PROVE UFFICIALI DEGLI ANNI PASSATI

IMAT

2023

A B ✓ D E

SVOLTA CON SOLUZIONI COMMENTATE

Il perché di ogni risposta

WHAT'S IN THIS DOCUMENT

Prova di ammissione IMAT 2023, pubblicata dal Ministero dell'Università e della Ricerca (accessoprogrammato.mur.gov.it). Versioni, soluzioni e commenti di TestBuddy, che non è collegata al Ministero.

- The questions with the answers in random order
- Under each question the correct answer and why every other answer is wrong

Reading skills and knowledge acquired during studies	4 questions
Logical reasoning and problem-solving	3 questions
Questions	44 questions
Biology	1 questions
Chemistry	2 questions
Physics and Mathematics	5 questions
Total	**59 questions**

This version has **59 of the 60 questions** of the paper, the ones with our explained solution; the full paper is in the «official paper» file.

HOW TO USE IT

1 · TIMED

Give yourself about a minute and a half per question, no notes, as in the exam.

2 · CHECK

Mark the wrong answers and read why each one is wrong, not only the right one.

3 · REVIEW

Go back to the topics where you made most mistakes and redo the questions in the app.

READING SKILLS AND KNOWLEDGE ACQUIRED DURING STUDIES

1 **Preliminary global average temperatures taken so far in June are nearly 1C (1.8F) above levels previously recorded for the same month, going back to 1979. While the month is not yet complete and may not set a new June record, climate scientists say it follows a pattern of strengthening global heating that could see this year named the hottest ever recorded, topping 2016.**
The long-term warming conditions caused by the burning of fossil fuels will likely receive a further pulse of heat via El Niño, a naturally reoccurring phenomenon where sections of the Pacific Ocean heat up, typically causing temperatures to spike across the world.
According to the text, which one of the following is true?

- **A** **The June temperature this year is consistent with an observed trend.**
- **B** Temperatures in June are not related to the El Niño phenomenon.
- **C** The El Niño phenomenon limits the effects of burning fossil fuels.
- **D** This year, June will be the hottest month on record since 1979.
- **E** June 1979 was the hottest month to date.

Correct answer: A

The preliminary temperature data for June aligns with a long-term **strengthening global heating** trend. Scientists observe that this early spike continues a consistent pattern of rising averages since 1979.

Why the other answers are wrong

- **B) Temperatures in June are not related to the El Niño phenomenon.**: Global atmospheric conditions respond directly to Pacific sea surface changes. Warmer equatorial waters trigger temperature increases across different regions.
- **C) The El Niño phenomenon limits the effects of burning fossil fuels.**: Natural ocean cycles act as amplifiers rather than buffers. Pacific warming delivers an additional heat pulse to the atmosphere.
- **D) This year, June will be the hottest month on record since 1979.**: The calendar month remains unfinished, preventing a final verification. The report explicitly warns that June may not break the previous monthly maximum.
- **E) June 1979 was the hottest month to date.**: The text mentions 1979 only as the start of the **comparison period**. Data tracking begins then without identifying that specific month as a historical peak.

2 **Which of the following pairs of character/book is wrong?**

A Edmond Dantès – The Count of Monte Cristo
B Florentino Ariza – Love in the Time of Cholera
C Gregor Samsa – The Metamorphosis
D **Elizabeth Bennet – Little Women**
E Leopold Bloom – Ulysses

Correct answer: D

Elizabeth Bennet belongs to Jane Austen's *Pride and Prejudice*, not *Little Women*. That novel by Louisa May Alcott follows the **March sisters**. This mismatch makes the pair incorrect.

Why the other answers are wrong

- **A)** Edmond Dantès is accurately paired with Alexandre Dumas' *The Count of Monte Cristo* where he serves as the main character.
- **B)** Florentino Ariza is correctly connected to Gabriel García Márquez's *Love in the Time of Cholera* as a central figure.
- **C) Gregor Samsa – The Metamorphosis**: Gregor Samsa is properly linked to Franz Kafka's *The Metamorphosis* as the story's protagonist.
- **E)** Leopold Bloom is **correctly matched** with James Joyce's *Ulysses* as its central protagonist.

3 **The work known as De Bello Gallico is**

A an opera by Richard Wagner.
B a collection of poems on the Gallic war by Horace.
C **Julius Caesar's account of the Gallic war.**
D a painting by Eugène Delacroix.
E a sculpture by Auguste Rodin.

Correct answer: C

De Bello Gallico is **Caesar**'s first-person **historical account** of his military campaigns in Gaul between 58 and 50 BC. He composed the text in **Latin prose** to justify his actions to the Roman Senate and citizens. The title translates directly to On the Gallic War.

Why the other answers are wrong

- **A) an opera by Richard Wagner.**: It is a written work from ancient Rome, not an opera by Richard Wagner.
- **B) a collection of poems on the Gallic war by Horace.**: Caesar wrote it in prose form, while Horace was a later poet who did not author it.
- **D) a painting by Eugène Delacroix.**: It is a written historical account, not a painting by Eugène Delacroix.
- **E) a sculpture by Auguste Rodin.**: It is a written work, not a sculpture by Auguste Rodin.

4 **In a parliamentary system of government, the President of the Republic is**

A Head of State and Head of the High Council of the Judiciary.

B Head of Government and Head of the High Council of the Judiciary.

C Head of Government but not Head of State.

D **Head of State but not Head of Government.**

E neither Head of State nor Head of Government.

Correct answer: D

In a parliamentary system the president functions as **Head of State** while **executive power** belongs to the prime minister. This division ensures clear separation between ceremonial duties and daily governance.

Why the other answers are wrong

- **A) Head of State and Head of the High Council of the Judiciary.**: Overseeing the judiciary council applies specifically to **Italy** and certain nations but does not characterize parliamentary systems generally.
- **B) Head of Government and Head of the High Council of the Judiciary.**: Administrative execution demands **parliamentary confidence**, which designates the prime minister as the actual government chief.
- **C) Head of Government but not Head of State.**: The presidency constitutes the **Head of State** role while governmental leadership belongs to the cabinet.
- **E) neither Head of State nor Head of Government.**: The **constitutional mandate** clearly establishes the incumbent as the national representative rather than an administrative leader.

LOGICAL REASONING AND PROBLEM-SOLVING

5 **You have 1 pair of new-born rabbits (one male and one female) that can breed when they reach maturity. You also have 3 pairs of mature rabbits (3 males and 3 females) that can start breeding immediately. They follow these rules:**
• Each mature pair of rabbits produces one new pair of offspring (one male and one female) at the end of each month
• Each offspring pair takes one month to mature
How many rabbits do you have at the end of the 3rd month?

A 14
B **36**
C 42
D 28
E 18

Correct answer: B

Count **pairs** first and multiply by **two** to find individual rabbits. At the end of **month 1** the three mature pairs produce three new pairs for seven total. At the end of **month 2** four pairs breed adding four new pairs to reach eleven. At the end of **month 3** seven pairs breed yielding seven new pairs for eighteen total. Doubling gives $18 \times 2 = 36$ rabbits.

Why the other answers are wrong

- **A)** 14 counts only seven pairs matching the population size at the end of the first month.
- **C)** 42 represents twenty-one pairs but only eighteen pairs exist at the end of the third month.
- **D)** 28 corresponds to fourteen pairs and fails to account for all pairs born through the third month.
- **E)** 18 counts the number of pairs instead of converting to individual rabbits.

