Name:

1. (a) State what is meant by an *ideal* gas.

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(2)

(b) The internal volume of a gas cylinder is 2.0×10^{-2} m^3. An ideal gas is pumped into the cylinder until the pressure becomes 20 MPa at a temperature of 17 °C.

Determine

(i) the number of moles of gas in the cylinder.

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(2)

(ii) the number of gas atoms in the cylinder.

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(2)

(c) (i) Using your answers in (b), determine the average volume occupied by one gas atom.

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(1)

(ii) Estimate a value for the average separation of the gas atoms.

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(2)

(Total 9 marks)

Name:

2. This question is about an experiment to measure the temperature of a flame.

(a) Define *heat (thermal) capacity*.

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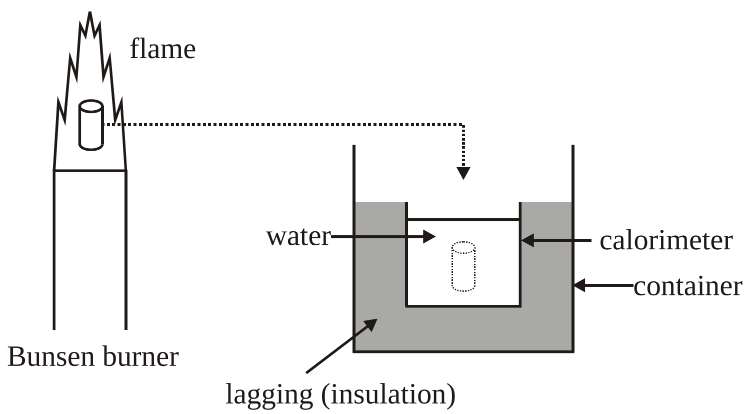
(1)

A piece of metal is held in the flame of a Bunsen burner for several minutes. The metal is then quickly transferred to a known mass of water contained in a calorimeter.



The water into which the metal has been placed is stirred until it reaches a steady temperature.

(b) Explain why

(i) the metal is transferred as quickly as possible from the flame to the water.

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(1)

(ii) the water is stirred.

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(1)

The following data are available:

heat capacity of metal	$= 82.7 \text{ J K}^{-1}$
heat capacity of the water in the calorimeter	$= 5.46 \times 10^2 \text{ J K}^{-1}$
heat capacity of the calorimeter	$= 54.6 \text{ J K}^{-1}$
initial temperature of the water	$= 288 \text{ K}$
final temperature of the water	$= 353 \text{ K}$

(c) Assuming negligible energy losses in the processes involved, use the data to calculate the temperature *T* of the Bunsen flame.

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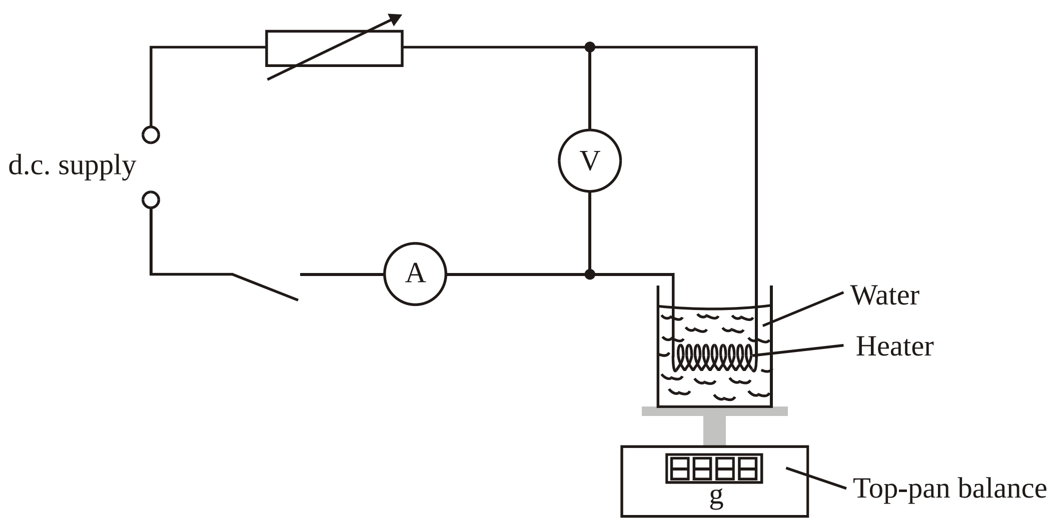
(4)
(Total 7 marks)

3. Some students were asked to design and carry out an experiment to determine the specific latent heat of vaporization of water. They set up the apparatus shown below.



