OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL AS

PHYSICS (9630)

Unit 1: Mechanics, materials and atoms

Tuesday 23 May 2017 Morning Time allowed: 2 hours

B

Materials

For this paper you must have:
- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12–25	
TOTAL	

Section A

Answer **all** questions in the spaces provided.

0 1 Complete the table by stating whether each quantity is a vector or a scalar and by stating its SI unit. The first row of the table has been completed for you.

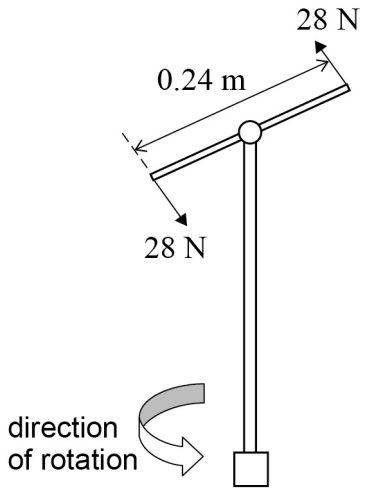
[2 marks]

Quantity	**Vector or scalar**	**SI unit**
Displacement	Vector	m
Velocity		
Weight		
Energy		

2

0 2 **Figure 1** shows a tool designed to turn taps on underground water pipes. An operator applies a 28 N force to each handle of the tool. The handles and forces are horizontal and the forces are at 90° to the handle and make the tool turn anticlockwise.

Figure 1



0 2 . 1 Define the moment of a force about a point.

[2 marks]

0 2 . 2 Calculate the work done by the operator when the tool is turned through **three** complete revolutions.

[2 marks]

work done = _____ J

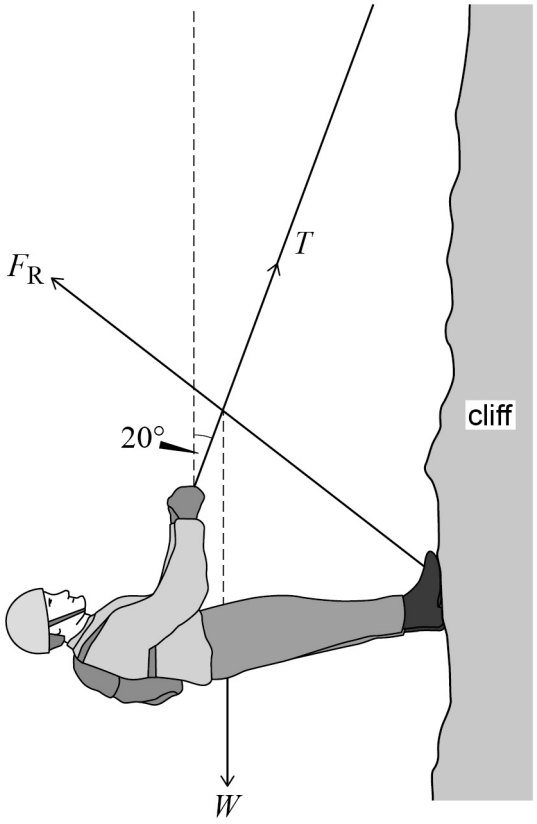
4

0 3 **Figure 2** shows a rock climber abseiling down a cliff. At the instant shown the climber is stationary and in equilibrium. The force exerted by the cliff on the climber's feet is F_R. The other forces acting on the climber are:

tension in the rope T = 610 N at 20° to the vertical

climber's weight W = 590 N

Figure 2



Calculate the vertical component of F_R.

[3 marks]

vertical component = _____ N

3

0 4 Complete the equation below to show the decay of a neutron.
Show the proton numbers, nucleon numbers and symbols of all three particles produced.

[3 marks]

$$^{1}_{0}n \longrightarrow \begin{matrix}\cdots\cdots \\ \cdots\cdots\end{matrix} \quad \cdots\cdots + \quad \begin{matrix}\cdots\cdots \\ \cdots\cdots\end{matrix} \quad \cdots\cdots + \quad \begin{matrix}\cdots\cdots \\ \cdots\cdots\end{matrix} \quad \cdots\cdots$$

3

0 5 Explain the difference between a quantity with the unit **GW** and a quantity with the unit **GW h**.

