INDIAN NATIONAL JUNIOR SCIENCE OLYMPIAD – 2019

Duration: 3 Hours
Maximum Marks: 180

Dated: 2nd February, 2019

INSTRUCTIONS

- The question paper is divided into Sections A and B. All answers should be **written in the answer sheet booklet only** which will be collected at the end of the examination. The question paper need not be submitted to the examiner.

- Use only black or blue pen to write your answers in the Answer Sheet. Do not use a pencil.

- Before starting, please ensure that you have received a copy of Question Paper containing a total of 23 (23 sides on 12 sheets) pages.

Section A

- Section A consists of 30 questions each with 4 alternatives. Out of which only one is correct.
- You get 3 marks for every correct answer and –1 for every wrong answer.

- For Section A, you have to indicate the answers by putting a 'X' in the appropriate box against the relevant question number, as indicated below:

Marking a cross ⊠ means affirmative response (selecting the particular choice)
Do not use ticks or nay other signs to mark the correct answers.

- Once marked, the answer should not be changed as far as possible. However in an extreme case, if you want to change the answer you can do so as shown below:


Sections B

- Section B consists of 8 question with a total of 90 points.

- The points for the questions in Section B vary depending on the number of answers and the complexity of the question. These points have been indicated along with the question.

- Contradictory answers will not be considered for marking.

SECTION – A

1. Liver is an organ that maintains constant levels of different substances in the blood. Levels of one such substance entering the liver during three types of body activities (I – III) are shown.
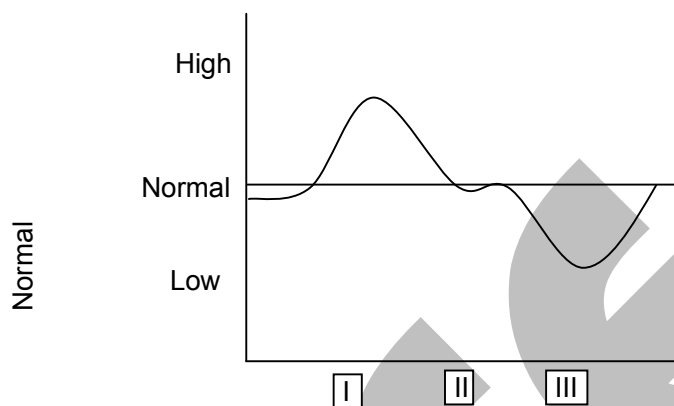
The substance and three activities I – III respectively must be:

	Substance	Activity		
		I	II	III
(A)	Glucose	Exercise	Resting	Sleep
(B)	CO_2	Exercise	Sleep	After meals
(C)	Glucose	After meals	Resting	Exercise
(D)	O_2	Exercise	Sleep	Resting

2. Maintaining a proper internal fluid environment is essential for any organism. Marine invertebrates whose body fluids are isotonic to sea water can face several problems when exposed to brackish water of estuaries or fresh water of lakes and rivers. Variation of internal osmotic concentration with external osmotic concentration in three marine invertebrates is shown in the graph.
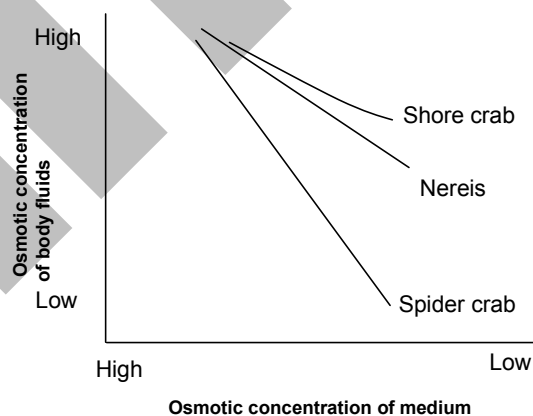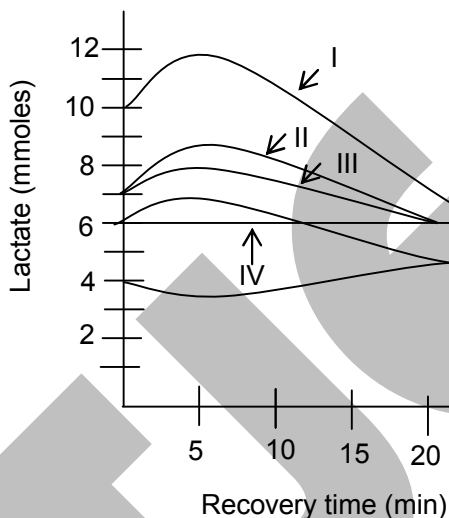

