BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Science Education

Department of Mathematics and Science Education

OCT 2024

DP003/PH002

Thermal Physics

Duration: Three (3) Hours

INTSRUCTIONS

- *Answer ALL questions in Section A and any THREE questions from Section B. Section A carries 40 marks and each question of Section B carries 20 marks.*
- *Show ALL formulae and substitutions in ALL calculations.*
- *Leave your answers correct to 2 decimal places*

You may not start to read the questions printed on the subsequent pages until instructed to do so by the Invigilator.

SECTION A (40 MARKS)

(Answer **ALL** questions from this section)

QUESTION 1 (40 MARKS)

a) Distinguish between '***intensive***' and '***extensive***' properties. (2)

b) Define the term '**thermometric property**'. State the thermometric property that defines the temperature scale in a liquid-in-glass thermometer. (3)

c) Volume of a fixed mass of liquid.

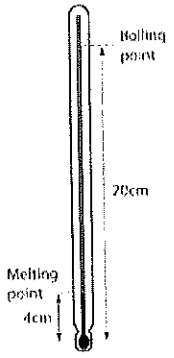
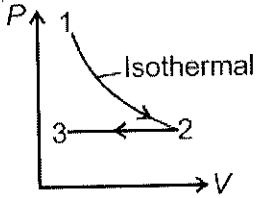


Figure above shows the length of the mercury thread of a thermometer at melting point and boiling point of water. What is the length of the mercury thread when the thermometer is dipped into a hot liquid of temperature 70°C? (6)

d) Calculate the efficiency of a power plant if the efficiencies of the boiler, turbine and generator are 88, 40 and 98%, respectively. (4)

e) One mole of a monoatomic gas undergoes the process 1 - 2 and 2 - 3 as shown.



Sketch the corresponding graph of pressure against temperature. Briefly explain how you arrived at your answer. (5)

f) Using the kinetic model of gases, explain why the pressure exerted by a fixed mass of gas increases when its volume is reduced at constant temperature. (6)

g) With the aid of a labeled diagram, briefly describe how a thermocouple works. (5)

h) How long will it take a 50 W heater to melt 2 kg of ice at 0 °C? (5)

i) Why is a burn from 100 degrees C steam more severe than a burn from water at 100 degrees C? (4)

SECTION B

(Answer ANY THREE (3) questions from this section.)

QUESTION 2 (20 MARKS)

a) What is the difference between
   i) Heat Capacity and Specific Heat?
   ii) Latent Heat and Specific Heat? (4)

b) If you pour 0.0200 kg of water at 20.0 degrees Celsius onto a 1.50-kg block of ice (which is initially at -10.0 degrees Celsius), what will be the final temperature?(16)

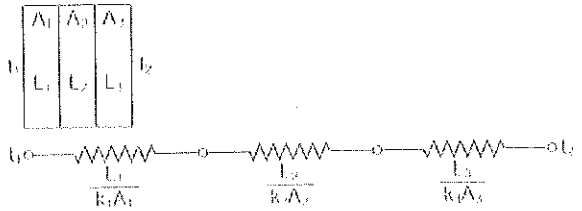
QUESTION 3 (20 MARKS)

a) The vertical flow of air in the atmosphere can be summarized as; air expands and cools as it rises, and contracts and grows warmer as it descends. This can be a typical example of an adiabatic process. What do you understand by the term **'adiabatic process'**? (2)

b) Derive an expression for work done in adiabatic expansion. Define the symbols you have used (18)

QUESTION 4 (20 MARKS)

j) Derive an expression for the heat flow rate through parallel walls of thickness L_1, L_2 and L_3, having surface areas A_1, A_2 and A_3, thermal conductivities k_1, k_2, and k_3, respectively, with the first and last walls maintained at temperatures t_1 and t_2. (3)
Hint: You may refer to the diagram below to visualize the setup of conductors



k) Calculate the rate of heat loss through the vertical walls of a boiler furnace of size 4 m by 3 m by 3 m high. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/mK, a layer of ceramic blanket insulation of thermal conductivity 0.2 W/mK and 8 cm thick, and a steel protective layer of thermal conductivity 55 W/mK and 2 mm thick. The inside temperature of the fire brick layer was measured at 600$_0$ C and the temperature of the outside of the insulation 60$_0$ C. Also find the interface temperature of layers. (18)

QUESTION 5 (20 MARKS)

a) State the Zeroeth law of thermodynamics. (2)

b) Despite its apparent simplicity, the Zeroeth law has the consequence of implying the existence of an important state variable, the empirical temperature θ. Use it to prove that systems in equilibrium have the same temperature. (18)

THE END

Some useful constants

Constant	Value
Boltzmann constant	$1.38 \times 10^{-23}\ m^2 2\ kgs^{-2}K^{-1}$
Planck's constant	$6.63 \times 10^{-34} m^2 kg\ /\ s$
Speed of light in a vacuum	$3 \times 10^8 ms^{-1}$
specific heat capacities of liquid water	4.184kJ/(kg°C)
specific heat capacity of ice	2.108 kJ/(kg°C)