CBSE Class 10 Science 2026-27

Sample Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)

Time Allowed: 3 hours **Maximum Marks: 80**

General Instructions

(i) This question paper consists of **39 questions** in **3 sections**. Section A is Biology, Section B is Chemistry and Section C is Physics.

(ii) **All questions are compulsory.** However, an internal choice is provided in some questions. A student is expected to attempt only one of the alternatives in these questions.

(iii) Section A (Biology) has questions 1 to 16, Section B (Chemistry) has questions 17 to 29 and Section C (Physics) has questions 30 to 39.

(iv) The question paper carries **80 marks**. Time allowed is **3 hours**. There is no change in the question paper design and assessment pattern for the academic session 2026-27.

Section A: Biology (30 marks)

1. During photosynthesis, what happens to carbon dioxide and water as glucose is formed? [1 mark]

(A) Carbon dioxide gains hydrogen, while water loses electrons.

(B) Carbon dioxide loses oxygen, while water gains oxygen.

(C) Carbon dioxide is oxidised, while water is reduced.

(D) Both carbon dioxide and water undergo reduction.

Correct Answer: (A) Carbon dioxide gains hydrogen, while water loses electrons.

Solution:

Concept:

- Photosynthesis is a redox process. Oxidation means loss of electrons or hydrogen, or gain of oxygen.
- Reduction means gain of electrons or hydrogen, or loss of oxygen. We must find which raw material is reduced and which is oxidised.

Step 1: Look at the overall reaction

$$6CO_2 + 12H_2O \xrightarrow{\text{light, chlorophyll}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Carbon dioxide is the carbon source. It is built up into glucose, which has far more hydrogen and far less oxygen per carbon atom than CO_2 has.

Step 2: What happens to carbon dioxide In the dark (Calvin) reactions, CO_2 is converted into glucose using hydrogen supplied by NADPH. It gains hydrogen and loses oxygen. So carbon dioxide is REDUCED.

Step 3: What happens to water In the light reactions, water is split. It gives up electrons and hydrogen ions, and oxygen gas is released. Water loses electrons and hydrogen, so water is OXIDISED. The electrons and hydrogen ions it gives are used to reduce CO_2.

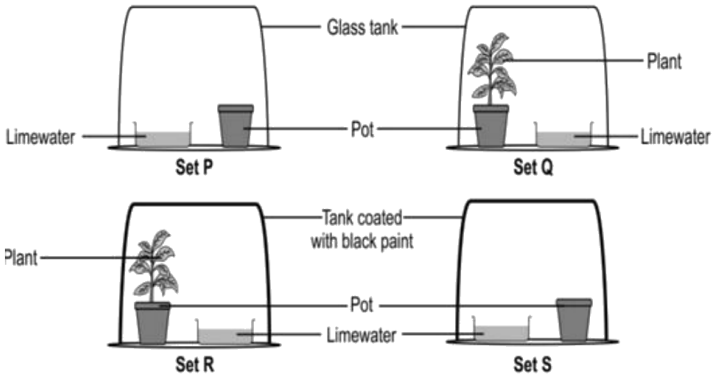
Step 4: Check option (A) Carbon dioxide gains hydrogen (reduction) and water loses electrons (oxidation). Both parts are correct, so (A) is TRUE.

Step 5: Check the other options Option (B): the first part is fine, but water does not gain oxygen. Water is split and it releases oxygen, so (B) is wrong.
Option (C): this is the exact opposite. CO_2 is reduced and water is oxidised, so (C) is wrong.
Option (D): only CO_2 is reduced. Water is oxidised, so both cannot be reduced and (D) is wrong.

Step 6: Conclusion Carbon dioxide is reduced (gains hydrogen) and water is oxidised (loses electrons). This is option (A).

Quick Tip to Solve: Decide which substance gives up electrons and hydrogen (oxidised) and which one gains hydrogen (reduced) when glucose is made.

2. Lime water turns cloudy in the presence of a gas, which is a by-product of respiration. Shown below are four setups kept in sunlight for 24 hours. In which setup is lime water expected to be the cloudiest?



[1 mark]

(A) P

(B) Q

(C) R

(D) S

Correct Answer: (C) R

Solution:

Concept:

- Lime water turns cloudy when carbon dioxide (CO_2) is passed through it.
- The CO_2 here comes from respiration of the living plant.
- So the cloudiest lime water will be in the setup where the most CO_2 builds up.

Step 1: Key facts to use 1. Respiration goes on in a plant all the time, in light and in darkness, and it releases CO_2.
2. Photosynthesis needs light and it USES CO_2. So in sunlight a plant takes in the CO_2 made by its own respiration.
3. A pot with no plant has no living tissue, so it makes no CO_2.

Step 2: Set P There is no plant. Nothing respires, so no extra CO_2 is released. Lime water stays almost clear.

Step 3: Set Q The plant is in a clear tank in sunlight. It respires and also photosynthesises. Photosynthesis consumes the CO_2 released by respiration, so very little CO_2 collects. Lime water turns only slightly cloudy or stays clear.

Step 4: Set R The plant is in a tank coated with black paint, so no light reaches it. Photosynthesis cannot happen. The plant only respires, so CO_2 keeps collecting for 24 hours. Lime water turns very cloudy.

Step 5: Set S The tank is blackened but there is no plant. No living thing is present, so no CO_2 is produced. Lime water stays clear.

Step 6: Conclusion Only set R has a living plant that respires without photosynthesis. So the most CO_2 collects there and its lime water is the cloudiest. This is option (C).

Quick Tip to Solve: Respiration gives out carbon dioxide all day and night. Photosynthesis uses it up only when there is light. Find the setup with a plant and no light.

3. During urine formation, tubular reabsorption and secretion take place in the kidneys. Which of the following sets correctly indicates both the substances that are reabsorbed in the kidneys? [1 mark]

(A) Glucose and salts

(B) Glucose and starch

(C) Glycogen and salts

(D) Glycogen and starch

Correct Answer: (A) Glucose and salts

Solution:

Concept:

- The kidney first filters blood in the glomerulus. The filtrate holds useful things along with waste.
- In the tubule of the nephron, the useful substances are taken back into the blood. This is called selective reabsorption.

Step 1: What is reabsorbed The tubule takes back glucose, amino acids, salts (ions such as sodium) and a large amount of water. The amount of water reabsorbed depends on how much excess water the body has.

Step 2: Check the given substances Glucose is a small molecule that is present in blood and in the filtrate. It is reabsorbed. Salts are also reabsorbed as needed.
Starch is a storage carbohydrate of plants. It is not found in human blood, so there is nothing to reabsorb.
Glycogen is a storage carbohydrate of the liver and muscles. It is a very large molecule kept inside cells, so it is not in the blood filtrate either.

Step 3: Match with the options Only the pair glucose and salts has two substances that are both reabsorbed. Option (A) is correct. Options (B), (C) and (D) each contain starch or glycogen, which are never reabsorbed by the kidney.

Step 4: Conclusion Glucose and salts are reabsorbed in the kidney tubule. This is option (A).

Quick Tip to Solve: Reabsorption takes back useful small substances from the filtrate. Ask whether starch or glycogen is ever present in the blood filtrate.

4. In a controlled experiment, the anthers of a mustard plant's flowers were carefully removed in the bud stage before they matured. The bud was covered with a paper bag.
What will be the most likely result for these flowers? [1 mark]

(A) They will still produce seeds and fruit through self-pollination.

(B) They will attract more insects and produce larger flowers but no fruit.

(C) They will not produce any seeds or fruits.

(D) They will produce seeds and fruits that are genetically identical to the parent.

Correct Answer: (C) They will not produce any seeds or fruits.

Solution:

Concept:

- The anther is the male part of a flower. It makes pollen grains that carry the male gametes.
- Removing the anthers of a bud before it matures is called emasculation. Covering the bud with a

bag stops pollen from coming from outside.

Step 1: Recall how seeds form A seed forms only after fertilisation. Fertilisation needs pollen to reach the stigma (pollination), then the male gamete must fuse with the egg in the ovule. The ovule becomes the seed and the ovary becomes the fruit.

Step 2: Apply it to this experiment Mustard flowers are bisexual, but here the anthers have been removed, so the flower has no pollen of its own. The paper bag also blocks insects and wind, so no pollen from another flower can arrive. No pollination means no fertilisation, so no seeds and no fruit.

Step 3: Why the other options are wrong (A) needs pollen from the same flower. The anthers are gone, so there is no pollen.
(B) is wrong because the bag keeps insects away, and removing anthers does not make flowers larger. Also fruit cannot form without fertilisation.
(D) is wrong because no seeds form at all. Seeds formed by sexual reproduction would also carry variation and would not be exact copies of the parent.

Step 4: Conclusion Without pollen and with the bud bagged, fertilisation cannot occur. No seeds or fruits form. This is option (C).

Quick Tip to Solve: Anthers give pollen. Without pollen and with a bag stopping outside pollen, ask whether fertilisation can happen.

5. The Vas deferens and the Oviduct are both targets for surgical contraception (Vasectomy and Tubectomy respectively). Analysing the process of reproduction, what common biological event is prevented by blocking both these structures? [1 mark]

(A) The production of gametes (sperm and egg).

(B) The implantation of the fertilized egg into the uterine wall.

(C) The successful meeting and fusion of the male and the female gametes.

(D) The release of hormones - testosterone and estrogen.

Correct Answer: (C) The successful meeting and fusion of the male and the female gametes.

Solution:

Concept:

- Vasectomy and tubectomy are surgical methods of birth control. In vasectomy the vas deferens is cut and tied.
- In tubectomy the oviduct (fallopian tube) is cut and tied. We need the one event that both operations stop.

Step 1: What each tube does The vas deferens carries sperms from the testis to the urethra. The oviduct carries the egg from the ovary to the uterus, and fertilisation normally takes place inside it. Blocking the first stops sperms from leaving. Blocking the second stops the egg moving and also stops sperms from reaching it.

Step 2: Common result In both cases the sperm and the egg cannot meet, so fertilisation (fusion of the gametes) cannot happen. Option (C) states this.

Step 3: Why the other options are wrong (A) The testes and ovaries are untouched, so gametes are still produced. Only their passage is blocked.
(B) Implantation comes after fertilisation. Since no zygote forms, implantation is prevented only as a later effect, and it is not the common event that is directly blocked.

(D) Testosterone and oestrogen are made by the testes and ovaries. These organs are not touched, so hormone release continues.

Step 4: Conclusion Both operations stop the male and female gametes from meeting and fusing. This is option (C).

Quick Tip to Solve: The testes and ovaries are not touched. Think about what these two tubes carry, and what has to happen between a sperm and an egg.

6. The male gamete of an apple plant has seventeen chromosomes. What is the number of chromosomes in the female gamete and in the cells of the adult plant respectively? [1 mark]

(A) 17,17

(B) 17,34

(C) 34,34

(D) 34,51

Correct Answer: (B) 17,34

Solution:

Concept:

- Gametes are haploid. They carry one set of chromosomes, called n.
- Body cells of the adult plant are diploid. They carry two sets, called $2n$.
- One set comes from the male gamete and one set from the female gamete.

Step 1: Female gamete Male and female gametes carry the same number of chromosomes, because a zygote must get equal sets from both parents. Male gamete: $n = 17$. So the female gamete also has 17 chromosomes.

Step 2: Adult plant cells The zygote is formed by fusion of the two gametes, so its chromosome number is

$$17 + 17 = 34$$

The zygote divides by mitosis. Mitosis keeps the number the same, so all cells of the adult plant have 34 chromosomes.