Choose the correct statement.
(A) Nereis shows a better osmoregulatory capacity than shore crab.
(B) Spider crab shows the most effective regulation of osmotic concentration of body fluids among the three invetebrates.
(C) When in low salt conditions, body fluid of shore crab is hypertonic compared to surrounding medium.
(D) In order to survive in low salt conditions, spider crab has to take in salts from surrounding water.

3. 'A newly hatcked chick grows to fully adult male or female in about 18 weeks' time. During this time, different body parts show characteristic growth pattern. In an experiment, a pair of

goggles were fixed on the eyes of a chick immediately after hatching such that only red wavelength of light passes through them. When the goggles are removed at the end of 7 days, the chick develops a peculiar eye defect. Given that longer wavelengths of light focus most posteriorly in the eye, the most likely defect that the chick has developed is:
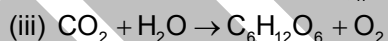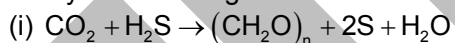(A) Myopia (B) Hypermetropia
(C) Astigmatism (D) Colour blindness

4. During extensive activity, there is accumulation of lactic acid in muscles. This could lead to cramp and fatigue. Training of athletic activity helps body remove lactate from the muscles and shuttle it to other non-muscular parts. Lactate levels of four swimmers during recovery period are shown. Which of these represents the best quality of clearance?

(A) I (B) II
(C) III (D) IV

5. Study the following three reactions:
(i) $CO_2 + H_2S \rightarrow (CH_2O)_n + 2S + H_2O$

(ii) $CO_2 + S + H_2O \rightarrow (CH_2O)_n + H_2SO_4$

(iii) $CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$

Which reaction/s represent/s autrophic nutrition?
(A) (iii) only (B) (i) and (iii) only
(C) (ii) and (iii) only (D) (i), (ii) and (iii)

6. The oxygen consumption for four animals is tabulated below.

Animal	Oxygen consumption per kg body mass per hour (Litre O_2 kg^1 h^{-1})
I	0.68
II	0.21
III	1.65
IV	0.07

Animals I – IV most likely could be respectively:
(A) Elephant, Cat, Human and Mouse
(B) Cat, Mouse, Elephant and Human
(C) Human, Cat, Elephant and Mouse
(D) Cat, Human, Mouse and Elephant

7. It was 3:30 in the afternoon when Ajay reached the cinema hall after 20 minutes walk from his house. He entered the cinema hall in a hurry. It took him a few moments to see the

What changes must have occurred in his eyes during this period?
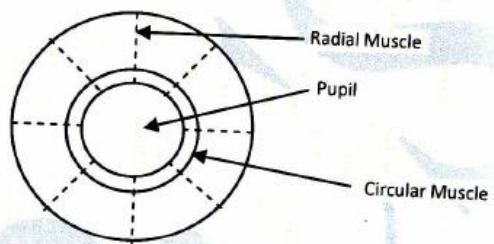
(A) Circular muscles relax, radial muscles relax and pupil contracts.
(B) Circular muscles relax, radial muscles contract and pupil dilates.
(C) Circular muscles contract, radial muscles contract and pupil dilates.
(D) Circular muscles contract, radial muscles relax and pupil contracts.

8. In case of kidney failure, dialysis is recommended using artificial kidneys. An artificial kidney contains numerous semipermeable tubes suspended in a dialyzing fluid. The dialyzing fluid is iso-osmotic to blood. These semi – permeable tubes are similar to the nephrons, the structural and functional units of kidney.

While the artificial kidney simulates a normal kidney, which of the following processes does not occur in an artificial kidney?
(A) Reabsorption of water
(B) Filtration of urea
(C) Retaining of plasma salts and clotting factors in the blood
(D) Retaining of platelets in the blood.

9. A researcher centrifuged human blood at low speed to separate the red blood cells (RBCs) and white blood cells (WBCs). She then suspended the pellet of RBC's in saline (0.9% NaCl). She subsequently put a drop of the RBS suspension into three different solutions as indicated below. What will be her observations for solutions I, II and III respectively?

