GENERAL

1. Bangalore's latitude is roughly 13˚N. At noon, on one day during which months would a vertical object cast no shadow?
   a. June and Dec
   b. <u>Apr and Aug</u>
   c. Mar and September
   d. May and November.

2. COVAXIN^{TM} by Bharat Biotech is an indigenous vaccine against Covid-19. Which type of vaccine is it?
   a. Encapsulated mRNA encoding the spike protein
   b. Adenovirus expressing the SARS-CoV-2 spike protein
   c. <u>Inactivated SARS-CoV-2 virus</u>
   d. Modified antisense-RNA targeting the SARS-CoV-2 spike protein

3. There is an annoying delay in the voice on Zoom calls. This is because:
   a. There is a delay when the signal is transmitted to the Zoom data-server in the US, and then to the other computer.
   b. Zoom consumes a lot of computer time and so it slows down your computer.
   c. Your network bandwidth is poor, so it stores a long sentence before forwarding it to the next machine.
   d. <u>Switches and routers along the network adds delays to the signal.</u>

4. Two balls are drawn at random from a box having 2 red and 4 blue balls. What is the probability of drawing one red and one blue ball?
   a. 2/5
   b. <u>8/15</u>
   c. 1/15
   d. None of the above

5. A screw gauge gives the following reading to measure the diameter of a wire.
   Main scale reading: 0 mm
   Circular scale reading: 52 divisions.
   Given that 1 mm on main scale corresponds to 100 divisions of the circular scale, the diameter of wire from the above data is:
   a. <u>0.052 cm</u>
   b. 0.026 cm
   c. 0.005 cm
   d. 0.52 cm

6. A mosquito-borne disease was known to be prevalent in the foothills of a mountain in Africa. However, over the last decade, the disease has increasingly been found among people living higher up in the mountain. The possible reason for this phenomenon is:
   a. The disease is now transmitted by a different vector in those living in higher altitudes.
   b. Infected people tend to move higher up as it is cooler.

    c. People living higher up in the mountain have become susceptible to the disease

    d. <u>The altitudinal range of the mosquitoes has expanded due to global warming</u>

7. Which of the following is not a zoonotic disease?
    a. <u>Measles</u>
    b. Covid-19
    c. Dengue Fever
    d. Leprosy

8. A heritable disease in humans starts expressing after 45 years of age and leads to fatality more often than not. Which of the following statements is the correct prediction regarding the occurrence of the disease in the population?
    a. It will be a very rare as natural selection will keep the disease allele in check
    b. It will be very common as natural selection will favour the late onset
    c. <u>Natural selection will have negligible role in determining its frequency</u>
    d. Over time, the disease will become milder due to the action of natural selection against the disease

9. Bacillus Calmette-Guerin (BCG) is a vaccine that is primarily used against tuberculosis. You review a paper in which the authors test if BCG vaccination can provide protection against COVID19. They administer the BCG vaccine to 50 adults living in a village and one month later find that no one injected with BCG was sick with COVID19, even though infections were recorded in neighbouring villages. They make the claim that BCG protects from COVID19. What is the main reason to reject this paper?
    a. Villagers may have moved and become infected.
    b. While the data strongly supports that BCG vaccination prevents COVID19, BCG is a vaccine so it is likely that is beneficial anyway.
    c. BCG and the causative agent of COVID19 are very different – one a bacterium and one a virus so the question of BCG having any effect on COVID19 is impossible.
    d. <u>The current study design does not support their claim - there is no control group.</u>

10. If the arithmetic mean of two positive numbers is equal to square of their geometric mean. What is their harmonic mean?
    a. <u>1</u>
    b. 0
    c. ½
    d. Cannot say

11. 8 professionals can paint a house in 12 days. However, it takes 12 amateurs 16 days to paint the same house. 16 professional painters started painting the house. After 3 days, 10 of them were replaced by 4 amateurs. Now how many days will they take to complete the remaining painting?

a. 8 days
b. 10 days
c. 12 days
d. <u>6 days</u>

12. If all permutations of the word "BIKE" are listed in alphabetical order (1. BEIK; 2. BEKI; 3. BIEK; 4. BIKE etc.), what will be the position of "IBEK" in the list?