The current was switched on and maintained constant using the variable resistor. The readings of the voltmeter and the ammeter were noted. When the water was boiling steadily, the reading of the top-pan balance was taken and, simultaneously, a stopwatch was started. The reading of the top-pan balance was taken again after 200 seconds and then after a further 200 seconds.

The change in reading of the top-pan balance during each 200 second interval was calculated and an average found. The power of the heater was calculated by multiplying together the readings of the voltmeter and the ammeter.

(a) Suggest how the students would know when the water was boiling steadily.

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(1)

(b) Explain why a reading of the mass lost in the first 200 seconds and then a reading of the mass lost in the next 200 second interval were taken, rather than one single reading of the mass lost in 400 seconds.

(2)

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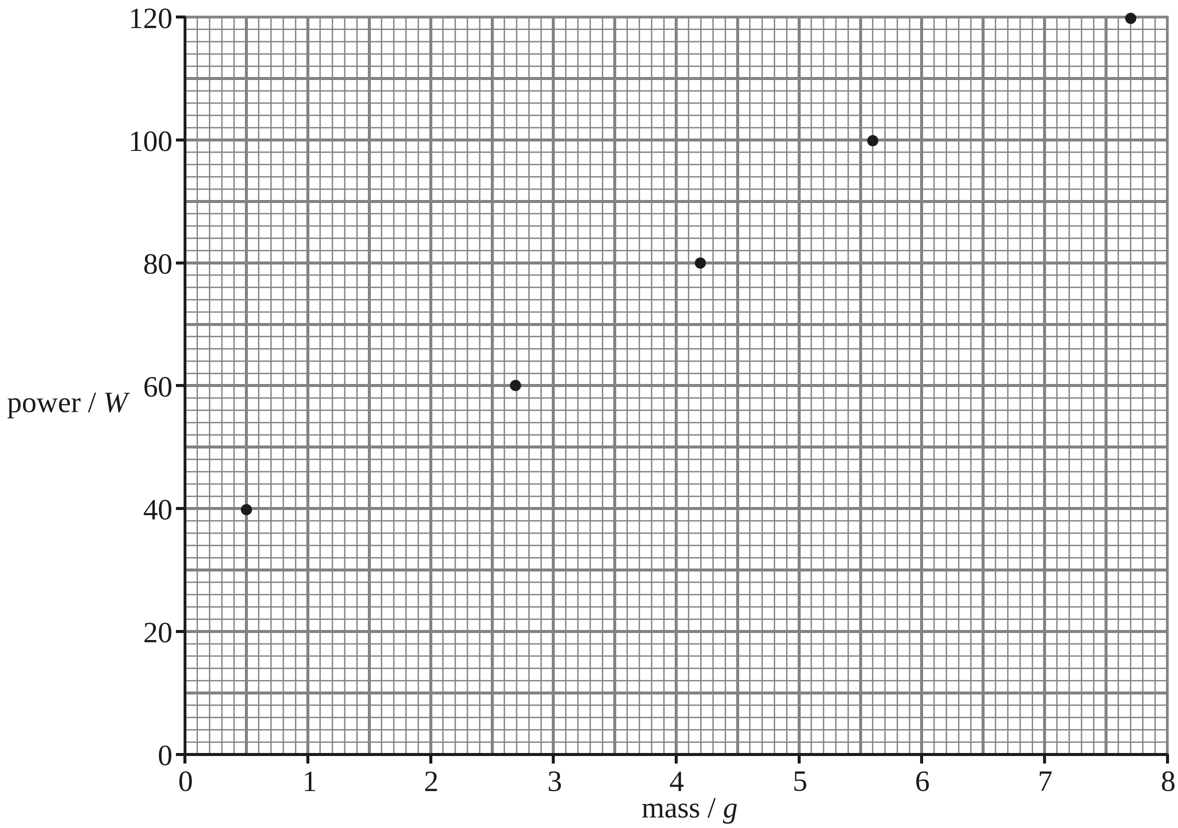
The students repeated the experiment for different powers supplied to the heater. A graph of the power of the heater against the mass of water lost (the change in balance reading) in 200 seconds was plotted. The results are shown below. *(Error bars showing the uncertainties in the measurements are not shown.)*



(c) (i) On the graph above, draw the best-fit straight line for the data points.

(1)

(ii) Determine the gradient of the line you have drawn.

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(3)

In order to find a value for the specific latent heat of vaporization L, the students used the equation

$$P = mL,$$

where P is the power of the heater and m is the mass of water evaporated **per second**.

(d) Use your answer for the gradient of the graph to determine a value for the specific latent heat of vaporization of water.