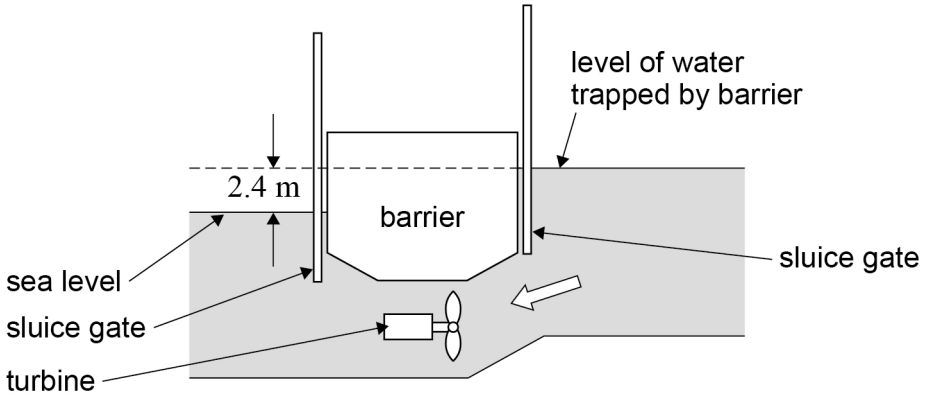
[2 marks]

2

Turn over for the next question

0 6 **Figure 3** shows a cross-sectional view of a barrier in a tidal power station. The barrier traps sea water behind a barrier at high tide. After high tide, the sea level outside the barrier falls. When the difference in water levels is sufficient, sluice gates are opened, allowing the trapped water to flow past turbines. The water falls through a mean height of $2.4\ \text{m}$ as it flows through the barrier.

Figure 3



0 6 . 1 The water trapped by the barrier has a surface area of $23\ \text{km}^2$ and a mean depth of $9.7\ \text{m}$.
Show that the mass of water trapped by the barrier is approximately $2.5 \times 10^{11}\ \text{kg}$.
density of sea water = $1.1 \times 10^3\ \text{kg m}^{-3}$

[2 marks]

0 6 . 2 All of the trapped water flows through the barrier.
Calculate the change in gravitational potential energy of the water as it flows through the barrier.

[1 mark]

change in potential energy = _____ J

0 6 . 3 The efficiency of the power station is 42% and the water is released over a time period of 6.0 hours.
Calculate the average power output of the power station during this time.

[3 marks]

average power = _____ W

0 6 . 4 Suggest **two** causes of inefficiency in the power station.

[2 marks]

1 _____

_____

2 _____

_____

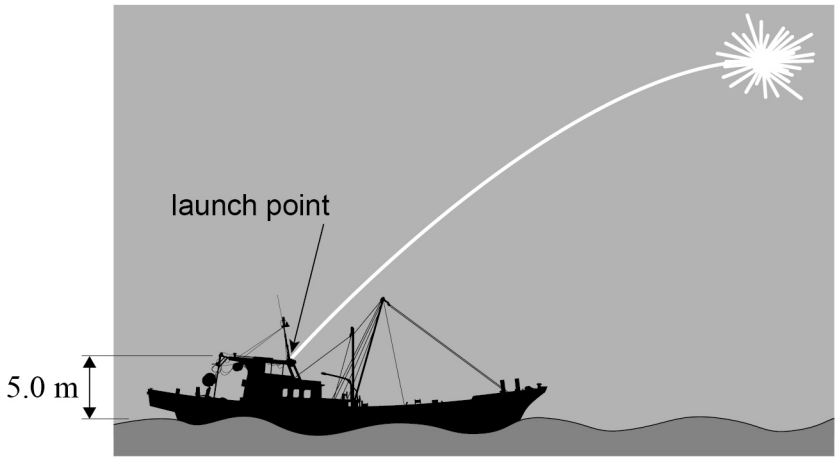
8

Turn over for the next question

0 7 A signal flare is a projectile that is launched into the air from a stationary boat to attract attention in an emergency. The signal flare ignites at the top of its trajectory.

