BINDURA UNIVERISTY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

PHYSICS AND MATHEMATICS DEPARTMENT

DIPLOMA IN SCIENCE EDUCATION

PHYSICS PART 1.1

DEC 2019

PH002: THERMAL PHYSICS

TIME: 3 HOURS

INSTRUCTIONS

Answer **question one** in Section A and **any three** questions from Section B.
Section A carries 40 marks and each question in Section B carries 20 marks.

Physical Constants
Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}
Universal Gravitation Constant, $G = 6.7 \times 10^{-11}$ Nm^{2}kg^{-2}
Acceleration due to gravity, $g = 9.8$ ms^{-2}

Specific heat capacity of water = 4.2×10^3 J Kg^{-1}K^{-1}
Specific heat capacity of aluminum = 9.1×10^2 J Kg^{-1}K^{-1}
Velocity of light, c = 3.00×10^8 ms^{-1}
The molar mass constant, R = 8.31 J K^{-1} mol^{-1}
Molar mass of hydrogen molecule = 2.0×10^{-31} Kg mol^{-1}

Thermal conductivity of brick, k = 0.13 W m^{-1} K^{-1}
Thermal conductivity of glass, K=0.80 Wm^{-1}k^{-1}

SECTION A:

Answer ALL Questions from this Section

1 (a) Explain what is meant by the following, (i) internal energy of a substance
(ii) temperature [4]

(b) Distinguish between (i) temperature and heat
(ii) Absolute scale and empirical scale of temperature [6]

(c) Define specific latent heat of fusion. [2]

(d) (i) State the thermometric substance and the thermometric property of the mercury- in –glass thermometer. [2]

(ii) State any two advantages of using thermocouple thermometers over mercury thermometers [2]

(e) Three metal strips of the same length are heated by the same flame at the same time. Explain why matches placed at the end of these strips do not light up at the same time. [2]

(f) A gas with volume of 0, $1m^3$ expands at a constant pressure of 1.5×10^5Pa to treble its volume. Calculate the work done by the gas. [3]

g) State the three gas laws. [6]

(h) The volume of some air, assumed to be an ideal gas, in the cylinder of a car engine is 540 cm^3 at a pressure of 1.1 x 10^5 Pa and a temperature of 27^0C.The air is suddenly compressed, so that no thermal energy enters or leaves the gas, to a volume of 30cm^3.The pressure rises to 6.5 x 10^6 Pa.
Determine the temperature of the gas after the compression. [3]

(i) Find the root mean square speed of 1 mole of nitrogen molecules at a pressures of 01 kPa and temperature of 300 K. Note that 1 mole of nitrogen has a mass of 28 grams = 0.028 kg. [4]

(j) Give four assumptions made in the kinetic theory of gases. [4]

(k) Distinguish between adiabatic process and isothermal process. [2]

SECTION B:

2 (a) What is meant by the following: 1 thermometric substance?
2 thermometric property
3 fixed point [6]

(b) (i) The readings of a resistance thermometer are 20.0 Ω at ice point, 28.2 Ω at steam point and 23.1 Ω at an unknown temperature. Calculate the unknown temperature on the Celsius scale of the thermometer [9]

(ii) Room temperature is 25 ^{0}C. What is the temperature on the thermodynamic temperature scale? [2]

(c) Give any three reasons why is mercury used in thermometers. [3]

3 (a) (i) When are two bodies said to be in thermal equilibrium? [3]

(ii) State the Zeroth law of thermodynamics [3]

(b) How many 20 g ice cubes, whose initial temperature is -10 °C, must be added to 1.0 L of hot tea, whose initial temperature is 90 °C, in order that the final temperature of the mixture be 10 °C? Assume all the ice melts in the mixture and the specific heat of tea is the same as that of water.

Latent heat of fusion of ice = L_v = 333 kJ. kg^{-1} = 333000 J. kg^{-1}
Specific heat of water = c_{water} = *4190* J. kg^{-1} K^{-1}
Specific heat of ice = c_{ice} = 2100 J. kg^{-1} K^{-1}
Assume that the tea has the same properties as water. Note that 1 litre of water has a mass of 1 kg. [7]

(c) (i) Draw and label a liquid in glass thermometer. [4]

(ii) Explain how it works when measuring temperature. [3]

4 (a) Outline the **three** main heat transfer processes. [6]

(b) One end of a uniform metal rod is maintained at 100 °C and the other at room temperature. Sketch a ***labelled*** graph to show how the temperature gradient varies with distance along the rod when its sides are:

(i) Efficiently lagged [2]
(ii) Unlagged [2]
(iii) Explain the shape of each graph. [2]

(c) (i) Write down an equation relating the rate of flow of heat through a thin slice of a solid to the temperature gradient across it. State the meaning of any other symbol which appears in the equation. [3]

(ii) Heat is conducted through a closed window of area1.5m^{-2} containing a single glass pane of uniform thickness of 0.004m.The indoor temperature is 20°C and the outdoor temperature is 10°C.Calculate

1 temperature difference between the two sides
2 temperature gradient
3 the rate of flow of heat through the window [5]

5 (a) State the first law of thermodynamics in terms of the increase in internal energy ΔU, the heating q of the system and the work done on the system. [3]

(b) The volume occupied by 1.00 mol of liquid water at 100 ^{0}C is 1.87×10^{-5} m^3. When the water is vaporized at an atmospheric pressure of 1.03×10^5 Pa, the water vapour has a volume of 2.96×10^{-2} m^3. The latent heat required to vaporize 1.00 mol of water at 100 ^{0}C and 1.03×10^5 Pa is 4.05×10^4 J.

Determine, for this change of state,

(i) The work ΔW done on the system, [3]
(ii) The heating ΔQ of the system, [3]
(iii) The increase in internal energy ΔU of the system. [3]

(c) A kettle is rated 2.3 kW. A mass of 750 g of water at 20 ^{0}C is poured into the kettle. When the kettle is switched on, it takes 2.0 minutes for the water to start boiling. In a further 7.0 minutes, one half of the mass of water is boiled away.

(i) Define the term specific heat capacity. [4]

(ii) Estimate, for this water:

1 the specific heat capacity, [2]

2 the specific latent heat of vaporization. [2]

6. (a) (i) The ideal gas equation is given as PV = nRT. Give the meanings of the symbols used. [5]

(ii) An amount of 1, 00 moles of helium 4 gas is contained in a cylinder at a pressure of $1{,}02 \times 10^5$ Pa and temperature of 27°C. Calculate the volume of the cylinder. [8]

(b) The product of the pressure p and volume V of an ideal gas of density ρ at temperature T is given by the expressions

$$p = \frac{1}{3}\rho\langle c^2\rangle \qquad \text{and} \qquad pV = NkT,$$

Where N is the number of molecules and k is the Boltzmann constant.

(i) Explain the meaning of the symbol $\langle c^2\rangle$. [3]

(ii) Deduce that the mean kinetic energy E_K of the molecules of an ideal gas is given by the expression

$$E_K = \frac{3}{2}kT. \qquad [4]$$

END OF EXAMINATION