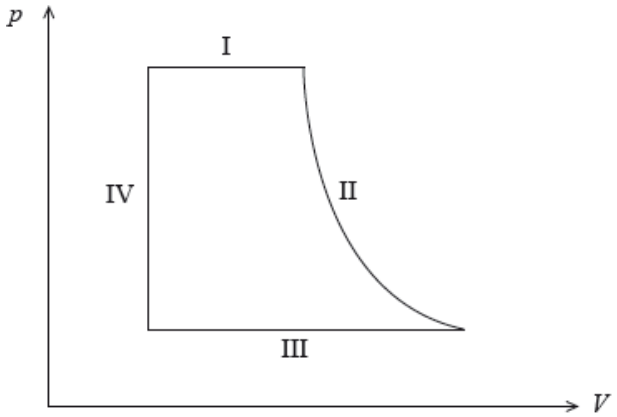
HL Paper 1

The diagram shows the pressure p and volume V relationship for one cycle of operation of an engine.



Which of the labelled parts of the cycle identify isobaric changes and adiabatic changes of state?

	Isobaric	Adiabatic
A.	IV only	I and II only
B.	I and III only	II and IV only
C.	II and III only	IV only
D.	I and III only	II only

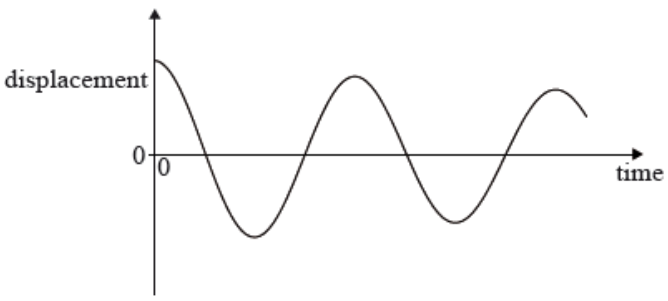
Markscheme

D

Examiners report

[N/A]

The graph below represents the variation with time of the displacement of an oscillating particle.



The motion of the object is

A. over damped.

B. critically damped.

C. lightly damped.

D. not damped.

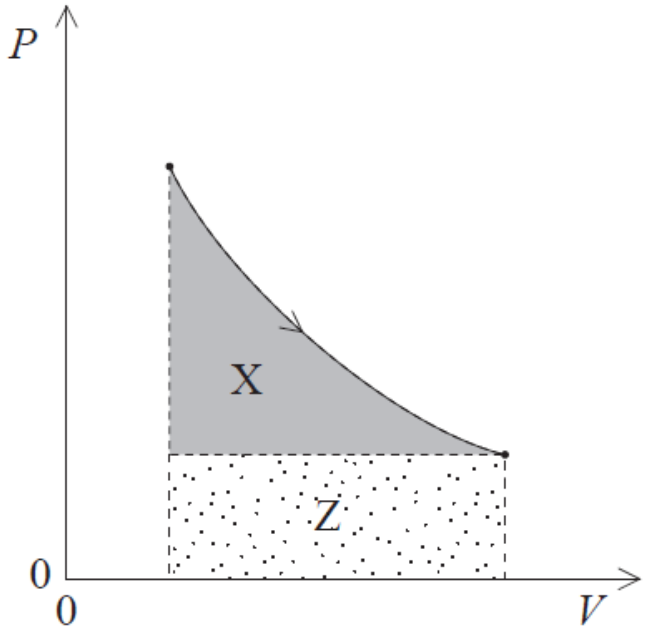
Markscheme

C

Examiners report

[N/A]

The graph shows the variation of pressure *P* with volume *V* for a gas undergoing an adiabatic expansion.



Which of the following areas correctly identifies the work done by the gas?

A. X
B. X+Z
C. X–Z
D. Z

Markscheme

B

Examiners report

The work done on a gas is the total area under a P-V graph. Many candidates incorrectly opted for response A.