Figure 4 shows the trajectory of the signal flare to the point when it ignites.

Figure 4



The signal flare is launched with a vertical component of velocity of $58\ \text{m s}^{-1}$ from a point $5.0\ \text{m}$ above sea level. Assume that its weight is the only force acting on the signal flare after it has been launched.

0 7 . 1 Calculate the maximum height above sea level reached by the signal flare.

[3 marks]

maximum height = _____ m

0 7 . 2 Show that the time taken for the signal flare to reach the maximum height is approximately 6 s.

[2 marks]

0 7 . 3 The signal flare is launched at an angle of 70° to the horizontal.

Calculate the horizontal distance of the signal flare from its launch point when it reaches its maximum height.

[3 marks]

horizontal distance = _____ m

0 7 . 4 In practice, the motion of the signal flare is affected by air resistance.

State and explain how air resistance will affect the maximum height and horizontal distance from the launch point at which the signal flare ignites.

[3 marks]

_____

_____

_____

_____

_____

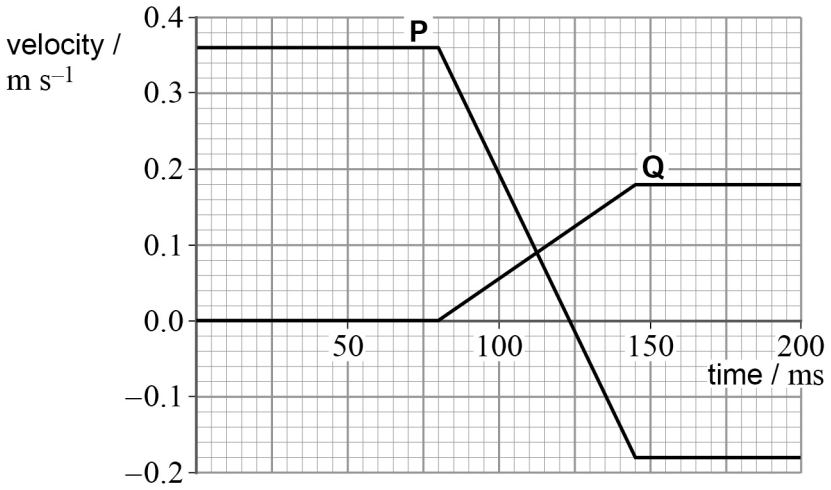
_____

_____

11

0 8 Two trolleys, **P** and **Q**, are on a horizontal, frictionless runway. Trolley **Q** is stationary when trolley **P** collides with it. Trolley **P** has a mass of 1.2 kg.
Figure 5 is a graph of the variation of the velocities of both trolleys before, during and after the collision.

Figure 5



0 8 . 1 Calculate the change in momentum of trolley **P** as a result of the collision.

[2 marks]

change in momentum = _____ kg m s^{-1}

0 8 . 2 Calculate the horizontal force applied to trolley **P** during the collision.

[2 marks]

force = _____ N

0 8 . 3 Show that the mass of trolley **Q** must be $3.6\ \text{kg}$.

[3 marks]

0 8 . 4 Determine whether the collision is elastic.

[3 marks]

The collision is _____

10

Turn over for the next question

0 9 Positron Emission Tomography (PET) scans can be used for examining cancers. Fluorine-18 (^{18}F) decays by positron emission. The positron collides with another particle and undergoes annihilation. Radiation from this annihilation is used to build a picture of the cancer.

A solution containing ^{18}F with an activity of $320\ \text{MBq}$ is injected into a patient.

0 9 . 1 Describe the properties of a positron.

[2 marks]

0 9 . 2 Explain what is meant by annihilation in this case.

