



X857/76/12

**Physics
Paper 1 — Multiple choice**

Duration — 45 minutes

Total marks — 25

Attempt ALL questions.

You may use a calculator.

Instructions for the completion of Paper 1 are given on *page 02* of your answer booklet X857/76/02.

Record your answers on the answer grid on *page 03* of your answer booklet.

Reference may be made to the data sheet on *page 02* of this question paper and to the relationships sheet X857/76/22.

Space for rough work is provided at the end of this booklet.

Before leaving the examination room you must give your answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



DATA SHEET

COMMON PHYSICAL QUANTITIES

| Quantity | Symbol | Value | Quantity | Symbol | Value |
|--|--------|---|-------------------|--------|------------------------------------|
| Speed of light in vacuum | c | $3.00 \times 10^8 \text{ m s}^{-1}$ | Planck's constant | h | $6.63 \times 10^{-34} \text{ J s}$ |
| Magnitude of the charge on an electron | e | $1.60 \times 10^{-19} \text{ C}$ | Mass of electron | m_e | $9.11 \times 10^{-31} \text{ kg}$ |
| Universal Constant of Gravitation | G | $6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ | Mass of neutron | m_n | $1.675 \times 10^{-27} \text{ kg}$ |
| Gravitational acceleration on Earth | g | 9.8 m s^{-2} | Mass of proton | m_p | $1.673 \times 10^{-27} \text{ kg}$ |
| Hubble's constant | H_0 | $2.3 \times 10^{-18} \text{ s}^{-1}$ | | | |

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

| Substance | Refractive index | Substance | Refractive index |
|-------------|------------------|-----------|------------------|
| Diamond | 2.42 | Water | 1.33 |
| Crown glass | 1.50 | Air | 1.00 |

SPECTRAL LINES

| Element | Wavelength (nm) | Colour | Element | Wavelength (nm) | Colour |
|----------|-----------------|-------------|----------------|------------------------|---------------|
| Hydrogen | 656 | Red | Cadmium | 644 | Red |
| | 486 | Blue-green | | 509 | Green |
| | 434 | Blue-violet | | 480 | Blue |
| | 410 | Violet | Lasers | | |
| | 397 | Ultraviolet | Element | Wavelength (nm) | Colour |
| | 389 | Ultraviolet | Carbon dioxide | 9550 } 10590 } | Infrared |
| Sodium | 589 | Yellow | Helium-neon | 633 | Red |

PROPERTIES OF SELECTED MATERIALS

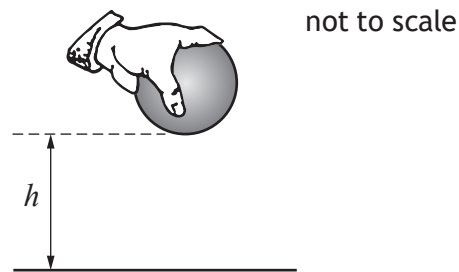
| Substance | Density (kg m^{-3}) | Melting point (K) | Boiling point (K) |
|-----------|--------------------------------|-------------------|-------------------|
| Aluminium | 2.70×10^3 | 933 | 2623 |
| Copper | 8.96×10^3 | 1357 | 2853 |
| Ice | 9.20×10^2 | 273 | |
| Sea Water | 1.02×10^3 | 264 | 377 |
| Water | 1.00×10^3 | 273 | 373 |
| Air | 1.29 | | |
| Hydrogen | 9.0×10^{-2} | 14 | 20 |

The gas densities refer to a temperature of 273 K and a pressure of $1.01 \times 10^5 \text{ Pa}$.

Total marks — 25

Attempt ALL questions

1. A specially adapted ball has an electronic timer, which starts to time when the ball is released and stops timing when the ball strikes a surface.



The ball is dropped from rest through a height h onto a hard surface.

The time recorded on the ball is 0.40 s.

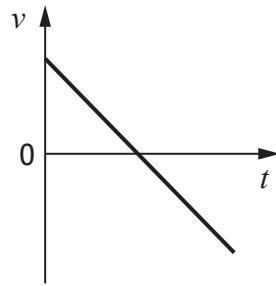
The effects of air resistance can be ignored.