6 **The half-life of a radioactive element is the time needed for half of the material to decay. You have a certain quantity of a mineral containing two radioactive elements X and Y, whose half-lives are 2 and 3 years, respectively. Also, no physical process can produce elements X or Y. If today the ratio X:Y (mass/mass) is 8:1, what will it be after 6 years?**

- **A** **4:1**
- **B** 32/1
- **C** 16:1
- **D** 2:1
- **E** 1:1

Correct answer: A

After six years, element **X** undergoes **three half-lives** and its mass drops to $\frac{1}{8}$. Element **Y** undergoes **two half-lives** and its mass drops to $\frac{1}{4}$. Starting from an **initial ratio** of $8:1$, the remaining amounts yield a **final ratio** of $4:1$.

Why the other answers are wrong

- **B) 32/1**: This result implies a growing proportion of X, ignoring the fact that X decays faster than Y.
- **C) 16:1**: Element X decays faster than Y, so the numerical ratio must decrease from $8:1$.
- **D) 2:1**: The relative portion of X only halves over the period, making it impossible to fall to one-quarter of its start.
- **E) 1:1**: After six years the leftover amounts naturally form a $4:1$ proportion instead of matching equally.

7 **You want to buy a sandwich from your favourite store but are on a strict diet, so the sandwich must satisfy these requirements:**
• protein content: at least 20 g
• fat content: less than 10 g
• energy: at least 1,300 kJ

These are the types of sandwich available (energy, proteins, fats, salt equivalent, price):
• Tuna: 1579 kJ, 18 g, 14 g, 1.4 g, 7.20 €
• Beef: 1320 kJ, 22 g, 9 g, 1.5 g, 6.90 €
• Chicken: 1337 kJ, 23 g, 5 g, 1.1 g, 6.80 €
• Vegetables: 1198 kJ, 9 g, 15 g, 1.2 g, 6.50 €
• Salmon: 1620 kJ, 22 g, 12 g, 2.1 g, 7.10 €
• Ham: 1164 kJ, 19 g, 8 g, 1.9 g, 6.60 €
• Turkey: 1210 kJ, 20 g, 4 g, 1.7 g, 6.70 €

What is the minimum that you can spend for your sandwich?

A 6.90 €
B 6.70 €
C 6.60 €
D 6.80 €
E 7.10 €

Correct answer: D

The **chicken sandwich** meets all three dietary requirements. It provides $23\ \mathrm{g}$ **protein**, $5\ \mathrm{g}$ **fat**, and $1337\ \mathrm{kJ}$ **energy**. Among the valid options, it costs 6.80.

Why the other answers are wrong

- **A) 6.90 €**: This corresponds to the beef sandwich, which satisfies the criteria but has a higher price.
- **B) 6.70 €**: This option describes the turkey sandwich, which delivers only $1210\ \mathrm{kJ}$ of energy.
- **C) 6.60 €**: This option matches the ham sandwich, which fails both the protein and energy thresholds.
- **E) 7.10 €**: This refers to the salmon sandwich, which contains $12\ \mathrm{g}$ of fat and exceeds the limit.

QUESTIONS

8 **Copernicus is the European Earth Observation Programme which was established in 1998 to monitor the many ecosystems of our planet. It uses a constellation of 6 'Sentinel' satellites as well as dozens of third-party satellites to protect us from natural and manmade disasters. It collects and makes available accurate environmental data to address climate change, pollution, and deforestation, aiding evidence-based decision-making. Copernicus fuels scientific research and plays a pivotal role in tracing disease outbreaks, tracking marine pollution, determining the quality of air and water, studying ocean levels and evaluating the melting of the arctic polar ice cap. The Copernicus European Observation Programme provides enormous social, environmental and scientific benefits, and it should continue to be funded.**
Which one of the following, if true, would most strengthen the argument above?

A There are a number of similar projects run by other international agencies.
B The Copernicus project requires international cooperation to be effective.
C Some of Copernicus' benefits can be provided by other means.
D Social and scientific advances are of equal importance.
E **The economic benefits derived from the Copernicus programme outweigh its costs.**

Correct answer: E

The argument supports continued funding because Copernicus provides many benefits. If its **economic benefits outweigh its costs**, that provides an additional reason to keep funding it.

Why the other answers are wrong

- **A) There are a number of similar projects run by other international agencies.**: Similar projects run by other international agencies do not show that funding Copernicus is worthwhile. They might duplicate its work.
- **B) The Copernicus project requires international cooperation to be effective.**: International cooperation may be a requirement for Copernicus to be effective, but it does not provide a reason to fund the programme.
- **C) Some of Copernicus' benefits can be provided by other means.**: If some benefits can be provided by other means, that could weaken the case for funding Copernicus.
- **D) Social and scientific advances are of equal importance.**: Saying that social and scientific advances are equally important does not show whether Copernicus's benefits justify continued funding.

9 **There is a commonly held belief, known as the 'Matthew effect', that students who start with poor academic attainment early in school make less progress over time than their higher-achieving peers. But recent research has shed new light on this topic. A study examined patterns of growth in literacy and numeracy among more than 150,000 young people in Australia. Researchers tested pupils regularly between year 3 and year 9. They found that students who began with high achievement in reading and numeracy tests in year 3 were not making the amount of progress to year 9 of which they were capable. On the other hand, students starting with below average test scores made more progress from year 3 to year 9 than students starting above average. This compensatory growth pattern was seen in both reading and numeracy but was especially significant in reading.**
Which one of the following can be drawn as a conclusion from the above passage?

A Numerical skills are harder to improve than language skills.

B It is easier to teach brighter students than those who are below average.

C **Early promise does not guarantee high achievement in the long-term.**

D Rates of improvement from a low base will always be more rapid than progress from a higher base.

E The 'Matthew effect' is the result of low expectations by teachers.

Correct answer: C

The study shows that pupils with **initial high achievement** made less long-term progress than expected. Conversely, students with lower starting scores demonstrated **greater overall growth**. This pattern proves that **early promise does not guarantee sustained academic mastery**.

Why the other answers are wrong

- **A) Numerical skills are harder to improve than language skills.**: Observed differences in progress rates simply reflect growth trajectories and do not prove that numerical skills are inherently harder to develop than language skills.
- **B) It is easier to teach brighter students than those who are below average.**: The passage does not discuss **teaching difficulty** and makes no comparison between instructional ease for different ability levels.
- **D) Rates of improvement from a low base will always be more rapid than progress from a higher base.**: Empirical data from a single student cohort cannot justify an **absolute claim** that improvement from a low base will always proceed faster than progress from a higher base.
- **E) The 'Matthew effect' is the result of low expectations by teachers.**: The text focuses strictly on student performance data and provides zero evidence linking the Matthew effect to teacher expectations.

BIOLOGY

10 **Glucose can feed into the biochemical pathways noted in the options below. Each pathway generates a net yield of ATP molecules per molecule of glucose feeding into the pathway. Rank the reactions listed below in order of the total number of net ATP molecules produced, ranked from largest to smallest?**
1. Ethyl alcohol fermentation of four molecules of glucose
2. Lactic acid fermentation of six molecules of glucose
3. The electron transport chain stage of cellular respiration following the metabolism of a single molecule of glucose through the glycolytic and citric acid cycle stages.
4. Glycolysis of seven glucose molecules

A 4-2-3-1
B 4-2-1-3
C **3-4-2-1**
D 3-4-1-2
E 2-1-4-3

Correct answer: C

Ethanol **fermentation** and lactic acid fermentation each produce a net yield of $2\ \mathrm{ATP}$ per glucose molecule. Therefore, four molecules yield $8\ \mathrm{ATP}$, while six yield $12\ \mathrm{ATP}$. Isolated **glycolysis** also generates a net of $2\ \mathrm{ATP}$ per glucose, giving $14\ \mathrm{ATP}$ for seven molecules. Complete cellular respiration funnels electrons to the **electron transport chain**, producing approximately $26–28\ \mathrm{ATP}$ from a single glucose molecule during **aerobic oxidation**. The descending ATP production order is therefore reaction 3, followed by 4, 2, and finally 1.

