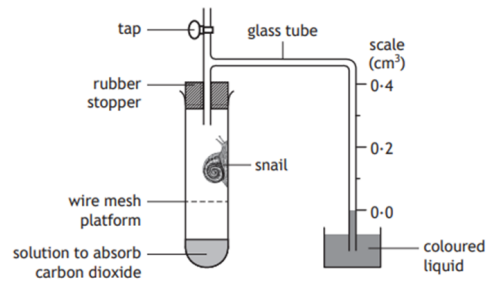# Measuring Metabolic Rates Past Papers

1. The effect of temperature on the metabolic rate of a snail was investigated using the respirometer shown.
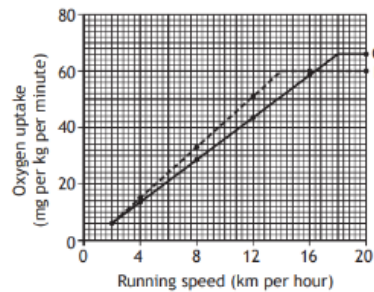

The experiment was carried out at 10°C, 15°C, 20°C and 25°C. At each temperature, the tap was left open for 15 minutes then closed and readings were taken from the scale every 2 minutes.

Identify how the dependent variable was measured.

A   Temperature change

B   Heat production

C   Oxygen consumption

D   Carbon dioxide production

2. The graph below shows how running speed affected the oxygen uptake of two athletes, P and Q.

Which line in the table below shows the fittest athlete based on the information in the graph?

	Athlete	Reason for conclusion
A	P	reached their maximum running speed sooner
B	P	reached their maximum oxygen uptake sooner
C	Q	had a higher running speed than P
D	Q	had a higher maximum oxygen uptake than P

3. An investigation was carried out to determine the respiration rate of maggots at different temperatures.

A probe was used to measure the CO_2 concentration in a sealed flask containing 20 maggots over a 10 minute period at three different temperatures.

The results are shown in the table.

Time (minutes)	CO_2 concentration (ppm)		
	3 °C	20 °C	30 °C
0	7100	7315	7105
2	7760	8010	8330
4	8160	8920	10 480
6	8500	9940	11 980
8	8840	11 840	13 470
10	9150	13 040	15 200

The conclusion relating to the aim of this investigation is, as the temperature increases the rate of

A CO_2 production increases

B CO_2 production decreases

C   respiration increases

D   respiration decreases.

4. Maximum oxygen uptake per kg body mass can be used as a measure of fitness. Four athletes were weighed then given a fitness test during which their maximum oxygen uptake was measured.
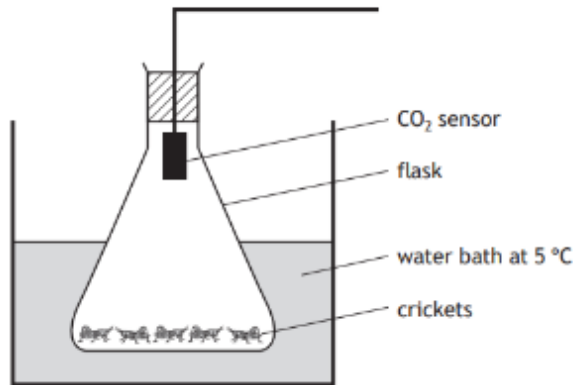
Which line in the table below shows results for the least fit athlete?

Athlete	Body mass (kg)	Maximum oxygen uptake (litres per minute)
A	60	3·6
B	55	3·6
C	60	3·7
D	55	3·7

1 . An investigation was carried out to compare the rate of metabolism in a species of cricket, *Gryllus assimilis*, at different temperatures.

Five crickets were placed in a sealed flask which was fitted with a carbon dioxide (CO_2) sensor as shown in the diagram below.

The flask was placed in a water bath at 5 °C and left for 10 minutes.

The CO_2 produced per minute was then measured. This procedure was repeated at 10, 15, 20 and 30 °C.

The results are shown in the table below.

Temperature (°C)	Rate of CO_2 production (units per minute)
5	300
10	500
15	800
20	1200
30	1600

(a)　(i) Give a reason why the flask was left for 10 minutes at each temperature **before** each reading was taken.　　1

_____

_____

(ii) A control flask should be included in this investigation.

