

**NATIONAL UNIVERSITY OF SINGAPORE
DEPARTMENT OF BIOLOGICAL SCIENCES
ADVANCED PLACEMENT TEST
(SAMPLE)
LSM1401 FUNDAMENTALS OF BIOCHEMISTRY
June-20XX---Time Allowed: 2 hours**

INSTRUCTIONS TO CANDIDATES

1. This paper contains a total of 60 questions and comprises 9 printed pages including this cover page.
2. This is a **CLOSED-BOOK** test.
3. Answer **ALL** questions. Use the **Answer Sheet (Form CC1)** for **ALL** your answers and shade the appropriate circles with a **soft (2B) pencil**. Ensure that each mark is **dark** and **completely fills** the circle. Do **not** answer directly on the question booklet.
4. **Both programmable and non-programmable calculators** without remote communication function are allowed to be used.
5. No Helpsheet(s) or Formula Sheet(s) will be provided.
6. For each question, select the **best** answer from the five suggested answers. **No marks** will be **deducted** for **incorrect answers**.
7. **DO NOT REMOVE THIS QUESTION PAPER FROM THE TEST VENUE.**
8. **DO NOT OPEN THIS QUESTION PAPER UNTIL YOU ARE TOLD TO DO SO.**

1. What is the pH of a solution that contains 25 micromoles per litre of H^+ ions?
- (A) 1.6
 (B) 2.6
 (C) 3.6
 (D) 4.6
 (E) 5.6

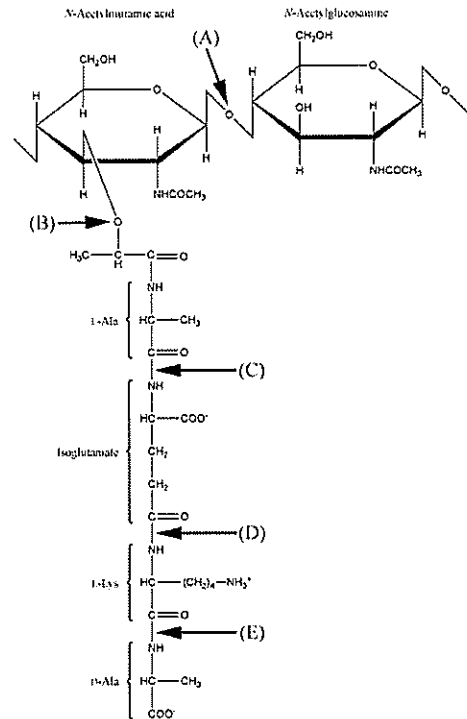
2. Which of the following is/are evidence(s) that mitochondria were once free-living organisms?
- I. They produce ATP.
 II. They contain their own DNA.
 III. They are found in all eukaryotic cells.
- (A) II only.
 (B) I and II only.
 (C) I and III only.
 (D) II and III only.
 (E) I, II, and III.

3. An amino acid commonly found at the end of an α -helix (helix-breaking behaviour) is
- (A) Phe (F).
 (B) Leu (L).
 (C) Glu (E).
 (D) Met (M).
 (E) Pro (P).

4. In an enzyme-catalysed reaction, the enzyme molecules
- (A) raise the average energy of the reactants.
 (B) change the rate of the forward and reverse reactions.
 (C) lower the overall free energy change of the reaction.
 (D) raise the energy of activation.
 (E) change the equilibrium constant of the reaction.

5. True statements about triacylglycerols include which of the following?
- I. They are stored in highly anhydrous forms.
 II. They are generally negatively charged at physiological pH.
 III. They yield large amounts of ATP on complete oxidation.
- (A) I only.
 (B) I and II only.
 (C) II and III only.
 (D) I and III only.
 (E) I, II, and III.

6. The peptidoglycan of the bacterial cell wall is resistant to proteases but not lysozymes. In the repeating unit of the peptidoglycan structure shown below, which bond would be hydrolysed by lysozyme?



7. Which of the following statements is NOT characteristic of catabolic reactions?
- (A) Glycolysis is an example of a catabolic pathway.
 (B) They are divergent processes in which a few precursors form a wide variety of polymeric products.
 (C) They often involve the hydrolysis of macromolecules.
 (D) They often produce NADH or $FADH_2$.
 (E) They serve to generate energy.
8. All of the following are important characteristics of DNA EXCEPT
- (A) A 1:1 ratio between pyrimidine residues and purine residues.
 (B) Adenine base pairs with uracil.
 (C) Hydrogen bonding between base pairs.
 (D) Information contained in the sequence of one strand can be determined by the sequence of the complementary strand.
 (E) Information is accessed through transcription of the information into RNA.

