Thermodynamics - 2023 A2 Physics 9702

1. Nov/2023/Paper_9702/41/No.2

(a) Define specific heat capacity.

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.... [2]

(b) An ideal gas of mass 0.35 kg is heated at a constant pressure of 2.0×10^5 Pa so that its internal energy increases by 7600 J. During this process, the volume of the gas increases from 0.038 m^3 to 0.063 m^3 and the temperature increases by 56 °C.

(i) Show that the magnitude of the work done on the gas is 5000 J.

[1]

(ii) Explain whether the work done on the gas is positive or negative.

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.... [2]

(iii) Determine the magnitude of the thermal energy q transferred to the gas.

q = ... J [2]

(iv) Calculate the specific heat capacity of the gas for this process. Give a unit with your answer.

specific heat capacity = ... unit .... [2]

(c) The gas in **(b)** is now heated at constant volume rather than at constant pressure. The increase in internal energy of the gas is the same as in **(b)**.

Use the first law of thermodynamics to explain whether the specific heat capacity of the gas for this process is less than, the same as, or greater than the answer in **(b)(iv)**.

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.... [3]

[Total: 12]

2. Nov/2023/Paper_9702/42/No.3

(a) State what is meant by the internal energy of a system.

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.... [2]

(b) Use the first law of thermodynamics to explain what happens to the internal energy:

(i) of a spring when it is stretched at constant temperature within its elastic limit

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.... [3]

(ii) of a sample of water when it evaporates from a rain puddle on a hot day.

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.... [3]

[Total: 8]

3. June/2023/Paper_9702/41/No.4b(ii , iii)

(b) An ideal gas has amount of substance *n*.
The gas is initially in state X, with pressure 2*p* and volume *V*.
The gas is cooled at constant volume to state Y, with pressure *p*.
The gas is then heated at constant pressure to state Z, with volume 2*V*.
Finally, the gas returns at constant temperature to state X.

(ii) On Fig. 4.1, sketch the variation with volume of pressure for the gas as the gas undergoes the three changes. The state X is labelled. Label states Y and Z.

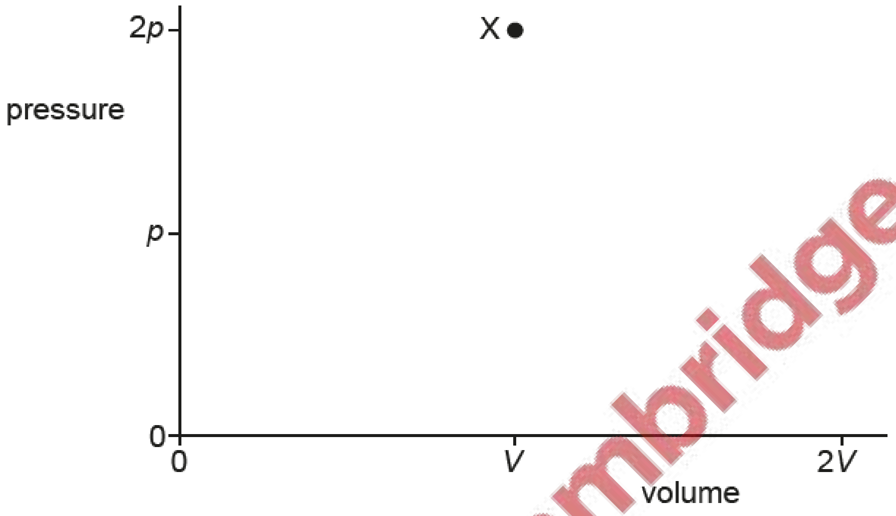

Fig. 4.1

[3]

(iii) During the change of state from Y to Z, the increase in internal energy of the gas is *U*. During the change of state from Z to X, the work done on the gas is *W*.

Complete Table 4.1 to indicate, for each of the three changes of state, the increase in internal energy of the gas, the thermal energy transferred to the gas and the work done on the gas, in terms of *p*, *V*, *U* and *W*.

Table 4.1

change	increase in internal energy of gas	thermal energy transferred to gas	work done on gas
X to Y			
Y to Z	$+U$		
Z to X			$+W$

[5]

4. June/2023/Paper_9702/42/No.3

(a) State the first law of thermodynamics. Identify the meaning of any symbols that you use.

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.... [2]

(b) The state of an ideal gas is continuously changed according to the cycle ABCDA shown in Fig. 3.1.

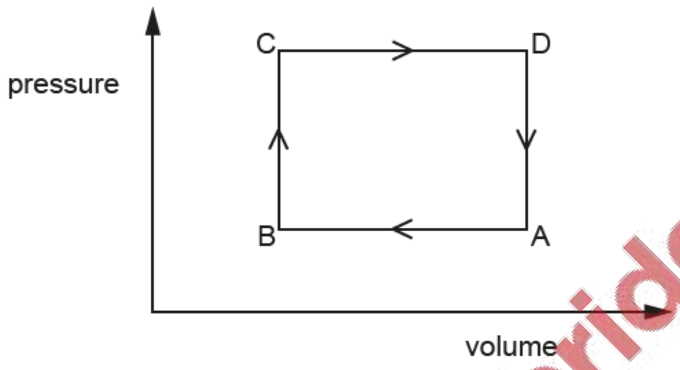

Fig. 3.1

(i) Complete Table 3.1 for the changes A to B and B to C by placing two ticks (✓) in each row.

Table 3.1

change	change in internal energy			work done on gas		
	decrease	no change	increase	negative	zero	positive
A to B						
B to C						

[4]

(ii) Use the first law of thermodynamics to describe and explain the energy transfers associated with one complete cycle ABCDA.

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.... [3]

[Total: 9]

5. March/2023/Paper_9702/42/No.2b(ii), (iii)

(b) A fixed amount of helium gas is sealed in a container. The helium gas has a pressure of 1.10×10^5 Pa, and a volume of 540 cm^3 at a temperature of 27 °C.

The volume of the container is rapidly decreased to 30.0 cm^3. The pressure of the helium gas increases to 6.70×10^6 Pa and its temperature increases to 742 °C, as illustrated in Fig. 2.1.

initial state	final state
1.10×10^5 Pa	6.70×10^6 Pa
540 cm^3	30.0 cm^3
27 °C	742 °C

Fig. 2.1

No thermal energy enters or leaves the helium gas during this process.

(ii) The first law of thermodynamics may be expressed as

$$\Delta U = q + W.$$

Use the first law of thermodynamics to explain why the temperature of the helium gas increases.

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.... [2]

(iii) The average translational kinetic energy E_K of a molecule of an ideal gas is given by

$$E_K = \frac{3}{2}kT$$

where k is the Boltzmann constant and T is the thermodynamic temperature.

Calculate the change in the total kinetic energy of the molecules of the helium gas.

change in kinetic energy = ... J [3]