Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420UB0-1

Z22-3420UB0-1

WEDNESDAY, 8 JUNE 2022 – AFTERNOON

PHYSICS – Unit 2:
Forces, Space and Radioactivity

HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**6**	
3.	**7**	
4.	**11**	
5.	**7**	
6.	**9**	
7.	**14**	
8.	**12**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7(a)**.

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Equations

speed = $\dfrac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\dfrac{\text{change in velocity}}{\text{time}}$	$a = \dfrac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
distance travelled = area under a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
kinetic energy = $\dfrac{\text{mass} \times \text{velocity}^2}{2}$	$\text{KE} = \frac{1}{2}mv^2$
change in potential energy = mass × gravitational field strength × change in height	$\text{PE} = mgh$
force = spring constant × extension	$F = kx$
work done in stretching = area under a force-extension graph	$W = \frac{1}{2}Fx$
momentum = mass × velocity	$p = mv$
force = $\dfrac{\text{change in momentum}}{\text{time}}$	$F = \dfrac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \dfrac{u+v}{2}\,t$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$
moment = force × distance	$M = Fd$

SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
μ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^{3}
M	1×10^{6}
G	1×10^{9}
T	1×10^{12}

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Answer **all** questions.

1. (a) Background radiation occurs due to the decay of an unstable nucleus releasing alpha, beta or gamma radiation.

Complete the table below to state what each type of radiation is. [3]

Type of radiation	Symbol	What it is
Alpha	${}^{4}_{2}\alpha$	....
Beta	${}^{0}_{-1}\beta$	....
Gamma	γ	....

(b) A teacher demonstrates how to determine the background radiation count in her laboratory.
She uses a radiation detector and measures 18 counts in 30 seconds.

(i) Determine the background radiation count in counts per second. [1]

Background radiation = ... counts per second

(ii) Suggest **two** ways that the teacher could improve her measurement of background radiation. [2]

1. ....

2. ....

(iii) Explain why the background radiation count is much higher in some parts of the country than others. [2]

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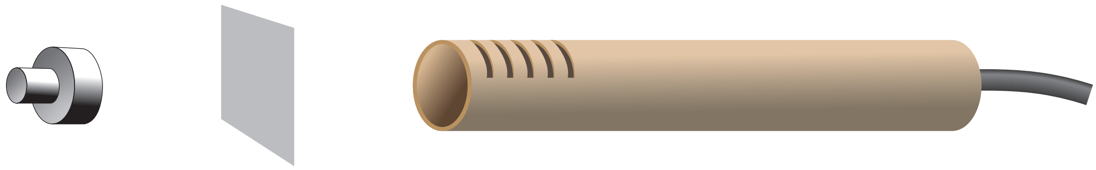
(c) The teacher now demonstrates an experiment to identify the radiation emitted by different sources.
The count rate is measured, first with no absorber present and then with paper and aluminium absorbers separately.



The results are shown in the table below. They are corrected for background radiation.

Source	Count rate (counts per second)		
	No absorber	Paper	Thin aluminium
1	312	313	312
2	389	57	0

(i) Write **yes (Y) or no (N)** in each box to show which type(s) of radiation is (are) emitted by each source. [4]

	Alpha	Beta	Gamma
Source 1			
Source 2			

(ii) Explain **one** change the teacher could make to extend the investigation to confirm to the class the conclusions made. [2]

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14

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2. The table below gives data about some objects in our solar system.