Microwave ovens cause the water molecules in food to resonate. Water molecules have a natural frequency of vibration *f*. In order to heat the food most effectively, the frequency of the microwaves should have a value

A. less than *f*.
B. equal to *f*.
C. greater than *f*.
D. as large as possible.

Markscheme

B

Examiners report

[N/A]

Which of the following can be deduced from the second law of thermodynamics?

A. Thermal energy cannot spontaneously transfer from a low temperature region to a high temperature region.
B. Thermal energy cannot spontaneously transfer from a high temperature region to a low temperature region.
C. The entropy of an isolated system always decreases with time.
D. The entropy of an isolated system is the measure of the internal energy of the system.

Markscheme

A

Examiners report

[N/A]

Which of the following is equivalent to the principle of energy conservation?

A. Newton’s first law
B. The first law of thermodynamics
C. Newton’s second law
D. The second law of thermodynamics

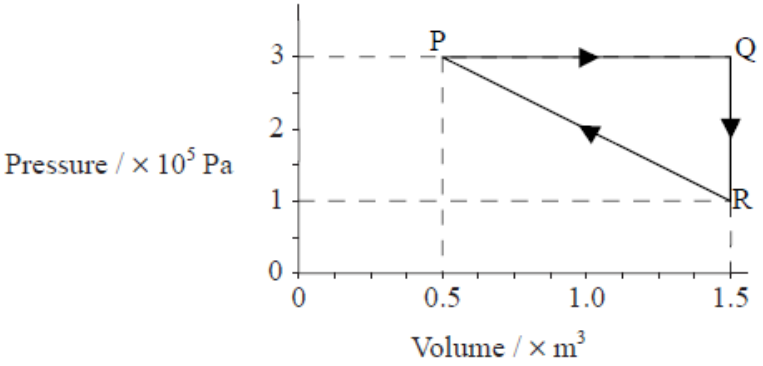
Markscheme

B

Examiners report

[N/A]

An ideal gas undergoes the thermodynamic changes represented in the *P* –*V* diagram below (P→Q→R→P).



Which of the following is the net work done by the gas in a cycle?

A. 4.5×10^5 J
B. 3.0×10^5 J
C. 1.0×10^5 J
D. Zero

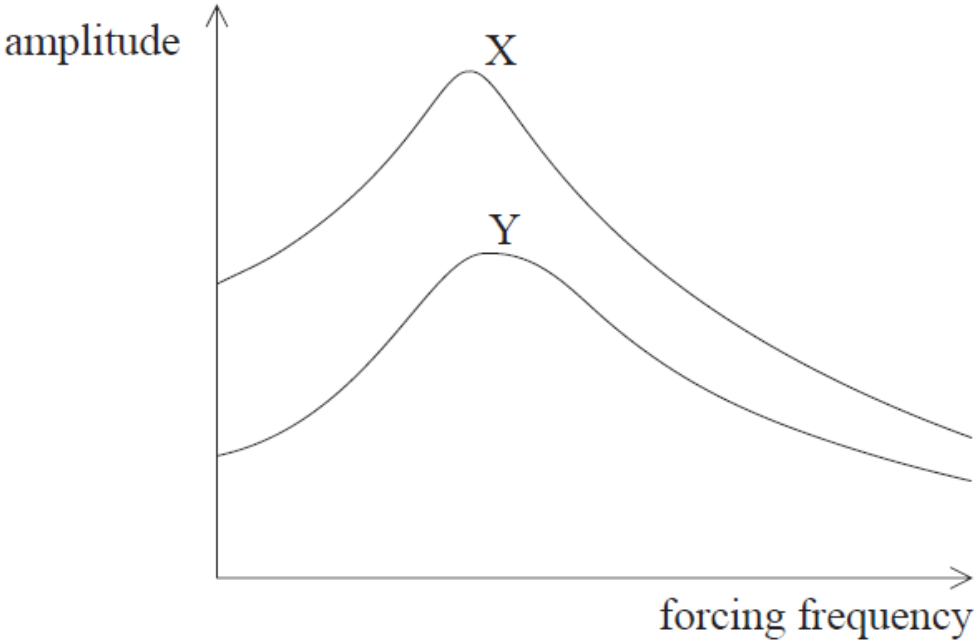
Markscheme

C

Examiners report

[N/A]

Two oscillators X and Y are undergoing forced oscillations each at a frequency close to the natural frequency of each oscillator. The graph shows the variation of amplitude with forcing frequency for each oscillator.