a. 9
b. 11
c. <u>13</u>
d. 15

13. The figure is of a square sheet measuring 10cm x 10cm. Squares with side a cm are cut out from the four corners. The resulting sheet is bent into a box. Find the value of a that maximizes the volume of the box so formed.
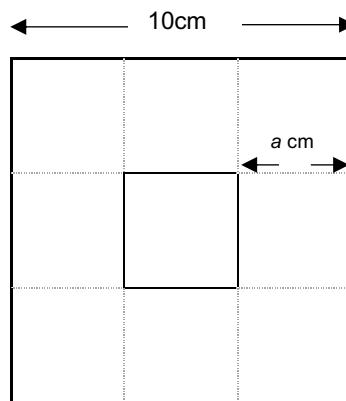
a. 5
b. 3/5
c. <u>5/3</u>
d. 4

14. A speaks the truth in 75% cases whereas B lies in 20% cases. In what percent of cases are they likely to contradict each other narrating the same incident?

a. 30%
b. <u>35%</u>
c. 40%
d. 45%

15. A DNA nucleotide pair has an average mass of approximately 660 daltons. Write down the picogram amount, rounded to the closest integer, of DNA in a diploid human nucleus.

There are 6.4×10^9 nucleotide pairs in a human diploid nucleus
Avogadro's number is 6×10^{23}

a. <u>7 pg</u>
b. 1 pg
c. 70 pg
d. 10 pg

PHYSICS

1. From the circuit diagram below, what the value of the resistance across A & B?
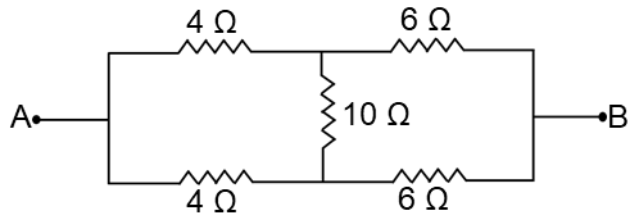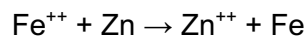

   a. <u>5</u>
   b. 10
   c. 15
   d. 20

2. What is the work done on 5 electrons moving through a uniform electric field from a potential of 0 volts to a potential of 10 millivolts (mV). The movement is parallel to the electric field.

   (Charge of electron = - 1.6 × 10^{-19} C)

   a. - 8 × 10^{-18} J
   b. -1.6 10^{-19} J
   c. <u>- 8 × 10^{-21} J</u>
   d. 3.125 × 10^{17} J

3. According to the third law of thermodynamics, entropy of a perfect crystal at absolute zero temperature is
   a. always negative
   b. always positive
   c. <u>equal to zero</u>
   d. equal to one

4. A nuclear reactors fuel rods are immersed in water, which acts as a coolant and a moderator. You notice a blue glow around the fuel rods. This is due to
   a. Luminescence of radium produced during the decay of uranium
   b. Superheating the water around the reactor vessel causing the release and ignition of hydrogen
   c. Ionisation of water resulting in electrical arcing with the walls of the reactor vessel
   d. <u>Charged particles emitting radiation when they exceed the speed of light in water</u>

5. Which of the following is correct about a closed electric circuit including a battery and a resistor?
   a. charges move through the circuit because the resistor supplies energy.
   b. <u>charges move through the circuit because the battery maintains an electric potential difference across the ends of the external circuit.</u>

   c. charges move because they are supplied by the battery.

   d. charges move through the circuit because they can acquire kinetic energy from the resistor.

6. The standard electrode potential for the half cell reactions are:

$$Zn^{++} + 2e^- \rightarrow Zn, E^o = -0.76 \text{ V}$$
$$Fe^{++} + 2e^- \rightarrow Fe, E^o = -0.44 \text{ V}$$
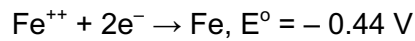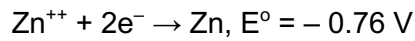
What is the e.m.f. of the cell reaction

$$Fe^{++} + Zn \rightarrow Zn^{++} + Fe$$

   a. - 1.20 V
   b. +1.20 V
   c. <u>+ 0.32 V</u>
   d. - 0.32 V

7. Which of the following is true regarding the surface tension of plasma membrane?
   a. Surface tension of plasma membrane is more than pure lipid structures
   b. <u>Surface tension of plasma membrane is less than pure lipid structures</u>
   c. Surface tension of plasma membrane is same as that of pure lipid structures
   d. Plasma membranes do not have surface tension

