THE OPEN UNIVERSITY OF SRI LANKA
ADVANCED CERTIFICATE IN SCIENCE
TAF 2525-PHYSICS – 3
FINAL EXAMINATION
DURATION – THREE HOURS

Date: 18.09.2022 **Time: 1.30 pm to 4.30 pm**

Part -A

- **The Question paper (Part A) consists of 25 multiple choice questions**
- **Answer all the questions**
- **Answers for the all Multiple Choice Questions, by underline the correct answer**
- **At the end of the examination you should submit the question paper with answer sheet.**
- **Maximum marks for this part is 50%.**

- **$g = 10\ ms^{-2}$**
- **Latent Heat of Fusion $334 \times 10^3\ J\ kg^{-1}$**
- **Latent Heat of Vaporization $226 \times 10^4\ J\ kg^{-1}$**
- **$\varepsilon_0 = 8.86 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$**
- **$\mu_0 = 4\pi \times 10^{-7}\ N\ A^{-2}$**
- **e (Charge of Electron) $= 1.6 \times 10^{-19} C$**
- **R (Universal Gas Constant = $8.3\ J\ mol^{-1}\ K^{-1}$**

1. An aluminum piece and a wooden piece have been left in a room for a few hours. When you go and touch them the aluminum seems colder than wood. Select the correct option. Assume room temperature to be 25 °C.

   (1) Both have the same temperature greater than 25 °C
   (2) Aluminum has a greater temperature than wooden piece
   (3) Aluminum has a lower temperature than wooden piece
   (4) Both have the same temperature equal to 25 °C
   (5) None of above

2. The reverse process of vapor becoming liquid is

   (1) Vaporization (2) Freezing (3) Condensation (4) Sublimation (5) None of above

3. The amount of heat required to raise the temperature of 1 kg of a substance by one Kelvin is

   (1) Thermal conductivity (2) Specific heat capacity (3) Latent heat (4) Heat capacity

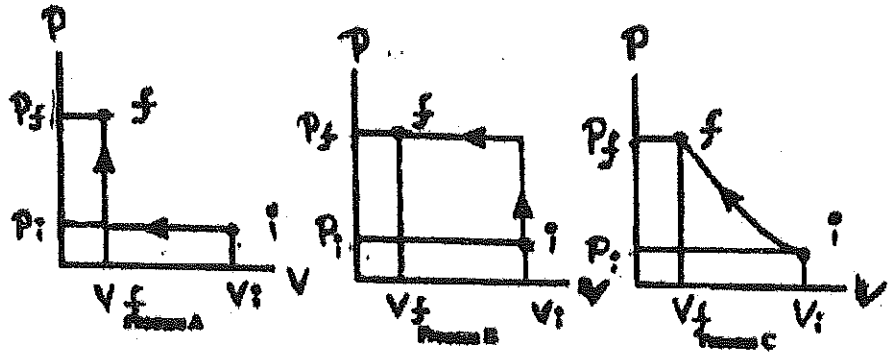
   (5) None of the above

4. A perfect gas at 27 °C is heated at constant pressure so as to double its volume the temperature of the gas becomes
(1) 54 °C (2) 157 °C (3) 327 °C (4) 400 °C (5) 427 °C

5. If 315 J of heat is applied to the system, and the system does 20 J of work, find the change in an internal energy.

(1) 295 J (2) 335 J (3) 0 J (4) 340 J (5) 205 J

6. An ideal gas is taken from state (Pi, Vi) to state (P_f, V_f) in three different ways. Identify the process in which the work done on the gas the most.



(1) Process A (2) Process B (3) Process C (4) Equal work is done in Process A, B &C
(5) None of above

7. A box contains 10^5 molecules. The average kinetic energy of each molecule is 0.5×10^{-6} J. With respect to an observer at rest the box, having a mass of 1 kg, is moving with a velocity of 2 m/s. What is the value of kinetic energy that will contribute to the internal energy?