Why the other answers are wrong

- **A) 4-2-3-1**: This choice swaps the position of reaction 3 with reaction 4, ignoring that the electron transport chain produces significantly more ATP than isolated glycolysis alone.
- **B) 4-2-1-3**: This sequence places reaction 3 at the end despite it generating the highest ATP yield from complete aerobic oxidation. It also incorrectly ranks the fermentation and glycolysis totals.
- **D) 3-4-1-2**: This ranking incorrectly states that lactic acid fermentation ($12\ \mathrm{ATP}$) produces less energy than ethanol fermentation ($8\ \mathrm{ATP}$), which contradicts their identical per-glucose yields multiplied by different substrate amounts.
- **E) 2-1-4-3**: This order reverses the correct positions of reactions 1, 2, and 4, and erroneously assigns the lowest ATP value to the full aerobic pathway.

QUESTIONS

11 **Duchenne muscular dystrophy (DMD) is a genetic condition marked by the gradual deterioration of muscle tissue. Recent studies have revealed that DMD arises from specific changes in a vital protein called dystrophin, responsible for maintaining the integrity of muscle cells. The gene responsible for producing this protein follows an inheritance pattern known as X-linked recessive.**
Which of the following statements is wrong according to the above?

A To develop the condition, a woman must inherit two recessive alleles of this gene.

B To develop the condition, a man must inherit one of the recessive alleles of this gene.

C **Women are more likely to suffer from DMD than men.**

D DMD is a sex-linked inherited disease.

E The rate at which the mutated allele spreads is influenced by the rate at which the associated X chromosome spreads within the population.

Correct answer: C

Duchenne muscular dystrophy follows an **X-linked recessive** inheritance pattern. **Males** possess only one X chromosome, so a single mutant allele triggers the disease, while **females** generally require two mutant alleles to manifest it. This genetic mechanism makes men much more likely to develop the condition than women, making statement C false.

Why the other answers are wrong

- **A) To develop the condition, a woman must inherit two recessive alleles of this gene.**: Under this recessive inheritance model, a female requires two copies of the mutated allele, one on each X chromosome, to express the disease phenotype.
- **B) To develop the condition, a man must inherit one of the recessive alleles of this gene.**: A male inherits only one X chromosome from his mother, so acquiring just one recessive allele is sufficient to cause the clinical symptoms.
- **D) DMD is a sex-linked inherited disease.**: The condition is correctly classified as **sex-linked** because the responsible gene resides exclusively on the X chromosome.
- **E) The rate at which the mutated allele spreads is influenced by the rate at which the associated X chromosome spreads within the population.**: The transmission frequency of the mutated allele tracks with the population distribution of its carrying **X chromosome**, which accurately reflects its chromosomal location and inheritance path.

12 **In the table below, you can find the minimum, maximum and optimum pH values that are required for enzymes X, Y, Z, W, and Q to function.**

Enzyme	Minimum pH	Optimum pH	Maximum pH
X	6.4	7.1	8.2
Y	3.9	5.3	7.2
Z	4.0	6.2	8.5
W	8.0	9.1	12.1
Q	1.3	5.4	9.5

Which of the pairs of enzymes listed below cannot function together in the same environment?

A **Y and W**
B W and Q
C X and Y
D Y and Z
E X and Z

Correct answer: A

Enzymes **Y** and **W** cannot operate simultaneously because their required **pH** intervals lack any intersection. Y functions between 3.9 and 7.2, while W demands values from 8.0 to 12.1. No single environment can sustain both activities at once.

Why the other answers are wrong

- **B) W and Q**: Their ranges overlap between 8.0 and 9.5, allowing concurrent activity.
- **C) X and Y**: Their operational windows share the interval from 6.4 to 7.2, supporting joint function.
- **D) Y and Z**: Their working intervals intersect across the span from 4.0 to 7.2.
- **E) X and Z**: They possess a compatible region between 6.4 and 8.2, enabling them to coexist.

13 **Which of the following is absent from the genome of a virus that utilizes DNA as its primary molecule?**

A Adenine
B Deoxyribose
C Guanine
D Thymine
E Uracil

Correct answer: E

A DNA-based viral genome relies on nucleotides containing four specific nitrogenous bases. These bases attach directly to the sugar **deoxyribose** to form the genetic polymer. The pyrimidine **uracil** exclusively substitutes for thymine in RNA architectures. Therefore, uracil remains completely absent from DNA viral genomes.

Why the other answers are wrong

- **A)** Adenine is a fundamental purine base consistently found within DNA strands.
- **B)** Deoxyribose serves as the essential pentose sugar component of the DNA backbone.
- **C)** Guanine is a standard purine base inherently present in all DNA molecules.
- **D)** Thymine is a pyrimidine base normally incorporated into DNA genetic material.

14 **In which of the following events do hormones secreted by the adrenal gland and pancreas play a role together?**
1. Balancing the amount of calcium in the bone and blood.
2. Accelerating sodium absorption in the renal tubules.
3. Balancing the glucose level in the blood.

A 2 and 3
B 3 only
C 1 and 2
D 1
E 1, 2, and 3

Correct answer: B

The adrenal gland produces adrenaline and cortisol, while the pancreas secretes insulin and glucagon. These hormones coordinate to stabilize blood glucose levels. This joint function matches statement 3. Statement 1 addresses calcium balance, which depends on parathyroid hormone and calcitonin. Statement 2 covers renal sodium reabsorption, driven exclusively by aldosterone.

Why the other answers are wrong

- **A) 2 and 3**: Option 2 lacks any pancreatic contribution since sodium absorption relies solely on aldosterone. Combining an incorrect statement with statement 3 invalidates this choice.
- **C) 1 and 2**: Option 1 describes calcium homeostasis, regulated by parathyroid hormone and calcitonin. Option 2 describes sodium transport, controlled by aldosterone. Neither process involves pancreatic hormones.
- **D) 1**: Option 1 focuses on calcium distribution between bone and blood. This pathway operates independently of adrenal and pancreatic signaling.
- **E) 1, 2, and 3**: Only statement 3 represents a cooperative hormonal mechanism. Options 1 and 2 introduce unrelated regulatory systems that exclude pancreatic involvement.

15 **Which of the following examples represent conditions regulated by homeostasis in the body?**
1. Blood glucose concentration
2. Body temperature
3. Water levels
4. Body weight

A 1 and 4
B 4 only
C 1 and 2
D 1 only
E 1, 2 and 3

Correct answer: E

Homeostasis maintains a stable internal environment by controlling vital variables. The body actively regulates **blood glucose** concentration, **body temperature** and **water levels** through continuous feedback mechanisms. These three conditions must remain within strict physiological limits for normal cellular function.

Why the other answers are wrong

- **A) 1 and 4**: Incorrect because it wrongly includes body weight while leaving out temperature and water levels, which are both actively stabilized.
- **B) 4 only**: Incorrect because body weight is not a fixed homeostatic variable and fluctuates over time, whereas glucose, temperature and water levels are strictly maintained.
- **C) 1 and 2**: Incorrect because it omits water levels, an essential parameter that the kidneys and endocrine system continuously monitor and adjust.
- **D) 1 only**: Incorrect because temperature and water levels are equally controlled by the body, making the first condition alone incomplete.