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(3)

(e) The theory of the experiment would suggest that the graph line should pass through the origin. Explain briefly why the graph does not pass through the origin.

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(2)

(Total 12 marks)

Name:

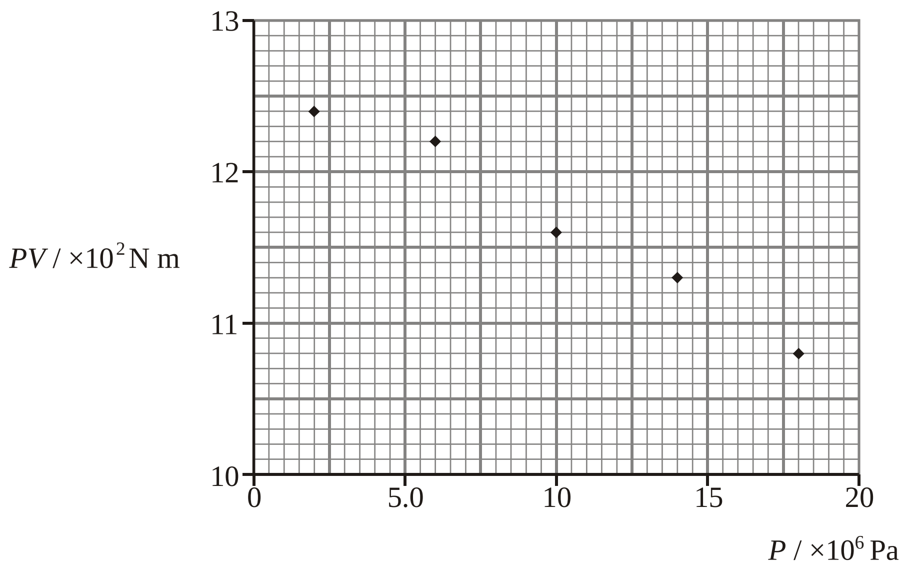
4. Data analysis question

At high pressures, a real gas does not behave as an ideal gas. For a certain range of pressures, it is suggested that the relation between the pressure P and volume V of one mole of the gas at constant temperature is given by the equation

$$PV = A + BP$$

where A and B are constants.

In an experiment to measure the deviation of nitrogen gas from ideal gas behaviour, 1 mole of nitrogen gas was compressed at a constant temperature of 150 K. The volume V of the gas was measured for different values of the pressure P. A graph of the product PV of pressure and volume was plotted against the pressure P and is shown below. (Error bars showing the uncertainties in measurements are not shown).



(a) Draw a line of best fit for the data points.

(1)

(b) Use the graph to determine the values of the constants A and B in the equation

$$PV = A + BP.$$

Constant A ....

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Constant B ....

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(5)

(c) State the value of the constant B for an ideal gas.

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(1)

(d) The equation $PV = A + BP$ is valid for pressures up to 6.0×10^7 Pa.

(i) Determine the value of PV for nitrogen gas at a pressure of 6.0×10^7 Pa.

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(2)

(ii) Calculate the difference between the value of PV for an ideal gas and nitrogen gas when both are at a pressure of 6.0×10^7 Pa.

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(2)

(e) In the original experiment, the pressure P was measured to an accuracy of 5 % and the volume V was measured to an accuracy of 2 %. Determine the absolute error in the value of the constant A.

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(3)
(Total 14 marks)

Name:

5. This question is about modelling the thermal processes involved when a person is running.

When running, a person generates *thermal energy* but maintains approximately constant *temperature*.

(a) Explain what *thermal energy* and *temperature* mean. Distinguish between the two concepts.

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(4)

The following simple model may be used to estimate the rise in temperature of a runner assuming no thermal energy is lost.

A closed container holds 70 kg of water, representing the mass of the runner. The water is heated at a rate of 1200 W for 30 minutes. This represents the energy generation in the runner.

(b) (i) Show that the thermal energy generated by the heater is 2.2×10^{6} J.

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(2)

(ii) Calculate the temperature rise of the water, assuming no energy losses from the water. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

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(3)

(c) The temperature rise calculated in (b) would be dangerous for the runner. Outline **three** mechanisms, other than evaporation, by which the container in the model would transfer energy to its surroundings.

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(6)

A further process by which energy is lost from the runner is the evaporation of sweat.

(d) (i) Percentage of generated energy lost by sweating: 50%

Specific latent heat of vaporization of sweat: 2.26×10^6 J kg^{-1}

Using the information above, and your answer to (b)(i), estimate the mass of sweat evaporated from the runner.

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(3)

(ii) State and explain **one** factor that affects the rate of evaporation of sweat from the skin of the runner.

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(2)

(Total 20 marks)