(1). 0.05 J (2). 2.05 J (3). 0 J (4). 2 J (5) 1.5 J

8. A constant torque acting on a uniform circular wheel changes its angular momentum from A to 5A in 8 seconds. The magnitude of this torque is,

(1) 3A/4 (2) A (3) A/2 (4) A /4 (5) 2A

9. A steel and a copper bar are joined end to end. The area of the steel bar is half the area of the copper bar. Their lengths are equal to 10 cm each. Temperature of free ends of steel & copper rod are 0 °C & 100 °C respectively. Thermal conductivity of steel (KS) = 50 J/ s mK & Thermal conductivity of copper (Kc) =384 J/s mK. Calculate equivalent thermal conductivity of the combined bar.

(1) 63 °C (2) 63 K (3) 336 °C (4) 36 K (5) 36 °C

10. Young's modulus of a substance is defined as,

(1) Stress/Strain (2) Stress × Strain (3) Strain/Stress (4) 1/Stress (5) 1/Strain

11. A rocket works on the principle of conservation of

(1) Mass (2) Linear momentum (3) Energy (4) Angular momentum (5) Charge

12. A small sphere is suspended by a thread of length L. The horizontal velocity that should be given to it so that it may just reach the same height as the point of suspension is,

(1) $\sqrt{gL}$ (2) $\sqrt{5gL}$ (3) $2gL$ (4) $\sqrt{2gL}$ (5) $\sqrt{3gL}$

13. A motor car of mass m travels with a uniform speed v on a circular bridge of radius r. When the car is at the highest point of the bridge, then the force exerted by the car on the bridge is

(1) mg (2) $mg + \frac{mv^2}{r}$ (3) $mg - \frac{mv^2}{r}$ (4) $\frac{mv^2}{r}$ (5) $2mg$

14. Young's modulus of steel is 2×10^{11} Nm^{-2}. A steel wire has a length of 1 m and area of cross section 1 mm^2. The work required to increase its length by 1 mm is,

(1) 0.1 J (2) 1 J (3) 10 J 4) 100 J 5. 200 J

15. A hollow sphere and a solid sphere, having the same mass, are released from rest simultaneously from the top of an inclined plane which of the two will reach the bottom first?

(1) Solid sphere
(2) Hallow sphere
(3) The one which has the greater density
(4) The one which has the greater volume
(5) Both will reach the bottom simultaneously

16. A wire of length L and radius r is fixed at one end a force F applied to the other end produces an extension$l$. The extension produces in another wire of the same material, of length 2L and radius 2r, by a force 2F is,

(1) $l/2$ (2) l (3) $2l$ (4) $4l$ (5) $3l/2$

17. A solid float in liquid A with half its volume immersed and in liquid B with 2/3 of its volume immersed. The density of the liquid A and B are in the ratio,

(1) 4:3 (2) 3:2 (3) 3:4 (4) 1:3 (5) 1:2

18. A steel ball of radius 2 mm acquires a terminal velocity of 20 cm s^{-1} in a liquid. The terminal velocity of another steel ball of radius 1 mm in the same liquid will be,

(1) 5 cm s^{-1} (2) 10 cm s^{-1} (3) 40 cm s^{-1} (4) 80 cm s^{-1} (5) 100 cm s^{-1}

19. The rate of the steady volume flow of water through a capillary tube of length l and radius r, under a pressure difference p, is V. What is the rate of steady flow through a series combination of the tube with another tube of same length and half the radius if the same pressure difference p is maintained across the combination?

(1) V/16 (2) V/17 (3) 16V/ 17 (4) 17V/ 16 (5) None of the above

20. Rain drops are spherical because of

(1) Gravitational force (2) Surface tension (3) Viscosity of water (4) Air resistance

(5) None of the above

21. Water rise to a height of 2 cm in a capillary tube held vertically. When the tube is tilted 60^0 from vertical, the length of the water column in the tube will be

(1) 1.0 cm (2) 2.0 cm (3) 3.0 cm (4) 4.0 cm (5) 5.0 cm

22. Consider following statements about Moment of Inertia I

(A) It is depend only on mass m

(B) It is a scalar quantity

(C) It is Units is kg^2m^2

From the above statements,

(1) Only A & B are correct (2) Only B & C is correct (3) Only B is correct

(4) All are correct (5) All are incorrect

(23) A flywheel of moment of inertia 10 kg m^2 about the perpendicular axis through the center, is connected to a motor. The motor accelerates the flywheel from rest to 300 revolutions in a minute. What would be the work done on the flywheel in joules?

