9 **(a)** Sample of material A and sample of material B are at different initial temperatures when they are placed in a thermally insulated container and allowed to come to *thermal equilibrium*.

Fig. 9.1 gives the graph of variation with time t of their temperature θ. Sample A has a mass of 5.0 kg; sample B has a mass of 1.5 kg.

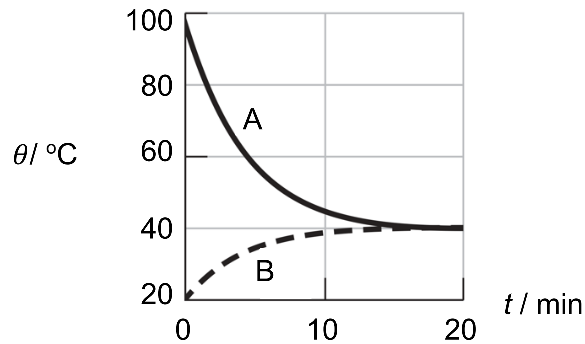

Fig. 9.1

Fig. 9.2 is a plot for material B. It shows the temperature change $\Delta\theta$ that the material undergoes when thermal energy Q is transferred to it. The change in temperature $\Delta\theta$ is plotted against the thermal energy Q per unit mass of the material.

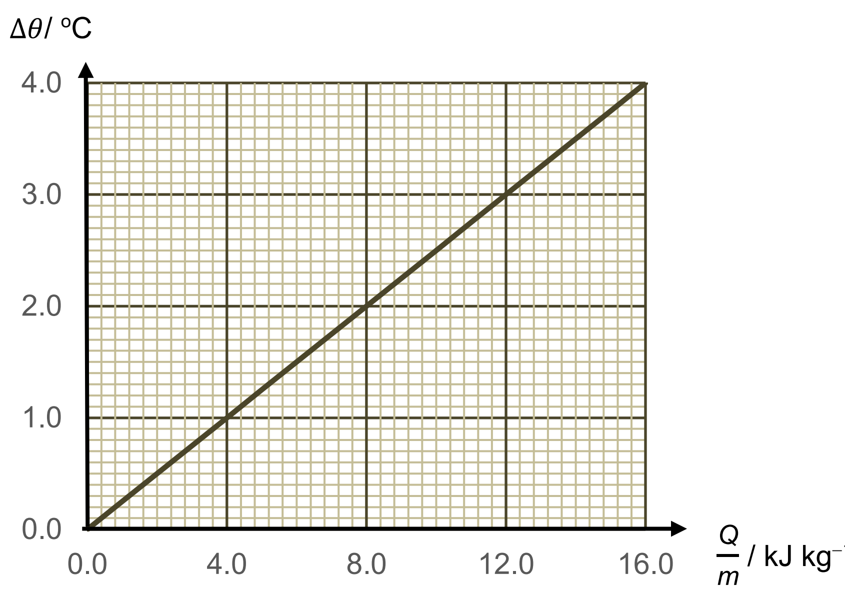

Fig. 9.2

(i) Explain what is meant by sample A and sample B in thermal equilibrium and thus comment about their temperature.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Use Fig. 9.2 to find specific heat capacity of material B.

specific heat capacity =………………………… J kg^{-1} K^{-1} [2]

(iii) Use your answer in **(a)(ii)** and **Fig. 9.1** to find the specific heat capacity of material A.

specific heat capacity = ………………………… J kg^{-1} K^{-1} [2]

(iv) Sketch on Fig. 9.2 the change in temperature $\Delta\theta$ versus the thermal energy Q per unit mass for material A. [1]

(b) Fig. 9.3 shows a cylinder containing ideal gas and closed by a movable piston. The cylinder is kept submerged in an ice-water mixture.

process 1: The piston is quickly pushed down from position 1 to position 2. The process occurs so fast that there is not enough time for heat to be transferred.

process 2: The piston is held at position 2 until the gas is again at the temperature of the ice-water mixture.

process 3: The piston then is slowly raised back to position 1.

