiency = 0.12 J ÷ 0.16 J = 0.75 [75%]	**2**

Question Number	Question	
15(b)(i)	The capacitor is then charged to 12 V again and then discharged through a 16 Ω resistor. Show that the time constant for this discharge is approximately 35 ms.	
	Answer	Mark
	$(t = CR) = 2200 \times 10^{-6}$ (F) × 16 (Ω) = 35.2 (ms) (1)	**1**

Question Number	Question	
15(b)(ii)	Sketch a graph of current against time for this discharge on the grid below. You should indicate the current at t = 0 and t = 35 ms.	
	Answer	Mark
	Curve starting on I axis but not reaching t axis(1) I_0 = 1.6 V / 16Ω = 100 mA shown on axis(1) Curve passing through about 37 mA at t = 35 ms(1)	**3**

Question Number	Question
15(c) (i)	Capacitors are used in audio systems when connecting the amplifier to the loudspeaker. In one such circuit the capacitor has a value of 2200 μF and the loudspeaker has a resistance of 16 Ω.  The loudspeaker produces longitudinal sound waves. What is meant by longitudinal in this context?

	Answer	Mark
	The vibrations of the air particles (1) are parallel to the direction of travel of the wave (energy) (1)	**2**

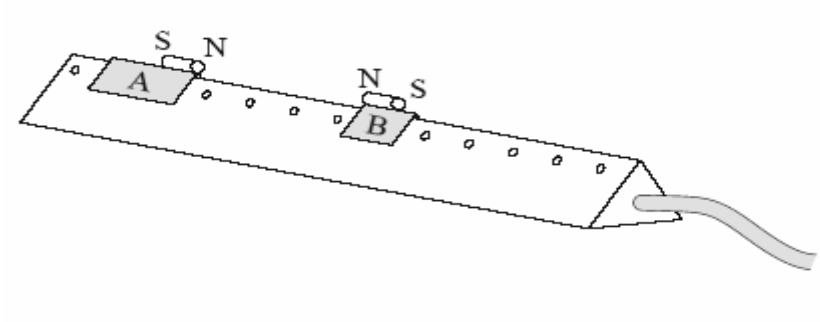
Question Number	Question	
15(c)(ii)	Ideally, the time constant for such a circuit should be much greater than the time period of the lowest frequency note. Discuss the extent to which this circuit would be effective if the lowest frequency note is 20 Hz.	
	Answer	Mark
	$T = 1/f$ = 50 ms(1) Sensible comment related to time constant of 35 ms(1)	**2**

Question Number	Question	
16(a)	In their famous experiment conducted in 1932, Cockcroft and Walton accelerated protons through a potential difference of 300 kV and used them to bombard a lithium ($^{7}_{3}\mathrm{Li}$) target. They found that two alpha particles were produced. The energy of the alpha particles was subsequently calculated from the tracks they made in a cloud chamber. Complete the nuclear equation for this event. $^{7}_{3}\mathrm{Li}$ + ⟶	
	Answer	Mark
	$_{3}Li^{7}$ + $_{1}p^{1}$ = $_{2}He^{4}$ + $_{2}He^{4}$ completing LHS (1) completing RHS(1)	**2**

Question Number	Question	
16(b)(i)	Cockcroft and Walton reported to the Royal Society that "if momentum is conserved in the process, then each of the α-particles must take up equal amounts of energy, and from the observed range of the α-particles we conclude that an energy of 17.2 million electron-volts [MeV] would be liberated in this disintegration process." State two other properties, in addition to momentum, that are conserved in such a process.	
	Answer	Mark
	Charge (1) (mass/) energy (1)	**2**

Question Number	Question	
(b)(ii)	Use the data below to show that the energy released in this process is approximately 2.8×10^{-12} J. Mass of lithium nucleus = 7.0143 u Mass of proton = 1.0073 u Mass of α-particle = 4.0015 u	
	Answer	Mark
	Mass of Li + p = 7.0143 u + 1.0073 u = 8.0216 u (1) Mass of 2 α-particles = 2×4.0015 u = 8.0030 u (1) Δm = 8.0216 u − 8.0030 u = 0.0186 u = $0.0186 \times 1.66 \times 10^{-27}$ kg = 3.09×10^{-29} kg (1) $\Delta E = c^2 \Delta m = (3.00 \times 10^{8}\ \mathrm{m\ s^{-1}})^2 \times 3.09 \times 10^{-29}$ kg = 2.78×10^{-12} J (1) [Allow ecf from equation]	**4**