Object	Mass (units)	Diameter (km)	Length of day (hours)	Year length (days)	Orbital speed (km/s)	Mean temperature (°C)	Distance from Sun (units)
Mercury	0.330	4 879	4 222.6	88	47.4	167	0.39
Venus	4.87	12 104	2 802	225	35	464	0.72
Earth	5.97	12 756	24	365	29.8	15	1.00
Moon	0.073	3 475	708.7		1	–20	
Mars	0.642	6 792	24.7	687	24.1	–65	1.52
Jupiter	1 898	142 984	9.9	4 331	13.1	–110	5.20
Saturn	568	120 536	10.7	10 747	9.7	–140	9.54
Uranus	86.8	51 118	17.2	30 589	6.8	–195	19.18
Neptune	102	49 528	16.1	59 800	5.4	–200	30.06
Pluto	0.0146	2 370	163.3	90 560	4.7	–225	39.53

(a) (i) Use the information from the table to **tick** (✓) the **two** correct statements below. [2]

Neptune is hotter than the Moon. ☐

The mean temperature of the Moon is 5 degrees less than the Earth. ☐

A year on Earth is about 4 times longer than a year on Mercury. ☐

Mercury orbits the Sun with a speed around 10 times greater than Pluto. ☐

(ii) Pluto was once considered to be a planet but is now classed as a dwarf planet. Use the data in the table to suggest a reason for the change. [1]

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(iii) Ceres is another dwarf planet and it is the only dwarf planet located in the asteroid belt. Estimate its distance from the Sun. [1]

Distance from the Sun = ... units

(b) Elin concludes that rocky planets with the greatest mass have the shortest day length. Explain the extent to which the data supports this conclusion. [2]

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3. Nuclear fusion can take place in a fusion reactor.

(a) Deuterium is one isotope of hydrogen, H, which consists of 1 proton and 1 neutron.

Tritium is another isotope of hydrogen which consists of 1 proton and 2 neutrons.

In one nuclear fusion reaction, deuterium and tritium undergo nuclear fusion to form helium, He, and one neutron.

Produce a **balanced nuclear equation** for the fusion of deuterium and tritium. [3]

.... + ... ⟶ .... + ...

(b) (i) Explain why nuclear fusion is difficult to achieve on Earth. [2]

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(ii) One advantage of nuclear fusion compared to nuclear fission is that it doesn't produce radioactive waste.
State **two** reasons why radioactive waste is difficult to store safely. [2]

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4. A class investigated radioactive decay using 50 dice, each with 8 sides.

They rolled the dice and removed any which landed with an 8 facing upwards, to represent a decayed nucleus.

They recorded the number of dice remaining.

They rolled the remaining dice and again removed any which landed with an 8 facing upwards.

This was repeated until they had rolled the dice 10 times in total.

Some of the results are shown in the table below.

Number of throws	Number of dice remaining
0	50
2	37
4	29
6	23
8	18
10	15

(a) (i) Plot the data on the grid opposite and draw a suitable line. [3]