8. Hydrophobic interactions originate from
   a. Coulombic forces
   b. <u>Entropic forces</u>
   c. Gravitational forces
   d. None of the above

9. An iron bar and a brass bar of equal length and cross-sectional area, are joined at one end. A tensile force is applied to the free ends as shown.
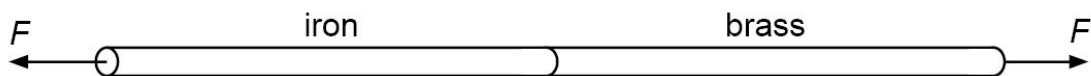
If the Young's modulus of iron is twice that of brass, then which is the following is correct?
   a. <u>The extension of brass is twice that of iron</u>
   b. The extension of iron is twice that of brass
   c. The stress of brass is twice that is iron
   d. The stress of iron is twice that of brass

10. A satellite takes 24 hours to orbit the Earth. It is replaced for a newer one that is carrying more modern equipment making it 2 times lighter. The new satellite has an

orbit time of 24 hours. What is the ratio of the radius of the new satellites orbit to that of the older one?

    a. 1:2
    b. <u>1:1</u>
    c. 1:√2
    d. 2:1

11. Due to friction with molecules of the surrounding solution, particles sedimenting in a mixture reach terminal velocity when subjected to ultracentrifugation. The sedimentation coefficient (S) for a particle is defined as the ratio of terminal velocity (v_t) to the centrifugal acceleration applied to the particle (a_c).

$$S = v_t / a_c$$

If each Svedberg unit (S value) is defined as 10^{-13} seconds, approximately how long would it take for a free 50S ribosomal subunit to travel the length of a 9 cm ultracentrifuge tube subjected to a centrifugal force of 50,000 times gravity (*g*)? Recall that *g* is approximately 10 m/s^2.

    a. <u>10 hrs</u>
    b. 10 min
    c. 50 min
    d. 5 h

12. The acceleration due to gravity on the surface of the Earth is about six times its value on the Moon. If the density of the Earth is 1.67 times the Moon's, what is the ratio of the diameter of the Earth to that of the Moon?

    a. 1.6
    b. 3.1
    c. <u>3.6</u>
    d. 6.4

13. A simple pendulum of length L and mass M is initially at rest. You want to give it an initial kick so that it subsequently swings up by exactly 90 degrees before swinging back. The velocity your kick should impart to the pendulum to do this should be proportional to: (g is acceleration due to gravity)

    a. M
    b. √M/g
    c. √L/g
    d. <u>√gL</u>

14. Unpolarized light is incident on a pair of ideal linear polarizers whose transmission axes make an angle of 45° with each other. The transmitted light intensity through both polarizers is what percentage of the incident intensity?

    a. 0%
   b. 75%
    c. 50%
    d. <u>25%</u>

15. The velocity of blood in an artery can be determined using the Doppler effect with ultrasound. Blood in an artery is moving directly towards a piezoelectric transducer, which emits ultrasound at a frequency of 7.5MHz. The shifted frequency is:

    a. Either high or low depending on blood velocity

b. Either high or low depending on blood pressure
c. <u>Higher than 7.5MHz</u>
d. Lower than 7.5MHz

CHEMISTRY

1. 700 ml of colourless solution is present in each of two bottles, A and B. The label on A reads, 1 M NaCl, while that on B reads 1 mole NaCl. Which of the following statement is correct?
   a. The amount of NaCl in in each bottle is the same
   b. The concentration of NaCl in each bottle is the same
   c. <u>Bottle A has less amount of NaCl than Bottle B</u>
   d. The concentration of NaCl is more in Bottle A than in Bottle B

2. The pKa of a monobasic organic acid is 4.2. The pH at which 95% of the acid will be in ionized form is:
   a. 5.02
   b. <u>5.38</u>
   c. 2.92
   d. 3.71