Step 3: Why the other options are wrong (A) 17 for the adult plant is wrong, because that is the gamete number and not the body-cell number.
(C) 34 for the female gamete is wrong, because gametes have only half the number.
(D) 51 would need three sets of chromosomes, but fertilisation only joins two sets.

Step 4: Conclusion The female gamete has 17 chromosomes and the adult plant cells have 34. This is option (B).

Quick Tip to Solve: A gamete carries one set of chromosomes (n). The body cells carry two sets (2n). Both gametes carry the same number.

7. A fish living in a pond ecosystem feeds on small aquatic insects (larvae). These insect larvae, in turn, feed on green algae and small photosynthetic bacteria.
In this specific food chain, what is the trophic level classification of fish? [1 mark]

(A) Producer

(B) Primary Consumer

(C) Secondary Consumer

(D) Tertiary Consumer

Correct Answer: (C) Secondary Consumer

Solution:

Concept:

- A food chain shows who eats whom. Each step is a trophic level.
- Producers make their own food. Primary consumers eat producers.
- Secondary consumers eat primary consumers. Tertiary consumers eat secondary consumers.

Step 1: Build the chain from the passage Green algae and photosynthetic bacteria make food using sunlight, so they are PRODUCERS (level 1). Insect larvae eat them, so larvae are PRIMARY CONSUMERS (level 2). The fish eats the larvae, so the fish is a SECONDARY CONSUMER (level 3).

Step 2: Write the chain

$$\text{Green algae} \rightarrow \text{Insect larvae} \rightarrow \text{Fish}$$

Step 3: Why the other options are wrong (A) Producer: the fish cannot make its own food.
(B) Primary consumer: the fish does not eat the algae directly. It eats larvae.
(D) Tertiary consumer: this would need one more consumer below the fish, and none is given.

Step 4: Conclusion The fish feeds on primary consumers, so it is a secondary consumer. This is option (C).

Quick Tip to Solve: Write the food chain from producer to fish and count the levels. Algae is level 1.

8. Assertion (A): The rate of breathing in aquatic organisms is much lower than in the terrestrial organisms.
Reason (R): The amount of oxygen dissolved in water is less as compared to the amount of oxygen in air. [1 mark]

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Correct Answer: (D) A is false but R is true.

Solution:

Concept:

- We must check the Assertion and the Reason one by one, and then see how they are related.

Step 1: Check the Reason (R) Air has about 21 percent oxygen. In water, only a small amount of oxygen is dissolved, much less than in the same volume of air. So the Reason is TRUE.

Step 2: Check the Assertion (A) Because water holds so little oxygen, an aquatic animal must pass

a lot of water over its gills to get enough. So fish breathe much FASTER than land animals. The Assertion says the rate is lower, so the Assertion is FALSE.

Step 3: Pick the option A is false and R is true. That is option (D).

Step 4: Why the other options are wrong (A) and (B) say that A is true, but A is false.
(C) says R is false, but R is true.

Step 5: Conclusion The assertion is false and the reason is true. This is option (D).

Quick Tip to Solve: Check each statement separately. Think about whether low dissolved oxygen makes aquatic animals breathe faster or slower.

9. Assertion (A): In an ecosystem, 1% of energy is available for transfer from one trophic level to the next.
Reason (R): An average of 10% of the food eaten by organisms is available for flow in the form of chemical energy. [1 mark]

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Correct Answer: (D) A is false but R is true.

Solution:

Step 1: Recall the 10 percent law of energy flow In a food chain, energy enters through the producers. Every time energy passes to the next trophic level, most of it is lost as heat.
Organisms use energy for respiration, movement, growth and keeping the body warm. Some parts of the food are also never eaten or never digested.
Only about 10% of the energy of one trophic level is stored in the body of the next level and is available to it as chemical energy. This is called the 10 percent law.
For example, if green plants hold 1000 J of energy, the herbivores that eat them get about 10% of $1000 = 100$ J.

Step 2: Check the Assertion (A) The Assertion says only 1% of the energy goes to the next level. The correct average value is 10%, not 1%.
So Assertion (A) is FALSE.

Step 3: Check the Reason (R) The Reason says that on average 10% of the food eaten by organisms is available for flow as chemical energy. This is exactly the 10 percent law.
So Reason (R) is TRUE.

Step 4: Check each option Option (A) needs A to be true. A is false, so (A) is wrong.
Option (B) also needs A to be true, so (B) is wrong.
Option (C) says A is true and R is false. It is the opposite of what we found, so (C) is wrong.
Option (D) says A is false and R is true. This matches our finding, so (D) is correct.

Step 5: Conclusion Assertion is false because the energy transferred is about 10% and not 1%. The reason is a true statement. This is option (D).

Quick Tip to Solve: Recall the 10 percent law of energy flow. Compare 1% in the assertion with the real value.

10. A. Due to narrowing of the bile duct, the bile secretion from the liver to the small intestine was obstructed. How will the process of digestion be affected?
B. How does the length of the intestine depend on the nature of food habit in different animals? [2 marks]

Solution:

Step 1: Part A: Recall what bile does Bile juice is made by the liver, stored in the gall bladder and sent to the small intestine through the bile duct.
Food that leaves the stomach is acidic. The pancreatic enzymes work only in an alkaline medium. Bile makes the food alkaline.
Bile salts also break the large fat globules into many small globules. This is called emulsification. Small globules give the fat-digesting enzyme more surface to act on.

Step 2: Part A: What happens when the duct is narrow Little bile reaches the small intestine. The food stays acidic, so pancreatic enzymes cannot work at their best.
Fats are not emulsified, so they remain in large globules and the enzyme acts slowly on them.
So digestion becomes improper, and fat digestion is affected most.

Step 3: Part B: Link the length of the intestine to the food Herbivores such as a cow or a goat eat grass. Grass has a lot of cellulose, which takes a long time to digest. So herbivores need a long small intestine.
Carnivores such as a tiger or a lion eat meat. Meat is easy to digest, so they have a shorter small intestine.

Step 4: Conclusion Blocked bile duct means improper digestion of fats. Herbivores have a longer small intestine than carnivores.

Quick Tip to Solve: Think about the two jobs of bile. For part B, compare the food of a cow and a tiger.

11(A). Which parts of the brain perform certain actions for which we do not have any thinking control? What are such actions called, give two examples. [2 marks]

Solution:

Step 1: Find the part of the brain The brain has three main regions: fore-brain, mid-brain and hind-brain.
The fore-brain is the thinking part. The mid-brain and the hind-brain control actions that go on without our thought.
The hind-brain has the medulla, which controls these actions.

Step 2: Name such actions Actions that happen without any thinking control are called involuntary actions.

Step 3: Give two examples 1. Change in blood pressure.
2. Salivation (release of saliva).
3. Vomiting.
Any two of these are enough.

Step 4: Conclusion The mid-brain and hind-brain control the actions. They are called involuntary actions, such as blood pressure and salivation.

Quick Tip to Solve: Think about which part of the brain works without our thought, and what such actions are called.

OR

11(B). How is the information of touch in the 'sensitive plant' controlled and coordinated? [2 marks]

Solution:

Step 1: What happens in the sensitive plant The sensitive plant (Mimosa pudica) folds its leaves and droops when we touch it.
Plants have no nerve cells and no brain, so the message of touch cannot travel along nerves.

Step 2: How the touch message travels The information of touch is passed from cell to cell by electrical-chemical means. The signal moves from the cell that was touched to the other cells.

Step 3: How the movement happens Plant cells have no special muscle proteins like animal cells. Instead, they change shape by changing the amount of water in them.
Some cells lose water and shrink, and other cells gain water and swell. This change in shape moves the leaf and makes it droop.

Step 4: Conclusion Touch is communicated by electrical-chemical signals from cell to cell. Cells swell or shrink with water changes, which moves the leaf.

Quick Tip to Solve: Plants have no nerves. Think of how a signal can pass between cells and how cells can change shape with water.

12. What changes are observed in the uterus subsequent to implantation of the young embryo in a human female? [2 marks]

Solution:

Step 1: Recall what implantation means After fertilisation, the zygote divides and forms a ball of cells, the embryo. The embryo gets attached (implanted) in the wall of the uterus.

Step 2: Change 1: the lining of the uterus The uterine lining becomes thick, and it is richly supplied with blood vessels. This blood supply brings food and oxygen to nourish the growing embryo.

Step 3: Change 2: the placenta A special tissue called the placenta develops. It is a disc-like structure embedded in the uterine wall.
The placenta forms a connection between the uterus and the embryo. It has villi on the embryo side and blood spaces on the mother's side.
Through this connection the embryo receives glucose and oxygen from the mother, and waste made by the embryo is removed into the mother's blood.

Step 4: Conclusion The uterine lining thickens with many blood vessels, and the placenta forms between the uterus and the embryo.

Quick Tip to Solve: Think about how the embryo gets food after implantation. Two changes in the uterus help it.

13. How do muscles move at the cellular level and respond when processed messages are received from the brain? [3 marks]

Solution:

Step 1: Recall the path of the message The brain processes the information and sends a message along motor nerves. This message is an electrical impulse.
The motor nerve ends at a muscle, so the impulse reaches the muscle cells.

Step 2: What the muscle cell does When the nerve impulse reaches the muscle, the muscle cells move by changing their shape so that they shorten.

Step 3: How the shape changes Muscle cells have special proteins. In response to the nervous electrical impulse, these proteins change both their shape and their arrangement inside the cell.
The new arrangement of the proteins gives the muscle cell a shorter form. Many cells shortening together make the whole muscle contract and the body part moves.

Step 4: Conclusion The muscle cells shorten when the special proteins in them change shape and arrangement after the nerve impulse arrives.

Quick Tip to Solve: Follow the nerve impulse to the muscle cell and think about what the special proteins in it do.

14. Study the food chain given below:

Phytoplankton ⟶ zooplankton ⟶ small fishes ⟶ large fish

A. In the given food chain, the amount of energy available at the fourth trophic level is 10 kJ, what will be the energy available at the producer level?
B. Is it possible to have three more trophic levels in the above food chain? Justify.
C. Which of these trophic levels will have the maximum amount of pesticide, if it had washed down in the water body from agricultural fields. Why? [3 marks]

Solution:

Concept:

- Phytoplankton is the producer (first trophic level). Zooplankton is the second level, small fishes the third level and large fish the fourth level.
- We use the 10 percent law: only 10% of the energy of a level passes to the next level.

Step 1: Part A: Energy at the producer level The fourth level has 10 kJ. This is 10% of the third level, so the third level has $10 \times 10 = 100$ kJ.
The third level is 10% of the second level, so the second level has $100 \times 10 = 1000$ kJ.
The second level is 10% of the producers, so the producers have $1000 \times 10 = 10000$ kJ.

$$\text{Energy at producer level} = 10 \times 10 \times 10 \times 10 = 10^4 \text{ kJ}$$

Step 2: Part B: Three more trophic levels The chain already has four levels. Three more would make seven levels.
Starting from 10000 kJ at the producers, the energy at levels 4, 5, 6 and 7 would be 10 kJ, 1 kJ, 0.1 kJ and 0.01 kJ. The seventh level gets only 0.01 kJ, which is far too little to support any organism.
So it is not possible. The loss of energy at each step is so large that very little usable energy is left for the higher levels. This is why food chains have only three to five trophic levels.