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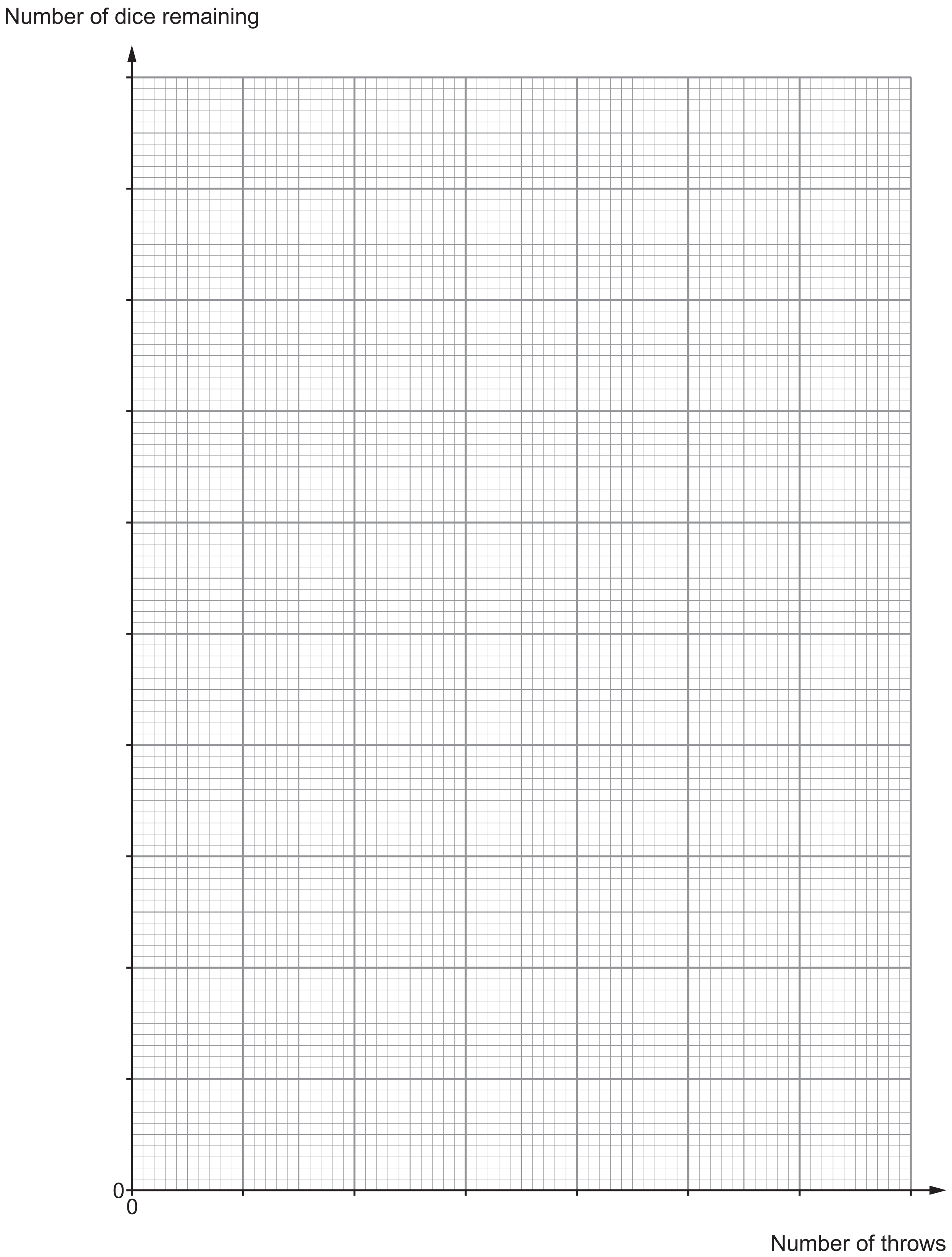

Turn over.

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(ii) Use your graph to determine how many dice were removed on the 3^{rd} **throw**. [2]

Number of dice removed = ...

(iii) Determine how many throws it took for the initial number of dice to halve.
Show how you obtained your answer on the graph. [2]

Number of throws = ...

(iv) If the experiment was repeated with 1 000 dice, use your results to predict how many throws it would take to reduce them to 125. [2]

Number of throws = ...

(b) Explain why it is preferable to use a larger sample size in this experiment. [2]

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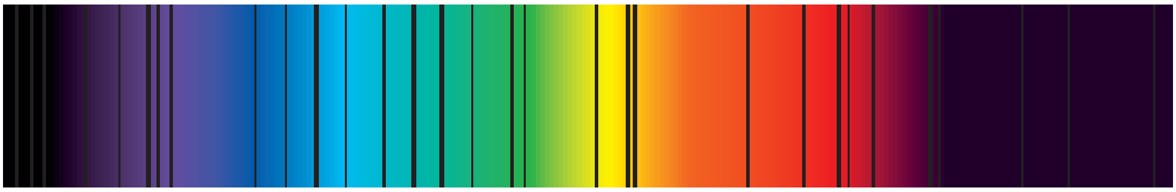
5. The diagram shows the absorption spectrum of light from the Sun.



(a) Explain how the dark lines are formed **and** how the spectrum can be used to identify the elements present in the Sun. [3]

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(b) Many scientists believe that the Universe began with the Big Bang, 15.5 billion years ago.
State **two** pieces of evidence for the Big Bang **and** explain how they support this theory. [4]

Evidence 1: ....