3. Which amino acid may produce following titration curve profile?
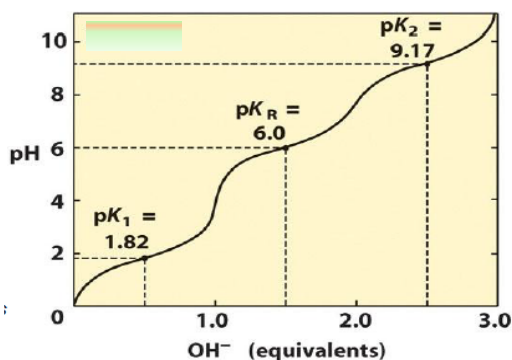
   a. Phe
   b. <u>His</u>
   c. Val
   d. Leu

4. CH_3CHO and $C_6H_5CH_2CHO$ can be distinguished chemically by:
   a. Tollen's reagent test
   b. Fehling solution test
   c. Benedict test
   d. <u>Iodoform test</u>

5. 8.4 mg $NaHCO_3$ powder was slowly added to 10 ml 0.03 M HCl in a 50ml beaker with stirring. After all effervescence has seized, what should be the pH of the solution?
   a. <u>1.69</u>
   b. 2.00
   c. 2.23

    d. 1.52

6. Using the bond energy data given in the parenthesis, what would be the expected enthalpy for the following reaction

$$H_2(g) + F_2(g) \rightarrow 2HF(g)$$
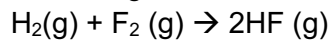
(H-H: 432 kJ/mol; F-F: 154 kJ/mol; H-F: 565 kJ/mol)?
    a. <u>-544 kJ/mol</u>
    b. +544 kJ/mol
    c. -21 kJ/mol
    d. +21 kJ/mol

7. At 25 °C and zero ionic strength, water self-dissociation results in:

$$Kw = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

If it is known that Kw increases with increasing temperature, what will be the pH of neutral water at 65°C?
    a. Slightly less than 14
    b. Equal to 7
    c. <u>Slightly less than 7</u>
    d. Slightly more than 7

8. In the below hydropathy plot of a protein, positive values are regions of the protein that are considered hydrophobic based on primary amino acid sequence. What type of protein is this?
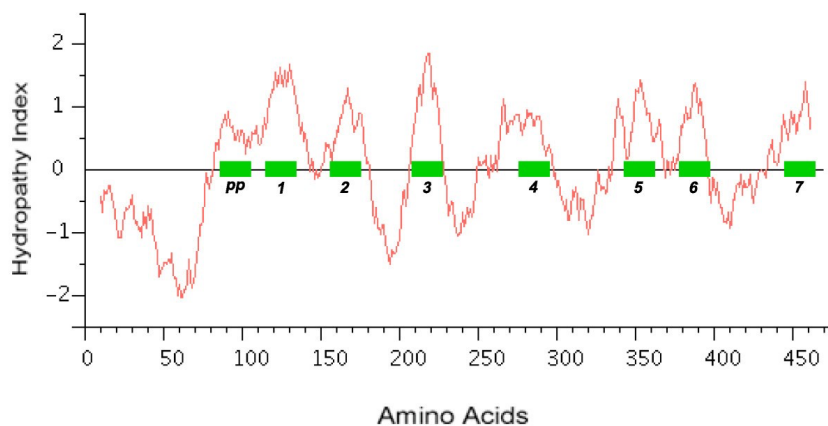
    a. Lipid-anchored membrane protein
    b. <u>Multiple-pass integral membrane protein</u>
    c. Cytosolic protein
    d. Cannot say. I need more information.

9. How many chiral centres does this molecule below have:
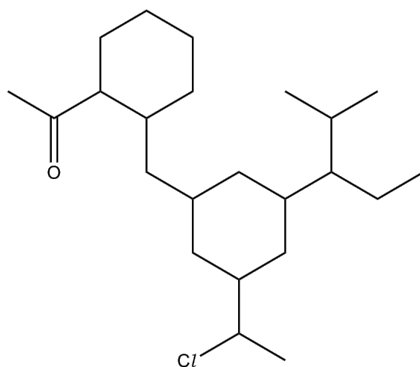
a. 2
b. <u>7</u>
c. 8
d. 9

10. If 1.14 Kg of octane are burned in the complete combustion reaction shown below, how many Kg of carbon dioxide will be produced (atomic mass of C, O and H are 12, 16 and 1, respectively)?