Describe the control and explain its purpose in the investigation.　　2

Description _____

_____

Explanation _____
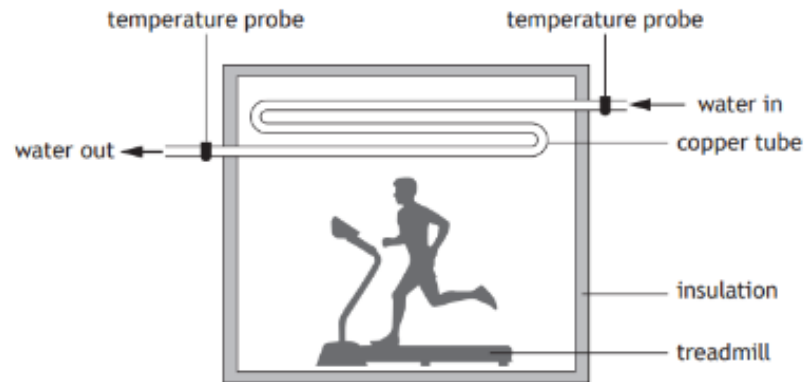
_____

(b) Draw a conclusion from these results.　　1

_____

_____

2 An investigation was carried out to study the effect of intensity of exercise on metabolic rate.

A calorimeter was used to determine metabolic rate as shown in the diagram.

MARK

temperature probe   temperature probe

water in

water out

copper tube

insulation

treadmill

An individual walked on a treadmill in the calorimeter for 30 minutes and the temperature increase of the water was calculated every 5 minutes.

The procedure was repeated in another calorimeter with a different individual who ran on the treadmill.

The results are shown in the table.

	Temperature increase of the water (°C)	
Time (minutes)	Walking	Running
0	0	0
5	0.2	0.4
10	0.3	0.6
15	0.5	0.9
20	0.8	1.1
25	1.1	1.3
30	1.4	1.6

(a) Explain how the design of the calorimeter allowed metabolic rate to be determined.

2

(b) Name the independent variable in this investigation.

1

_____

(c) Identify two variables, not already mentioned, that should be controlled for a valid conclusion to be drawn.

2

1. _____

2. _____

(d) Predict the temperature increase after 35 minutes of walking on the treadmill.

1

_____ °C

(e) Draw a conclusion from the results of this investigation.

1

_____

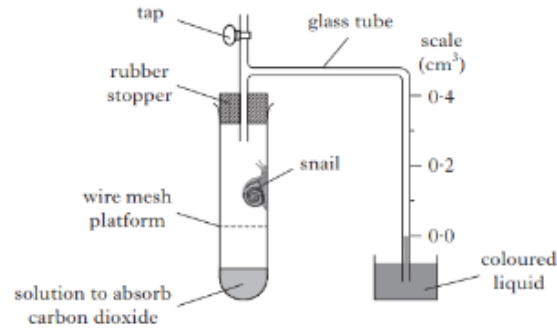_____

3

3 In an investigation into the metabolic rate of a snail at rest, its oxygen uptake was measured using the apparatus shown in the diagram below.

Marks

The apparatus was kept at 10 °C with the tap open for 15 minutes. To start the experiment, the tap was closed and the reading on the scale recorded.

Every 2 minutes for 10 minutes, the oxygen uptake was recorded by taking readings from the scale.

The results are shown in the table below.

Time after tap closed (minutes)	Oxygen uptake (cm³)
0	0·00
2	0·04
4	0·08
6	0·12
8	0·18
10	0·20

(a) (i) Explain why the apparatus was left for 15 minutes with the tap open before readings were taken.

_____

_____ 1

(ii) To ensure validity, identical apparatus was set up without the snail. Explain why this ensures valid results.

_____

(b) (i) Identify the dependent variable in this investigation.

_____

(ii) To increase the reliability of results, the experiment was repeated several times.

Mar

Identify **one** variable, **not already mentioned**, which would have to be kept the same each time to ensure that the procedure was valid.

_____ 1

(c) The mass of the snail was 5·0 g.

Use the results in the table to calculate the average rate of oxygen uptake per gram of snail per minute over the 10 minute period.

Space for calculation

_____ cm³ per gram per minute 1

(d) Predict the effect of an increase in temperature to 15 °C on the oxygen uptake by the snail and justify your answer.

Prediction _____

Justification _____

_____ 1

(e) Explain how the respiration of the snail and the presence of the solution in the test tube results in the movement of liquid on the scale.

