

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (HONS) BIOMEDICAL ENGINEERING

SEMESTER ONE EXAMINATIONS 2023/24

**MOLECULAR PRINCIPLES OF BIOMEDICAL
ENGINEERING**

MODULE NO: BME4002

Date: Monday 8th January 2024

Time: 2:00pm – 4:00pm

INSTRUCTIONS TO CANDIDATES:

Candidates are advised that the examiners attach importance to legibility of writing and clarity of expression. **YOU ARE STRONGLY ADVISED TO PLAN YOUR ANSWERS**

There are **THREE** sections.

Answer **ALL** questions from Section A and Section B.

Answer **ONE** question from Section C.

Write all answers in answer booklet.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Calculators are permitted, but all working must be shown.

A formulae sheet, together with the genetic code table, can be found at the end of the paper.

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

SECTION A: Answer ALL questions in this section; 1 mark per question, 29 marks in total.

1. Which of the following are found in both DNA and RNA?
 - a. Ribose, phosphate groups, and adenine.
 - b. Deoxyribose phosphate groups, and guanine.
 - c. Phosphate groups, guanine, and cytosine.
 - d. Phosphate groups, guanine, and thymine.

2. What is produced during translation?
 - a. tRNA.
 - b. mRNA.
 - c. Polypeptides.
 - d. None of the above.

3. The covalent bonds that hold the primary structure of a protein together are called:
 - a. Disulphide bonds.
 - b. Phosphodiester bonds.
 - c. Glycosidic bonds.
 - d. Peptide bonds.

4. The cytosol:
 - a. Has a pH less than 6.
 - b. Is predominantly made of water.
 - c. Has a thin consistency.
 - d. Is found in between cells.

5. If a double stranded DNA molecule is found to be composed of 30% guanine, how much uracil would be expected?
 - a. 0%.
 - b. 20%.
 - c. 30%.
 - d. 70%.

6. Which of the following is a function of the smooth endoplasmic reticulum?
 - a. Detoxification of poisons.
 - b. Production of ATP.
 - c. rRNA synthesis.
 - d. Protein folding.

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

7. If 5 moles of MgCl_2 are dissolved in 1L of water, what is the concentration of the resulting solution?

- a. 0.2 M.
- b. 5 M.
- c. 0.2 moles.
- d. 5 moles.

8. Which of the following statements about enzymes is NOT true?

- a. Enzymes act as catalysts.
- b. Enzymes can provide a microenvironment in which reactions take place.
- c. Enzymes are unchanged by the chemical reaction in which they are involved.
- d. Enzymes are unspecific and can therefore generally recognise multiple substrates.

9. The atomic mass of an element is equivalent to:

- a. The total number of protons in one atom.
- b. The total number of protons **and** electrons in one atom.
- c. The total number of protons **and** neutrons in one atom.
- d. The total number of protons, neutrons **and** electrons in one atom.

10. Which of the following are not made of eukaryotic cells?

- a. Humans.
- b. Protists.
- c. Bacteria.
- d. Plants.

11. Which of the following is attached to glycerol in a triglyceride?

- a. Inositol.
- b. Fatty acid.
- c. Phosphate.
- d. Glucose.

12. Which of the following is not a stage of cell signalling?

- a. Transduction.
- b. Response.
- c. Osmosis.
- d. Reception.

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

13. Which of the following statements about water molecules is true?
- The molecule is completely uncharged.
 - The molecule is slightly charged.
 - The molecule is ionic.
 - The molecule has a lattice structure.
14. _____ are pyrimidines; _____ are purines (fill in the blanks).
- Adenine and guanine; cytosine and thymine.
 - Cytosine and guanine; adenine and thymine.
 - Cytosine and thymine; adenine and guanine.
 - Uracil and adenine; thymine and guanine.
15. How many chromosomes do human gametes have?
- 22.
 - 23.
 - 44.
 - 46.
16. Point mutations:
- Can have no effect on the resulting protein structure.
 - Can have a minor effect on the resulting protein structure.
 - Can have a major effect on the resulting protein structure.
 - All of the above are true.
17. The enzyme used in PCR starts copying at which of the following positions?
- At the end of free single-stranded RNA
 - At any open point.
 - At RNA primers attached to either end of the desired gene.
 - At DNA primers attached to either end of the desired gene.
18. Which of the following statements is NOT correct about the phospholipid molecules in the plasma membrane?
- Each phospholipid molecule has three nonpolar tails.
 - Each phospholipid molecule has one polar head.
 - The phospholipid tails are not hydrophobic.
 - The phospholipid heads face outward.

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

19. The most common covalent cross-links in proteins are sulphur–sulphur bonds that form between two amino acids with SH (thiol) groups as side chains. Which amino acid has this side chain?

- a. Tryptophan.
- b. Methionine.
- c. Cysteine.
- d. Proline.

20. The bonds between DNA base pairs are:

- a. Phosphodiester bonds.
- b. Glycosidic bonds.
- c. Hydrogen bonds.
- d. Peptide bonds.

21. Which of the following types of chromosomal aberration results in a part of the chromosome rotating 180°?

- a. Inversion.
- b. Duplication.
- c. Substitution.
- d. Translocation.

22. Which of the following mutation types results in a single amino acid being changed in the protein being coded for?

- a. Silent.
- b. Synonymous.
- c. Nonsense.
- d. Missense.