Solution I	Solution II	Solution III
Detergent	Distilled water	5% NaCl

(A) Lysis, lysis, swelling   (B) Swelling, no change, shrinkage
(C) Lysis, Lysis, shrinkage   (D) No change, shrinkage, swelling.

10. The thyroid gland secretes thyroxine (T_4) and triiodothyronine (T_3), together known as thyroid hormone. The secretion of thyroid hormone is regulated by thyrotropin – releasing hormone (TRH) and thyroid – stimulating hormone (TSH) as schematically represented below:
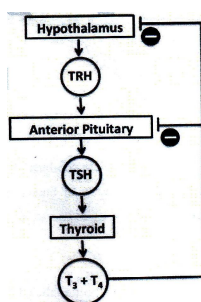
One of the actions of thyroid hormone is to increase the basal metabolic rate (BMR) of a person. A person who has suddenly gained weight and has a swollen neck goes to a doctor. The person also feels tired and mentally dull. Clinical analysis shows that the person has low levels of T_4. The doctor feels that either the pituitary or the thyroid is non-functional. In order to identify the impaired organ the person is given TSH simulation. Which one of the following observations and the conclusions made is correct?
(A) If there is no change in the T_4 levels, it indicates problem of the pituitary.
(B) If it leads to increase in the T_4 levels, it indicates problems of the pituitary.
(C) If it leads to increase in the T_4 levels, it indicates problem of the thyroid.
(D) If it leads further decrease in the T_4 levels, it indicates problems of the thyroid.

11. Consider a hypothetical situation where the mass of neutron in argon is made half and the mass of electron in argon is doubled with respect to their actual masses. In this case, the atomic mass of $_{18}Ar^{40}$ will approximately
(A) remain the same   (B) become half
(C) increase by 45%   (D) reduce by 27%

12. One spoon of a sample of common salt weighs approximately 0.5 g. It contains 40% sodium and 380 micrograms of iodine. Assuming that the sample contains only sodium iodide and chloride ions, the number of chloride ions present in one spoon of this sample is closest to
(A) 5×10^{20} (B) 5×10^{21}
(C) 5×10^{22} (D) 5×10^{23}

13. An LPG gas cylinder regularly used in the household contains a mixture of butane an propane. If 5 litres of this mixture on complete combustion produces 17 litres of CO_2 at atmospheric pressure and 25°C, then the ratio of butane to propane in the mixture (Assume that both the gases in the cylinder are in vapour phase)
(A) 3 : 2   (B) 2 : 3
(C) 4 : 1   (D) 1 : 4

14. In a chemistry laboratory, a student found a bottle labeled 'Acid'. As it was a solid, was curious to find out what it is. She weighed 0.42 g of this and made a solution of it and titrated it with 0.17 M NaOH solution. The volume of NaOH required to obtain the end point was 33.8 mL. If the molecular formula of the acid is $C_6H_{10}O_4$, find out the n umber of protons per acid molecule that take part in the reaction and the amount of acid required to neutralize 1 mole of alkali.
(A) 1 proton and 73 g   (B) 2 protons and 146 g
(C) 1 proton and 46 g   (D) 2 protons and 73 g

15. The graph that indicates the relation between the variables P and V of an ideal gas at a constant temperature is:
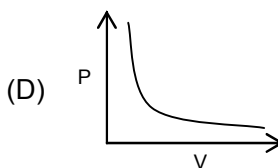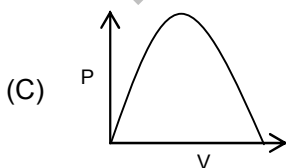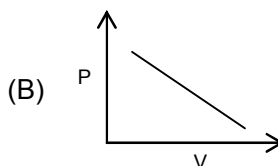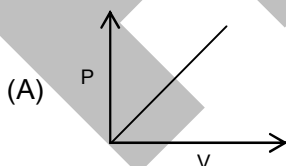
16. The position of some metals in the electrochemical series in decreasing electropositive character is Mg > Al > Zn > Cu > Ag. In a chemical factory, a worker by accident used a copper rod to stir a solution of aluminium nitrate; he was scared that now there would be some reaction in the solution, so he hurriedly removed the rod from the solution and observed that
(A) the rod was coated with Al   (B) an alloy of Cu and Al was being formed.
(C) the solution turned blue in colour   (D) there was no reaction.

