BINDURA UNIVERSITY OF SCIENCE EDUCATION
BIOLOGICAL SCIENCES DEPARTMENT
BScBZH/ HBScBioTec/ HBScEd/ BScEd
MOLECULAR GENETICS (BZH 208/ BTEC212)

EXAMINATION = AUG 2024
2 HOURS (100 MARKS)

INSTRUCTIONS TO CANDIDATES
Answer FOUR questions. You MUST answer QUESTION 1 (Section A) and any THREE questions from section B. Each question carries 25 MARKS. Where a question contains sub-divisions, the mark value of each sub-division is given in brackets. Illustrate your answer where appropriate with large clearly labelled diagrams. You should not spend more than thirty minutes on each question.

SECTION A (COMPULSORY)

1. Discuss the use of gel electrophoresis and UV spectrophotometry in quantification of DNA highlighting the strengths and weaknesses of each method.

SECTION B

2. (a) Describe the central dogma of molecular biology as proposed by Francis Crick. (10 marks)
   (b) Outline modifications made to the dogma to date. (15 marks)

3. Write short notes on any **FIVE** of the following:
   (a) Essential amino acids. (5 marks)
   (b) Differences between DNA and RNA. (5 marks)
   (c) Pseudogenes. (5 marks)
   (d) Hershey and Chase experiment. (5 marks)
   (e) Properties of genetic material. (5 marks)
   (f) Ames test. (5 marks)

4. (a) Give a detailed description of DNA packaging in chromosomes. (20 marks)
   (b) Distinguish between euchromatin and heterochromatin. (5 marks)

5. Explain the following mechanisms of DNA repair:
   (a) Base Excision Repair (BER). (8 marks)
   (b) Mismatch Repair (MMR). (8 marks)
   (c) Double Strand Break Repair. (9 marks)

6. Write an essay on regulation of gene expression in prokaryotes.

END OF EXAMINATION QUESTION PAPER

(d) Write down an equation relating the rate of flow of heat through a thin slice of a solid to the temperature gradient across it. State the meaning of any other symbol which appears in the equation. [5]

(e) Outline two processes by which heat may be conducted through a solid [4]

(f) Figure 2 represents a wave profile propagating in the positive x-direction.

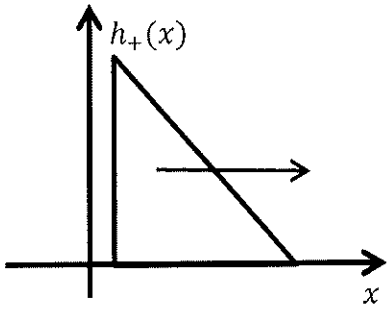

Figure 2: Wave profile propagating in the positive x-direction

Sketch the corresponding wave disturbance. [2]

(g) Explain why the expression

$$\psi(x,t) = f\left(t \mp \frac{x}{c}\right)$$

is said to represent a propagating wave. Define all the physical quantities in the expression. [6]

(h) Imagine a physics faculty meeting with a hiring decision at stake. One opinionated professor starts shouting such that the sound volume in the room is 70 dB. Pretty soon nine (9) other professors join in, so all ten (10) are shouting simultaneously with equal volume. What is the new volume in the room? [6]

SECTION B

Attempt any three questions.

2. (a) Give the Entropy Statement of the Second Law of Thermodynamics and show that heat flow from a higher temperature isotherm to a lower temperature isotherm is in accordance with this law. [4]

(b) State and prove Carnot's theorems. [10]

(c) An inventor, I. M. Klever, claims to have designed a heat engine with the following specifications:

Power developed ..... $76\ kW$
Fuel burned per hour ..... $4\ kg$
Heating value of the fuel ..... $75\ MJkg^{-1}$
Temperature limits ..... $727\ ^{\circ}C$ *and* $27\ ^{\circ}C$

Examine the feasibility of these claims. [6]

3 (a) Circular water waves move outward from a bobbing cork at a point. The cork bobs up and down and back again-a complete cycle-once per second, and generates waves that measure $10\ cm$ from crest to crest. Some time after the wave motion has been established, we begin to time the motion with a stopwatch. At a certain time $t = 10\ s$ on the watch, we notice that the wave profile has the shape shown below.

