



**University of Ruhuna- Faculty of Technology**  
**Bachelor of Engineering Technology Honours**  
**Level 1 (Semester II) Examination, November/December 2023**  
**Academic year 2021/2022**

**Course Unit: ENT1253 Engineering Properties of Matter**

**Duration: 3 hours**

**Instructions to Candidates**

- Answer all questions.
- This paper contains two parts (A and B) on 8 pages.  
Part A: Multiple Choice                      20×2= 40 marks  
Part B: Essay questions                      5×12= 60 marks  
Total    100 marks
- Answers for part A should be provided in the answer sheet.
- Calculators are permitted to use.
- All answers should be in appropriate units to earn full marks.

**Standard constants**

- 1atm =  $1.01 \times 10^5 \text{ N/m}^2$
- Density of water is  $1000 \text{ kg/m}^3$
- Density of iron is  $8000 \text{ kg/m}^3$
- Density of Mercury is  $13600 \text{ kg/m}^3$
- Threshold of human hearing:  $I_0 = 1 \times 10^{-12} \text{ Watts/m}^2$
- Density of sea water=  $1030 \text{ kg/m}^3$
- Gravitational acceleration =  $9.81 \text{ ms}^{-2}$
- Speed of light in air =  $3 \times 10^8 \text{ ms}^{-1}$
- Speed of sound in air =  $340 \text{ ms}^{-1}$
- Specific heat of metal =  $450 \text{ J/ (kg } ^\circ\text{C)}$

**Part A: Multiple Choice Questions.**

For each multiple-choice question, shade in the circle that corresponds to your answer in the given answer sheet.

## Part A

1. What is the electron configuration of  $\text{Zn}^{2+}$  (Atomic number of Zn = 30)?
  - a)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
  - b)  $1s^2 2s^2 2p^6 3s^2 4s^2 3p^6 3d^8$
  - c)  $1s^2 2s^2 2p^6 3s^2 4s^2 3p^3 3d^6$
  - d)  $1s^2 2s^2 2p^6 3s^2 3p^5 3d^6$
2. Select the correct statement regarding the "triple point" of a substance.
  - a) The point on a phase diagram at which the substance is indistinguishable between liquid and gaseous states.
  - b) The point on a phase diagram at which the three states of matter: gas, liquid, and solid coexist.
  - c) The point on a phase diagram which represents the transition between gaseous and liquid states.
  - d) None of the above.
3. Select the correct statement regarding the phase change of a matter.
  - a) The kinetic energy of the system changes while potential energy remains constant.
  - b) The absorbed or released energy during a phase change is utilized to change the temperature of the system.
  - c) There is no temperature change until a phase change is complete, but the amount of heat (energy) does.
  - d) None of the above.
4. You are given an unknown solid material which has following characteristics.
  - Lower melting point
  - Poor electrical conductivity
  - Soluble in nonpolar liquids but not in water

Based on the given characteristics, identify the type of solid.

- a) Ionic solid
- b) Metallic Solid
- c) Atomic Solid
- d) Covalent Solid

5. Select the incorrect combination from the statements below.

- a) Polymeric solids: light in weight with significant degrees of strength.
- b) Superconductors: can conduct electricity with zero resistance when heated up to very high temperatures
- c) Nanocrystalline solids: very small crystalline regions, often at the nanometer scale, embedded within an amorphous matrix.
- d) Composite solids: Combination of different types of materials, such as fibers embedded in a matrix.

Answer questions 6 and 7 referring to the following description.

A cylindrical rubber specimen is kept at 3000 m depth in the ocean. If the initial height and diameter are 0.8 m and 0.3 m respectively and the bulk modulus of water is  $2.2 \times 10^9 \text{ Nm}^2$ , answer the following.

6. What is fractional compression of the rubber specimen?

- a) 1.37%
- b) 1.34%
- c) 1.40%
- d) 1.50%

7. What is the final volume of the specimen?

- a)  $0.0456 \text{ m}^3$
- b)  $0.0557 \text{ m}^3$
- c)  $0.0570 \text{ m}^3$
- d)  $0.0658 \text{ m}^3$

8. Select the correct statement/s on "Polymorphism."

- i) Graphite and diamonds are polymorphs of carbon.
- ii) Polymorphs are crystalline materials that have the same chemical composition but different molecular packing.
- iii) The prevailing crystal structure of a polymorph depends on the external pressure and density of the material.

- a) i and ii only
- b) ii and iii only
- c) i and iii only
- d) All are correct

9. An iron block is kept in the bottom of a water tank. The weight of the block is 5kg. What is the magnitude of reaction force exerted on the iron block? Assume that the density of iron is  $8000 \text{ kgm}^{-3}$ .

