Edexcel Physics Unit 5

Past Paper Pack

2010-2013

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Tuesday 29 June 2010 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

N36116A

1/1/1/1/1/1/

edexcel
advancing learning, changing lives

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 Protactinium has a half-life of 70 s. A sample of protactinium is prepared and monitored over a period of time. Which of the following statements is correct?

☒ **A** The activity of the protactinium will be zero after 140 s.

☒ **B** The activity of the protactinium will be 25% of its initial value after 140 s.

☒ **C** The activity of the protactinium will be 12.5% of its initial value after 280 s.

☒ **D** The activity of the protactinium will never become zero.

(Total for Question 1 = 1 mark)

---

2 A mass is hung from a spring and set into vertical oscillation. Which row in the table correctly shows the kinetic energy E_k of the mass at maximum displacement and the potential energy E_p of the mass at the equilibrium position.

		Maximum displacement position	Equilibrium position
☒	**A**	E_k is a maximum	E_p is minimum
☒	**B**	E_k is a maximum	E_p is a maximum
☒	**C**	E_k is zero	E_p is a maximum
☒	**D**	E_k is zero	E_p is minimum

(Total for Question 2 = 1 mark)

---

3 Scientists believe that our universe began with a big bang, and is presently expanding. The ultimate fate of the universe depends upon the total amount of matter in the universe. One possibility is a big crunch where the universe eventually contracts back into a point of infinite density. A universe with such a future would be described as being

☒ **A** closed.

☒ **B** critical.

☒ **C** flat.

☒ **D** open.

(Total for Question 3 = 1 mark)

---

4 The relative masses of oxygen and hydrogen molecules are 32 and 2 respectively. For any given temperature, the ratio

$$\frac{\text{root mean square speed of oxygen molecules}}{\text{root mean square speed of hydrogen molecules}}$$ is given by

☒ **A** $\frac{1}{16}$

☒ **B** $\frac{1}{4}$

☒ **C** 4

☒ **D** 16

(Total for Question 4 = 1 mark)

5 On a Hertzsprung-Russell diagram our Sun is located on the main sequence. Which of the following statements is correct?

☒ **A** All giant stars are larger and cooler than our Sun.

☒ **B** All giant stars are larger and hotter than our Sun.

☒ **C** All white dwarf stars are smaller and hotter than our Sun.

☒ **D** All white dwarf stars are hotter and brighter than our Sun.

(Total for Question 5 = 1 mark)

6 In which of the following situations would a blue shift be observed?

☒ **A** Source and observer moving with the same velocity.

☒ **B** Source moving along a circular path around an observer.

☒ **C** Source moving away from a stationary observer.

☒ **D** Source moving towards a stationary observer.

(Total for Question 6 = 1 mark)

7 The average kinetic energy of the molecules in a gas is proportional to

☒ **A** the number of molecules in the gas.

☒ **B** the specific heat capacity of the gas.

☒ **C** the temperature of the gas.

☒ **D** the total mass of the gas.

(Total for Question 7 = 1 mark)

8 X and Y are identical stars. When viewed from Earth the flux from star X is 4 times the flux from star Y. Which of the following explanations is possible?

☒ **A** X is twice as far away as Y.

☒ **B** X is four times as far away as Y.

☒ **C** Y is twice as far away as X.

☒ **D** Y is four times as far away as X.

(Total for Question 8 = 1 mark)

9 For a black-body radiator, the frequency at which maximum radiation of energy occurs is proportional to

☒ **A** T^{-4}

☒ **B** T^{-1}

☒ **C** T

☒ **D** T^{4}

(Total for Question 9 = 1 mark)

10 Newton's law of gravitation can be applied to the Earth-Moon system. Which of the following statements is **not** correct?

☒ **A** The value of G at the surface of the Moon is the same as that at the surface of the Earth.

☒ **B** The gravitational force between the Earth and the Moon is proportional to the square of the separation of the Earth and the Moon.

☒ **C** The gravitational force between the Earth and the Moon is proportional to the mass of the Moon.

☒ **D** The orbital time of the Moon about the Earth is independent of the mass of the Moon.

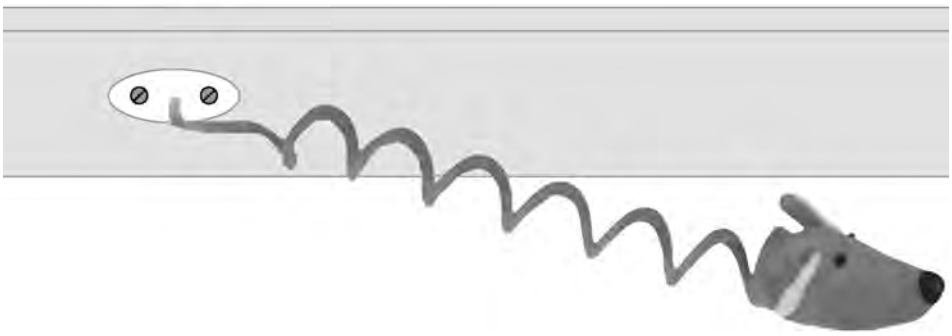
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A toy for cats consists of a plastic mouse of mass *m* attached to a spring. When the mouse is on a low-friction horizontal surface, with the spring attached to a rigid support as shown, it performs simple harmonic motion when given a small displacement *x* from its equilibrium position and released.



(a) Show that the acceleration of the mouse, *a*, is given by $a = -\left(\frac{k}{m}\right)x$, where *k* is the stiffness of the spring.

(2)

.....

.....

.....

.....

(b) The mouse has a mass *m* = 0.15 kg and the spring extends by 20 cm when the mouse is supported vertically by the spring.

Calculate the frequency of oscillation of the mouse if it is set into oscillation on a low friction horizontal surface.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

Frequency = ...

(Total for Question 11 = 7 marks)

12 Radioisotopes are often used for medical applications. ^{131}I is a β^--emitter, and can be used to treat an overactive thyroid gland. When a small dose of ^{131}I is swallowed, it is absorbed into the bloodstream. It is then concentrated in the thyroid gland, where it begins destroying the gland's cells.

(a) Patients are advised that radiation detection devices used at airports may detect increased radiation levels up to 3 months after the treatment. Explain how it is possible for the activity of the ^{131}I to be detected outside the body.

(2)

.....

.....

.....

(b) (i) The half-life of ^{131}I is 8 days. What fraction of the original number of iodine atoms will have decayed after a period of 24 days?

(2)

.....

.....

.....

Fraction = ...

(ii) Doctors wish to prescribe a sample of ^{131}I of activity 1.5 MBq. The sample is prepared exactly 24 hours before it is due to be swallowed by the patient. Calculate the activity that the sample should have when it is prepared.

(3)

.....

.....

.....

.....

Activity = ... MBq

(Total for Question 12 = 7 marks)

13 When nearby stars are observed over a period of a year, their positions are seen to move in tiny ellipses relative to the background of more distant stars.

(a) Explain why relative movement of these nearby stars is observed.

(3)

.....

.....

.....

(b) By means of a labelled diagram, outline the steps necessary for this effect to be used to find the distance to nearby stars.

(3)

(c) The effect is too small for the distances to more distant stars to be determined. Outline a method which can be used for more distant stars.

(1)

.....

.....

.....

.....

(Total for Question 13 = 7 marks)

14 Ionisation smoke detectors contain a small amount of the radioactive isotope americium. ^{241}Am is an α-emitter. It has a half-life of 432 years, and the activity from the source in a new smoke detector is about 3.5×10^4 Bq.

(a) Explain why the radiation produced by a smoke detector does not pose a health hazard.

(1)

.....

.....

.....

(b) (i) Complete the nuclear equation for the decay of americium.

(2)

$$^{241}_{\quad\ldots}\text{Am} \rightarrow {}^{\ldots}_{93}\text{Np} + {}^{\ldots}_{\quad\ldots}\alpha$$

(ii) Using data from the table, calculate the energy, in MeV, of α-particles released when a nucleus of americium-241 undergoes alpha decay.

(3)

Nuclide	Mass/u
Am	241.056 822
Np	237.048 166
α-particle	4.002 603

.....

.....

.....

.....

.....

Energy = ... MeV

(c) An ionisation smoke detector is sold with the guarantee that it "lasts a lifetime". Comment on the appropriateness of this guarantee, based on its use of americium-241.

(1)

.....

.....

.....

(Total for Question 14 = 7 marks)

*15 The Sun behaves as an approximate black-body radiator with peak energy radiation occurring at a wavelength of 5.2×10^{-7} m.

(a) (i) Show that the Sun has a surface temperature of about 6000 K.

(2)

(ii) The radiation received from the Sun at the top of the atmosphere is 1.37 kW m^{-2}. Show the Sun's luminosity is about 4×10^{26} W.

Distance from the Sun to the Earth = 1.49×10^{11} m

(2)

(iii) Hence calculate the radius of the Sun.

(2)

Radius = ...

(b) The huge power output of the Sun is due to nuclear fusion reactions taking place within its core. State and explain the conditions necessary for fusion to occur.

(3)

.....

.....

.....

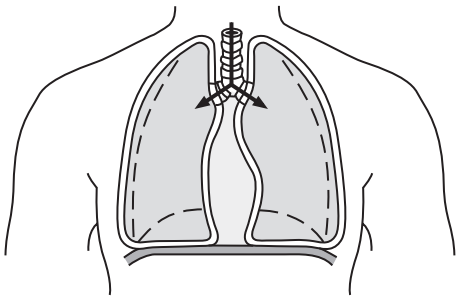
.....

.....

.....

(Total for Question 15 = 9 marks)

16 When your diaphragm contracts, the pressure in the chest cavity is lowered below atmospheric pressure and air is forced into your lungs.



(a) The diaphragm contracts and the lung capacity increases by 20%. State **two** assumptions you would need to make to calculate the new pressure in the lungs if the initial pressure is known.

(2)

.....

.....

.....

.....

(b) (i) The volume of air inhaled in a typical breath is 2.5×10^{-4} m^3 and an adult takes about 25 breaths per minute. Show that the mass of air taken into the lungs each second is about 1×10^{-4} kg.

Density of air = 1.2 kg m^{-3}

(2)

.....

.....

.....

.....

(ii) If body temperature is 37.6 °C and the temperature outside the body is 20.0 °C, calculate the rate at which energy is used to warm air up to body temperature.

Specific heat capacity of air = 1000 J kg^{-1} K^{-1}

(2)

.....

.....

.....

.....

Rate = ...

(Total for Question 16 = 6 marks)

*17 The Hubble Space Telescope (HST) was launched in 1990 into an orbit of radius 6940 km. The satellite makes 15 complete orbits of the Earth every 24 hours and its position high above the Earth's atmosphere has allowed high quality images of extremely distant objects to be produced.

(a) (i) Show that the HST has a centripetal acceleration of about 8 m s^{-2}.

(4)

(ii) The HST is kept in orbit by the gravitational pull of the Earth. Use your answer to (a)(i) to calculate a value for the mass of the Earth.

(3)

Mass = ...

(b) The telescope was named in honour of Edwin Hubble who measured the red shift of light from a number of galaxies and related it to their distance from the Earth.

Explain what is meant by the term *red shift* in this context and state the inference that Hubble made from his measurements.

(2)

(c) The song "Nine Million Bicycles" by Katie Melua includes the lines, "We are 12 billion light years from the edge, that's a guess, no one can ever say it's true".

(i) Explain how the line "12 billion light years from the edge" implies an age of 12 billion years for the universe.

(2)

.....

.....

.....

.....

(ii) Calculate the value of the Hubble constant consistent with an age of 12 billion years for the universe.

1 billion years = 3.15×10^{16} s

(2)

.....

.....

.....

.....

Hubble constant = ...

(iii) These lyrics were famously contested by Dr Simon Singh in the Guardian newspaper. He argued that the correct age was 13.7 billion years, and disputed that scientists had guessed the age of the universe. As a result Katie performed the song with revised lyrics.

Discuss the suggestion in the song that values for the age of the universe are only guesses.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for Question 17 = 16 marks)

*18 Read this passage and answer the questions that follow.

The Millennium Bridge opened on 10 June 2000 as London's first new Thames crossing in more than 100 years. The bridge uses "lateral suspension" – an engineering innovation that allows suspension bridges to be built without tall supporting columns. Tens of thousands of people crossed the bridge on its opening day. The structure was designed to take the weight, but suddenly the bridge began to sway and twist in regular oscillations. The worst of the movement occurred on the central span where the edge of the bridge oscillated through a total distance of 70 mm.

To solve the problem the engineers decided to use damping mechanisms – giant shock absorbers to limit the bridge's response to external forces. They decided to use two systems: viscous dampers, similar to car shock absorbers, and tuned mass dampers. A tuned mass damper is a large mass stiffened by springs.

(a) Name the effect that results in a system being driven into large amplitude oscillations, and state the condition necessary for this to happen.

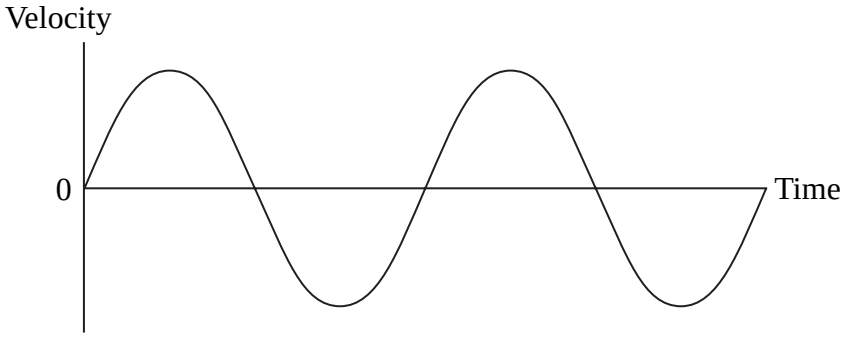
(2)

.....

.....

.....

(b) The graph shows the variation of velocity with time at the edge of the central span of the bridge.



Mark on this graph:

(i) An instant X at which the displacement was a maximum.

(1)

(ii) An instant Y at which the acceleration was zero.

(1)

(c) Before modification the edge of the central span of the bridge oscillated with simple harmonic motion, and had a maximum acceleration of 0.89 m s^{-2}. Calculate the maximum velocity of the edge of the central span of the bridge.

(4)

.....

.....

.....

.....

.....

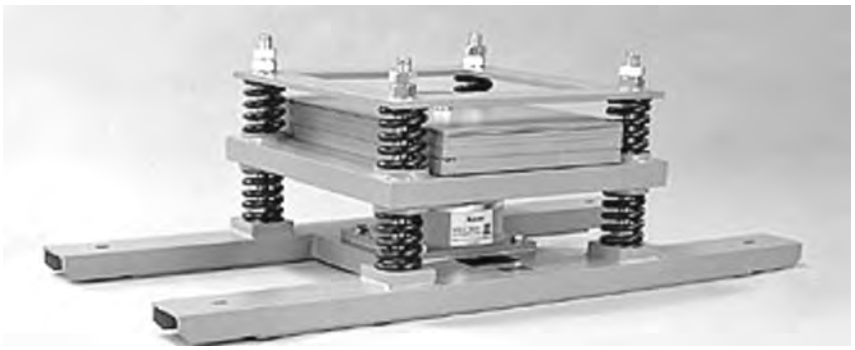
.....

.....

.....

Maximum velocity = ...

(d) The photograph shows the tuned mass dampers which were fitted to the bridge. They are tuned to the natural frequency of oscillation of the bridge.



Discuss how the tuned mass dampers reduce the amplitude of the oscillations of the bridge and explain why they must be very heavily damped.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for Question 18 = 11 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Wednesday 2 February 2011 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

N36114A

1/1/1/1/1/1/1/

N 3 6 1 1 4 A 0 1 2 4

edexcel
advancing learning, changing lives

SECTION A

Answer ALL questions

For questions 1–10, in Section A, 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 statements about nuclear fission is correct?

☒ **A** A uranium-235 nucleus can only undergo fission after absorbing a proton.

☒ **B** Kinetic energy is conserved during fission.

☒ **C** Linear momentum is not conserved during fission.

☒ **D** The fission fragments have a total mass less than that of the nucleus just before fission.

(Total for Question 1 = 1 mark)

---

2 Which of the following statements is correct?

☒ **A** Electrostatic forces have a much longer range than gravitational forces.

☒ **B** Gravitational forces have a much longer range than electrostatic forces.

☒ **C** Gravitational and electrostatic forces both obey an inverse square law.

☒ **D** Gravitational and electrostatic field strength are both scalar quantities.

(Total for Question 2 = 1 mark)

---

3 Two different sized boxes, P and Q, both contain the same number of nitrogen molecules. The molecules in box P have twice the root mean square speed of those in box Q. Which of the following must be correct?

☒ **A** The density of the gas in box P is greater than that in box Q.

☒ **B** The mean momentum of the molecules in box P is greater than those in box Q.

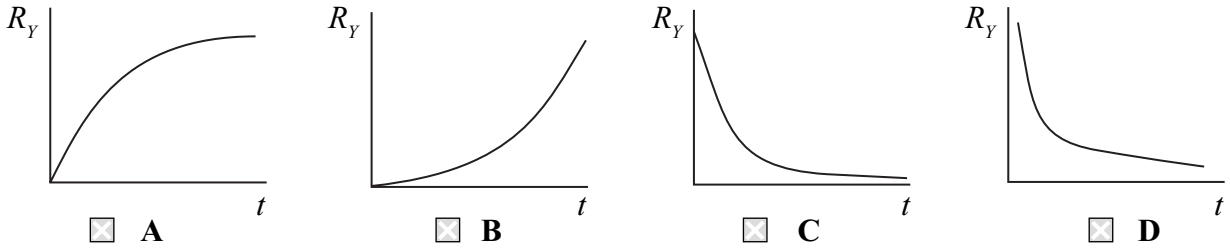
☒ **C** The pressure exerted by the gas in box P is greater than that in box Q.

☒ **D** The temperature of the gas in box P is greater than that in box Q.

(Total for Question 3 = 1 mark)

---

4 A sample of radioactive element X decays into a stable element Y. Which graph shows the rate of formation of element Y, R_Y with time, t?



☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 4 = 1 mark)

5 Two stars with the same luminosity might produce different radiation fluxes at Earth. This is primarily due to the stars having different

☒ **A** diameters

☒ **B** distances from the Earth

☒ **C** motions through the Universe

☒ **D** surface temperatures

(Total for Question 5 = 1 mark)

6 The gravitational field strength at the surface of Mars is one third that at the surface of the Earth. A mass-spring system with a frequency of 3.0 Hz at the surface of the Earth would have a frequency at the surface of Mars of

☒ **A** 5.2 Hz

☒ **B** 3.0 Hz

☒ **C** 1.7 Hz

☒ **D** 1.0 Hz

(Total for Question 6 = 1 mark)

7 Which of the following statements about the possible fate of the Universe is **not** correct?

☒ **A** If the Universe is open then it will continue to expand forever.

☒ **B** If the Universe is open then it will eventually reach a maximum size.