16 **Which of the following structures in a plant cell are surrounded by a double membrane?**

A Mitochondria, Vacuole, Golgi Apparatus
B Nucleus, Plastid, Golgi Apparatus
C Plastid, Endoplasmic Reticulum, Vacuole
D Plastid, Mitochondria, Nucleus
E Golgi Apparatus, Ribosome, Mitochondria

Correct answer: D

plastids and mitochondria each contain an inner and an outer lipid bilayer. The nucleus is wrapped in a double-membrane **nuclear envelope**. These three structures therefore share a two-layer boundary.

Why the other answers are wrong

- **A)** Mitochondria possess two membranes. The vacuole and Golgi apparatus are bounded by a single phospholipid layer.
- **B) Nucleus, Plastid, Golgi Apparatus**: Nucleus and plastids have dual layers. The Golgi apparatus relies on a single membranous network.
- **C) Plastid, Endoplasmic Reticulum, Vacuole**: **plastids** are double-membraned. The endoplasmic reticulum and vacuole each consist of one membrane.
- **E) Golgi Apparatus, Ribosome, Mitochondria**: Mitochondria feature two membranes. The Golgi apparatus uses one layer while ribosomes lack any surrounding membrane.

17 **Listed below are three different families with genotypes related to colour blindness which is an X-linked recessive disorder.**

Family	Mother	Father
1	X^RX^r	X^RY
2	X^rX^r	X^RY
3	X^RX^r	X^rY

Among the families, which ones can have a colour-blind daughter?

A **3**
B 1
C 2
D 1 and 2
E 2 and 3

Correct answer: A

A daughter inherits one X chromosome from each parent. To express the disorder, she must be X^rX^r. Only family 3 can supply these alleles because the **father** carries X^r and the mother can contribute X^r.

Why the other answers are wrong

- **B) 1**: The father in family 1 is healthy and will always hand down X^R to his daughters.
- **C) 2**: The mother in family 2 consistently gives X^r, yet the paternal X^R dominates and leaves daughters unaffected.
- **D) 1 and 2**: Both fathers in families 1 and 2 possess X^R. They transmit this allele to every daughter, which prevents colour blindness.
- **E) 2 and 3**: Family 2 contains the same barrier, since the father holds X^R and guarantees its passage to all female offspring.

18 **Which of the following conditions is necessary for a mutation to play a role in the process of evolution?**

A Formation by the effect of X-rays

B Having a dominant mutation

C Occurrence in body cells

D Having a recessive mutation

E Occurrence in germ cells

Correct answer: E

Evolution requires genetic changes to be **inherited** by offspring. Only mutations in **germ cells** can be transmitted to the next generation and alter **allele frequencies** in a population over time.

Why the other answers are wrong

- **A) Formation by the effect of X-rays**: The origin mechanism is irrelevant; mutations frequently arise from DNA replication errors without any external radiation like X-rays.
- **B) Having a dominant mutation**: Dominance level does not determine evolutionary impact; both dominant and recessive variants can be passed down and selected.
- **C) Occurrence in body cells**: Somatic mutations remain confined to the individual and are never transferred to progeny, preventing any evolutionary effect.
- **D) Having a recessive mutation**: Recessive mutations can contribute to evolution, but recessiveness is not a requirement for inheritance or population change.

19 **Redox reactions play a vital role in many cellular processes. Which of the following statements and examples best describes redox reactions in living things?**

A Redox reactions involve the absorption of light, where the molecule that gains light is reduced, and the molecule that loses light is oxidized.

B Redox reactions involve the formation of covalent bonds, where the molecule that gains bonds is reduced, and the molecule that loses bonds is oxidized.

C **Redox reactions involve the transfer of electrons, where the molecule that gains electrons is reduced, and the molecule that loses electrons is oxidized.**

D Redox reactions involve the destruction of molecules, where the molecule that gains fragments is reduced, and the molecule that loses fragments is oxidized.

E Redox reactions involve the absorption of energy, where the molecule that gains energy is reduced, and the molecule that loses energy is oxidized.

Correct answer: C

Redox reactions involve **electron transfer** between chemical species. The molecule that gains electrons undergoes **reduction**, while the one that loses electrons undergoes **oxidation**. During cellular respiration, NAD^+ gains electrons to form NADH.

Why the other answers are wrong

- **A) Redox reactions involve the absorption of light, where the molecule that gains light is reduced, and the molecule that loses light is oxidized.**: Light absorption can initiate certain biological processes, but oxidation and reduction are strictly defined by electron movement, not light.
- **B) Redox reactions involve the formation of covalent bonds, where the molecule that gains bonds is reduced, and the molecule that loses bonds is oxidized.**: Covalent bonds may form or break during these reactions, but the defining shift involves changes in electron ownership rather than bond count.
- **D) Redox reactions involve the destruction of molecules, where the molecule that gains fragments is reduced, and the molecule that loses fragments is oxidized.**: Gaining or losing molecular fragments describes metabolic breakdown or synthesis, which does not inherently define reduction or oxidation.
- **E) Redox reactions involve the absorption of energy, where the molecule that gains energy is reduced, and the molecule that loses energy is oxidized.**: Energy changes often accompany redox reactions, yet gaining or losing energy does not determine whether a reaction is oxidative or reductive.

20 **Study the following table which shows the genotypes of individuals in a population for a specific genetic trait. The trait is determined by a single gene with two alleles, A and a.**

Individual	Genotype
1	AA
2	Aa
3	Aa
4	aa
5	AA

Based on the given data, what is the frequency of the A allele in this population?

A 0.8

B **0.6**

C 0.4

D 0.2

E 1.0

Correct answer: B

The two AA individuals contribute four A alleles, and the two Aa individuals contribute one each. There are six A alleles among $2 \times 5 = 10$ alleles, so the frequency is $\frac{6}{10} = 0.6$.

Why the other answers are wrong

- **A) 0.8**: The population has six A alleles out of ten, not eight.
- **C)** 0.4 is the frequency of the a allele, not the A allele.
- **D)** 0.2 is the proportion of individuals with genotype aa, not the frequency of the A allele.
- **E) 1.0**: The frequency is not 1.0 because not every allele in the population is A.

21 **Which of the following anatomical structures is responsible for regulating the circadian rhythm?**

A Thalamus
B Amygdala
C Hippocampus
D Corpus callosum
E Pineal gland

Correct answer: E

The **pineal gland** produces **melatonin**, a hormone that synchronizes the biological clock with light and dark cycles. It directly regulates **circadian rhythm** and sleep-wake timing.

Why the other answers are wrong

- **A) Thalamus**: The thalamus mainly relays sensory information to the cerebral cortex for processing, leaving circadian control to other centers.
- **B) Amygdala**: The amygdala specializes in processing emotions and fear responses, which operates independently of the sleep-wake cycle.
- **C) Hippocampus**: The hippocampus is essential for memory formation and spatial navigation, so it does not participate in daily biological scheduling.
- **D) Corpus callosum**: The corpus callosum physically links the left and right cerebral hemispheres to facilitate communication between them.

22 **Photosynthesis is a vital process in which plants and some other organisms convert light energy into chemical energy. Which of the following represents the balanced equation for the overall reaction of photosynthesis?**

A $C_6H_{12}O_6 + 6CO_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$
B $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$
C $C_6H_{12}O_6 + 6CO_2 + \text{energy} \rightarrow 12CO_2 + 6H_2O$
D $C_6H_{12}O_6 + 6CO_2 + \text{energy} \rightarrow 6CO_2 + 6H_2O$
E $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6CO_2 + \text{energy}$

Correct answer: B

Photosynthesis uses light to transform carbon dioxide and water into chemical energy stored in **glucose**. The process releases **oxygen** as a byproduct. The equation requires energy input and balances perfectly with six carbon, twelve hydrogen, and eighteen oxygen atoms on both sides.