17. A white compound P was dissolved in the water and electricity was passed through it resulting in the formation of gas Q. This gas was then passed through a slurry of another white compound R. The product obtained from this reaction is commonly used a germicide. P, Q and R respectively, are
(A) $NaCl$, Cl_2, $Ca(OH)_2$ (B) Na_2SO_4, SO_2, $Al(OH)_3$
(C) $NaHCO_3$, CO_2, Na_2CO_3 (D) $AlCl_3$, Cl_2, $Al(OH)_3$

18. Iron present in spinach can be estimated by titrating it with potassium permanganate. Small amount of spinach leaves are weighted and dissolved in acid to extract the iron in solution. The solution is then titrated and the following reaction takes place during this titration.
$$Fe^{2+} + \_\_MnO_4^- + \_\_H^+ \rightarrow Mn^{2+} + \_\_Fe^{3+} \_\_H_2O$$
When properly balanced with the simplest set of whole number coefficients, the sum of the coefficients in the balanced equation is
(A) 16   (B) 18
(C) 22   (D) 24

19. A disproportionation reaction occurs with a simultaneous oxidation and reduction of the same species in the reaction. Which of the following is NOT a disproportionation reaction?
(A) $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$ (B) $3S + 2H_2O \rightarrow SO_2 + 2H_2S$
(C) $NH_4NO_3 \rightarrow N_2O + 2H_2O$ (D) $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$

20. Some metals impart very bright colours such as red, pink, yellow to the flame when heated. The cause of this phenomenon is the excitation of electrons in the outermost electronic shell. The electronic configuration in the outermost shell of these metals is represented as
(A) $(n-1)s^2p^6, ns^2p^1$ (B) $(n-1)s^2p^6d^{10}, ns^1$
(C) $(n-1)s^2p^6, ns^1$ (D) $ns^2p^6d^1$

21. A particle is travelling with uniform acceleration of magnitude a. During successive time intervals $\Delta t_1, \Delta t_2$ and Δt_3 its average velocities are v_1, v_2, and v_3 respectively. Then
(A) $\dfrac{v_2 - v_1}{\Delta t_2 - \Delta t_1} = \dfrac{v_3 - v_2}{\Delta t_3 - \Delta t_2}$ (B) $\dfrac{v_2 - v_1}{\Delta t_1 + \Delta t_2} = \dfrac{v_3 - v_2}{\Delta t_3 + \Delta t_2}$

(C) $\dfrac{v_1 + v_2}{\Delta t_1 + \Delta t_2} = \dfrac{v_2 + v_3}{\Delta t_2 + \Delta t_3}$ (D) $\dfrac{v_2 + v_1}{\Delta t_2 - \Delta t_1} = \dfrac{v_3 + v_2}{\Delta t_3 - \Delta t_2}$

22. A river is flowing at 4km/hr from west to east. Two swimmers P and Q can both swim at 2 km/hr in still water. The minimum time in which it is possible for the swimmers to cross the river in t_{min}. Both of them start swimming from the same point O on the bank of the river in different directions as shown. The point X is directly across from the point O.
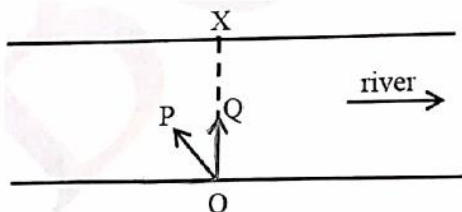

Choose the correct statement.
(A) P will reach the point X in time t_{min}
(B) Q will reach the point X in time t_{min}
(C) P will reach a point somewhere east of X in time t_{min}
(D) Q will reach a point somewhere east of X in time t_{min}

23. A stone of mass m falls from a height H on soft muddy ground and sinks to a depth of H/2. Assume that the mud exerts a constant resistive force of magnitude F. Neglecting air resistance, F is
(A) 2mg
(B) mg/2
(C) 3mg
(D) mg