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Evidence 2: ....

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7

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6. (a) (i) A car is travelling at initial velocity, u, of 15 m/s when it **decelerates** at a constant rate of 3.5 m/s^2 for a distance, x, of 20 m.

Use an equation from page 2 to determine the final velocity, v, of the car. [3]

v = ... m/s

(ii) During the deceleration, the work done on the driver reduces his kinetic energy from 5 625 J to 2 125 J over a distance of 20 m.

Use the equation:

work done = force × distance

to determine the mean force acting on the driver. [3]

Mean force = ... N

(b) Airbags are designed to rapidly inflate in the event of a collision.
Explain how they help to keep passengers safe. [3]

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9

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7. (a) State Newton's **three** laws of motion **and** explain how they each apply to the motion of skydivers from when they first jump from a plane until they first reach terminal speed. [6 QER]

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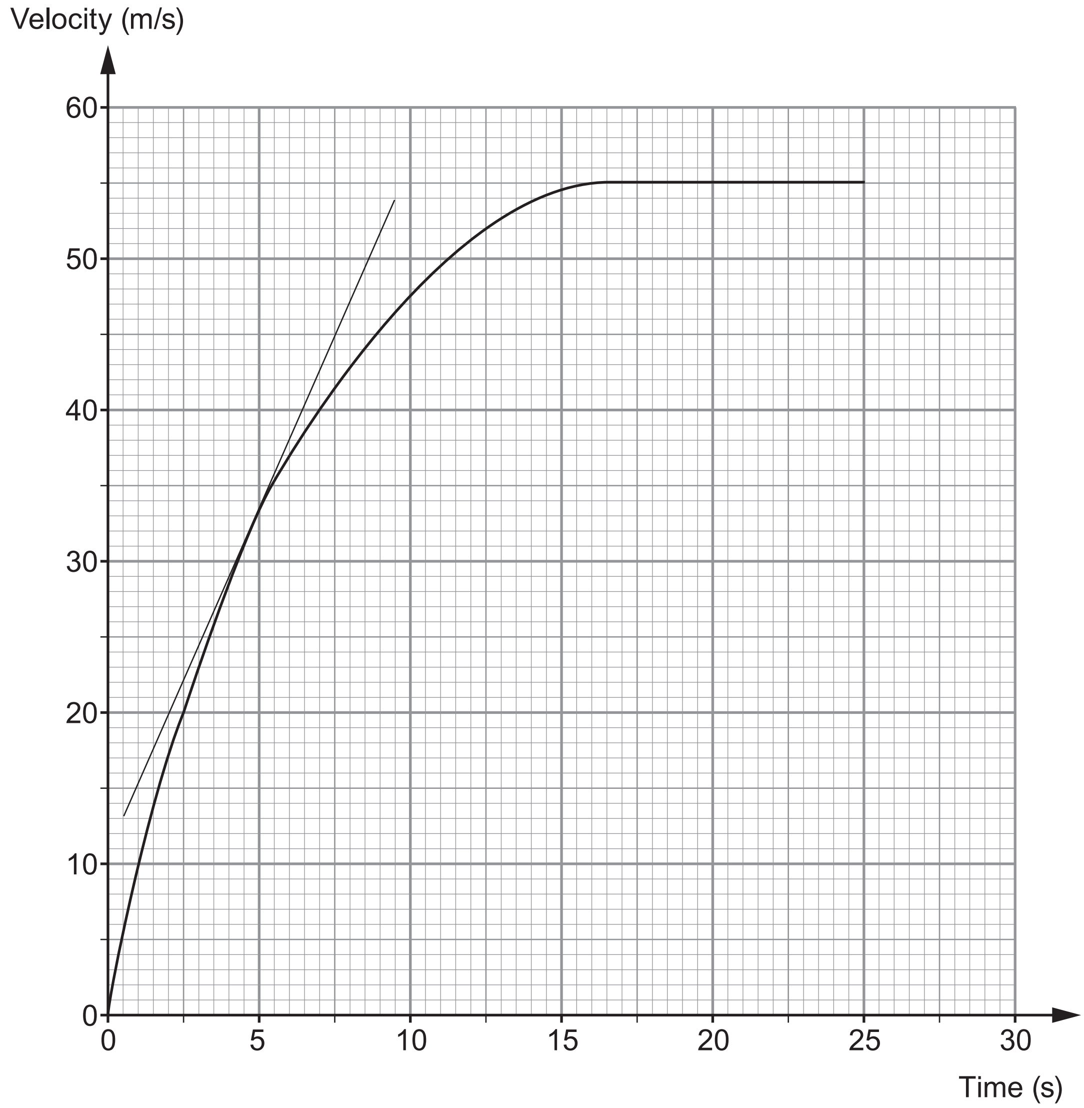
(b) The velocity-time graph below shows the motion of a skydiver.
A tangent has been drawn at 5 seconds.