_____

_____

_____ 2

M/

4 A study was carried out to compare the metabolic rates of different animals. The body mass and metabolic rate of each animal are shown in the table.

Animal	Body mass (kg)	Metabolic rate (kJ/kg/day)
Wood pigeon	0.3	414.0
Collared dove	0.2	447.0
Roe deer	45.0	96.0
Red deer	200.0	57.5
Herring gull	1.5	220.0

(a) Describe the relationship between the body mass of animals and their metabolic rate. **1**

_____

_____

(b) Calculate how many times greater the metabolic rate of a wood pigeon is compared to a red deer. **1**

Space for calculation

_____ times greater

(c) State why metabolic rate was expressed as per kg. **1**

_____

_____

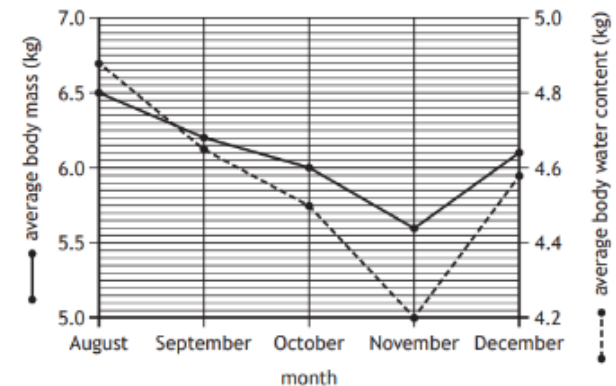(d) Name a piece of equipment used in measuring metabolic rate. **1**

_____

5

5 Freshwater crocodiles (*Crocodylus johnsoni*) in Northern Australia aestivate for up to three months. A study was carried out to investigate aestivation in freshwater crocodiles. The body temperature, metabolic rate, and air temperature were recorded.

The results are shown in the table.

Month	Average body temperature (°C)	Average metabolic rate (kJ/kg/day)	Average air temperature (°C)
August	25.9	36.0	26.2
September	27.9	26.1	28.0
October	27.8	26.5	27.5
November	28.9	25.7	29.5
December	28.7	36.7	28.9

The graph shows the average body mass and the average body water content of the crocodiles between August and December.

(d)

Using information from the table and the graph:

(i) calculate the average energy consumption per day of a crocodile in October. **1**
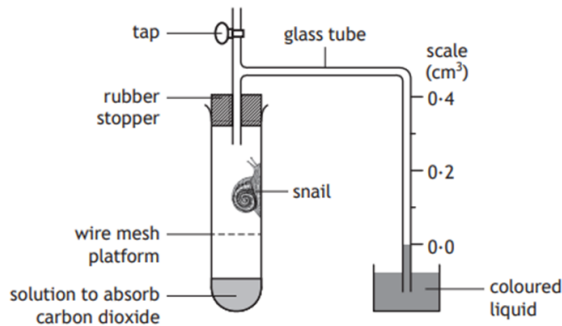
Space for calculation

_____ kJ/day

(ii) state the average metabolic rate when the average body mass was 5.6 kg. **1**

_____ kJ/kg/day

1. The effect of temperature on the metabolic rate of a snail was investigated using the respirometer shown.
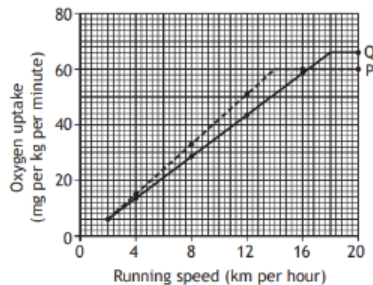

The experiment was carried out at 10°C, 15°C, 20°C and 25°C. At each temperature, the tap was left open for 15 minutes then closed and readings were taken from the scale every 2 minutes.

Identify how the dependent variable was measured.

A Temperature change

B Heat production

C Oxygen consumption

D Carbon dioxide production

2. The graph below shows how running speed affected the oxygen uptake of two athletes, P and Q.

Which line in the table below shows the fittest athlete based on the information in the graph?

	Athlete	Reason for conclusion
A	P	reached their maximum running speed sooner
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3. An investigation was carried out to determine the respiration rate of maggots at different temperatures.

A probe was used to measure the CO_2 concentration in a sealed flask containing 20 maggots over a 10 minute period at three different temperatures.