(1) 500 π^2 (2) 900 π^2 (3) 1800 π^2 (4) 4000 π^2 (5) 6000 π^2

(24) During an adiabatic expansion the increase in volume is associated with,

(1) Decrease in pressure and decrease in temperature

(2) Decrease in pressure and increase in temperature

(3) Increase in pressure and decreasing in temperature

(4) No change in pressure and increase in temperature

(5) Increase in pressure and increase in temperature

(25) One fourth of ($\frac{1}{4}$) of the total volume of a body is immersed in water with density 1000 kg m^{-3}. What would be the density of the object?

(1) 200 kg m^{-3} (2) 250 kg m^{-3} (3) 300 kg m^{-3} (4) 2000 kg m^{-3} (5) 4000 kg m^{-3}

(4× 25 = 100 Marks)

Part – B (Essay)

- **Answer any four (04) questions only.**
- **If more than (04) question are answered only the first four will be marked.**
- **Each question earns twenty five (25) marks, amounting to total of 50% marks.**

1. A. State the principle of conservation of angular momentum. (5 Marks)

An ice skater spine with arms stretched at 2 rev s^{-1} and her momentum of inertia is 1.40 kg m^2. She pulls her arms in and her momentum of inertia is reducing to 0.56. What is the new rate of rotation? (5 Marks)

B. Suppose a car is travelling round a circular bend (Radius of the bend is r) with uniform speed on a horizontal road.

i. Explain the how to travel car around the circular bend. (5 Marks)

ii. If coefficient of the static friction between the road and tire is μ and gravitational acceleration is g, obtain the expression of maximum velocity (V) of the car. (5 Marks)

iii. Calculate the maximum speed of the car which can safety negotiate a horizontal circular bend of radius 60m, on a dry day. Assume that coefficient of static friction in dry weather to be 0.78. (5 Marks)

2. A. Write down equation for density and the hydrostatic pressure of a certain point of liquid column. (5 Marks)

i. In order to determine the internal radius of a capillary tube, a mercury column was drawn in and length measured as 9.732 cm. The mass of mercury is 1.012g. What is the internal radius of the capillary tube? (The density of mercury is 13,600 kg m^{-3}) (5 Marks)

ii. Calculate the hydrostatic difference in blood pressure between the brain and the foot in a person of height 1.92 m. (The density of blood is 1060 kg m^{-3}) (5 Marks)

B. State Archimedes' principle and principle of flotation. (5 Marks)

The density of ice is 920 kg m^{-3}. The average density of sea water in which an iceberg floats is 1025 kg m^{-3}. What fraction of the iceberg is beneath the surface of water?

(5 Marks)

3. Define the coefficient of surface tension and state its units. (5 Marks)

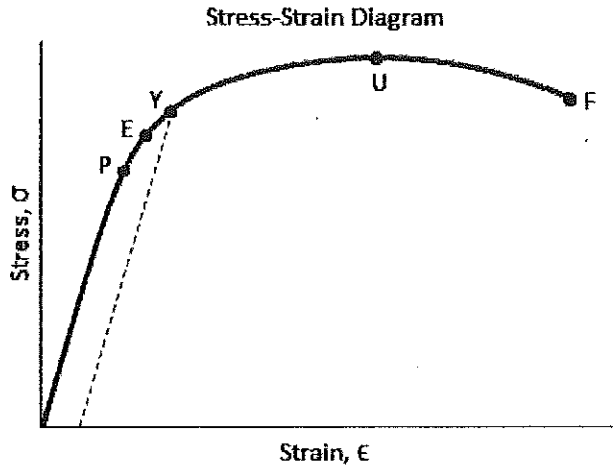
(i). Let the surface tension of the liquid be T and the angle of contact is θ. White done expression for the vertical component of the upward force supporting the weight of a liquid. (5 Marks)

(ii) Show that $h = \frac{2T\,Cos\theta}{rpg}$ (10 Marks)

(iii) A capillary tube with of internal diameter 1.0 mm is placed vertically dipped in water. Assuming the angle of contact to be zero, find the height of the water rise in the capillary tube. The density of the water = 1000 kg m^{-3} and the coefficient of surface tension of water $=7.25 \times 10^{-2}$ N m^{-1}. (5 Marks)

4. (A)(i) Explain the terms tensile stress and tensile strain (5 marks)

(ii)A stress- stain graph for a certain metal wire is shown in Figure.



