University of Ruhuna-Faculty of Technology

Bachelor of Engineering Technology Honors Degree

Level I Semester II Examination, September 2020

Course Unit: ENT1253 Engineering Properties of Matter

Time Allowed 3 hours. **Date: September 2020**

The format of the examination will be as follows:

Part A: Multiple Choice	20×2= 40 marks
Part B: Structured questions	5×12= 60 marks
Total	100 marks

All answers should be in appropriate units to earn full marks.

Standard constants:

R = 8.31 J/mol. K

1atm = 1.01×10^5 N/m^2

Avogadro's number = 6.022×10^{23}

Specific heat of water is 4200 J/ (kg.K)

Density of water is 1000 Kg/m^3

Density of gold is 19300 Kg/m^3

Threshold of human hearing: Io =1 x 10^{-12} Watts/m^2

Speed of Light in air is 2.9 ×10^8 ms^{-1}

Part A: Multiple Choice Questions.

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

1. If a metal wire is stretched a little beyond its elastic limit (or yield point), and released, it will
   a. loose its elastic property completely
   b. not contract
   c. contract, but its final length will be greater than its initial length
   d. contract only up to its length at the elastic limit

2. The following four wires of length L and the radius r are made of same material. Which of these will have the largest extension when the same tension is applied?
   a. L = 50 cm, r = 0.25 mm
   b. L = 100 cm, r = 0.5 mm
   c. L = 200 cm, r = 1 mm
   d. L = 3000 cm, r = 1.5 mm

3. Under the action of load F_1, the length of a string is L_1 and that under F_2 is L_2. The original length of the wire is
   a. $[L_1F_1 - L_2F_2] / [F_1 + F_2]$.
   b. $[L_1F_2 - L_2F_1] / [F_1 - F_2]$.
   c. $[L_1F_2 - L_2F_1] / [F_2 - F_1]$.
   d. $[L_1F_2 - L_2F_1] / [F_1 + F_2]$.

4. The second harmonic of a guitar string has a frequency of 165 Hz. If the speed of waves on the string is 120 m/s, what is the length of the string?
   a. 0.36 m
   b. 0.73 m
   c. 1.10 m
   d. 1.40 m

5. A large tank is filled with water to a depth of 6 m. If the Point X is 1 m from the bottom and the Point Y is 2 m from the bottom, how does P_X, the hydrostatic pressure due to the water at Point X, compare to P_Y the hydrostatic pressure due to the water at Point Y?
   a. $2P_X = P_Y$
   b. $5P_X = 4P_Y$
   c. $4P_X = 5P_Y$
   d. $P_X = 4P_Y$

6. A plastic cube 0.5 m on each side and with a mass of 100 kg floats in water. What fraction of the volume of the cube is above the surface of the water? (take density of water as 1000 kg/m^3).
   a. 0.20
   b. 0.25
   c. 0.50
   d. 0.75

7. When consider about the below situations, the Doppler effect is not occurred in
   a. a source of sound moves toward a listener.
   b. a listener moves toward a source of sound.
   c. a listener and a source of sound remain at rest with respect to each other.
   d. a listener and a source of sound move toward or away from each other.

8. A block of Styrofoam, with a density of ρ_s and volume V, is pushed completely beneath the surface of a liquid whose density is ρ_L and released from rest. Given that $\rho_L > \rho_S$, which of the following expressions gives the magnitude of the initial upward acceleration of the block? (here g is the gravitational acceleration)
   a. $(\rho_L - \rho_s).g$
   b. $\left(\frac{\rho_L}{\rho_s} - 1\right).g$
   c. $\left(\frac{\rho_L}{\rho_s} + 1\right).g$
   d. $\left(\frac{\rho_L}{\rho_s} + 1\right)^2.g$

9. Which of the following equations is correct for calculating the focal point of a spherical mirror?
   a. $1/f = 1/p - 1/q$
   b. $1/f = 1/p + 1/q$
   c. $1/p = 1/f + 1/q$
   d. $1/q = 1/f + 1/p$

10. A pump is used to send water through a hose, the diameter of which is 10 times that of the nozzle through which the water exits. If the nozzle is 1 m higher than the pump, and the water flows through the hose at 0.4 m/s, what is the gauge pressure of the water at the pump?
   a. 260 kPa
   b. 400 kPa
   c. 810 kPa
   d. 1080 kPa

11. When cooking oil is heated in a frying pan, the oil moves around in the pan more easily. The main reason for this is that with rise in temperature, there is a decrease in
   a. surface tension.
   b. viscosity.
   c. angle of contact.
   d. density.