[3 marks]

0 9 . 3 Calculate the time taken for the activity of the ^{18}F to fall from its initial activity to 10 MBq.

half-life of ^{18}F = 110 min

[2 marks]

time taken = _____ min

7

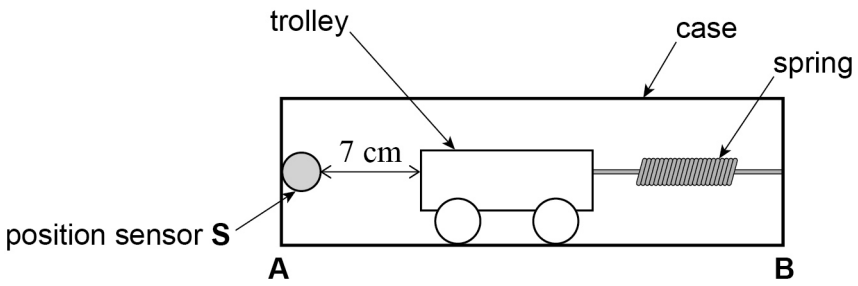
Turn over for the next question

Section B

Answer **all** questions in this section.

1 0 **Figure 6** shows an accelerometer that measures the acceleration of a lorry. The case of the accelerometer is rigidly attached to a lorry.

Figure 6



When the lorry is at rest or moving at a constant velocity on a horizontal road the spring is at its natural length and the trolley is in its equilibrium position. The trolley can move in a horizontal direction along **AB** without being affected by friction.

When the trolley moves relative to the case, its position is measured using a position sensor **S**. The displacement of the trolley from its equilibrium position is proportional to the acceleration of the lorry.

1 0 . 1 When the lorry moves with constant acceleration, the spring extends by 5.3 cm. Then the trolley becomes stationary relative to the case. Explain why the trolley behaves in this way.

[3 marks]

1 0 . 2 The spring obeys Hooke's law and has a spring constant of $6.0\ \text{N m}^{-1}$. The trolley has a mass of $0.20\ \text{kg}$.
Calculate the acceleration of the lorry that causes the spring to extend by $5.3\ \text{cm}$.
[2 marks]

acceleration of lorry = _____ m s^{-2}

1 0 . 3 Explain **one** way in which the design of the accelerometer can be modified to measure accelerations that are approximately twice as big as in Question **10.2**.
[1 mark]

_____

_____

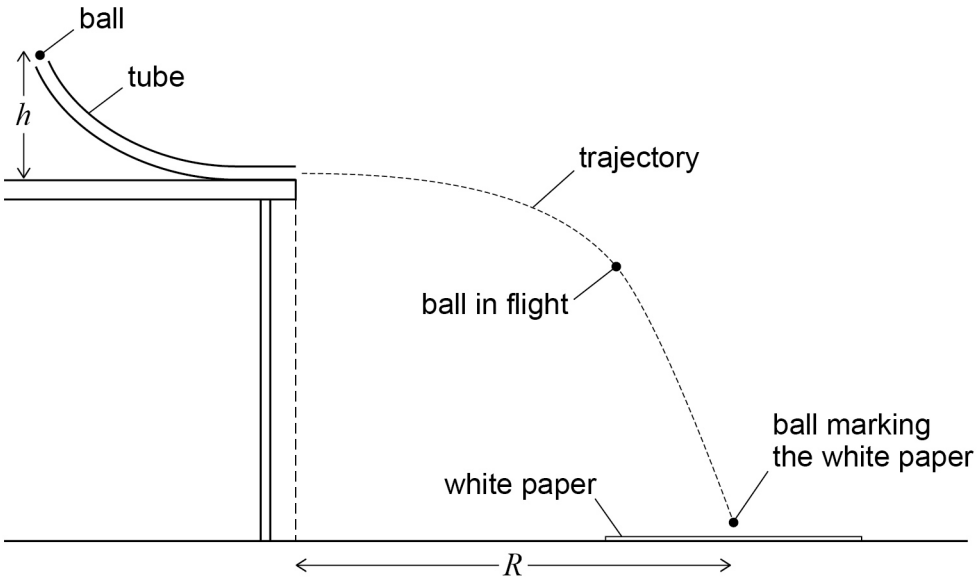
_____

6

Turn over for the next question

1 1 **Figure 7** shows the apparatus used to investigate the relationship between the release height h and the range R for a ball projected horizontally to fall freely under gravity.