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

a. 9.1
b. 11.4
c. 5.7
d. <u>3.5</u>

11. Which of the following statements are true?
    a. Vmax of an enzyme remains constant with increasing enzyme concentrations.
    b. <u>K_M of an enzyme for a substrate remains constant with increasing enzyme concentrations.</u>
    c. K_M of an enzyme for a substrate increases with increasing enzyme concentrations.
    d. Both K_M and Vmax of an enzyme remains constant with increasing enzyme concentrations.

12. Which monomer can form both polymers below:


a.

b.

c.

d.
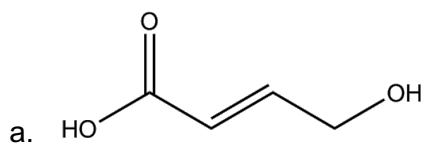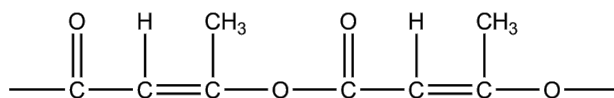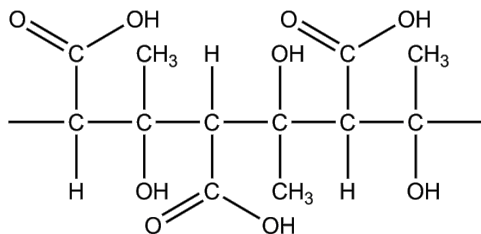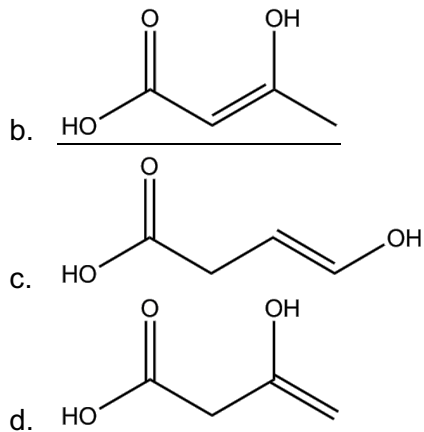
13. One DNA strand is attached to another DNA strand by
    a. hydrogen bonds between the sugars.
    b. covalent bonds between the sugars and bases.
    c. covalent bonds between the sugars and phosphates.
    d. hydrogen bonds between the bases.

14. You find that a compound with the formula $C_5H_{10}O$ has 4 peaks in its ^{1}H-NMR spectrum. What is the chemical?
    a. 3-methylbutan-2-one
    b. pentanal
    c. pentan-2-one
    d. pentan-3-one

15. What are the deamination products of cytosine and 5-methyl cytosine, respectively?

Cytosine (C)   Thymine (T)   Uracil (U)

Guanine (G)   Adenine (A)
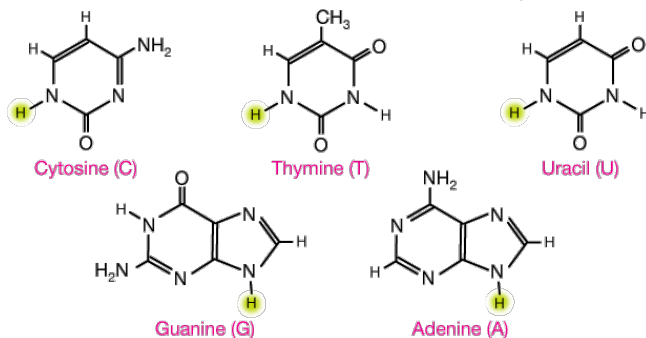
    a. Thymine and uracil
    b. Thymine in both cases
    c. Uracil and thymine
    d. Uracil in both cases

BIOLOGY
    1. Making a protein from a gene in eukaryotic cells involves:
        a. first, transport of mRNA, then its processing, then transcription, then translation
        b. first, transcription of the RNA, then its transport, then processing, then translation

    c. first, translation of the RNA, then its transport, then its processing, then transcription

    d. <u>first, transcription of RNA, then its processing, then its transport, then translation</u>

2. The 2020 Nobel prize in Chemistry was awarded to Jennifer Doudna and Emmanuel Charpentier for their work on developing CRISPR-Cas system for gene editing. This system is naturally:

    a. An anti-viral defense mechanism found in plants

    b. <u>An anti-viral defense mechanism found in bacteria</u>

    c. An anti-bacterial defense mechanism found in plants

    d. An anti-bacterial defense mechanism found in simple eukaryotes such as fungi

3. At which mitotic stage can standard karyotyping be performed using photomicroscopy of cells?

    a. Interphase

    b. Prophase

    c. <u>Metaphase</u>

    d. Anaphase

4. Which of the following amino acids to you expect to find in higher proportion within histones compared to a cytoskeletal protein?