Question Number	Question	
(b)(iii)	Hence discuss the extent to which Cockcroft and Walton's results confirm Einstein's prediction that E is equal to mc^2.	
	Answer	Mark
	$= \frac{2.78\times10^{-12}\ \text{J}}{1.60\times10^{-19}\ \text{J eV}^{-1}}$ = 1.74 × 10^7 eV = 17.4 MeV (1) The incoming proton has an energy of 300 keV = 0.30 MeV (1) So total energy = 17.4 MeV + 0.3 MeV = 17.7 MeV (1) The calculated energy differs by $\frac{17.7\ \text{Mev} - 17.2\ \text{Mev}}{\frac{1}{2}(17.7+17.2)\ \text{MeV}}\times100\%$ ≈ 3% (1) The experiment therefore provides strong evidence for Einstein's prediction (1)	**5**

Question Number	Question	
17 (a)	State the principle of conservation of linear momentum.	
	Answer	Mark
	Total (linear) momentum of a system is constant, (1) provided no (resultant) external force acts on the system(1)	**2**
Question Number	Question	
17 (b)	The diagram shows two gliders on an air track. The magnets on the top of the gliders repel each other. The mass of glider A is 300 g and that of glider B is 100 g.  Glider A is given a push to start it moving towards glider B which is initially at rest. Describe how you could determine the velocity of A before the gliders interact and the velocities of both A and B after the interaction. You may add to the diagram to show any additional apparatus required.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence Use of a light gate (1) Use of second light gate(1) Connected to timer **or** interface + computer (accept 'log-it') (1) Cards on gliders(1) Measure length of cards(1) Velocity = length ÷ time(1)	**6**

Question Number	Question	
17 (c)	A student obtains the following velocities: velocity of A before interaction = 5.2 cm s^{-1} velocity of A after interaction = 2.7 cm s^{-1} velocity of B after interaction = 7.5 cm s^{-1} Show if these results confirm that momentum is conserved in the interaction;	
	Answer	Mark
	Multiplies mass × velocity to find at least one momentum (1) 1560 g cm s^{-1} (0.0156 kg m s^{-1}) before and after (1)	**2**

Question Number	Question	
18(a)(i)	A do-it-yourself company is advertising a wind turbine that they state can deliver a power of 1 kW. Their specification provides the following data: • area swept out by the blades in one revolution = 2.4 m^2 • power output = 1 kW at a wind speed of 12.5 m s^{-1} • typical operating speed of blades = 600 revolutions per minute Show that the length of each blade is approximately 0.9 m.	
	Answer	Mark
	Use of $A = \pi r^2$ leading to 0.87 (m) (1)	**1**

Question Number	Question	
18(a)(ii)	Show that the angular velocity of the blades at the typical operating speed is approximately 63 rad s^{-1}.	
	Answer	Mark
	Correct use of $\omega = 2\pi/t$ leading to 62.8 (rad s^{-1}) (1)	**1**

Question Number	Question	
18(a)(iii)	Calculate the speed at which the tips of the blades will then be traveling. Speed =	
	Answer	Mark
	Correct use of $v = r\omega = 55$ m s^{-1} [allow use of show that value] (1)	**1**

Question Number	Question	
18(b)(i)	The theoretical power available from a wind turbine is given by $p = \frac{1}{2} \rho A v^3$ where ρ = density of air = 1.3 kg m^{-3} A = area swept out by blades per revolution v = wind speed Show that when the wind speed is 12.5 m s^{-1}, the theoretical power from the advertised turbine is about 3 kW Power = ...	
	Answer	Mark
	Substitution into $p = \frac{1}{2} \rho A v^3$ (1) 3047 (W) (1)	**2**

Question Number	Question	
18(b)(ii)	Suggest 2 reasons why the actual power is less than the theoretical power.	
	Answer	mark
	Air is hitting at an angle/all air not stopped by blades (1) Energy changes to heat and sound (1)	**2**