24. A wire of length L and resistance R has uniform cross section. A potential difference of 10 volt is applied across the wire as shown. A cell of emf E (< 10 volt) and of internal resistance r is connected through a galvanometer between points A and C. The point C, at a distance l from A, is chosen such that the galvanometer reads zero. The length l depends on
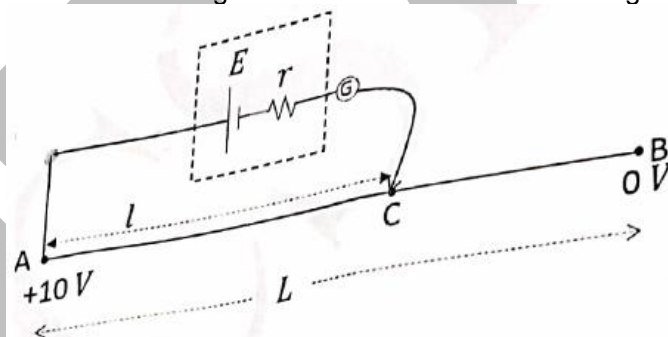

(A) E only
(B) E and L only
(C) E and r only
(D) E, r and L only

25. A concave mirror of focal length f and diameter d (d << f) is kept horizontally and filled with water. Rays of light parallel to the mirror axis are incident on it. After reflection, the rays will focus close to
(A) 0.25f
(B) 1.33f
(C) f
(D) 0.75f

26. Two mirrors OA and OB make an angle of 50° with each other. An object C is placed on the angular bisector of angle AOB
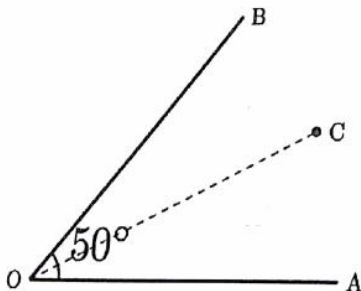
The total number of images of the object formed by the mirrors will be:
(A) 5   (B) 6
(C) 7   (D) 8

27. A 420.0 W heater is used to raise the temperature of water flowing through a tube of length 2.4 m by 5.0° C. Assuming that the efficiency of heating is 50%, the flow rate of water (in litre/minute) is
(A) 0.3   (B) 0.6
(C) 1.2   (D) 1.8

28. Consider two arrangements of N identical resistors, one is parallel and the other is series. Each of these arrangements are connected to batteries of the same voltage. The ratio of power dissipated in the parallel arrangement to the series arrangement is
(A) N   (B) I/N
(C) N^2 (D) I/N^2

29. White light from a distance extended source is incident on a convex lens. Its image is seen on a screen kept at the focal plane of the lens. The top half of the lens is covered with a green filter and bottom half with a red filter. Chose the correct statement.
(A) The top half of the image will be green and the bottom half will be red
(B) The top half of the image will be red and bottom half will be green
(C) The image will be white
(D) The image will be yellow

30. In Rutherford's experiment the correct plot for the number (N) of the alpha particles scattered against scattering angle θ is
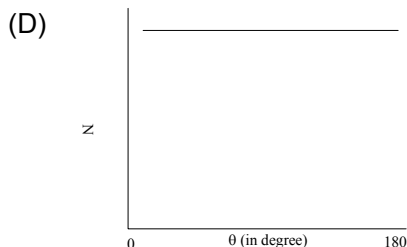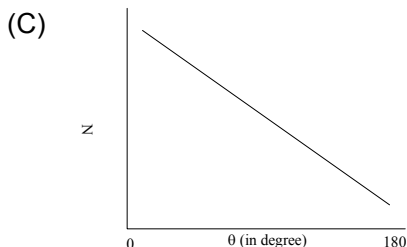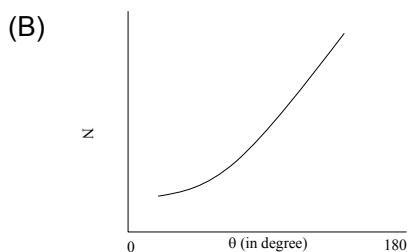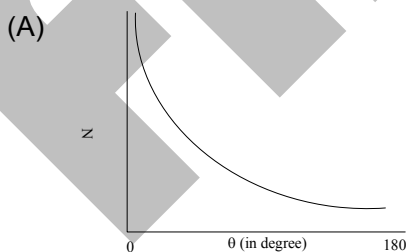
Questions 31 to 38 are long questions. Marks are indicated in the brackets. Answer the questions only in the answer sheet provided.