23. A protein can be unfolded by a process called:

- a. Renaturation.
- b. Denaturation.
- c. Oxidation.
- d. Reduction.

24. Which of the following is NOT required for PCR?

- a. dNTPs.
- b. Thermostable polymerase.
- c. RNA primer.
- d. DNA template.

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

25. Which of the following is **not** a step in PCR?

- a. Extension.
- b. Denaturing.
- c. Annealing.
- d. Ligating.

26. How many possible codon combinations make up the standard 20 amino acid code?

- a. 16.
- b. 20.
- c. 64.
- d. An infinite number.

27. The presence of double bonds makes a fatty acid:

- a. Saturated.
- b. Hydrogenated.
- c. Oxygenated.
- d. Unsaturated.

28. Energy is released when:

- a. A phosphate group is added to a molecule of ATP.
- b. A phosphate group is released from a molecule of ATP.
- c. A phosphate group is either added or released from a molecule of ATP.
- d. A nitrate group is released from a molecule of ATP.

29. At pH7, amino acids are:

- a. Always negatively charged.
- b. Always positively charged.
- c. Always uncharged.
- d. Sometimes charged and sometimes uncharged.

[Total for Section A: 29 marks]

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

SECTION B: Answer ALL questions in this section; varying marks per question, 36 marks in total.

1. Explain how the four different bases in DNA can code for the 20 amino acids found in proteins.

[6 marks]

2. A patient presents herself at a genetic counselling clinic saying that her and her partner want to have a baby, but she is concerned that any child she has may have the autosomal dominant condition Huntington's disease. She herself has the disease and is homozygous for the mutation which causes the disease. Previous tests have shown that her partner is not a carrier for the mutation which causes the disease. With the use of a Punnett square calculate the percentage likelihood of their baby being affected by the disease.

[5 marks]

3. Design the PCR primers (12 bases in length) which would be required to copy the target region (red) of the sequence below (Figure 1). What would be the size (in base pairs) of the resulting product?

----- Target -----
5' TGCCTTCGTACGTGTACACGTGGGACATACGTACACAGGTAGACTGATACCAAGTGTCGGAAAT 3'

Figure 1: DNA sequence for Question 3

[6 marks]

4. Describe, with the help of an illustration, the chemical composition of a nucleotide, and explain how nucleotides join together to form a **single strand** of DNA.

[6 marks]

PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

5. Use the formulae sheet at the back of the exam paper to assist you with the following calculations.

a) What is the concentration of a solution with a volume of 1.25 L containing 600.00 g of calcium phosphate? ($M_r = 310.1$).

[2 marks]

b) Calculate how would you dilute the solution described in part (a) to make 150.00 mL of a 500.00 mM solution.

[2 marks]

c) When attempting to make the solution in part (b), you accidentally end up with a volume of 200.00 mL instead of 150.00 mL. What molarity solution do you now have? What percentage error is this?

[3 marks]

[Total 7 marks]

6. See Table 1 at the end of the paper for the genetic code table. You have been given the following double-stranded sequence of DNA:

5' ATGCCGATCTCATGCCGGTCGACCGTC 3' *Non-template strand*
3' TACGGCTAGAGTACGGCCAGCTGGCAG 5' *Template strand*

a) Assuming transcription begins at the start of the sequence, what sequence of mRNA would be produced from this sequence during transcription?

[2 marks]

b) Using the information supplied in Table 1, what amino acid sequence would be produced from your mRNA sequence in part (a) during translation?

[2 marks]

c) Write down the non-template strand sequence in your answer book, and then clearly change one base to introduce an example of a missense mutation, before briefly explaining what a missense mutation is.

[2 marks]

[Total 6 marks]

[Total for Section B: 36 marks]
PLEASE TURN THE PAGE

School of Engineering
Biomedical/Medical Engineering
Semester 1 Examinations 2023/24
Molecular Principles of Biomedical Engineering
Module No. BME4002

SECTION C: Answer ONE question only; 35 marks.

1. Give a detailed account of the processes of transcription and translation.

[35 marks]

OR

2. Write an essay on the polymerase chain reaction, with reference to the purpose, mechanism and reagents involved.

[35 marks]

OR

3. With reference to the principles of inheritance, explain why a single mutation in DNA does not necessarily result in genetic disease.

[35 marks]

[Total for Section C: 35 marks]

END OF QUESTIONS

PLEASE TURN THE PAGE FOR FORMULA SHEET

School of Engineering
 Biomedical/Medical Engineering
 Semester 1 Examinations 2023/24
 Molecular Principles of Biomedical Engineering
 Module No. BME4002

Formulae sheet and genetic code table – feel free to detach this sheet from the rest of the exam paper

$$\text{Moles} = \frac{\text{Mass}}{M_r}$$

$$\frac{\text{Moles}}{\text{Solvent volume (L)}} = \text{Molarity (M)}$$

$$M_1V_1 = M_2V_2$$

$$\% \text{ error} = \frac{\# \text{ experimental} - \# \text{ theoretical}}{\# \text{ theoretical}} \times 100$$

Table 1: The Genetic Code

		Second letter					
		U	C	A	G		
First letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G	
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G	
	A	AUU } AUC } Ile AUA } AUG Met	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G	
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G	
						Third letter	

END OF PAPER