COVENANT UNIVERSITY NIGERIA

TUTORIAL KIT
OMEGA SEMESTER

PROGRAMME: CHEMICAL ENGINEERING

COURSE: GEC 221

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GEC 221: THERMODYNAMICS

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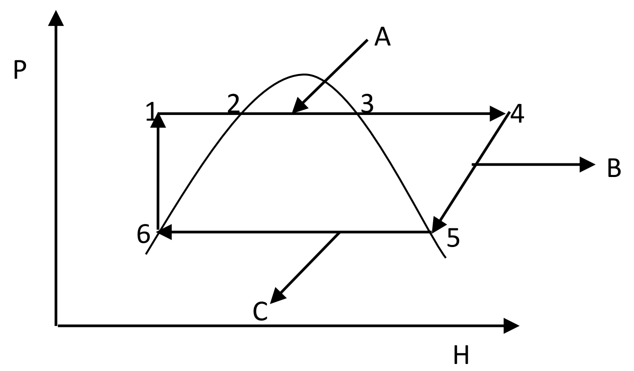
1. 2 kg of a gas are squeezed in a device from a volume of $1.4m^3$ to a volume of $0.9m^3$ with a pressure of $100{,}000N/m^2$, and it is known from considerations that the internal energy **decreases** by 12,000J. (**NOTE**; 1 Nm = 1Joule). What is the work done?
2. Define a thermodynamic system.
3. From question 1, calculate the energy transferred as heat
4. The second virial coefficient , **B**, of water vapour at 250^0C and 10 bar is $\frac{-0.1482m^3}{kgmol}$. Given Universal Gas Constant to be $R = 8.314x10^{-2}\frac{bar.m^3}{kgmol.K}$. Calculate the volume using the ideal gas law and calculate the compressibility factor by using the ideal gas law. Also calculate the volume by using virial equation of state truncated at second term and compressibility factor Z by using virial equation of state truncated at second term.
5. A substance expands from $V_1 = 1ft^3$ to $V_2 = 6\ ft^3$ in a constant pressure process at 100 Ib_f/in^2. The initial and final internal energies are $U_1 = 40$ Btu and $U_2 = 20$ Btu respectively. Given the **conversion factors; 1 Btu = 1055.06J 1 Ib_f = 4.4482N 1 ft^3 = 0.028317m^3 1 m = 39.37in , Determine the work done.**
6. What instrument is needed to measure the enthalpy of a system? Is work a form of stored energy?
7. What is the energy transferred as heat in question 5?
8. Define a thermodynamic property and list all variables that are thermodynamic properties and those not thermodynamic properties.
9. **It is necessary to store 1 Ibmole of methane at temperature of 122 ºF and a pressure of 600 atm.**

   Given R (universal gas law constant) = $0.7302\frac{ft^3\ atm.}{Ibmole.\ ^oR}$ and

   ºR (degree Rankine) = º F + 460 . Use the information to answer Questions 1 and 2.
   What is the volume of the vessel that must be provided (use the ideal gas law). Convert the answer to the SI unit.
10. In the series PV = a (1 + B'P + C'P^2 + …), the constants are functions of ………………..
11. The 2^{nd} law of thermodynamics could be written as……..
12. The equation for a mechanically reversible constant volume process is given as………………………
13. A heat engine using water as working fluid operates between boiler (BO) and condenser (CO) temperature of 320 ºC and 190 ºC, respectively. The Heat Engine Cycle represented on a Pressure versus Enthalpy diagram is shown below.



A, B, and C represent

14. Define a reversible system
15. From question 13, What does line 4-5 represent. Also what does line 6-1 represent.
16. For a given material the second virial coefficient B is a function of ……………..
17. From question 13,Calculate Q_{BO} and Q_{CO}.
18. The Fluid at point 3 is…………………………
19. From question 13, Calculate the Rankine thermal efficiency
20. The Fluid at point 4 is…………………………………………….

GEC 221: THERMODYNAMICS SOLUTIONS

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1.

$\Delta V = V_2 - V_1$

$= (1.4-0.9)\ m^3 = 0.5\ m^3$

$\Delta U = -12,000\ J$

Work done, $W = P\ \Delta V = 105\ N/m^2 \times 0.5\ m^3$

$= 50,000\ Nm = 50,000\ J$

3. $\Delta U = Q + W$

$Q = -12000-50000$

$= -62,000J$

5. Using the conversion factor,

P = 689,469.62 N/m2

Work done, $W = P\ \Delta V$

$=689,469.62\ N/m2\ (6-1)\ (ft^3 .\ 0.028317\ m^3/1ft^3)$

$= -97618.56$ Nm. It is negative because substance expands.

7. $\Delta U = Q + W$

$\Delta U = (U_2-U_1)$

$= (20-40)\ Btu\ = -20\ Btu$

$-20\ Btu\ .\ (1055.06\ J)/\ 1\ Btu$

$= -21101.2\ J$

$Q = -21101.2\ J + 97618.56\ J$

$Q = 76,517.6\ J$

9. $^oR = 122 + 460\ = 582\ ^oR$

$PV = nRT$

$V = nRT/P$

Substituting values,

$V = 0.708\ ft^3$

Converting, $0.708\ ft^3\ .\ (1\ m)^3/(3.2808\ ft)^3$

$= 0.02\ m^3$

11. $dU = dQ/T$

13. A = Boiler (Q_{BO}), B = Turbine (Work, W), C = Condenser (Q_{CO})

15 Line 4-5 = Isentropic expansion. Line 6-1 Isenthalpic pumping.

17 From Figure, Pick the values of H_1, S_4, and S_3 from the Steam Table

Then,

$Q_{BO} = H_4 - H_1$

$H_4 = H_3 + T_3 (S_4 - S_3)$

Substituting the values

$H_4 = 3377.42$ kJ/kg

$Q_{BO} = 3377.42 - 419.0$

= 2958.42 kJ/kg

Similarly, $Q_{CO} = H_5 - H_6$

19 Rankine thermal efficiency

$= W/Q_{BO} = H_4 - H_5/Q_{BO}$

= 0.237