Question Number	Question	
18(c)(i)	The manufacturer has to ensure that when the turbine is attached to a chimney stack, the force exerted on the chimney does not cause it to collapse. The turbine is designed to cut out at a wind speed of 14 m s^{-1}. Calculate the mass of air hitting the blades each second when the wind speed is 14 m s^{-1}. Mass of air =	
	Answer	Mark
	Attempts to find volume per second ($A \times v$) (1) 44 kg s^{-1} (1)	**2**

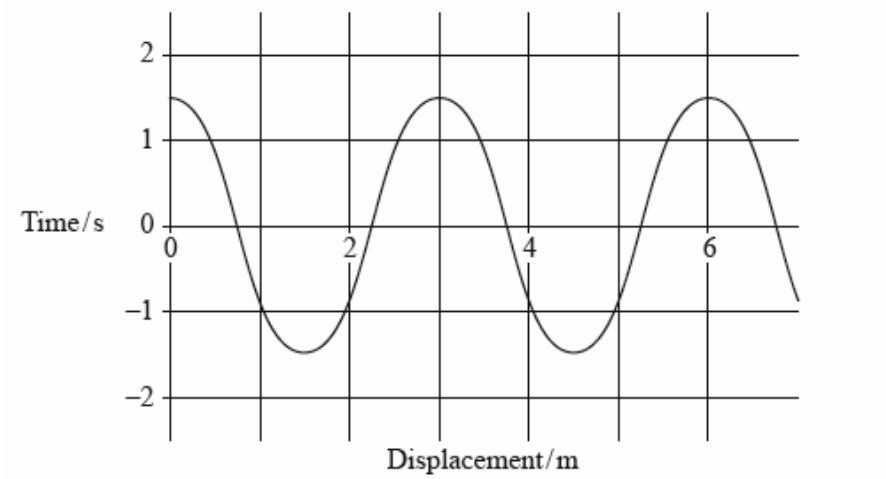
Question Number	Question	
18(c)(ii)	Hence calculate the maximum force that the wind could exert on the blades. Maximum force = ……	
	Answer	Mark
	Use of $F = \Delta mv / \Delta t$(1) F = 610 N(1)	**2**

Question Number	Question	
18(d)	The average wind speed in the UK is 5.8 m s^{-1}, which results in an actual average power output of 100W. Discuss whether it would be better for the environment to replace some filament light bulbs with low energy bulbs than to use this turbine. Assume each filament light bulb is rated at 100 W and each low energy bulb is rated at 11 W.	
	Answer	Mark
QWC(i,iii)	Recognises that 100 W is produced over 24 hours (1) Estimates if this would fulfil lighting needs for a day(1) Estimates energy used by low energy bulbs in day(1) Conclusion(2) The answer must be clear and be organised in a logical sequence <u>Example:</u> The 100 W is an average over the whole day. Most households would use light bulbs for 6 hours a day in no more than 4 rooms, so this would mean no other energy was needed for lighting. 4 low energy bulbs would be 44 W for 6 each hours so would require energy from the National grid. [Accept an argument based on more light bulbs/longer hours that leads to the opposite conclusion]	**5**

Unit 5: Physics from Creation to Collapse

Question Number	Question	
1	A valid set of units for specific heat capacity is	
	Answer	Mark
	C	**1**

Question Number	Question	
2	The gravitational field strength on the surface of the Earth is g. The gravitational field strength on the surface of a planet of twice the radius and the same density is	
	Answer	Mark
	B	**1**

Question Number	Question	
3	A child is playing on a swing. The graph shows how the displacement of the child varies with time.  The maximum velocity, in m s^{-1}, of the child is	
	Answer	Mark
	B	**1**

Question Number	Question	
4	Cosmic background radiation is a remnant of the big bang and appears to pervade the universe. It has a maximum wavelength in the microwave region of the electromagnetic spectrum. This can be calculated to correspond to a temperature of about 3 K. This calculation is based on the assumption that	
	Answer	Mark
	C	**1**

