A2-2005 Q4

(a) An electric kettle is filled with 1.50 kg of water at 20°C.The power of the kettle's element is 2.1 kW. After switching on, the water reaches boiling point in 240 s. Calculate a value for the specific heat capacity of water. Assume that all the energy produced by the element is transferred to the water.

(b) The thermostat of the kettle jams and the water continues to boil. After 800 s only one-half of the water remains, the rest having turned to vapour. Calculate a value for the specific latent heat of vaporisation of water at 100°C.

(c) The vapour in (b) has a density 1/1600 of that of boiling water. Estimate the ratio of the mean separation of water molecules at 100°C in the vapour to that in the liquid.

(10 marks)

A2-2008 Q5

When water is heated from 0 °C its density increases initially, and then decreases as the temperature continues to rise.

(a) Explain how the fact that water at its freezing point is less dense than water a few degrees warmer prevents a pond from freezing solid overnight when the air temperature drops to below zero.

(b) A unit volume of water at 0°C has a volume V at temperature T°C given by

$$V = 1 + aT + bT^2,$$

where $a = -6.105 \times 10^{-5}\ °C^{-1}$
$b = 7.733 \times 10^{-6}\ °C^{-2}$.

i. If water was used as the expanding liquid in a glass thermometer, describe the behaviour of the length of the water column (or thread) as the thermometer was warmed up from 0 °C to 10 °C.

ii. Sketch a graph (no values are required) of the length of the water column against temperature

(c) Calculate the temperature range over which the thermometer will give readings that could represent either of two temperatures.

(d) At what temperature is the water column in the thermometer at its shortest?

(10 marks)

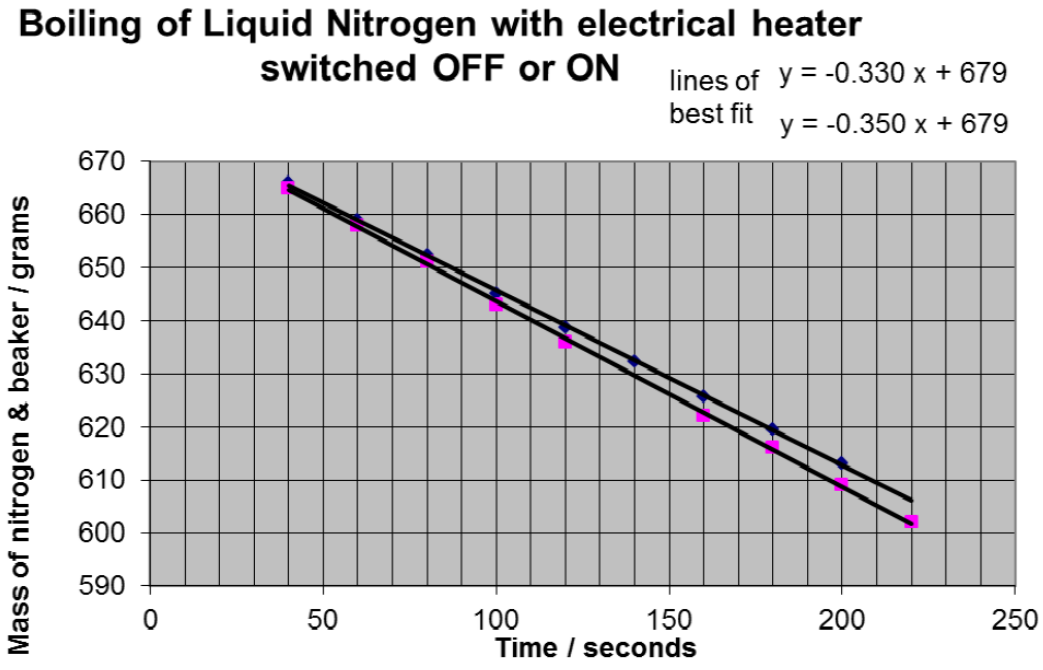
A2-2012 Q6

When liquid nitrogen at a temperature of 77 kelvin or -196 °C is poured into a beaker, it is observed to boil continuously as heat enters it from the surroundings. When stored in a full 25 litre Dewar flask (an insulated steel container similar to a thermos flask), it takes 100 days for all of the liquid nitrogen to boil away. The rate at which heat enters (i.e. power entering) the Dewar flask is very low and we can estimate the value using the results of the following experiment.

Figure 3. Liquid nitrogen Dewar

Figure 4. Electrical heater suspended in liquid nitrogen

A beaker of liquid nitrogen is placed on an electronic balance and readings of the mass are taken every twenty seconds. A small electrical heater is suspended in the liquid, and the experiment is carried out twice, once with the heater turned off and then repeated with the heater connected to the electrical supply. A graph is plotted of the two sets of results and the lines of best fit are obtained, along with the equations. The graph is shown below.



(question continued overleaf)

a) Calculate the rate of loss of liquid nitrogen in grams per second, for each of the two cases, using the data from the graph. The equations for the lines of best fit are given.

b) The heater supply is V=3.9 volts, I=1.2 amps. Calculate the number of joules per second supplied by the heater.

c) Calculate the energy from the heater required to boil away one gram of liquid nitrogen.

d) Calculate the heat power from the room entering the beaker of nitrogen.

e) Calculate the average power that must enter the full 25 litre Dewar to boil away the nitrogen in 100 days. Density of liquid nitrogen is 810 kg m^{-3} (1 m^3 = 1000 litres).

(12 marks)