The height h is

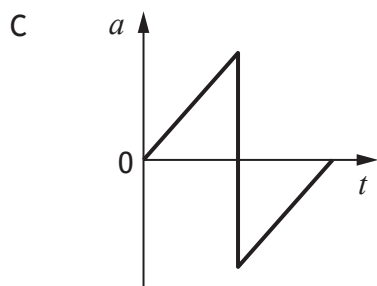
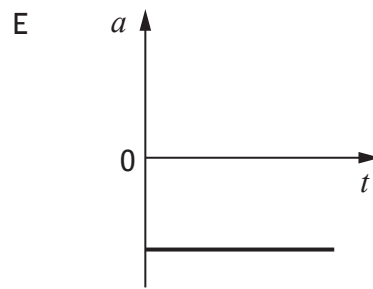
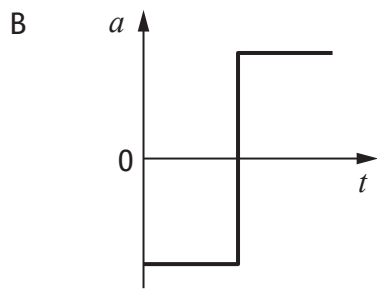
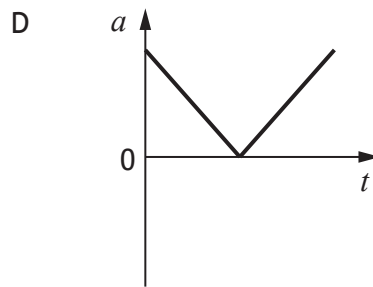
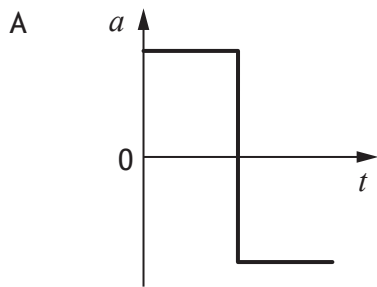
- A 0.20 m
- B 0.78 m
- C 1.56 m
- D 1.96 m
- E 3.92 m.

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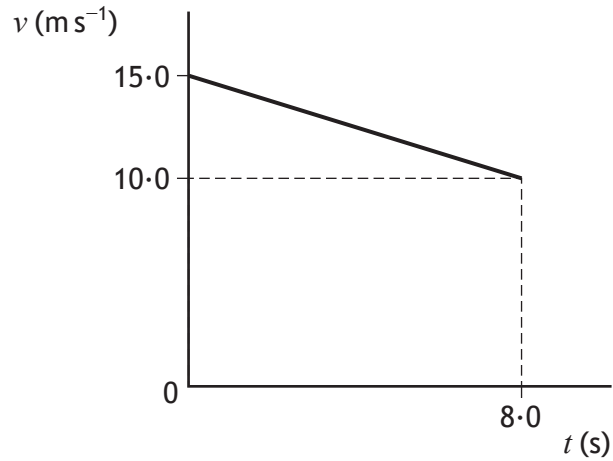
2. The velocity-time ($v-t$) graph for an object travelling in a straight line is shown below.



Which of the following is the corresponding acceleration-time ($a-t$) graph?



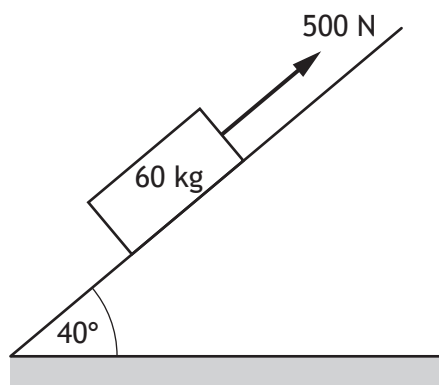
3. The velocity-time ($v-t$) graph for an object travelling along a straight line is shown.