31.   (9 MARKS) In an experiment, a student exposed seedlings of a plant species to two different light conditions:
i. Full sun
ii. Shade (50% of full sun)
Assume that all the remaining conditions are same for both the groups. Plants from both the groups were collected at the ends of 6 weeks and various parameters were measured. The mean value for each parameter is given in the table.

Parameter	Condition	
	Sun	Shade
Leaf area (cm^2)	42	24
Leaf weight (g)	0.126	0.061
Stem weight (g)	0.283	0.138
Root weight (g)	0.239	0.089
Total weight (g)	0.648	0.288

A student made the following hypotheses (statements about the possible effect of different conditions on plants). You have to say whether these hypotheses are supported by the data given in the table or not.
Hypothesis I:
Plants grown in sun will show more shoot growth than root growth as compared to plants grown in shade.

(1.5 MARKS)

(A) Which of the following ratios can help to test hypothesis I?
a. Leaf weight/ root weight
b. Leaf area / leaf weight
c. (Leaf weight + stem weight) / root weight
d. Stem weight / Root weight

Put a cross (X) in the appropriate box.
(B) Calculate the value of the ratios for sun and shade plants based on the option selected by you in (A).
(i) Value of the ratio obtained for plants in the sun: _____   (1.5 MARKS)
(II) Value of the ratio obtained for plants in shade condition ___   (1.5 MARKS)

(C) Put a cross (X) against the correct statement.
(i) The values obtained in (B) support Hypothesis I: ___
(ii) The values obtained in (B) do not support Hypothesis I : ___

(Questions (B) and (C) will be given marks only if the answer to (A) is correct)

Hypothesis 2:

Leaves produced by plants in shade condition will be thicker than those produced in sunny conditions.   (1.5 MARKS)

(D) Which of the following ratios can help to test hypothesis 2?
a. Leaf weight / leaf area
b. Leaf area / shoot weight
c. Leaf weight / total plant weight

d. Shoot weight / total plant weight

Put a cross (X) in the appropriate box.

(E) In another experiment the growth of plants was studied under two conditions as given below, (under sufficient light in both):

(I) Condition X: water is supplied in sufficient quantity required for normal growth.
(II) Condition Y: 50% of the required quantity of water is supplied.
What would be the expected results?
(A) Increase in leaf weight to stem weight ratio in Y as compared to X
(B) Decrease in leaf thickness in Y as compared to X
(C) Decreases in shoot weight to root weight ratio in Y as compared to X
(D) Increase in leaf weight to stem weight ratio in X as compared to Y

Put a cross (X) in the appropriate box

32. (12 marks) Rajesh went to a doctor to check his blood glucose level. Doctor used a reagent which is colourless and turns pink in presence of glucose. More the concentration of glucose, greater the intensity of colour. This colour intensity can be quantitated using an instrument 'colorimeter'. Following table gives colorimeter readings for four standard glucose concentrations.

mg%	Readings
20	0.15
40	0.29
80	0.61
120	0.91

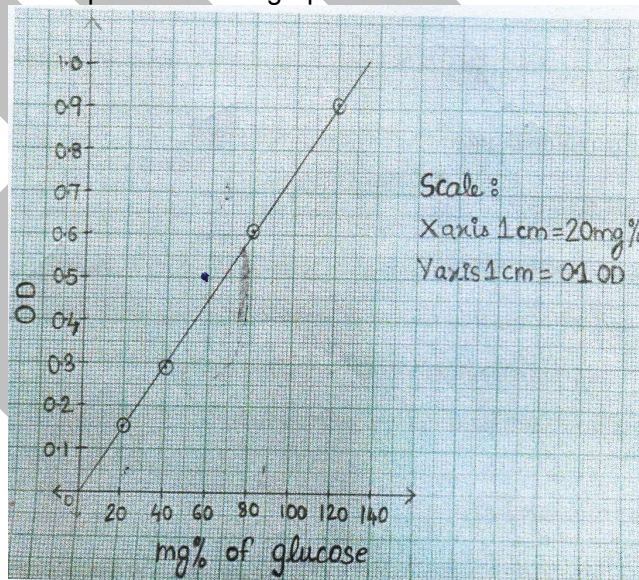Note that all colorimeter readings values above 0.05 are considered positive.

