



PAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, APPLIED SCIENCES AND NATURAL RESOURCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	LEVEL: 6
COURSE CODE: TPH601S	COURSE NAME: THERMAL PHYSICS
SESSION: JUNE 2022	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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INSTRUCTIONS	
1.	Write all your answers in the answer booklet provided.
2.	Read the whole question before answering.
3.	Begin each question on a new page.

PERMISSIBLE MATERIALS
Non-programmable Scientific Calculator

THIS EXAMINATION QUESTION PAPER CONSISTS OF 4 PAGES
(INCLUDING THIS FRONT PAGE)

QUESTION 1**[23]**

1.1 Define the following thermodynamic terms:

(10)

- (a) System
- (b) Universe
- (c) Control volume
- (d) Extensive property
- (e) Temperature

1.2 Assume that a system 1 with temperature T_1 and system 2 with temperature T_2 are in thermal contact with each other. There will be exchange of heat between the two systems if there is a temperature gradient (i.e., when T_1 is not equal to T_2). What would be the thermodynamic state if the process of heat exchange continues until the temperatures are equal?

(2)

1.3 State the Zeroth Law of thermodynamics.

(2)

1.4 Use the principle of the zeroth law of thermodynamics to briefly discuss the triple point of water.

(3)

1.5 If the temperature of a system is 0°C , what would be the temperature on the Kelvin scale?

(2)

1.6 Suppose that you wish to identify an unknown liquid by measuring its boiling point accurately. You first use a constant-volume gas thermometer to measure the pressure (p) of the confined gas to be 2.7 atm^* at the triple point of water. Then you bring the same confined gas to equilibrium with the unknown boiling liquid and measure $p = 4.2 \text{ atm}$. What is the temperature of vaporization on the Kelvin scale?

(4)**QUESTION 2****[41]**

2.1 Suppose a copper rod of length $l = 5.31 \text{ mm}$ was heated and expanded to a length of 5.36 mm . The initial and final temperatures for the rod are 275.15 K and 342.15 K respectively. Calculate the coefficient of linear expansivity (α) of the copper rod.

(4)

2.2 An oil trucker loaded about $21\,000 \text{ L}$ of diesel on a hot day in Walvis Bay, Namibia. On his way to deliver the oil in Johannesburg, South Africa, a cold weather was encountered, where the temperature was 45°C lower than that of Walvis Bay and Johannesburg. How many litres were delivered to Johannesburg, when $\beta = 9.50 \times 10^{-4} \text{ }^\circ\text{C}^{-1}$ for diesel and $\alpha = 1.10 \times 10^{-5} \text{ }^\circ\text{C}^{-1}$ for steel tank?

(5)

2.3 An aluminium block ($c = 9.10 \times 10^2 \text{ J.kg}^{-1} \text{ K}^{-1}$) of mass 0.50 kg at a temperature of 200°C is dropped into an aluminium calorimeter cup of mass 0.20 kg containing 1.50 kg of water ($c = 4.2 \times 10^3 \text{ J.kg}^{-1} \text{ K}^{-1}$) at 40°C . The system is adiabatically covered and attains equilibrium at a final temperature T_f .

(a) Use the definition of specific heat capacity, write down heat gained or loss for each medium and set the equation $Q_{total} = 0$. (5)

(b) Calculate T_f attained during equilibrium. (5)

2.4 Heat of vaporization is the amount of energy per unit mass that must be transferred as heat when the sample completely undergoes phase change. The latent heat of vaporization during the process is $2.256 \times 10^6 \text{ J.kg}^{-1}$. Suppose 0.015 kg of liquid water at a temperature of 100°C was converted to steam at standard atmospheric pressure, 1 atm . The volume of water changes from initial volume value of $0.50 \times 10^{-2} \text{ m}^3$ as a liquid to $2.50 \times 10^{-2} \text{ m}^3$ as steam.

(a) How much work is done by the system during this process? (2)

(b) How much energy is transferred as heat during that process? (2)

(c) What is the change in internal energy of the system during that process? (2)

2.5 Complete the table by filling in the correct information. Write down the answer and the corresponding answer according to the first law the thermodynamics. (5)

Process	Restriction	Outcomes
Closed cycle	(i).....	(ii).....
Free Expansion	(iii).....	$\Delta U = 0$
(iv).....	$Q = 0$	(v).....

2.6 Suppose a gas is confined in a cylinder with a movable piston with a heavy metal object placed on top. Its volume is changed from initial state (V_i) to final state (V_f) at a constant pressure. Prove that the differential work done by the system when the metal object is removed, and a piston moves an infinitesimal distance $d\vec{s}$ is

$$W = \int_{V_i}^{V_f} p dV \quad (4)$$

2.7 Consider a system of an ideal gas. Show that the work done in an adiabatic system is given by:

$$W = \frac{1}{\gamma-1} (p_1 V_1 - p_2 V_2), \text{ where } \gamma \text{ is a ratio of molar specific heat at a constant pressure to molar specific heat at constant volume, i.e. } \gamma = \frac{C_p}{C_v}. V_1, p_1 \text{ being initial state and } V_2, p_2 \text{ is final state of volume and pressure respectively.} \quad (7)$$

QUESTION 3**[20]**

3.1 Study the following figure (Fig. 1). In process $a \rightarrow b$, 200 J of heat was added to the system; in process $b \rightarrow d$, 720 J of heat was added to the system.

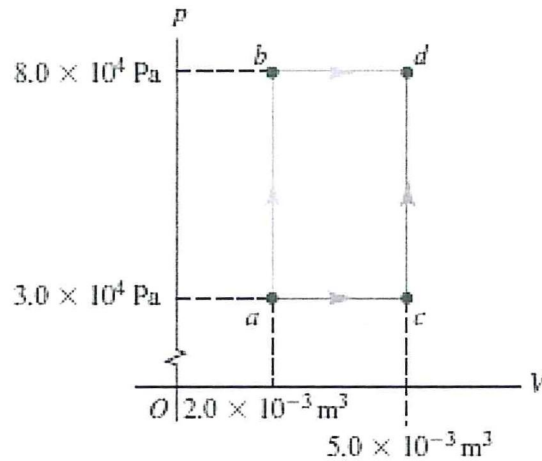


Fig. 1

Find the following;

- (a) the internal energy change in process $a \rightarrow b$. (3)
 - (b) the internal energy change in process $a \rightarrow b \rightarrow d$. (5)
 - (c) the total heat added in process $a \rightarrow c \rightarrow d$. (5)
- 3.2 Explain the methods by which the internal energy of a system can be altered. (3)
- 3.3 What is isochoric (isometric) process? If 1265 J of heat energy is added to a gas in an isochoric process, evaluate the change in internal energy of the gas. (4)

QUESTION 4**[16]**

- 4.1 Derive of Maxwell Relation from Helmholtz Free energy. (8)
- 4.2 Evaluate C_v for *one mole* of ideal argon gas ($R=8.31 \text{ J.K}^{-1} \text{ mol}^{-1}$). (3)
- 5.3 What is Entropy? Define second law of thermodynamics from entropy point of view. (5)

END OF EXAMINATION!