PHYSICS **Max.Marks:80**

SECTION-1

(SINGLE CORRECT CHOICE TYPE)

Section-I (Single Correct Answer Type, Total Marks: 24) contains 8 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. For each question you will be awarded 3 marks if you darken ONLY the bubble corresponding to the correct answer and zero marks if no bubble is darkened. In all other cases, minus one (-1) mark will be awarded.

21. A brass scale is graduated at $10°C$. What is the true length (at $30°C$) of a copper rod which measures 60.00cm on this scale at $30°C$? (Coefficient of linear expansion of brass and copper are $18\times10^{-6}K^{-1}$ and $17\times10^{-6}K^{-1}$ respectively.

A) 59.08cm B) 59.98cm C) 60.02cm D) 60.01cm

22. A solid body x of heat capacity C is kept in an atmosphere whose temperature is 300 K. At t=0 the temperature of x is $T_0 = 400$ K. [Newton's law of cooling is applicable and can be written as $-\frac{dT}{dt} = k_1(\Delta T)$.] At t=0 the body x is connected to a large body y which is at temperature 300K (and having very large heat capacity) through a conducting rod of length L, cross-sectional area A and thermal conductivity k_2. The temperature of x at any time 't' is

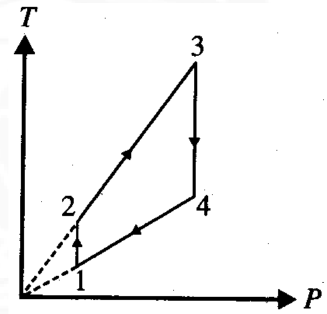
A) $300 - 100e^{-t\left[k_1 + \frac{k_2A}{CL}\right]}$ B) $300 + 100e^{-t\left[k_1 + \frac{k_2A}{CL}\right]}$

C) $400e^{-t\left[k_1 + \frac{k_2A}{CL}\right]}$ D) $300 + 100e^{-t\left[k_2 + \frac{k_1A}{CL}\right]}$

23. Ice has formed on a shallow pond and a steady state has been reached with the air above the ice at $-5.20°C$ and the bottom of the pond at $3.98°C$. If the total depth of ice + water is 1.42 m, how thick is the ice? (Assume that the thermal conductivities of ice and water are 1.67 and 0.502 W/m . K, respectively.) (Neglect radiation losses)

A) 0.75 m B) 1.15 m C) 2.25 m D) 1.30 m

24. Two moles of an ideal monatomic gas under goes a reversible cyclic process as shown in Figure. The temperatures in different states are given as $6T_1 = 3T_2 = 2T_4 = T_3 = 1800K$. Determine the work done by the gas during the cycle. ($1 \rightarrow 2, 3 \rightarrow 4$ are isobars)

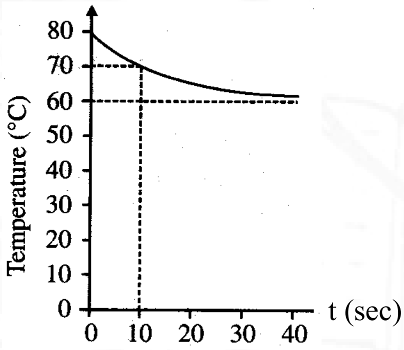


A) -10 kJ B) -20 kJ C) 15 kJ D) 20 kJ

25. Two thin spherical shells of different materials, one with double the radius and one-fourth wall thickness of the other, are filled with ice. Temperatures of outer surfaces of two shells are same and maintained constant. If the times taken for complete melting of ice in the larger radius one to the smaller one are in the ratio of 25 : 16, then their corresponding material thermal conductivities are in the ratio

A) 4 : 5 B) 5 : 4 C) 8 : 25 D) 25 : 8

26. A vessel contains M grams of water at a certain temperature and water at certain other temperature is passed into it at a constant rate of m g/s. The variation of temperature of the mixture with time is shown in figure. The value of M and m are, respectively (the heat exchanged during a long time from the start is 800 cal) (Neglect heat capacity of the vessel)

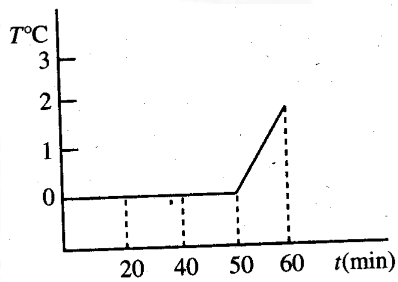


A) 40 & 2 B) 40 & 4 C) 20 & 4 D) 20 & 2

27. A thermally insulated piece of metal is heated under atmospheric pressure by a current so that it receives electric energy at a constant power P. This leads to an increase of absolute temperature T of the metal with time t as follows: $T(t)=T_0\left[1+a(t-t_0)\right]^{1/4}$. Here, a, t_0 and T_0 are constants. The heat capacity $C_P(T)$ of the metal is