Rajesh's blood sample showed a reading 0.75.
A standard graph of OD values against the concentration of glucose is given.
(A) What is the molar concentration of glucose in Rajesh's blood? _____
Show extrapolation in the graph and calculations in the box   (3 marks)

Doctor than gave Rajesh 100 g glucose to eat and tested his urine and blood samples at the intervals of 30, 60, 90 and 120 min. The readings in the colorimeter were as follows:

Min	Reading for blood sample	Reading for urine sample
30	0.55	0.33

60	0.75	0.15
90	1.0	0.25
120	1.2	0.35

(B) Plot graphs of glucose concentration in blood and urine against time in the given graph paper in the answer sheet. (3 marks)

(C) What is the concentration of glucose(in mg%) in the blood reaching nephron at 80 min? (2 marks)

(D) What is the concentration of glucose above which the kidneys start removing it in urine? (4 marks)

33. (9 Marks) Consider a self-sustaining ecosystem consisting of three components X, Y and Z set up in a laboratory for several weeks. During a 26-day observation period, it was disturbed by human intervention on a particular day. The population size of the three components during this period is tabulated below.

Day	Population size		
	Component X	Component Y	Component Z
1	10	40	200
4	11	42	220
7	15	54	210
10	14	53	190
13	14	43	220
17	0	120	100
20	0	130	30
23	0	30	30
26	0	15	150

(A) Assign the correct component alphabet to each of the following:
(i) Primary producer ____ (1.5 Marks)
(ii) Herbivore ____ (1.5 Marks)
(iii) Carnivore ____ (1.5 Marks)

(B) The average biomass of a producer is 0.0060 g and that of a herbivore is 0.0025 g. Using the population sizes on day 1, calculate the transfer of energy in the form of biomass(in %) from producers to herbivores occurring in the ecosystem (3 marks)

Show your calculation in the box
Answer: _____

(C) Indicate the day and the most likely activity that has disturbed the balance of ecosystem
Answer: Day _____
Activity: _____
Option for activity:
(a) Removal of component X.
(b) Addition of component Y.
(c) Partial removal of component Z.

34. (13.5 MARKS) Acid rain is a term referring to rain having a pH lower than that of natural rain. Historic monuments built with various materials such as iron coated with layers of $CaCO_3$ and Na_2SO_4 can get damaged by acid rain. Acid rain can lead to flaking of this coat. One such sample of coating was brought to the lab to be analysed. The weight of sample was 0.626 g.

The analyst added the sample to aqueous oxalic acid and completely precipitated the calcium as calcium oxalate (CaC_2O_4). The calcium oxalate precipitate obtained was then dissolved in sulphuric acid and resulting oxalic acid $(H_2C_2O_4)$ formed was titrated with a standard KMnO₄ solution. The titration of the oxalic acid required 17.8 mL of 0.1MKMnO₄ solution.

(A) Balance the equation for the titration reaction between $KMnO_4$ and $H_2C_2O_4$. (Only entirely correct answer will be given marks).

$\_KMnO_4 + \_H_2C_2O_4 + \_H_2SO_4 + \_K_2SO_4 + \_MnSO_4 + \_H_2O + \_CO_2$
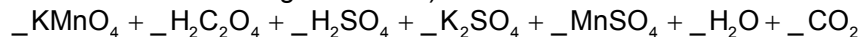
(B) Identify the oxidizing agent and the reducing agent in the reaction.

(i) _____is an oxidizing agent.

(ii) _____ is a reducing agent.

(C) Calculate the number of moles of oxalic acid reacted with the $KMnO_4$.

Show your calculations in the box.

Answer: _____ moles of oxalic acid

(D) Calculate the mass (in g) of $CaCO_3$ in the original sample. (2 Marks)
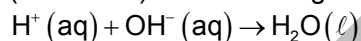
Show your calculations in the box.

Answer: _____ g of $CaCO_3$.

(E) Find the percent (%) of Na_2SO_4 present in the original sample. (2 Marks)

Show your calculations in the box.

Answer: _____.

35. (6 MARKS): The following acid-base reaction is performed in a thermos flask.

$H^+(aq) + OH^-(aq) \rightarrow H_2O(\ell)$

The temperature of 90 g of water rises from $29^\circ C$ to $30.5^\circ C$ when 0.010 mole of H^+ is reacted with 0.010 mole of OH^-.

Calculate:

(A) The heat absorbed by water. (4 Marks)

Show your calculations in the box.