    a. <u>K and R</u>

    b. L and A

    c. D and E

    d. F and W

5. A human cell passes through 4 phases called A, B, C and D, each phase lasting for different lengths of time. At the end of D the cell returns to A to continue this cycle. In an experiment, a static snapshot of 10^6 unsynchronized cells was taken, and it was found that 300,000 cells were in phase A, 400,000 cells were in phase B, 200,000 were in phase C and the rest in phase D. If the total time spent by one cell in the four phases is known to be 24 hours, which of the following statements is true?

    a. The time spent in phase A is 5.2 hours.

    b. <u>The time spent in phase B is 9.6 hours.</u>

    c. The time spent in phase C is 3.8 hours.

    d. The time spent in any one phase cannot be obtained from the given information.

6. Biologist Lynn Margulis is a proponent of the theory of endosymbiosis, which suggests that the mitochondria of modern eukaryotic cells evolved from bacteria living symbiotically within early eukaryotic cells. Which of the following is supporting evidence for this theory?

    a. Mitochondria require the internal environment of the eukaryotic cell to replicate.

    b. <u>Mitochondrial rRNA is more similar to bacterial rRNA than to eukaryotic rRNA transcribed from nuclear DNA.</u>

    c. Mitochondria are morphologically indistinguishable from free-living bacteria.

    d. Mitochondria that are removed from eukaryotic cells and placed in a growth medium can generate fully functioning free-living cells.

7. A genetic cross was set between two heterozygous mice with agouti coat colour. Agouti is dominant over normal coat colour. The F1 phenotypic ratio with regards to coat colour (agouti: wild type) was 2:1. A possible explanation for this could be:
    a. The agouti gene converted to wild type counterpart.
    b. <u>Homozygous lethality associated with the agouti locus.</u>
    c. Incomplete penetrance.
    d. Variable expressivity.

8. A group of 3 cells, the P6p, P5p and the anchor cell are clustered together in the C.elegans hypodermis. Normally the P6p cell gives divides 3 times and forms the vulva. You find that if the P6p cell is destroyed, the P5p divides and will form the vulva. If the anchor cell is destroyed, neither the P6p cell nor the P5p cell form the vulva. How do you interpret this data?
    a. The anchor cell inhibits the P6p from forming a vulva.
    b. <u>The anchor cell induces vulval formation by the P6p cell.</u>
    c. The P6p cell inhibits vulval formation by the anchor cell.
    d. The P5p cell induces vulval formation by the P6p cell.

9. Bacterial antibiotics can interfere with all of the following, except:
    a. Protein Synthesis
    b. Peptidoglycan Synthesis
    c. <u>Reverse Transcription</u>
    d. DNA Synthesis

10. A series of beakers of water of different temperatures are placed in front of you. You place your finger in each one, and select the beaker containing water of the highest temperature. How did your brain know?
    a. The brain receives action potentials of different intensities that are proportional to the temperature.
    b. Action potentials are only sent when the temperature of the water exceeds a certain threshold
    c. <u>The number of action potentials per second increases as temperature increases.</u>
    d. Action potentials are received in a different part of the brain when temperatures are higher

11. Meiosis is used to generate gametes. When is meiosis completed in mammalian females?
    a. During oogonia maturation in the fetal ovaries
    b. In all primary oocytes during maturation at puberty
    c. In an individual oocyte during the female ovarian cycle
    d. <u>During fertilization</u>

12. DNA was isolated from wild type (Gal$^+$) and mutant (Gal$^-$) *E.coli* cells and separated by density gradient centrifugation technique. DNA from Gal$^-$ strain acquired a lower position. This indicates that the mutation is caused by:
    a. Inversion

b. <u>Insertion</u>
c. Missense mutation
d. Point mutation

13. A bacterial strain has the following features with regards to growth: (i) Will grow on agar supplemented with Arginine (arg), Tryptophan (trp) and Leucine (leu). It is not capable of growing on media supplemented with (ii) arg and trp (iii) leu and trp, however it grows on media supplemented with (iv) arg and leu. What is the genotype of the bacterial strain?
    a. arg-, leu+, trp-
    b. leu+, arg- ,trp+
   c. <u>leu-, arg-, trp+</u>
    d. arg+, leu+, trp-

