**NATIONAL UNIVESITY OF SCIENCE AND TECHNOLOGY**

**APPLIED PHYSICS DEPARTMENT**

**SPH 1203– THERMAL PHYSICS**

**SUPPLEMENTARY EXAMINATION**

**BSc HONOURS APPLIED PHYSICS: PART I:**

**JULY 2013 DURATION: 3HOURS**

ANSWER ALL PARTS OF QUESTION ONE IN SECTION A AND ANY THREE QUESTIONS FROM SECTION B. SECTION A CARRIES 40 MARKS AND SECTION B CARRIES 60 MARKS.

*SHOW ALL YOUR STEPS CLEARLY IN ANY*

**SECTION A**

1. (a) Define the following terms giving examples of each:

 (i) Thermodynamic coordinates

 (ii) Thermal equilibrium [6]

 (b) Write down the First Law of thermodynamics of a composite system such as a paramagnetic gas. State which of the thermodynamic coordinates are intensive and extensive quantities. [6]

(c) Distinguish a reversible from irreversible process. Give one example of each process. [4]

(d) Show that for an adiabatic transformation $TV^{γ-1}$ is a constant [5]

 ( e ) Express $ β\_{p }$ and $K\_{T }$ in terms of the partial derivatives of the

 ideal gas thermodynamic coordinates. [5]

(f) Give an example of a cyclic process and stating its purpose. [4]

(g) (i) Calculate the work done by one mole of a gas during a quasi-static isothermal volume $V\_{1}$ to a final volume $V\_{f}$ when the equation of state

 is: p$\left(v-b\right)=RT$ [6]

(ii ) Name the equation in (i) and compare it to the ideal gas equation. [4]

SECTION B

2. (a) Write down the First Law of Thermodynamics defining all the quantities involved and stating which one of these quantities does the Law define. [4]

 (b) If the internal energy U is a function of any two of $p V and T.$ Show that if we choose $V and T$ then

 $dQ=\left(\frac{∂U}{∂T}\right)dT+\left[\left(\frac{∂u}{∂v}\right)\right.\left.+p\right]dV$ [6]

 (c ) From the expression in (b) show that the internal energy is a function

 of T only if the system is an ideal gas. [6]

 (d) Define the quantities $C\_{H} and C\_{M}$ showing how they are related to the quantities involved in the first law of thermodynamics for a paramagnetic gas. [4]

3. (a) An air-standard diesel cycle has the following quasi- static processes;

 1$\rightarrow 2$ is an adiabatic compression of air

 2$\rightarrow 3$ is an isobaric increase in temperature and volume.

 3$\rightarrow $4 is an adiabatic expansion with a drop in temperature.

 and 4 $\rightarrow 1$ is an isochoric process with a drop in pressure and temperature.

 Make a labelled sketch of this cyclic process. [6]

 (b) Deduce an expression for the efficiency of an engine operationg in an idealized air-standard cycle. [8]

 (c) Compare the efficiency of this cyclic process to that of the Otto cycle. [6]

4. 4 a) If a paramagnetic substance obeys Curie’s Law show that the work done during a quasi-static isothermal change of state is:

 $W=\frac{μ\_{0}T}{2C\_{c}}\left(M\_{f}^{2}-M\_{i}^{2}\right) $ [8]

 b) A volume of $2x10^{-4}m^{3}$ of a paramagnetic substance is maintained at a constant temperature. A magnetic field is increased quasi-statically and isothermally from 0.0 to $10^{6}Am^{-1}$. Assuming Curie’s equation to hold and Curie’s constant to be 0.15 deg.

1. How much work ls done to change the magnetization of the material when the temperature is 300 K and when it is 1 K? [6]
2. How much work is done at both temperatures by the agent supplying the magnetic field?

 [6]

5. (a) If Maxwell’s distribution of speeds of molecules is given as:

 $dn\_{v}=\frac{4n}{\sqrt{π}}β^{{3}/{2}}v^{2}e^{-βv^{2}}$ where $β= \frac{m}{2kT}$

1. Define $v\_{rms}$ of the molecules [4]
2. From this distribution show how you can compute the most probable speed of the molecules and the root mean squared speed of the molecules. [6]
3. If the translation - energy distribution is in the form:

$ dn\_{E}=nf(E,T)$, where E is the translational-energy, write out the function $f(E,T)$ and make a sketch of it as a function of E with T a constant. [10]

 6. (a) State Kirchoffs Law and state its relationship to the Stefan Boltzmann Law. [6]

 (b) Write down expressions for the rate at which heat is transferred between

 any two bodies in any two modes of heat transfer that you are familiar

 with. [6]

 (c) Suppose that heat conduction occurs at a constant rate $\dot{Q}$ from one end of a metal bar of crossectional area A and length L whose thermal conductivity is K. Write down an expression for difference in temperature of the ends of the metal bar. [8]

**END OF EXAMINATION**