12. When light is going from a more density to a less density medium, the critical angle is the angle of incidence for which the angle of refraction is
   a. 90°.
   b. 45°.
   c. 180°.
   d. 75°.

13. When the angle of contact between a solid and a liquid is 90°, then
   a. Cohesive force > Adhesive force.
   b. Cohesive force < Adhesive force.
   c. Cohesive force = Adhesive force.
   d. Cohesive force >> Adhesive force.

14. Which position of the object will produce a magnified virtual image, if a concave mirror of focal length 15 cm is being used?
   a. 10 cm
   b. 15 cm
   c. 30 cm
   d. 35 cm

15. A sheet can be made waterproof by coating it with a substance that changes the angle of contact
    a. 90^0.
    b. To zero.
    c. From acute to obtuse.
    d. From obtuse to acute.

16. The threshold of hearing is 10^{-12} watts/m^2. What is the sound intensity in decibels for a sound source emitting 10^{-6} watts/m^2?
    a. 50dB
    b. 60dB
    c. 6dB
    d. 10^6dB

17. Repeatable entity of a crystal structure is known as
    a. Crystal.
    b. Lattice.
    c. Unit cell.
    d. Miller indices.

18. What is the atomic packing factor of BCC structure?
    a. 0.68
    b. 0.57
    c. 0.75
    d. 0.91

19. A unit cell that contains lattice points only at the corners is known as
    a. Primitive unit cell.
    b. Secondary unit cell.
    c. Layered unit cell.
    d. Derived unit cell.

20. Which symbols represent atoms that are isotopes?
    a. C^{14} and N^{14}
    b. O^{16} and O^{18}
    c. C^{12} and N^{14}
    d. Rn^{222} and Ra^{222}

Part B: Structured questions

Answer all five questions. Show all your work, including listing the appropriate variables, the correct substitution of the formula, and the final answer with the correct units to receive full credit.

Q1.

a) What are the common states of matters?

(1 marks)

b) Briefly explain the main differences among three types of chemical bonds.

(2 marks)

c) Zinc has five naturally occurring isotopes: 48.63% of ^{64}Zn, with an atomic weight of 63.929 amu; 27.90% of ^{66}Zn, with an atomic weight of 65.926 amu; 4.10% of ^{67}Zn, with an atomic weight of 66.927 amu; 18.75% of ^{68}Zn, with an atomic weight of 67.925 amu; and 0.62% of ^{70}Zn, with an atomic weight of 69.925 amu. Calculate the average atomic weight of Zn.

(3 marks)

d) What is the difference between atomic structure and crystal structure?

(2 marks)

e) Copper has an atomic radius of 0.128 nm, an FCC crystal structure and an atomic weight of 63.5 g/mol. Compute its theoretical density of copper.

(4 marks)

Q2.

a) Briefly explain reflection and refraction of light.

(1 marks)

b) What is the law of reflection?

(1 marks)

c) An object of 5 cm in length is held 25 cm away from a concave mirror of focal length 10 cm.

i. Draw the ray diagram.

ii. Find the position of the image formed.

iii. Find the magnification of image.

(6 marks)

d) Draw a labelled ray diagram to locate the image of an object formed by a diverging lens of focal length 20 cm when the object is placed 30 cm away from the lens.

(4 marks)

Q3.

a) Briefly explain the following terms with help of a stress and strain plot for a ductile material.

i. Breaking stress

ii. Yield stress

iii. Ultimate tensile stress

(6 marks)

b) The yield stress and ultimate tensile stress for steel is 2.48×10^8 Pa and 4.89×10^8 Pa, respectively. A steel wire of 10 m length and 2 mm cross sectional diameter is subjected to longitudinal tensile stress. Young's modulus of steel is $E = 2 \times 10^{11}$ Pa.

i. Calculate the maximum elongation that can be produced in the wire without permanently deforming it. How much force is required to produce this extension?

ii. Calculate the maximum stretching force that can be applied without breaking the wire.