- a) 44.25 N
- b) 39.25 N
- c) 50.00 N
- d) 42.92 N

10. A liquid is poured into a capillary tube from the upper hole as shown in Figure 1. What is the maximum height (H) of the liquid that can be held inside the tube? Assume that the angle of contact is zero, the radius of the capillary tube is r, the density of the liquid is  $\rho$  and the surface tension of the liquid is  $\gamma$ .

- a)  $H = \frac{4\gamma}{\rho g r}$
- b)  $H = \frac{2\gamma}{\rho g r}$
- c)  $H = \frac{4\gamma}{3\rho g r}$
- d)  $H = \frac{\gamma}{2\rho g r}$



Figure 1

11. Calculate the speed of light in diamond (refractive index of diamond = 2.42).

- a)  $1.24 \times 10^8 \text{ m/s}$
- b)  $2.42 \times 10^8 \text{ m/s}$
- c)  $1.42 \times 10^8 \text{ m/s}$
- d)  $3 \times 10^8 \text{ m/s}$

12. Optical fiber communication works on the principle of

- a) refraction
- b) diffraction
- c) total internal reflection
- d) scattering

13. If a lens is cut into two pieces perpendicular to the principal axis and only one part is used instead, the intensity of the image.

- a) remains the same
- b) becomes  $\frac{1}{4}$  times.
- c) becomes 2 times.
- d) becomes 4 times.

14. At a constant temperature, the pressure and the volume of a gas are given as 1 atm and 5 liters respectively. When the pressure is increased to 2 atm, what is the volume of the gas?

- a) 1 liter
- b) 5 liters
- c) 10 liters
- d) 2.5 liters

15. For a gas, which pair of variables are inversely proportional to each other (if all other conditions remain constant)?

- a) P, T
- b) P, V
- c) V, T
- d) n, V

16. A person prefers to sit by a fire pit during the cold winter months. Which of the following heat transfer types gives him the most heat?

- a) Convection and radiation together
- b) Radiation will provide quick warmth
- c) Convection.
- d) Conduction from the fire

17. The lengths of two identical metal rods of same area of cross section are given by 0.5 m and 0.8 m respectively. Assuming that the rate of heat conduction through the two rods is same, calculate the temperature difference between the ends of the first rod if the temperature difference between the ends of the second rod is  $72^{\circ}\text{C}$ .

- a)  $115.5^{\circ}\text{C}$
- b)  $18^{\circ}\text{C}$
- c)  $45^{\circ}\text{C}$
- d) None of the above

18. What is the relationship between the coefficient of area expansion(A) and coefficient of volume expansion(B)?

- a)  $B = 1.5A$
- b)  $A = 1.5B$
- c)  $A = 3B$
- d)  $B = 3A$

19. Metal pipes used to carry water sometimes burst in the winter. This is because:

- a) Water expands when it freezes.
- b) Metal contracts higher than water
- c) Outer surface of the pipe contracts higher than the inner surface
- d) Metal expands higher than water.

20. What astronomers call "the red shift" is due to the \_\_\_\_\_ as described in Doppler effect.

- a) decrease in wavelength.
- b) increase in wavelength.
- c) source is moving towards the observer
- d) observer is moving towards the source

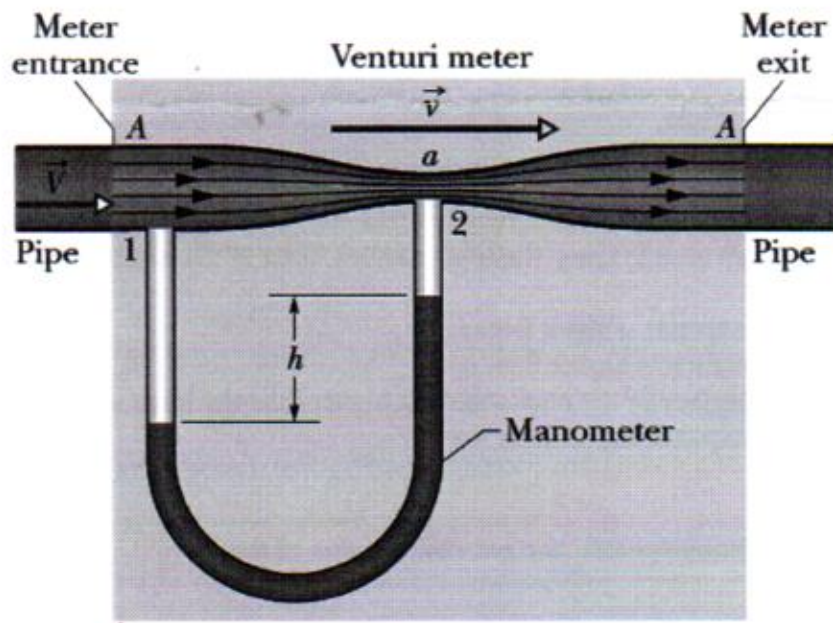
**Part B**

1. Bernoulli's principle is widely used in fluid dynamics to analyze fluid flows.

a) Write down Bernoulli's principle and define the parameters. (03 marks)

