



MACHAKOS UNIVERSITY

University Examinations 2021/2022

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION
TECHNOLOGY)

BACHELOR OF SCIENCE (APPLIED PHYSICS AND TECHNOLOGY)

BACHELOR OF EDUCATION (SPECIAL NEEDS EDUCATION)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SPH 203/209: THERMAL PHYSICS

DATE:17/03/2022

TIME: 2:00-4:00 PM

INSTRUCTIONS TO CANDIDATES

Answer question ONE (COMPULSORY) and any other TWO questions.

Question one carries 30 marks, all other questions carry 20 marks each

USEFUL CONSTANTS

- i) Specific heat capacity of water $c_w = 4.184 \text{ J/g } ^\circ\text{C}$
- ii) Linear coefficient of expansion of steel $\alpha = 11.7 / ^\circ\text{C}$
- iii) Specific heat capacity of ice $c_{ice} = 2.077 \text{ J/g } ^\circ\text{C}$
- iv) Latent heat of Fusion of ice $L_f = 333 \text{ J/g}$
- v) a and b constants for Oxygen are $1.36 \text{ atmL}^2/\text{mol}^2$ and 0.0318 L/Mol , respectively
- vi) a and b constants for C_4H_{10} are $14.7 \text{ L}^2 \cdot \text{bar}/\text{Mol}^2$ and 0.123 L/Mol , respectively
- vii) Ideal gas constant $R=0.08206 \text{ L}\cdot\text{atm}/\text{Mol}\cdot\text{K}$

- viii) Stefan-Boltzmann constant $\delta = 5.67 \times 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4}$
- ix) Avogadro's number $A = 6.02 \times 10^{23}$
- x) Boltzmann constant $K_B = 1.38 \times 10^{-23} \text{ JK}^{-1}$
- xi) Ideal Gas constant 8.315 J / Mol.K

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Differentiate between reversible process and irreversible process. (2 marks)
- b) State the Boyle's law and give its mathematical their expression (2 marks)
- c) List any three assumptions of the Kinetic theory of gases (3 marks)
- d) With the aid of P-V diagrams, explain the meaning of the following thermodynamic processes
- i). Isobaric process (2 marks)
- ii). Adiabatic process (2 marks)
- e) A 0.05kg of metal is heated to 200°C and then dropped into a beaker containing 0.04kg of water initially at 20°C. if the final equilibrium temperature of the mixed system is 22.4°C, determine:
- i). The specific heat capacity of the metal (3 marks)
- ii). The amount of energy transferred to the water as the metal is cooled. (2 marks)
- f) A steel railroad track has a length of 35.0 m when the temperature is 10.0 °C. Determine its length when the temperature is 100.0 °C. (4 marks)
- g) In a quasi-static isothermal compression of an ideal gas, show that the work done is given by
- $$W = -RT \ln \frac{V_f}{V_i} \quad \text{where symbols have their usual meaning} \quad (4 \text{ marks})$$
- h) The wavelength at the peak of spectral distribution of a black-body at 4000 K is 674 nm. Determine the temperature when the peak is at 450 nm. (3 marks)
- i) Calculate the pressure exerted by 0.35 mole of oxygen gas in a volume of 6.5 L at 32 °C using van der Waals equation. (3 marks)

QUESTION TWO (20 MARKS)

- a) Differentiate between a black body and gray body. (4 marks)
- b) With the aid of a diagram explain ultraviolet catastrophe in blackbody radiation. (8 marks)
- c) Given that α is the coefficient of linear expansivity and β is the coefficient of volume expansivity, show that $\beta = 3\alpha$. State the assumptions made. (8 marks)

QUESTION THREE (20 MARKS)

- a) Differentiate between the terms chemical, mechanical and thermal equilibrium. (6 marks)
- b) On a warm summer day, the air temperature is 65 F. express this temperature in Degree Celsius ($^{\circ}\text{C}$) (3 marks)
- c) Find the amount of energy (J) required to heat 12.5 g of ice at -10.0°C to water at 0.0°C . (5 marks)
- d) Using P-V diagram and their respective expressions, describe work done in:
- (i) Expansion process (2 marks)
 - (ii) Compression process (2 marks)
 - (iii) Cyclic process (2 marks)

QUESTION FOUR (20 MARKS)

- (a) Differentiate between
- i). Latent heat of fusion and latent heat of vaporization (2 marks)
 - ii). Heat capacity and specific heat capacity (2 marks)
- (b) A 75.0 g piece of lead (specific heat = $0.130 \text{ J/g}^{\circ}\text{C}$), initially at 435°C , is set into 125.0 g of water, initially at 23.0°C . Calculate the final temperature of the mixture. (6 marks)
- (c) (i) show that the work done for an isothermal reversible expansion of a real gas according to the van der Waals equation of state is (6 marks)

$$W_{\text{Rev}} = nRT \lg \left(\frac{V_1 - nb}{V_2 - nb} \right) + an^2 \left(\frac{1}{V_1} - \frac{1}{V_2} \right)$$

- (ii) Calculate the work done when 0.171 mol of n-butane (C_4H_{10}) gas expands from 1.55L to 3.55L at 325K. Assume that the gas is ideal and it obeys van der Waals equation. (4 marks)

QUESTION FIVE (20 MARKS)

- a) Given that the velocities of the molecules are v , $2v$, $3v$, $4v$ & $5v$ m/s. Show that the r.m.s speed is given by $v\sqrt{11}$ m/s (4 marks)
- b) An ideal gas has initial temperature of 27°C . The temperature of the gas is increased to 927°C . Find the ratio of final V_{rms} to the initial V_{rms} (3 marks)
- c) (i) Differentiate between diffusion and effusion (2 marks)
(ii) State and explain three modes of heat transfer (6 marks)
- d) show that for an adiabatic process $PV^\gamma = \text{constant}$, where $\gamma = \frac{c_p}{c_v}$ (5 marks)