Step 3: Part C: Level with the most pesticide Pesticides washed into the water are absorbed by the

phytoplankton. They are not broken down by the body and are not removed easily, so they stay in the body.
Each consumer eats many organisms of the lower level, so the pesticide gets collected and becomes more concentrated at every step. This is called biological magnification.
The large fish is at the top of the chain, so it has the maximum amount of pesticide.

Step 4: Conclusion A. 10000 kJ. B. No, because too much energy is lost at every level. C. Large fish, because of biological magnification.

Quick Tip to Solve: Use the 10 percent law: multiply by 10 to go down a level. Pesticides are not broken down, so they build up along the chain.

15(A). In order to study patterns of inheritance, Neha had performed typical Mendelian experiments with pea plants in the field. In experiment one, she crossed a pea plant having white flowers (vv) with another pea plant bearing violet flowers (VV). In another experiment, in addition to the colour of the flower she also focussed on the height of the pea plant. This time she crossed a pea plant having violet flowers and tall height (VVTT) with another pea plant having white flowers and short height (vvtt).
What percentage is expected for the following traits as a result of these experiments? Give a reason.
Violet flowers in F1 and F2 generation in experiment one? [1 mark]

Solution:

Step 1: Write the cross of experiment one Parents: white (vv) and violet (VV). Violet (V) is the dominant trait and white (v) is recessive.
Gametes: the white plant makes only v. The violet plant makes only V.

Step 2: Find the F1 generation

$$vv \times VV \rightarrow Vv$$

Every F1 plant is Vv. Since V is dominant, all of them show violet flowers. So F1 has 100% violet flowers.

Step 3: Find the F2 generation F1 plants (Vv) are self-crossed. Each makes two kinds of gametes, V and v.

$$Vv \times Vv \rightarrow 1\,VV : 2\,Vv : 1\,vv$$

VV and Vv both give violet flowers, which is $1 + 2 = 3$ out of 4. Only vv gives white flowers (1 out of 4).

$$\text{Violet in F2} = \frac{3}{4} \times 100 = 75\%$$

Step 4: Conclusion F1 has 100% violet flowers and F2 has 75% violet flowers, because violet (V) is dominant over white (v).

Quick Tip to Solve: Write the gametes of vv and VV, then self-cross the F1 plant. Violet is dominant.

15(B). Tall height plants with white flowers in F2 generation in experiment two? [1 mark]

Solution:

Step 1: Write the cross of experiment two

$$VVTT \times vvtt \rightarrow VvTt \text{ (all F1 plants are violet and tall)}$$

Violet (V) and tall (T) are dominant. White (v) and short (t) are recessive.

Step 2: Find the F2 ratio F1 plants (VvTt) are self-crossed. Each makes four kinds of gametes: VT, Vt, vT and vt.
A 4 x 4 Punnett square gives 16 boxes. These fall in four groups:
Violet and tall: 9.
Violet and short: 3.
White and tall: 3.
White and short: 1.

$$9 : 3 : 3 : 1$$

Step 3: Pick the group asked in the question Tall plants with white flowers need vv for colour and at least one T for height. They are vvTT and vvTt, which is 3 boxes out of 16.

$$\frac{3}{16} \times 100 = 18.75\%$$

A tall plant with white flowers shows one dominant trait (tall) and one recessive trait (white).

Step 4: Conclusion 3/16, which is 18.75% of the F2 plants, are tall with white flowers.

Quick Tip to Solve: The F2 of a dihybrid cross has the ratio 9:3:3:1. Find the box for tall and white.

15(C). Percentage of medium height plants with light violet flowers in F1 and F2 generations in experiment two? Give a reason. [2 marks]

Solution:

Step 1: Recall what Mendel found In pea plants, a trait does not blend. A plant is either tall or short, and its flowers are either violet or white.
Even a single copy of the dominant allele (T or V) gives the same result as two copies of it.

Step 2: Look at the F1 generation All F1 plants are VvTt. They are tall and violet, not medium height and not light violet.

Step 3: Look at the F2 generation F2 plants are only violet tall, violet short, white tall or white short, in the ratio 9 : 3 : 3 : 1.
There are no medium-height plants and no light violet flowers in any box.

$$\text{Percentage} = 0\%$$

Step 4: Conclusion 0% in F1 and 0% in F2. The traits do not blend, so no medium height or light violet plants are formed.

Quick Tip to Solve: Mendel's traits do not blend. Ask whether a half-way trait is possible.

OR

15(D). Percentage of short height plants with white flowers in F1 and F2 generations in experiment two? [2 marks]

Solution:

Step 1: Find the F1 plants

$$VVTT \times vvtt \rightarrow VvTt$$

All F1 plants show only the dominant traits, which are violet and tall. A short plant with white flowers is a plant with both recessive traits, so none is seen in F1. The percentage in F1 is 0%.

Step 2: Find the F2 plants Self-crossing VvTt gives 16 boxes with the ratio 9 : 3 : 3 : 1.
A short plant with white flowers must be vvtt, as both traits are recessive. Only 1 box out of 16 is vvtt.

$$\frac{1}{16} \times 100 = 6.25\%$$

Step 3: Conclusion F1 has 0% and F2 has 1/16 (6.25%) short plants with white flowers.

Quick Tip to Solve: Short and white are both recessive, so the plant must be vvtt. Find its share in 16 boxes.

16(A).



Observe the structure of hearts A, B and C shown above and answer the following questions
I. Which of the hearts depicted above is present in both birds and Mammals and how are they able to maintain their body temperature? Give reason for your answer.
II. Which of the hearts depicted above is present in fishes, how does circulation of blood take place in them? [5 marks]

Solution:

Step 1: Identify the three hearts Heart A has two chambers. This is the heart of fishes.
Heart B has three chambers. This is the heart of amphibians and most reptiles.
Heart C has four chambers. This is the heart of birds and mammals.

Step 2: Part I: Heart in birds and mammals The heart present in both birds and mammals is C, the four-chambered heart.
In this heart the right side and the left side are fully separated. Oxygen-rich blood and oxygen-poor blood do not mix.

Step 3: Part I: Reason for body temperature Because the two kinds of blood do not mix, a highly efficient supply of oxygen reaches the body.
Birds and mammals have high energy needs. They constantly use energy to keep their body temperature steady. Plenty of oxygen helps them release this energy, so they can maintain their body temperature.

Step 4: Part II: Heart in fishes and its circulation Fishes have heart A, a two-chambered heart.
The heart pumps blood to the gills. There the blood is oxygenated. It then passes directly from the

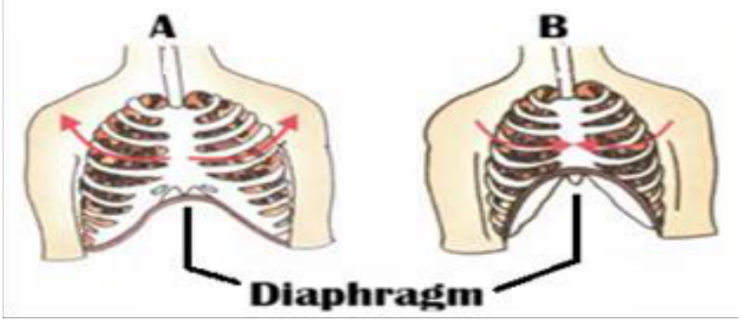
gills to the rest of the body.
So the blood goes only once through the heart in one cycle of passage through the body. This is called single circulation.

Step 5: Conclusion I. Heart C (four-chambered) is in birds and mammals. II. Heart A (two-chambered) is in fishes, with single circulation.

Quick Tip to Solve: Count the chambers in each heart. Think about why mixing of blood matters for animals that make a lot of heat.

OR

16(B). I. Observe both the diagrams A and B. Which diagram indicates inhalation? Describe how it occurs.



II. If diffusion were to move oxygen in our body, it is estimated that it would take 3 years for a molecule of oxygen to get to our toes from our lungs. Then, how is oxygen delivered to all parts of our body? [5 marks]

Solution:

Step 1: Part I: Pick the diagram for inhalation In diagram A, the ribs are lifted and the diaphragm is flattened. This is inhalation.
In diagram B, the ribs are lowered and the diaphragm is dome-shaped. This is exhalation.

Step 2: Part I: Describe how inhalation occurs 1. The ribs get lifted (they move up and outward).
2. The diaphragm is flattened (it moves down).
3. Both changes make the chest cavity larger, so the air pressure inside the chest falls.
4. Air from outside is sucked in and fills the lungs.

Step 3: Part II: Why diffusion alone is not enough Diffusion is far too slow to move oxygen over long distances in a big body. A molecule would need about 3 years to reach the toes.
So the body uses a transport system, the blood, to carry oxygen quickly.

Step 4: Part II: How oxygen is delivered The respiratory pigment haemoglobin has a very high affinity for oxygen. It is present in the red blood corpuscles.
Haemoglobin picks up oxygen in the lungs. The heart then pumps this oxygen-rich blood to all the parts of the body.

Step 5: Conclusion I. Diagram A shows inhalation, with ribs lifted and the diaphragm flattened. II. Haemoglobin in the blood carries oxygen, and the heart pumps it to all parts.

Quick Tip to Solve: Look at the ribs and the diaphragm in each diagram. For part II, think of the pigment in red blood cells.

Section B: Chemistry (25 marks)

17. Chameleons contain crystals that reflect light and produce colour. Adjusting the spacing between these crystals, they can alter the wavelengths of light reflected, thus changing their skin colour. Based on the above information, we can infer that the change in colour by chameleons is a:

[1 mark]

(A) chemical change because change in colour takes place.

(B) chemical change because wavelength of reflected light changes.

(C) physical change because the space between crystals is adjusted.

(D) physical change because light is reflected by crystals.

Correct Answer: (C) physical change because the space between crystals is adjusted.

Solution:

Concept:

- The skin of a chameleon has tiny crystals that reflect light. The colour we see depends on the wavelength of the light they reflect.
- The chameleon changes the gap between these crystals. A different gap reflects a different wavelength, so the skin shows a different colour.
- The passage never says that any new substance is made. Only the spacing of the same crystals changes.

Step 1: Recall the test for physical and chemical change In a chemical change a new substance forms. It has new properties and the change is usually hard to reverse. Rusting of iron and curdling of milk are examples.
In a physical change no new substance forms. Only the shape, size, state, arrangement or appearance changes. The change can usually be reversed.

Step 2: Apply the test to the chameleon The crystals stay the same crystals. They only move closer together or farther apart.
No new substance is formed, and the chameleon can go back to its old colour by restoring the gap. So this is a physical change.
The reason is that the space between the crystals is adjusted. This matches option C.

Step 3: Why the other options are wrong Option A is wrong. A change of colour alone does not prove a chemical change. We need a new substance, and here there is none.
Option B is wrong. The wavelength of reflected light changes only because the spacing changes. A change in wavelength is not a chemical reaction.
Option D is wrong. The change is physical, but the reason is not correct. Crystals reflect light all the time. The colour changes because the spacing changes, not because light is reflected.

Step 4: Conclusion The colour change of a chameleon is a physical change because only the space between the crystals is adjusted. This is option C.

Quick Tip to Solve: Ask yourself whether any new substance is formed when the chameleon changes colour.