Why the other answers are wrong

- **A)** $C_6H_{12}O_6 + 6CO_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$: Glucose is consumed during the process rather than synthesized. Carbon atoms do not match between reactants and products.
- **C)** $C_6H_{12}O_6 + 6CO_2 + \text{energy} \rightarrow 12CO_2 + 6H_2O$: Glucose is incorrectly treated as a reactant instead of a product. Oxygen atoms are not balanced across the reaction arrow.
- **D)** $C_6H_{12}O_6 + 6CO_2 + \text{energy} \rightarrow 6CO_2 + 6H_2O$: Glucose remains a reactant and oxygen is not released. Carbon balance is incorrect.
- **E)** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6CO_2 + \text{energy}$: The equation produces carbon dioxide instead of oxygen. Energy is misplaced among the products rather than reactants. Carbon atoms fail to balance.

23 **What is the correct order of the following events that occur immediately after acetylcholine binds to postsynaptic receptors of a muscle fibre, causing the muscle to contract?**

1) Ca^{2+} ions diffuse into the sarcoplasm.
2) The muscle fibre membrane is depolarised.
3) The myosin binding site on the actin filament is uncovered.

A 3, 2, 1
B **2, 1, 3**
C 2, 3, 1
D 1, 2, 3
E 1, 3, 2

Correct answer: B

Acetylcholine binding opens ligand-gated channels, allowing sodium influx that triggers **sarcolemma depolarisation**. The resulting action potential travels down T-tubules and activates ryanodine receptors, causing Ca^{2+} **release** from the sarcoplasmic reticulum. Free calcium then binds to **troponin C**, pulling tropomyosin aside to uncover myosin-binding sites on actin filaments. Thus, the required physiological sequence is $2 \rightarrow 1 \rightarrow 3$.

Why the other answers are wrong

- **A) 3, 2, 1**: Sets protein site exposure as the initial event, ignoring its absolute dependence on prior intracellular calcium. Calcium mobilisation itself requires upstream electrical activation, so reversing these steps violates excitation–contraction coupling principles.
- **C) 2, 3, 1**: Correctly starts with membrane depolarisation but incorrectly places binding site exposure before calcium accumulation. Tropomyosin displacement strictly depends on calcium interaction with regulatory proteins, preventing early site exposure.
- **D) 1, 2, 3**: Posits calcium liberation preceding electrical signalling. Sarcoplasmic reticulum channel opening is mechanically coupled to voltage sensors, making pre-depolarisation calcium diffusion incompatible with established physiology.
- **E) 1, 3, 2**: Arranges both calcium diffusion and structural site exposure ahead of the triggering voltage shift. Without initial membrane polarization, downstream ion mobilisation and protein conformational changes lack an upstream stimulus.

24 **What percentage of the three base codons that can be made using the standard genetic code are stop codons?**

A 18.8%
B 7.8%
C **4.7%**
D 9.4%
E 14.1%

Correct answer: C

Each position in a three-base codon can hold one of four nucleotides, producing a total of $4^3 = 64$ combinations. The standard genetic code defines exactly **three stop codons**: UAA, UAG and UGA. Computing the proportion as $\frac{3}{64} \times 100 = 4.6875\%$ and rounding yields 4.7%.

Why the other answers are wrong

- **A) 18.8%**: This figure assumes a much higher frequency of termination signals than present in the standard code.
- **B) 7.8%**: This percentage does not match the calculated fraction of three stop codons over the sixty-four possible triplets.
- **D) 9.4%**: This value stems from an incorrect estimation and does not correspond to the actual proportion.
- **E) 14.1%**: This result represents a miscalculation that ignores the true $\frac{3}{64}$ ratio.

25 **Which of the following statements accurately describes prokaryotic DNA?**

A Prokaryotic DNA contains introns and exons within its coding regions.
B Prokaryotic DNA is highly condensed and organized into chromatin fibers.
C Prokaryotic DNA is associated with histone proteins and undergoes meiotic cell division during replication.
D Prokaryotic DNA is linear, with multiple chromosomes contained within a nuclear membrane.
E **Prokaryotic DNA consists of circular chromosomes located within the cytoplasm.**

Correct answer: E

Prokaryotic cells contain a **circular chromosome** located in the nucleoid region. This area sits directly within the cytoplasm and lacks a surrounding **nuclear membrane**.

Why the other answers are wrong

- **A) Prokaryotic DNA contains introns and exons within its coding regions.**: Prokaryotic genes typically lack an **intron-exon structure**. Only eukaryotic coding regions commonly split transcripts this way.
- **B) Prokaryotic DNA is highly condensed and organized into chromatin fibers.**: **Chromatin fibers** form when DNA wraps around specific proteins. This packaging model belongs exclusively to eukaryotic genomes.
- **C) Prokaryotic DNA is associated with histone proteins and undergoes meiotic cell division during replication.**: Prokaryotes do not undergo meiotic division during replication. They also do not associate their DNA with histone proteins.
- **D) Prokaryotic DNA is linear, with multiple chromosomes contained within a nuclear membrane.**: Prokaryotes possess a **single circular chromosome** instead of multiple linear ones. Their genetic material remains free in the cytoplasm.

26 **A fragment of double-stranded DNA molecule contains 12 phosphates and 2 adenines. Given this information, what is the total number of purine bases, deoxyribose sugars and hydrogen bonds respectively, present in the described DNA molecule?**

A 6, 16, 12
B **6, 12, 16**
C 12, 24, 28
D 4, 12, 12
E 6, 12, 20

Correct answer: B

Twelve **phosphates** indicate twelve nucleotides and twelve **sugars**. The two strands form six **base pairs**, each containing one **purine**. The adenines create two A–T associations, while the remainder are G–C associations. This yields a total of $2 \times 2 + 4 \times 3 = 16$ **hydrogen bonds**.

Why the other answers are wrong

- **A) 6, 16, 12**: Incorrect because twelve nucleotides contain twelve sugars, not sixteen, and the correct hydrogen bond count is sixteen, not twelve.
- **C) 12, 24, 28**: Incorrect because the fragment contains six purines, twelve sugars, and sixteen hydrogen bonds, making all listed values incorrect.
- **D) 4, 12, 12**: Incorrect because every base pair contributes one purine, resulting in six purines rather than four, and the hydrogen bond total is sixteen, not twelve.
- **E) 6, 12, 20**: Incorrect because the six base pairs produce sixteen hydrogen bonds, not twenty.

27 **Which of the following statements accurately describes the surface area-to-volume ratio and cell growth?**

A The surface area-to-volume ratio varies randomly during cell growth.
B The surface area-to-volume ratio is unrelated to cell growth.
C The surface area-to-volume ratio increases as the cell grows larger.
D **The surface area-to-volume ratio decreases as the cell grows larger.**
E The surface area-to-volume ratio remains constant during cell growth.

Correct answer: D

As a cell grows larger, **surface area** increases with the square of its linear size while **volume** increases with the cube. This geometric relationship causes the **surface area-to-volume ratio** to drop consistently. A smaller ratio reduces the available membrane per unit of cytoplasm for essential exchanges with the environment.

Why the other answers are wrong

- **A) The surface area-to-volume ratio varies randomly during cell growth.**: It does not vary randomly; it decreases predictably as the cell enlarges while retaining a similar shape.
- **B) The surface area-to-volume ratio is unrelated to cell growth.**: It is not unrelated because cell size directly affects the proportional balance between boundary and interior.
- **C) The surface area-to-volume ratio increases as the cell grows larger.**: The ratio does not increase because volume grows faster than surface area.
- **E) The surface area-to-volume ratio remains constant during cell growth.**: It does not remain constant because surface area and volume increase at fundamentally different rates.

28 **Which of the following statements regarding the Golgi apparatus is correct?**

A **The Golgi apparatus processes and packages proteins to be exported from the cell.**

B There is no Golgi apparatus in neuronal cells.