9. A plasma pH of 6.8 doesn't seem too far away from a normal pH of 7.4, but it will result in severe acidosis. How many times is the concentration of H^+ greater at pH 6.8 than that at pH 7.4?
- (A) 0.1
 (B) 0.6
 (C) 4
 (D) 10
 (E) 20

10. Which of the following is the proper sequence for mitosis?
- I. Metaphase
 II. Telophase
 III. Prophase
 IV. Anaphase
- (A) I, III, IV, II.
 (B) I, II, III, IV.
 (C) III, I, IV, II.
 (D) IV, I, III, II.
 (E) III, IV, I, II.

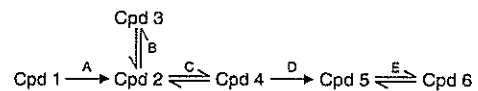
11. Collagen has the following characteristics EXCEPT
- (A) tropocollagen is the basic structural unit.
 (B) there is about 33% glycine in collagen.
 (C) both intermolecular and intramolecular crosslinks help to stabilise the collagen fibrils.
 (D) modification of prolines occurs prior to collagen synthesis.
 (E) inextendable fibrous protein component of connective tissues.

12. In the presence of a fixed concentration of a competitive inhibitor, which of the following would best characterise an enzyme-catalysed reaction when the substrate concentration is increased?
- (A) The inhibition decreases.
 (B) The inhibition does not change.
 (C) The K_m increases.
 (D) The V_{max} decreases.
 (E) The V_{max} increases.

13. Which of the following is NOT a component of a ganglioside?
- (A) A ceramide structure.
 (B) A sphingosine derivative.
 (C) Glucose or galactose.
 (D) One or more phosphates.
 (E) One or more sialic acids.

14. Which of the following comparisons between glycogen and cellulose is NOT true?
- (A) The glucose units of glycogen are linked by $\alpha(1\rightarrow4)$ glycosidic bonds but those in cellulose are linked by $\beta(1\rightarrow4)$ bonds.
 (B) Glycogen consists of highly branched chains but cellulose consists of linear chains.
 (C) Glycogen may be hydrolysed by α - and β -amylases but cellulose may only be hydrolysed by cellulase.
 (D) Animals produce enzymes capable of hydrolysing glycogen but do not produce cellulose-hydrolysing enzymes.
 (E) A glycogen molecule has many reducing ends but a cellulose molecule has one reducing end only.

15. Consider the following multienzyme metabolic pathway.



Which is the best point for regulating the production of Compound 6?

- (A) Reaction A.
 (B) Reaction B.
 (C) Reaction C.
 (D) Reaction D.
 (E) Reaction E.
16. The melting profile for a DNA is found to differ in two different salt solutions. In 0.001 M NaCl, $T_m = 55^\circ\text{C}$ and in 0.01 M NaCl, $T_m = 65^\circ\text{C}$. The fundamental reason for this difference is
- (A) higher salt concentration increases the electrostatic repulsions between phosphates.
 (B) the base stacking is more effective in high salt.
 (C) hydrogen bonding between complementary bases is enhanced with high salt.
 (D) higher salt concentration decreases the electrostatic repulsions between phosphates.
 (E) more energy is required to heat up the higher salt solution.