Which of the following correctly identifies the system that has the greater amount of damping and the greater natural frequency of oscillation?

	Greater amount of damping	Greater natural frequency
A.	X	X
B.	X	Y
C.	Y	X
D.	Y	Y

Markscheme

D

Examiners report

This question elicited a number of comments on the G2s and the statistics showed that the topic had been sufficiently understood by only the better candidates. These two systems were clearly not identical – otherwise they would have had the same y-intercept. Y had a blunter peak which was visibly to the right of X's peak, making D the best answer.

A fixed mass of gas is compressed in a very short period of time. Which of the following describes this process?

A. Adiabatic
B. Isobaric
C. Isochoric (isovolumetric)
D. Isothermal

Markscheme

A

Examiners report

[N/A]

The entropy of a system is a measure of the system's

A. total energy only.
B. degree of disorder and total energy.
C. degree of disorder only.
D. degree of disorder and average kinetic energy.

Markscheme

C

Examiners report

[N/A]

A system consists of a refrigerator with its door open operating in a thermally insulated room. What are the change in the entropy of the system and the change in temperature of the room?

	Entropy change of system	Temperature change of room
A.	decreases	decreases
B.	decreases	increases
C.	increases	decreases
D.	increases	increases

Markscheme

D

Examiners report

The fridge is switched on and is within a closed system. This means that, as the fridge is consuming energy, the room will rise in temperature.

An ideal gas expands isothermally from a state X to a new state of volume V. The work done by the gas is W. Which of the following is correct for an adiabatic expansion of the gas from state X to a new state of volume V?

	Change in internal energy	Work done
A.	$\Delta U > 0$	greater than W
B.	$\Delta U < 0$	greater than W
C.	$\Delta U > 0$	less than W
D.	$\Delta U < 0$	less than W

Markscheme

D

Examiners report

[N/A]

Which of the following correctly describes the entropy changes of the water molecules and the universe when a sample of water freezes?

	Water molecules	Universe
A.	increases	increases
B.	decreases	increases
C.	increases	decreases
D.	decreases	decreases

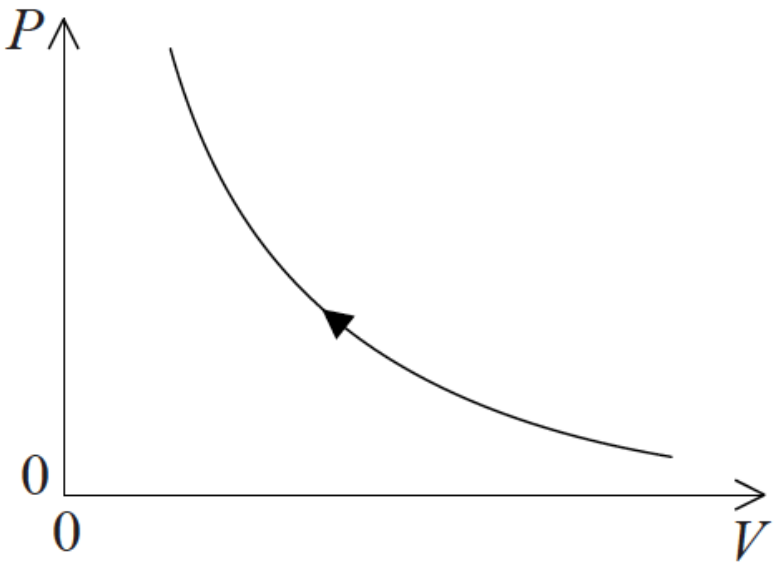
Markscheme

B

Examiners report

[N/A]

The pressure–volume (*P*–*V*) graph shows an adiabatic compression of a fixed mass of an ideal gas.