A) $\frac{4P}{aT_0}$ B) $\frac{4PT^3}{aT_0^4}$ C) $\frac{2PT^3}{aT_0^4}$ D) $\frac{2P}{aT_0}$

28. A cooking vessel on a slow burner contains 5 kg of water and an unknown mass of ice in equilibrium at $0°C$ at time $t=0$. The temperature of the mixture is measured at various times and the result is plotted as shown in figure. During the first 50 min the mixture remains at $0°C$. From 50 min to 60 min, the temperature increases to $2°C$. Neglecting the heat capacity of the vessel, the initial mass of the ice is (Assume rate of heat given by the burner is constant)



A) $\frac{10}{7}kg$ B) $\frac{5}{7}kg$ C) $\frac{5}{4}kg$ D) $\frac{5}{8}kg$

SECTION-2

(MORE THAN ONE TYPE)

Section - II (Multiple Correct Answers Type, Total Marks: 16) contains 4 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE or MORE may be correct. For each question you will be awarded 4 marks if you darken ALL the bubble(s) corresponding to the correct answer(s) ONLY and zero marks otherwise. There are no negative marks in this section.

29. During the freezing of water to ice at 273K at atmospheric pressure

A) Positive work is done by the ice-water system on its surroundings

B) Positive work is done on the ice-water system by its surroundings

C) The internal energy of the ice-water system increases

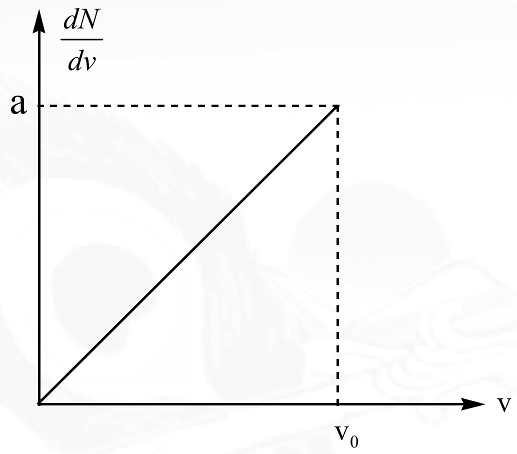
D) The internal energy of the ice-water system decreases

30. At which of the following temperature(s), are the readings on Fahrenheit and Celsius scales numerically negative of each other?

A) $-\frac{80}{7}°F$ B) $\frac{80}{7}°C$ C) $40°C$ D) None of the above

31. Graph shows a hypothetical speed distribution for a sample of N gas molecules.

Given $\frac{dN}{dv}=0$ for $v>v_0$.



A) the value of av_0 is 2 N

B) the ratio v_{avg}/v_0 is equal to $\frac{2}{3}$

C) The ratio $\frac{v_{rms}}{v_0}$ is equal to $\frac{1}{\sqrt{2}}$

D) Three fourth of the total molecules has a speed between $\frac{v_0}{2}$ and v_0

32. Two identical objects A and B are at temperatures T_A and T_B respectively. Both objects are placed in a room with perfectly absorbing walls maintained at temperature T $(T_A > T > T_B)$. The objects A and B attain the temperature T eventually. Select the wrong statements from the following

A) A only emit radiation, while B only absorbs it until both attain the temp T

B) A loses more heat by radiation than it absorbs, while B absorbs more radiation than it emits, until they attain the temperature T

C) Both A & B only absorb radiation, but do not emit it, until they attain the temp T

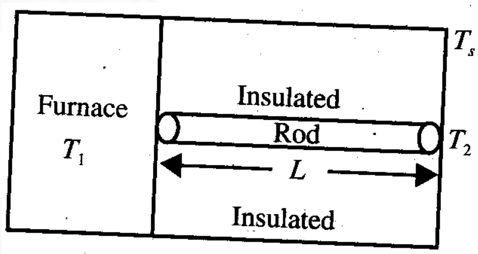
D) Each object continues to emit and absorb radiation even after attaining the temperature T

SECTION-3
[INTEGER TYPE]

Section-III (Integer Answer Type, Total Marks: 24) contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9. The bubble corresponding to the correct answer is to be darkened in the ORS. For each question you will be awarded 4 marks if you darken ONLY the bubble corresponding to the correct answer and zero marks otherwise. There are no negative marks in this section.

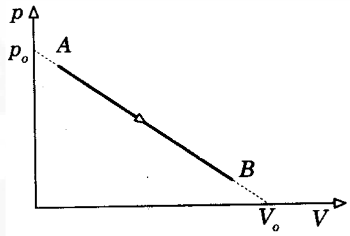
33. One end of a rod of length L and cross sectional area A is kept in a furnace at temperature T_1. The other end of the rod is kept at a temperature T_2. The thermal conductivity of the material of the rod is K and emissivity of the rod is ***e***. It is

given that $T_2 = T_S + \Delta T$, where $\Delta T << T_S$, T_S is the temperature of the surroundings. If $\Delta T = \alpha(T_1 - T_s)$, then the proportional constant $\alpha = \frac{K}{\beta e\sigma L T_S^3 + K}$. Mark the value of β in OMR sheet (Consider that heat is lost only by radiation at the end where the temperature of the rod is T_2.)