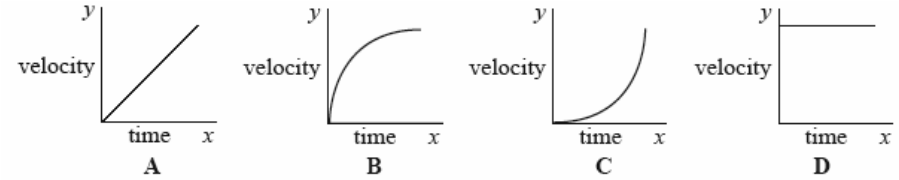
Question Number	Question	
5	A student is asked "What is meant by background radiation?" She writes "It is the radiation produced by the rocks in the ground." This answer is	
	Answer	Mark
	C	**1**

Question Number	Question	
6	A car driver notices that her rear view mirror shakes a lot at a particular speed. To try to stop it she sticks a big lump of chewing gum on the back of the mirror. Which one of the following statements is correct?	
	Answer	Mark
	D	**1**

Question Number	Question	
7	The ***x***-axis of a Hertzsprung-Russell diagram is log ***T***. This is because	
	Answer	Mark
	A	**1**

Question Number	Question	
8	The spectrum of visible light from the Sun contains a number of dark lines known as Fraunhofer lines. This is due to	
	Answer	Mark
	B	**1**

Question Number	Question	
9	All quasars show large red shifts in the light received from them. This shows that they	
	Answer	Mark
	D	**1**

Question Number	Question	
10	A space rocket takes off vertically from the surface of the Earth. Assuming the thrust remains constant which graph best represents the variation of velocity of the rocket with time 10. If the universe expands forever it can be described as  	
	Answer	Mark
	C	**1**

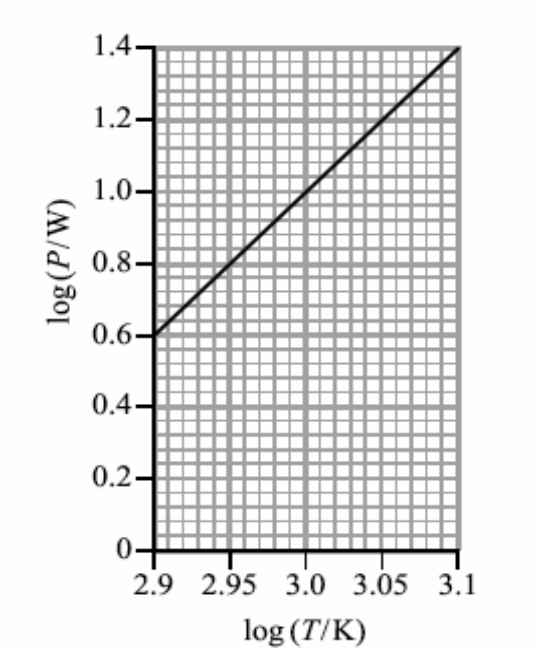
Question Number	Question	
11(a)	An ideal gas is contained in a volume of $2.0 \times 10^{-3}\ m^3$. Explain why the internal energy of an ideal gas is only kinetic.	
	Answer	Mark
	as ideal gases do not have forces between molecules so no potential energy	**2**

Question Number	Question	
11(b)	The pressure of the gas is 1.2×10^5 Pa and its temperature is 27 ^oC. Calculate the number of molecules of gas within this container. Number of molecules =	
	Answer	Mark
	use of pv = NkT conversion of T to kelvin and answer = 5.8×10^{22} molecules	**2**

Question Number	Question	
12(a)	Smoke detectors contain an alpha emitting source. Describe how you would determine whether this radioactive source emits alpha particles only.	
	Answer	Mark
	use of counter (+GM tube) determine background count in absence of source place source **close** to detector and: place sheet of paper between source and counter (or increase distance from source 3-7 cm of air) reduces count to background	**4**

Question Number	Question	
12(b)	State why smoke detectors do not provide a radiation risk in normal use.	
	Answer	Mark
	alpha radiation only has range of 5 cm in air / wouldn't get through casing	**1**

Question Number	Question	
13	Two stars in the night sky appear equally bright to an observer. The Ancient Greeks thought that all stars were the same distance from the Earth. State and explain **two** reasons why these two stars do not need to be the same distance from the observer.	
	Answer	Mark
	reason (1) and consequence(1) reason (1) and consequence(1) 2 from: Could be different sizes; So larger one could be further away Could be different temperatures; So hotter one could be further away Different luminosities; So more luminous one could be further away	**4**