Which of the following correctly describes what happens to the temperature and the internal energy of the gas during the compression?

	Temperature	Internal energy
A.	decreases	decreases
B.	increases	no change
C.	decreases	no change
D.	increases	increases

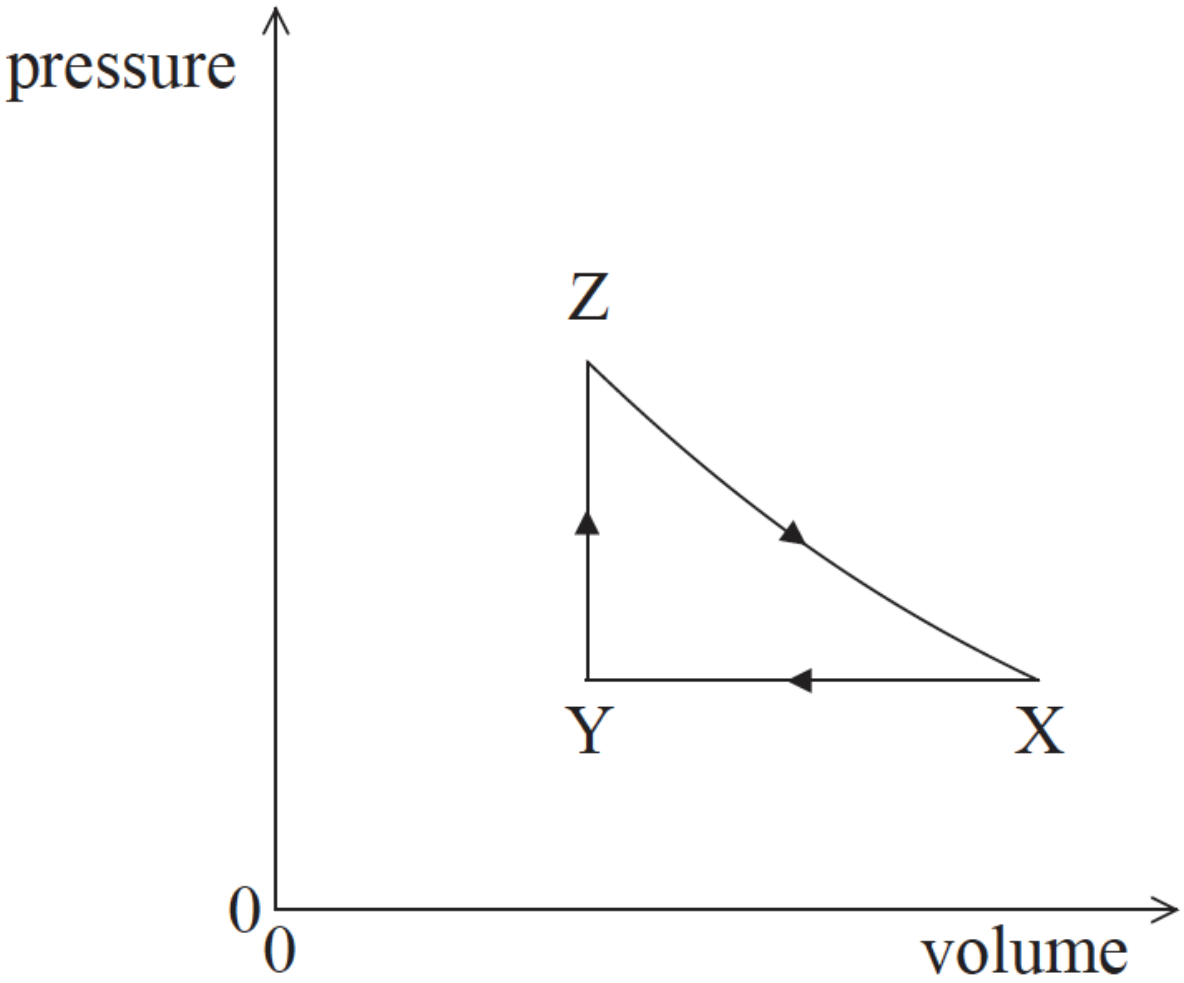
Markscheme

D

Examiners report

[N/A]

The diagram shows the pressure volume relationship for a fixed mass of an ideal gas that undergoes a cycle XYZ.