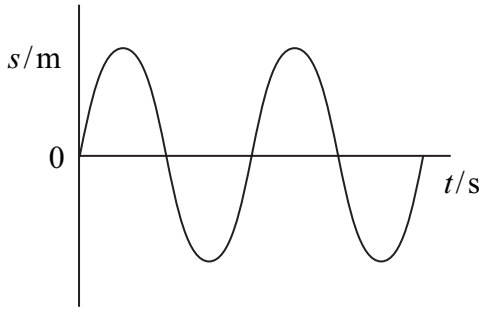
☒ **C** If the Universe is closed then it will eventually reach a maximum size.

☒ **D** If the Universe is closed then it will reach a maximum size and then contract.

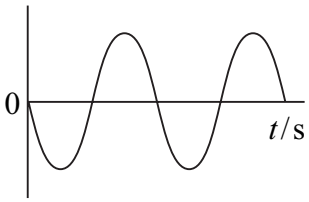
(Total for Question 7 = 1 mark)

Use the graphs below for questions 8, 9 and 10.

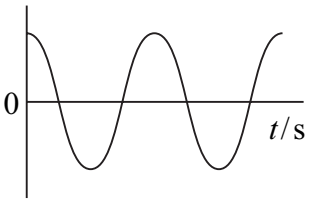
The graph below shows how displacement varies with time for a particle moving with undamped simple harmonic motion during a particular time interval.



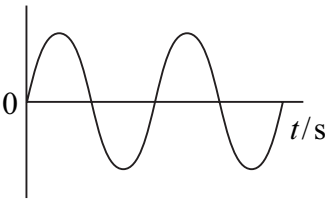
For each of the questions 8 to 10, which of the following graphs best represents the quantities described during the corresponding time interval? Each graph may be used once, more than once or not at all.



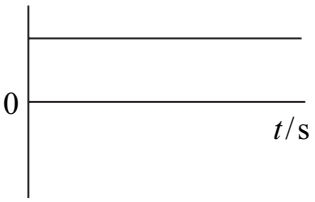
A



B



C



D

8 The velocity of the particle.

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

(Total for Question 8 = 1 mark)

9 The acceleration of the particle.

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

(Total for Question 9 = 1 mark)

10 The total energy of the particle.

(1)

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

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) A typical aerosol can is able to withstand pressures up to 12 atmospheres before exploding. A 3.0×10^{-4} m^3 aerosol contains 3.0×10^{22} molecules of gas as a propellant. Show that the pressure would reach 12 atmospheres at a temperature of about 900 K.

1 atmosphere = 1.0×10^5 Pa

(2)

.....

.....

.....

.....

*(b) Some such aerosol cans contain a liquid propellant. The propellant exists inside the can as a liquid and a vapour. Explain what happens when such an aerosol can is heated to about 900 K.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 11 = 5 marks)

12 The planet Mars has a mean distance from the Sun of 2.3×10^{11} m compared with the Earth's mean distance from the Sun of 1.5×10^{11} m.

(a) Calculate the ratio $\frac{\text{Sun's radiation flux at distance of Mars}}{\text{Sun's radiation flux at distance of Earth}}$.

(2)

Ratio = ...

(b) With reference to your answer in (a), comment on the suggestion that Mars could be capable of supporting life.

(2)

(Total for Question 12 = 4 marks)

13 A Cepheid variable star contracts and expands repeatedly and as it does, so its luminosity varies. By measuring the period of this variation, astronomers can determine the star's average luminosity.

(a) A Cepheid variable star is a type of standard candle. Discuss the use of standard candles in astronomy.

(4)

(b) As well as the variation in luminosity of the Cepheid, changes in the frequency of the detected radiation are also observed.

Suggest how the Doppler effect may account for these changes.

(2)

(Total for Question 13 = 6 marks)

14 A copper wire, diameter 1.63 mm and length 105 km, is to be melted down to sell for scrap.

(a) (i) Show that the mass of the wire is about 2000 kg.

density of copper = 8960 kg m^{-3}

(3)

(ii) The wire is initially at a temperature of 25 °C and its melting point is 1085 °C. Calculate the energy required to raise the temperature of the wire to its melting point.

specific heat capacity of copper = 385 J kg^{-1} K^{-1}

(2)

Energy = ...

(b) Once the melting point is reached, there is no further increase in temperature until all of the copper has melted. Discuss what happens to the energy of the copper atoms before and during the melting process.

(2)

(Total for Question 14 = 7 marks)

15 The Moon takes 27.3 days to make one complete orbit of the Earth.

(a) (i) Show that the orbital angular velocity of the Moon is about 3×10^{-6} rad s^{-1}.

(2)

(ii) Calculate the radius of the Moon's orbit.

mass of Earth = 6.4×10^{24} kg

(4)

Radius = ...

(b) The Moon is gradually moving further away from the Earth because of the action of tides.

(i) State and explain how this increasing distance affects the moon's orbital period.

(2)

(ii) In 200 years the radius of the Moon's orbit is predicted to increase by 8 m.

Calculate the rate of increase of the radius of the orbit in cm per year.

(1)

.....

.....

.....

.....

Rate of increase = ... cm per year

*(iii) In practice, the rate of increase of the orbital radius due to tidal action will not have been constant. Suggest why this rate of change might have been different in the very distant past.

(3)

.....

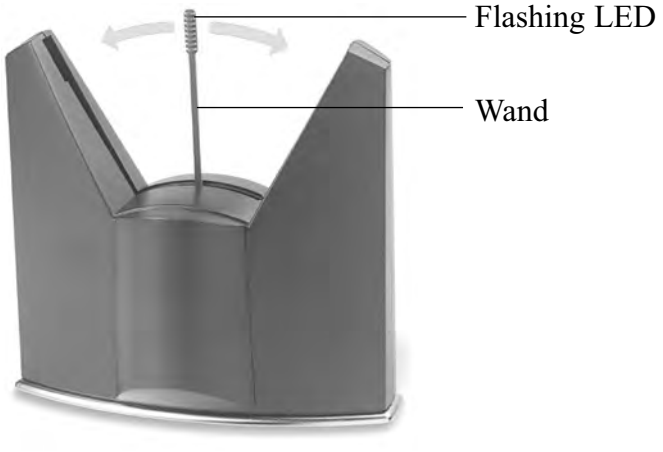
.....

.....

.....

(Total for Question 15 = 12 marks)

16 Observing the display of a 'floating image' clock relies on the phenomenon of 'persistence of vision'. The clock has a wand with a set of flashing light-emitting diodes (LEDs) at its end. The wand oscillates rapidly back and forth and takes only 0.0625 s to sweep from one end to the other. The wand becomes almost invisible to the eye, while the flashing LEDs create a floating image effect.



(a) The tip of the wand moves with simple harmonic motion as it sweeps through a distance of 10.0 cm from one end to the other.

(i) Calculate the frequency of the wand's oscillation.

(2)

Frequency = ...

(ii) The speed of the wand varies as it sweeps back and forth. At what point will the speed of the wand be a maximum?

(1)

(iii) Calculate the maximum speed of the tip of the wand.

(2)

Maximum speed = ...

(b) In normal operation the clock may make a faint ticking or humming sound. An unstable surface supporting the clock can result in noisy operation due to resonance.

(i) Explain what is meant by resonance.

(2)

(ii) The clock is mounted on rubber feet so that it does not make direct contact with surfaces. Explain how this helps to reduce the effects of resonance.

(2)

(Total for Question 16 = 9 marks)

17 In September 1987, two youngsters in Brazil removed a stainless steel cylinder from a machine in an abandoned clinic. Five days later they sold the cylinder to a scrap dealer who prised open a platinum capsule inside to reveal a glowing blue powder. The powder was found to contain caesium-137 and had an activity of 5.2×10^{13} Bq.

Caesium-137 is a β^--emitter with a half-life of 30 years.

*(a) Discuss the dangers to the youngsters of possessing this cylinder for 5 days.

(3)

(b) Complete the equation to represent the decay of caesium-137 into barium.

(2)

$$^{137}_{55}\text{Cs} \rightarrow \text{\_\_\_\_}\,\text{Ba} + \text{\_\_\_\_}\,\beta^-$$

(c) (i) The decay of caesium into barium is a random process. Why is the decay process described as random?

(1)

(ii) Show that the decay constant for the caesium-137 is about 7×10^{-10} s^{-1}.

(2)

(d) In September 2007, 20 years after the cylinder was removed from the machine, the substance was still highly radioactive. Calculate the number of caesium-137 atoms remaining in the powder.

(4)

Number = ...

(e) Caesium-137 is one of the products from the nuclear fission of uranium-235 in a nuclear reactor.

(i) Complete the equation for this reaction and show the number of neutrons released.

(1)

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{137}_{55}\mathrm{Cs} + {}^{95}\mathrm{Rb} + {}^{1}_{0}\mathrm{n}$$

(ii) Explain the significance to the operation of the reactor of the number of neutrons emitted in each fission.

(2)

(Total for Question 17 = 15 marks)

18 Records of people walking on fire have existed for thousands of years. Walking across hot coals without getting burned does seem impossible, especially when the coals are at a temperature of 1500 K. However, as long as they do not take too long to walk across the coals, firewalkers won't get burned.

The explanation may have something to do with the relatively small amount of thermal energy involved. Although the coals are hot, the total amount of thermal energy transferred to the soles of the walker's feet is small. This is a little like quenching a red hot metal bar in a trough of cold water. The metal bar cools rapidly, transferring thermal energy to the water, but the rise in temperature of the water is quite small because of the relatively large value for the specific heat capacity of the water.

(a) Describe an experiment you could carry out to measure the specific heat capacity of a metal, assuming that you have a number of metal washers which can be heated to a known temperature in a Bunsen flame and plunged into a container of water. State the measurements that you would need to make and give the theoretical basis of the calculation that you would carry out.

What assumption would you make in calculating the specific heat capacity of the metal?

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(b) Coals used for firewalking typically glow a dull red, with the peak energy emission taking place at a wavelength of about 2 μm.

(i) To which region of the electromagnetic spectrum does this wavelength belong?

(1)

.....

(ii) Show that a peak wavelength of 2.00 μm corresponds to a black-body temperature of about 1500 K.

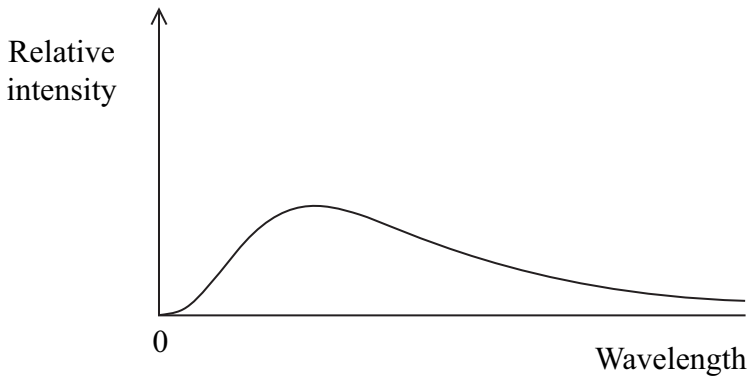
(2)

(iii) The coals have an average radius of 2.5 cm. Assuming that each coal behaves as a black-body radiator, calculate the rate at which energy is radiated from each coal at a temperature of 1500 K.

(3)

(iv) The graph shows the shape of the spectrum for radiation emitted from a black-body radiator at 1500 K. Add a second curve to show the shape of the spectrum for a temperature of 2000 K.

(2)



(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Monday 27 June 2011 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P38417A

1/1/1/1/1/

edexcel
advancing learning, changing lives

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 Samples of nitrogen gas and helium gas are at the same temperature. Compared with the helium molecules, the nitrogen molecules have

☒ **A** a lower mean square speed.

☒ **B** the same mean square speed.

☒ **C** a higher mean square speed.

☒ **D** a mean square speed dependent upon the amount of each gas.

(Total for Question 1 = 1 mark)

2 Which of the following descriptions **cannot** apply to the oscillations of a system undergoing resonance?

☒ **A** Damped

☒ **B** Driven

☒ **C** Forced

☒ **D** Free

(Total for Question 2 = 1 mark)

3 During an earthquake, steel-framed buildings absorb energy because steel is

☒ **A** ductile.

☒ **B** elastic.

☒ **C** stiff.

☒ **D** strong.

(Total for Question 3 = 1 mark)

4 On a Hertzsprung-Russell diagram, the main sequence shows

- ☒ **A** only the most luminous stars.
- ☒ **B** only the most massive stars.
- ☒ **C** stars near the end of their lives.
- ☒ **D** stars principally fusing hydrogen.

(Total for Question 4 = 1 mark)

5 Which one of the following does **not** contribute to background radiation?

- ☒ **A** Dead matter
- ☒ **B** Living matter
- ☒ **C** Mobile phones
- ☒ **D** Rocks

(Total for Question 5 = 1 mark)

6 When a forced oscillation is damped, the amplitude

- ☒ **A** builds up quite slowly.
- ☒ **B** constantly rises and falls.
- ☒ **C** is always small.
- ☒ **D** is reduced.

(Total for Question 6 = 1 mark)

7 The ultimate fate of the Universe is uncertain because

- ☒ **A** atmospheric absorption limits our observations.
- ☒ **B** our galaxy is not typical of other galaxies in the Universe.
- ☒ **C** the total average density of the Universe is uncertain.
- ☒ **D** we cannot observe very distant galaxies.

(Total for Question 7 = 1 mark)

8 A radioactive source is placed 2 cm from a detector. The count rate decreases slightly if a sheet of paper is placed between the source and the detector. It is reduced to background radiation level when the paper is replaced with a 1 cm thickness of aluminium.

The correct conclusion is that the source emits

☒ **A** alpha radiation only.

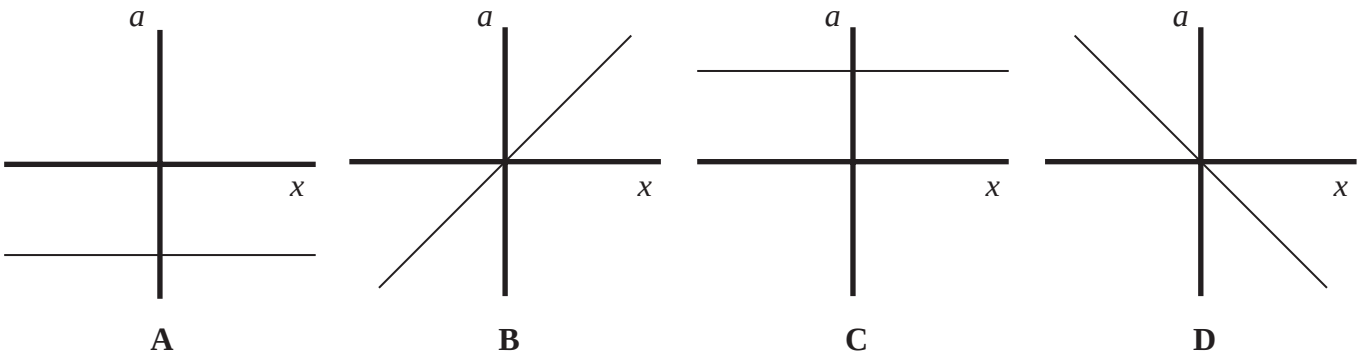
☒ **B** alpha and beta radiation.

☒ **C** beta and gamma radiation.

☒ **D** gamma radiation only.

(Total for Question 8 = 1 mark)

9 A mass-spring system is set into simple harmonic motion. Which graph shows the variation of the acceleration, *a*, of the mass with its displacement, *x*?



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

☒ **A**

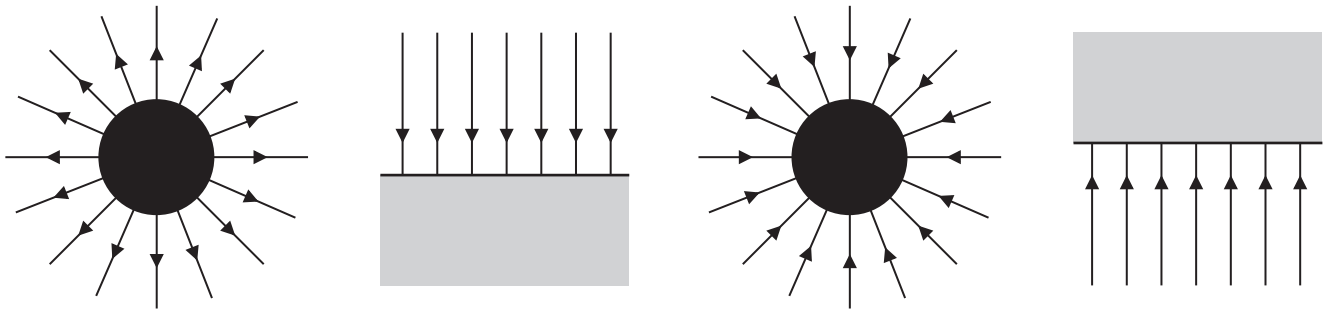
☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 Electric and gravitational fields can be represented in similar ways. Which of the diagrams below **cannot** be used for a gravitational field?



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

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

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) State what astronomers mean by a standard candle.

(1)

.....

.....

(b) The luminosity of Sirius is 8.94×10^{27} W and its distance from the Earth is 8.08×10^{16} m.

Calculate the radiant energy flux of Sirius at the Earth.

(2)

.....

.....

.....

.....

Radiant energy flux = ...

(Total for Question 11 = 3 marks)

12 (a) Derive an expression for the gravitational field strength g at a distance r from the centre of a mass M. Use the list of equations at the end of this question paper.

(2)

.....

.....

.....

(b) Use your expression to calculate g at the surface of the Earth.

mass of Earth $M_E = 5.97 \times 10^{24}$ kg
radius of Earth $r_E = 6.38 \times 10^6$ m

(1)

.....

.....

g = ...

(Total for Question 12 = 3 marks)

13 The heating element of a hair dryer supplies 2.1 kW to the air flowing past it.

(a) The hair dryer is connected to a 230 V supply.

Calculate the minimum current in the heating element.

(2)

.....

.....

.....

Current = ...

(b) (i) The fan in the hair dryer blows air at 20 °C across the heating element at a rate of 0.068 kg s^{-1}.

Calculate the temperature of the air emerging from the hair dryer.

specific heat capacity of air = 1.01×10^3 J kg^{-1} K^{-1}

(2)

.....

.....

.....

.....

.....

.....

Exit temperature = ...

(ii) Describe the energy changes that occur as air is blown past the heating element.

(2)

.....

.....

.....

.....

(Total for Question 13 = 6 marks)

14 A football has a diameter of 22.5 cm. It contains air at a temperature of 20 °C and a pressure of 1.65×10^5 Pa. When the football is left in direct sunlight, the temperature of the air in the football increases to 40 °C.

In the following calculations, assume that the volume of the football remains constant.

(a) (i) Show that the new pressure exerted by the air in the football is about 2×10^5 Pa.

(2)

.....

.....

.....

.....

(ii) State another assumption you made in your calculation.

(1)

.....

