BINDURA UNIVERISTY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION/ SCIENCE AND ENGINEERING

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION / DEPARTMENT OF ENGINEERING AND PHYSICS

BACHELOR OF SCIENCE EDUCATION DEGREE PHYSICS / BACHELOR OF SCIENCE HONOURS DEGREE IN ENVIRONMENTAL PHYSICS AND ENERGY SOURCES

PH301/HPH212: THERMODYNAMICS

DURATION: 3 HOURS

AUG 2024

INSTRUCTIONS

Answer ALL parts of Section A and any THREE questions from Section B.

Section A carries 40 marks and each question in Section B carries 20 marks.

CONSTANTS: Planck's constant $h = 6.626 \times 10^{-34}\ \mathrm{m^2 kg/s}$
Boltzmann constant, $k = 1.38 \times 10^{-23}$ J/K,
Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$
Avogadro constant, $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
The molar mass constant, $R = 8.31\ \mathrm{J\ K^{-1}\ mol^{-1}}$

SECTION A

Question 1

(a) State the forbidden devices for the two forms of the second law of Thermodynamics (3)

(b) (i) What is meant by saturated vapour and saturated vapour pressure? (2)

(ii) Describe and explain the conditions necessary for Phase equilibrium (3)

(iii) What is the importance of the sublimation curve? (1)

(c)(i) Sketch a graph to show how the wavelength λ_m of radiation emitted with maximum intensity by a black body varies with temperature (3)

(ii) What is the significance of the area under the intensity-wavelength graph? (1)

(iii) A reversible heat engine has an efficiency of 0.6 when it absorbs 400kJ of energy as heat from a reservoir at 537. Calculate the sink temperature and the energy rejected as heat to the sink. (5)

(d) (i) Explain the following : entropy, entropy crisis and Heat death (6)

(ii) What are the properties of a thermodynamic universe? (3)

(e) Prove the following for an adiabatic process in an ideal gas;

$$TV^{\gamma-1} = Constant \quad (4)$$

(f) Derive the expression for the entropy of one mole of an ideal gas (4)

(g) Calculate the entropy change of 3kg of water at 100°C when it is evaporated to steam at 100°C. Specific latent heat of vaporization of water is $2{,}26 \times 10^6 JK^{-1}g$ at 100°C. (5)

SECTION B

Question 2

(a) State the central equation of thermodynamics. (2)

(b)(i) State Clausius statement and Kelvin - Plank statement of the second law of thermodynamics (4)

(ii) Using the central equation of thermodynamics

$$Tds = dU + pdV$$

Show that

$$dS = C_V \frac{dT}{T} + \alpha_v \beta_T dV \quad (5)$$

(c) (i)State the Helmholtz free energy function (F), Internal energy function (U) and the Enthalpy (H) state functions. (3)

(ii) Using the F, E, H and G state functions, derive the four Maxwell Relations (6)

Question 3

(a) (i) What are the conditions for a process to be isentropic? (1)

(ii) Calculate the change in entropy when 1kg of water $C_p = 4, 2 \times 10^6 kgK^{-1}$ is heated reversibly and isobarically between 20°C and 100°C (3)

(iii) For an irreversible free expansion, show that

$$dS = nRL2$$

n = number of moles , R = universal gas constant (4)

(b) (i) A beaker of water with thermal capacity, C_P, is heated

from $T_i = 293K$ to $T_f = 373\,K$

The heating process is done reversibly and isobaric ally between the two temperatures. Calculate the net entropy change of the Universe $\Delta S^{universe}$ that occurs (4)

(ii) What is $\Delta S^{universe}$ if the water is heated in two stages by placing it first on a reservoir at 50°C and when it reaches that temperature, transferring it to a second reservoir at 100 °C for the final heating? (4)

(iii) With the aid of a well labelled diagram, show that in any irreversible process the energy that becomes unavailable for work is always $T_o\Delta S^{universe}$ (Where T_o is the temperature of the second reservoir with the lowest temperature). (4)

Question 4

(a) (i) State the Carnot-Clausius theorem for a perfect gas. (1)

(ii) For an infinitesimal reversible process, show that C_P=C_V+nR (4)

(iii) Show that for a gas expanding isothermally from V_1 to V_2

$$W = P_2V_2\ln\left(\frac{V_2}{V_1}\right)$$ (5)

(b) (i)What are the properties of black body radiation? (4)

(ii) State Rayleigh-Jeans' formula for the intensity of blackbody radiation and explain the symbols that you have used. (3)

(iii) Describe and explain the ultraviolet catastrophe phenomena (3)

Question 5

(a)(i) Explain what is meant by 'critical temperature' of a real gas (1)

(ii) Derive the equation of state for real gases (3)

(iii) Show that the Clausius -Claypeyron equation for the slope of the phase boundary is given as

$$\frac{dP}{dT}=\frac{l}{T(V_2-V_1)}=\frac{L}{T(V_2-V_1)} \quad (5)$$

b) (i)For an ideal gas where $U = U(T)$ and $C_v = \left(\frac{\partial U}{\partial T}\right)_v = \frac{dU}{dT}$,

Show that the entropy of one mole of an ideal gas is given by the expression

$$S = C_V lnT + RlnV + S_O$$ Where S_o is a constant

V is the volume of one mole of the gas and T is temperature? (7)

(ii) Express the entropy (S) as a function of temperature and pressure. (4)

Question 6

(a)(i) What is meant by Superconductivity and Superfluidity? (4)

(ii) Outline the main properties of first order and second order phase changes. Give two examples of each of them (6)

(b) For each of the following processes, state whether the process is reversible or irreversible and state which of the quantities S, H, U, F and G are unchanged:

(i) an isothermal quasistatic expansion of an ideal gas in a cylinder fitted with a frictionless piston (2)

(ii) as in (i) but for a non - ideal gas (2)

(iii) a quasistatic adiabatic expansion of a gas in a cylinder fitted with a frictionless piston. (2)

(iv) an adiabatic expansion of an ideal gas into a vacuum (free expansion).

(v) a throtting process of a gas through a porous plug (the Joule-Kelvin effect). (2)

END OF EXAM

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AUG 2024

DEPARTMENT OF GEOGRAPHY

BACHELOR OF SCIENCE EDUCATION HONOURS DEGREE (HBSCED)/

BACHELOR OF SCIENCE EDUCATION DEGREE (BSCED)

GG413: GEOGRAPHY OF SOUTHERN AFRICA

TIME: 2 ¼ HOURS

ANSWER ANY THREE QUESTIONS. USE ILLUSTRATIONS AND DIAGRAMS WHERE RELEVANT. MARKS FOR EACH QUESTION ARE INDICATED IN BRACKETS [ ].

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1. With reference to specific examples discuss the rationale for land reform in Southern Africa. [25]
2. Discuss the contribution of land reform to food security in Zimbabwe. [25]
3. Explain the origins of land conflicts in Southern Africa and the problems that have emanated from these conflicts. [25]
4. 'Addressing land ownership and distribution of a country is critical to national stability and economic prosperity' Discuss with reference to Southern Africa. [25]
5. 'Population mobility within Southern Africa is among the world's greatest'. Elaborate with specific examples. [25]

END OF EXAMINATION