In which part(s) of the cycle is external work done **on** the gas?

A. Y→Z only

B. Y→Z and Z→X only

C. X→Y and Z→X only

D. X→Y only

Markscheme

D

Examiners report

Water in a container freezes. Which of the following correctly describes the change in entropy of the water and its surroundings?

	Change in entropy of water	Change in entropy of surroundings
A.	decrease	decrease
B.	decrease	increase
C.	increase	decrease
D.	increase	increase

Markscheme

B

Examiners report

[N/A]

An isolated system consists of a block of ice floating in a glass of water. The ice melts completely at constant temperature. Which of the following identifies the change in internal energy of the system and the change in entropy of the system?

	Internal energy	Entropy
A.	no change	increase
B.	no change	decrease
C.	increase	decrease
D.	increase	increase

Markscheme

A

Examiners report

There were a number of comments on this question from the teachers. In this situation the slight change in volume of the water/ice can be taken as negligible and it must be assumed that the water is not at 0°C, otherwise no melting would occur. The statistics showed that the better candidates understood this, choosing A as the best response.

An ideal gas expands adiabatically. What energy change is **true** for the gas?

A. It gains thermal energy from the surroundings
B. It loses thermal energy to the surroundings
C. Its internal energy increases
D. Its internal energy decreases

Markscheme

D

Examiners report

There were two aspect to this – adiabatic means no thermal energy transfer (ruling out A and B); expansion means work done on the surroundings and loss of internal energy to do the work. D is the only response matching this.

An ideal gas undergoes adiabatic expansion from state X to a new state of volume *V*. During this process the work done by the gas is *W*. What is the change in internal energy and the work done in an **isothermal** expansion of this gas from X to *V*?

	Change in internal energy	Work done
A.	0	greater than *W*
B.	0	less than *W*
C.	greater than 0	less than *W*
D.	less than 0	same as *W*

Markscheme

A

Examiners report

[N/A]

The entropy of a system

A. will decrease if the system’s temperature is increased.

B. is related to the degree of disorder in the system.

C. must always increase.

D. is always conserved.

Markscheme

B

Examiners report

[N/A]

A positive amount of thermal energy Q is transferred to an ideal gas from its surroundings. The internal energy of the gas increases and the gas does a positive amount of work W on its surroundings. The change of state of the gas is