Figure 7



The position of the ball striking the floor is recorded as a mark on the white paper, enabling R to be measured.
The tube is flexible and clamped so that h can be varied but the lower end is fixed in position to project the ball horizontally.

Table 1 shows some of the results from the experiment.

$\overline{R}$ is the mean of three measurements of the range (R_1, R_2 and R_3) for each value of h.

Table 1

h/m	R_1/m	R_2/m	R_3/m	$\overline{R}$/m
0.200	0.480	0.490	0.496	0.489
0.300	0.614	0.627	0.598	0.613
0.400	0.718	0.707	0.726	0.717
0.500	0.804	0.803	0.820	0.809

1 1 . 1 Estimate the percentage uncertainty in $\overline{R}$ when h = 0.300 m.

[1 mark]

uncertainty = ± _____ %

1 1 . 2 The time T taken for the ball to travel from the end of the tube to the floor was 0.28 ± 0.01 s.

Explain why T is expected to be constant in this experiment.

[2 marks]

1 1 . 3 Explain why the speed v of the ball as it leaves the tube can be calculated using

$$v = \frac{\overline{R}}{T}$$

[2 marks]

Question 11 continues on the next page

1 1 . 4 Calculate v when $h = 0.300$ m.

[1 mark]

$v =$ _____ m s^{-1}

1 1 . 5 Estimate the absolute uncertainty in your answer for v.

[3 marks]

absolute uncertainty = ± _____ m s^{-1}

1 1 . 6 Describe how a systematic error in the measurement of R can be avoided.

[1 mark]

_____

_____

_____

10

Section C

Each of the questions in this section is followed by four responses, **A**, **B**, **C**, and **D**.
For each question select the best response.

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

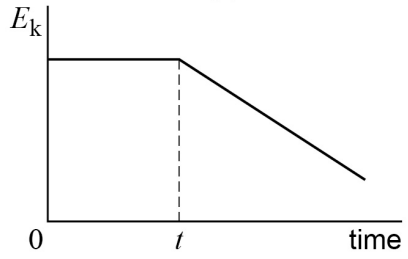
If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

1 2 A body is travelling at a constant speed in a straight line. At time t, a constant force begins to act on the body at right angles to the original direction of motion of the body.

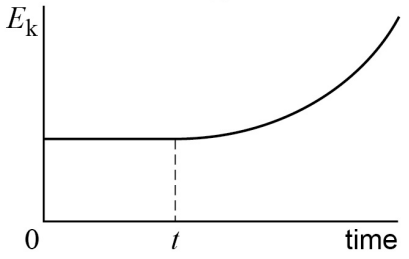
Which graph shows the variation of the kinetic energy E_k of the body with time?

[1 mark]

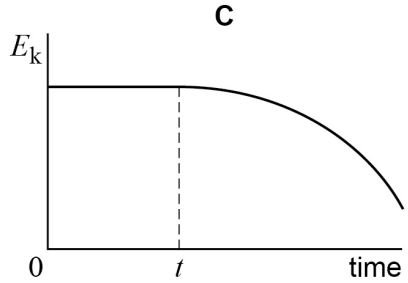
A



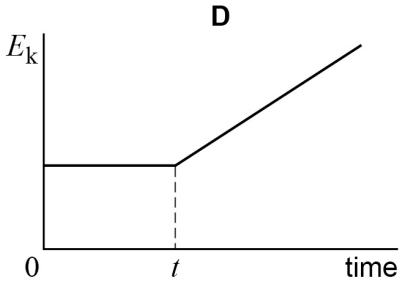
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

1 3 A firework is launched vertically into the sky. It explodes before it reaches its maximum height.

Which row correctly states whether momentum and kinetic energy are conserved or not conserved at the instant the firework explodes?

[1 mark]

	Momentum	**Kinetic energy**	
A	not conserved	not conserved	⬭
B	not conserved	conserved	⬭
C	conserved	not conserved	⬭
D	conserved	conserved	⬭

1 4 A car has an engine that is 36% efficient. During a journey, the car does $14\ \text{MJ}$ of useful work.

What is the energy wasted by the car during the journey?

