STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2011-12 & thereafter)

SUBJECT CODE : 11PH/MC/TS24

B.Sc. DEGREE EXAMINATION APRIL 2014
BRANCH III - PHYSICS
SECOND SEMESTER

REG. No._____

COURSE : MAJOR – CORE
PAPER : THERMAL PHYSICS AND STATISTICAL MECHANICS
TIME` : 30 MINS. MAX. MARKS : 30

SECTION – A

TO BE ANSWERED IN THE QUESTION PAPER ITSELF

ANSWER ALL QUESTIONS: (30 x 1 = 30)

I CHOOSE THE CORRECT ANSWER:

1. A balloon is filled with cold air and placed in a warm room. It reaches thermal equilibrium with the air of the room by
   a) rising to the ceiling b) sinking to the floor
   c) contracting d) expanding

2. The zeroth law of thermodynamics allows us to define
   a) work b) pressure c) temperature d) internal energy

3. Two different objects have the same mass and temperature. Equal quantities of energy are absorbed as heat by each. Their final temperatures may be different because they have different
   a) thermal conductivities b) heat capacities c) densities d) volumes

4. The heat capacity of object B is twice that of object A. Initially A is at 300K and B is at 450 K. They are placed in thermal contact and the combination is isolated. The final temperature of both objects is
   a) 200K b) 300K c) 450K d) 400K

5. Inside a room at a uniform comfortable temperature, metallic objects generally feel cooler to the touch than wooden objects do. This is because
   a) a given mass of wood contains more heat than the same mass of metal
   b) metal conducts heat better than wood
   c) heat tends to flow from metal to wood
   d) the human body, being organic, resembles wood more closely than it resembles metal

6. An iron stove, used for heating a room by radiation, is more efficient if
   a) its inner surface is highly polished
   b) its outer surface is covered with aluminum paint
   c) its outer surface is rough and black
   d) its outer surface is highly polished

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7. An ideal gas undergoes an isothermal process starting with a pressure of 2×10^5 Pa and a volume of 6 cm^3. Which of the following might be the pressure and volume of the final state?
   a) 1×10^5 Pa and 10 cm^3 b) 3×10^5 Pa and 6 cm^3
   c) 4×10^5 Pa and 4 cm^3 d) 6×10^5 Pa and 2 cm^3

8. An isothermal process for an ideal gas is represented on a p-V diagram by
   a) a horizontal line b) a portion of a hyperbola
   c) a portion of an ellipse d) a portion of a parabola

9. The speeds of 25 molecules are distributed as follows: 5 in the range from 2 to 3m/s, 10 in the range from 3 to 4m/s, 5 in the range from 4 to 5m/s, 3 in the range from 5 to 6m/s, 1 in the range from 6 to 7m/s, and 1 in the range from 7 to 8m/s. Their average speed is about:
   a) 2m/s b) 3m/s c) 4m/s d) 5m/s

10. The internal energy of an ideal gas depends on
    a) the temperature only b) the pressure only
    c) the volume only d) the temperature and pressure only
11. The pressure of an ideal gas is doubled in an isothermal process. The root-mean-square speed of the molecules
    a) does not change b) increases by a factor of $\sqrt{2}$
    c) decreases by a factor of $1/\sqrt{2}$ d) increases by a factor of 2

12. The pressure of an ideal gas is doubled during a process in which the energy given up as heat by the gas equals the work done on the gas. As a result, the volume is:
    a) doubled b) halved c) unchanged d) the process is impossible

13. The specific heat of a polyatomic gas is greater than the specific heat of a monatomic gas because
    a) the polyatomic gas does more positive work when energy is absorbed as heat
    b) the monatomic gas does more positive work when energy is absorbed as heat
    c) the energy absorbed by the polyatomic gas is split among more degrees of freedom
    d) the pressure is greater in the polyatomic gas

14. The mean free path of molecules in a gas is proportional to:
    a) the average molecular speed b) the reciprocal of the molecular diameter
    c) the molecular concentration d) the reciprocal of the molecular concentration

15. The change in entropy is zero for:
    a) reversible adiabatic processes b) reversible isothermal processes
    c) reversible isobaric processes d) all adiabatic processes

II FILL IN THE BLANKS:

16. The number of degrees of freedom of a triatomic molecule equals _____.
17. According to the Maxwellian speed distribution, as the temperature increases the most probable speed _____.
18. The mean free path of molecules in a gas is proportional to _____ of the diameter of the molecules.
19. A hot object and a cold object are placed in thermal contact and the combination is isolated. They transfer energy until they reach a common temperature. The change ΔS_h in the entropy of the hot object is found to _____.
20. A heat engine absorbs energy of magnitude $|Q_H|$ as heat from a high temperature reservoir, does work of magnitude $|W|$, and transfers energy of magnitude $|Q_L|$ as heat to a low temperature reservoir. Its efficiency is given by _____

III STATE WHETHER TRUE OR FALSE:

21. According to the first law of thermodynamics, the increase in the internal energy during any process equals the heat input minus the work done on the gas.
22. The difference in entropy $\Delta S = (Sf - Si)$ for two states i and f of a system can be computed as the integral of dQ/T provided a reversible path is used for the integral.
23. For a gas at thermal equilibrium the average speed v, the most probable speed v_p, and the root-mean-square speed v_{rms} are in the order: $v_p < v_{rms} < v$.
24. Bose-Einstein statistics is applicable to half-integer spin particles.
25. The minimum value of number of microstates corresponding to a given macrostate is unity.

IV ANSWER BRIEFLY:

26. Define Gibbs function and mention its importance.

27. Define the coefficient of performance of a reversible refrigerator.

28. Write down the relation connecting the first and second laws of thermodynamics and explain the symbols.

29. State third law of thermodynamics.

30. Define the term ‘ensemble’ and mention the three types of ensemble.

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SECTION – B

ANSWER ANY FIVE QUESTIONS: (5 x 5 = 25)

1. Find the diameter of CO_2 molecule from the following viscosity data: coefficient of viscosity = 14.5 x 10^{-6} SI units at room temperature and 1 atm. pressure, Boltzmann constant = 1.38 x 10^{-23} SI units.

2. An ideal gas with c_v = 3R/2, occupies a volume of 4 m^3 at a pressure of 8 atm. and a temperature of 127 deg.C. The gas expands to a final pressure of 1 atm. Calculate the final volume, temperature, work done, heat absorbed and change in internal energy for i) a reversible, isothermal expansion and ii) a reversible, adiabatic expansion (gas constant = 8.31 SI units).

3. Determine the change in entropy involved in the reversible process of converting unit mass of water at 0 deg.C to steam at 100 deg.C, given that specific heat at constant pressure = 4180 SI units and latent heat of transformation at 1 atm. Pressure = 22.6 x 10^5 SI units.

4. Find the change in melting point of wax if the pressure is varied by 1 atm., given data: latent heat of fusion = 1.39 x 10^5 SI units, melting point of wax= 52.7 deg.C, increase in volume per unit mass = 125 cc.

5. Calculate the thermodynamic probability of the macrostate in which 3 indistinguishable particles are distributed between 2 levels, with 2 particles in the 1^{st} level having a degeneracy factor of 3 and 2^{nd} level with two-fold degeneracy, when the particles obey i) B-E statistics and ii) F-D statistics.

6. Derive the expression for the coefficient of thermal conductivity of a gas.

7. Treating T and V as independent variables, derive the first TdS equation from the combined expression of first and second laws of thermodynamics.

SECTION – C

ANSWER ANY THREE QUESTIONS: (3 x 15 = 45)

8. a) List out the assumptions of Planck and obtain the Planck's black body radiation law
   b) Deduce Wien's and Rayleigh-Jeans' laws from it.

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9. State the principle of heat engine. Describe how the reverse of the heat engine cycle leads to refrigeration cycle and obtain its coefficient of performance.

10. a) Write down the Clausius and Kelvin's statements of second law of thermodynamics.
    b) Define entropy and obtain the expression for change of entropy of an ideal gas.
    c) Show that the change in entropy in any reversible cycle is zero and that in an irreversible cycle is always positive .

11. Describe the theory and experiment to produce low temperatures by adiabatic demagnetization process

12. a) Derive the Maxwell's law of velocity distribution.
    b) Obtain the expressions for the most probable, mean and rms values of molecular velocity.