18. Rishita summarizes the chlor-alkali process in the following table.

Option	Product	Formed	Use
I	Hydrogen	At cathode	Used as a fuel
II	Chlorine	At anode	Used to make margarines
III	Sodium Hydroxide	Near cathode	To make soap
IV	Sodium Hydroxide	Near anode	To make bleaching powder

Identify the options that are correctly matched. [1 mark]

(A) I, II and III

(B) I and III

(C) II and IV

(D) I, II, III and IV

Correct Answer: (B) I and III

Solution:

Step 1: Recall the chlor-alkali process In this process we pass electricity through a concentrated solution of sodium chloride (brine). The equation is:

$$2NaCl + 2H_2O \rightarrow 2NaOH + Cl_2 + H_2$$

Chlorine gas collects at the anode (the positive electrode). Hydrogen gas collects at the cathode (the negative electrode). Sodium hydroxide stays in the solution near the cathode.

Step 2: Recall the uses of the three products Hydrogen is used as a fuel and in making ammonia and in hydrogenation of vegetable oils to make margarine.
Chlorine is used to make bleaching powder, to disinfect drinking water and to make PVC.
Sodium hydroxide is used to make soap and detergents, paper and artificial fibres.

Step 3: Check row I Hydrogen forms at the cathode and is used as a fuel. Both parts are correct, so row I is correctly matched.

Step 4: Check row II Chlorine does form at the anode, so the middle column is right. But chlorine is not used to make margarine. Margarine is made using hydrogen. So row II is wrong.

Step 5: Check row III Sodium hydroxide is formed near the cathode and is used to make soap. Both parts are correct, so row III is correctly matched.

Step 6: Check row IV Sodium hydroxide forms near the cathode, not near the anode. Also bleaching powder is made from chlorine, not from sodium hydroxide. So row IV is wrong.

Step 7: Conclusion Only rows I and III are correctly matched. This is option B.

Quick Tip to Solve: Remember where each product forms in the electrolysis of brine, and which product is used for which job.

19. Manjeet wants to wash clothes, but the water available is hard. He compares the action of soap and detergent in hard water, to decide which one to use for washing his clothes. He observes:Soap forms scum in hard water.Detergent produces lather easily in hard water.Which of the following inferences is correct? [1 mark]

(A) Ca^{2+} and Mg^{2+} ions react with soap, forming insoluble compounds, whereas detergents do not form such insoluble salts.

(B) Soap is acidic, and detergents are basic.

(C) Soap react with Na^{+} ions in hard water to form scum while detergents do not react with Na^{+} ions.

(D) Detergents form lather easily because they are ionic compounds and react with Ca^{2+} and Mg^{2+} ions while soaps do not react with hard water.

Correct Answer: (A) Ca^{2+} and Mg^{2+} ions react with soap, forming insoluble compounds, whereas detergents do not form such insoluble salts.

Solution:

Step 1: Know what hard water contains Hard water has dissolved calcium and magnesium salts. So it contains Ca^{2+} and Mg^{2+} ions.

Step 2: Know what soap and detergent are Soap is the sodium or potassium salt of a long-chain fatty acid. Detergent is usually the sodium salt of a sulphonic acid or an ammonium salt with a long carbon chain.
Both have a long carbon tail that dissolves in oil and an ionic head that dissolves in water.

Step 3: Explain the observation When soap meets Ca^{2+} or Mg^{2+}, it forms calcium or magnesium soap, which does not dissolve in water:

$$2\,RCOONa + Ca^{2+} \rightarrow (RCOO)_2Ca \downarrow + 2\,Na^{+}$$

This white solid is the scum. It uses up the soap, so less lather forms.
The calcium and magnesium salts of detergents are soluble in water. So no scum forms and the detergent keeps on lathering. This supports option A.

Step 4: Why the other options are wrong Option B is wrong. Soap is a salt of a strong base and a weak acid, so it is mildly basic. A detergent is almost neutral. The scum is not caused by acidity or basicity.
Option C is wrong. Soap is already a sodium salt, so Na^{+} ions cannot make it insoluble. The scum is caused by calcium and magnesium ions.
Option D is wrong. Soaps are ionic too, and soaps do react with hard water. That is exactly why scum forms with soap.

Step 5: Conclusion Calcium and magnesium ions make insoluble salts with soap but not with detergents. This is option A.

Quick Tip to Solve: Think about which ions make hard water hard, and whether their salts with soap and with detergent dissolve.

20. Which of the following salts contain water of crystallisation:
(i) Plaster of Paris, (ii) Washing soda, (iii) Baking soda and (iv) Gypsum. [1 mark]

(A) (i), (ii) and (iii)

(B) (i), (iii) and (iv)

(C) (ii), (iii) and (iv)

(D) (i), (ii) and (iv)

Correct Answer: (D) (i), (ii) and (iv)

Solution:

Concept:

- Water of crystallisation is the fixed number of water molecules present in one formula unit of a salt crystal.
- It is written after a dot in the formula, such as $CuSO_4 \cdot 5H_2O$.

Step 1: Write the formula of each salt (i) Plaster of Paris: $CaSO_4 \cdot \frac{1}{2}H_2O$. It has half a molecule of water per formula unit.
(ii) Washing soda: $Na_2CO_3 \cdot 10H_2O$. It has ten molecules of water.
(iii) Baking soda: $NaHCO_3$. There is no separate water in the formula.
(iv) Gypsum: $CaSO_4 \cdot 2H_2O$. It has two molecules of water.

Step 2: Pick the salts Salts (i), (ii) and (iv) contain water of crystallisation. Baking soda does not. The H in NaHCO3 belongs to the bicarbonate ion. It is not water of crystallisation.

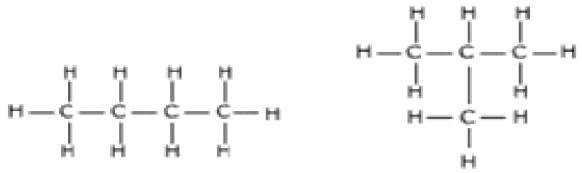
Step 3: Why the other options are wrong Options A, B and C each include (iii) baking soda, which has no water of crystallisation. So all three are wrong. Option D leaves out (iii) and keeps the other three.

Step 4: Conclusion Plaster of Paris, washing soda and gypsum contain water of crystallisation. This is option D.

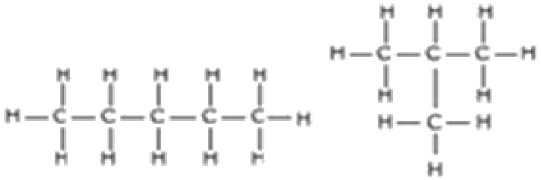
Quick Tip to Solve: Write the chemical formula of each salt and look for water molecules after a dot.

21. Which of the following pair of compounds are isomers? [1 mark]

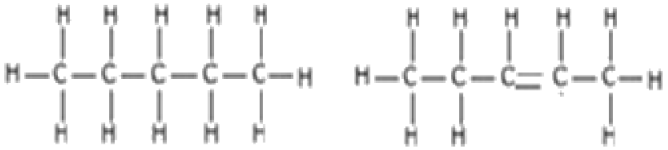
(A) A.



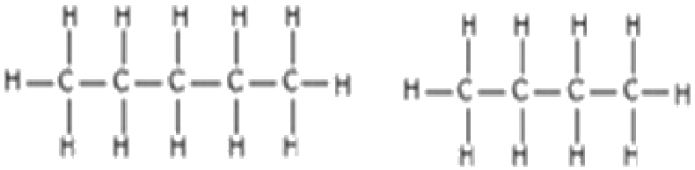
(B) B.



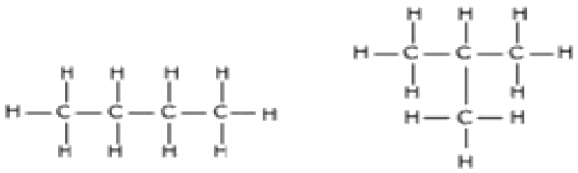
(C) C.



(D) D.



Correct Answer: (A) A.



Solution:

Step 1: Recall what isomers are Isomers are compounds with the same molecular formula but different structures. So first we must count the carbon and hydrogen atoms in each drawing.

Step 2: Count the atoms in option A Left: 4 carbons in a straight chain. Hydrogens: 3 + 2 + 2 + 3 = 10. This is butane, C_4H_{10}.
Right: a chain of 3 carbons with a fourth carbon joined to the middle one. Hydrogens: 3 + 1 + 3 + 3 = 10. This is 2-methylpropane (isobutane), C_4H_{10}.
Same formula, different structure (straight and branched). They are isomers.

Step 3: Check the other options Option B: left is pentane, C_5H_{12}. Right is 2-methylpropane, C_4H_{10}. The formulas differ, so they are not isomers.
Option C: left is pentane, C_5H_{12}. Right has a double bond and the formula C_5H_{10}. It is pentene, so the formulas differ.
Option D: left is pentane, C_5H_{12}. Right is butane, C_4H_{10}. The number of carbons differs, so they are not isomers.

Step 4: Conclusion Only option A shows two compounds with the same molecular formula and different structures. The answer is option A.

Quick Tip to Solve: Count carbons and hydrogens in both structures. Isomers have the same formula but different arrangement.

22. A food label is given below. E304 and E307b are added to the flavoured biscuits.



Which of the following is added to food packets for the same reason? [1 mark]

(A) salt

(B) vinegar

(C) nitrogen

(D) vanilla

Correct Answer: (C) nitrogen

Solution:

Concept:

- On the label, E304 and E307b are listed under the word Antioxidants. So they are added to stop oxidation of the food.
- We have to find another item that is added to food for the same reason.

Step 1: Recall why antioxidants are needed Fats and oils in food react with oxygen of the air and turn rancid. The food then gets a bad smell and taste.
Antioxidants slow down this oxidation, so the food stays fresh for longer.

Step 2: Check each option Salt is a preservative. It stops the growth of microbes by drawing water out of them. It is not mainly added to stop oxidation, so A is wrong.
Vinegar is also a preservative. Its acid keeps microbes away. So B is wrong.
Nitrogen gas is filled in packets of chips and biscuits. It pushes out the oxygen, so the fats in the food cannot get oxidised. This is the same job an antioxidant does. So C is correct.
Vanilla is a flavouring agent. It adds taste and has nothing to do with oxidation. So D is wrong.

Step 3: Conclusion Nitrogen is added to food packets to prevent oxidation, as antioxidants do. This is option C.

Quick Tip to Solve: Antioxidants stop food from reacting with oxygen. Which option does the same job?

23. Electrical wires made of aluminum [1 mark]

(A) corrode easily as aluminium is a very reactive metal.

(B) corrode easily because porous flaky aluminium oxide is formed.

(C) do not corrode easily as aluminium oxide forms a protective layer.

(D) do not corrode easily as aluminium is less reactive than metals like sodium, magnesium and zinc.

Correct Answer: (C) do not corrode easily as aluminium oxide forms a protective layer.

Solution:

Step 1: Recall what happens to aluminium in air Aluminium is a fairly reactive metal. When it is exposed to air, it quickly reacts with oxygen and forms a very thin layer of aluminium oxide:

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

This oxide layer is hard, thin and non-porous. It sticks firmly to the metal surface.

Step 2: Link it to wires The oxide layer blocks air and moisture from reaching the metal below. So the corrosion stops after the first thin layer forms.
This is why aluminium wires last long and do not corrode easily. This is option C.

Step 3: Why the other options are wrong Option A is wrong. Aluminium is reactive, but that is the reason the protective oxide forms. It does not lead to easy corrosion.
Option B is wrong. The oxide of aluminium is not porous or flaky. A flaky, porous layer is typical of rust on iron, which lets corrosion go deeper.
Option D is wrong. Aluminium is more reactive than zinc, not less. Also, reactivity is not the reason for resisting corrosion. The oxide layer is.