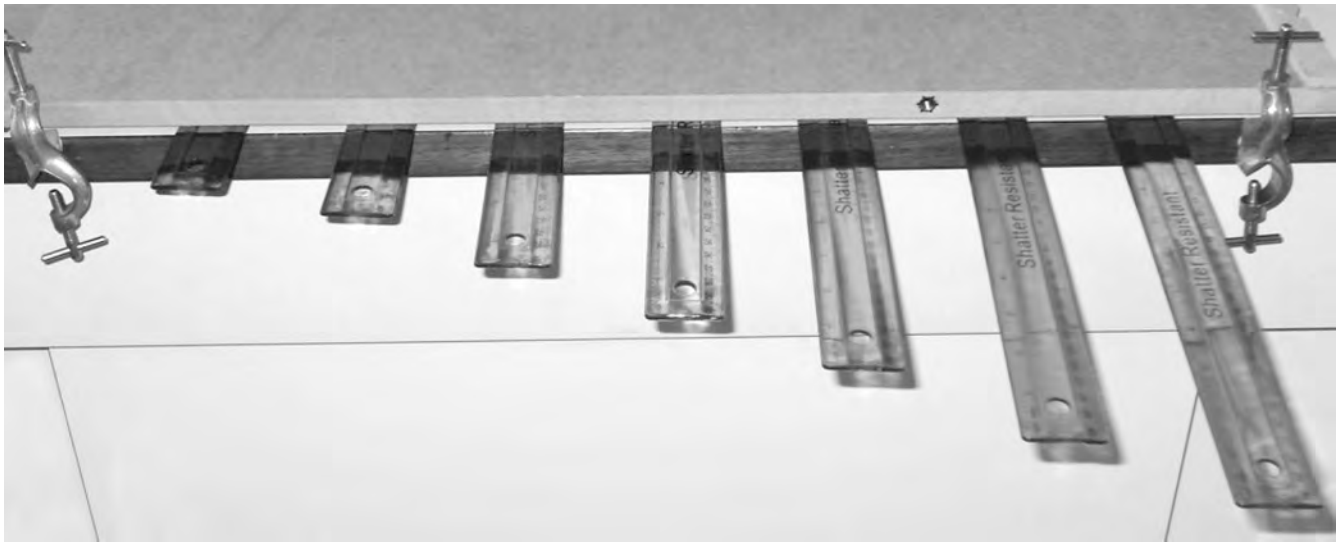
(b) Air is then released from the football until the pressure returns to its original value. Assuming that the temperature remains at 40 °C, calculate the number of molecules that escape.

(3)

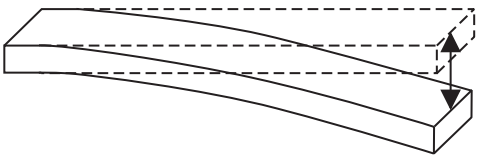
Number of molecules escaping = ...

(Total for Question 14 = 6 marks)

15 A student makes the "ruler piano" shown in the photograph.



One end of each ruler is held flat on the desk whilst the other end is set into oscillation. Each ruler oscillates at a different frequency. Some of the rulers produce an audible sound.



(a) State the condition for an oscillation to be simple harmonic.

(2)

.....

.....

.....

(b) The end of one ruler moves through 5.0 cm from one extreme position to the other, and makes 10 complete oscillations in 4.5 s.

Calculate the maximum velocity of this end.

(3)

Maximum velocity = ...

(c) A standing wave is set up on each oscillating ruler.

Explain why each length of ruler oscillates at a different frequency.

(3)

(Total for Question 15 = 8 marks)

16 Polonium-210 is an alpha-emitter with a half-life of 138 days. It emits alpha particles of energy 5.3 MeV as it decays to a stable isotope of lead.

One small pellet of polonium-210 contains 1.3×10^{21} atoms.

(a) (i) Show that the initial activity of this polonium pellet is about 8×10^{13} Bq.

(3)

(ii) Hence show that the rate of energy release by the pellet is more than 60 W.

(3)

(b) The radius of the pellet is 2.25 mm and its equilibrium temperature would be about 1000 K.

(i) Assuming that 5% of the energy released is radiated away, show that this approximate value of temperature is correct.

(3)

(ii) Calculate the wavelength at which peak energy radiation occurs.

(2)

.....

.....

.....

.....

Wavelength of peak energy radiation = ...

(iii) State the region of the electromagnetic spectrum in which this wavelength of radiation would be found.

(1)

.....

(c) Explain why very small quantities of polonium-210 are a health hazard only if taken into the body.

(2)

.....

.....

.....

.....

(Total for Question 16 = 14 marks)

17 Fission and fusion are both nuclear processes that release energy. About 20% of the UK's energy need is currently provided by the controlled fission of uranium. Intensive research continues to harness the energy released from the fusion of hydrogen.

(a) (i) Fission of uranium-235 takes place after the absorption of a thermal neutron. Assume such neutrons behave as an ideal gas at a temperature of 310 K.

Show that the square root of the mean square speed of the neutrons is about 3000 m s^{-1}.

mass of neutron = 1.0087u

(3)

.....

.....

.....

.....

.....

(ii) Complete the equation for the fission of uranium-235.

(2)

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{.....}_{92}\mathrm{U} \rightarrow {}^{138}_{.....}\mathrm{Cs} + {}^{96}_{37}\mathrm{Rb} + {}_{.....}{}^{1}_{0}\mathrm{n}$$

(iii) Calculate the energy released in a single fission. Hence determine the rate of fission necessary to maintain a power output of 2.5 GW.

	Mass / u
^{235}U	235.0439
^{138}Cs	137.9110
^{96}Rb	95.9343

(4)

Fission rate = ...

(b) *(i) State the conditions for fusion and hence explain why it has proved difficult to maintain a sustainable reaction in a practical fusion reactor.

(4)

(ii) The nuclear reaction below represents the fusion of two deuterium nuclei. Complete the equation and identify particle X.

(1)

$$ {}^{2}_{1}\mathrm{D} + {}^{2}_{1}\mathrm{D} \rightarrow {}^{3}_{1}\mathrm{H} + {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{X} $$

Particle X is a .....

(iii) Despite the difficulties, the quest for a practical fusion reactor continues.

State **two** advantages fusion power might have over fission power.

(2)

1.....

.....

2.....

.....

(Total for Question 17 = 16 marks)

18 Current theory predicts that there is a massive black hole at the centre of every galaxy. It is suggested that if galaxies approach, then their central black holes begin to orbit each other until the galaxies merge.

In 2009, astronomers found convincing evidence of two such black holes orbiting as a binary system. From data collected, they estimated that the separation of the black holes was 3.2×10^{15} m and that their masses were 1.6×10^{39} kg and 4.0×10^{37} kg.

(a) (i) State the origin of the force that maintains the black holes in an orbit.

(1)

.....

(ii) Show that the magnitude of this force is about 4×10^{35} N.

(2)

.....

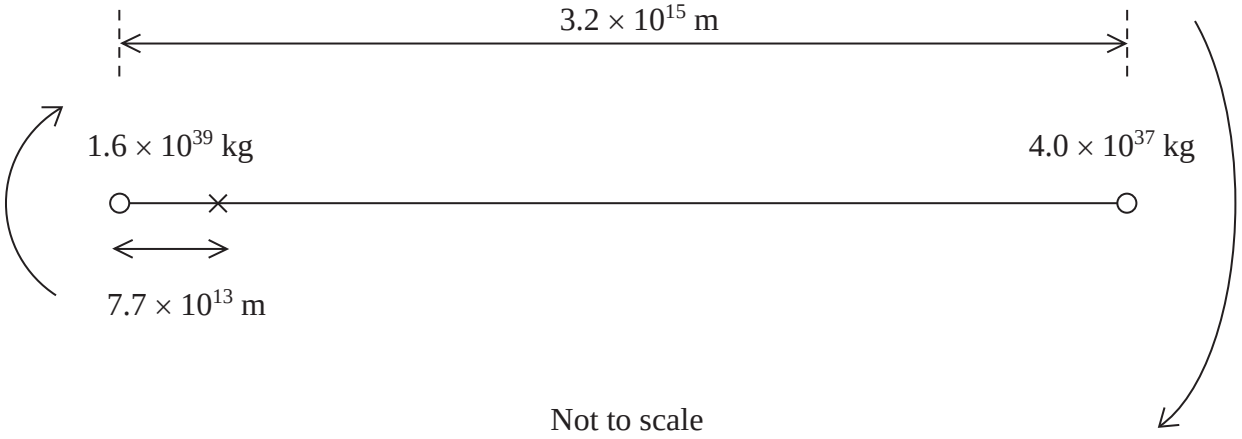
.....

.....

.....

.....

(iii) The black holes orbit about a point 7.7×10^{13} m from the larger mass black hole.



Not to scale

Show that the orbital time of the binary system is about 100 years.

(3)

(b) As the black holes swallow up matter, radiation is emitted. To observers on Earth this radiation appears to be red shifted.

*(i) State what red shift means and discuss the conclusions that can be drawn from the observation that radiation from all distant galaxies is red shifted.

(3)

(ii) Suggest why the light from both black holes is red shifted, even though the black holes are orbiting each other and hence moving in opposite directions.

(2)

(iii) The observed red shift for the two black holes was 0.38.

Calculate the distance of the merging galaxies from the Earth.

$H_o = 1.6 \times 10^{-18}\ s^{-1}$

(3)

Distance from the Earth = ...

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Friday 27 January 2012 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39850A

1/1/1/1/

P 3 9 8 5 0 A 0 1 2 8

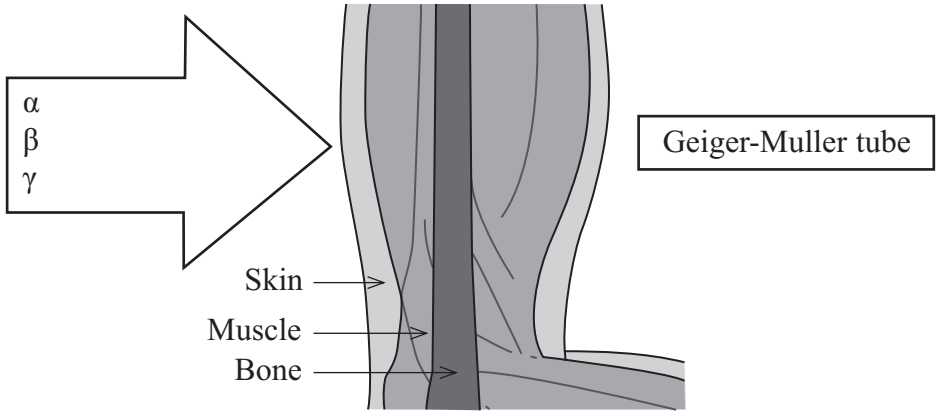
PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 The diagram shows radiation from a radium source approaching a person's arm. A Geiger-Muller tube on the other side of the arm detects radiation.



The radiation detected is substantially less than would be detected without the arm in position. This is because the

☒ **A** bone is absorbing α-radiation.

☒ **B** muscle is absorbing α-radiation.

☒ **C** muscle is absorbing β-radiation.

☒ **D** skin is absorbing γ-radiation.

(Total for Question 1 = 1 mark)

2 In the equation $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$, the term $\langle c^2\rangle$ represents

☒ **A** the mean speed of the molecules.

☒ **B** the mean speed of the molecules squared.

☒ **C** the mean square speed of the molecules.

☒ **D** the mean velocity of the molecules.

(Total for Question 2 = 1 mark)

3 A bridge vibrates gently as cars are driven across it. This is an example of

- ☒ **A** forced oscillation.
- ☒ **B** free oscillation.
- ☒ **C** resonance.
- ☒ **D** stationary waves.

(Total for Question 3 = 1 mark)

4 A Hertzsprung-Russell diagram is plotted for an old star cluster. Compared with a young cluster containing a similar number of stars there will be fewer

- ☒ **A** light main sequence stars.
- ☒ **B** massive main sequence stars.
- ☒ **C** red giant stars.
- ☒ **D** white dwarf stars.

(Total for Question 4 = 1 mark)

5 About 25% of the mass of our Universe is thought to consist of dark matter. A key property of dark matter is that it

- ☒ **A** absorbs all electromagnetic-radiation.
- ☒ **B** cannot be detected.
- ☒ **C** emits no detectable electromagnetic-radiation.
- ☒ **D** exerts no gravitational force.

(Total for Question 5 = 1 mark)

6 Cosmologists describe the universe as being open, closed or flat.
A closed universe is one which

- ☒ **A** has always been the same size.
- ☒ **B** has a maximum size.
- ☒ **C** has an uncertain future.
- ☒ **D** will expand forever.

(Total for Question 6 = 1 mark)

7 The total number of free neutrons immediately after a fission reaction

- ☒ **A** goes down.
- ☒ **B** goes up.
- ☒ **C** may increase or decrease.
- ☒ **D** must stay constant.

(Total for Question 7 = 1 mark)

8 The pressure exerted by an ideal gas, maintained at a constant temperature, is inversely proportional to the volume occupied by the gas.

Which of the following statements is **not** true?

- ☒ **A** The average molecular kinetic energy remains constant.
- ☒ **B** The gas must consist of identical molecules.
- ☒ **C** The mass of gas is fixed.
- ☒ **D** The number of molecules in the gas doesn't change.

(Total for Question 8 = 1 mark)

9 In many ways electrical and gravitational forces are similar.

One key difference is that only

- ☒ **A** electrical forces can be attractive and repulsive.
- ☒ **B** electrical forces have an infinite range.
- ☒ **C** gravitational forces can be attractive and repulsive.
- ☒ **D** gravitational forces have an infinite range.

(Total for Question 9 = 1 mark)

10 The magnitude of the fractional change in frequency, $\Delta f/f$, produced in the Doppler effect depends upon

- ☒ **A** the relative velocity of the source and the observer.
- ☒ **B** the wavelength of the radiation being emitted by the source.
- ☒ **C** whether it is the source or the observer that is moving.
- ☒ **D** whether the source and observer are approaching or receding.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 In a physics lesson a student learns that the Earth is 81 times more massive than the Moon. Searching the Internet, she is surprised to discover that the gravitational field strength at the surface of the Earth is only 6 times greater than that at the surface of the Moon.

Use the above data to compare the radius of the Earth with that of the Moon.

(3)

(Total for Question 11 = 3 marks)

12 The Earth can be considered to be a black body radiator at a temperature of 25 °C.

radius of Earth = 6380 km

(a) Calculate the total power radiated from the Earth.

(2)

Total power radiated = ...

(b) Calculate the wavelength of the peak energy radiation for the Earth.

(2)

Wavelength of the peak energy radiation = ...

(c) State the region of the electromagnetic spectrum in which this wavelength is found.

(1)

(Total for Question 12 = 5 marks)

13 (a) Define simple harmonic motion.

(2)

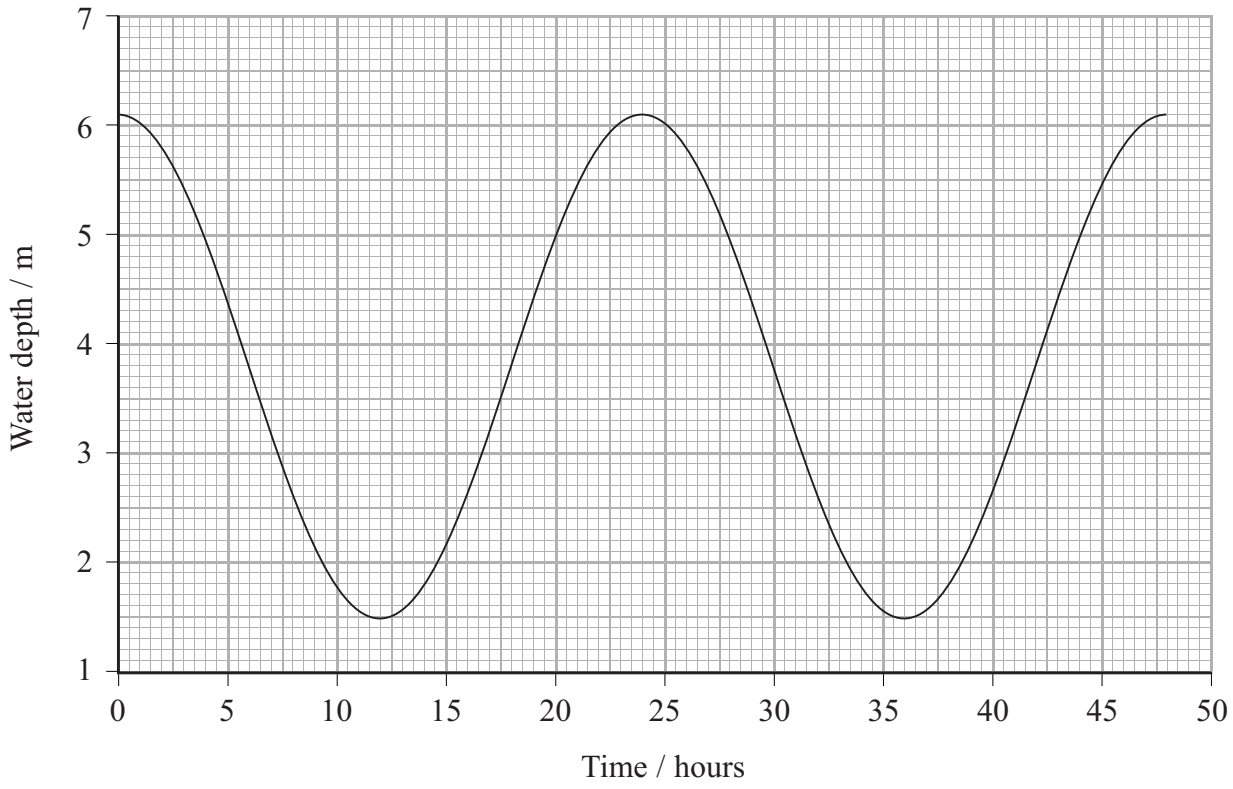
.....

.....

.....

.....

(b) The graph shows the variation in water level displacement with time for the water in a harbour. The water level displacement varies with simple harmonic motion.



(i) Use the graph to calculate the amplitude and the time period of the variation in the water level displacement.

(2)

Amplitude = ...