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8	8840	11 840	13 470
10	9150	13 040	15 200

The conclusion relating to the aim of this investigation is, as the temperature increases the rate of

A CO_2 production increases

B CO_2 production decreases

C respiration increases

D respiration decreases.

4. Maximum oxygen uptake per kg body mass can be used as a measure of fitness. Four athletes were weighed then given a fitness test during which their maximum oxygen uptake was measured.
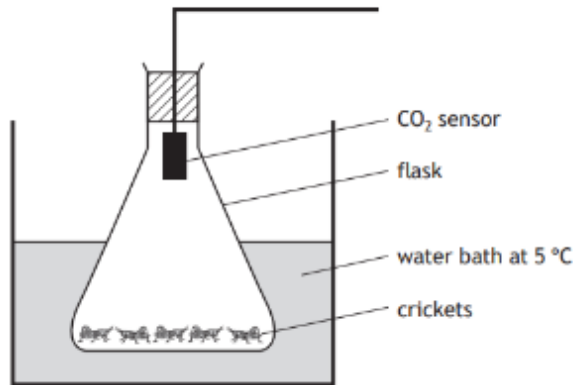
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Athlete	Body mass (kg)	Maximum oxygen uptake (litres per minute)
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D	55	3·7

6

1 An investigation was carried out to compare the rate of metabolism in a species of cricket, *Gryllus assimilis*, at different temperatures.

Five crickets were placed in a sealed flask which was fitted with a carbon dioxide (CO_2) sensor as shown in the diagram below.

The flask was placed in a water bath at 5 °C and left for 10 minutes.

The CO_2 produced per minute was then measured. This procedure was repeated at 10, 15, 20 and 30 °C.

The results are shown in the table below.

Temperature (°C)	Rate of CO_2 production (units per minute)
5	300
10	500
15	800
20	1200
30	1600

(a) (i) Give a reason why the flask was left for 10 minutes at each temperature **before** each reading was taken. **1**

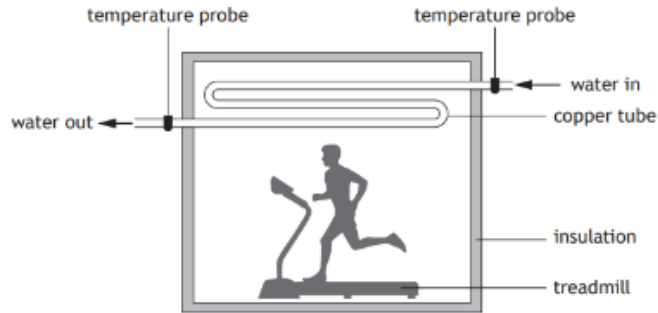To allow crickets to adjust/reach the correct temperature

(b) Draw a conclusion from these results. **1**

As the temperature increased, the rate of metabolism increased.

2 . An investigation was carried out to study the effect of intensity of exercise on metabolic rate.

MARK

A calorimeter was used to determine metabolic rate as shown in the diagram.

temperature probe   temperature probe
water in
water out
copper tube
insulation
treadmill

An individual walked on a treadmill in the calorimeter for 30 minutes and the temperature increase of the water was calculated every 5 minutes.

The procedure was repeated in another calorimeter with a different individual who ran on the treadmill.

The results are shown in the table.

Time (minutes)	Temperature increase of the water (°C)	
	Walking	Running
0	0	0
5	0.2	0.4
10	0.3	0.6
15	0.5	0.9
20	0.8	1.1
25	1.1	1.3
30	1.4	1.6

(a) Explain how the design of the calorimeter allowed metabolic rate to be determined.

2

1st mark: probes measure the increase/change in water temperature

OR Copper tube has a large surface area. OR good conductor of heat

OR Insulation reduces/ prevents heat loss.   (1 mark)

2nd mark: Metabolic rate can be measured by heat production/ OR Metabolism give out heat.

(b) Name the independent variable in this investigation.

1

Intensity of exercise

(c) Identify two variables, not already mentioned, that should be controlled for a valid conclusion to be drawn.

2

Age/sex/fitness/clothing/food intake/hydration levels
1.

Thickness of insulation/incline of treadmill/
2.
oxygen concentration/temp   at start

(d) Predict the temperature increase after 35 minutes of walking on the treadmill.