Step 4: Conclusion Aluminium wires do not corrode easily because a protective oxide layer forms on them. This is option C.

Quick Tip to Solve: Think about the thin oxide film that forms on aluminium in air.

24. The following question consists of two statements: Assertion (A) and Reason (R). Answer this question by selecting the appropriate option given below.
Assertion (A): Onion extract loses its smell, when it is added to baking soda solution whereas it retains its smell when added to lemon juice.
Reason (R): Onion acts as an olfactory indicator. [1 mark]

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Correct Answer: (B) Both A and R are true, and R is not the correct explanation of A.

Solution:

Step 1: Check the Assertion Baking soda solution is basic and lemon juice is acidic.
Onion extract keeps its smell in an acid, such as lemon juice. It loses its smell in a base, such as baking soda solution. So the assertion is TRUE.

Step 2: Check the Reason An olfactory indicator is a substance whose smell changes in acidic or basic solutions. Onion, vanilla essence and clove oil are common examples.

So the reason is also TRUE.

Step 3: Decide whether R explains A The assertion describes what we observe with onion in a base and an acid. The reason only tells the kind of substance onion is. It does not say why the smell is lost in the base or kept in the acid.
As given in the official marking scheme, R is not the correct explanation of A. So the answer is option B.

Step 4: Why the other options are wrong Option A is wrong because it says R is the correct explanation of A.
Option C is wrong because R is true. Onion is a well-known olfactory indicator.
Option D is wrong because A is true.

Step 5: Conclusion A and R are both true, but R is not the correct explanation of A. This is option B.

Quick Tip to Solve: Check each statement alone first. Then ask whether the reason really explains the assertion.

25. Carbon forms millions of compounds whereas silicon, which is just below it in the Periodic Table, forms a few compounds. Explain the reason for the difference in their ability to form compounds. [2 marks]

Solution:

Concept:

- Carbon and silicon are in the same group (Group 14). Both have 4 valence electrons and both show a valency of 4.
- Yet carbon makes millions of compounds and silicon makes only a few. We must find what is different about the two atoms.

Step 1: Key Idea: Catenation Catenation is the ability of atoms of the same element to join with each other and form long chains, branched chains and rings.
How far catenation goes depends on how strong the bond between two like atoms is.

Step 2: Why carbon forms so many compounds Carbon is in the second period, so its atom is very small. The shared pair of electrons in a C-C bond is held close to both nuclei.
This makes the C-C bond very strong (about 350 kJ per mole) and stable, so long chains do not break easily.
Carbon also forms strong bonds with hydrogen, oxygen, nitrogen and halogens, and it can make double and triple bonds. Chains, branches, rings and isomers are all possible, so the number of compounds is huge.

Step 3: Why silicon forms only a few compounds Silicon is in the third period, so its atom is much bigger. The shared pair in an Si-Si bond is far from the nuclei and is held weakly.
The Si-Si bond is much weaker (about 225 kJ per mole), so long silicon chains break easily and react with water and air.
Silicon therefore shows very limited catenation and forms only a few compounds.

Step 4: Conclusion Carbon has a small size, so it forms strong and stable C-C bonds and shows extensive catenation. Silicon is larger, forms weak Si-Si bonds and shows very little catenation.

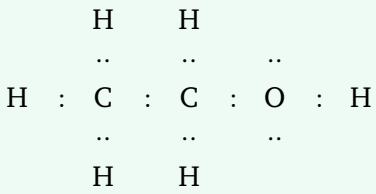
Quick Tip to Solve: Think about the size of the two atoms and the strength of the bond between two like atoms (catenation).

26(A). **An organic compound "X" with formula C_2H_6O is used to blend with petrol in order to reduce the dependence on fossil fuels and lower down the harmful emissions from the cars. It is also used as a solvent in medicines such as tincture iodine, cough syrups and many tonics.**
(i) Draw the electron dot structure of "X".
(ii) Write the name and formula of the next homologue of "X".
(iii) Write the reaction of "X" with acetic acid to form a sweet smelling substance. [3 marks]

Solution:

Step 1: Identify compound X The formula C_2H_6O fits ethanol, C_2H_5OH. Ethanol is blended with petrol (it burns cleanly and cuts the use of fossil fuel) and it is the solvent in tincture iodine and cough syrups.
So X is ethanol.

Step 2: Part (i): Electron dot structure Count the valence electrons: 2 carbon atoms give $2 \times 4 = 8$, 6 hydrogen atoms give 6 and the oxygen atom gives 6. The total is 20 electrons.
Ethanol has 8 covalent bonds: 5 C-H bonds, 1 C-C bond, 1 C-O bond and 1 O-H bond. These use $8 \times 2 = 16$ electrons.
The other $20 - 16 = 4$ electrons stay on oxygen as two lone pairs. Each carbon now has 8 electrons around it and each hydrogen has 2.



Step 3: Part (ii): Next homologue A homologous series is a family of compounds in which each member differs from the next by one CH_2 unit.
Adding one CH_2 to C_2H_5OH gives C_3H_7OH. Its name is propanol (propan-1-ol).

Step 4: Part (iii): Reaction with acetic acid An alcohol and a carboxylic acid react to form an ester. This is called esterification. A few drops of conc. H_2SO_4 are used as a catalyst.
Here ethanol reacts with ethanoic (acetic) acid to give ethyl ethanoate, which has a sweet fruity smell, and water.

$$CH_3COOH + C_2H_5OH \xrightarrow{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

Step 5: Conclusion (i) the dot structure of ethanol is drawn above; (ii) the next homologue is propanol, C_3H_7OH; (iii) ethanol and acetic acid give ethyl ethanoate (ester) and water.

Quick Tip to Solve: Identify X from its formula and uses. Homologues differ by one CH2 unit. Alcohol plus carboxylic acid gives an ester.

OR

26(B). Ramya performs an experiment in the following two steps:
Step 1: Heats ethanol with conc. H_2SO_4 at 170°C to get product A.
Step 2: Passes hydrogen gas over product A, using Ni as a catalyst and gets product B.
(i) Name the products A and B.
(ii) Write the reactions involved in both the steps. [3 marks]

Solution:

Concept:

- Heating ethanol with excess conc. H_2SO_4 at 170°C (443 K) removes one molecule of water from ethanol. This is a dehydration reaction.
- The product has a double bond between the two carbon atoms. So A is ethene, $CH_2 = CH_2$.

Step 1: Understand step 2 Ethene is an unsaturated hydrocarbon. When hydrogen is passed over it with nickel as a catalyst, hydrogen adds across the double bond. This is called hydrogenation or an addition reaction.
The double bond becomes a single bond and the product is the saturated hydrocarbon ethane, CH_3CH_3. So B is ethane.

Step 2: Part (i): Names Product A = ethene.
Product B = ethane.

Step 3: Part (ii): Reactions Step 1 (dehydration):

$$CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4,\ 170^\circ C} CH_2 = CH_2 + H_2O$$

Step 2 (hydrogenation):

$$CH_2 = CH_2 + H_2 \xrightarrow{Ni} CH_3CH_3$$

Step 4: Conclusion A is ethene and B is ethane. Step 1 is dehydration of ethanol and step 2 is hydrogenation of ethene.

Quick Tip to Solve: Conc. sulphuric acid at 170 C removes water from ethanol. Nickel with hydrogen adds hydrogen to a double bond.

27. Give reason for the following:
A. A solution of sports electrolyte drink conducts electricity, but coconut oil does not.
B. Milkiness disappears when excess of carbon dioxide is passed through lime water.
C. An iron bridge near the sea rusts much faster than an iron bridge located in a dry hilly region. [3 marks]

Solution:

Step 1: Reason A: conduction of electricity Electric current in a liquid is carried by moving ions. A sports electrolyte drink has dissolved salts such as sodium and potassium chloride, which split into free ions in water. These ions move and carry current, so the drink conducts.
Coconut oil is made of neutral covalent molecules. It has no free ions or charged particles, so it cannot conduct electricity.

Step 2: Reason B: milkiness of lime water Lime water is calcium hydroxide solution. When a little carbon dioxide is passed, it forms insoluble calcium carbonate, which makes the water milky.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

With excess carbon dioxide, calcium carbonate reacts further with water and carbon dioxide to form calcium hydrogen carbonate, which is soluble in water.

$$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$$

As the insoluble solid dissolves, the milkiness goes away.

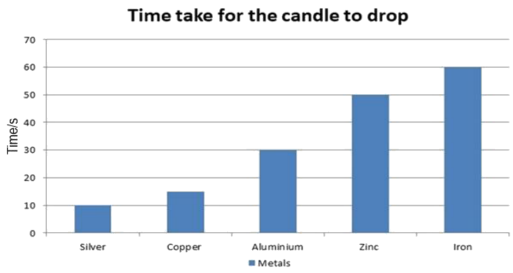
Step 3: Reason C: rusting near the sea Rusting needs both oxygen and moisture. Air near the sea is full of moisture (high humidity), and it also carries salt spray that helps the iron corrode faster.
In a dry hilly region the air has very little moisture, so rusting is slow.

Step 4: Conclusion A: the drink has free ions and the oil has none. B: insoluble CaCO3 changes to soluble Ca(HCO3)2. C: moist sea air speeds up rusting.

Quick Tip to Solve: A needs mobile ions. B is a two-stage reaction of limewater with CO2. C needs moisture for rusting.

28(A). Aavya and Vihan are studying the properties of metals in school. They decide to design and conduct an experiment to test the relative conduction of heat by metals. They use the apparatus (Figure) with rods of five different metals aluminium, silver, copper, iron and zinc attached to a central point. This central point is heated using a burner. The metal rods are of equal length and thickness. They observe that the candles at the end of the rods fall at different times. (Study the graph)





On the basis of the graph obtained, which metal is the best conductor of heat? [1 mark]

Solution:

Concept:

- Each candle is stuck at the end of a metal rod with wax. The candle drops when the heat has travelled along the rod and melted the wax.
- So the shorter the time to drop, the faster heat moves along that rod, and the better that metal is as a conductor of heat.

Step 1: Read the graph Time taken: silver 10 s, copper 15 s, aluminium 30 s, zinc 50 s, iron 60 s.
Silver has the smallest time (10 s), so heat flows fastest through silver.

Step 2: Conclusion Silver is the best conductor of heat because its candle dropped first, after only 10 s.

Quick Tip to Solve: The metal whose candle drops in the least time conducts heat fastest.

28(B). Gold is a better conductor of heat than aluminium but it is not as good as copper. The time taken for the candle to drop if one of the rods were made of gold would have been: [1 mark]

(A) 15 s

(B) 20 s

(C) 35 s

(D) 10 s

Correct Answer: (B) 20 s

Solution:

Step 1: Place gold on the conductivity order Better conductor means shorter drop time. From the graph, copper takes 15 s and aluminium takes 30 s.
Gold is better than aluminium, so its time is less than 30 s. Gold is not as good as copper, so its time is more than 15 s.

Step 2: Fix the range So the time for gold lies between 15 s and 30 s, that is $15 \text{ s} < t < 30 \text{ s}$. Among the options only 20 s fits.

Step 3: Why the other options are wrong Option (i) 15 s: this is the time for copper. Gold is not as good as copper, so its time must be longer than 15 s.
Option (iii) 35 s: this is more than 30 s (aluminium). Gold would then be worse than aluminium, which contradicts the statement.
Option (iv) 10 s: this is the time for silver. Gold is poorer than copper, so it cannot match silver.

