MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

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 SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCTAION (SCIENCE)

SPH 203/209 THERMAL PHYSICS 1

DATE: 9/8/2021 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

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 $c_w = 4.184 J/g\ ^oC$

ii) Linear coefficient of expansion of steel $\alpha = 11.7 \times 10^{-6}\ /^o C$

iii) Specific heat capacity of ice $c_{ice} = 2.077\ J/g\ ^oC$

iv) Latent heat of Fusion of ice $L_f = 333\ J/g$

v) 1 calorie = 4.184 joules

vi) Molar mass of Nitroge = 28.014 a.m.u

vii) a and b constants for Oxygen are 1.36 $atmL^2/mol^2$ and 0.0318 L/Mol, respectively

viii) a and b constants for C_4H_{10} are $14.7L^2.bar/Mol^2$ and 0.123L/Mol, respectively

ix) Ideal gas constant R=0.08206 L.atm/Mol.K

x) Stefan-Boltzmann constant $\delta = 5.67 \times 10^{-8} Wm^{-2} K^{-4}$

QUESTION ONE (30 MARKS)

a) State:

i. The Boyle's law and give its mathematical expression (2 marks)

ii. Two assumptions of Kinetic theory of gases (2 marks)

iii. The 1st Law of Thermodynamics (2 marks)

b) Differentiate between reversible process and irreversible process. Give one example of each (4 marks)

c) Explain the meaning of the following thermodynamic processes

i. Isobaric process (1 mark)

ii. Isochoric process (1 mark)

d) How many Calories (nutritional) will you burn by drinking 1.0 L of water, initially at 36.5 ^{o}F (standard refrigeration temperature)? Assume that the body must expend energy to heat the water to body temperature at 98.6 ^{o}F. (4 marks)

e) A steel railroad track has a length of 30.0 m when the temperature is 0.0 °C. Determine its length when the temperature is 70.0 °C. (3 marks)

f) In a quasi-static isothermal compression of an ideal gas, show that the work done is given by $W = -RT \ln \frac{V_f}{V_i}$ where symbols have their usual meaning (4 marks)

g) The wavelength at the peak of spectral distribution of a black-body at 4300 K is 674 nm. Determine the temperature when the peak is at 420 nm (3 marks)

h) Calculate the pressure exerted by 0.35 mole of oxygen gas in a volume of 6.5 L at 32 ^{o}C using

i. The ideal gas equation and (2 marks)

ii. van der Waals equation (2 marks)

QUESTION TWO (20 MARKS)

a) State the Wien's displacement law and give its mathematical expression (3 marks)

b) Determine the solar energy over the area of 1 m^2. The temperature of the sun's surface is 6000 K and the temperature of the surrounding is 300 K (2 marks)

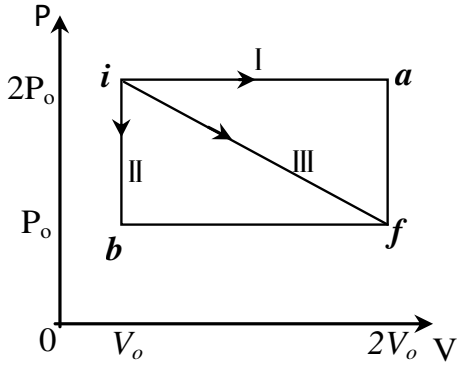
c) Given that α is the coefficient of linear expansivity and β is the coefficient of volume expansivity, show that $\beta = 3\alpha$. State the assumptions made. (6 marks)

d) i Differentiate between diffusion and effusion (2 marks)

ii. It has taken 192 seconds for 1.4 L of an unknown gas to effuse through a porous wall and 84 seconds for the same volume of N_2 gas to effuse at the same temperature and pressure. Calculate the molar mass of the unknown gas (4 marks)

e) In the following P-V diagram, show that work done along path *ia* is given by:

$$W = -\frac{3}{2}P_oV_o$$ (3 marks)



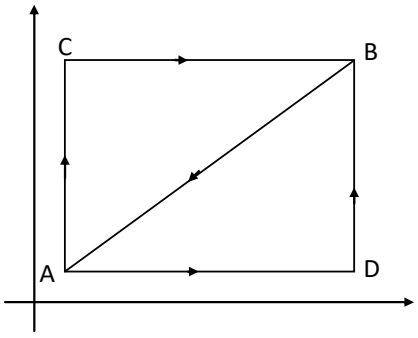
QUESTION THREE (20 MARKS)

a) Define the term thermal equilibrium (2 marks)

b) On a warm summer day, the air temperature is 70 F. express this temperature in Degree Celsius (^oC) (2 marks)

c) Heat of 500 J is added to ideal gas that is expanding from $0.2m^3$ to $0.3m^3$ at a constant pressure of 4000 Pa. Calculate the change in internal energy using the first law of thermodynamics (4 marks)

d) When a system is taken from state A to B, along path ACB, 80 KJ of heat flow into the system and it does 30KJ of work.



i. Determine the amount of heat which will flow into the system along the path ADB if the work done by it along this path is 10 kJ. (3 marks)

ii. If the system is returned from B to A along a straight path, calculate the amount of work and direction of heat interactions (Along path BA). (3 marks)

e) 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. Thermal equilibrium and absolute zero temperature (2 marks)

ii. Latent heat of fusion and latent heat of vaporization (2 marks)

iii. Heat capacity and specific heat capacity (2 marks)

a) A girl is trying to decide what to wear. The surroundings (bedroom) are at 20.0 °C. If the skin temperature of the girl is 35 °C, calculate the net energy loss by radiation from her body in 10.0 minutes. Assume that the emissivity of skin is 0.900 and that the surface area of the girl is 1.50 m^2. (4 marks)

b) 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)

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

ii. Calculate the work done when 0.171mol 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) State and explain three modes of heat transfer (6 marks)

b) show that for an adiabatic process $PV^{\gamma} =$ constant, where $\gamma = \frac{c_P}{c_V}$ (5 marks)

c) A tank used for filling helium balloons has a volume of 0.3 m^3 and contains 2.0 mol of helium gas at 20.0°C. Assuming that the helium behaves like an ideal gas,

i. Determine the total translational kinetic energy of the molecules of the gas (3 marks)

ii. Determine the average kinetic energy per molecule (3 marks)

iii. Using the fact that the molar mass of helium is 0.004 kg/mol, determine the rms speed of the atoms at 20.0 °C (3 marks)