



UNIVERSITI SAINS MALAYSIA

Final Examination
2016/2017 Academic Session

May/June 2017

JIF 415 – Statistical Mechanics
[Mekanik Statistik]

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper contains **SIX** printed pages before you begin the examination.

Answer **ALL** questions. You may answer **either** in English or in Bahasa Malaysia.

Read the instructions carefully before answering.

In the event of any discrepancies in the exam questions, the English version shall be used.

*Sila semak kertas peperiksaan ini mengandungi **ENAM** muka surat yang bercetak sebelum anda menjawab sebarang soalan.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab soalan **sama ada** dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca setiap arahan dengan teliti sebelum menjawab.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

Constants:

Universal gravitational constant $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

1 Pa = 1 N m⁻²

1 atm = 1.013 × 10⁵ Pa

Molar gas constant $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$

Permeability constant $\mu_0 = 4\pi \times 10^{-7} \text{ wb A}^{-1} \text{ m}^{-1}$ (or H m⁻¹)

Permittivity constant $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

Planck's constant $h = 6.6 \times 10^{-34} \text{ J s}$

$c = 3 \times 10^8 \text{ m s}^{-1}$

1 eV = 1.60 × 10⁻¹⁹ J

Electron rest-mass $m_e = 9.11 \times 10^{-31} \text{ kg}$

Mass of proton = 1.007276 amu

Mass of neutron = 1.008665 amu

Avogadro's number $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

1 u = 1.66 × 10⁻²⁷ kg = 931 MeV

Answer ALL questions.

1. (a) What is a canonical ensemble?
(10 marks)
- (b) Show that the Helmholtz free energy, F , can be related to the partition function, Z , as $F = -kT \ln Z$, where k is the Boltzmann constant and T the temperature.
(15 marks)
2. In a two-level system, the first excited state is 10 eV higher than the ground state. Find the
 - (a) ratio of the atoms that are in the excited state at room temperature $T = 300\text{K}$.
(10 marks)
 - (b) temperature when only 0.1% of atoms are in the excited state.
(15 marks)
3. (a) What are fermions?
(5 marks)
- (b) Find the Fermi level in Na if each atom contributes only one electron to the electron gas.
(10 marks)

- (c) Determine the velocity of an electron that has a kinetic energy in the vicinity of the Fermi energy.
(10 marks)
4. (a) Describe the Kinetic Theory of Gases.
(10 marks)
- (b) From the Maxwell-Boltzmann distribution function, find the \bar{V} and V_{rms} of an ideal gas.
(15 marks)

Jawab SEMUA soalan.

1. (a) *Apakah himpunan kanonikal?*
(10 markah)
- (b) *Tunjukkan bahawa tenaga bebas Helmholtz, F , boleh dikaitkan dengan fungsi pemetakan, Z , sebagai $F = -kT \ln Z$, yang mana k adalah pemalar Boltzmann dan T adalah suhu.*
(15 markah)
2. *Dalam suatu sistem dua paras, paras teruja adalah 10 eV lebih tinggi daripada paras asas. Cari*
 - (a) *nisbah atom yang berada di paras teruja pada suhu bilik, $T = 300K$.*
(10 markah)
 - (b) *suhu di mana hanya 0.1% atom berada di paras teruja.*
(15 markah)
3. (a) *Apakah fermion?*
(5 markah)
- (b) *Cari paras Fermi dalam Na jika setiap atom hanya menyumbang satu elektron saja kepada gas elektron.*
(10 markah)

- (c) *Tentukan halaju suatu elektron yang mempunyai tenaga kinetik di persekitaran tenaga Fermi.*
(10 markah)
4. (a) *Huraikan Teori Kinetik Gas.*
(10 markah)
- (b) *Dari fungsi taburan Maxwell-Boltzmann, carilah \bar{V} dan V_{rms} bagi gas unggul.*
(15 markah)