A. isochoric (isovolumetic).

B. isobaric.

C. isothermal.

D. adiabatic.

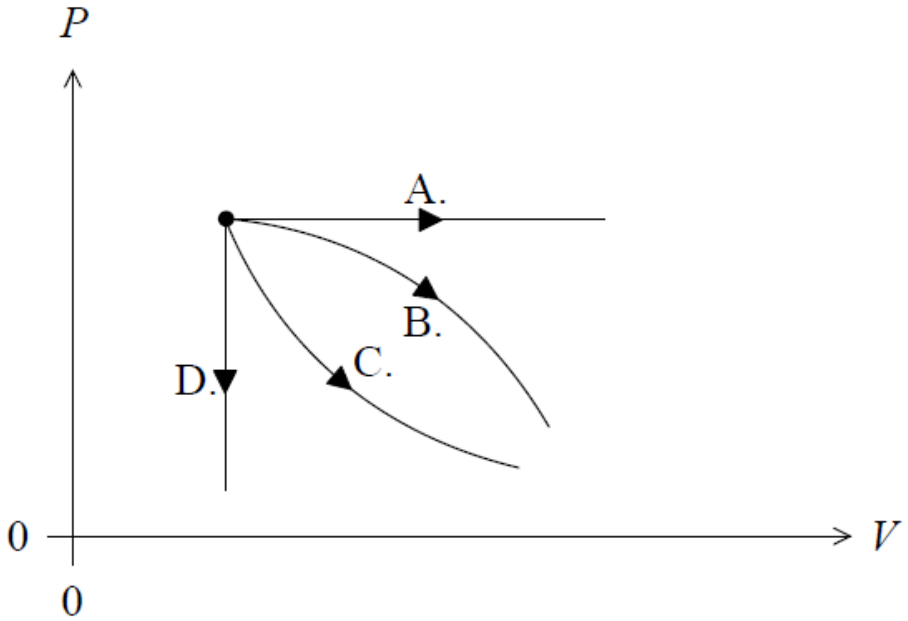
Markscheme

B

Examiners report

[N/A]

In the *P*–*V* diagram below, which line could represent an adiabatic change for an ideal gas?



Markscheme

C

Examiners report

[N/A]

A block of ice at 0°C is placed on a surface and allowed to melt completely to give water at 0°C. During this process the entropy of the

A. molecules in the block has decreased.

B. surroundings has increased.

C. universe has increased.

D. universe has decreased.

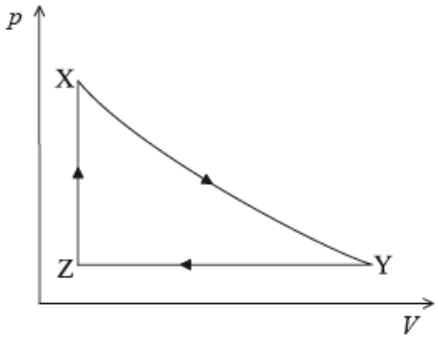
Markscheme

C

Examiners report

[N/A]

The graph below shows the variation of the pressure p with volume V of an ideal gas during one cycle of an engine.



Which of the following correctly names the thermodynamic process associated with the parts $\mathrm{Y} \rightarrow \mathrm{Z}$ and $\mathrm{Z} \rightarrow \mathrm{X}$ of the cycle?

	Y→Z	Z→X
A.	isobaric	isochoric
B.	isobaric	isothermal
C.	isochoric	isobaric
D.	isochoric	isothermal

Markscheme

A

Examiners report

[N/A]

Which of the following statements is consistent with the second law of thermodynamics?

A. Thermal energy can ow by itself from a cold to a hot body.
B. A heat engine can be 100 % ef cient.
C. In natural processes, total entropy tends to increase.
D. The entropy in every closed system is constant.

Markscheme

C

Examiners report

[N/A]

Which process will increase the entropy of the local surroundings?

A. The melting of a block of ice

B. Evaporation of water vapour

C. The isothermal expansion of a gas

D. The adiabatic expansion of a gas

Markscheme

C

Examiners report

There is evidence of much guessing in this question and it elicited a few adverse comments from the teachers. But both A and B are logically equivalent so must be wrong. As an adiabatic expansion involves no thermal exchange with the surroundings, this will not affect the entropy of the local surroundings. Hence C must be correct by elimination.

During an adiabatic expansion, a gas does 50J of work against the surroundings. It is then cooled at constant volume by removing 20J of energy from the gas. The magnitude of the total change in internal energy of the gas is

A. 70 J.
B. 50 J.
C. 30 J.
D. 20 J.

Markscheme

A

Examiners report

The following statement refers to question 11 and question 12.

A gas is contained in a thermally insulated cylinder by a freely moving piston. The volume of the gas is increased reversibly by moving the piston.

Which term identifies the change of state of the gas?