b) What are the main assumptions made when deriving Bernoulli's principle? (02 marks)

c) A venturi meter is used to measure the flow speed of a fluid in a pipe. The meter is connected between two sections of the pipe as shown in **figure 2**. The cross-sectional area "A" of the entrance and exit of the meter matches the pipe's cross-sectional area. Between the entrance and exit, the fluid flows from the pipe with speed V and then through a narrow "throat" of cross-sectional area "a" with speed v. A manometer connects the wider portion of the meter to the narrower portion. The change in the fluid's speed is accompanied by a change  $\Delta p$  the fluid's pressure, which causes a height difference h of the liquid (mercury) in the two arms of the manometer. Assume that the density of fluid is  $\rho$ .



**Figure 2**

i) By applying Bernoulli's equation and the equation of continuity show that,

$$V = \sqrt{\frac{2a^2 \Delta p}{\rho(A^2 - a^2)}}$$

(04 marks)

- ii) Suppose that the fluid is fresh water and diameters of the pipe, and the throat are 8 cm and 5.3 cm respectively. The difference in the height of the mercury columns in the manometer ( $h$ ) is 8 cm. Calculate the speed of water ( $V$ ) at the entrance.

(03 marks)

2.

I. The changes in material dimension to mechanical forces is called deformation.

- a) Write down two (02) main differences in elastic deformation and plastic deformation.

(02 marks)

- b) A cubic metal block with each side of original length 80 cm is subjected to a compression force of 100 kN. The length of the block in the lateral direction has increased by 0.05%. Determine the Poisson's ratio of the metal. Assume that the elastic modulus is given by 120 MPa.

(03 marks)

II. The property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules is called surface tension of the liquid.

- a) Develop an equation for the pressure difference of a water droplet in terms of its radius and surface tension.

(02 marks)

- b) As shown in Figure 3, soap bubble **A** of radius  $r_1$  and another bubble **B** of radius  $r_2$  are brought together so that the combined bubble has a common interface of radius  $r_3$ . Develop a relationship between  $r_1$ ,  $r_2$ ,  $r_3$ .

(05 marks)

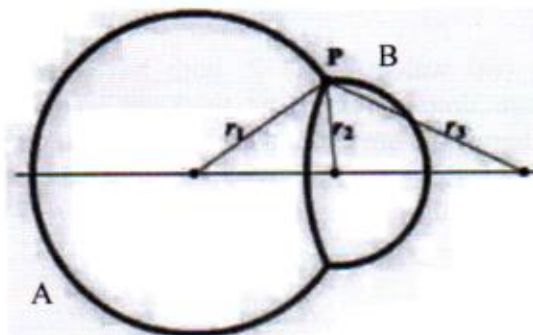


Figure 3

3.

a) A source of sound moves towards an observer. What happens to the speed of sound in the medium?

(1 mark)

b) A man is standing on a cliff hears the echo of his shout after 1s. What is the distance between the man and the mountain which his voice is reflected?

(3 marks)

c) A man jumps from a building with a source of sound. When he reaches halfway down, he starts the siren at 100Hz. A person standing below him on the ground hears the first sound to be of frequency 120Hz. What is the height of the building?

(8 marks)

4.

a) In anomalous expansion of water, at what temperature, the density of water is maximum?

(01 mark)

b) If 1 kg of wood absorbs 200 kJ of heat energy, its temperature changes from 25 °C to 150 °C. In this case, what will be the specific heat of wood?

(03 marks)

c) A metal ball of mass 0.5 kg falls freely from a height of 10 m and bounces back to a height of 5.5 m from the ground. If the dissipated energy in this process is absorbed by the ball, what is the rise in its temperature?

(08 marks)

5.

a) If the pressure in an enclosed gas is doubled and its temperature rises from 27 °C to 127 °C, how would be the volume of it changed?

(06 marks)

b) Consider two walls, 1 and 2, both have the same surface area and the same temperature drop across their thickness. The ratio of the thermal conductivity between two walls are given as  $k_1/k_2 = 2$ . The thickness ratio between the two walls is given by  $L_1/L_2 = 4$ . Then what would be the ratio of the heat transfer rate  $Q_1/Q_2$  between two walls?

(06 marks)

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