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Contents

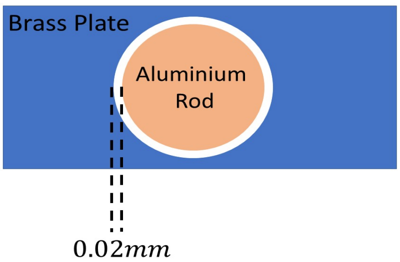
1 Heat Conduction and Expansion

1. **PSPM 13/14**
Calculate the heat transferred in 24 hours through a $2.4m^2$ metal sheet of thickness $1cm$ when the temperature difference between the surface is $0.5^o\ C$. Given the thermal conductivity coefficient of the metal is $16Wm^{-1}K^{-1}$. [**Ans:** $Q = 1.66(10^8)\ J$]

2. **PSPM 14/15**

   (a) Define the coefficient of area thermal expansion, β. [**Ans:** $\beta = \frac{\Delta A}{A\ \Delta T}$]

   (b) The figure below shows an aluminium rod with radius $5cm$ and ahving a clearance of $0.02mm$ completely around it within a hole in a brass plate of $20^o\ C$. The coefficient of linear thermal expansion of brass and aluminium are $1.9\times10^{-5}\ {}^oC^{-1}$ and $2.4\times10^{-5}\ {}^oC^{-1}$ respectively.



   i. Calculate the lowest temperature if both metals are heated until the clearance is 0. [**Ans: 100.3** $^o\ C$]

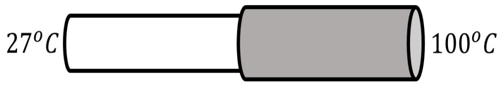
   ii. Would such a tightly fit be possible if the plate is aluminium and the rod is brass and both metals are heated? Explain your answer. [**Ans: No,** $\alpha_{Al} > \alpha_{Brass}$]

3. **PSPM 15/16**

   (a) Define the coefficient of volume thermal expansion.

   (b) A composite rod is made by joining a copper rod of diameter $4cm$ with an iron rod of similar diameter. The rod is insulated and its ends are kept at two different temperatures as shown in the figure above. The oefficient of thermal conductivity of copper and iron are $385Wm^{-1}K^{-1}$ and $80Wm^{-1}K^{-1}$ respectively. Determine the temperature at the joint. [**Ans:** 130.1^oC]

4. **PSPM 17/18**



The figure above shows a rod with both ends at different temperatures. The right half of the rod is insulated while the left half is not insulated. Sketch the graph of temperature against distance of the rod.

5. **PSPM 18/19**
The dimension of an aluminium wire at room temperature (27^oC) is $150m$ long and cross sectional area of $3.0(10^{-6})m^2$. It is then melted to form a spherical ball. If the coefficient of linear thermal expansion of the aluminium is $22.2(10^{-6})m\ K^{-1}$, calculate the

   (a) volume of the spherical ball at room temperature [**ans:** $4.5(10^{-4})m^3$]

   (b) Change in the volume of the sphere if it is heated to 200^oC.[**Ans:** $5.18(10^{-6})m^3$]

   (c) change in the volume of sphere if is cooled to -7^oC [**Ans:** $-1.01(10^{-6})m^3$]

6. **PSPM 19/20**

   (a) A gold rod is in contact with a silver rod. The gold end and the silver end of the compound rod are at 90^oC and 30^oC respectively. The silver rod has thermal conductivity $427 Wm^{-1}K^{-1}$, length $2.5cm$ and cross sectional area $7.85 \times 10^{-5} m^2$. If $341.3J$ heat flows through the gold rod in $10s$, calculate the temperature at the contact surface. [**Ans:** $55.46\ ^oC$]

(b) The area of a metal plate changes from $120m^2$ to $120.059m^2$ when the temperature increases by 30^oC. Calculate the coefficient of linear expansion of the metal. [**Ans:** $8.19(10^{-6}\ ^oC^{-1})$]

2 Kinetic Model of Gases

1. **PSPM 13/14**
   The mass of an empty $50 litres$ gas cylinder is $4.8kg$. The cylinder is filled with nitrogen gas up to a pressure of $60atm$. Given the room temperature is $29^o\ C$ and the molecular weight of nitrogen 28, calculate the new mass of the cylinder [**Ans:** $M_{mass} = 8.19\ kg$]

2. **PSPM 14/15**

   (a) A balloon is filled with helium at $25\ ^oC$. The mass of a helium atom is $6.65 \times 10^{-27}\ kg$. Calculate the
      i. root mean square speed of the helium atom[**Ans:** $v_{rms} = 1.36 \times 10^3 ms^{-1}$]
      ii. kinetic energy of $0.5 mol$ helium atom. [$E_k = 1857J$]