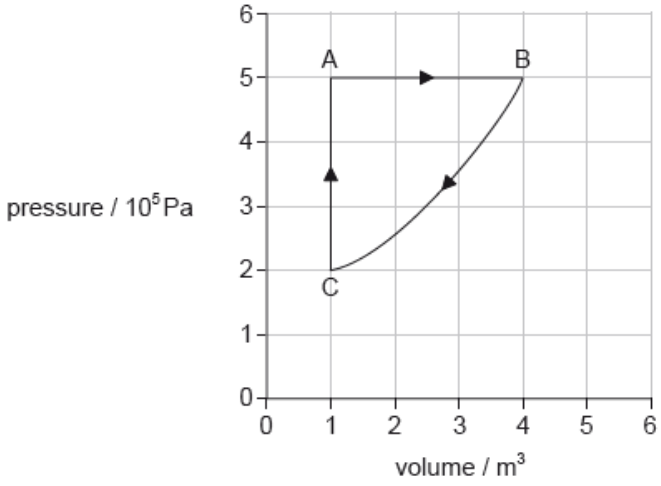
A. Isobaric
B. Isochoric
C. Isothermal
D. Adiabatic

Markscheme

D

Examiners report

The graph shows how the volume of a system varies with pressure during a cycle ABCA.



What is the work done in joules during the change AB?

A. 15×10^5

B. 9.0×10^5

C. 4.5×10^5

D. 0

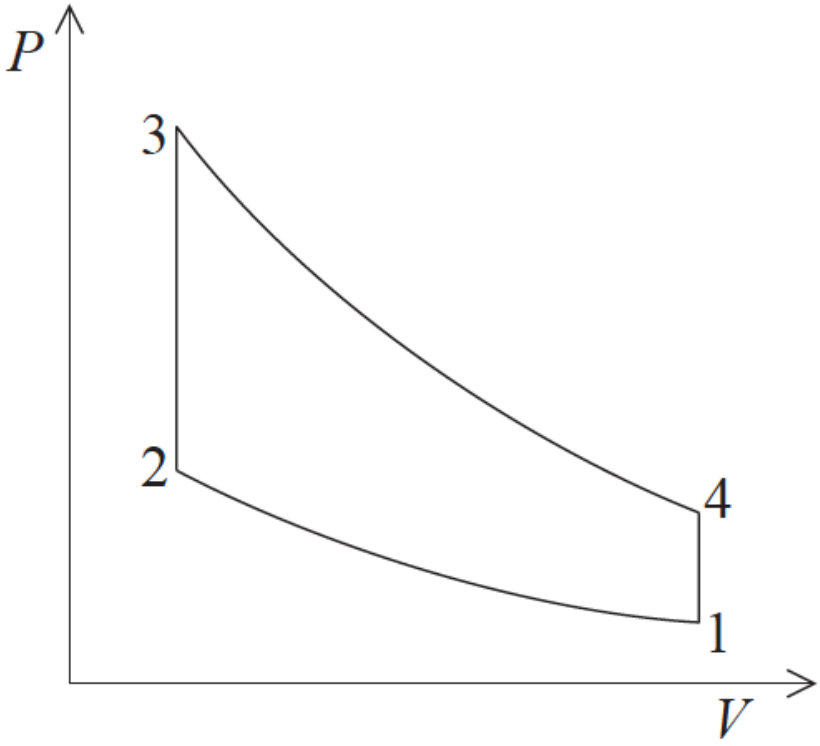
Markscheme

A

Examiners report

[N/A]

The diagram shows a *P*–*V* cycle for a particular gas.



In which of the following changes is **no** work being done?