Step 4: Conclusion The time for gold must lie between that of copper (15 s) and aluminium (30 s). Only option (ii) 20 s is in this range.

Quick Tip to Solve: Better conductor means shorter time. Gold must lie between copper (15 s) and aluminium (30 s).

28(C). Attempt either sub-part C or D.

The length of all the metal rods is increased by 20% without any change in the thickness. Will the time required for the candles to drop be affected? How and why? [2 marks]

Solution:

Step 1: Decide what changes Only the length of every rod is increased. The thickness, the metals and the heating are unchanged.

Step 2: Explain how conduction happens In conduction, particles at the hot end vibrate faster and pass the energy to the next particles, and this goes on along the rod. The particles themselves do not travel along the rod.

Step 3: Effect of a longer rod Heat now has to cover a longer distance to reach the candle end, so it needs more time to melt the wax. So yes, the time for the candles to drop will increase for every metal.
All rods are made longer by the same fraction, so the metals keep the same order. Silver still drops first and iron last.

Step 4: Conclusion Yes, the time will increase for all metals because heat has to travel through a longer distance, but the order of dropping stays the same.

Quick Tip to Solve: Heat has to travel through the rod. What happens to the time if the distance is longer?

OR

28(D). Mayank tries the experiment with an apparatus similar to figure (1). He ensures the length of all metal rods is the same. However, the thickness of rods is not the same in his apparatus. Will the inference he draws on the basis of his experiment be correct? Justify your answer. [2 marks]

Solution:

Step 1: Recall the rule for a fair test To compare metals, only one factor (the type of metal) may change. Length and thickness of the rods must be the same for every metal.

Step 2: Look at Mayank's set up Mayank keeps the length equal but uses rods of different thickness. Now two things differ between the rods: the metal and the thickness.

Step 3: Decide A thicker rod holds more metal and takes more time to carry the heat to its end. So the drop time depends on thickness as well as on the metal.
We cannot tell whether a short drop time is due to a better conductor or just a thinner rod. So his inference will not be correct.

Step 4: Conclusion No. The inference will not be correct because the rods must have the same dimensions. A thicker rod will take more time to conduct heat.

Quick Tip to Solve: In a fair test only one factor may change. Which two factors differ here?

29(A). I. Refer to the dialogue between Alisha, Drishti and Bhushan in the chemistry lab. They are discussing rusting of iron and formation of ammonia gas. Who all do you agree with and why?
Alisha: The formation of ammonia by reaction of nitrogen with hydrogen is a reduction reaction.
Dristhi: Both rusting of iron and formation of ammonia are redox reactions.
Bhushan: Rusting of iron is an oxidation reaction.
II. Assess the following chemical equations. Identify the error(s) and rewrite the equation after correction.
(i) $MgCl_2 + AgNO_3 \rightarrow AgCl_2 + MgNO_3$
(ii) $Al + H_2SO_4 \rightarrow Al_2SO_4 + H_2O$ [5 marks]

Solution:

Step 1: Recall the meaning of the terms Oxidation is the gain of oxygen or loss of hydrogen (or electrons). Reduction is the loss of oxygen or gain of hydrogen (or electrons). A redox reaction is one in which oxidation and reduction happen together. One cannot occur without the other.

Step 2: Part I: Check Alisha In $N_2 + 3H_2 \rightarrow 2NH_3$, nitrogen gains hydrogen, so nitrogen is reduced. This part of her statement is true.
But hydrogen is oxidised in the same reaction (its oxidation number goes from 0 to +1). So the reaction is a redox reaction, not just a reduction. Alisha is only partly correct.

Step 3: Part I: Check Bhushan In rusting, iron combines with oxygen, so iron is oxidised. This is true. But oxygen is reduced at the same time, so rusting is also a redox reaction. Bhushan is only partly correct.

Step 4: Part I: Check Drishti Drishti says both reactions are redox reactions. In ammonia formation nitrogen is reduced and hydrogen is oxidised. In rusting iron is oxidised and oxygen is reduced. So Drishti is fully correct.

Step 5: Part II (i): Correct the equation Errors: silver chloride is $AgCl$ (not $AgCl_2$, because Ag is $+1$ and Cl is -1). Magnesium nitrate is $Mg(NO_3)_2$ (not $MgNO_3$, because Mg is $+2$). The equation is also not balanced.
Atom count after correcting the formulae: Mg 1, Cl 2, Ag 1, N 2 on the right side but Ag 1 and N 1 on the left side. Put 2 before $AgNO_3$ and 2 before $AgCl$.

$$MgCl_2 + 2AgNO_3 \rightarrow 2AgCl + Mg(NO_3)_2$$

Step 6: Part II (ii): Correct the equation Errors: aluminium sulphate is $Al_2(SO_4)_3$ (Al is $+3$ and sulphate is -2). Also a metal reacting with a dilute acid gives hydrogen gas, not water.
Balance: 3 sulphate groups on the right need 3 H_2SO_4 on the left, and 2 Al atoms need 2 Al on the left. 3 H_2SO_4 give 6 H, so 3 H_2 are formed.

$$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$$

Step 7: Conclusion Drishti is correct. Alisha and Bhushan are only partially correct because oxidation and reduction always go together. Corrected equations: (i) MgCl2 + 2AgNO3 gives 2AgCl + Mg(NO3)2; (ii) 2Al + 3H2SO4 gives Al2(SO4)3 + 3H2.

Quick Tip to Solve: Oxidation and reduction always occur together. Correct the formulae using valency, then balance.

OR

29(B). I. Refer to the dialogue between Daljeet and Avik in the chemistry lab. They have learnt about decomposition reactions. Who has understood decomposition reactions correctly? Justify your answer.
Daljeet: During a decomposition reaction, a substance decomposes to give two simpler compounds. $MgCO_3$ decomposes on heating to magnesium oxide and carbon dioxide.
Avik: No, during a decomposition reaction, a substance decomposes to give two elements. Water on electrolysis gives hydrogen and oxygen, both are elements.
II. Analyse the observations given in following two cases. Are these observations correct? Give reasons to support your answer.
(i) Iron fillings are added to an aqueous solution of magnesium sulphate.
Observation: The colourless solution turns greenish due to formation of iron sulphate.
(ii) Aluminium metal is added to dilute sulphuric acid
Observation: Brisk effervescence are seen due to evolution of a gas. [5 marks]

Solution:

Step 1: Recall what a decomposition reaction is In a decomposition reaction a single compound breaks down into two or more simpler substances. The products can be elements, compounds, or a mix of both. There is no rule that they must be two compounds or two elements.

Step 2: Part I: Check Daljeet Daljeet's example is correct. $MgCO_3 \rightarrow MgO + CO_2$ gives two compounds, so it is a decomposition.
But his general statement is incomplete. Products can also be elements, so he has understood only part of the idea.

Step 3: Part I: Check Avik Avik's example is correct. Electrolysis of water gives hydrogen and oxygen, which are elements, and it is also a decomposition.
But he is wrong to say the products must be two elements. Daljeet's example shows compounds can

form too. So Avik has also understood only part of the idea.
Both students are partially correct.

Step 4: Part II (i): Iron and magnesium sulphate A more reactive metal displaces a less reactive metal from its salt solution. Magnesium is more reactive than iron.
So iron cannot displace magnesium from magnesium sulphate. No reaction takes place and the solution stays colourless. The observation is incorrect.

Step 5: Part II (ii): Aluminium and dilute sulphuric acid Aluminium reacts with dilute sulphuric acid and gives hydrogen gas.

$$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$$

Hydrogen is released as a few bubbles. Brisk effervescence is what we see when carbon dioxide is released, for example when a carbonate meets an acid. So the observation, as stated, is incorrect.

Step 6: Conclusion Both Daljeet and Avik have partially understood decomposition. Observation (i) is incorrect because iron is less reactive than magnesium. Observation (ii) is incorrect because hydrogen gives only few bubbles; brisk effervescence is seen with carbon dioxide.

Quick Tip to Solve: A decomposition starts from one compound and may give elements or compounds. Use the reactivity series for part II.

Section C: Physics (25 marks)

30. A student wants to determine the focal length of a convex lens using sunlight. Which of the following practical procedures will give the most accurate result? [1 mark]

(A) Move the lens close to a wall and measure the blurred circle.

(B) Hold the lens above a sheet of paper and adjust until the smallest, brightest spot is formed.

(C) Measure the thickness of the lens with a scale.

(D) Look through the lens at a distant object.

Correct Answer: (B) Hold the lens above a sheet of paper and adjust until the smallest, brightest spot is formed.

Solution:

Concept:

- The focal length f of a convex lens is the distance from the optical centre to the point where parallel rays meet after refraction.
- Sunlight comes from a very far away source, so its rays are almost parallel.
- The sharp point where they meet is the principal focus.

Step 1: Know the method Hold the lens so that sunlight passes through it. Place a sheet of paper behind the lens. Move the lens up and down until the spot on the paper is the smallest and brightest. The distance between the lens and the paper is then the focal length. Measuring it with a scale gives a good value.

Step 2: Check option A A blurred circle means the paper is not at the focus. The rays have not yet met, or have already crossed and spread out. The size of a blurred circle depends on the paper position, so it does not give the focal length. Option A is wrong.

Step 3: Check option B The smallest and brightest spot is the real image of the sun. It forms exactly

at the principal focus. This is the correct practical method, so option B is right.

Step 4: Check options C and D Option C measures the thickness of the lens. The thickness does not equal the focal length, because f also depends on the radii of curvature and the refractive index. Option D only forms an image in the eye. It gives no measurable distance. Both options are wrong.

Step 5: Conclusion The smallest, brightest spot on the paper marks the focus, so the distance from the lens to the paper gives the focal length. This is option (B).

Quick Tip to Solve: Sunlight gives parallel rays. Where do parallel rays meet after passing through a convex lens?

31. An electrical appliance rated 1000 W is operated at 250 V. What current does it draw? [1 mark]

(A) 0.25 A

(B) 2.5 A

(C) 4.0 A

(D) 10 A

Correct Answer: (C) 4.0 A

Solution:

Concept:

- The appliance is rated 1000 W, so its power is $P = 1000$ W.
- It runs at $V = 250$ V.
- We need the current I it draws.

Step 1: Choose the formula Electric power is the product of voltage and current:

$$P = V \times I$$

So the current is $I = \dfrac{P}{V}$.

Step 2: Substitute the values

$$I = \frac{1000}{250} = 4 \text{ A}$$

Step 3: Why the other options are wrong Option A (0.25 A) comes from dividing the other way round, $250/1000 = 0.25$. That is V/P, which is not a current. Option B (2.5 A) and option D (10 A) do not match $1000/250$. Option D would be right only for a 2500 W appliance at 250 V. Only 4.0 A satisfies $P = VI$. So option C is correct.

Step 4: Conclusion The appliance draws a current of 4 A, which is option (C).

Quick Tip to Solve: Use $P = VI$ and solve for I.

32. Assertion (A): The apparent depth of a coin in water is less than its real depth.
Reason (R): Light bends away from the normal when it travels from water to air. [1 mark]

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Correct Answer: (A) Both A and R are true, and R is the correct explanation of A.

Solution:

Concept:

- The assertion says the apparent depth of a coin in water is less than its real depth.
- This is true.
- A coin at the bottom of a tank looks raised, so the water looks shallower than it really is.