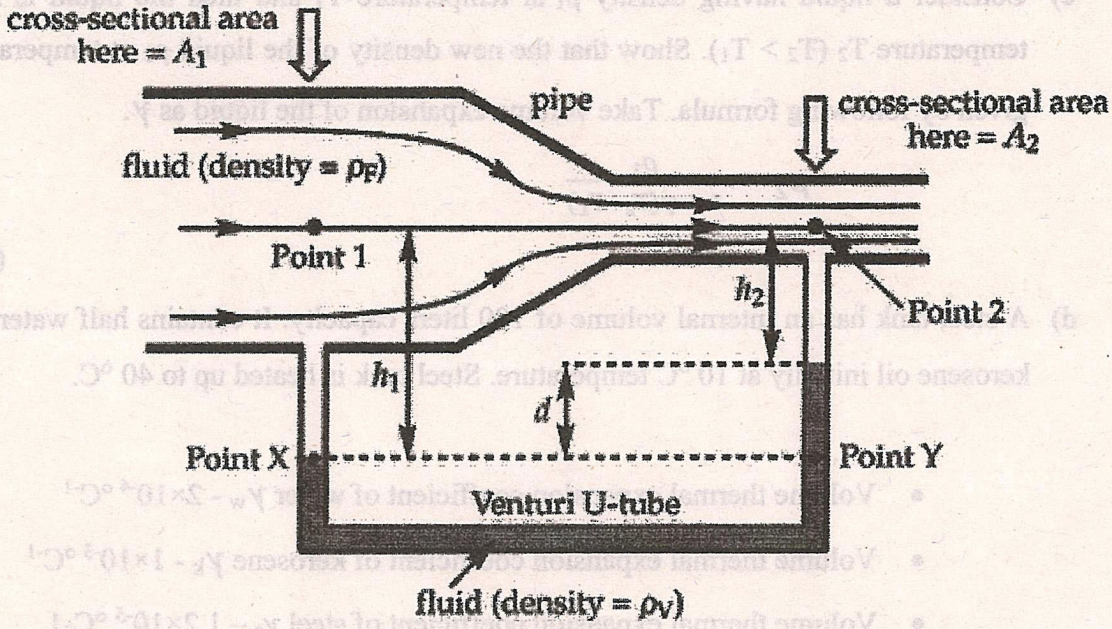
(6 marks)

Q4.

a) State the Bernoulli's equation with the necessary conditions of the fluid that are required to satisfy in order to apply the equation.

(2 marks)

b) The figure below shows a pipe fitted with a Venturi U-tube. Fluid of density ρ_f flows at a constant flow rate and with negligible viscosity through the pipe, which constricts from a cross-sectional area A_1 at Point 1 to a smaller cross-sectional area A_2 at Point 2. The upper portion of both sides of the Venturi U-tube contain the same fluid that is flowing through the pipe, while the lower portion is filled with a fluid of density ρ_v (which is greater than ρ_f). At Point 1 in the pipe, the pressure is P_1 and the flow speed is v_1; at Point 2 in the pipe, the pressure is P_2 and the flow speed is v_2. All the fluid within the Venturi U-tube is stationary.



i. What is P_X, the hydrostatic pressure at Point X? Write your answer in terms of P_1, ρ_f, h_1, and g.

ii. What is P_Y, the hydrostatic pressure at Point Y? Write your answer in terms of P_2, ρ_f, ρ_v, h_2, d, and g.

iii. Write down the result of Bernoulli's Equation applied to Points 1 and 2 in the pipe and solve for $P_1 - P_2$.

iv. Since $P_X = P_Y$, set the expressions you derived in parts 1 and 2 equal, and use this equation to find $P_1 - P_2$.

v. Derive an expression for the flow speed, V_2, and the flow rate, f, in terms of A_1, A_2, d, ρ_f, ρ_v, and g. Show that V_2 and f are proportional to square root of d.

(10 arks)

Q5.

a) Define linear coefficient of thermal expansion.

(1 mark)

b) Prove that area thermal coefficient of expansion twice the linear thermal coefficient of expansion.

(2 marks)

c) Consider a liquid having density ρ_1 at temperature T_1 and then the liquid is heated to temperature T_2 ($T_2 > T_1$). Show that the new density of the liquid ρ_2 at temperature T_1 is given by following formula. Take volume expansion of the liquid as γ.

$$\rho_2 = \frac{\rho_1}{1 + \gamma(T_2 - T_1)}$$

(3 marks)

d) A steel tank has an internal volume of 100 liters capacity. It contains half water and half kerosene oil initially at 10 °C temperature. Steel tank is heated up to 40 °C.

- Volume thermal expansion coefficient of water γ_w - 2×10^{-4} °C^{-1}
- Volume thermal expansion coefficient of kerosene γ_k - 1×10^{-3} °C^{-1}
- Volume thermal expansion coefficient of steel γ_s – 1.2×10^{-5} °C-1
- Density of kerosene at 10 °C – 0.8 kg/l

i. Calculate volume expansion of each component in liters.
ii. Calculate the spill volume of kerosene in liters.
iii. Calculate the density of kerosene at 40 °C.
vi. Calculate the spill mass of kerosene.

(6 marks)