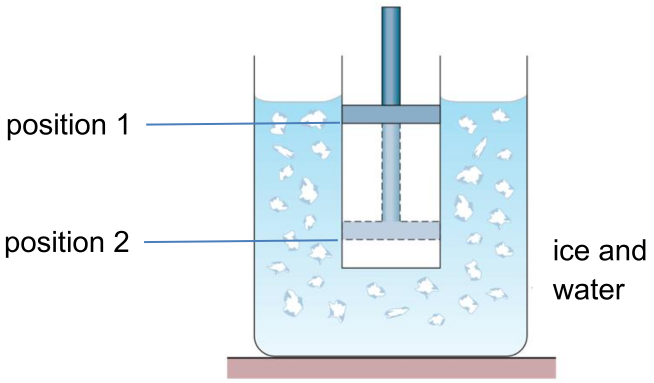

Fig. 9.3

Fig. 9.4 is a pressure-volume diagram for the processes.

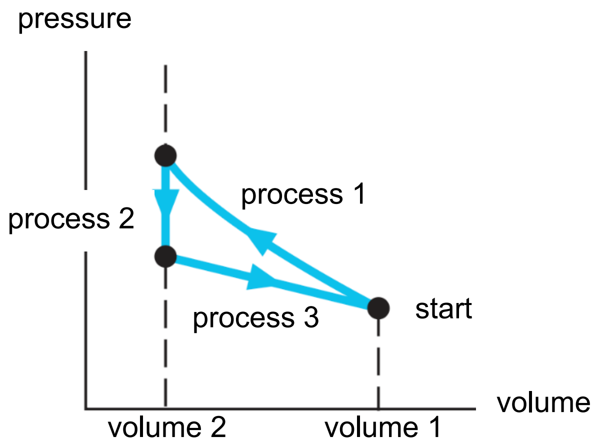

Fig. 9.4

(i) The equation below describes first law of thermodynamics

$$\Delta u = q + w$$

Explain what each term means.

Δu : …………………………………………….

q : ……………………………………………

w : ……………………………………………

[2]

(ii) For process 1, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5.

[1]

	Δu	q	w
process 1			
process 2			
process 3			

Fig. 9.5

(iii) For process 2, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………… [3]

(iv) For process 3, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………… [2]

(v) If 100 g of ice is melted during the cycle, determine the work done on the gas?

Specific latent heat of fusion of water = 334 J g^{-1}

work done = ………………………… J [2]

(c) **(i)** A student uses a constant-volume gas thermometer to measure the pressure of a gas at different temperatures on a Celsius scale. The results are shown in Fig. 9.6.

Temperature / °C	Pressure / kPa
0	100
100	137

Fig. 9.6

Assuming that pressure is proportional to absolute temperature, estimate the temperature in °C at which the pressure of the gas would become zero.

temperature = ……………… °C [2]

(ii) Experiments were carried out with different gases at different initial pressures. Fig. 9.7 shows that the thermometer readings tend to the same point nearly independent of the type of gas at low pressure.

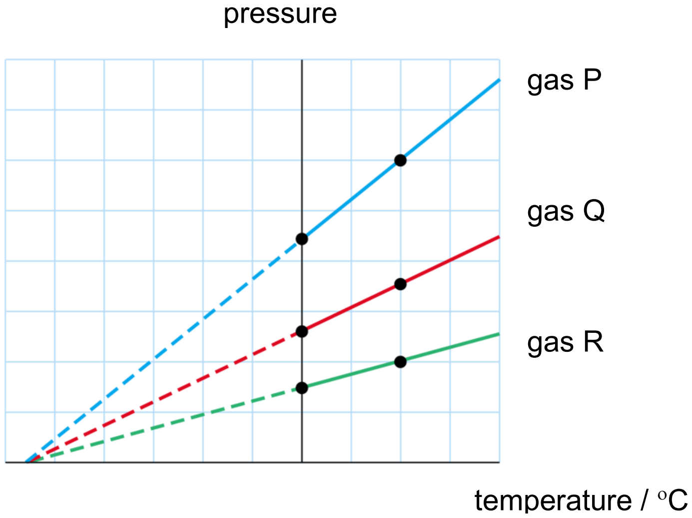

Fig. 9.7

Suggest a reason why different gases may agree only at low pressure.

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.... [1]