[1 mark]

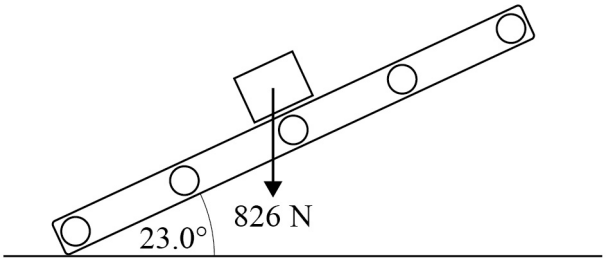
A $5.0 \times 10^6\ \text{J}$ ⬭

B $9.0 \times 10^6\ \text{J}$ ⬭

C $2.2 \times 10^7\ \text{J}$ ⬭

D $2.5 \times 10^7\ \text{J}$ ⬭

1 5 A conveyor belt of length $12.0\ \text{m}$ lifts a box of weight $826\ \text{N}$. The conveyor belt is at an angle of $23.0°$ to the horizontal.



What is the work done against gravity on the box by the conveyor belt?

[1 mark]

A 3870 J ⬭

B 4210 J ⬭

C 9120 J ⬭

D 9910 J ⬭

1 6 A $53.5\ \text{kg}$ mass is held $6.8\ \text{m}$ above the ground.

What is the most appropriate value for the gravitational potential energy of the mass?

[1 mark]

A 3.6 kJ ⬭

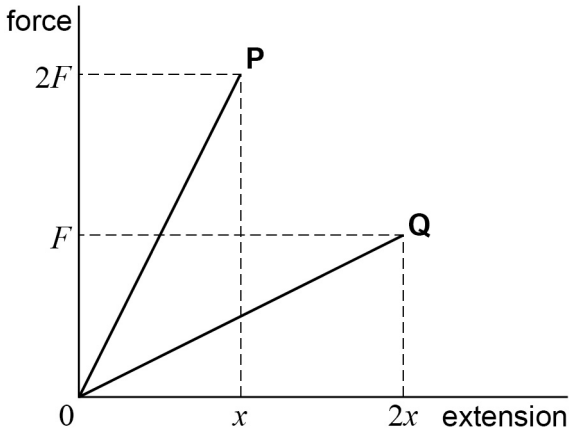
B 3.57 kJ ⬭

C 3.569 kJ ⬭

D 3.638 kJ ⬭

Turn over for the next question

1 7 The graph shows the variation of force with extension for two springs, **P** and **Q**. The energy stored in spring **P** is E and the spring constant of **P** is k.



What are the energy stored and the spring constant for spring **Q**?

[1 mark]

	Energy stored in **Q**	Spring constant of **Q**	
A	$\frac{E}{2}$	$2k$	⬭
B	E	$\frac{k}{4}$	⬭
C	E	$2k$	⬭
D	$2E$	$\frac{k}{4}$	⬭

1 8 Which of the following is **not** a correct unit for tensile stress?

[1 mark]

A Pa ⬭

B $\mathrm{J\ m^{-3}}$ ⬭

C $\mathrm{kg\ m^{-1}\ s^{-2}}$ ⬭

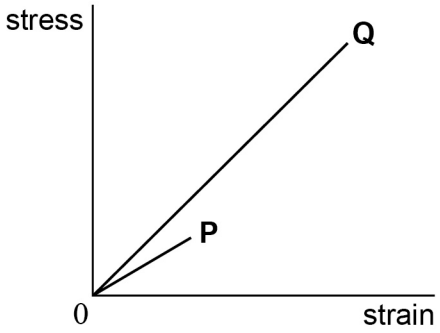
D $\mathrm{N\ m^{-1}\ s^{-2}}$ ⬭

1 9 Material **P** has a higher Young modulus but a lower ultimate tensile stress than material **Q**.