(iii)Referring to the structure and behavior of the metal under a tensile force, explain about the each point P, E, Y, U, and F. (5 Marks)

B. A mass of 20 kg was gradually applied to the lower end of a vertical steel wire of length 1.6 m and radius 1.0 mm assuming that the proportional limit is not exceeded, calculate,

(i) The extension of the steel wire (5 Marks)
(ii) The energy stored in the wire (5 Marks)

(iii)The loss in gravitational potential energy of the wire during loading and explain the reason for the difference between the answer b and c. (5 Marks)

5. Answer for both Part A and B

A. (i) Expression related to linear expansion is given as $l_\theta = l_o(1 + \alpha\theta)$. Name the parameters in the expression. (3 Marks)

(ii) Drive a relationship between the coefficient of linear expansion and coefficient of area expansion. (2 Marks)

(iii) A circular section of radius 5 cm is removed from a square steel plate of length 8 cm at 10 °C. Find the new area of the plate at a temperature of 60 °C. The coefficient of linear expansion of steel (α) =$11 \times 10^{-6}\ ^{o}C^{-1}$. (5 Marks)

B. State the Boyle's law (2 Marks)

(i) Draw the variation of Pressure (P) with 1/ Volume (1/V) of ideal gases at the different temperatures T_1, T_2 and T_3 where $T_1 > T_2 > T_3$ (3 Marks)

(ii) Using the Boyle's law and Charles's law, Derive an equation of PV = n RT symbols have their usual meaning. State any assumptions that you used in deriving the expression. (4 Marks)

Air molecules are trapped in 25.0 m^3 at a temperature of 27 °C and 1 atm pressure. ($R = 8.31\ Jmol^{-1}K^{-1}$ Avogadro no. $A = 6.023 \times 10^{23}$)

(i) Write down the relationship between the universal gas constant (R) and Boltzmann constant (k). (2 Marks)

(ii) Calculate the number of air molecules trapped in the given volume. (4 Marks)

6. A. Define the latent heat of fusion and write down the unit of it. (2 Marks)

(i) Consider the 1 kg of ice cube at -20 °C, calculate amount of heat energy needed to increase 100 °C of water. (2 Marks)

(ii) If energy is supplied through 500 W heater, find the time taken to reach 100 °C of water. (2 Marks)

(iii) Now the 1 kg of ice cube at -20 °C is added to the 2 kg of steam at 100 °C. Calculate the final temperature of the mixture. (4 Marks)

B. Figure 01 shows that a steam chamber and copper cube are connected to an AB metal rod. The temperature (θ) of the copper cube is measured with time (t). After a few minutes temperature of the copper cube is achieved at the steady state of 50 °C.

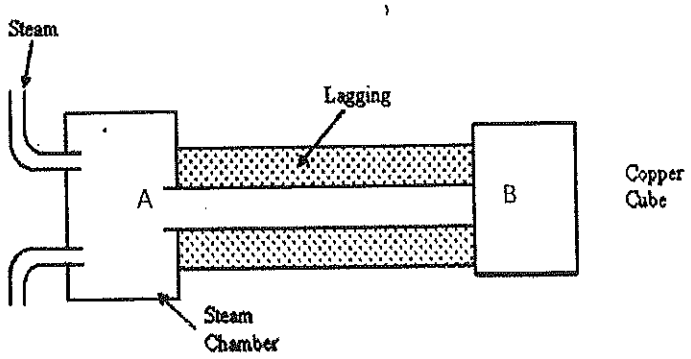


Figure 1.

(i) Draw the possible variation of temperature (θ) of the copper cube with time (t). (3 Marks)

(ii) Cooling rates (R) of the Copper cube at is given by $R = 0.24\ (\theta - \theta_R)$. What is the unit of R.? (2 Marks)

(iii) Calculate R at the steady state temperature ($\theta_R = 30\ ^\circ C$) (5 Marks)

(iv) The cross-sectional area of the rod = $1.2 \times 10^{-4}\ m^2$ and length of the rod = 0.4 m then calculate the thermal conductivity of the metal rod. (5 Marks)

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