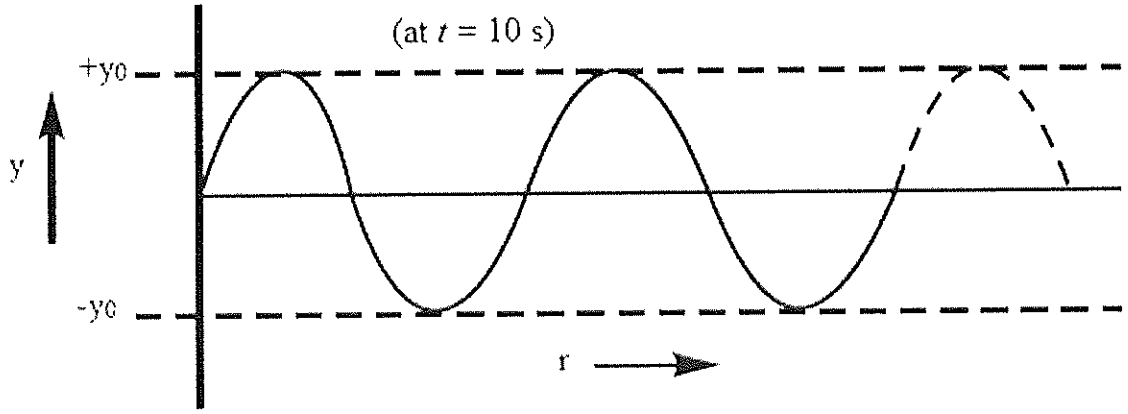

Figure 1: The wave profile

(i) What is the wave Period T for this water wave? [3]

(ii) What is its wavelength λ? [1]

(iii)What is its wave speed v? [3]

(iv) What is the phase angle ϕ for a wave front at position $x = 102.5\ cm$ at time $t = 10\ s$? [3]

(v) What is the wave displacement y on the wave front at $x = 102.5\ cm$? [3]

(VI) If we focus on the wave motion at the position $x = 105\ cm$ and let time vary, what kind of motion do we observe? [3]

4. (a) Explain the following forms of the first law of thermodynamics:

(i) $\Delta E = Q - W$ [2]

(ii) $dE = dQ - dW$ [2]

(iii) $Q \equiv \oint dQ = \oint dW \equiv W$ [2]

The symbols have their usual meanings.

(b) Suppose that one mole of a monatomic gas is subjected to a cyclic process which appears as a circle on the $P - V$ plane below.

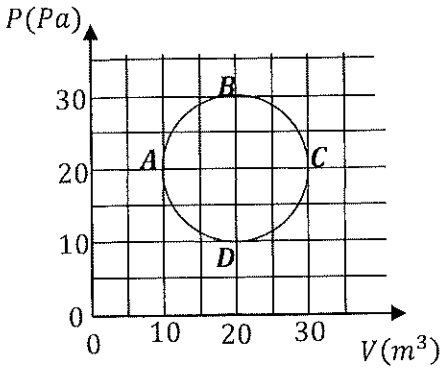

Figure: 3 P – V indicator diagram for a cyclic

Find the following quantities:

(i) The net work done by the gas in one cycle. [5]

(ii) The internal energy difference of the gas between state C and state A. [4]

(iii) The heat absorbed by the gas in going from A to C via the path ABC of the cycle. [5]

5. (a) Explain the concept of degrees of freedom in the kinetic theory of gases? State the equipartition of energy theorem showing how the concept of degrees of freedom is involved. [6]

(b) How many degrees of freedom does a diatomic molecule have? Use a diagram to show how they arise. You may neglect any vibrations. [6]

(c) Consider an ideal gas whose density is 1.3 kgm^{-3} at standard pressure (1 atmosphere) and temperature (normal-ice-point). If the speed of sound propagation in this gas is 330 ms^{-1}, calculate the degrees of freedom of the gas molecules. [8]

6. (a) Explain the following terms encountered during the course of lectures on wave motion:

(i) normal mode of vibration; [1]
(ii) eigenfrequency; [1]
(iii) fundamental mode; [1]
(iv) overtones; [1]
(v) harmonics; and [1]
(vi) spectrum. [1]

(b) Two open-ended organ pipes of lengths 0.41 m and 0.43 m are excited simultaneously in their fundamental modes. What two frequencies does a listener actually hear? The speed of sound in the organ pipes is 344 ms^{-1}. [5]

(c) Compare the lengths of an open-ended and a closed-ended organ pipe which emit the same fundamental note. [4]

(d) A flexible string of length 0.99 m and mass 1 $gram$ is stretched by a tension of T newtons. Find the tension if the string vibrates in three segments with a frequency of 500 Hz. [5]

END OF PAPER