A. 1 → 2
B. 1 → 2 → 3
C. 1 → 2 → 3 → 4
D. 2 → 3

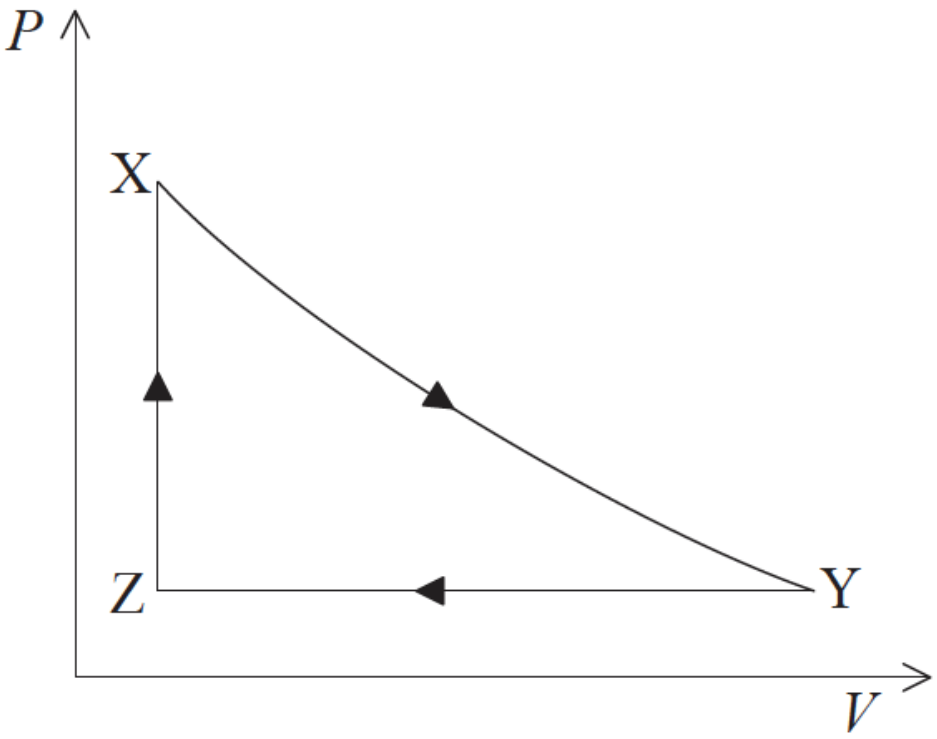
Markscheme

D

Examiners report

[N/A]

The graph shows the variation of pressure *P* with volume *V* of an ideal gas during a thermodynamic cycle.



During which stages is work done on the gas and work done by the gas?

	Work done on gas	Work done by gas
A.	X→Y only	Y→Z only
B.	X→Y and Z→X	Y→Z only
C.	Y→Z only	Z→X and X→Y
D.	Y→Z only	X→Y only

Markscheme

D

Examiners report

[N/A]

Which of the following gives the conditions for maximum amplitude in forced, but damped, oscillations?

	Driving frequency	Damping
A.	greater than natural frequency	as large as possible
B.	equal to natural frequency	as large as possible
C.	greater than natural frequency	as small as possible
D.	equal to natural frequency	as small as possible

Markscheme

D

Examiners report

[N/A]

The following statement refers to question 11 and question 12.

A gas is contained in a thermally insulated cylinder by a freely moving piston. The volume of the gas is increased reversibly by moving the piston.

Which of the following gives the correct entropy change of the gas and the surroundings?

	Entropy change of the gas	Entropy change of the surroundings
A.	decrease	decrease
B.	no change	decrease
C.	decrease	no change
D.	no change	no change

Markscheme

D

Examiners report

There were many comments on this question from the teachers, ranging from it being unfair to it being impossible. The physics of the situation is clear, though. The process is adiabatic, as there is no thermal energy transfer involved. It is also reversible. Hence there is no change of entropy either in the gas or the surroundings (Entropy change = ΔQ/T). Alternatively it can be argued that the total entropy cannot decrease, hence, by elimination, D must be the best answer. This question is covered by the syllabus item 10.3.3 and was deemed fair.

A piece of ice melts at constant temperature. Which of the following gives the correct change in the entropy of the water molecules and that of the surroundings?

	entropy of water molecules	entropy of surroundings
A.	increases	decreases
B.	decreases	decreases
C.	increases	increases
D.	decreases	increases

Markscheme

A

Examiners report

A large number of candidates opted for C. This stems from the misconception that the entropy of the surroundings must always increase, but there are situations where there may be a decrease in the entropy of the surroundings.