1 A car of mass 970 kg is travelling at 27 m s^{-1} when the brakes are applied. The car is brought to rest in a distance of 40 m.

(a) **(i)** Calculate the kinetic energy of the car when it is travelling at 27 m s^{-1}.

kinetic energy = ... J **[1]**

(ii) Hence calculate the average braking force on the car stating any assumption that you make.

average braking force = ... N

assumption .....

..... **[3]**

(b) The car has four brake discs each of mass 1.2 kg. The material from which the discs are made has a specific heat capacity of 520 J kg^{-1} K^{-1}.

(i) Calculate the temperature rise of each disc after braking from a speed of 27 m s^{-1}. Assume all the kinetic energy of the car is converted into internal energy of the brake discs equally during braking.

temperature rise = ... °C **[2]**

(ii) State and explain **two** reasons why the actual temperature rise will be different.

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

(iii) Suggest one modification to the design of the disc braking system that could reduce the temperature rise of the discs.

.....

.....

..... **[1]**

[Total: 11]

2 **(a)** **(i)** The pressure p and volume V of a quantity of an ideal gas at absolute temperature T are related by the equations $pV = nRT$ and $pV = NkT$. In these equations identify the symbols n and N.

n .....

N .....

[1]

(ii) Choose one of the equations in **(i)** and show how Boyle's law follows from it.

.....

.....

..... **[2]**

(iii) Show that the product of pV has the same units as work done.

[1]

(b) The graph in Fig. 5.1 shows the variation of pressure, p, with the reciprocal of volume, $1/V$, of 0.050 kg of oxygen behaving as an ideal gas.

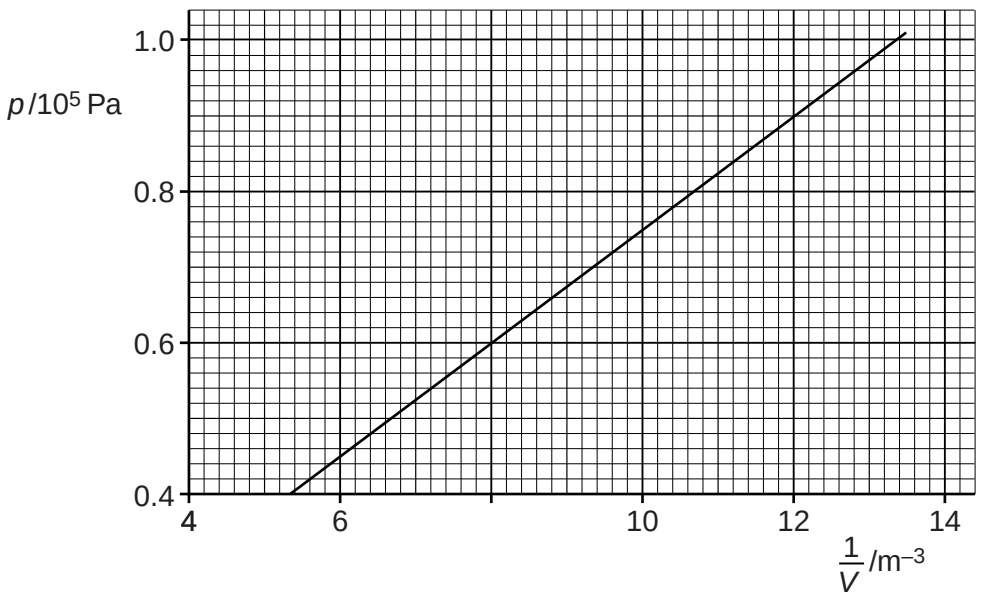

Fig. 5.1

(i) Use the graph to show that the variation of p with $\frac{1}{V}$ is taking place at constant temperature.

[2]

(ii) The molar mass of oxygen is $0.016\,\text{kg}\,\text{mol}^{-1}$. Calculate the temperature, in °C, of the oxygen in **(i)**.

temperature = ... °C **[3]**

[Total: 9]

3 **(a)** Describe

(i) the motion of atoms in a solid at a temperature well below its melting point

.....

..... **[1]**

(ii) the effect of a small increase in temperature on the motion of these atoms

.....

..... **[1]**

(iii) the effect on the internal energy and temperature of the solid when it melts.

.....

.....

..... **[2]**

(b) Fig. 6.1 shows the apparatus used to determine the specific heat capacity of a metal. A block made of the metal is heated by an electrical heater that produces a constant power of 48 W. In order to reduce heat loss from the sides, top and bottom of the block, it is covered by a layer of insulating material.