Question Number	Question	
14(a)	The graph shows how the logarithm of the electrical power *P* supplied to a filament lamp varies with the logarithm of the temperature *T* of the filament.  *P* is related to *T* by a power law: $P = k T^n$ Use the graph to determine n. n = ……..	
	Answer	Mark
	attempt to find gradient eg evidence of triangle on graph or values of dy/dx (1) value of n (1)	**2**

Question Number	Question	
14(b)	A student suggests that this relationship is predicted by the Stefan-Boltzmann law. Comment on this statement.	
	Answer	Mark
	needs T^4 (1) (electrical) power P related to luminosity (1)	**2**

Question Number	Question	
15(a)	The Hubble constant is thought to be about 70 000 m s^{-1} Mpc^{-1}. Give one reason why the value of this constant is uncertain.	
	Answer	Mark
	difficult to measure distances to "far" objects accurately / difficult to measure speeds of far objects accurately (1)	**1**

Question Number	Question	
15(b)	State how an estimate of the age of the Universe can be calculated from the Hubble constant.	
	Answer	Mark
	appreciate 1/H is age of universe(1)	**1**

Question Number	Question	
15(c)	Explain how the ultimate fate of the Universe is associated with the Hubble constant.	
	Answer	Mark
	fate of universe depends on the density of the universe(1) link between gravity and density(1) Hubble "constant" is changing due to gravitational forces (1)	**3**

Question Number	Question	
16(a)	Potassium-40 ($_{19}$ K) is unstable. Calculate the binding energy per nucleon for potassium-40. Nuclear mass of potassium-40 = 39.953548 u Mass of one neutron = 1.008 665 u Mass of one proton = 1.007 276 u Binding energy per nucleon=	
	Answer	Mark
	19 protons identified(1) calculation of mass defect (1) Conversion to kg(1) use of $E = mc^2$ (1) divide by 40(1) $=1.37 \times 10^{-12}$ J(1) [eg 19 x 1.007276 = 19.138244 +21 x 1.008665 = 40.320209 – 39.953548 = 0.36666 $\times 1.66 \times 10^{-27} = 6.087 \times 10^{-28}$ $\times c^2 = 5.5 \times 10^{-11}$ $/40 = 1.37 \times 10^{-12}$ J]	**6**

Question Number	Question	
16(b)	Explain what is meant by the random nature of nuclear decay.	
	Answer	Mark
	cannot identify which atom/nucleus will be the next to decay can estimate the fraction /probability that will decay in a given time / cannot state exactly how many atoms will decay in a set time	**1**

Question Number	Question	
16(c)(i)	Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium-40 to argon-40. The half-life of of potassium-40 is 1.3×10^9 years. Show that the decay constant of potassium-40 is about 5×10^{-10} y^{-1}.	
	Answer	Mark
	conversion of half life to decay constant [eg $\lambda = \ln 2 / 1.3 \times 10^9 = 5.3 \times 10^{-10}$ y^{-1}]	**1**

Question Number	Question	
16(c)(ii)	In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40. Calculate the age of the rock sample in years.	
	Answer	Mark
	add both masses to find initial mass(1) use of $N = N_o e^{-\lambda t}$ (1) rearrange to make t subject(1) Answer = 4.2×10^9 years (1) (if 0.84 used instead of 0.94 3 max) [eg total initial mass 0.94 $t = \ln 0.1 / 0.94 / 5.3 \times 10^{-10}$ $= 4.2 \times 10^9$]	**4**

Question Number	Question	
17(a)(i)	Show that the acceleration of the hydrogen atom, *a*, is given by $a = -\frac{kx}{m}$ where ***x*** is the displacement of the hydrogen atom.	
	Answer	Mark
	Use of F= - kx (1) F = ma(1)	**2**

Question Number	Question	
17(a)(ii)	Hence derive the equation $T = 2\pi\sqrt{\frac{m}{k}}$ for the period of natural oscillations of the hydrogen atom.	
	Answer	Mark
	cf with a = $-\omega^2 x$ ie $\omega^2 = k/m$(1) use of $T = 2\pi / \omega$ to result (1)	**2**