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(i) Acceleration can be calculated by measuring the gradient of a velocity-time graph. Calculate the acceleration of the skydiver at **5 s** by using the tangent shown. [3]

Acceleration = ... m/s^2

(ii) Describe how the acceleration changes over the 25 s shown. [2]

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(iii) Use the graph and an equation from page 2 to estimate the distance travelled by the skydiver in the **first 5 s**. [3]

Distance travelled = ... m

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8. This question is about momentum.

(a) State the principle of conservation of momentum. [2]

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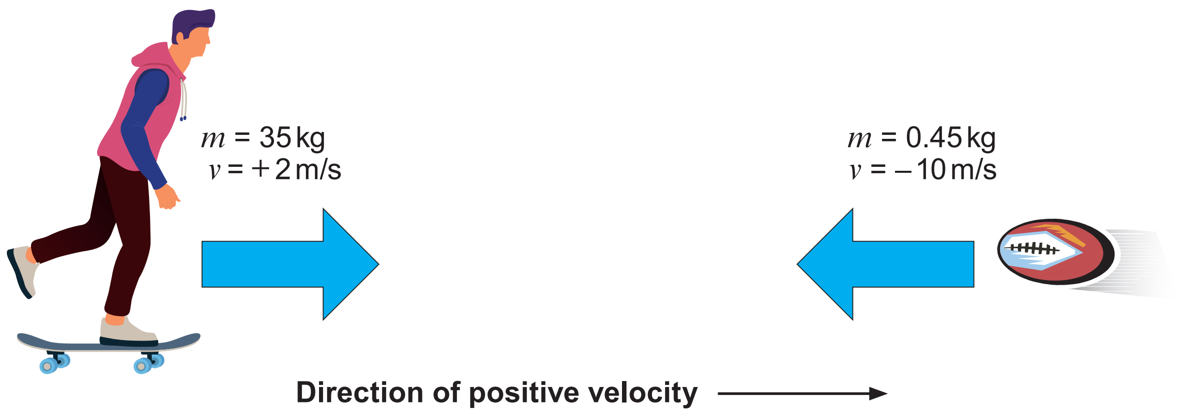
(b) A skateboarder of mass 35 kg moving with a velocity of 2 m/s catches and holds on to a 0.45 kg rugby ball thrown directly towards him at 10 m/s.



Use the equation:

$$\text{momentum} = \text{mass} \times \text{velocity}$$

to calculate the **total** momentum of the skateboarder and the ball before the collision and give the unit. [4]

Total momentum = ...

Unit = ...

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(c) Use an equation from page 2 to calculate the velocity of the skateboarder after he catches the rugby ball. [2]

Velocity = ... m/s

(d) Tomos suggests that **kinetic energy** is conserved in this collision.
Explain, by using calculations, whether or not you agree.
Use an equation from page 2. [4]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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