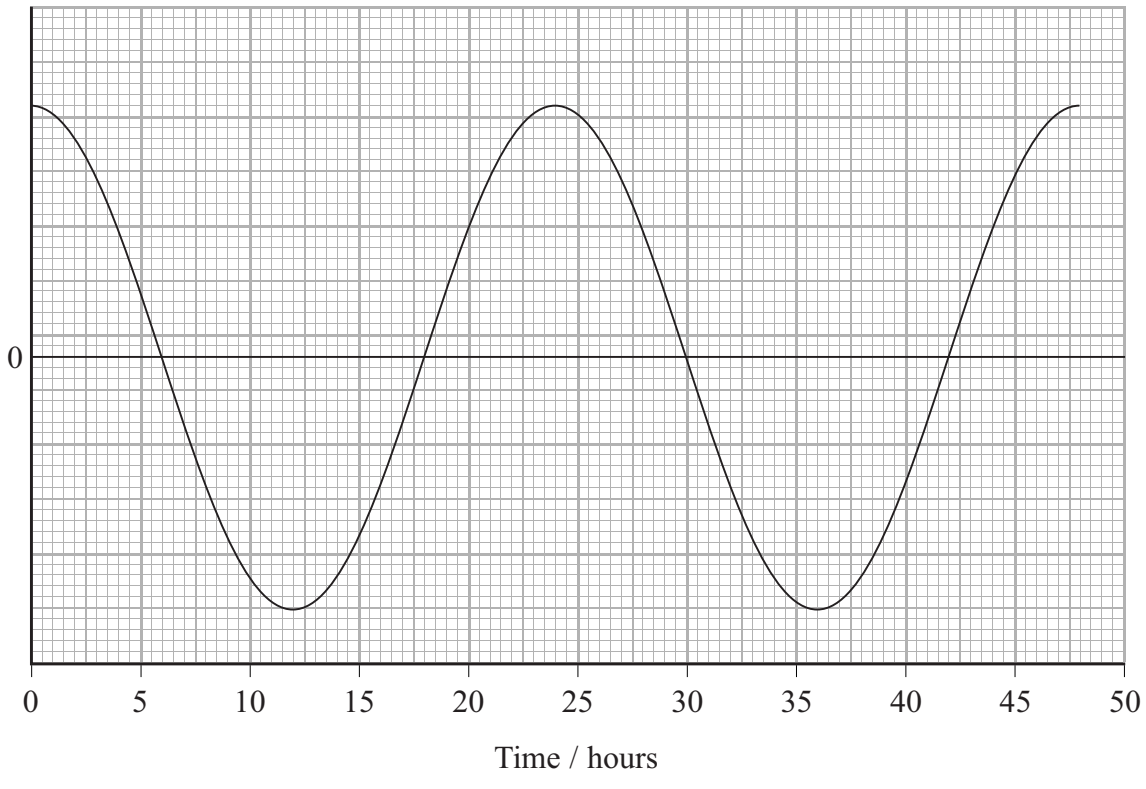
Time period = ...

(ii) Show that the maximum rate of change of water level displacement is about 0.6 m hour^{-1}.

(3)

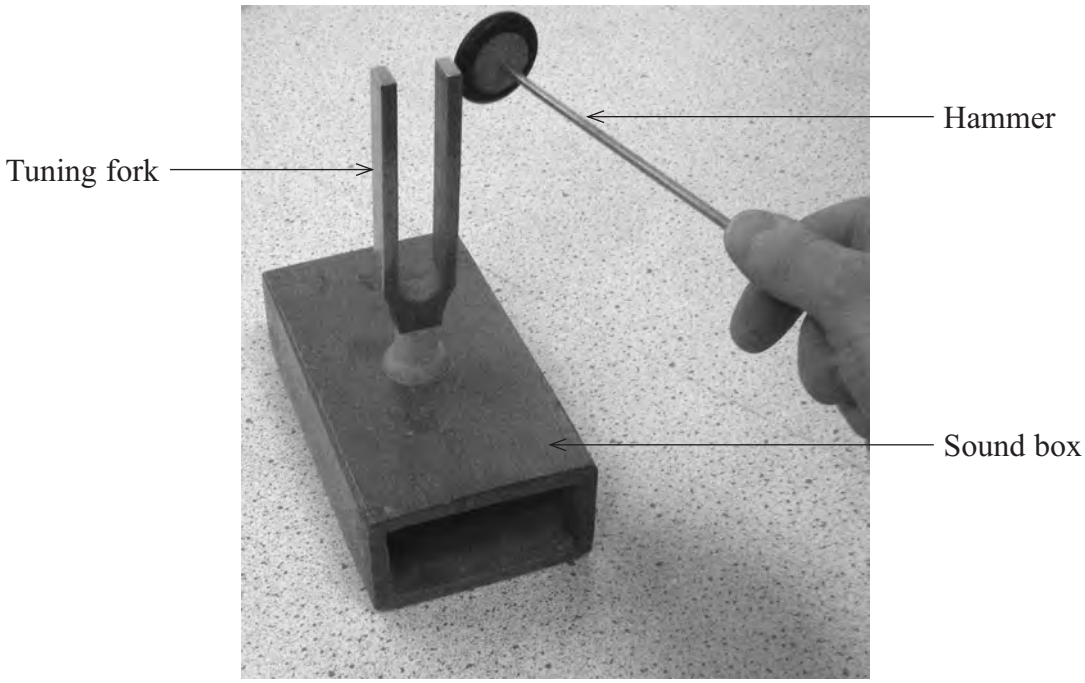
(iii) On the axis below sketch how the rate of change of water level displacement varies with time for the interval 0–30 hours. The variation in water level displacement with time has been drawn for you. You need not add any numerical values to the y-axis.

(2)



(Total for Question 13 = 9 marks)

***14** When a tuning fork is struck with a rubber hammer, a pure sound of fixed frequency is produced. The photograph shows a tuning fork connected to a wooden sounding box.



- The sounding box amplifies the sound produced when the tuning fork is struck.
- The sound lasts for a shorter time than if the tuning fork were to be struck identically but without the sounding box.

Explain these observations.

(5)

(Total for Question 14 = 5 marks)

15 A washing machine uses 15 litres of water in a hot-wash cycle in which the machine is set to wash at 60 °C.

1.0 litre of water has a mass of 1.0 kg

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(a) On a particular day the inlet temperature of the water is 15 °C. Show that the energy that must be supplied in order to bring the water to the correct temperature is about 3 MJ.

(2)

.....

.....

.....

.....

(b) (i) The power of the heater is 2.5 kW. Calculate the minimum time it takes for the water to be brought to the correct temperature.

(2)

.....

.....

.....

.....

Minimum time = ...

(ii) State an assumption you made in your calculation.

(1)

.....

(c) The washing machine is connected to a 230 V supply. What current is drawn from the supply by the heater?

(2)

Current = ...

(Total for Question 15 = 7 marks)

16 (a) The Moon orbits the Earth in a circular path.

Explain why the Moon maintains this circular path and what determines the radius of the path.

(2)

(b) A bucket is swung in a vertical, circular path as shown.

The bucket is half filled with water and swung. The water stays in the bucket, even at the top of the circular path, as long as the speed of the bucket exceeds a certain value.

Explain why.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 16 = 5 marks)

17 A pan attached to a spring balance is used to determine the mass of fruit and vegetables in a supermarket.

A bunch of bananas is dropped into the pan. The pan oscillates with an initial amplitude of 10 cm. The total mass of bananas and pan is 0.55 kg.

The spring constant of the system is 120 N m^{-1}.

(a) Calculate the period of oscillation of the pan.

(2)

Period = ...

(b) The oscillations of the pan are damped.

(i) Explain what is meant by this statement.

(2)

(ii) Sketch a graph to show how the displacement of the damped pan varies with time.

(3)

(Total for Question 17 = 7 marks)

18 The radioactive isotope carbon-14 undergoes decay with a half-life of 5730 years. While an organism is living, it takes in carbon from the atmosphere and the ratio of carbon-14 to the stable isotope carbon-12 in the organism is constant. After death the ratio changes, as the carbon-14 continues to decay but no more carbon is taken in. This is the basis of radiocarbon dating.

Archaeologists have used radiocarbon dating to pinpoint the date of construction of Stonehenge, an ancient stone circle in south west England. The archaeologists unearthed dead organic material from under the stones and sent a sample of it to Oxford University for analysis. Scientists at the university determined that the ratio of carbon-14 to carbon-12 in the sample was only 60% of that found in living organisms.

(a) Explain what is meant by a radioactive isotope.

(2)

(b) Radioactive decay is a random process. Explain what this means.

(2)

(c) Calculate the decay constant of carbon-14 and hence the time since Stonehenge was constructed.

(6)

Time = ...

(d) The rate of production of carbon-14 in the atmosphere has decreased since Stonehenge was constructed. Explain how this would affect the scientists' calculations of when Stonehenge was constructed.

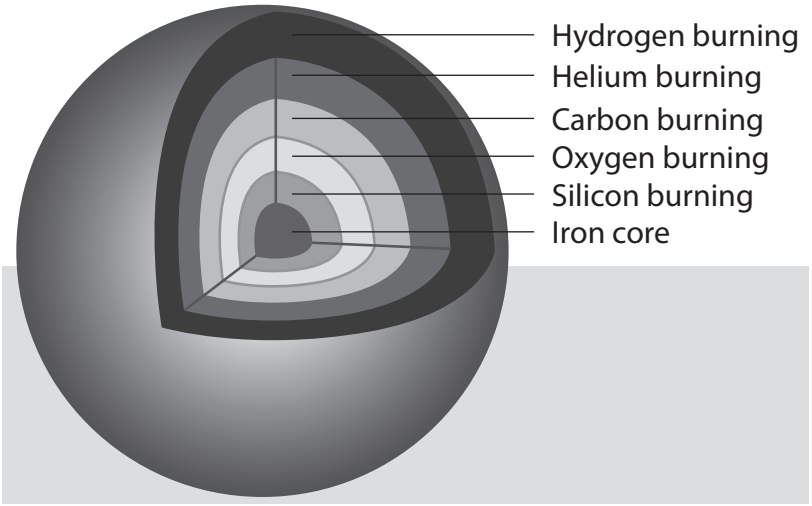
(3)

(Total for Question 18 = 13 marks)

19 The following passage is taken from a newspaper article.

Stars exist by fusing hydrogen within their cores. This process generates heat which pushes the star outwards. This outward pressure is matched by the gravitational forces pulling the star inwards. This maintains an equilibrium, allowing the star to radiate away vast amounts of energy for long periods of time. Our Sun has been in this state for about 4.5 billion years.

Eventually the star runs out of hydrogen to fuse, and so changes occur which allow fusion of helium to form heavier elements. Massive stars can produce elements up to iron in their cores by fusion.



Once a star's core has been converted into iron no further fusion can take place and the rapid collapse of the star results in a supernova explosion.

The remnant of the supernova may be a neutron star or black hole, depending upon the remnant's mass.

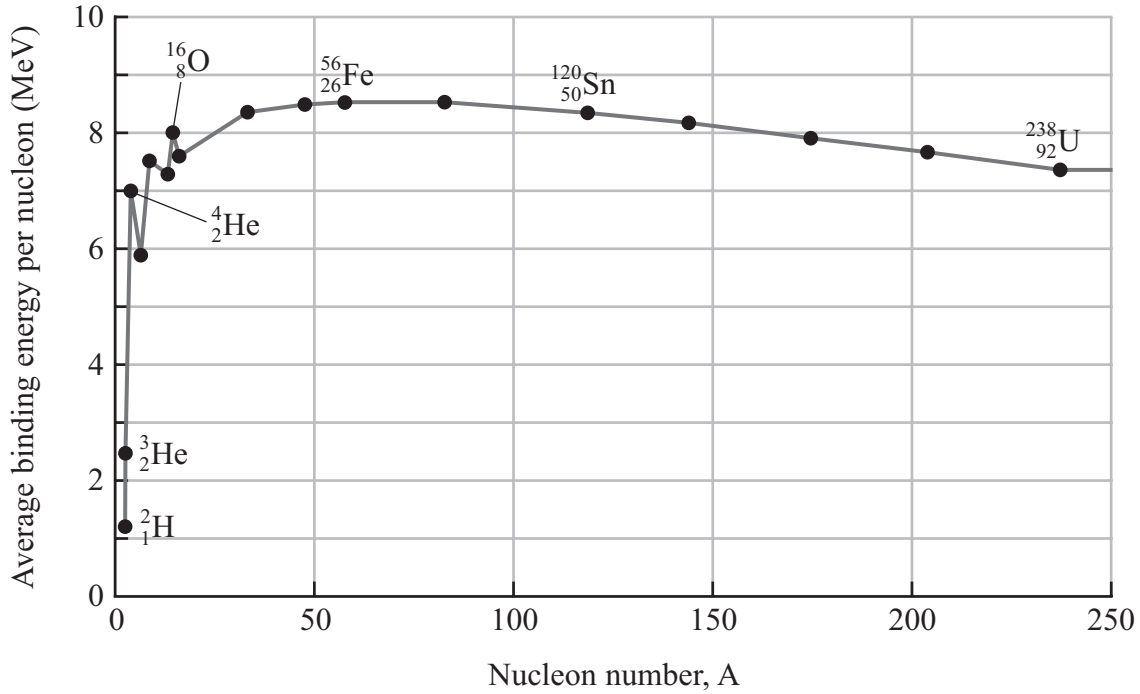
*(a) The conditions needed for fusion to occur make it difficult to replicate outside of a star.

State and explain:

- how the process of fusion is able to release energy
- the conditions necessary for fusion to occur
- why the conditions are difficult to replicate outside of a star.

(6)

(b) The graph shows the average binding energy per nucleon for a range of isotopes.



Massive stars can only produce elements up to iron (Fe) in their cores by fusion.
Use information from the graph to explain why.

(3)

A type 1a supernova occurs when a white dwarf star in a close binary system accumulates matter from its companion star. This eventually leads to a supernova outburst. Type 1a supernovae are used by astronomers as standard candles.

(c) (i) State what is meant by a standard candle.

(1)

(ii) A type 1a supernova is observed in a distant galaxy. Its flux at the Earth is measured to be 1.84×10^{-15} W m^{-2}. Theory predicts that it has a luminosity of 2.0×10^{36} W.

Show that the distance of the galaxy from the Earth is about 9×10^{24} m.

(2)

(iii) The light from the galaxy is found to be red-shifted. State what this tells us about the galaxy.

(1)

(iv) The redshift is measured to be 0.064. Calculate a value for the Hubble constant.

(3)

Hubble constant = ...

(Total for Question 19 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Monday 18 June 2012 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39856A

1/1/1/C2/C2/

P 3 9 8 5 6 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 sealed gas jar contains a mixture of different gases. At a given temperature, the mean kinetic energy of the molecules of each gas

☒ **A** depends upon how much of each gas is present.

☒ **B** is greater for the gas with less massive molecules.

☒ **C** is greater for the gas with more massive molecules.

☒ **D** is the same for each gas in the mixture.

(Total for Question 1 = 1 mark)

2 Before carrying out an experiment to measure the activity from a radioactive source, it is usual to measure the background count. The background count obtained is **not** affected by the

☒ **A** location of the experiment.

☒ **B** temperature of the surroundings.

☒ **C** time interval used for the count.

☒ **D** type of detector being used.

(Total for Question 2 = 1 mark)

3 Health and safety guidelines state that radioactive sources suitable for school experiments should only be handled using long tongs, and only for restricted periods of time. Select the row in the table that gives the type of radiation that is most dangerous to the human body, in these circumstances, with the correct reason.

	Type of radiation	Reason
☒ **A**	α-radiation	it is the most ionising
☒ **B**	α-radiation	it is the most massive
☒ **C**	β-radiation	it can penetrate up to a metre of air
☒ **D**	β-radiation	it can penetrate the skin and enter the body

(Total for Question 3 = 1 mark)

4 Which of the following is **not** an example of simple harmonic motion?

- ☒ **A** A car bouncing on its suspension system.
- ☒ **B** A child jumping on a trampoline.
- ☒ **C** A person bouncing on the end of a bungee cord.
- ☒ **D** A swinging pendulum in a grandfather clock.

(Total for Question 4 = 1 mark)

5 Two distant stars are observed through a telescope. Star A is observed to be half as bright as star B. Star A is calculated to be twice as far away as star B.

Which of the following is correct?

- ☒ **A** Star A has half the luminosity of star B.
- ☒ **B** Star A has the same luminosity as star B.
- ☒ **C** Star A has twice the luminosity of star B.
- ☒ **D** Star A has 8 times the luminosity of star B.

(Total for Question 5 = 1 mark)

6 The electrostatic interaction between two charges and the gravitational interaction between two masses can be represented by similar equations.

Which of the following is correct?

- ☒ **A** The force variation in both fields obeys an inverse square law.
- ☒ **B** Both fields are examples of strong interactions.
- ☒ **C** Both have a field strength variation that is inversely proportional to distance.
- ☒ **D** Electric charge is exactly analogous to mass.

(Total for Question 6 = 1 mark)

7 When one system is driven into oscillation by another, the driven system

- ☒ **A** exhibits resonance.
- ☒ **B** has a large increase in amplitude.
- ☒ **C** vibrates at its natural frequency.
- ☒ **D** vibrates at the driver frequency.

(Total for Question 7 = 1 mark)

8 The interior of a star has conditions that are ideal for sustainable fusion reactions. The general conditions for fusion require a very large

☒ **A** amount of hydrogen and temperature.

☒ **B** amount of hydrogen and pressure.

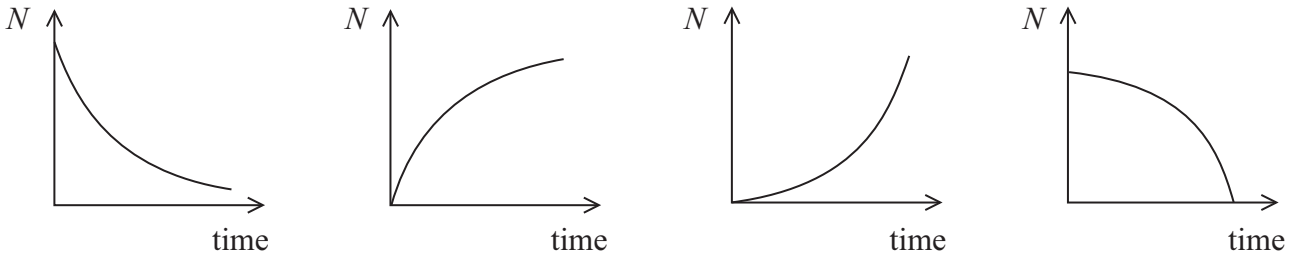
☒ **C** density and pressure.

☒ **D** density and temperature.

(Total for Question 8 = 1 mark)

9 Some rocks contain lead as a result of radioactive decay. In one such decay a fixed amount of polonium decays to a stable isotope of lead.

Which graph correctly shows the variation with time of the number of lead atoms, *N*, produced from the decay of polonium in the rock.



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

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 Current theories give a number of alternatives for the future evolution of our universe. According to current theory, an open universe

☒ **A** eventually reaches a maximum size.

☒ **B** expands forever.

☒ **C** has an unpredictable future.

☒ **D** is a steady state universe.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

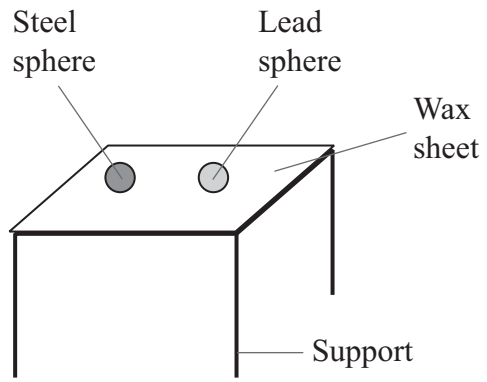
11 In 1965, two American scientists, Penzias and Wilson, were testing a very sensitive microwave detector. They discovered that the detector was picking up microwave "noise" at a frequency of 160 GHz that appeared to come from all directions equally. Upon investigation they found that the "noise" was the same day and night, throughout the year.

Suggest how this microwave "noise" may show evidence for an expanding universe.

(3)

(Total for Question 11 = 3 marks)

12 Two metal spheres of the same size are heated to a temperature of 100 °C in a water bath. One of the spheres is made of lead and the other of steel. The spheres are then placed onto a sheet of paraffin wax as shown. Paraffin wax melts at 55 °C.



