NO WRITING IS PERMITTED IN THE FIRST 10 MIN.
For partial marking you need to SHOW ALL YOUR WORK.

1. (a) A battery is connected in series to a resistor, which is immersed in water. Would you classify the flow of energy from the battery to the resistor as "heat" or "work"? Why? What about the flow of energy from the resistor to the water?

   (b) Give an example of a process in which no heat is added to a system, but its temperature increases. Then give an example of a process in which heat is added to a system but its temperature does not change.

2. In this question you will estimate the temperature of the flame in a Bunsen burner fed with a mixture of hydrogen and air at 298K? In the flame the reaction $2H_2(g) + O_2(g) \rightarrow 2H_sO(g)$ takes place.

   (a) Imagine that the reaction takes place adiabatically and the heat liberated warms up the reaction products from the initial temperature to the final temperature T. Find T. You are given that the heat of formation of gaseous water is -241.8 kJ mol^{-1} and the C_P's (in J K^{-1} mol^{-1}) of gaseous H_2O and N_2 are 33.6 and 29.1 respectively.

   (b) State all the assumptions you made in arriving at your answer in part 2a.

   (c) Suggest ways to get a more accurate value of the adiabatic flame temperature.

3. In this question you will investigate the pressure dependence of C_P.

   (a) From the definition of C_P write an expression for $\left(\frac{\partial C_P}{\partial P}\right)_T$.

   (b) Now show that

   $$\left(\frac{\partial C_P}{\partial P}\right)_T = -\mu_{\mathrm{JT}} \left(\frac{\partial C_P}{\partial T}\right)_P - C_P \left(\frac{\partial \mu_{\mathrm{JT}}}{\partial T}\right)_P$$

   where the Joule-Thomson coefficient, $\mu_{\mathrm{JT}} = \left(\frac{\partial T}{\partial P}\right)_H$.

4. This question is based on the paper by M. J. O'Neill, Anal. Chem. **38**, 1331 (1966).

   (a) The constant terms in equations 9 and 13 (in Table I) are negative although the constant pressure heat capacity, C_P, is a positive quantity. How do you resolve this apparent contradiction?

   (b) Explain, with a figure, the last two sentences in the third paragraph on p. 1335, which starts with "One advantage of differential calorimetry $\cdots$".

   (c) Why is there a jump in the C_P between 420 and 430 K in Fig. 10 of the paper?