Which row in the table shows the acceleration of the object during the 8.0 s and the displacement of the object at 8.0 s?

| | Acceleration (m s^{-2}) | Displacement (m) |
|---|------------------------------------|------------------|
| A | -0.63 | 100 |
| B | -0.63 | 140 |
| C | -1.9 | 100 |
| D | -1.9 | 120 |
| E | -3.1 | 140 |

4. A pulling force of 500 N is applied to a 60 kg block on a slope as shown.

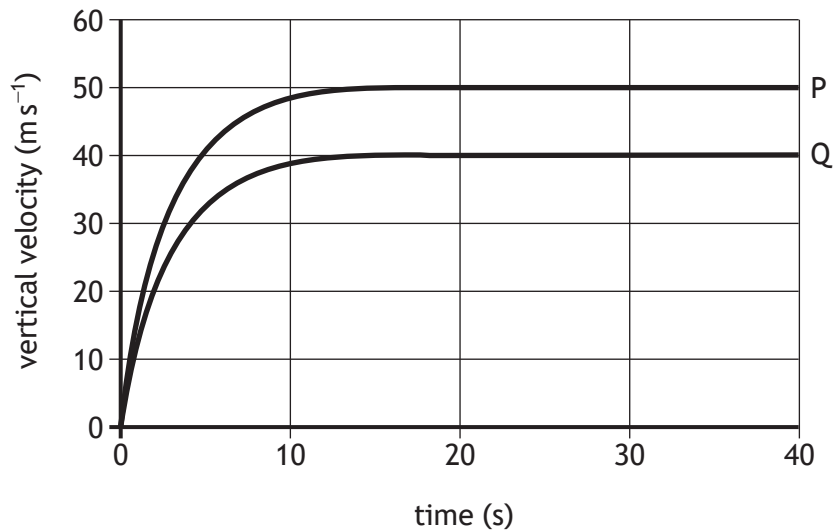


The maximum acceleration of the block is

- A 2.0 m s^{-2}
- B 5.4 m s^{-2}
- C 6.3 m s^{-2}
- D 7.5 m s^{-2}
- E 8.3 m s^{-2} .

5. Two objects, P and Q, of the same mass are dropped from the same height.

The graph shows how the vertical velocities of the two objects vary with time for the first 40 s of their fall.



A group of students make the following statements based on information from the graph.

- I The terminal velocity of object P is 50 m s^{-1} .
- II Object Q reaches its terminal velocity at 10 s.
- III At 40 s, both objects have fallen through the same distance.

Which of these statements is/are correct?

- A I only
 - B I and II only
 - C I and III only
 - D II and III only
 - E I, II and III
6. The total mass of a motorcycle and rider is 250 kg.
- During braking they are brought to rest from a speed of 16 m s^{-1} in a time of 10.0 s.
- The maximum energy that could be converted to heat in the brakes is

- A 2000 J
- B 4000 J
- C 32 000 J
- D 40 000 J
- E 64 000 J.

7. A carpenter is building a doorframe using a nail gun. The nail gun of mass 5.0 kg fires a nail of mass 4.0 g.

The nail gun and nail are initially at rest.

The speed of the nail immediately after firing is 150 m s^{-1} .

The recoil speed of the nail gun immediately after firing is

- A 0.005 m s^{-1}
B 0.05 m s^{-1}
C 0.12 m s^{-1}
D 1.2 m s^{-1}
E 120 m s^{-1} .
8. The escape velocity v of an object is the minimum velocity required to allow the object to escape the gravitational field of a planet.

The following relationship is used to determine the escape velocity

$$v = \sqrt{\frac{2GM}{r}}$$

where G is the Universal Constant of Gravitation

M is the mass of the planet

r is the radius of the planet.

A planet has a mass of $4.87 \times 10^{24} \text{ kg}$ and a radius of $6.05 \times 10^6 \text{ m}$.