C Lysosomes digest the vesicles released from the Golgi apparatus so the proteins can be released from the cell.

D The Golgi apparatus processes lipid molecules as they enter the cell.

E Before exiting the cell, the proteins packaged in the Golgi apparatus are transported to the nucleus for translation verification.

Correct answer: A

The Golgi apparatus **modifies**, sorts, and packages proteins received from the endoplasmic reticulum into vesicles. Some vesicles carry proteins for secretion from the cell.

Why the other answers are wrong

- **B) There is no Golgi apparatus in neuronal cells.**: Neurons have a Golgi apparatus.
- **C) Lysosomes digest the vesicles released from the Golgi apparatus so the proteins can be released from the cell.**: Secretory vesicles fuse with the plasma membrane to release their contents. Lysosomes are involved in digestion.
- **D)** The Golgi apparatus can modify lipids, but it does not process them as they enter the cell.
- **E) Before exiting the cell, the proteins packaged in the Golgi apparatus are transported to the nucleus for translation verification.**: Translation occurs at ribosomes. Before secretion, proteins are not sent to the nucleus for verification.

29 **In which reactions of glycolysis are isomerase enzymes involved?**

A To convert fructose 1-6-diphosphate to glyceraldehyde 3-phosphate and dihydroxy-acetone phosphate.

B During the phosphorylation of both glucose and fructose-1-phosphate.

C When four enzyme-catalysed reactions convert each triose phosphate molecule to a molecule of pyruvate.

D In the steps in which dehydrogenase enzymes are involved.

E **When glucose-6-phosphate is changed to fructose-6-phosphate.**

Correct answer: E

Phosphoglucose isomerase converts $\text{glucose} - 6 - \text{phosphate}$ into $\text{fructose} - 6 - \text{phosphate}$. This step relies on a molecular **rearrangement** of the carbon backbone. The atomic composition remains identical throughout the process.

Why the other answers are wrong

- **A) To convert fructose 1-6-diphosphate to glyceraldehyde 3-phosphate and dihydroxy-acetone phosphate.**: The breakdown of $\text{fructose} - 1,6 - \text{bisphosphate}$ yields $\text{glyceraldehyde} - 3 - \text{phosphate}$ and $\text{dihydroxyacetone} - \text{phosphate}$. This cleavage is catalysed by **aldolase**, not an isomerase.
- **B) During the phosphorylation of both glucose and fructose-1-phosphate.**: Adding phosphate groups to sugars requires **kinases**. These enzymes mediate phosphorylation transfers, which operate via a completely different mechanism than structural isomerisation.
- **C) When four enzyme-catalysed reactions convert each triose phosphate molecule to a molecule of pyruvate.**: Transforming triose phosphates into pyruvate involves **five reactions**, not four. While phosphoglycerate mutase participates later in the sequence, the statement miscounts the steps and misidentifies the primary conversion logic.
- **D) In the steps in which dehydrogenase enzymes are involved.**: Dehydrogenases facilitate **oxidation–reduction** cycles that shuttle electrons and hydrogen ions. Redox chemistry requires coenzymes like NAD^+, making it unrelated to the intramolecular shift performed by isomerases.

30 **Given the polynucleotide sequence AUGCCGC, can you tell which is the 5’ end?**

A Yes, the 5' end begins with the start codon AUG.

B **No, unless you know the position of the phosphate group, you cannot differentiate the 3' end from the 5' end.**

C No, you cannot tell without the sequence of the complementary strand.

D Counting the number of hydrogen bonds between the nitrogenous bases provides sufficient information to determine the 5' end.

E There is no difference between the 5’ and 3’ ends of a single strand of DNA.

Correct answer: B

The nucleobases themselves do not indicate strand polarity. The $5'$ end is chemically defined by a **phosphate** group attached to the sugar's $5'$ carbon, while the $3'$ end carries a **hydroxyl** group. Without knowing the orientation or the specific terminal groups, the written sequence cannot determine which end is $5'$.

Why the other answers are wrong

- **A) Yes, the 5' end begins with the start codon AUG.**: AUG functions as a start codon only when read in the correct $5'$ to $3'$ direction. Its appearance at the beginning of the text does not establish the physical polarity of the molecule.
- **C) No, you cannot tell without the sequence of the complementary strand.**: Knowing the complementary strand's sequence only establishes base-pairing relationships. It still leaves the absolute orientation and terminal chemistry of the original strand completely undefined.
- **D) Counting the number of hydrogen bonds between the nitrogenous bases provides sufficient information to determine the 5' end.**: Hydrogen bonding patterns between paired bases reveal pairing stability but provide zero information about the chemical identity of either terminus.
- **E) There is no difference between the 5’ and 3’ ends of a single strand of DNA.**: The $5'$ and $3'$ termini are chemically distinct due to their different functional groups. Additionally, the presence of uracil identifies this molecule as RNA rather than DNA.

31 **Which statement or set of statements about oxidative phosphorylation is correct?**

1. Complex I of the electron transport chain transfers electrons from $FADH_2$ to coenzyme Q.

2. ATP synthase utilises the energy of the proton gradient to catalyze the conversion of ADP to ATP.

3. Oxygen serves as an electron acceptor in complex III.

4. Complex IV receives electrons from NADH.

A 4

B 3

C 2, 3 and 4

D 1 and 2

E 2

Correct answer: E

Statement 2 is accurate because **ATP synthase** harnesses the energy stored in the **proton gradient** to catalyze the conversion of ADP to ATP.

Why the other answers are wrong

- **A) 4**: Statement 4 is incorrect since Complex IV receives electrons exclusively from cytochrome c, not directly from NADH.
- **B) 3**: Statement 3 is inaccurate as molecular oxygen functions solely as the terminal electron acceptor at Complex IV.
- **C) 2, 3 and 4**: This option fails because oxygen accepts electrons only at Complex IV, and Complex IV does not interact directly with NADH.
- **D) 1 and 2**: Statement 1 is false because Complex I transfers electrons from NADH to coenzyme Q, while $\mathrm{FADH_2}$ enters the chain through Complex II.

32 **The 19th century monk Gregor Johann Mendel conducted simple hybridisation experiments and established a series of laws of inheritance. Which of the points listed below accurately reflect Mendel's laws?**
1. Alternative forms of genetic characteristics can be inherited from parents.
2. Specific heritable factors or traits are inherited independently of other heritable factors.
3. Gametes are created by random segregation.
4. If one allele is dominant over another allele, the phenotype reflects the dominant allele.
5. Individuals with heritable traits more suited to the environment will have an increased chance of survival.

A 1, 2 and 3
B **1, 2, 3 and 4**
C All the statements are correct
D 1 and 5
E 4 and 5

Correct answer: B

Statements 1 through 4 accurately describe Mendelian principles. Alleles alternate as trait forms and undergo **random segregation** during gamete formation. These factors follow **independent assortment** across different traits and obey clear dominance rules. Statement 5 refers to evolutionary adaptation rather than genetic inheritance.

Why the other answers are wrong

- **A) 1, 2 and 3**: It omits statement 4, which correctly defines genetic dominance.
- **C) All the statements are correct**: It includes statement 5, which describes natural selection instead of a Mendelian law.
- **D) 1 and 5**: It incorrectly adds statement 5 while missing the independent assortment and segregation rules stated in 2 and 3.
- **E) 4 and 5**: It relies on statement 5 concerning natural selection and excludes the core inheritance mechanisms listed in statements 1 to 3.

CHEMISTRY

33 **A simple ion of element A can be represented:**
$_{x}^{2x+2}A^{2+}$
How many electrons are present in this ion?