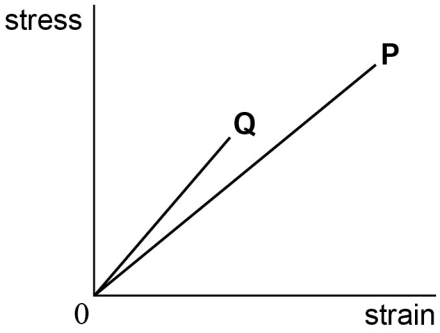
Which graph shows the correct stress–strain relationships for **P** and **Q**?

[1 mark]

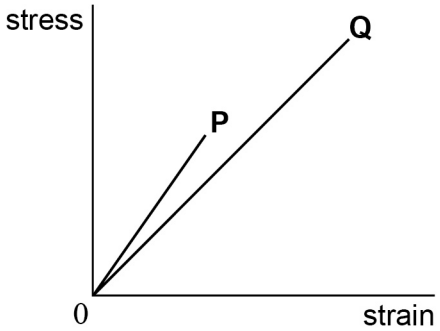
A



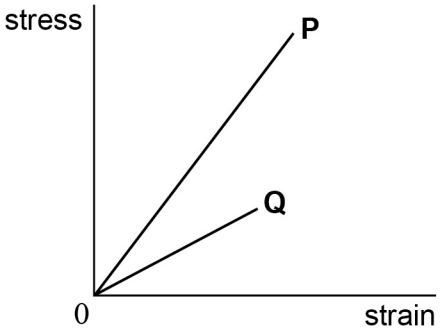
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Turn over for the next question

2 0 When an elastic metal wire of initial length l and diameter d is stretched with a force F, the extension is e. A second wire of the same material has an initial length of $2l$ and diameter $\frac{d}{2}$.

Neither wire exceeds its limit of proportionality.

What is the extension of the second wire when it is stretched with a force of $\frac{F}{2}$?

[1 mark]

A e ⬭

B $2e$ ⬭

C $4e$ ⬭

D $8e$ ⬭

2 1 Antiprotons, antineutrons and positrons have different magnitudes of specific charge.

What is the order of the specific charges, from smallest to largest?

[1 mark]

A antineutron, positron, antiproton ⬭

B antineutron, antiproton, positron ⬭

C positron, antineutron, antiproton ⬭

D antiproton, antineutron, positron ⬭

2 2 Radon-222 ($^{222}_{86}$Rn) is part of the decay chain of uranium-238 ($^{238}_{92}$U). Only α, β^- and γ decays are observed in the decay chain.

What are the numbers of alpha particles and beta particles emitted when $^{222}_{86}$Rn is produced from $^{238}_{92}$U?

[1 mark]

	Number of alpha particles emitted	Number of beta particles emitted	
A	4	2	⬭
B	8	2	⬭
C	4	4	⬭
D	8	4	⬭

2 3 A sample of a radioactive material with a half-life $T_{½}$ has an initial uncorrected count rate of 6.500 counts s^{-1} when measured in a laboratory. The background count rate in the laboratory is 0.500 counts s^{-1}.

What is the uncorrected count rate of the sample after $2T_{½}$?

[1 mark]

A 1.125 counts s^{-1} ⬭

B 1.500 counts s^{-1} ⬭

C 1.625 counts s^{-1} ⬭

D 2.000 counts s^{-1} ⬭

Turn over for the next question

2 4 The count rate from a radioactive source is measured using a Geiger-Müller (GM) tube placed very close to the source. The count rate is measured with no absorber between the source and the GM tube. The measurement is then repeated with thin paper and finally with aluminium of thickness 5 mm between the tube and the source. The count rates, corrected for the background, are shown.

Absorber	**Corrected count rate / counts s^{-1}**
none	876
thin paper	247
aluminium of thickness 5 mm	251

What types of radiation are emitted by the source?

[1 mark]

A alpha, beta and gamma ⬭

B alpha and gamma only ⬭

C alpha and beta only ⬭

D beta and gamma only ⬭

2 5 Which conservation rules were originally used to predict the existence of the neutrino?

[1 mark]

A conservation of charge and energy in gamma decay ⬭

B conservation of energy and momentum in all types of decay ⬭

C conservation of energy and momentum in beta decay ⬭

D conservation of mass and charge in alpha decay ⬭

14

END OF QUESTIONS

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