S 5 EXERCISE IN THERMODYNAMICS

1. Explain the fact that the heat required to raise the temperature of a fixed mass of gas at constant volume by 1K is different from that required when the pressure is kept constant.
   i. Derive an expression for the difference in molar heat capacities of a gas.
   ii. State the conditions necessary for a reversible isothermal process
2. A fixed mass of gas at a pressure P_1 and volume V_1 expands isothermally to a pressure P_2 and volume V_2.
   i. Derive an expression for the work done by the gas.
   ii. A gas of volume 2 litres at a temperature of 27^oC and pressure of 1.5×10^5 Pa is heated at constant pressure until its volume doubles. It is then cooled at constant volume back to its original temperature before finally being compressed isothermally to its original volume. Draw a p-V diagram of the whole cycle and find the net work done by the gas.
3. State Boyle's law.
   i. Describe an experiment to verify Boyle's law.
   ii. Derive the ideal gas equation
   iii. A cylinder contains 100 litres of gaseous oxygen at a pressure of 1.217×10^7 Pa and temperature 20^oC. Assuming oxygen behaves as an ideal gas in this region of pressure and temperature, find the volume of liquid oxygen (density 1140 kg m^{-3}) that may be made by liquefying completely the contents of the cylinder. [Relative molecular mass of oxygen = 32]
4. A gas at a pressure of 1.2×10^6 Pa and temperature 90^oC expands adiabatically to twice its volume and then compressed isothermally to its original volume. [Take ratio of the principal heat capacities,
   i. Find the final pressure and temperature of the gas.
   ii. Sketch and label the two stages on a P-V diagram.
5. An ideal gas at a pressure of 2.0×10^6Pa occupies a volume of $2.0 \times 10^{-3}m^3$ at 47.5^0C. The gas expands adiabatically to a final pressure of 1.1×10^5Pa. The ratio of specific heat capacity at constant pressure to that at constant volume is 1.4. Calculate the:

i. Number of moles of the gas
ii. Final volume of the gas
iii. Work done by the gas

6. The temperature of one mole of oxygen gas at a pressure of 3.0×10^5 Pa falls from 80^oC to 17^oC when the gas expands adiabatically. Find the final pressure of the gas.[Take $\gamma = 1.40$]
   i. Explain the conditions for a reversible adiabatic change.
   ii. Explain why a gas heats up when it is compressed adiabatically.
7. An ideal gas of volume 1×10^{-3} m^3 at s.t.p expands at a constant pressure to a volume of 3.0×10^{-3} m^3. Calculate :
   i. The work done by the gas.
   ii. The final temperature of the gas.