Answer: q_{water} = _____.

(B) Heat evolved during the reaction of 17 g OH^- with 1 g H^+ (2 Marks)

Show your calculations in the box.

Answer: _____.

36. (10.5 MARKS) The molecular formula of gaseous compound is to be determined. This compound is found to be composed of 85.7% by mass carbon and 14.3% by mass hydrogen. It s density is 2.28 gL^{-1} at 300 K and 1 atm. pressure. From the given data,

(A) Calculate the number of moles of carbon atoms present in 100 g of compound. (2 Marks)

Show your calculations in the box.

Answer: _____.

(B) Calculate the number of moles of hydrogen atoms present in 100 g of compound. (2 Marks)

Show your calculations in the box.

Answer: _____.

(C) The empirical formula of the compound is: _____. (1 Mark)

(D) Moles Litre of the compound at NTP = _____. (2 Marks)

Show your calculations in the box.

(E) Empirical formula units = _____. (2 Marks)

(F) Molecular formula: _____. (1.5 Marks)

37. (12 MARKS) As shown in the grid figure given below, there is a foot rule of dimensions $12''$ × $3''$ kept on and above the principal axis of a small concave mirror of radius of curvature $24''$. Distances from the pole of the mirror along the principal axis are marked. The $6''$ mark of the foot rule is at the center of curvature of the mirror.
Draw the image of the foot rule on the grid <u>in the answer sheet</u> using the same scale to which the foot rule is drawn. Show the calculations required for drawing the image in the box provided in the answer sheet.
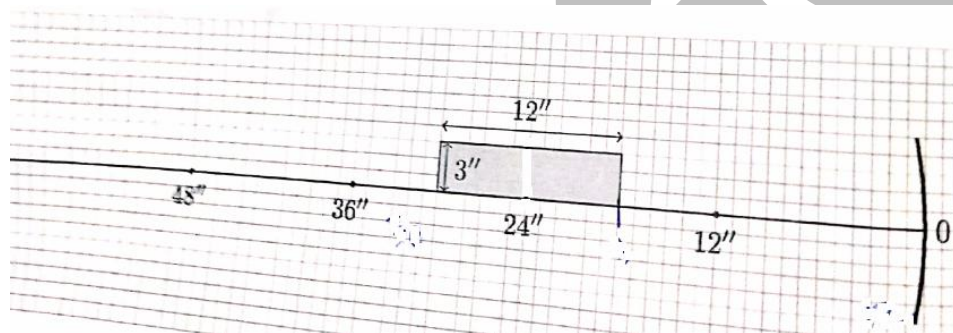
38. (18 MARKS) The experiment of the Resonance Tube is commonly performed to determine the speed of sound. The experimental setup is as follows. A hollow tube open at both ends can be suitably lowered into water inside a jar as shown in the figure. A speaker of variable frequency is held just above the top end of the tube.
Sound waves from the speaker are allowed to enter into the tube from the top. On gradually raising or lowering the tube in the water, it is observed that when a certain length is above the water level, a loud sound is audible due to resonance. The length of the tube above the water at this position is recorded as L. According to the theory if λ is the wavelength of the sound then

$$\left(\frac{\lambda}{4} = L + e \right)$$

Where e is the end correction given by e = 0.3d (d = inner diameter of the tube)
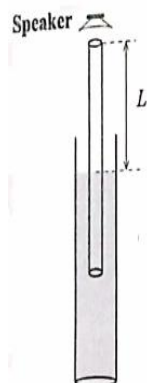
A given setup of this experiment uses a tube of inner diameter 5.0 cm. Values of L recorded for different frequencies are as given below.

No.	Frequency f (Hz)	L (cm)
1.	400	19.9
2.	500	16.0
3.	750	10.0
4.	1000	7.5
5.	1250	5.1

(A)   Choose proper variables X and Y to produce a suitable linear graph which can be used to determine the speed of sound. Indicate these variables in the answer sheet.   (4 Marks)
   (i)   Variable on the x axis (X): _____.
   (ii)   Variable on the y axis (Y): _____.

(B)   Fill the data table used to plot the graph.

(C)   Use the graph sheet to produce a suitable linear graph.

(D)   Determine the speed of sound using the graph plotted.

   Show your calculations in the box.

   Speed of sound in air: _____.