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)

(Total 6 marks)

2. This question is about thermal physics.

(a) Explain why, when a liquid evaporates, the liquid cools unless thermal energy is supplied to it.

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(3)

(b) State **two** factors that cause an increase in the rate of evaporation of a liquid.

1. ....

2. ....

(2)

(c) Some data for ice and for water are given below.

Specific heat capacity of ice = 2.1×10^3 J kg^{-1} K^{-1}
Specific heat capacity of water = 4.2×10^3 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice = 3.3×10^5 J kg^{-1}

A mass of 350 g of water at a temperature of 25 °C is placed in a refrigerator that extracts thermal energy from the water at a rate of 86 W.

Calculate the time taken for the water to become ice at –5.0 °C.

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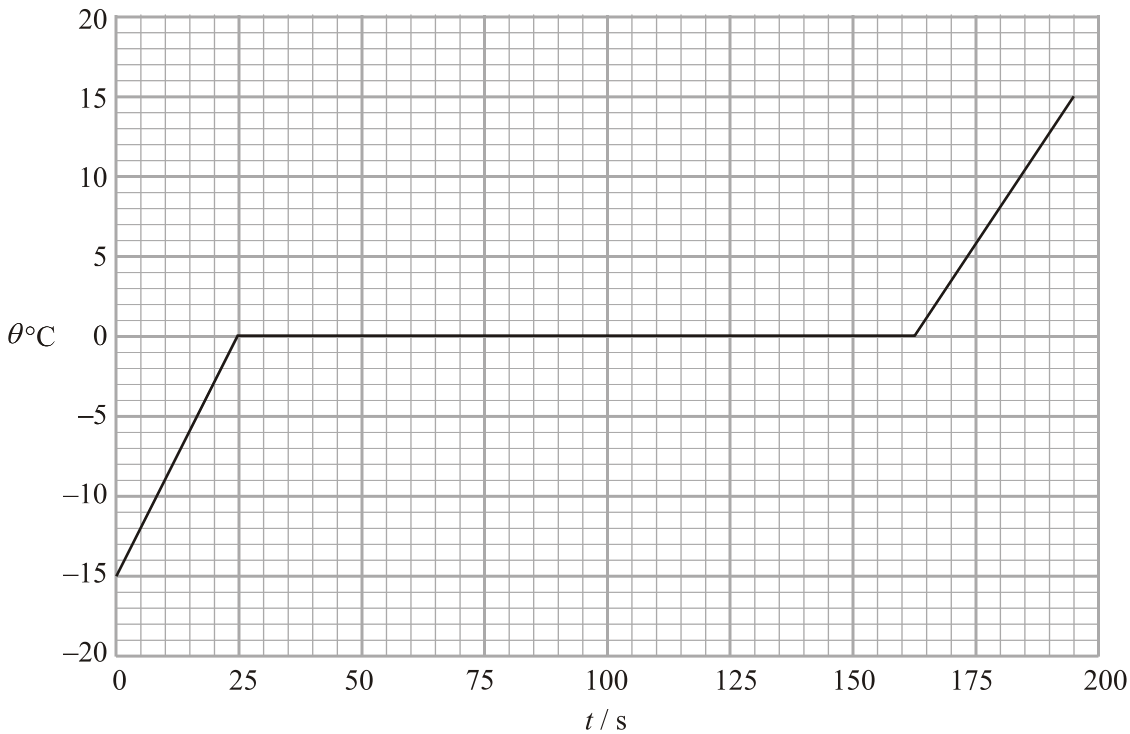
(4)
(Total 9 marks)

Name:

3. This question is about the change of phase (state) of ice.

A quantity of crushed ice is removed from a freezer and placed in a calorimeter. Thermal energy is supplied to the ice at a constant rate. To ensure that all the ice is at the same temperature, it is continually stirred. The temperature of the contents of the calorimeter is recorded every 15 seconds.

The graph below shows the variation with time t of the temperature θ of the contents of the calorimeter. *(Uncertainties in the measured quantities are not shown.)*



(a) On the graph above, mark with an X, the data point on the graph at which all the ice has just melted.

(1)

(b) Explain, with reference to the energy of the molecules, the constant temperature region of the graph.

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(3)

The mass of the ice is 0.25 kg and the specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

(c) Use these data and data from the graph to

(i) deduce that energy is supplied to the ice at the rate of about 530 W.

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(3)

(ii) determine the specific heat capacity of ice.

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(3)

(iii) determine the specific latent heat of fusion of ice.

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(2)
(Total 12 marks)

Name:

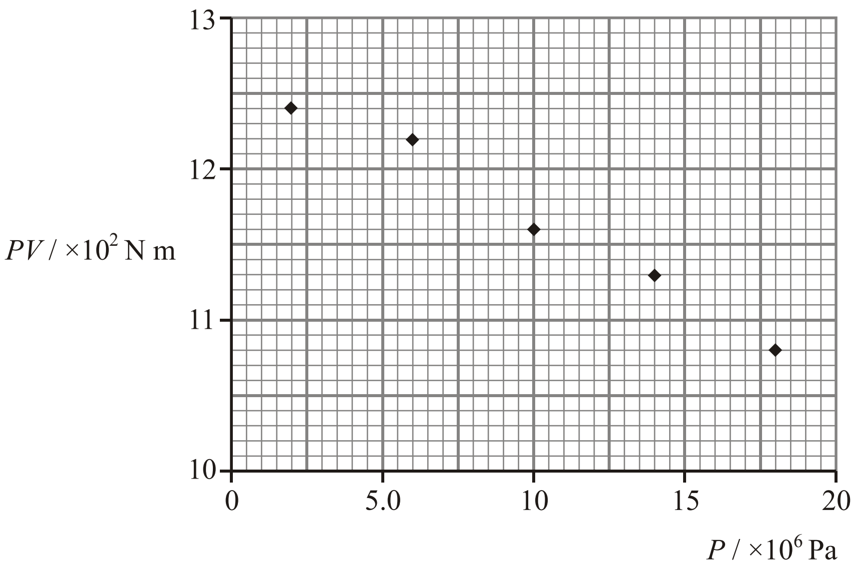
4. Data analysis question

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)
(Total 11 marks)

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)

Name:

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) Describe, in terms of molecular behaviour, why evaporation causes cooling.

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(3)

(ii) Percentage of generated energy lost by sweating: 50%
Specific latent heat of vaporization of sweat: 2.26×10 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)

(iii) State and explain **two** factors that affect the rate of evaporation of sweat from the skin of the runner.

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(4)
(Total 25 marks)