	Mass / g	**Specific heat capacity /J kg^{-1} K^{-1}**
Lead sphere	50	130
Steel sphere	34	490

(a) The steel sphere melts through the wax sheet and drops to the floor. The temperature of the steel sphere when it reaches the floor is 53 °C.

Calculate the thermal energy lost by the steel sphere from the time when it was removed from the water bath.

(2)

.....

.....

.....

.....

Thermal energy lost = ...

(b) The lead sphere is only able to partially melt the wax, so does not drop to the floor.

Explain this observation.

(2)

.....

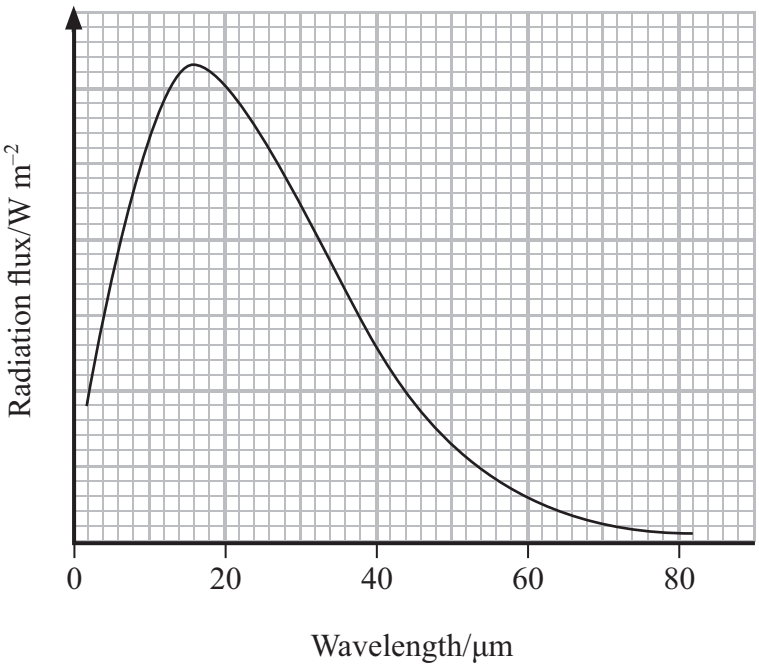
.....

.....

.....

(Total for Question 12 = 4 marks)

13 The radiation emitted from an asteroid is monitored and the following spectrum obtained.



(a) (i) State the wavelength at which the peak radiation flux from the asteroid occurs.

(1)

Wavelength of peak radiation flux = ...

(ii) Use the data to estimate the temperature of the asteroid.

(2)

.....

.....

.....

.....

Temperature of asteroid = ...

(b) The asteroid is in a circular orbit, of known radius, about the Sun. The average speed of the asteroid cannot be determined directly.

State the two extra data values that you would need in order to calculate the orbital period of the asteroid.

(2)

1 .....

2 .....

(c) This asteroid is about 1.5×10^{11} m from the planet Jupiter.

Calculate the magnitude of the gravitational field strength of Jupiter at this distance.

mass of Jupiter = 1.9×10^{27} kg

(2)

.....

.....

.....

.....

Gravitational field strength of Jupiter = ...

(Total for Question 13 = 7 marks)

14 A magazine article states that an inflated balloon contains about two hundred billion trillion (2×10^{23}) air molecules.

(a) Taking the balloon to be a sphere of volume 8.2×10^{-3} m^3 in a room at a temperature of 22 °C, show that this figure for the number of molecules is correct.

pressure of air in balloon = 1.1×10^5 Pa

(2)

.....

.....

.....

.....

*(b) The article also states that the internal energy of the air in the balloon could become zero if the temperature of the gas became low enough.

Explain what is meant by the internal energy of the air and discuss whether the statement is correct.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 14 = 6 marks)

15 (a) Astronomers determine the distance to a nearby star using trigonometric parallax.

Describe the measurements that must be taken to determine this distance.

You may use a diagram to aid your description.

(2)

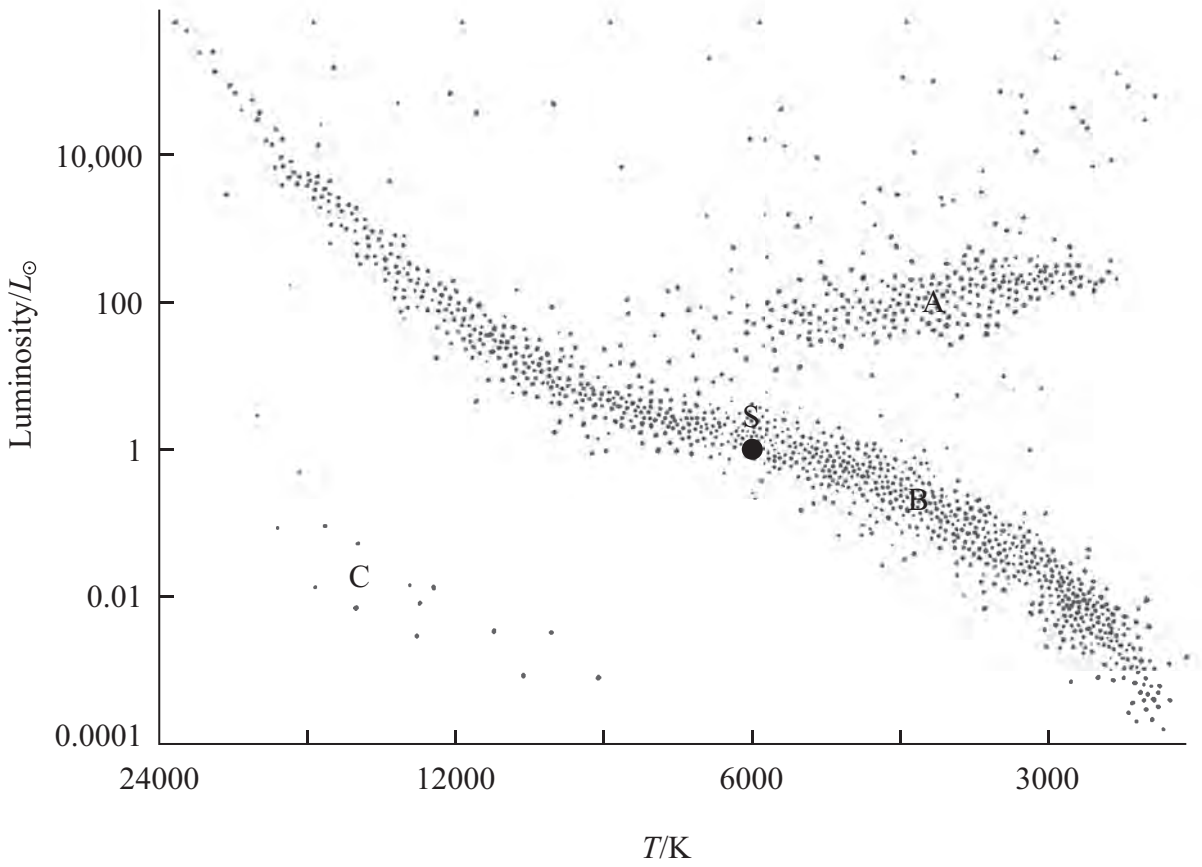
*(b) Radiation received at the Earth from a distant galaxy is redshifted. The distance to the galaxy can be determined from this redshift.

State what is meant by redshift, and explain how it allows the distance to the galaxy to be determined.

(4)

(Total for Question 15 = 6 marks)

16 (a) The position of our Sun, S is shown on the Hertzsprung-Russell (H-R) diagram below.



(i) Identify the three main regions of the H-R diagram.

(3)

Region A = ...

Region B = ...

Region C = ...

(ii) Add lines to the diagram to show the evolutionary path of our Sun from the time when it comes to the end of its hydrogen-burning phase.

(2)

(b) Most stars are too far away from the Earth for astronomers to observe them as anything more than a point source of radiation.

Explain how astronomers calculate the sizes of these stars using information from the H-R diagram.

(3)

(Total for Question 16 = 8 marks)

17 The photograph shows a nodding tiger toy. The tiger is placed on a car's dashboard and its head nods up and down as the car is driven along a rough road surface.

It is noticed that at a particular speed the tiger's head vibrates with maximum amplitude.

(a) (i) What is the name of this phenomenon?

(1)

.....

(ii) Describe the conditions necessary for this phenomenon to occur.

(2)

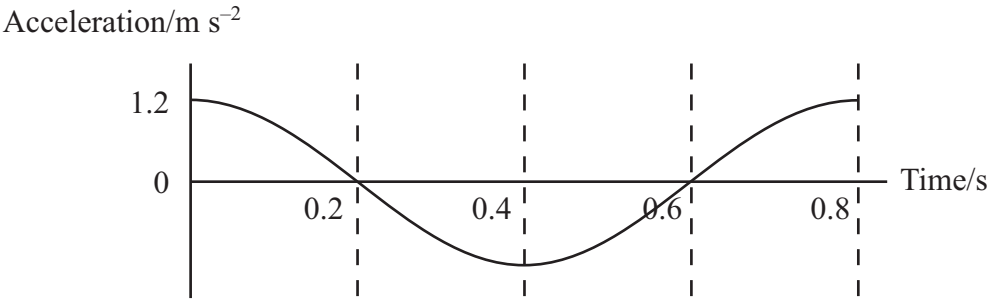
.....

.....

.....

(b) (i) The graph shows the variation of acceleration with time for the tiger's head. Using values from the graph calculate the amplitude of oscillation of the tiger's head.

(3)



Amplitude of oscillation = ...

(ii) Sketch a graph of the head's displacement against time over the same time interval on the axes below.

(2)

(Total for Question 17 = 8 marks)

18 In a demonstration to her class, a teacher pours popcorn kernels onto a hot surface and waits for them to pop. The kernels pop one by one. There is a large rate of popping at first and this rate decreases as time goes on. However, the order in which the kernels pop cannot be predicted.

*(a) How realistic is this demonstration as an analogy to radioactive decay? Consider aspects of the demonstration that are similar to radioactive decay and aspects that are different.

(4)

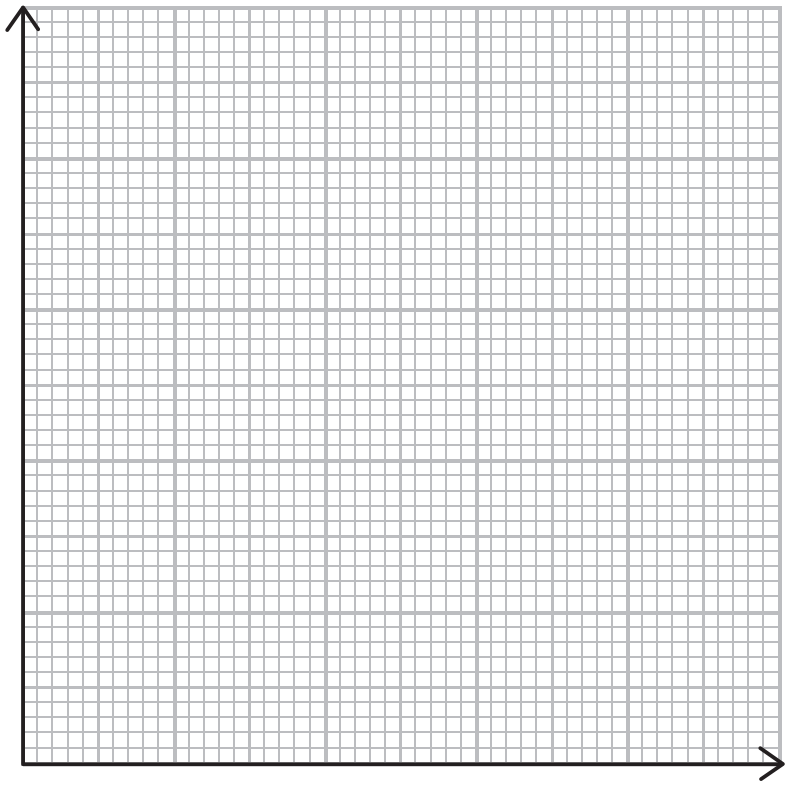
(b) In another demonstration, bags of popcorn are placed in a microwave oven for different lengths of time. Initially, each bag contains the same number of kernels. Once the bags are removed from the oven they are opened and the number of unpopped kernels counted. Assume that the popcorn obeys a similar rule to radioactive decay.

The results from the demonstration are shown in the table:

Time in oven / s	Number of unpopped kernels, N	ln (N)
0	100	4.61
30	78	4.36
60	61	4.11
90	47	3.85
120	37	3.61
150	29	3.37

(i) Use the data to draw a graph to show that the half-life of this process is about 80 s.

(6)



Half-life of popcorn = ...

(ii) A bag of popcorn is placed in the microwave oven until three quarters of the kernels have popped.

Determine the time for which the bag is in the oven.

(1)

Time = ...

(Total for Question 18 = 11 marks)

19 In 2010 The National Ignition Facility (NIF) in California began experiments to produce viable fusion. They used an extremely powerful laser to fuse hydrogen nuclei.

The following "recipe for a small star" was found on the NIF website:

- Take a hollow, spherical, plastic capsule about 2 mm in diameter.
- Fill it with 150 μg of a mixture of deuterium and tritium, the two heavy isotopes of hydrogen.
- Take a laser that for about 15 ns can generate 500×10^{12} W.
- Focus all this laser power onto the surface of the capsule.
- Wait at least 10 ns.

Result: one miniature star.

(a) Give one similarity and one difference between the nuclei of deuterium and tritium.

(2)

Similarity .....

Difference .....

(b) Show that the energy supplied by the laser in a time period of 15 ns is about 8 MJ.

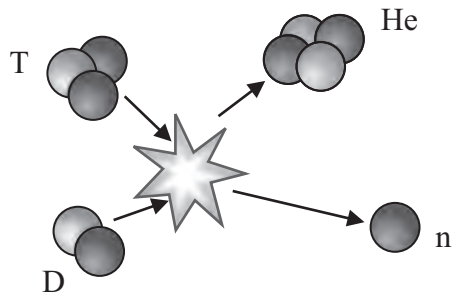
(2)

.....

.....

.....

(c) The diagram represents the fusion of deuterium, D, and tritium, T, to form helium, He.



(i) Complete the nuclear equation to represent the fusion of deuterium and tritium to form helium.

(2)

$$\text{\_\_}\,D + \text{\_\_}\,T \rightarrow \text{\_\_}\,He + \text{\_\_}\,n$$

(ii) Use the data in the following table to show that about 20 MeV of energy is released when this fusion reaction takes place.

	Mass / MeV/c^2
Neutron	939.6
Deuterium	1875.6
Tritium	2808.9
Helium	3727.4

(2)

(iii) Estimate the number of fusions that need to take place in 15 ns if the "miniature star" is to produce the same amount of energy as the laser supplies.

(2)

Number of fusions = ...

(iv) Calculate the kinetic energy, in MeV, of the neutron released by the fusion of deuterium and tritium nuclei. Assume that the net momentum of the nuclei before fusion is zero.

(4)

Neutron kinetic energy = ... MeV

(d) Nuclear power stations currently use the process of fission to release energy. Outline the process of fission.

(3)

.....

.....

.....

.....

.....

(Total for Question 19 = 17 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Wednesday 23 January 2013 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH05/01

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41630A

1/1/1/1/1/

P 4 1 6 3 0 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 The ionising properties of radiations determine their penetrating power.

Which of the following statements is correct?

☒ **A** α-particles are not very ionising so they are stopped by thin paper.

☒ **B** α-particles are very ionising so can only travel a few centimetres in air.

☒ **C** γ-radiation is very penetrating because it is very ionising.

☒ **D** γ-radiation is not very penetrating because it is very ionising.

(Total for Question 1 = 1 mark)

2 A small satellite has a weight of 1200 N at the Earth's surface. It is launched into a circular orbit with radius equal to twice the radius of the Earth. The weight of the satellite in this orbit is

☒ **A** 0 N

☒ **B** 300 N

☒ **C** 600 N

☒ **D** 1200 N

(Total for Question 2 = 1 mark)

3 A number of conditions must be met if the fusion of hydrogen nuclei is to occur. Which condition, in a sample of hydrogen, is **not** necessary for nuclear fusion to occur?

☒ **A** very high density

☒ **B** very high mass

☒ **C** very high pressure

☒ **D** very high temperature

(Total for Question 3 = 1 mark)

4 New buildings in earthquake zones are often designed to be earthquake resistant. Such buildings incorporate mechanisms to reduce the transfer of kinetic energy from the ground to the building.

Which of the following would be the most important property of a material used in such a mechanism?

☒ **A** density

☒ **B** ductility

☒ **C** stiffness

☒ **D** strength

(Total for Question 4 = 1 mark)

5 The molecules in a material may possess kinetic energy E_k and potential energy E_p.

The internal energy is equal to

☒ **A** ΣE_k

☒ **B** $\Sigma E_k - \Sigma E_p$

☒ **C** $\Sigma E_k + \Sigma E_p$

☒ **D** ΣE_p

(Total for Question 5 = 1 mark)

6 Radioactive decay is sometimes described as being spontaneous. In this context spontaneous means

☒ **A** nothing can influence the decay.

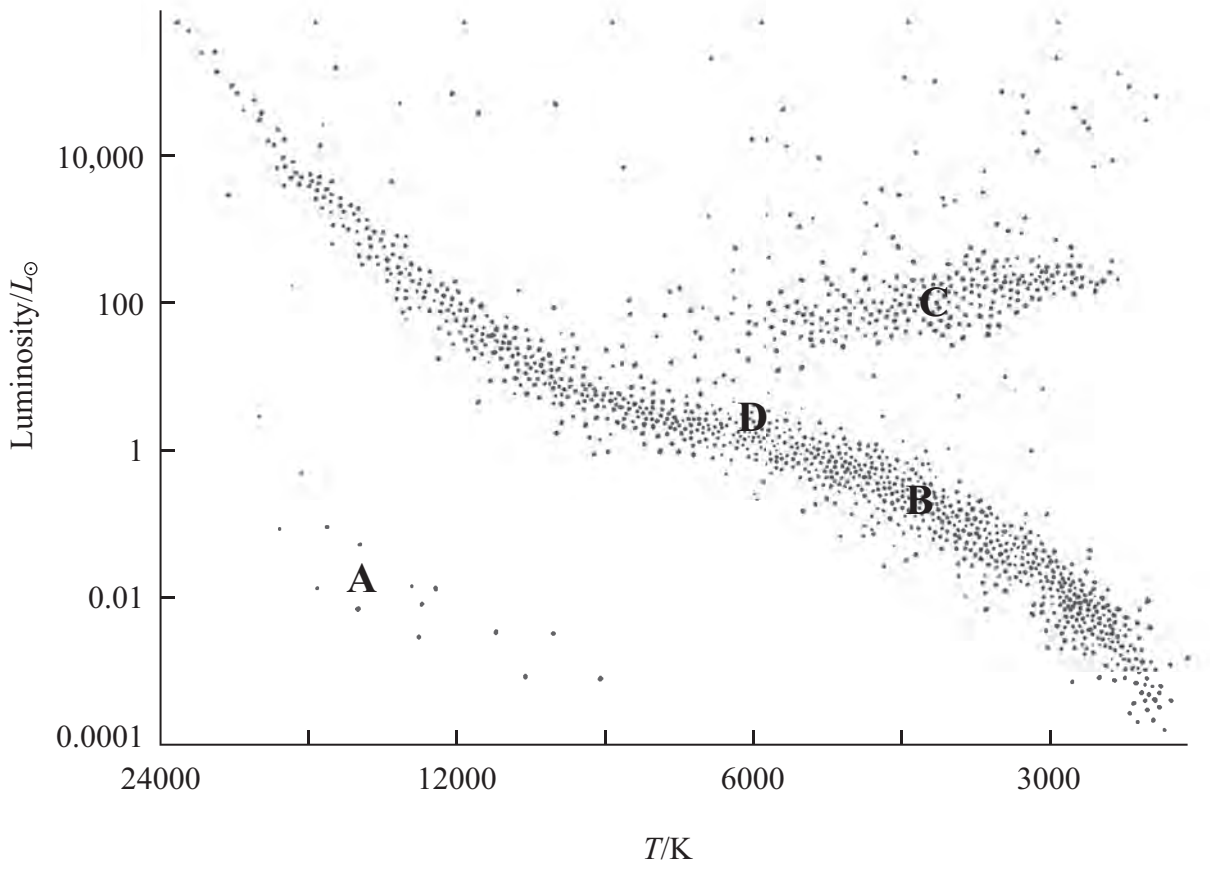
☒ **B** the decay is random.

