1. The main energy-producing reaction in all oxygen-using living organisms is oxidation of glucose:
\[ \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \]

(a) Using the data below, calculate the standard enthalpy of combustion of glucose.
\[ \Delta H_f^\circ_{298}, \text{ in kJ mol}^{-1} : \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) -1285; \ \text{CO}_2(\text{g}) -393; \ \text{H}_2\text{O}(\text{l}) -285 \]

(b) Calculate the standard free energy change for this reaction, \( \Delta G^\circ \) (298 K), given \( \Delta S^\circ = 181 \text{ J K}^{-1} \text{ mol}^{-1} \) for this reaction at 298 K.

(c) In a living cell, energy from glucose combustion is partly used to synthesise the energy-storage molecule, ATP:
\[ \text{ADP} + \text{P}_i \rightarrow \text{ATP} \quad \Delta G^\circ = +30.5 \text{ kJ mol}^{-1} \]
Assuming the efficiency of ATP synthesis is 41%, calculate the number of mole of ATP produced per mole of glucose oxidised.

(d) In the above equation for the synthesis of ATP, what is the significance of the positive sign of \( \Delta G^\circ \)?

2. For a particular chemical reaction, \( \Delta H = 5.5 \text{ kJ} \) and \( \Delta S = 25 \text{ J K}^{-1} \) and do not vary greatly with temperature. Under what temperature condition(s) is the reaction spontaneous?

3. What are the signs of \( \Delta G, \Delta H \) and \( \Delta S \) for the freezing of liquid water at \(-10 \ ^\circ\text{C}\)?

4. A piece of solid carbon dioxide, with a mass of 7.8 g, is placed inside a sealed container of air at a pressure of 740 mmHg. The container has a volume of 1.2 L and the temperature is 25 °C. What would be the partial pressure of carbon dioxide and the total pressure inside the container after all the carbon dioxide has vaporised?

5. A sample of nitrogen gas was collected over water at 20 °C and a total pressure of 1.00 atm. The vapour pressure of water under these conditions is 17.5 mmHg. If a total volume of 645 mL was collected, what mass of nitrogen was contained in the sample?