   (b) A 15 liter gas cylinder contains helium gas with pressure $1.01 \times 10^5\ Pa$ at 25^oC. When heated, the gas undergoes an isochoric process.
      i. Calculate the mass of the helium gas. [**Ans:** $m_{He} = 2.44(10^{-3})kg$]
      ii. If $500J$ of heat is added, calculate the change in the internal energy of the gas and sketch the graph of pressure against volume for the isochoric process. [**Ans:** $\Delta U = 500J$]
      iii. If the gas cylinder can withstand a pressure up to $4.55 \times 10^5\ Pa$, calculate the maximum quantity of gas at 45^oC. [**Ans:** $n = 2.58\ mol$]

3. **PSPM 15/16**

   (a) State the principle of equipartition of energy.

   (b) Calculate the rms speed of helium atoms at temperature $1 \times 10^{-4} K$. Molar mass of helium is $4gmol^{-1}$. [**Ans:** $v_{rms} = 0.79$]

4. **PSPM 17/18**

   (a) A $5 \times 10^{-3}\ m^3$ contains nitrogen at temperature 27^oC and pressure $1.2atm$. The gas pressure increases to $2.5atm$ when the tank is heated. Given the molar mass of nitrogen is $28g\ mol^{-1}$, calculate the chance in rms speed of the nitrogen molecules. [**Ans:** $\Delta v_{rms} = 229ms^{-1}$]

   (b) At the same temperature, which gas has a greater energy per mole: a diatomic gas or a monoatomic gas? Explain your answer.

5. **PSPM 18/19**
   The pressure of a $0.02m^3$ monoatomic gas in a container is $2atm$. The mass of each atom is $3.351 \times 10^{-23} g$. Calculate the

   (a) average translational kinetic energy of the gas. [$E_k = 6.08 \times 10^3\ J$]

   (b) internal energy of the gas [**Ans:**$6078J$]

   (c) v_{rms} value at 27^oC. [$609ms^{-1}$]

6. **PSPM 19/20**
   A sealed cylinder constained 1.2×10^{24} helium atoms at initial pressure $1.04 \times 10^5\ Pa$. The cylinder is heated until the final temperature and the change in the internal energy of the helium gas are $315K$ and $1.6 \times 10^3 J$ respectively. The molar mass of helium is $4gmol^{-1}$ Calculate the

   (a) density of the helium gas. [$\rho = 0.2\ kg\ m^{-3}$]

   (b) final pressure of the helium gas [$P = 1.31 \times 10^5\ Pa$]

3 Thermodynamics

1. **PSPM 13/14**

   (a) Define the following thermodynamics processes:
      i. Adiabatic
      ii. Isobaric

   (b) Derive the equation for work done in an isothermal process.

   (c) The figure below shows a $p - V$ graph for a series of thermodynamic processes, ABC. In process AB and BC, $160J$ and $600J$ are added to the system respectively. Calculate the change of the internal energy during the process ABC.[**Ans:** $\Delta U = 440J$]

2. **PSPM 15/16**

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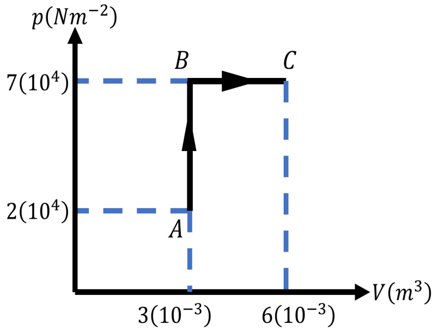
(a) On the same p – V graph, sketch individual curve for isothermal, isobaric and adiabatic process.

(b) Explain why a gas becomes colder when it expands adiabatically

3. **PSPM 17/18**



The figure above shows a series of thermodynamic processes ABC. During the process AB and process BC, $120J$ and $500J$ of heat are added respectively. Calculate the change in internal energy in the process ABC. [**Ans:** $410J$]

4. **PSPM 18/19**
One mole of an ideal gas is compressed isothermally from $4V$ to V. The work done on the gas is 4.5×10^3 J

(a) sketch p-V graph for this process

(b) Calculate the heat transferred during the compression. Is the heat absorbed or released by the system. [**Ans:** $Q_{releaed} = 4.5 \times 10^3 J$]

(c) Calculate the isothermal process temperature. [**T** $= 390.6K$]

5. **PSPM 19/20**
A $0.8m^3$ container at 60^oC is filled with $0.6mol$ of ideal gas. The gas is isothermally compressed to a volume of $0.2m^3$. Then the gas expands isobarically to its initial volume. Calculate the work done in the process. [**Ans:** $\sum W = 2.68kJ$]