17. A section of a polypeptide chain with the sequence
 –Gly–Ser–Gln–Leu–His–Trp–Ala–Lys–Val–Glu–Tyr–
 is folded into an α -helix. To which amino acid is the peptide N–H group of tryptophan hydrogen bonded?
 (A) Glycine.
 (B) Serine.
 (C) Glutamine.
 (D) Glutamate.
 (E) Tyrosine.
18. Buffers have all of the following characteristics EXCEPT
 (A) they have relatively flat titration curves at the pH values where they buffer.
 (B) they resist changes in their pH values as acid or base is added.
 (C) they are typically composed of a weak acid and its conjugate base.
 (D) they buffer best at the half-way point between the two pK_a values of polyprotic acids.
 (E) they buffer where the amounts of conjugate base are nearly equivalent to the amounts of weak acid.
19. Which of the following statements on the fluid mosaic model of biological membranes is FALSE?
 (A) The biological membrane is a fluid matrix of mobile lipids and proteins.
 (B) The biological membrane is a multi-component solution of lipids and proteins.
 (C) The biological membrane is composed of bilayer arrangements of lipids.
 (D) The biological membrane is penetrated with extrinsic proteins.
 (E) The biological membrane has proteins that interact with the aqueous environment on both membrane surfaces.
20. The Michaelis constant for the substrate of an enzyme is 3.25×10^{-5} M. If the initial velocity is 0.12 mmol/min when substrate concentration is 0.18 M, what is the initial velocity of the enzyme when substrate concentration is 0.005 mM?
 (A) 0.016 mmol/min.
 (B) 0.073 mmol/min.
 (C) 0.119 mmol/min.
 (D) 0.120 mmol/min.
 (E) The initial velocity cannot be determined from the information given.
21. In eukaryotic cells, cytokinesis occurs following
 (A) G1 phase.
 (B) G2 phase.
 (C) M phase.
 (D) S phase.
 (E) T phase.
22. Oxaloacetate uniformly labelled with ^{14}C (equal amounts of ^{14}C in each of its carbon atoms) is condensed with unlabelled acetyl-CoA. After a single pass through the citric acid cycle back to oxaloacetate, what fraction of the original radioactivity will be found in the oxaloacetate?
 (A) 1/4.
 (B) 1/3.
 (C) 1/2.
 (D) 3/4.
 (E) All.
23. What is the nucleotide sequence of the DNA strand that is complementary to 5'-ATCGCAACTGCTACTA-3'?
 (A) 5'-TAGCGTTGACAGTGAT-3'
 (B) 5'-UAGUGACAGUUGCGAU-3'
 (C) 5'-TAGCGTTGACAGTGAT-3'
 (D) 5'-TAGTGACAGTTGCGAT-3'
 (E) 5'-ATCACTGTCAACGCTA-3'
24. A water lily produces one new leaf each day for each leaf it had the day before. Starting with a single leaf, it covered a 1-hectare pond in 15 days. How long will it take to cover a 2-hectare pond?
 (A) 15 days.
 (B) 16 days.
 (C) 20 days.
 (D) 25 days.
 (E) 30 days.

25. A new compound isolated from mitochondria is claimed to represent a previously unrecognised carrier in the electron transfer chain and is given the name coenzyme X. Which line of evidence is the LEAST conclusive in assigning this compound a position in the electron transfer chain?
- Alternate oxidation and reduction of the mitochondrion-bound coenzyme X can be readily demonstrated.
 - Removal of coenzyme X from the mitochondria results in a decreased rate of oxygen consumption.
 - The rate of oxidation and reduction of the mitochondrion-bound coenzyme is of the same order of magnitude as the overall rate of electron transfer.
 - When added to a mitochondrial suspension, coenzyme X is taken up very rapidly and specifically by the mitochondria.
 - All of the evidences are equally conclusive.
26. In normal adults blood pH is 7.40, and bicarbonate and carbon dioxide concentrations are 24.0 mM and 1.20 mM, respectively. Blood values of a patient who had swallowed 250 tablets of aspirin are pH = 7.24 and $[CO_2] = 1.10$ mM. What is the concentration of bicarbonate in the blood of the patient?
- The concentration of bicarbonate is 7.6 mM.
 - The concentration of bicarbonate is 8.5 mM.
 - The concentration of bicarbonate is 9.6 mM.
 - The concentration of bicarbonate is 15.2 mM.
 - The concentration of bicarbonate cannot be determined from the information given.
27. Which of the following amino acid residues would be most likely found buried within the core of a water-soluble globular protein?
- Serine.
 - Histidine.
 - Isoleucine.
 - Glutamic acid.
 - Lysine.
28. Which of the following statements about the properties of coenzymes are FALSE?
- They are usually actively involved in the catalytic reaction of the enzyme.
 - They tend to be stable to heat.
 - They can serve as intermediate carriers of functional groups.
 - They are protein components.
 - They may contain vitamins as part of their structure.
29. Which of the following statements about integral membrane proteins is true?
- They are always completely embedded in the lipid bilayer.
 - They are distributed symmetrically in the membrane.
 - They can be removed from the membrane only by membrane-disrupting agents.
 - They can 'flip' from one side of the bilayer to the other rapidly.
 - They have transmembrane domains that consist largely of hydrophilic amino acids.
30. Which of the following biological phenomena is attributed to the presence of carbohydrate groups?
- Concave shape of red blood cells giving a flattened and depressed appearance of at the centre.
 - Drastic drop in the blood pH of patients who had been hyperventilating.
 - Fragile blood vessels in sailors on long voyages whose diets were deficient of fresh fruits and vegetables.
 - Myoglobin's greater affinity for oxygen than haemoglobin.
 - Removal of aged red blood cells from circulation and subsequent degradation of the haemoglobin.
31. The insertion of how many nucleotides into a genetic sequence does less damage to the code than the insertion of other numbers of nucleotides?
- 1
 - 2
 - 3
 - 4
 - 5