A $x + 2$
B $2x$
C x
D $x - 2$
E $2x + 4$

Correct answer: D

The subscript x represents the **atomic number**, which equals the number of protons and the number of **electrons** in a neutral atom. The superscript $2+$ indicates a **charge** resulting from the loss of two **electrons**. Subtracting two from the initial count yields $x - 2$ electrons.

Why the other answers are wrong

- **A)** $x + 2$: This expression adds two electrons to the atomic number instead of removing them. A positive charge always corresponds to electron loss.
- **B)** $2x$: This calculation doubles the atomic number while completely ignoring the ion's $2+$ charge. It fails to adjust the particle balance for ionization.
- **C)** x: This value equals the number of electrons in a neutral atom of A. It does not account for the two particles lost during ion formation.
- **E)** $2x + 4$: This option incorrectly combines the mass number $2x + 2$ with the charge magnitude to produce $2x + 4$. The mass number counts nucleons and never determines the electron count.

34 **A sample of n moles of an ideal gas is contained in a closed system of fixed volume V m^3 at pressure P Pa and temperature 27.0 °C.**
If the gas is heated to 327.0 °C, what will be the pressure, in Pa, at this new temperature?
Assume absolute zero is at -273.0 °C

A $\frac{P}{2}$
B $\frac{27}{327}P$
C $2P$
D $\frac{327}{27}P$
E P

Correct answer: C

At constant **volume** and **moles**, the ideal gas law establishes that **pressure** scales directly with absolute **temperature** in **kelvin**. The initial state corresponds to $300.0\ \mathrm{K}$ while the final state reaches $600.0\ \mathrm{K}$. Because the absolute temperature exactly doubles, the final pressure becomes $2P$.

Why the other answers are wrong

- **A)** $\frac{P}{2}$: Heating the gas doubles its absolute temperature, so the pressure increases rather than halves.
- **B)** $\frac{27}{327}P$: It uses Celsius temperatures instead of kelvin and reverses the temperature ratio.
- **D)** $\frac{327}{27}P$: The temperature ratio must be calculated using kelvin, not degrees Celsius.
- **E)** Pressure increases when an ideal gas is heated at fixed volume, making a constant pressure outcome incorrect.

QUESTIONS

35 **A pH meter is used to test $0.1\ \text{mol L}^{-1}$ aqueous solutions of the following compounds:**

1. CH_3COOH

2. $NaCl$

3. H_2SO_4

4. $Ba(OH)_2$

5. HNO_3

Which of the following correctly lists these solutions in order of increasing pH?

A 2, 1, 4, 5, 3

B 3, 4, 1, 5, 2

C **3, 5, 1, 2, 4**

D 5, 3, 1, 2, 4

E 4, 2, 1, 5, 3

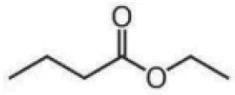
Correct answer: C

The compounds must be ranked by **increasing acidity**. At $0.1\ \text{mol L}^{-1}$, **sulfuric acid** releases the most H^+ ions because both dissociation steps contribute. **Nitric acid** is a strong monoprotic acid with higher pH. **Acetic acid** is a weak acid that ionizes partially, yielding a higher pH. **Sodium chloride** is a neutral salt. **Barium hydroxide** is a strong base providing the highest pH.

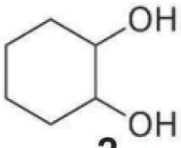
Why the other answers are wrong

- **A) 2, 1, 4, 5, 3**: Puts the neutral salt below weak acetic acid and ranks the strong base before all acids, contradicting established acid–base behavior.
- **B) 3, 4, 1, 5, 2**: Positions barium hydroxide as highly acidic instead of basic, violating its role as a strong base.
- **D) 5, 3, 1, 2, 4**: Exchanges sulfuric and nitric acid, failing to account for the additional protons from sulfuric acid's second dissociation step.
- **E) 4, 2, 1, 5, 3**: Reverses the entire scale by placing the strong base at the beginning and the strongest acids at the end.

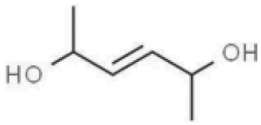
36 **Which of the following compounds are structural isomers of hexanoic acid?**



1.



2.



3.

A 2 and 3 only
B 3 only
C 1 and 2 only
D 1 only
E **1, 2 and 3**

Correct answer: E

Hexanoic acid has the molecular formula $C_6H_{12}O_2$. Compound 1 is a six-carbon **ester**. Compound 2 is a **cyclohexanediol**. Compound 3 is a six-carbon **diol** containing one **double bond**. Each molecule shares the exact atomic composition but differs in bonding arrangement, classifying all three as **structural isomers**.

Why the other answers are wrong

- **A) 2 and 3 only**: Incorrect because compound 1 is a six-carbon ester that shares the exact atomic composition $C_6H_{12}O_2$ with hexanoic acid.
- **B) 3 only**: Incorrect because compound 1 and compound 2 both satisfy the required molecular formula $C_6H_{12}O_2$ and differ structurally from the acid.
- **C) 1 and 2 only**: Incorrect because compound 3 maintains the identical molecular formula $C_6H_{12}O_2$ despite containing a carbon–carbon double bond.
- **D) 1 only**: Incorrect because compound 2 and compound 3 both possess the matching molecular formula and alternative structural arrangements.

37 **Consider the reaction:**

$H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$

Which of the following terms describes the role of HNO_3 in this reaction?

A An acid
B A base
C A catalyst
D A reducing agent
E An oxidising agent

Correct answer: B

$\mathrm{HNO_3}$ accepts a proton from $\mathrm{H_2SO_4}$ to form $\mathrm{H_2NO_3^+}$. A **proton acceptor** functions as a Brønsted–Lowry **base**.

Why the other answers are wrong

- **A) An acid**: $\mathrm{HNO_3}$ gains a proton in this mechanism while $\mathrm{H_2SO_4}$ acts as the proton donor.
- **C) A catalyst**: $\mathrm{HNO_3}$ is transformed into a different species instead of being regenerated unchanged at the end of the reaction.
- **D) A reducing agent**: Reduction requires electron gain which is completely absent in a simple proton exchange.
- **E) An oxidising agent**: This step involves only proton transfer without any change in oxidation states.

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38 **Which one of the following is a gaseous compound (at room temperature and pressure) that exists as linear molecules and reacts with water to form an acidic solution?**

A Carbon dioxide
B Nitrogen dioxide
C Sulfur dioxide
D Sulfur trioxide
E Silicon dioxide

Correct answer: A

Carbon dioxide ($\mathrm{CO_2}$) is gaseous at room temperature and pressure. Its molecular geometry is **linear** because the central carbon atom forms two double bonds and carries no lone pairs. Dissolving in water generates **carbonic acid**, resulting in an **acidic** solution.

Why the other answers are wrong

- **B)** Nitrogen dioxide ($\mathrm{NO_2}$) is a gas that forms an acidic solution in water, but its molecules are bent.
- **C)** Sulfur dioxide ($\mathrm{SO_2}$) is a gas that forms an acidic solution in water, but its molecules are bent.
- **D)** Sulfur trioxide ($\mathrm{SO_3}$) adopts a trigonal planar geometry rather than a linear one, and it is not a gas at room temperature.
- **E)** Silicon dioxide ($\mathrm{SiO_2}$) exists as a solid with a covalent network structure, not as a gas composed of discrete linear molecules.