Step 1: Read the reason The reason says light bends away from the normal when it goes from water to air. Water is denser than air, so light speeds up when it leaves the water. When light goes from a denser to a rarer medium, it bends away from the normal. So the reason is also true.

Step 2: Check if R explains A Rays from the coin bend away from the normal at the water surface. The eye traces these bent rays straight back and sees the coin at a point higher than the real one. So the coin looks closer to the surface. The bending in R is exactly what causes the effect in A. So R explains A.

Step 3: Check the other options Option B is wrong because R does explain A. Option C is wrong because R is true. Option D is wrong because A is true. The correct choice is option A.

Step 4: Conclusion Both A and R are true and R explains A, so the answer is option (A).

Quick Tip to Solve: Think about which way the rays bend when they leave water, and where the eye thinks the coin is.

33. A. State Snell's Law of refraction.
B. Define the refractive index of a material with respect to another material giving the mathematical expression. [2 marks]

Solution:

Step 1: Part A: Snell's law of refraction When light goes from one medium to another, it bends at the surface. Snell's law gives the rule for this bending. It says that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for light of a given colour and for a given pair of media.

Step 2: Write the law as an expression If i is the angle of incidence and r is the angle of refraction, then

$$\frac{\sin i}{\sin r} = \text{constant}$$

Step 3: Part B: Refractive index Take a ray going from medium 1 to medium 2. Let v_1 be the speed of light in medium 1 and v_2 the speed of light in medium 2. The refractive index of medium 2 with respect to medium 1 is the ratio of the speed of light in medium 1 to its speed in medium 2.

Step 4: Write the expression

$$n_{21} = \frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

The constant in Snell's law is this refractive index. It has no unit because it is a ratio of two speeds.

Step 5: Conclusion Snell's law: $\frac{\sin i}{\sin r}$ is constant for a given pair of media and a given colour of light. Refractive index: $n_{21} = \frac{v_1}{v_2}$.

Quick Tip to Solve: Snell's law relates the sines of the two angles. The refractive index compares the speeds of light in the two media.

34(A). I. State Joule's Law of heating.
II. What happens to the heat produced in a conductor if the resistance is doubled while keeping other variables constant? [2 marks]

Solution:

Step 1: Part I: Joule's law of heating When a current flows in a resistor, electrical energy changes to heat. Joule's law says that the heat produced in a resistor is: (i) directly proportional to the square of the current, for a given resistance; (ii) directly proportional to the resistance, for a given current; and (iii) directly proportional to the time for which the current flows.

Step 2: Write the formula Combining the three statements:

$$H = I^2Rt$$

where I is the current, R is the resistance and t is the time.

Step 3: Part II: Double the resistance Keep I and t the same and change R to $2R$. The new heat is

$$H' = I^2(2R)t = 2I^2Rt = 2H$$

Step 4: Read the result The new heat is twice the old heat. So if the resistance is doubled with the other variables constant, the heat produced also doubles.

Step 5: Conclusion Joule's law gives $H = I^2Rt$. If the resistance is doubled, the heat produced is doubled.

Quick Tip to Solve: Recall $H = I^2Rt$ and replace R by $2R$.

OR

34(B). I. Define resistivity.
II. Justify with an example why resistivity is an intrinsic property of a material. [2 marks]

Solution:

Step 1: Part I: Define resistivity The resistance of a wire depends on its length L and cross-sectional area A. It is given by

$$R = \frac{\rho L}{A}$$

where ρ is a constant for the material. This ρ is called the resistivity. It is the resistance of a wire of the material that has unit length and unit cross-sectional area.

Step 2: Find the unit Rearranging gives $\rho = \frac{RA}{L}$. So the unit is ohm times metre squared divided by metre, which is ohm metre (Ω m).

Step 3: Part II: Take an example Take two copper wires. Wire 1 has $L = 1$ m and $A = 1$ mm^2 $= 10^{-6}$

m^2, and its resistance is about $1.7 \times 10^{-2}\ \Omega$. Wire 2 has $L = 2$ m and the same area, and its resistance is about $3.4 \times 10^{-2}\ \Omega$.

Step 4: Calculate rho for both wires Wire 1: $\rho = \dfrac{RA}{L} = \dfrac{1.7 \times 10^{-2} \times 10^{-6}}{1} = 1.7 \times 10^{-8}\ \Omega\,\text{m}$.

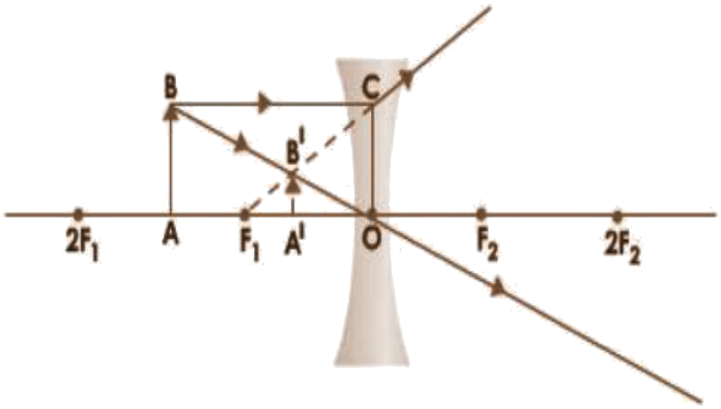
Wire 2: $\rho = \dfrac{3.4 \times 10^{-2} \times 10^{-6}}{2} = 1.7 \times 10^{-8}\ \Omega\,\text{m}$.

Step 5: Conclusion The resistance changed when the length changed, but the resistivity stayed the same. So resistivity depends only on the material (and on temperature), not on the size or shape of the wire. That is why it is an intrinsic property of a material.

Step 6: Conclusion Resistivity $\rho = \dfrac{RA}{L}$ depends only on the material, so it is an intrinsic property.

Quick Tip to Solve: Start from $R = \rho L/A$ and see what happens to RA/L when the wire size changes.

35.



A concave lens forms an image that is 1/3rd the size of the object, as shown in the diagram. If the object is placed 24 cm in front of the lens, determine:
A. the type of lens.
B. the image distance
C. the focal length of the lens [3 marks]

Solution:

Step 1: Part A: Identify the type of lens The figure shows a lens that is thinner at the centre and thicker at the edges. The ray parallel to the axis leaves the lens as if it came from the focus F_1 on the object side. The ray through the optical centre goes straight. These rays spread out. A lens that spreads parallel rays is a concave (diverging) lens. It always forms a virtual, erect and diminished image. So the lens is concave.

Step 2: Part B: Set up the magnification Magnification $m = \dfrac{h_i}{h_o} = \dfrac{v}{u}$. The image is 1/3rd the size of the object. A concave lens gives an erect image, so m is positive:

$$m = +\frac{1}{3}$$

The object is 24 cm in front of the lens. By the sign convention, $u = -24$ cm.

Step 3: Find the image distance

$$v = m \times u = \frac{1}{3} \times (-24) = -8\ \text{cm}$$

The negative sign shows that the image is on the same side of the lens as the object. It is virtual and lies 8 cm from the lens.

Step 4: Part C: Use the lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Put $v = -8$ cm and $u = -24$ cm:

$$\frac{1}{f} = \frac{1}{-8} - \frac{1}{-24} = -\frac{1}{8} + \frac{1}{24} = \frac{-3+1}{24} = -\frac{2}{24} = -\frac{1}{12}$$

Step 5: Read the focal length

$$f = -12 \text{ cm}$$

The negative sign again confirms a concave lens. The image at 8 cm lies between the focus (12 cm) and the lens, which matches the figure where B' is between F_1 and O.

Step 6: Conclusion The lens is concave, the image distance is -8 cm and the focal length is -12 cm.

Quick Tip to Solve: The image is erect, so $m = +1/3$. Use $v = mu$ and then the lens formula.

36. A. State the Right-Hand Thumb Rule and describe how it helps determine the direction of magnetic field around a current-carrying conductor.
B. Explain how the magnetic field changes with distance from the conductor. [3 marks]

Solution:

Concept:

- A straight wire carrying current produces a magnetic field around it. This field is not along the wire. It forms closed circles around the wire, in a plane at right angles to the wire.
- The question asks two things. Part A asks for a rule that tells us which way these circles point. Part B asks how strong the field is as we move away from the wire.

Step 1: State the Right-Hand Thumb Rule (Part A) Imagine holding the current-carrying straight conductor in your right hand. Keep the thumb stretched out along the wire.
The thumb must point in the direction of the conventional current. Then the curled fingers wrap around the wire.
The way the fingers curl gives the direction of the magnetic field lines around the conductor.

Step 2: How the rule gives the direction of the field Take a vertical wire with current going upward. Point the right thumb upward.
The fingers then curl anticlockwise when we look at the wire from above. So the field lines are anticlockwise circles around the wire.
If the current is reversed, the thumb points down. The fingers now curl clockwise, so the field direction also reverses.
So the rule lets us find the direction of the field at any point near the wire without doing an experiment.

Step 3: Variation of the field with distance (Part B) The magnetic field around a long straight conductor at a distance r from it is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

Here I is the current and μ_0 is a constant. For a fixed current, this gives

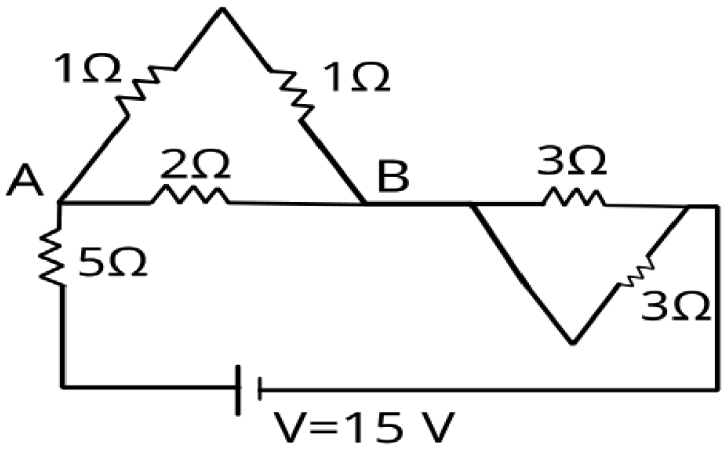
$$B \propto \frac{1}{r}$$

So the field is strongest very close to the wire. It becomes weaker as we move away, and it falls in inverse proportion to the distance.
If the distance is doubled, the field becomes half. In a diagram, the concentric circles are drawn farther apart as we move outward, which shows the weaker field.

Step 4: Conclusion Part A: with the thumb of the right hand along the current, the curled fingers show the direction of the field lines. Part B: the field is inversely proportional to the distance, so it decreases as we move away from the conductor.

Quick Tip to Solve: Hold the wire in your right hand with the thumb along the current. For part B recall that the field of a straight wire is inversely proportional to distance.

37.



The figure shows a circuit with a 15 V battery connected to several resistors. Using the given circuit diagram:
A. Find the total current supplied by the battery.
B. Calculate the potential difference between points A and B. [3 marks]

Solution:

Concept:

- Between A and B there are three paths: the 1 Ω and 1 Ω resistors joined one after the other, and the 2 Ω resistor. After B there are two 3 Ω resistors which are joined across the same two points. The 5 Ω resistor and the battery complete the loop.
- We shall reduce each part to one resistance. Then we will add the resistances that are in series.

