

Mid Semester Exam (MONSOON 2019)
Science I

Time: 90 min

Total: 25 marks

(1) The equation of state of a van der Waals gas is given by

$$(P + a \frac{n^2}{V^2})(\frac{V}{n} - b) = RT$$

where P is the pressure, V is the volume, T is the temperature, R is the gas constant, n is the number of moles of the gas, a and b are positive constants. Determine the second and third virial coefficients of this gas (Note: The equation of state of an ideal gas is $PV = nRT$ and you may need to use molar density in the virial expansion). [5]

(2) What are Hamilton's equations of motion? Why do we need them? [1]

(3) Compare the phase space trajectories of an isolated and a closed one-dimensional harmonic oscillators. [2]

(4) What is Boltzmann's entropy formula? What is its significance? [1]

(5) For a closed system at a constant temperature T , derive the relationships between the partition function and (a) internal energy (b) heat capacity (c) entropy and (d) Helmholtz free energy. [6]

(6) What are thermodynamic potentials? Under what conditions are they useful?

(7) Using the second law of thermodynamics, show that the process of flow of heat from a colder object to a hotter object is not spontaneous. You may assume that these two objects are in contact and they are isolated from the surroundings. [2]

(8) How is chemical potential related to the Gibbs free energy of system? [1]

(9) Discuss the following: (a) phase stability (b) phase diagram (c) phase boundary (d) phase transition (e) triple point. [4]