☒ **C** the decay can be predicted.

☒ **D** the decay is exponential.

(Total for Question 6 = 1 mark)

Questions 7 and 8 refer to the Hertzsprung-Russell diagram below.



7 Which letter A, B, C or D represents the region on the diagram where a white dwarf star would be shown?

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

(Total for Question 7 = 1 mark)

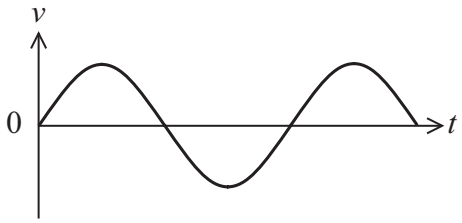
8 Which letter A, B, C or D represents the region on the diagram where our Sun would be shown?

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

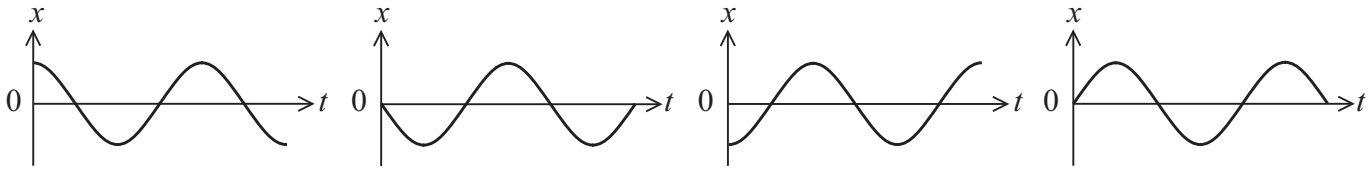
(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the diagram below.

The graph below shows how the velocity varies with time for an object undergoing simple harmonic motion.



9 Which graph shows the variation of displacement with time?



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

☒ **A**

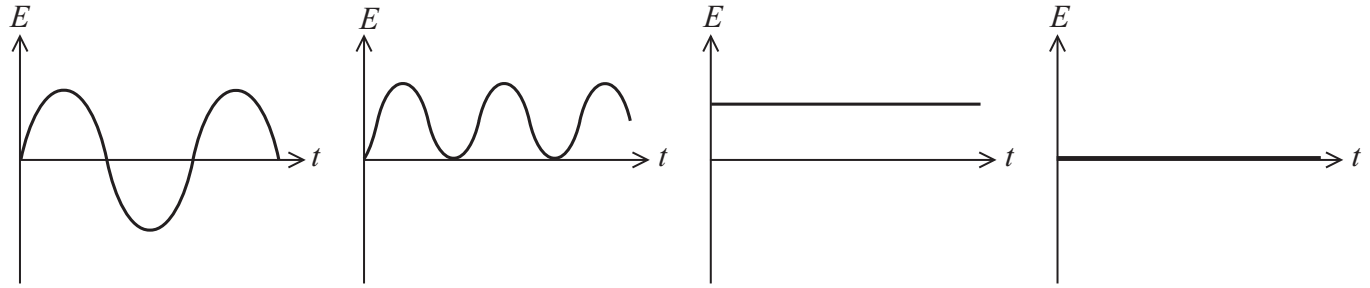
☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 Which graph shows the variation of total energy with time?



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

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A student carries out an experiment to investigate how the volume occupied by a gas depends upon the temperature.

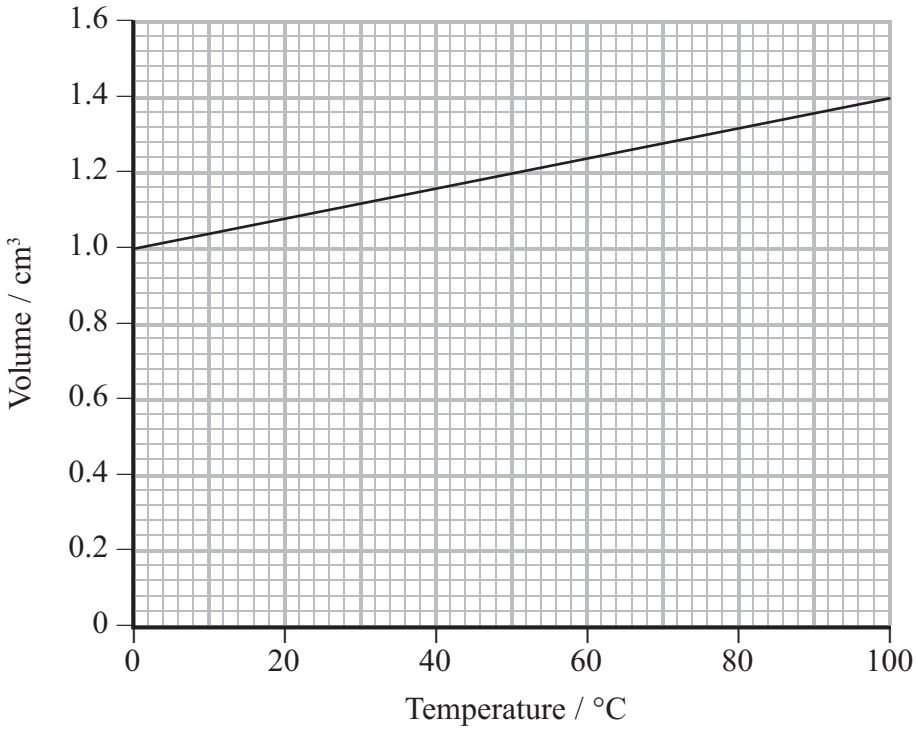
(a) What variables must the student control in this investigation?

(2)

.....

.....

(b) The following graph is obtained.



Explain how graphs such as this provide evidence for an absolute zero of temperature.

(2)

.....

.....

.....

.....

.....

(Total for Question 11 = 4 marks)

12 All living organisms contain ^{12}C and radioactive ^{14}C. The concentration of ^{14}C in the organism is maintained whilst the organism is alive, but starts to fall once death has occurred.

(a) The count rate obtained from wood from an old Viking ship is 14.7 min^{-1} per gram of wood, after being corrected for background radiation. The corrected count rate from similar living wood is 16.5 min^{-1} per gram of wood.

Calculate the age of the ship in years.

^{14}C has a half life of 5700 years.

(4)

Age of ship = ... years

(b) The concentration of ^{14}C in living organisms might have been greater in the past.

Explain how this would affect the age that you have calculated.

(2)

(Total for Question 12 = 6 marks)

13 Betelgeuse is our nearest red giant. It has a luminosity of 4.49×10^{31} W and emits radiation with a peak energy emission occurring at a wavelength of 850 nm.

Show that Betelgeuse has a surface temperature of about 3000 K. Hence calculate the ratio of the radius of Betelgeuse, r_B to the radius of the Sun, r_S.

$$r_S = 6.95 \times 10^8 \text{ m}$$

(5)

$r_B/r_S =$ .....

(Total for Question 13 = 5 marks)

***14** Cepheid variable stars have long been seen as examples of standard candles. Recent measurements have indicated that the movement of the star through interstellar material might result in the formation of a layer of dust around the star. This affects how bright the star appears.

Explain how standard candles are used in astronomy, and suggest how the existence of a layer of dust around a Cepheid variable star might affect the conclusions drawn by astronomers.

(6)

(Total for Question 14 = 6 marks)

15 A garden ornament consists of a plastic dragonfly mounted on a stick. The dragonfly's wings are attached to the body with springs, and they flutter up and down in a gentle breeze.

(a) When the air is not moving and the wings are displaced through a small vertical distance, they oscillate. The time for 10 oscillations is recorded. This is repeated twice more.

Time / s		
t_1	t_2	t_3
6.2	6.6	6.9

(i) Calculate the frequency of oscillation of the wings.

(3)

Frequency = ...

(ii) The oscillation of the wings is thought to be simple harmonic motion.

State the conditions required for the oscillations to be simple harmonic.

(2)

(b) The amplitude of the wings' oscillation dies down after only a small number of oscillations.

Explain why this happens.

(2)

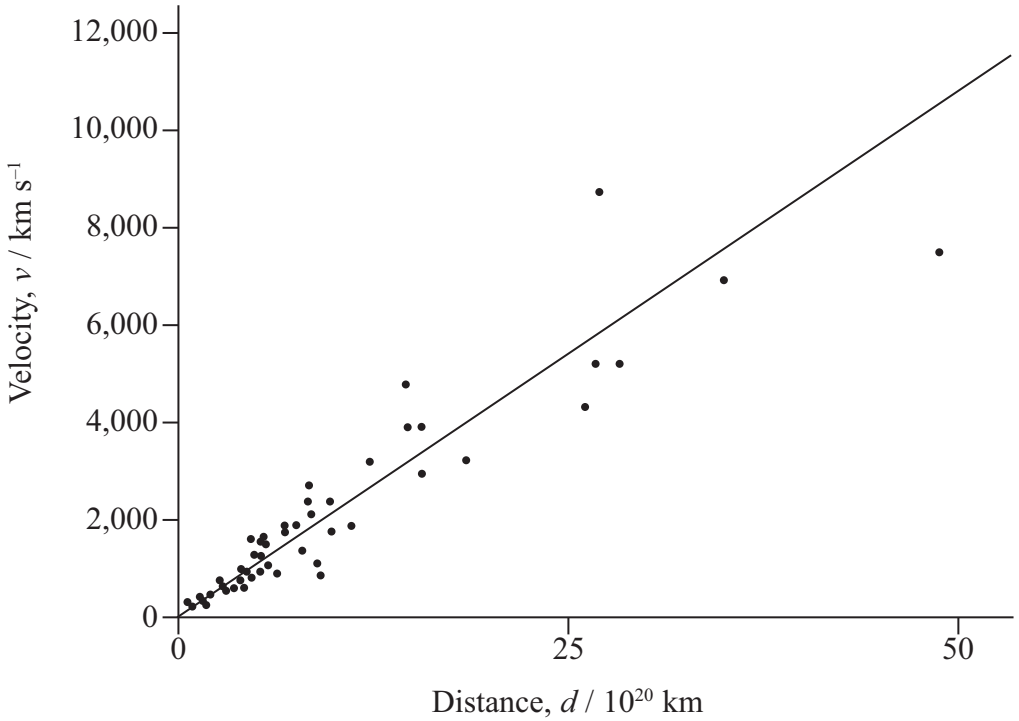
(c) In certain breezy conditions the wings are seen to oscillate with a very large amplitude.

Name this effect and state the condition for it to occur.

(2)

(Total for Question 15 = 9 marks)

16 The graph shows how the velocity varies with distance for a number of distant galaxies. All the galaxies are receding from Earth, and there appears to be a linear relationship between the velocity of recession and the distance to the galaxy.



(a) Use the graph to estimate an age for the Universe.

(4)

Age of the Universe = ...

*(b) Describe how astronomers would have determined the velocity of each galaxy.

(5)

*(c) Scientists are uncertain about the ultimate fate of the Universe.

Explain why.

(3)

(Total for Question 16 = 12 marks)

17 Communications satellites were first proposed in 1945 by the science fiction author Arthur C. Clarke. In an article published in the magazine Wireless World he asked whether rocket stations could give worldwide radio coverage.

In the article Clarke states:

"There are an infinite number of possible stable orbits, circular and elliptical, in which a rocket would remain if the initial conditions were correct. A velocity of 8 km s^{-1} applies only to the closest possible orbit, one just outside the atmosphere, and the period of revolution would be about 90 minutes. As the radius of the orbit increases the velocity decreases, since gravity is diminishing and less centrifugal force is needed to balance it."

(a) State what is meant in the article by the phrase "gravity is diminishing", and criticise the statement that "less centrifugal force is needed to balance (the satellite)".

(3)

(b) (i) By deriving an appropriate equation, show that the orbital speed of the satellite decreases as the radius of orbit increases.

(3)

(ii) By deriving an appropriate equation, show that the orbital period of a satellite increases as the orbital speed decreases.

(2)

(c) The period T of a satellite in a circular orbit is given by the equation

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

where r is the radius of orbit and M is the mass of the Earth.

Calculate the period of a satellite in an orbit 4.0×10^5 m above the surface of the Earth.

mass of the Earth = 5.98×10^{24} kg

radius of the Earth = 6.36×10^6 m

(2)

Period of satellite = ...

(d) After a time the radius of the satellite's orbit will start to decrease due to the resistive forces acting on the satellite from the atmosphere. As this happens the satellite speeds up.

Describe the energy changes occurring as the radius of the orbit decreases.

(2)

.....

.....

.....

.....

.....

.....

.....

(Total for Question 17 = 12 marks)

18 Electrical power generated by nuclear fission makes an important contribution to world energy needs. However Rutherford, who is credited with the discovery and first splitting of the nuclear atom, later said:

"The energy produced by the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine."

Rutherford carried out experiments that involved firing alpha particles at nitrogen atoms.

(a) (i) Complete the equation for the interaction between nitrogen and alpha particles.

(1)

$$^{14}_{7}\mathrm{N} + {}^{4}_{2}\alpha \rightarrow \ldots\ldots\mathrm{O} + \ldots\ldots{}^{1}\mathrm{p}$$

(ii) This interaction requires a small energy input. Other similar nuclear reactions may give an energy output of no more than 20 MeV, giving some justification to Rutherford's statement. Suggest why Rutherford's statement eventually turned out to be very inaccurate.

(1)

.....

.....

.....

(b) Uranium-235 is able to undergo fission when it absorbs a neutron to become uranium-236. The equation below shows a possible fission reaction.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3 \times {}^{1}_{0}\mathrm{n}$$

Use the data in the table to show that the energy released by the fission of one uranium nucleus is about 170 MeV.

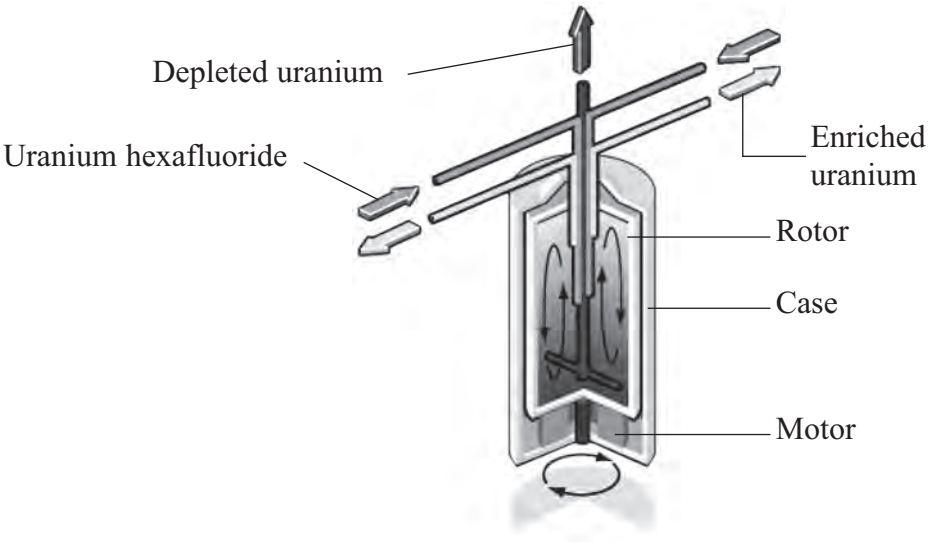
Isotope	Mass / 10^{-27} kg
^{235}U	390.29989
^{141}Ba	233.99404
^{92}Kr	152.64708
^{1}n	1.67493

(4)

(c) Naturally occurring uranium is more than 99% uranium-238. Fuel for a fission reactor requires at least 3% of the uranium to be uranium-235.

Uranium hexafluoride gas is used during the uranium enrichment process. It is fed into a centrifuge, and a rotating cylinder (rotor) sends the uranium-238 to the outside of the cylinder, where it can be drawn off, while the uranium-235 diffuses to the centre of the cylinder.

Gas centrifuge



(i) Give **one** similarity and **one** difference between the nuclei of uranium-238 and uranium-235.

(2)

Similarity .....

Difference .....

(ii) The rotor has a diameter of 30 cm and spins at a rate of 60,000 revolutions per minute.

Calculate the centripetal acceleration at the rim of the rotor.

(2)

Centripetal acceleration = ...

(iii) The rotor is subjected to huge forces because of the high spin rate.

Give **two** mechanical properties essential for the material from which the rotor is made.

(2)

Property 1 .....

Property 2 .....

(d) The waste heat from some power stations is transferred to water.

The San Onofre Nuclear Generating Station in California has reactors with a total output power of 2200 MW. These reactors circulate sea water at an average mass flow rate of 7.0×10^4 kg s^{-1}. The water is heated to approximately 11 K above the input temperature as it flows through condensers, before being discharged back into the ocean.

Show that the rate at which energy is removed from the reactors is about 3000 MW, and hence estimate a value for the efficiency of the electrical power generation process.

specific heat capacity of the sea water = 3990 J kg^{-1} K^{-1}

(4)

Efficiency = ...

(Total for Question 18 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Thursday 20 June 2013 – Morning **Time: 1 hour 35 minutes**	Paper Reference **6PH05/01**

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41636A

1/1/1/1/1/1/

P 4 1 6 3 6 A 0 1 2 8

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 mass is bouncing on the end of a vertical spring. Its motion will be simple harmonic if the spring

☒ **A** can store energy.

☒ **B** has elasticity.

☒ **C** is hung vertically.

☒ **D** obeys Hooke's law.

(Total for Question 1 = 1 mark)

2 When energy is supplied to a substance, changes in the average molecular kinetic energy (E_k) and the average molecular potential energy (E_p) can occur.

When energy is supplied to an ideal gas

☒ **A** both E_k and E_p increase.