32. Phosphorylase kinase catalyses the covalent modification of the less active glycogen phosphorylase *b* into the more active phosphorylase *a*:

$$\text{Phosphorylase } b + 2\text{ATP} \rightarrow \text{Phosphorylase } a + 2\text{ADP.}$$
 What is the classification number of phosphorylase kinase?
 (A) EC 1.1.7.38
 (B) EC 2.1.7.38
 (C) EC 3.1.7.38
 (D) EC 4.1.7.38
 (E) EC 5.1.7.38
33. Polar substances are transported across a membrane with the aid of membrane transport proteins such as porins but non-polar compounds are able to diffuse across biological membranes without the support of any specific transport system. Which of the following is the best explanation for the different ways these substances move across membranes?
 (A) The movement of polar substances across membranes must be coupled to the hydrolysis of ATP.
 (B) The binding of the non-polar compounds to the membrane transport proteins is very weak relative to the binding of polar substances.
 (C) The movement of non-polar compounds into the non-polar region of the membrane is energetically favourable.
 (D) The activation energy of the reaction involved in the movement of polar compounds across membranes is significantly higher.
 (E) The limitations of current technologies are unable to locate a specialised transport system that aids the movement of non-polar compounds across membranes.
34. Which of the following groups of organisms commonly cause the spoilage of refrigerated foods?
 (A) Halophiles.
 (B) Microaerophiles.
 (C) Mesophiles.
 (D) Psychrophiles.
 (E) Thermophiles.
35. Almost all of the oxygen an individual consumes in breathing is converted to
 (A) acetyl-CoA.
 (B) carbon dioxide.
 (C) carbon monoxide and then to carbon dioxide.
 (D) pyruvate.
 (E) water.
36. The eukaryotic transcription factor that exhibits a sequence specificity for the TATA box is
 (A) TFIIB.
 (B) TFIIIC.
 (C) TFIID/TBP.
 (D) TFIIIF.
 (E) TFIIF.
37. If, during transcription, a single nucleotide is mistakenly transcribed to a different nucleotide:
 (A) the protein product will necessarily be entirely different.
 (B) the protein product could be entirely different, or could be no different at all.
 (C) nothing will happen because the protein will be altered only if the mistakes are made during translation.
 (D) the amino acid sequence will change, but the protein function will remain unaltered.
 (E) none of the above is correct.
38. Trypsin is an intestinal protease with a pH optimum of 7.7. Which of the following weak acids would make the best buffer for the study of this enzyme?
 (A) Lactic acid ($pK_a = 3.86$)
 (B) Acetic acid ($pK_a = 4.76$)
 (C) Succinate ($pK_a = 5.48$)
 (D) *N*-tris(hydroxymethyl) aminomethane ($pK_a = 8.3$)
 (E) Bicarbonate ($pK_a = 10.20$)