Based on this information, the escape velocity from this planet is

- A $1.66 \times 10^{-28} \text{ m s}^{-1}$
B $1.29 \times 10^{-14} \text{ m s}^{-1}$
C $7.33 \times 10^3 \text{ m s}^{-1}$
D $1.04 \times 10^4 \text{ m s}^{-1}$
E $3.97 \times 10^9 \text{ m s}^{-1}$.
9. A spacecraft is travelling at $6.0 \times 10^7 \text{ m s}^{-1}$ relative to a star.
An observer on the spacecraft measures the speed of light emitted by the star to be
- A $2.4 \times 10^8 \text{ m s}^{-1}$
B $2.9 \times 10^8 \text{ m s}^{-1}$
C $3.0 \times 10^8 \text{ m s}^{-1}$
D $3.1 \times 10^8 \text{ m s}^{-1}$
E $3.6 \times 10^8 \text{ m s}^{-1}$.

[Turn over

10. A spacecraft is travelling at a speed of $0.45c$ relative to Earth.

An observer on Earth measures the time taken for the spacecraft to travel between two points to be 72 hours.

An observer on the spacecraft measures the time taken to travel between these two points to be

- A 53 hours
- B 64 hours
- C 72 hours
- D 81 hours
- E 90 hours.

11. The redshift of light from a distant galaxy is 0.125.

The approximate distance to this distant galaxy is

- A 3.75×10^7 m
- B 1.81×10^8 m
- C 5.43×10^{16} m
- D 1.63×10^{25} m
- E 1.30×10^{26} m.

12. A student makes the following statements about the Universe.

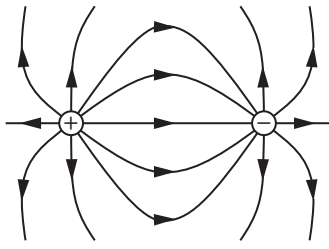
- I Measurements of the velocities of galaxies and their distances from us lead to the theory of the origin of the expanding Universe.
- II The mass of a galaxy can be estimated by the orbital speed of stars within it.
- III Evidence supporting the existence of dark matter comes from the accelerating rate of expansion of the Universe.

Which of these statements is/are correct?

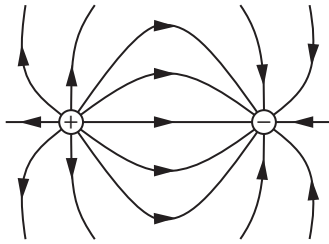
- A I only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

13. Which of the following diagrams represents the electric field between a positive point charge and a negative point charge?

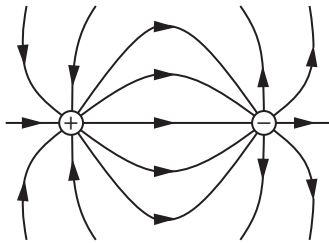
A



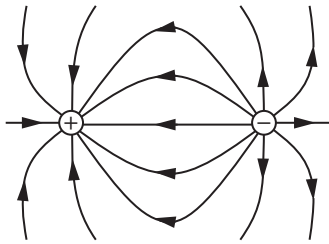
B



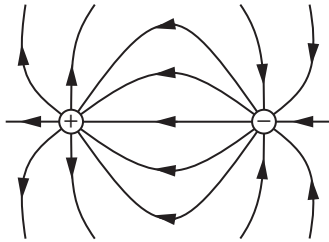
C



D



E



[Turn over

14. The group of matter particles known as fermions consists of

- A baryons only
- B quarks only
- C leptons only
- D quarks and leptons only
- E baryons and mesons only.

15. A certain type of composite particle is made of two up quarks and a strange quark.

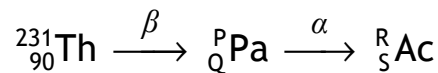
The charge on an up quark is $+\frac{2}{3}e$.

The charge on a strange quark is $-\frac{1}{3}e$.

Which of the following statements describes the nature and charge of this composite particle?

- A The particle is a meson with a charge of $+1e$.
- B The particle is a meson with a charge of $-1e$.
- C The particle is a meson with no charge.
- D The particle is a baryon with a charge of $-1e$.
- E The particle is a baryon with a charge of $+1e$.