☒ **B** E_k may increase.

☒ **C** E_p may increase.

☒ **D** E_k increases but E_p decreases.

(Total for Question 2 = 1 mark)

3 The force between two masses and the force between two charges can be modelled in a similar way, using gravitational and electric fields. A difference between these models is that

☒ **A** an electric field is always a radial field.

☒ **B** an electric field is always the stronger field.

☒ **C** a gravitational field cannot be shielded.

☒ **D** a gravitational field extends over an infinite range.

(Total for Question 3 = 1 mark)

4 α-Centauri is one of the nearest stars to our Sun. The surface temperatures of these two stars are about the same. α-Centauri has a 20% greater diameter than the Sun.

The ratio of the luminosity of α-Centauri to the luminosity of the Sun is about

☒ **A** 1.2

☒ **B** 1.4

☒ **C** 1.7

☒ **D** 2.1

(Total for Question 4 = 1 mark)

5 Scientists cannot be sure what their current models predict for the ultimate fate of the universe because

☒ **A** of the matter-antimatter asymmetry.

☒ **B** the average density of the universe is uncertain.

☒ **C** the Big Bang is just a theory.

☒ **D** the nature of dark matter is unknown.

(Total for Question 5 = 1 mark)

6 When measuring the count rate from a radioactive source it is usual to also measure the background count rate.

The background count rate must be

☒ **A** as large as possible for an accurate experiment.

☒ **B** measured when the source is in place.

☒ **C** recorded for the same time as the count rate.

☒ **D** subtracted from the count rate measured from the source.

(Total for Question 6 = 1 mark)

7 Air is a mixture of mostly nitrogen and oxygen molecules. The mass of an oxygen molecule is slightly greater than the mass of a nitrogen molecule.

On average, in a sample of air at a given temperature

☒ **A** the nitrogen and oxygen molecules have the same speed.

☒ **B** the nitrogen molecules are travelling more slowly than the oxygen molecules.

☒ **C** the oxygen molecules are travelling more slowly than the nitrogen molecules.

☒ **D** the molecules have relative speeds that depend upon the amount of each gas present.

(Total for Question 7 = 1 mark)

8 A lamp consists of a filament in a vacuum. Under normal working conditions the filament has a temperature of 1600 K. A similar filament lamp that is gas-filled has a filament temperature of 3200 K.

The ratio of the wavelength at which maximum intensity of radiation is emitted by the vacuum lamp to that for the gas-filled lamp is

☒ **A** 1:2

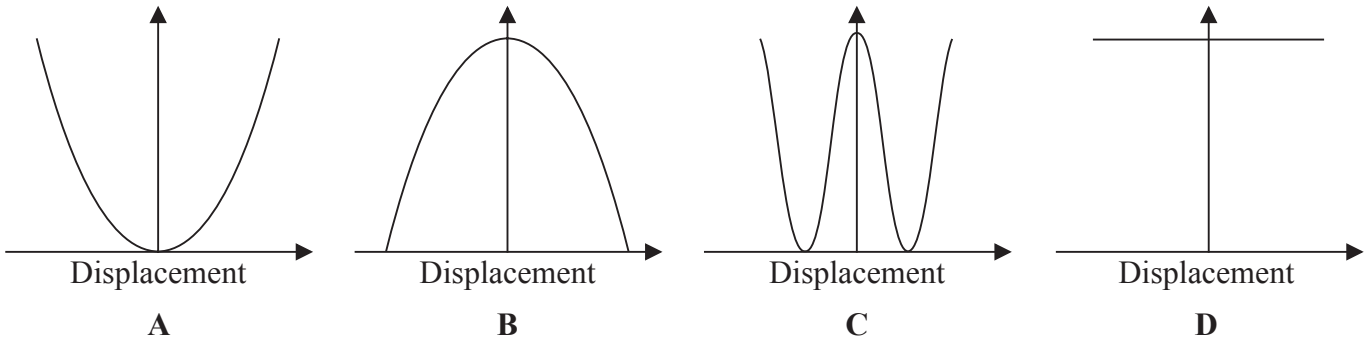
☒ **B** 1:1

☒ **C** 2:1

☒ **D** 16:1

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the graphs below.



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

9 For an object undergoing simple harmonic motion select the graph that represents the variation of kinetic energy with displacement.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 For an object undergoing simple harmonic motion select the graph that represents the variation of the total energy with displacement.

☒ **A**

☒ **B**

☒ **C**

☒ **D**

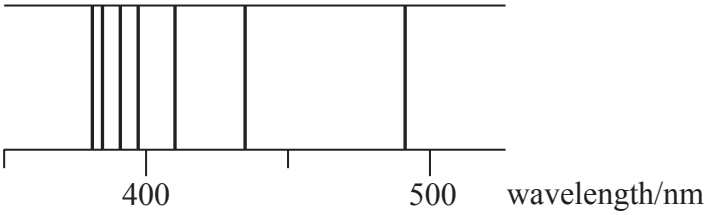
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

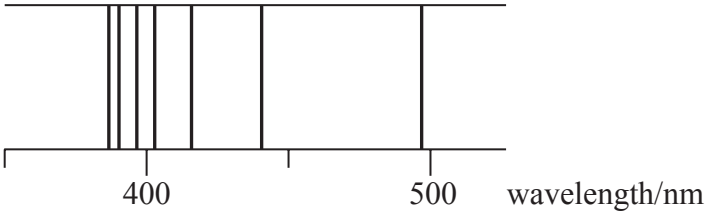
SECTION B

Answer ALL questions in the spaces provided.

11 The diagram shows part of the hydrogen line spectra obtained for radiation emitted from hydrogen in the laboratory and received from hydrogen in a distant galaxy.



Laboratory Spectrum



Distant Galaxy Spectrum

The lines in the distant galaxy spectrum are all shifted in wavelength compared to the lines in the laboratory spectrum.

State why the lines are shifted and what we can conclude about this distant galaxy.

(2)

.....

.....

.....

.....

(Total for Question 11 = 2 marks)

12 The heating element of an electric shower has a power of 6.0 kW.

(a) The shower is operated from a 230 V mains supply.

Calculate the resistance of the heating element.

(2)

Resistance = ...

(b) Water enters the shower at a temperature of 7.5 °C.

Calculate the water flow rate required to give an output temperature of 37.5 °C.

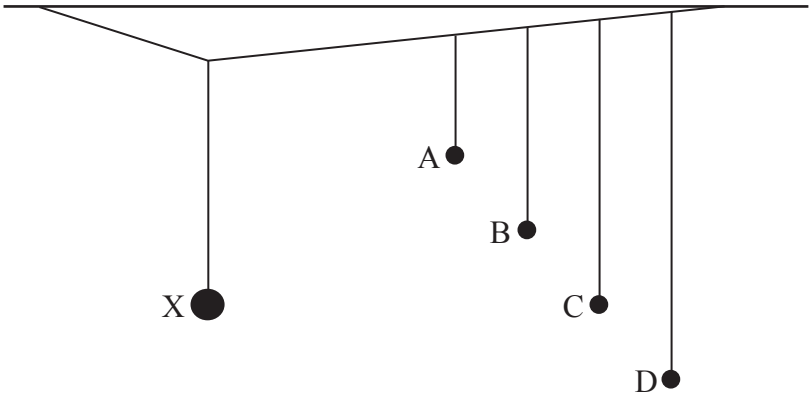
specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(3)

Flow rate = ...

(Total for Question 12 = 5 marks)

13 The diagram shows a number of pendulums hanging from a single thread. Pendulum X has a heavy lead sphere as the bob and the others have low mass bobs. When X is set into motion energy is transferred to the others which all begin to oscillate.

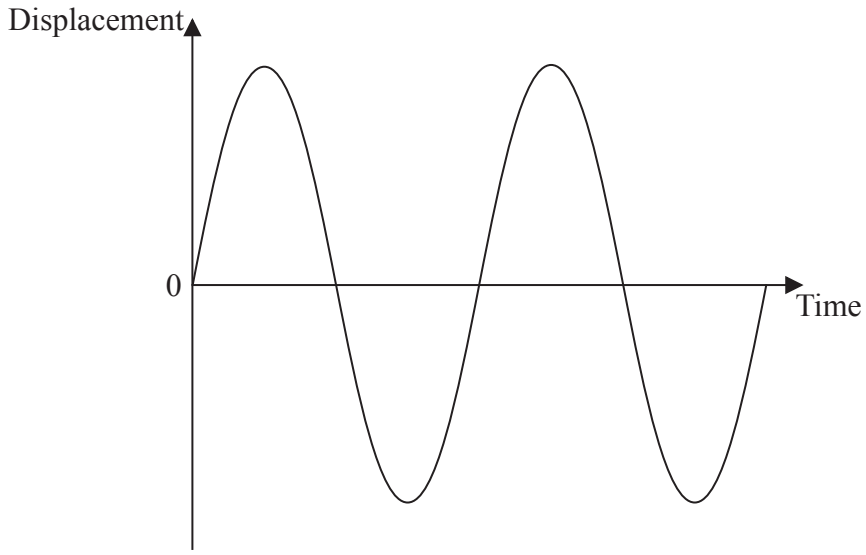


After a short time C is observed to have the largest amplitude of oscillation.

(a) Explain why pendulum C has the largest amplitude of oscillation.

(3)

(b) For an efficient energy transfer pendulum C must be at rest when pendulum X has its maximum kinetic energy. The graph below shows how the displacement of pendulum X varies with time.



Mark a point P on this graph showing an instant when pendulum X has a maximum kinetic energy, and add a curve to show how the displacement of pendulum C varies over the same time interval.

(2)

(Total for Question 13 = 5 marks)

***14** Parallax measurements are used to determine the distance to nearby stars, but this method is unsuitable for more distant objects.

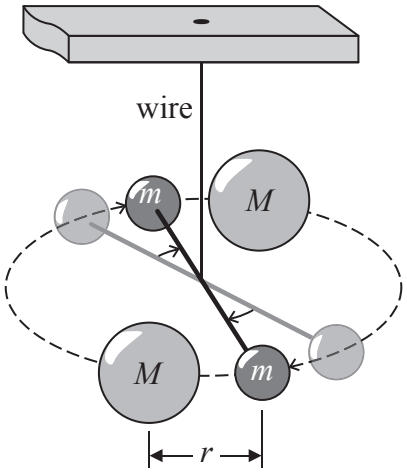
Outline how parallax measurements are used to determine the distance to nearby stars and explain how the use of a standard candle enables the distance to more distant objects to be determined.

(6)

(Total for Question 14 = 6 marks)

15 In the 18th century Henry Cavendish devised an experiment to determine the average density of the Earth. This involved the first laboratory determination of the universal gravitational constant G.

A light horizontal rod with a small metal sphere at each end was hung from a fixed point by a very thin wire. Two large lead spheres were then brought close to the small spheres causing the rod to oscillate and then settle into a new position of equilibrium.



(a) In a modern version of the experiment the following data was obtained:

mass of large lead sphere $M = 160$ kg

mass of small sphere $m = 0.75$ kg

distance $r = 0.23$ m

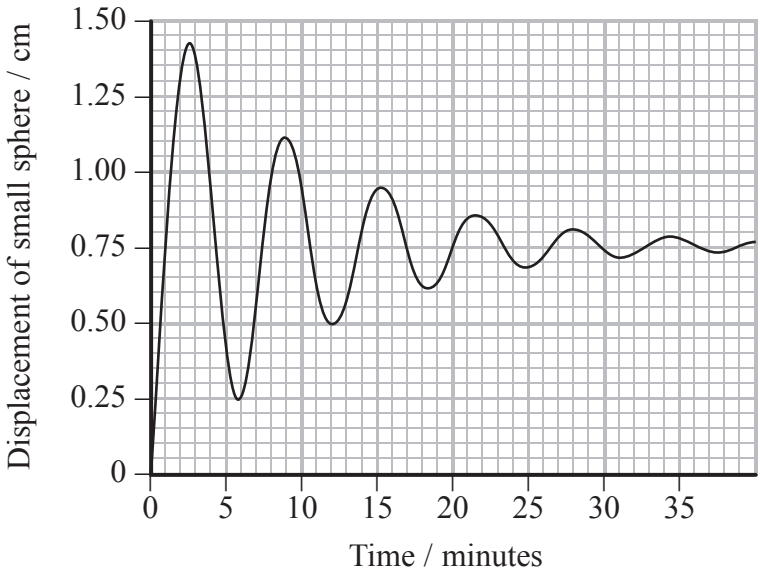
gravitational force between adjacent large and small spheres $F = 1.5 \times 10^{-7}$ N.

Use this data to calculate a value for G.

(2)

$G =$ ..... $Nm^2 kg^{-2}$

(b) The graph shows how the displacement of one of the small spheres varies with time.



(i) Use the graph to determine the period of oscillation of the sphere.

(2)

Period = ...

(ii) The amplitude of the oscillation decreases with each cycle.

Explain why this effect is observed.

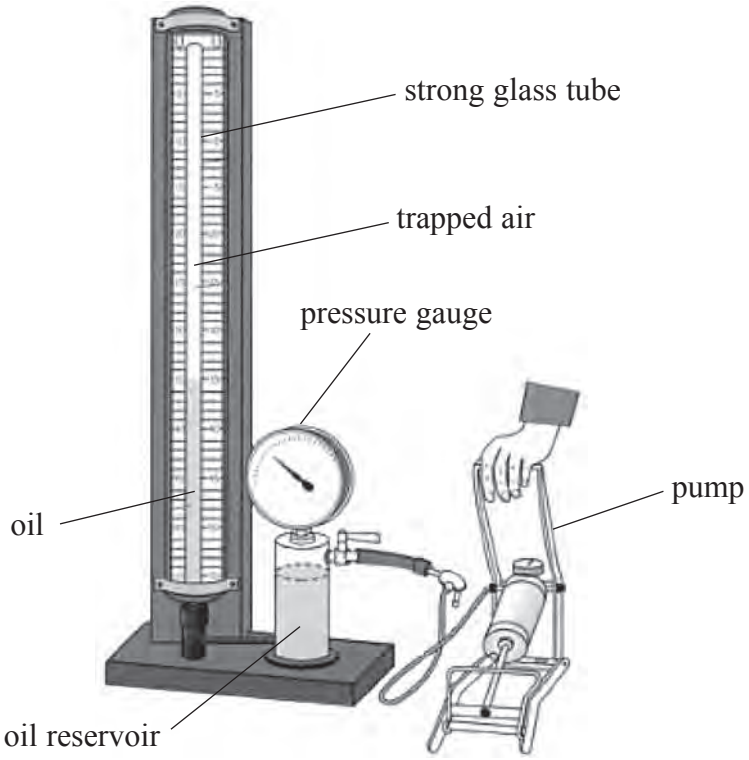
(2)

(iii) It is suggested that the decrease in amplitude is exponential. Use the graph to determine if this is approximately true.

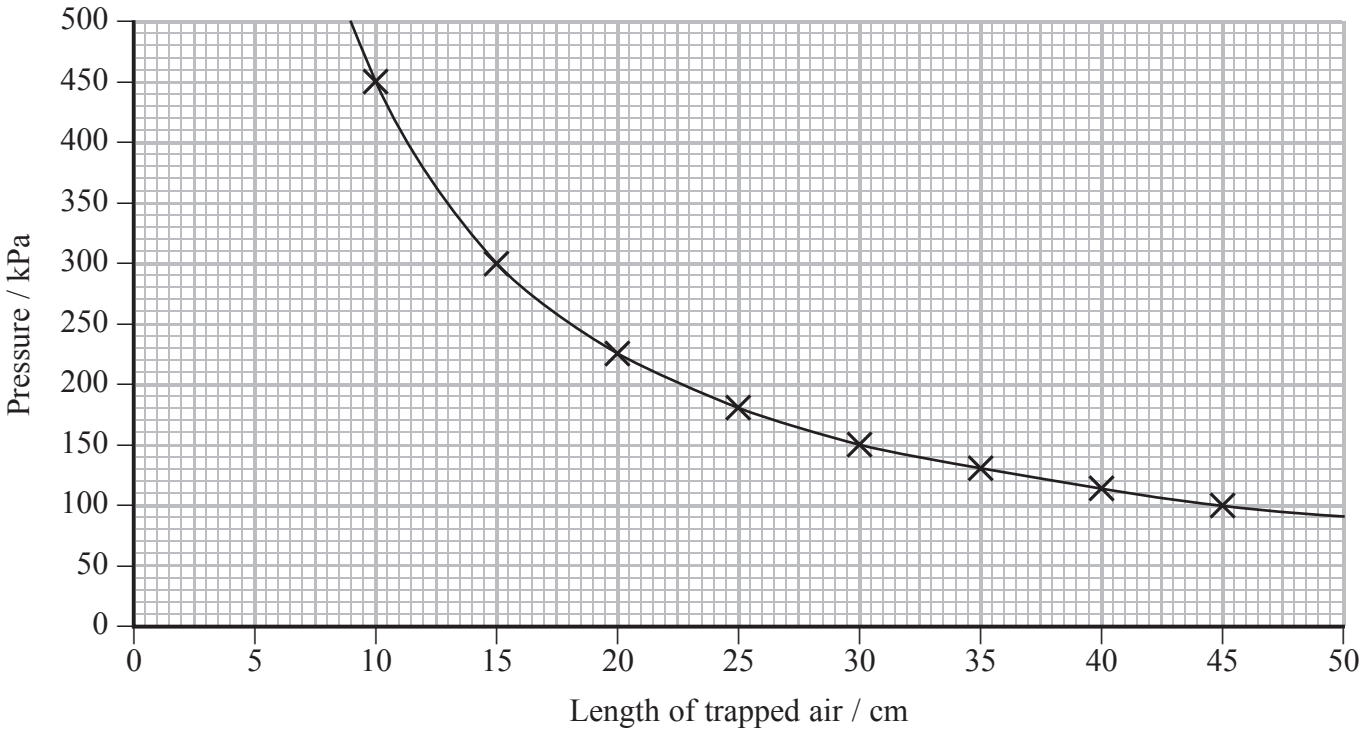
(3)

(Total for Question 15 = 9 marks)

16 A student uses the apparatus shown to investigate the relationship between pressure and volume of a gas.



Air is trapped in a glass tube of uniform cross-sectional area. As the pressure of the trapped air is increased, the length of trapped air decreases. The student collects data and plots the following graph.



(a) State the variables that should be controlled in this investigation.

(2)

(b) Theory suggests that, for the air trapped in the tube, the pressure p is inversely proportional to the volume V.

Use the graph to show that this relationship is correct. State an assumption that you are making.

(4)

(c) On the day that the investigation was carried out, the temperature in the laboratory was 20 °C.

Calculate the number of air molecules trapped in the tube.

cross-sectional area of tube = 7.5×10^{-5} m^2

(3)

Number of air molecules = ...

(d) State how the graph would change if

(i) the air molecules in the tube were replaced by the same number of molecules of hydrogen gas.