1

1.7
_____°C

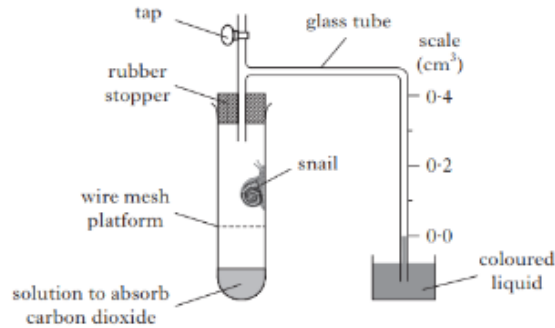(e) Draw a conclusion from the results of this investigation.

1

As Intensity of exercise increase, metabolic rate increases

3 In an investigation into the metabolic rate of a snail at rest, its oxygen uptake was measured using the apparatus shown in the diagram below.

Marks

The apparatus was kept at 10°C with the tap open for 15 minutes. To start the experiment, the tap was closed and the reading on the scale recorded.

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(a) (i) Explain why the apparatus was left for 15 minutes with the tap open before readings were taken.

To allow time for snail to adjust to temperature

1

(ii) To ensure validity, identical apparatus was set up without the snail.
Explain why this ensures valid results.

Proves snail was causing coloured liquid to rise/increase in oxygen uptake

(b) (i) Identify the dependent variable in this investigation.

Metabolic rate

(ii) To increase the reliability of results, the experiment was repeated several times.

Mar

Identify **one** variable, **not already mentioned**, which would have to be kept the same each time to ensure that the procedure was valid.

Diameter of tube/ concentration OR volume of solution to absorb CO_2

1

(c) The mass of the snail was 5·0 g.

Use the results in the table to calculate the average rate of oxygen uptake per gram of snail per minute over the 10 minute period.

Space for calculation   0.2 divide by 10 minutes divide by 5g

0.004   cm³ per gram per minute   1

(d) Predict the effect of an increase in temperature to 15°C on the oxygen uptake by the snail and justify your answer.

Prediction   increase

Justification   Nearer enzyme optimum temperature increases enzyme activity

required for respiration   1

(e) Explain how the respiration of the snail and the presence of the solution in the test tube results in the movement of liquid on the scale.

Oxygen taken in by snail whilst carbon dioxide given out absorbed by solution

Reducing volume in test tube drawing liquid up tube.

2

4 A study was carried out to compare the metabolic rates of different animals. The body mass and metabolic rate of each animal are shown in the table.

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Wood pigeon	0.3	414.0
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Herring gull	1.5	220.0

(a) Describe the relationship between the body mass of animals and their metabolic rate. **1**

As body mass increased, metabolic rate increased

(b) Calculate how many times greater the metabolic rate of a wood pigeon is compared to a red deer. **1**

Space for calculation

7.2
_____ times greater

(c) State why metabolic rate was expressed as per kg. **1**

Body masses are different

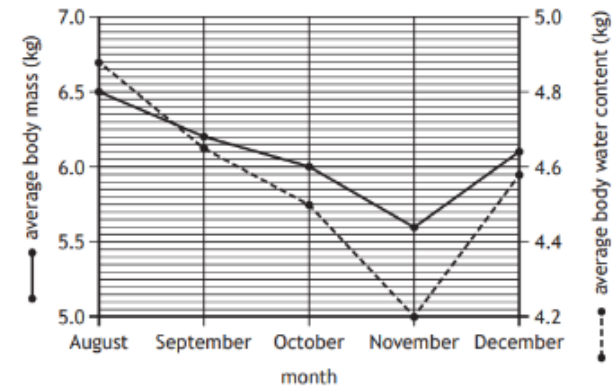(d) Name a piece of equipment used in measuring metabolic rate. **1**
Oxygen probe, carbon dioxide probe, respirometer, calorimeter

10

5 Freshwater crocodiles (*Crocodylus johnsoni*) in Northern Australia aestivate for up to three months. A study was carried out to investigate aestivation in freshwater crocodiles. The body temperature, metabolic rate, and air temperature were recorded.

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The graph shows the average body mass and the average body water content of the crocodiles between August and December.

(d)

Using information from the table and the graph:

(i) calculate the average energy consumption per day of a crocodile in October. **1**

Space for calculation

26.1 x 5

130.5
_____ kJ/day

(ii) state the average metabolic rate when the average body mass was 5.6 kg. **1**

____36____ kJ/kg/day