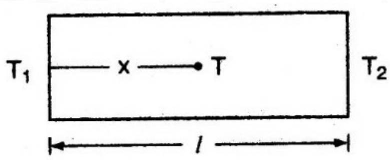
34. A cube of coefficient of linear expansion α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_l. When the temperature is raised by ΔT, the depth up to which the cube is submerged in the liquid remains the same. The value of $\frac{\gamma_l - \alpha_s}{\alpha_s} =$ ____

35. One mole of an ideal monoatomic gas undergoes a linear reversible process $A \to B$ shown in the P–V indicator diagram. (Initial and final volume of the gas during the process are $\frac{V_0}{2015}$ & $\frac{2014}{2015}V_0$ respectively)

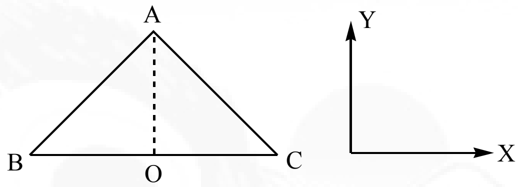


The volume of the gas when the process turns from an endothermic to an exothermic one is $\frac{KV_0}{8}$ where K=_______.

36. The ends of a thin cylindrical rod of length l are maintained at temperatures $T_1 = T_0$ and $T_2 (= 4T_0)$. If the thermal conductivity of the cylinder is directly proportional to the square root of temperature $\left(K \propto \sqrt{T}\right)$, then in steady state, temperature of the midpoint of the rod $T_3 = \left(\frac{a}{b}\right)^{b/c} T_0$. Then value of $\frac{a}{c}$ is _______



37. Three steel rods of equal length form an equilateral triangle ABC. Taking midpoint of BC as origin, the increase in y-coordinate of centre of mass per unit change in temperature is (Assume the length of each rod is 2m and $\alpha_s = 4\sqrt{3}\times 10^{-6}/°C$) $n\times 10^{-6} m$. Then $n =$ ____



38. A highly conducting solid cylinder of radius a and length l is surrounded by a co-axial layer of a material having thermal conductivity K and negligible heat capacity. Temperature of surrounding space (outside the layer) is T_0, which is higher than the temperature of the cylinder. If heat capacity per unit volume of the cylinder material is S and outer radius of the cylinder is b, time required to increase the temperature of the cylinder from T_1 to T_2 is (Assume end faces to be thermally insulated and given that b = 2a; $T_0 = 500K, T_1 = 300K, T_2 = 400K$ & $\ln 2 = 0.7$)

$\frac{Sa^2n^2}{200K}$ Where n = ________

SECTION-4

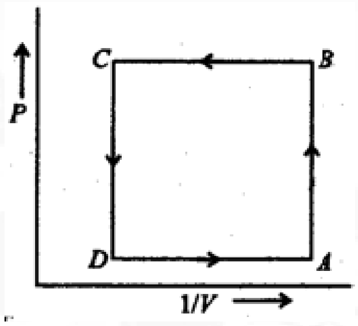
[Matrix Matching Type]

Section-IV (Matrix-Match Type, Total Marks: 16) contains 2 questions. Each question has four statements (A, B, C and D) given in Column I and five statements (p, q, r, s and t) in Column II. Any given statement in Column I can have correct matching with ONE or MORE statement(s) given in Column II. For example, if for a given question, statement B matches with the statements given in q and r, then for the particular question, against statement B, darken the bubbles corresponding to q and r in the ORS. For each question you will be awarded 2 marks for each row in which you have darkened ALL the bubble(s) corresponding to the correct answer(s) ONLY and zero marks otherwise. Thus, each question in this section carries a maximum of 8 marks. There are no negative marks in this section.

39. A closed container contains an ideal diatomic gas system at a temperature T_1 and pressure P_1. The gas is then reversibly heated through a 1% rise in its temperature, during which 20% of the molecules are dissociated into atoms.

Column-I	**Column-II**
A) Percentage increase in pressure of the system from P_1 is nearly	P) 5
B) Percentage increase in internal energy of the system is nearly	Q) 21
C) Percentage increase in the quantity $\frac{PV}{KT}$ of the system is (P = pressure, V = volume, T = Temperature, K = Boltzmann constant)	R) Zero
D) Difference in percentage increase of C_V and percentage increase of C_P of the system is nearly	S) 20
	T) 4

40. An ideal gas undergoes a reversible cyclic process according to the graph. P is pressure, V is volume, W is work done by the gas, ΔU is change in internal energy of the gas and Q is heat given to the system of gas.



Column-I	**Column-II**
A) For process AB	P) $\Delta U > 0, Q > 0$
B) For process BC	Q) $\Delta U < 0, Q < 0$
C) For process CD	R) $Q \times \Delta U \times W = 0$
D) For process DA	S) $Q \times \Delta U < 0$