39. The chromosomes and genes are actually replicated during
 (A) anaphase.
 (B) metaphase.
 (C) interphase.
 (D) prophase.
 (E) telophase.
40. The pK_a values of the carboxyl, amino, and R groups for histidine are 1.82, 9.2, and 6.0, respectively. What percentage of the histidine imidazole group is protonated at pH 7.2?
 (A) 0%.
 (B) 5.9%.
 (C) 94.1%.
 (D) 100%.
 (E) The percentage of protonation cannot be determined from the information given.
41. Which of the following types of bonds or interactions is the LEAST likely to be involved in stabilising the tertiary structure of most proteins?
 (A) Hydrophobic interactions.
 (B) Electrostatic interactions.
 (C) Hydrogen bonds.
 (D) Disulphide bonds.
 (E) Ester bonds.
42. Assume that carbons 3 and 4 in glucose are labelled with radioactive ^{14}C . Following glycolysis, the product pyruvate would be labelled on
 (A) carbon 2.
 (B) the carboxyl carbon.
 (C) the methyl carbon.
 (D) either the carboxyl or the methyl carbon.
 (E) either carbon 1, or carbon 2, or carbon 3.
43. You want to confirm if you have successfully introduced a foreign gene into a eukaryotic genome. Which of the following methods can be used?
 I. Restriction enzyme mapping.
 II. PCR.
 III. Southern blotting.
 IV. DNA sequencing.
 (A) I and II only.
 (B) II and III only.
 (C) III and IV only.
 (D) I, II, and III only.
 (E) II, III, and IV only.
44. What is/are the effect(s) on an individual who is deficient in triose phosphate isomerase, the enzyme that catalyses the interconversion of dihydroxyacetone phosphate and glyceraldehyde 3-phosphate (fifth reaction of glycolysis)?
 I. Dihydroxyacetone phosphate would accumulate unless there are other means of depletion.
 II. One mole of glucose would still result in the production of 2 moles of pyruvate.
 III. The net production of ATP and NADH from 1 mole of glucose would be 2 moles and 1 mole, respectively.
 (A) I only.
 (B) II only.
 (C) III only.
 (D) I and III only.
 (E) I, II, and III.
45. A single clone of interest can be distinguished from others in a mixture of clones by
 (A) testing the clones for antibiotic resistance.
 (B) mobility of the clones in gel electrophoresis.
 (C) a specific probe, usually a labelled complementary DNA.
 (D) digestion by restriction enzymes.
 (E) ultraviolet light using spectrophotometer.
46. In the process of hair-rebonding, thioglycolate is used to reduce the disulphide bonds of the α -keratin into their constituent cysteine residues. Which of the following will result in a similar effect as thioglycolate?
 (A) Exposure to oxygen.
 (B) Guanidine hydrochloride.
 (C) Mercaptoethanol.
 (D) Sodium dodecyl sulphate.
 (E) Urea.
47. The only substrate-level phosphorylation that forms a high-energy phosphate compound in the citric acid cycle is catalysed by
 (A) citrate synthase.
 (B) fumarase.
 (C) malate dehydrogenase.
 (D) succinate dehydrogenase.
 (E) succinyl Co-A synthase.