Question Number	Question	
17(b)(i)	What name is given to this phenomenon?	
	Answer	Mark
	resonance(1)	**1**

Question Number	Question	
17(b)(ii)	State the condition for it to occur.	
	Answer	Mark
	natural freq = forcing frequency(1)	**1**

Question Number	Question	
17(b)(iii)	Calculate the frequency of infrared radiation of wavelength 3.3 μm.	
	Answer	Mark
	use of $c = f\lambda$(1) answer 9.1 x 10^{13} Hz(1)	**2**

Question Number	Question	
17(b)(iv)	Hence calculate the stiffness of the hydrogen chloride bond.	
	Answer	Mark
	use of T = 1/f eg T = 1.1 x 10^{-14}(1) rearrange formula (1) to give 550 N/m(1)	**3**

Question Number	Question	
18(a)	A planet of mass m orbits a star of mass M. The radius of orbit is r. By considering the force required for circular motion in this situation, show that the period T of the orbit is given by $T^2 = \frac{4\pi^2 r^3}{GM}$	
	Answer	Mark
	equates $F = GMm/r^2$ and mv^2/r(1) Use of $v = 2\pi r/T$(1) Cancel m's To give $GMT^2 = 4\pi^2 r^3$ in any form(1)	**3**

Question Number	Question	
18(b)(i)	Measurements have shown that star HD70642 has a planet which orbits the star with a period of about 6 years. The → radius of the orbit is about 3× the radius of the Earth's orbit around the Sun. Use the formula in (a) to determine a value for the ratio $\frac{\text{mass of star HD70642}}{\text{mass of Sun}}$ = ...	
	Answer	Mark
	remove constants or cancel G 4π2(1) use of idea MT^2 / r^3 = Constant(1) substitution 27 /36 = M_{star} / M_{sun}(1)	**3**

Question Number	Question	
18(b)(ii)	Because of the presence of the planet, the star HD70642 does not remain at rest. Instead, the planet and star both orbit around their common center of mass. Explain why the orbiting speed of the star is very small in comparison to the speed of the planet.	
	Answer	Mark
	both will complete orbit in same time period(1) star covers small distance / orbit radius smaller compared to planet(1)	**2**

Question Number	Question	
18(c)	Astronomers discovered the planet by observing the "Doppler Wobble" effect. As the planet orbits the star, light from the star undergoes a Doppler shift in its frequency. Explain why this method is likely to only likely to detect **very large** planets.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence Larger planets will move centre of mass towards planet / away from star centre (1) Star moves faster(1) Doppler shift greater for larger speeds(1)	**3**

Question Number	Question	
19(a)	Complete the equation which shows a typical part of the CNO process. $\ldots\ {}_{8}\ldots + \ldots\ {}^{1}\ldots \rightarrow \ldots\ {}^{14}\mathrm{N} + \ldots\ {}^{\ldots}\ldots$	
	Answer	Mark
	top row : 17 1 (14) 4 (1) bottom row: 8 1 7 2 (1) other product – helium (1)	**3**

Question Number	Question	
19(b)	What is a white dwarf? Suggest why hydrogen fusion in the white dwarf is likely to be the CNO process.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence dead star / no longer any fusion(1) small dense hot / still emitting radiation/light(1) consisting of products of fusion such as carbon / oxygen / nitrogen(1)	**3**

Question Number	Question	
19(c)(i)	The temperature required for these processes is 10^{7} K. Calculate the mean kinetic energy, in keV, of the particles involved.	
	Answer	Mark
	use of 3/2 kT (1) conversion to eV(1) answer [1.3 (keV)] (1)	**3**

Question Number	Question	
19(c)(ii)	Explain how this temperature arises.	
	Answer	Mark
	gravitational force does work on hydrogen(1) increases internal energy of gas(1)	**2**

Question Number	Question	
19(d)	Astronomers use novae as standard candles. Explain what a standard candle is, and suggest what this implies about the processes occurring in a nova.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence A standard candle (in astronomical terms) produces a fixed amount of light /luminosity(1) Quantity of hydrogen (1) and fusion temperature (1) must be similar for various novae.	**3**

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