16. Two changes in a radioactive decay series are shown below.

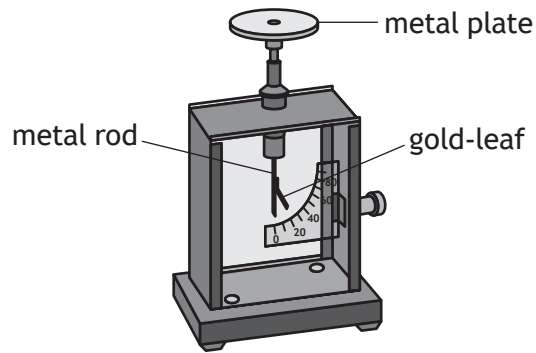


A Thorium nucleus emits a beta particle and the product, a Protactinium nucleus, emits an alpha particle.

Which row in the table shows the numbers represented by P, Q, R, and S?

| | P | Q | R | S |
|---|-----|----|-----|----|
| A | 231 | 89 | 227 | 87 |
| B | 231 | 91 | 227 | 89 |
| C | 227 | 88 | 227 | 87 |
| D | 231 | 91 | 231 | 89 |
| E | 227 | 88 | 223 | 86 |

17. An experiment to demonstrate the photoelectric effect is set up as shown.



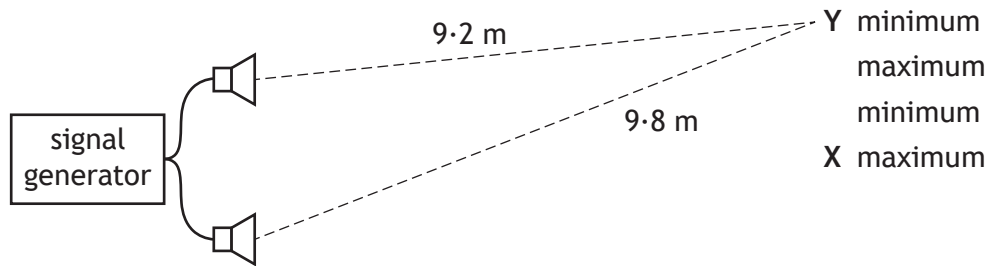
gold-leaf electroscope

Which row in the table shows the charge on the metal plate and the type of incident radiation most likely to cause photoelectric emission?

| | Charge on metal plate | Type of incident radiation |
|---|-----------------------|----------------------------|
| A | negative | green light |
| B | positive | ultraviolet |
| C | negative | infrared |
| D | positive | red light |
| E | negative | ultraviolet |

[Turn over

18. Two identical loudspeakers are connected to a signal generator as shown.



A microphone detects a maximum of sound at position X.

The microphone is now moved from X to Y.

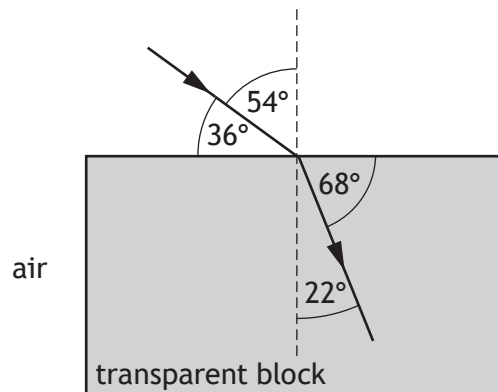
As the microphone is moved from X to Y, a series of maxima and minima of sound are detected.

The microphone detects the second **minimum** of sound at position Y.

The wavelength of sound emitted by the loudspeakers is

- A 0.17 m
- B 0.24 m
- C 0.30 m
- D 0.40 m
- E 0.60 m.

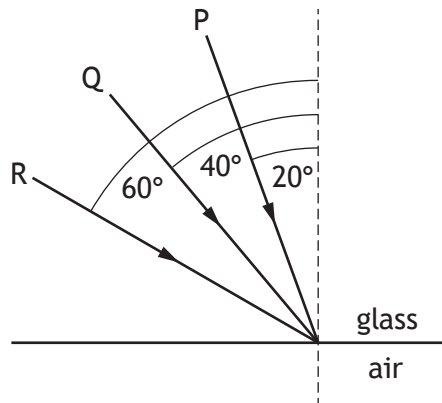
19. A ray of red light passes from air into a transparent block as shown.