Step 1: Combine the two 1 ohm resistors The two 1 Ω resistors are in series, because the same current passes through both.

$$R_1 = 1 + 1 = 2\ \Omega$$

Step 2: Find the resistance between A and B This 2 Ω combination is in parallel with the 2 Ω resistor, because both are joined across A and B.

$$\frac{1}{R_{AB}} = \frac{1}{2} + \frac{1}{2} = 1$$

$$R_{AB} = 1\ \Omega$$

Step 3: Combine the two 3 ohm resistors The two 3 Ω resistors share the same two end points, so they are in parallel.

$$\frac{1}{R'} = \frac{1}{3} + \frac{1}{3} = \frac{2}{3}$$

$$R' = 1.5\ \Omega$$

Step 4: Total resistance of the circuit The 5 Ω resistor, the block R_{AB} and the block R' carry the same current, so they are in series.

$$R_s = 5 + 1 + 1.5 = 7.5\ \Omega$$

Step 5: Current supplied by the battery (Part A) Use Ohm's law, $V = IR$.

$$I = \frac{V}{R_s} = \frac{15}{7.5} = 2\ \text{A}$$

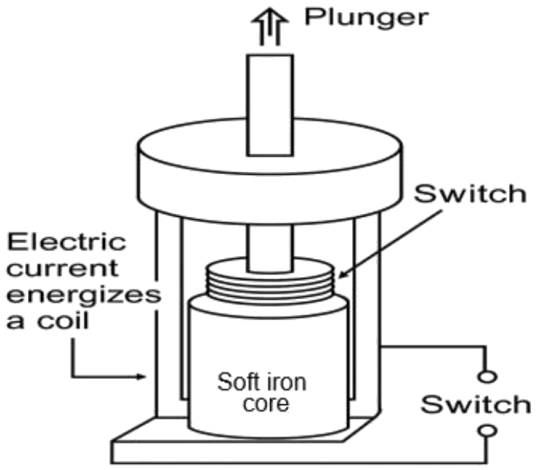
Step 6: Potential difference between A and B (Part B) The whole 2 A current flows through the block between A and B, whose resistance is 1 Ω.

$$V_{AB} = I \times R_{AB} = 2 \times 1 = 2\ \text{V}$$

Step 7: Conclusion The total current is 2 A and the potential difference between A and B is 2 V.

Quick Tip to Solve: Reduce the 1 + 1 ohm series pair, then the parallel groups, then add everything in series. Use V = IR for the A to B block.

38(A). A school has installed an automatic electromagnetic door-locking system at the main entrance. The locking mechanism uses a solenoid controlled by a switch at the security desk. When electricity flows through the solenoid, it creates a magnetic field strong enough to pull an iron bolt, unlocking the door.
As soon as the switch is turned off, the magnetic field disappears, and a spring pushes the bolt back, locking the door.



Why is an iron core kept inside the solenoid in this locking mechanism? [1 mark]

Solution:

Concept:

- A solenoid is a long coil of wire.
- When current flows in it, it makes a magnetic field like that of a bar magnet.
- The question asks why a soft iron core is kept inside this coil.

Step 1: What the iron core does Iron is a magnetic material. When it is placed inside the coil, the field of the coil magnetises it. The iron then adds its own strong field to the field of the coil.
The field lines get concentrated inside the iron core, so the total magnetic field becomes many times stronger than with an empty (air) core.

Step 2: Why this helps the door lock A stronger field gives a stronger pull on the iron bolt (plunger). So the bolt moves in quickly and surely, and the door unlocks even with a modest current.
The core is made of soft iron on purpose. Soft iron loses its magnetism as soon as the current stops. So when the switch is off, the bolt is free and the spring can push it back to lock the door.

Step 3: Conclusion The soft iron core concentrates and strengthens the magnetic field of the solenoid, so the pull on the bolt is much stronger. Being soft iron, it loses magnetism when the current is switched off.

Quick Tip to Solve: Think of what iron does to the field when kept inside a current-carrying coil.

38(B). How can we determine the magnetic poles in this solenoid? [1 mark]

Solution:

Concept:

- A solenoid acts like a bar magnet.
- One end behaves as a north pole and the other as a south pole.
- The poles depend on the direction of the current in the coil.

Step 1: Method 1: Right-Hand Thumb Rule for a coil Curl the fingers of your right hand along the direction of the current in the turns of the coil.
The stretched thumb then points toward the north pole of the solenoid. The end from which the thumb points away is the south pole.

Step 2: Method 2: Clock face rule Look at one end of the solenoid. If the current flows anticlockwise there, that end is the north pole. If it flows clockwise, that end is the south pole.

Step 3: Method 3: Test with a magnet Bring the known north pole of a bar magnet near one end of the solenoid while current flows.
If that end repels the north pole of the bar magnet, it is a north pole. If it attracts it, the end is a south pole.
A small compass needle can be used in the same way. Its north end is attracted to the south pole of the solenoid.

Step 4: Conclusion The poles are found with the Right-Hand Thumb Rule: curl the fingers in the direction of current and the thumb points to the north pole. A bar magnet can confirm it, because repulsion marks the north pole.

Quick Tip to Solve: Use the Right-Hand Thumb Rule for a coil, or test each end with a bar magnet whose north pole is known.

38(C). If the current in the solenoid is increased from 1 A to 2 A, explain how the magnetic effect changes and its effect on unlocking the door. [2 marks]

Solution:

Concept:

- The magnetic field inside a solenoid is produced by the current in its turns.
- The strength of this field depends on the current, the number of turns per unit length and the core material.

Step 1: Key Formula or Approach For a solenoid, $B = \mu_0 nI$, where n is the number of turns per unit length. For the same coil, n does not change, so $B \propto I$.

Step 2: Effect of changing the current from 1 A to 2 A The current is doubled, so the magnetic field inside the solenoid also doubles.

$$\frac{B_2}{B_1} = \frac{I_2}{I_1} = \frac{2}{1} = 2$$

Step 3: Effect on unlocking the door A stronger field makes a stronger magnetic pull on the iron bolt. The bolt is drawn in faster and more firmly against the spring.
So the door unlocks more effectively and more reliably. Even if the spring is stiff or the bolt is a little rusty, the pull is large enough to move it.

Step 4: Conclusion On increasing the current from 1 A to 2 A, the magnetic field doubles because B is directly proportional to I. The stronger pull unlocks the door more effectively.

Quick Tip to Solve: Field of a solenoid is directly proportional to the current in it.

OR

38(D). If the source of the current is fixed, how can we increase the magnetic field in the solenoid? [2 marks]

Solution:

Concept:

- The current source is fixed, so the current I cannot be changed.
- We can still change the coil itself.
- The field inside a long solenoid is $B = \mu_0 nI$, where n is the number of turns per unit length.

Step 1: Increase the number of turns Wind more turns of wire on the same length. The number of turns per unit length n rises, so B rises. Each turn adds its own field, and they all add up inside the coil.

Step 2: Reduce the length of the coil Keep the same number of turns but wind them closer in a shorter length. Then $n = N/L$ becomes larger, so the field becomes larger.

Step 3: Insert a soft iron core Place a soft iron rod inside the solenoid. The iron gets magnetised and concentrates the field lines, which makes the field many times stronger.

Step 4: Conclusion With the current fixed, the field can be increased by increasing the number of turns, reducing the length of the coil (more turns per unit length), or inserting a soft iron core. Any two points are enough.

Quick Tip to Solve: With the current fixed, think about the coil's turns per unit length and the core material.

39(A). A.

I. What is meant by accommodation of the human eye?

II. What is the near point of a normal eye and what does it signify?

III. Name which type of lens is used to correct the defect in which a person cannot see distant objects clearly.

IV. Draw a diagram to show how the choice of your lens in (d) helps to see distant objects clearly? [5 marks]

Solution:

Step 1: Part I: Accommodation The eye lens is flexible and its curved surfaces can change. The ciliary muscles make the lens thicker or thinner.
Accommodation is the ability of the eye lens to change its focal length so that objects at different distances are focused clearly on the retina.
For a near object the lens becomes thicker (shorter focal length). For a far object it becomes thinner (longer focal length).

Step 2: Part II: Near point The near point is the nearest point at which an object can be seen clearly without strain. For a normal adult eye it is about 25 cm from the eye.
It signifies the least distance of distinct vision. An object closer than this looks blurred, because the eye lens cannot become thick enough to focus it.

Step 3: Part III: Lens for the defect A person who cannot see distant objects clearly has myopia (short-sightedness). In this eye the image of a far object forms in front of the retina.
A concave (diverging) lens is used to correct myopia.
A convex lens is not used here. It would bring the rays even closer and the image would form still farther in front of the retina.

Step 4: Part IV: Diagram Draw the eyeball with the eye lens and the retina. On the left of the eye, draw a concave lens in front of the eye lens.
Draw parallel rays from a distant object O, shown as a dashed line to the right, falling on the concave lens. The concave lens spreads the rays out (diverges them).
These rays then enter the eye and the eye lens bends them. Draw them meeting at a point on the retina.
Label: concave lens, eye lens, retina, distant object O. The dashed extensions of the diverging rays go back to the far point of the myopic eye.

Step 5: Why the concave lens helps The concave lens makes the rays from a far object appear to come from the far point of the myopic eye. This point is closer than infinity, and the eye can focus it. So the image now falls on the retina and the person sees the distant object clearly.

Step 6: Conclusion I. Accommodation is the ability of the eye lens to change its focal length. II. The near point is about 25 cm, the closest distance of clear vision. III. A concave lens corrects myopia. IV. The diagram shows the concave lens in front of the eye bringing the image to the retina.

Quick Tip to Solve: Recall the defect in which far objects look blurred (myopia) and the lens that spreads the rays before they enter the eye.

OR

39(B). B.

I. What is dispersion of light?

II. Which colour of light deviates the least during dispersion through a prism?

III. State why the sky appears dark to an astronaut in outer space.

IV. Draw a simple labelled diagram to show how white light splits into different colours while passing through a glass prism. [5 marks]

Solution:

Step 1: Part I: Dispersion White light is a mixture of seven colours (violet, indigo, blue, green, yellow, orange, red). Each colour has its own wavelength and its own speed in glass, so each bends by a different amount.
The splitting of white light into its component colours on passing through a prism is called dispersion of light.

Step 2: Part II: Colour that deviates the least In glass, red light travels fastest and has the longest wavelength. It has the smallest refractive index, so it bends the least.
Violet has the shortest wavelength and bends the most. So red deviates the least.

Step 3: Part III: Dark sky in outer space On the earth, the sky is bright and blue because the air has gas molecules and fine particles that scatter sunlight in all directions.
In outer space there is no atmosphere. Nothing is there to scatter the sunlight toward the eyes of the astronaut, so the sky looks dark.

Step 4: Part IV: Diagram Draw a triangular glass prism. Mark a ray of white light falling on one side, and label it white light beam.
Show it bending toward the normal as it enters the prism. Inside the prism it begins to split into colours. On leaving the second face it bends away from the normal, and the colours spread more.
Show a spectrum on a screen with the colours in this order from the base side to the top: violet, indigo, blue, green, yellow, orange, red. Label V at the bottom (bent the most) and R at the top (bent the least).
Label the glass prism, the white light beam and the spectrum.

Step 5: Conclusion I. Dispersion is the splitting of white light into its colours. II. Red deviates the least. III. There is no atmosphere in space to scatter sunlight, so the sky looks dark. IV. A prism diagram shows violet bending most and red least.

Quick Tip to Solve: Think of how each colour bends in glass and what makes the sky look bright on the earth.