48. In order to perform PCR, the following reagents must be included
- DNA fragment, primers flanking the region of interest, dNTPs, buffer with magnesium ions, and DNA polymerase.
 - DNA fragment, primers flanking the region of interest, NTPs, buffer with magnesium ions, DNA polymerase, and DNA ligase.
 - DNA fragment, primers flanking the region of interest, dNTPs, buffer with magnesium ions, DNA polymerase, DNA ligase, and ATPs.
 - DNA fragment, primers flanking the region of interest, NTPs, buffer with magnesium ions, and DNA polymerase.
 - DNA fragment, primers flanking the region of interest, NTPs, buffer with magnesium ions, DNA polymerase, and DNA ligase.
49. Which of the following takes place during electron transport in the mitochondrion?
- Electrons are pumped from the intermembrane space to the matrix.
 - Electrons are pumped from the matrix to the intermembrane space.
 - Protons are pumped from the intermembrane space to the matrix.
 - Protons are pumped from the matrix to the intermembrane space.
 - NADH is pumped from the matrix to the intermembrane space.
50. Which of the following statements explain(s) why the P/O ratio for the oxidation of 1 mole of FADH_2 is less than that of NADH?
- Electrons from FADH_2 are transferred through a path that results in a lower contribution to the proton gradient than the electrons from NADH.
 - Electrons from FADH_2 are transferred through Complexes III and IV before being accepted by oxygen.
 - Electrons from FADH_2 enter the electron transport chain at a point that bypasses Complex I.
- I only.
 - I and II only.
 - I and III only.
 - II and III only.
 - I, II, and III.
51. All are characteristics of Okazaki fragments in prokaryotes EXCEPT
- newly synthesised short lagging strand fragments.
 - synthesis performed in the 5'→3' direction.
 - initiated with an RNA primer.
 - about 20-30 nucleotides in length.
 - binds anti-parallel to the template strand.
52. At the end of β -oxidation, the catabolism of 1 mole of nervonic acid (24:1- Δ^{15}) in a mammalian cell's mitochondrion would result in the production of
- Acetyl-CoA: 11 moles; FADH₂: 10 moles; NADH: 11 moles; NADPH: 0 mole.
 - Acetyl-CoA: 11 moles; FADH₂: 11 moles; NADH: 11 moles; NADPH: 0 mole.
 - Acetyl-CoA: 12 moles; FADH₂: 10 moles; NADH: 11 moles; NADPH: 0 mole.
 - Acetyl-CoA: 12 moles; FADH₂: 11 moles; NADH: 11 moles; NADPH: 0 mole.
 - Acetyl-CoA: 12 moles; FADH₂: 10 moles; NADH: 11 moles; NADPH: 1 mole.
53. All are properties of DNA polymerase III EXCEPT
- It is responsible for incorporating most of the nucleotides in the lagging strand.
 - It synthesizes most of the leading strand prior to aiding in the synthesis of the lagging strand.
 - It contains a 3' to 5' exonuclease activity.
 - It is a large protein complex containing more than five subunits.
 - Much greater processivity than DNA polymerase I.
54. An enzyme that was isolated from sheep exhibited maximum activity at pH 8.6. Which of the following buffers would be suitable for experiments on the activity of the enzyme at pH optimum?
- A buffer with $\text{p}K_a$ value of 8.0 and 80% deprotonated.
 - A buffer with $\text{p}K_a$ value of 8.0 and 20% protonated.
 - A buffer with $\text{p}K_a$ value of 8.0 and 80% protonated.
- I only.
 - I and II only.
 - I and III only.
 - II and III only.
 - I, II, and III.

55. Consider the following transamination reaction that requires pyridoxal phosphate as a coenzyme.
 $\text{Glutamate} + \alpha\text{-Keto Acid} \leftrightarrow \alpha\text{-Ketoglutarate} + \alpha\text{-Amino Acid}$
 If the α -keto acid is pyruvate, which of the following would be the α -amino acid?
 (A) Alanine.
 (B) Aspartic acid.
 (C) Asparagine.
 (D) Isoleucine.
 (E) Valine.
56. Which of the following correctly describes a difference between RNA and DNA polymerases?
 (A) RNA polymerases use dNTPs as building blocks, while DNA polymerases use NTPs.
 (B) DNA polymerases usually require a primer to initiate synthesis while most RNA polymerases do not.
 (C) RNA polymerases usually synthesise exons, while DNA polymerases synthesise introns and exons.
 (D) RNA polymerases polymerise $5' \rightarrow 3'$, while DNA polymerases polymerise $3' \rightarrow 5'$ as well as $5' \rightarrow 3'$.
 (E) None of the above.
57. The quantity of DNA per cell in several hundred cells of the tip of a young leaf was measured and found to range from 10 to 20 pg. Which of the following stages would a cell with 10 pg of DNA be at?
 I. After telophase.
 II. Early anaphase.
 III. G1 phase.
 (A) I only.
 (B) II only.
 (C) I and III only.
 (D) II and III only.
 (E) I, II, and III.
- (A) None of the above is correct.
58. Carbohydrate groups are able to form glycosidic bonds with which of the following amino acids?
 I. Arginine.
 II. Serine.
 III. Threonine.
 (A) II only.
 (B) I and II only.
 (C) I and III only.
 (D) II and III only.
 (E) I, II, and III.
59. As the detective investigating a crime, you are interested to see if the DNA in the hair follicle left at the scene matches any of the three prime suspects. Unknown to you, one of the suspects has had a kidney transplant. Which of the following is correct?
 (B) None of the DNA fingerprinting tests will be valid.
 (C) The DNA fingerprinting tests will be valid regardless of his transplant.
 (D) RFLP would be valid, but not STR.
 (E) STR would be valid, but not RFLP.
60. Plasmid A and gene B have two and three *Bam*HI sites, respectively. How many fragments do you expect to see if you cut a plasmid A carrying gene B using *Bam*HI and analyse it by gel electrophoresis?
 (A) Four.
 (B) Five.
 (C) Six.
 (D) Seven.
 (E) Eight.

– END OF PAPER –