The speed of this light in the block is

- A $1.39 \times 10^8 \text{ m s}^{-1}$
- B $1.91 \times 10^8 \text{ m s}^{-1}$
- C $2.62 \times 10^8 \text{ m s}^{-1}$
- D $3.00 \times 10^8 \text{ m s}^{-1}$
- E $4.73 \times 10^8 \text{ m s}^{-1}$.

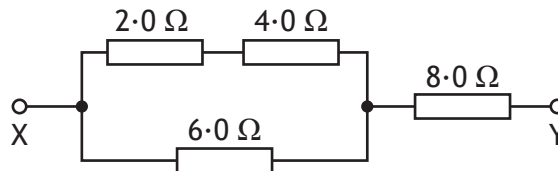
20. The diagram shows the path of three rays of red light P, Q and R in glass. The rays are incident at the glass-air boundary as shown.



The refractive index of the glass for this light is 1.50.

Which of these rays pass from the glass into the air at this boundary?

- A P only
 - B R only
 - C Q and R only
 - D P and Q only
 - E P, Q and R
21. Four resistors are connected as shown.



The total resistance between X and Y is

- A 1.0 Ω
- B 8.9 Ω
- C 9.1 Ω
- D 11 Ω
- E 20 Ω.

[Turn over

22. A resistor of resistance $100\ \Omega$ is rated at $4\ \text{W}$.

The maximum voltage which can be applied across the resistor without exceeding its power rating is

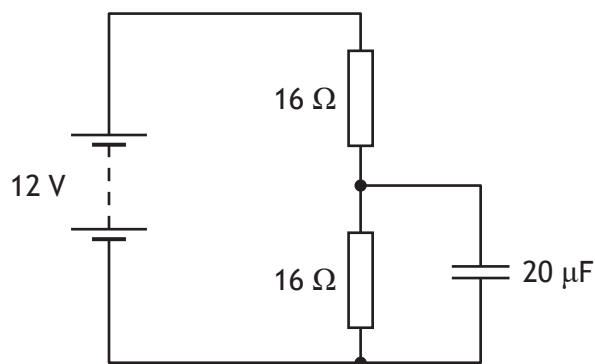
- A $0.04\ \text{V}$
- B $5\ \text{V}$
- C $20\ \text{V}$
- D $25\ \text{V}$
- E $400\ \text{V}$.

23. Capacitance is measured in farads.

One farad is equivalent to

- A one coulomb per volt
- B one joule per volt
- C one joule per coulomb
- D one volt per second
- E one joule per second.

24. A circuit containing a capacitor is set up as shown.

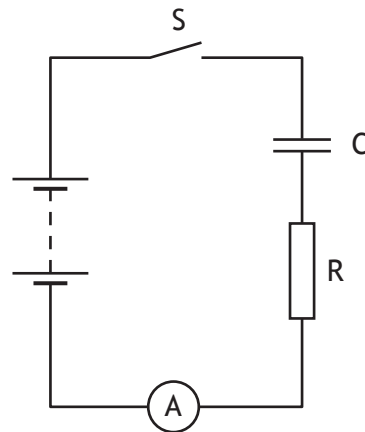


The battery has negligible internal resistance.

The maximum charge stored by the capacitor is

- A $3.6 \times 10^{-4}\ \text{C}$
- B $2.4 \times 10^{-4}\ \text{C}$
- C $1.2 \times 10^{-4}\ \text{C}$
- D $3.3 \times 10^{-6}\ \text{C}$
- E $1.7 \times 10^{-6}\ \text{C}$.

25. A circuit is set up as shown.



Capacitor C is initially uncharged.

Switch S is closed and the time taken for the capacitor to fully charge is recorded.

The switch is now opened and the capacitor is discharged.

Resistor R is replaced by a resistor of greater resistance.

The switch is again closed and the capacitor charges.

Which row in the table shows the effect of this change, if any, on the time taken to fully charge the capacitor and the maximum energy stored in the capacitor?

| | Time taken to fully charge the capacitor | Maximum energy stored in the capacitor |
|---|--|--|
| A | increases | increases |
| B | decreases | decreases |
| C | decreases | stays the same |
| D | increases | stays the same |
| E | stays the same | decreases |

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SPACE FOR ROUGH WORK

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