# BINDURA UNIVERSITY OF SCIENCE EDUCATION

## Faculty of Science Education

## Department of Mathematics and Science Education

Diploma in Science-Physics

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

(Answer **ALL** questions in this section.)

### QUESTION 1 (40 MARKS)

a) Two cars made from the same material, one white, one black are parked in the sun. After some time, one is much hotter to touch than the other. Which car is it? Explain your answer. (3)

b) The length of the alcohol column in a thermometer is 2.5cm and 17.5cm when the thermometer is dipped into melting ice and boiling water respectively. Find the distance between every 10°C of the scale on the thermometer. (6)

c) Calculate the efficiency of a power plant if the efficiencies of the boiler, turbine and generator are 88, 40 and 98%, respectively. (5)

d) A liquid of specific heat capacity of $3000JKg^{-1}K^{-1}$ rise from 15oc to 65°c in one minute when an electric heater is used. If the heater generates 63000J per minutes, calculate the mass of the water. (8)

e) In a gas thermometer, the pressure needed to fix the volume of 0.20 g of Helium at 0.50 L is 113.3 kPa. What is the temperature in Kelvins? (***Hint: You may assume that Helium under such conditions behaves like an ideal gas and its molar mass of He is 4g/mol***). (7)

f) A gas syringe is being heated and the piston begins to be move outwards and eventually stops. Using the kinetic model of gases, briefly explain why this happens. (8)

g) Explain why the heating element of a kettle should be positioned at the base. (3)

## SECTION B

### QUESTION 2 (20 MARKS)

a) If temperature is a measure of the average kinetic energy, shouldn't thermal energy and temperature be the same thing? (3)

b) Describe how you would demonstrate Brownian motion of smoke particles in the air. State and explain the observations. (10)

c) A plane wall is 20 cm thick with an area of 1 $m^2$ and has a thermal conductivity of 0.5 W/m. K. A temperature difference of 100°C is imposed across it. Calculate the heat flow ($Q$) (5)

d) A piece of iron of specific heat capacity $0.04JKg^{-1}K^{-1}$ and mass 400kg, is quickly dropped into 30kg of water at 10°c contain in a calorimeter of 120kg and specific heat capacity of $0.1JKg^{-1}K^{-1}$. If the temperature of the mixture is 30°c, calculate the initial temperature of the hot iron ($4200JKg^{-1}K^{-1}$ = specific heat capacity of water). (10)

e) Briefly describe how a thermistor works. (5)

f) A gas syringe is being heated and the piston begins to be move outwards and eventually stops. Explain.

g) Briefly discuss the greenhouse effect, making sure to address the following pertinent questions;

   a) What is the "greenhouse effect"? (2)

   b) Briefly explain why is it called the "greenhouse" effect? (2)

   c) Why have experts become worried about the greenhouse effect now? (3)

## SECTION B (60 MARKS)

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

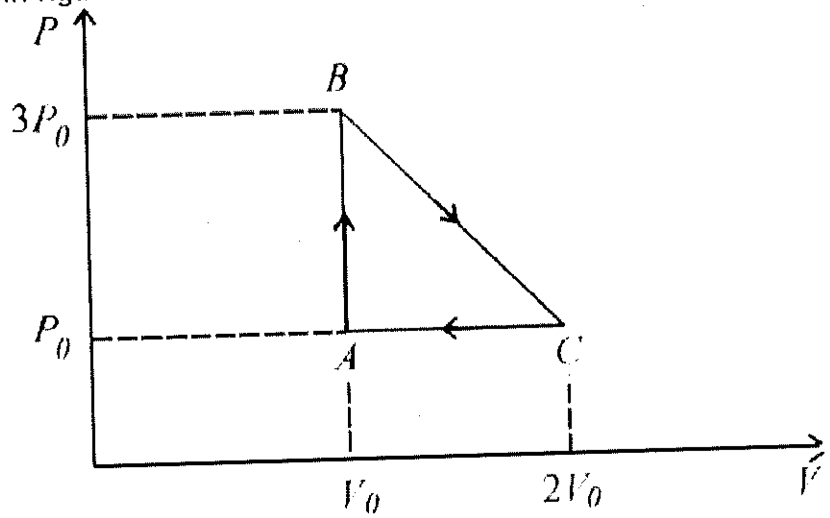
### QUESTION 2 (20 MARKS)

a) Define the term ***'ideal gas'***. (2)

b) An ideal gas at pressure $P$ and volume $V$ undergoes an adiabatic change. Show that, for this type of gas, $PV^{\gamma} = constant$. Hence also show that $TV^{\gamma-1} = constant$ where symbols have their usual meanings. (18)

### QUESTION 3 (20 MARKS)

One mole of an ideal monatomic gas is taken round the cyclic process ABCA as shown in figure.




Calculate;

a) the work done by the gas. (3)

b) the heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB, (6)

c) the net heat absorbed by the gas in the path BC, (5)

d) the maximum temperature attained by the gas during the cycle. (6)

## QUESTION 4 (20 MARKS)

a) Briefly discuss the term ***'performance of coefficient (COP)'*** showing how it can be useful to device users? (2)

b) Determine the coefficient of performance of a refrigerator that consumes 800 watts of power to remove heat at a rate of 5 BTU per second.

*Hint: 1BTU=1055.06J* (6)

c) A gas furnace has an efficiency of 75%. How many BTU will it produce from 1000 BTU of natural gas. (6)

d) Compare the heating efficiencies (maximum COP) of the same heat pump installed in Miami and in Buffalo. In Miami, since the climate is milder, assume that TH is 70 °F and that TL is 40 °F. In Buffalo, assume that TH is the same, but that TL (the outside temperature) is much lower, say (on average), 15 °F. (6)

## QUESTION 5 (20 MARKS)

a) A kettle is rated at 1.7 kW. A mass of 650 g of a liquid at 25°C is poured into a kettle.

When the kettle is switched on, it takes 3.5 minutes to start boiling.

Calculate the specific heat capacity of the liquid. (10)

b) To measure the heat capacity of an object, all you usually have to do is put it in thermal contact with another object whose heat capacity you know. As an example, suppose that a chunk of metal is immersed in boiling water (100°C), then is quickly transferred into a Styrofoam cup containing 250 g of water at 20°C. After a minute or so, the temperature of the contents of the cup is 24°C. Assume that during this time no significant energy is transferred between the contents of the cup and the surroundings. The heat capacity of the cup itself is negligible.

i) How much heat is lost by the water? (3)

ii) How much heat is gained by the metal? (1)

iii) What is the heat capacity of this chunk of metal? (3)

iv) If the mass of the chunk of metal is 100 g, what is its specific heat capacity? (3)

**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 | $3 \times 10^8 ms^{-1}$ |