14. The pedigree shown is of three generations and show which individuals suffer from genetic disorder that is 100% penetrant and appears after 40 years of age: individuals that show the disease are either shaded circles (female) or shaded males (squares), individuals that do not suffer from the disease are unshaded, although it should be noted that the grandchildren in generation C are still below 40 years of age. Below this is a restriction fragment length polymorphism (RFLP) of each individual's DNA; individual a in generation A is labelled Aa and so on.

    What is the chance that a child from a union between female Ch and the male, Ci (from a family with no history of disease) will never suffer from this disease?
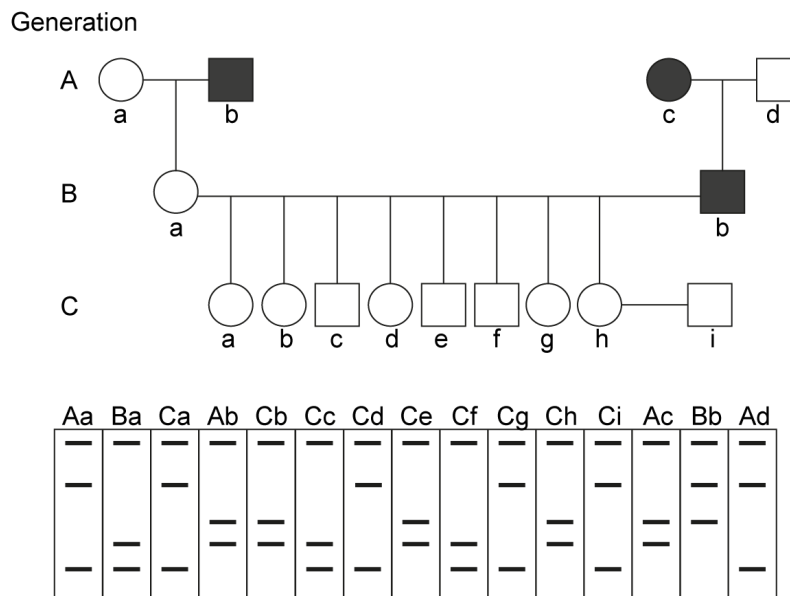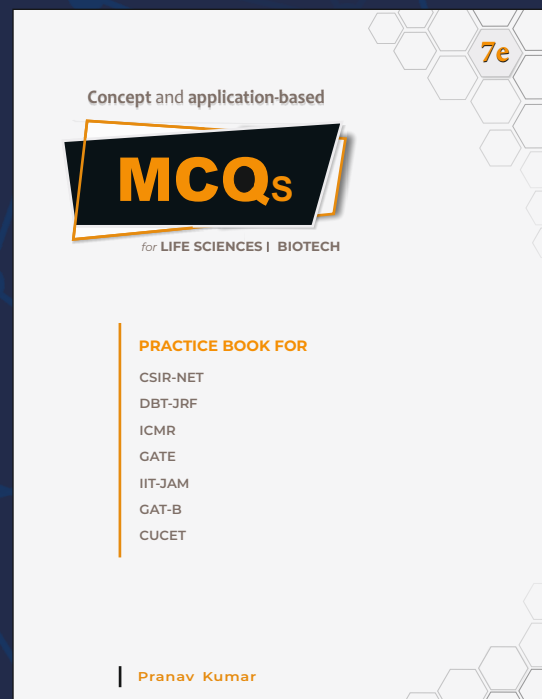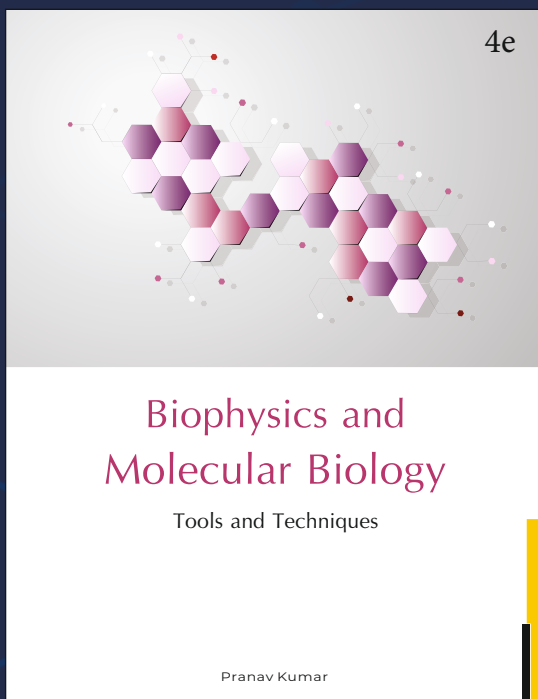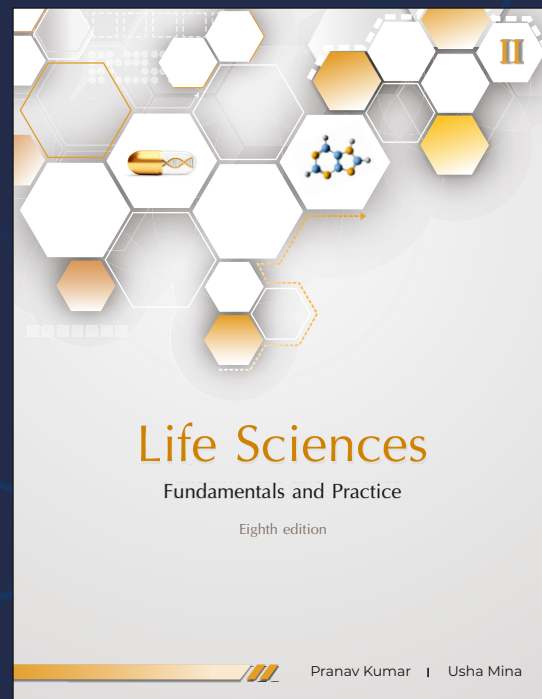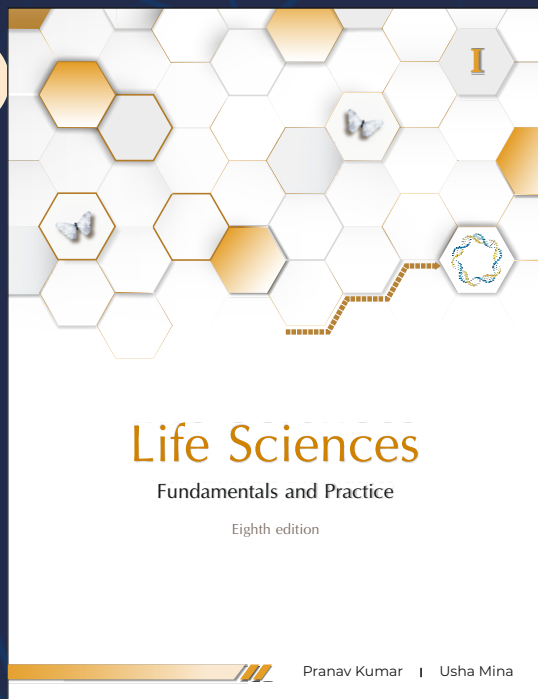

    a. 0%
    b. 25%
    c. <u>50%</u>
    d. 100%

15. A protein is purified from a cell extract. SDS-polyacrylamide gel electrophoresis is performed for analysis of the protein using treatment with dithiothreitol (DTT) and protease. The image of the gel is shown below. What can be inferred from the treatment of protein with DTT and protease. Note: the red band in two lanes is the protease used.
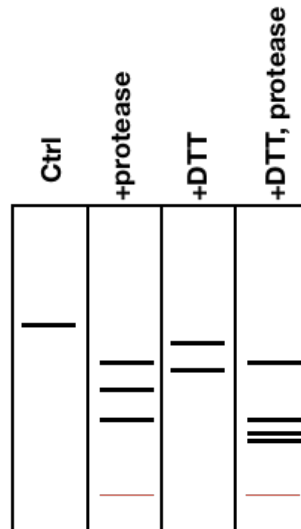
a. The protein has 3 protease cleavable sites
b. <u>The protein has two polypeptides linked by a disulfide bond and two protease sites</u>
c. The protein has multiple protease sites
d. The protein is a single polypeptide with a disulfide bond and 3 protease sites

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