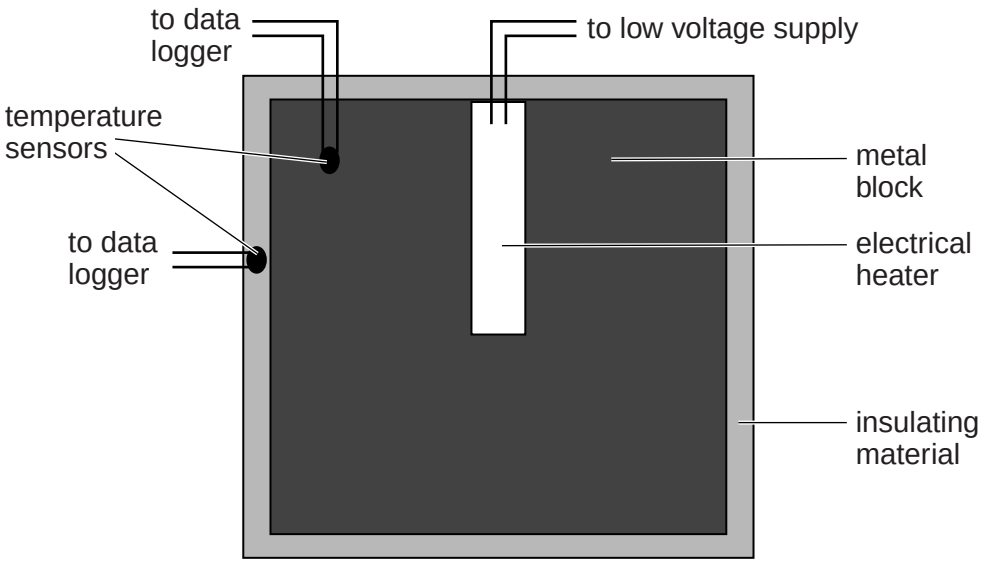

Fig. 6.1

Temperature sensors connected to a data logger show that the block and insulation are initially at the room temperature of 18 °C. The heater is switched on and after 720 seconds the sensors show that the temperature of the block is 54 °C and the average temperature of the insulating material is 38 °C.

(i) Use the information given above and the data shown below to determine the specific heat capacity of the metal block.

mass of metal block = 0.98 kg
power of heater = 48 W
specific heat capacity of the insulating material = 850 $J\,kg^{-1}\,K^{-1}$
mass of the insulating material = 0.027 kg

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ **[4]**

(ii) A second experiment is done without the insulating material and with the block again starting at 18 °C. Discuss whether the value of the specific heat capacity calculated from the second experiment is likely to be lower, the same or higher than the value calculated in **(i)**.

.....

.....

.....

..... **[2]**

[Total: 10]

4 **(a)** State the term used for the energy required to change a solid into a liquid.

You should use the appropriate technical term spelled correctly.

..... **[1]**

(b) **(i)** Define the *internal energy* of a system.

.....

.....

..... **[2]**

(ii) There is a change in internal energy when a mass of water at 100 °C becomes an equal mass of vapour at 100 °C. Explain why.

.....

.....

..... **[2]**

(c) **(i)** The air in a greenhouse has a volume of $15\,m^3$, a density of $1.2\,kg\,m^{-3}$ and a specific heat capacity of $990\,J\,kg^{-1}\,K^{-1}$. Immediately after sunset, the soil is transferring thermal energy to the air at an average rate of 12 W. Estimate the increase in temperature of the air in the greenhouse one hour after sunset as a result of this energy transfer from the soil.

increase in temperature = ... K **[3]**

(ii) Suggest two possible reasons why the actual increase in temperature of the air is likely to be much lower than this estimate.

.....

.....

..... **[2]**

[Total: 10]

5 **(a)** **(i)** State what is meant by a *perfectly elastic collision*.

.....

..... **[1]**

(ii) Explain, in terms of the behaviour of **molecules**, how a gas exerts a pressure on the walls of its container.

.....

.....

.....

.....

.....

.....

..... **[4]**

(iii) Explain, in terms of the behaviour of **molecules**, why the pressure of a gas in a container of constant volume increases when the temperature of the gas is increased.

.....

.....

.....

.....

..... **[2]**

(b) A weather balloon is filled with helium gas. Just before take-off the pressure inside the balloon is 105 kPa and its internal volume is $5.0 \times 10^3\,m^3$. The temperature inside the balloon is 20 °C. The pressure, volume and temperature of the helium gas change as the balloon rises into the upper atmosphere.

(i) The balloon expands to a volume of $1.2 \times 10^4\,m^3$ in the upper atmosphere where the temperature inside the balloon is –30° C. Calculate the pressure inside the balloon.

pressure = ... kPa **[3]**

(ii) Suggest why it is necessary to release helium from the balloon as it continues to rise.

.....

.....

..... **[1]**

[Total: 11]