8 **(a)** A mercury-in-glass thermometer is initially at 23.0 °C. It is used to measure the temperature of an insulated beaker of water that is at 37.4 °C. The bulb of the thermometer is inserted into the water, and the water is stirred until the reading on the thermometer becomes steady.

The mass of water in the beaker is 18.7 g.

The mass of mercury in the thermometer is 6.94 g.

The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

The specific heat capacity of mercury is 0.140 J g^{-1} K^{-1}.

(i) Calculate, the final steady temperature indicated by the thermometer in the water.

temperature = ... °C [3]

(ii) It may be assumed that negligible heat is lost to the surroundings during the measurement of the temperature of the water, due to sufficient insulation provided by the beaker.

State one other assumption that you have used in your calculations in part **(a)(i)**.

…….....

……..... [1]

(iii) Suggest **one** change that could be made to the design of the thermometer that would enable it to give a more accurate measurement of temperature.

…….....

……..... [1]

(iv) Explain why the thermometer in **(a)** does **not** provide a direct measurement of thermodynamic temperature.

……

……

…… [2]

(v) Thermodynamic temperature T may be determined by the behaviour of a type of substance for which T is proportional to the product of pressure and volume.

State the name of this type of substance.

…… [1]

(b) A sealed container of fixed volume V contains N molecules, each of mass m, of an ideal gas at pressure p. The gas is supplied with thermal energy Q.

(i) Explain why the internal energy of the gas is equal to the total kinetic energy of the molecules.

……

……

…… [2]

(ii) Explain, with reference to the first law of thermodynamics, why the increase in internal energy of the gas is Q.

……

……

…… [2]

(iii) Use the information in **(b)(ii)** to show that the specific heat capacity c of the gas is given by

$$c = \frac{3k}{2m}.$$

[3]

(iv) The container in **(b)** is now replaced with one that does not have a fixed volume. Instead, it now has a movable frictionless piston.

Suggest, with a reason, how the specific heat capacity of the gas would now compare with the value in **(b)(iii)**.

……

……

……

…… [2]

(v) The piston in **(b)(iv)** is now moved so that the gas expands, without supplying thermal energy.

Use kinetic theory to explain whether this will cause a change in the temperature of the gas.

……

……

……

…… [3]

[Total: 20]