(1)

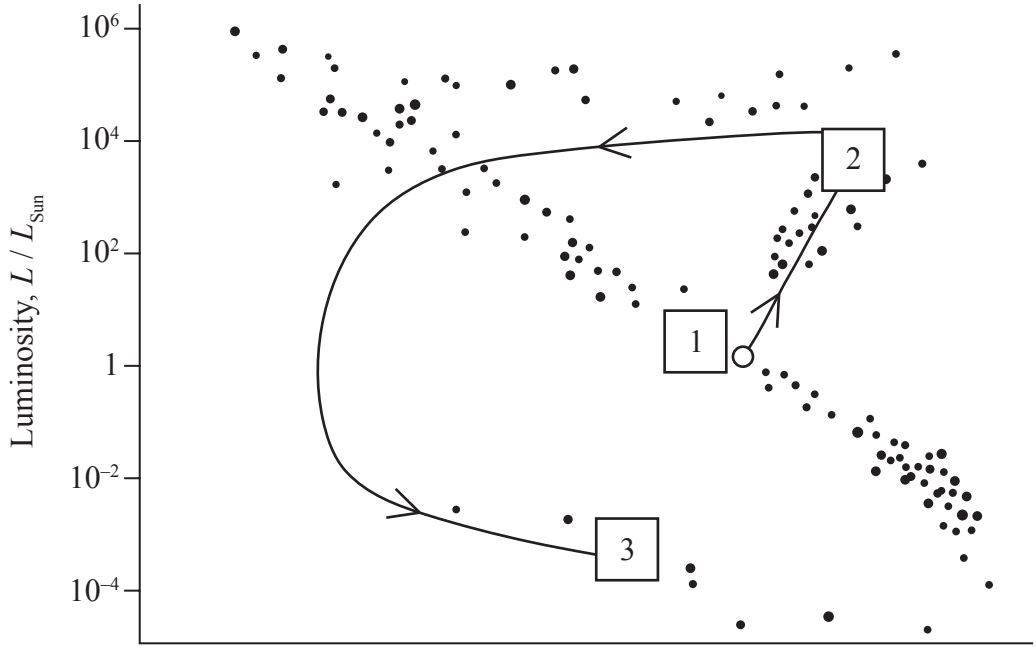
(ii) the temperature of the laboratory was substantially higher.

(2)

(Total for Question 16 = 12 marks)

17 The Sun has a surface temperature of 5800 K and is approximately 4.5 billion years old.

The Hertzsprung-Russell diagram maps the future evolution of the Sun, from its current position in area 1 of the diagram, through to its final position in area 3 of the diagram.



(a) (i) Complete a suitable temperature scale on the x-axis.

(2)

*(ii) Use the diagram to describe the lifecycle of the Sun starting from its present position in area 1 and concluding in area 3.

(6)

(b) The energy source for the Sun is the fusion of light nuclei to heavy nuclei. In its present stage of evolution hydrogen is being converted into helium in the core of the Sun.

(i) State and explain the conditions necessary for fusion to occur in a star.

(3)

(ii) In a star the fusion of hydrogen into helium takes place in a number of stages. The final stage is:

$$^{3}_{2}\text{He} + {}^{3}_{2}\text{He} \rightarrow {}^{4}_{2}\text{He} + 2 \times {}^{1}_{1}\text{H}$$

Calculate the energy released in MeV when one nucleus of the normal isotope of helium is produced.

(4)

Isotope	Mass / 10^{-27} kg
^{3}He	5.008238
^{4}He	6.646483
^{1}H	1.673534

Energy released = ... MeV

(Total for Question 17 = 15 marks)

18 On 1st November 2006, the former Russian spy Alexander Litvinenko fell ill. Twenty one days later he died from the radiation effects of polonium-210. Experts suggest that as little as 0.89 μg of polonium-210 would be enough to kill, although Mr Litvinenko's death was linked to a much larger dose of the radioactive isotope. Traces of the isotope were later found in washrooms at five locations around London visited by the Russian.

Polonium-210 has a half life of 138 days.

(a) (i) In a 0.89 μg sample of polonium-210 there are 2.54×10^{15} atoms of polonium. Show that the decay constant for polonium-210 is about 6×10^{-8} s^{-1}, and hence calculate the activity of a sample of this size.

(4)

Activity = ...

(ii) Calculate the fraction of polonium-210 nuclei that have decayed after a time of 21 days.

(3)

Fraction decayed = ...

(b) Polonium-210 emits alpha particles. Explain why polonium-210 is virtually harmless unless it is taken into the body.

(2)

(c) (i) Complete the equation below for the decay of polonium.

(2)

$$^{210}_{84}\text{Po} \rightarrow \text{.....Pb} + \text{.....}\alpha$$

(ii) State why the Pb nuclei would recoil from the alpha particles emitted during the decay.

(1)

(d) Radioactive decay is said to occur spontaneously and randomly. Explain what is meant by spontaneous and random in this context.

(2)

Spontaneous .....

Random .....

(e) Suggest why traces of the isotope were found in locations visited by the Russian.

(2)

(Total for Question 18 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 5: Physics from Creation to Collapse

Thursday 20 June 2013 – Morning **Time: 1 hour 35 minutes**	Paper Reference **6PH05/01R**

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P43324A

1/1/1/1/C2

P 4 3 3 2 4 A 0 1 2 4

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, 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 At night the Earth's surface cools down as energy is radiated away into space.

Most of the energy is radiated away as

☒ **A** infrared radiation.

☒ **B** microwaves.

☒ **C** ultraviolet radiation.

☒ **D** visible light.

(Total for Question 1 = 1 mark)

2 In a famous thought experiment, Schrödinger imagined that a cat is locked in a box, along with a radioactive atom that is connected to a tube containing a deadly poison. If the atom decays, it causes the tube to smash and the cat to die.

The random nature of radioactive decay means that the radioactive atom will

☒ **A** decay after one half-life.

☒ **B** probably decay after one half-life.

☒ **C** have a fixed probability of decaying in a given time interval.

☒ **D** have a number of possible decay paths.

(Total for Question 2 = 1 mark)

3 Mars has twice the mass of Mercury and is 4 times further away from the Sun.

The ratio of the gravitational force from the Sun on Mercury to the gravitational force from the Sun on Mars is

☒ **A** 0.5

☒ **B** 2.0

☒ **C** 8.0

☒ **D** 32

(Total for Question 3 = 1 mark)

4 A star is estimated to have approximately the same surface temperature as the Sun, but less than 1% of the Sun's luminosity.

The star is best classified as a

☒ **A** main sequence star.

☒ **B** red dwarf star.

☒ **C** red giant star.

☒ **D** white dwarf star.

(Total for Question 4 = 1 mark)

5 A radioactive source is placed a few cm away from a detector. There is no change in the count rate when a thin aluminium foil is placed between the source and the detector, but the count rate is reduced to the background rate when a 0.5 cm aluminium plate is introduced.

These observations show that the source must be emitting

☒ **A** alpha and beta radiation.

☒ **B** beta and gamma radiation.

☒ **C** beta radiation only.

☒ **D** gamma radiation only.

(Total for Question 5 = 1 mark)

6 Fission and fusion are both nuclear processes.

Which of the following statements is correct for both processes?

☒ **A** Neutrons are released.

☒ **B** No harmful radiation is produced.

☒ **C** The binding energy per nucleon increases.

☒ **D** The total mass increases.

(Total for Question 6 = 1 mark)

7 An object is hung from a vertical spring and undergoes undamped simple harmonic motion.

It is correct to say that there are **no** changes in the

☒ **A** elastic potential energy of the oscillating system.

☒ **B** gravitational potential energy of the oscillating system.

☒ **C** kinetic energy of the oscillating system.

☒ **D** total energy of the oscillating system.

(Total for Question 7 = 1 mark)

8 A car is travelling over a rough road surface. At low speed the ride is very bumpy with the car and its occupants suffering large amplitude vertical oscillations. However, when the car is driven at a higher speed the ride gets smoother.

This is because at the higher speed

☒ **A** the car leaves the ground and misses the bumps.

☒ **B** the car crushes the bumps and makes the road smoother.

☒ **C** there is a greater amount of damping in the car's suspension.

☒ **D** the car's suspension oscillates at a greater frequency than its natural frequency.

(Total for Question 8 = 1 mark)

9 The gravitational field strength at the surface of the Earth is 9.8 N kg^{-1}. A satellite is orbiting at a height above the ground equal to the radius of the Earth.

The gravitational field strength, in N kg^{-1}, at this height is

☒ **A** 0.0

☒ **B** 2.5

☒ **C** 4.9

☒ **D** 9.8

(Total for Question 9 = 1 mark)

10 The absolute temperature scale is a theoretical scale proposed by Lord Kelvin.

On this scale, zero is the temperature at which

☒ **A** all gases become liquids.

☒ **B** an ideal gas would exert no pressure.

☒ **C** the Celsius temperature is −373 °C.

☒ **D** water freezes.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Light from all distant galaxies is found to be shifted towards longer wavelengths. The more distant the galaxy, the greater the shift in wavelength.

State the conclusions that we can draw from this.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 11 = 3 marks)

12 A student is constructing a spreadsheet to calculate the radius R of some stars.
To obtain the radius, the surface temperature T of the star must first be calculated. She is given values for the stars' luminosities L and the wavelengths λ_{max} at which peak energy emission occurs. Part of the spreadsheet is shown, A is the surface area of the star.

	A	B	C	D	E
1	λ_{max} / 10^{-7} m	T / 10^{3} K	L / 10^{27} W	A / 10^{19} m^2	R / 10^{9} m
2	6.85	4.23	0.039		0.41
3	5.74	5.05	0.384	1.04	0.91
4	3.56	8.14	3.385	1.36	1.04
5					

(a) Write an equation to show how the value in B2 is calculated.

(1)

(b) Show that the value in D2 is about 0.2

(2)

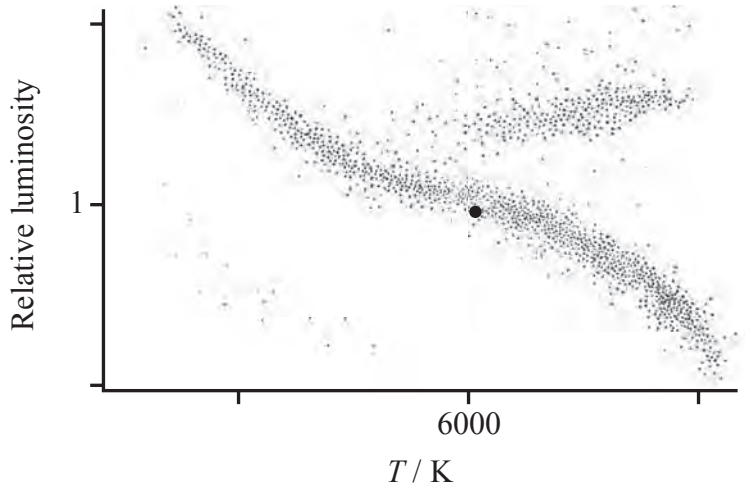
(c) The student was given the luminosity values to enter into column C.

Describe how astronomers could determine the luminosity of a star.

(2)

(Total for Question 12 = 5 marks)

13 This Hertzsprung-Russell diagram is a plot of relative luminosity against temperature for a large number of stars.



The position of the Sun, at a surface temperature of about 6000 K and a relative luminosity of 1, is marked on the diagram.

(a) Complete the temperature and relative luminosity scales by adding values at the positions shown.

(2)

(b) The Sun is an example of a main sequence star.

(i) State the fusion process taking place in the core of all main sequence stars.

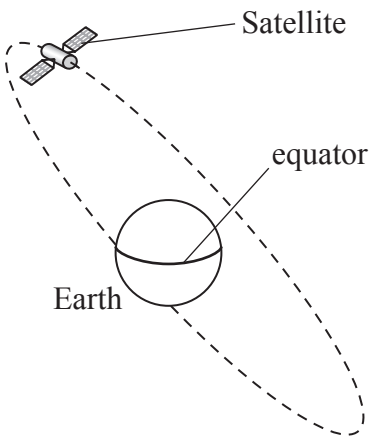
(1)

(ii) Draw a circle where the most massive main sequence stars are located on the diagram and explain why they are found in this position.

(3)

(Total for Question 13 = 6 marks)

14 The Global Positioning System (GPS) is a network of satellites orbiting the Earth. The satellites are arranged in six different orbital planes at a height of 20 200 km above the Earth's surface. Wherever you are, at least four GPS satellites are 'visible' at any time. The diagram shows a single satellite.



(a) Show that the GPS satellites take about 40 000 s (12 hours) to complete one orbit about the Earth.

mass of the Earth $M_E = 6.0 \times 10^{24}$ kg

radius of the Earth $R_E = 6400$ km

(4)

(b) Communications satellites are placed in orbit with an orbital time of 24 hours.

Explain why it is essential for communications satellites to be in such an orbit.

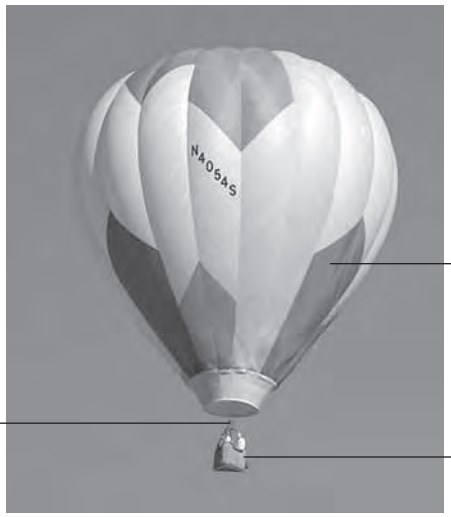
(2)

(c) State how the orbit of a GPS satellite differs from that of a communications satellite.

(2)

(Total for Question 14 = 8 marks)

15 Hot air ballooning is one way to explore the landscape. Air in a balloon is heated from underneath by a set of burners and the balloon starts to rise.



(a) Explain why heating the air causes the balloon to rise.

(2)

(b) In 1991, Per Lindstrand and Richard Branson become the first people to cross the Pacific in a hot air balloon.

With a volume of 7.4×10^4 m^3 the balloon was, at the time, the largest ever built.

Calculate the energy supplied by the burners to heat the air from 20.0 °C to 35.0 °C.

average density of air in the balloon = 1.20 kg m^{-3}

specific heat capacity of air = 1010 J kg^{-1} K^{-1}

(3)

Energy = ...

(c) The first balloons used were filled with hydrogen and sealed to keep the volume constant. As the balloon rose there would be changes in the pressure of the hydrogen due to the temperature changes of the atmosphere.

(i) Calculate the new pressure exerted by the hydrogen if the temperature changed from 20.0 °C to −5.0 °C, as the balloon rose from ground level.

pressure exerted by the hydrogen in the balloon at ground level = 1.01×10^5 Pa

(2)

New pressure = ...

(ii) State **two** assumptions that you must make to calculate this change.

(2)

*(iii) By considering the motion of molecules in the gas, explain why the pressure exerted by the gas decreases as it cools.

(3)

(Total for Question 15 = 12 marks)

16 According to astronomers in Denmark and Australia a common type of active galactic nucleus (AGN) could be used as an accurate "standard candle" for measuring cosmic distances. The technique has been used to measure distances corresponding to redshifts significantly larger than was previously possible.

(a) (i) State what is meant by a standard candle.

(1)

(ii) Explain how a standard candle is used to measure cosmic distances.

(2)

(b) (i) State what is meant by redshift.

(1)

(ii) Calculate the distance to a galaxy with a redshift $z = 0.12$

$H_0 = 2.1 \times 10^{-18}\ s^{-1}$

(2)

Distance to galaxy = ...

*(c) Discuss how astronomers were led to propose the existence of dark matter and the consequences of its existence for the ultimate fate of the universe.

(3)

(d) Explain why the observable universe has a finite size.

(2)

(Total for Question 16 = 11 marks)

17 Positron emission tomography (PET) is a nuclear medicine imaging technique. Pairs of gamma rays, produced when positrons from a radioisotope annihilate with electrons, are detected to form the image.

Radioisotopes used in PET scanning are typically isotopes with short half-lives such as carbon-11. Carbon-11 has a half-life of 1220 s and decays by positron emission to stable boron-11. Positrons are the antiparticles to electrons.

(a) Explain what is meant by a radioactive atom.

(2)

(b) Complete the equation for the decay of carbon-11.

$$^{11}_{6}C \rightarrow \ldots\ldots B + \ldots\ldots e^{+} + {}^{0}_{0}\nu_{e}$$

(2)

(c) Calculate the energy in joules released in a positron decay of carbon-11.

	Mass / MeV/c^2
positron	0.511
carbon	10 253.6
boron	10 252.2

(3)

Energy = ... J

(d) Explain why carbon-11 is a relatively safe radioisotope to use within the body.

(2)

(e) A patient was injected intravenously with a radioactive compound containing carbon-11 with an activity of 1.58×10^6 Bq.

The sample was prepared 3600 s before it was administered to the patient.

Calculate the activity of the sample when it was prepared.

(4)

Activity of the sample = ...

(Total for Question 17 = 13 marks)

18 A baby-bouncer is a light harness, into which a baby can be placed, suspended by a vertical spring.

The height of the baby-bouncer is adjusted so that the baby's feet are a few centimetres above the floor when the baby is in equilibrium in the harness. If the baby is then displaced downwards and released, the system oscillates vertically with simple harmonic motion.

It is stated in a textbook that "a mass-spring system that obeys Hooke's law will lead to simple harmonic motion when the mass is displaced."

*(a) Explain why a system consisting of a mass and a spring that obeys Hooke's law may be set into simple harmonic motion.

(3)

(b) The acceleration experienced by a baby of mass 8.2 kg is 0.49 m s^{-2} when the displacement from the equilibrium position is 3.0 cm.

Show that the period of vertical oscillations for this baby is about 1.6 s.

(3)

(c) The amplitude of the oscillations quickly decreases, so the baby has to keep kicking on the floor to maintain them.

(i) State the name given to oscillations that die away quickly.

(1)

(ii) State the name that is given to oscillations such as those that are kept going by the baby kicking on the floor.

(1)

(iii) If the baby kicks on the floor at a certain frequency, the amplitude of the bounces can be made to increase to a maximum.

Name this effect and calculate the frequency at which it occurs.

(2)

Frequency = ...

(d) The baby is replaced by a baby of less mass. This baby also kicks to produce maximum amplitude of oscillation. Without further calculation, explain how the frequency at which the baby must kick compares to that for the larger mass baby.

(2)

.....

.....

.....

.....

.....

(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9\ \text{N m}^2\ \text{C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i / \sin r = v_1 / v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l / A$
Current	$I = \Delta Q / \Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\max}$

Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

Unit 5

Energy and matter

Heating	$\Delta E = mc\Delta\theta$
Molecular kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Ideal gas equation	$pV = NkT$

Nuclear Physics

Radioactive decay	$\mathrm{d}N/\mathrm{d}t = -\lambda N$
	$\lambda = \ln 2/t_{\frac{1}{2}}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1m_2/r^2$

Observing the universe

Radiant energy flux	$F = L/4\pi d^2$
Stefan-Boltzmann law	$L = \sigma T^4 A$ $L = 4\pi r^2 \sigma T^4$
Wien's Law	$\lambda_{max} T = 2.898 \times 10^{-3}$ m K
Redshift of electromagnetic radiation	$z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$
Cosmological expansion	$v = H_0 d$