39 **Which of the following statements about 1Kg of water is correct?**

A Liquid water has a greater volume than ice as the particles have more kinetic energy

B Ice has a greater volume than liquid water as the particles have more kinetic energy

C Ice has a greater volume than liquid water as the particles are further apart

D Liquid water has a greater volume than ice as the particles are further apart

E Liquid water and ice have the same volume, which explains why ice partially floats in water

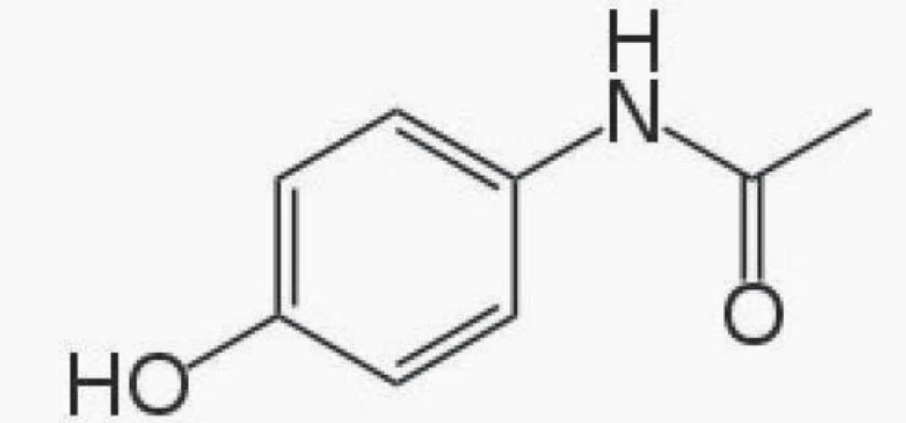
Correct answer: C

For the same mass of $1\ \mathrm{kg}$, **ice** occupies a larger volume than **liquid water**. This happens because **hydrogen bonds** hold the molecules in an open lattice, keeping them further apart and lowering density.

Why the other answers are wrong

- **A) Liquid water has a greater volume than ice as the particles have more kinetic energy**: Incorrectly states liquid water has greater volume; under standard conditions, liquid water contracts and takes up less space than frozen water.
- **B) Ice has a greater volume than liquid water as the particles have more kinetic energy**: Incorrectly attributes the volume increase to higher kinetic energy; the expansion is purely structural, not thermal.
- **D) Liquid water has a greater volume than ice as the particles are further apart**: Incorrectly claims particles are further apart in liquid water; molecular spacing is actually maximized in the solid phase due to the rigid arrangement.
- **E) Liquid water and ice have the same volume, which explains why ice partially floats in water**: Incorrectly claims equal volumes; ice actually expands, becoming less dense, which allows it to partially float.

41 **The structure of paracetamol is shown below:**
Which one of the following functional groups is present in paracetamol?



A Carboxylic acid
B Aldehyde
C Ketone
D **Amide**
E Amine

Correct answer: D

Paracetamol contains an **amide** group where a nitrogen atom is bonded directly to a **carbonyl** carbon ($-\mathrm{NH}-\mathrm{C}(=\mathrm{O})-$). This linkage confirms the functional class of the molecule.

Why the other answers are wrong

- **A) Carboxylic acid**: The structure lacks a carboxyl moiety ($-\mathrm{COOH}$), while the hydroxyl group ($-\mathrm{OH}$) attaches directly to an aromatic ring.
- **B) Aldehyde**: The carbonyl carbon does not carry a direct hydrogen substituent.
- **C) Ketone**: The carbonyl carbon bonds to a nitrogen atom instead of being flanked by two carbon atoms.
- **E) Amine**: The nitrogen atom is incorporated into the carbonyl-based linkage rather than existing as a free amine group.

42 **The formulae of the five most abundant substances in air are shown:**
N_2 O_2 Ar CO_2 H_2O
How many of these five substances are elements and how many of these five substances are made of molecules?

A Elements = 1, molecules = 2
B Elements = 3, molecules = 2
C Elements = 5, molecules = 4
D Elements = 1, molecules = 4
E Elements = 3, molecules = 4

Correct answer: E

Among the five substances, three are elements because they contain only one type of atom: nitrogen (N_2), oxygen (O_2) and argon (Ar). Four of them exist as molecules: N_2, O_2, carbon dioxide (CO_2) and water (H_2O). Argon is a noble gas and exists as individual atoms rather than molecules. Therefore, the correct classification is 3 elements and 4 molecular substances.

Why the other answers are wrong

- **A) Elements = 1, molecules = 2**: claims 1 element and 2 molecules, which misclassifies both the compound count and fails to recognize the molecular nature of water and carbon dioxide.
- **B) Elements = 3, molecules = 2**: claims only 2 molecules, ignoring that CO_2 and H_2O are also formed by discrete molecular units alongside N_2 and O_2.
- **C) Elements = 5, molecules = 4**: claims 5 elements, which is incorrect because CO_2 and H_2O are compounds consisting of different atoms, not pure elements.
- **D) Elements = 1, molecules = 4**: claims only 1 element, overlooking that diatomic gases N_2 and O_2 are pure elements just like monatomic Ar.

43 **Which of these elements has the highest first ionisation energy?**

A Sodium ($Z = 11$)

B Neon ($Z = 10$)

C Lithium ($Z = 3$)

D Argon ($Z = 18$)

E Potassium ($Z = 19$)

Correct answer: B

Neon possesses the highest first ionisation energy because its valence electrons occupy a **stable electron configuration** and sit **closer to the nucleus**. This proximity generates a stronger electrostatic attraction, requiring substantially more energy to remove an electron compared to the other elements listed.

Why the other answers are wrong

- **A) Sodium ($Z = 11$)**: Sodium is an alkali metal with a single valence electron. This electron resides in an outer shell where nuclear pull is weak, allowing it to be detached much more easily than neon's electrons.
- **C) Lithium ($Z = 3$)**: Lithium has a low atomic number with minimal proton count. Its lone electron occupies the second shell and lacks the tight binding seen in neon, resulting in a lower ionisation energy.
- **D) Argon ($Z = 18$)**: Argon maintains a filled outer subshell like neon. Nevertheless, its valence electrons occupy a higher energy level, placing them farther from the nucleus and reducing the effective nuclear charge.
- **E) Potassium ($Z = 19$)**: Potassium exhibits a large atomic radius. Its outermost electron is distant from the positive charge and experiences significant shielding, making it highly accessible for removal.

44 **Which of these molecules has an overall dipole moment?**

A SF_6

B BeF_2

C CF_4

D PF_5

E PF_3

Correct answer: E

$\mathrm{PF_3}$ adopts a trigonal pyramidal **geometry** due to one **lone pair** on phosphorus. The asymmetric shape prevents internal compensation. The molecule exhibits a net dipole moment.

Why the other answers are wrong

- **A)** SF_6: $\mathrm{SF_6}$ displays octahedral symmetry. Six identical bonds arrange opposite each other. **Vectors cancel** completely.
- **B)** BeF_2: $\mathrm{BeF_2}$ has a linear molecular shape. Two opposing bonds align on one axis. Equal forces neutralize each other.
- **C)** CF_4: $\mathrm{CF_4}$ features tetrahedral symmetry. Four identical bonds distribute charge uniformly. Dipole contributions cancel.
- **D)** PF_5: $\mathrm{PF_5}$ possesses trigonal bipyramidal symmetry. Axial and equatorial positions balance symmetrically. Net polarity vanishes.

45 **This reaction is used in the extraction of titanium from its ore.**

$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$

Which substances is/are the reducing agent(s) in this reaction?

A none of these substances - it is not a redox reaction

B Cl_2

C C and Cl_2

D **C**

E TiO_2

Correct answer: D

Carbon acts as the **reducing agent** because it is **oxidised** from oxidation state 0 in C to $+2$ in CO. This electron transfer reduces chlorine from 0 in $\mathrm{Cl_2}$ to -1 in $\mathrm{TiCl_4}$.

Why the other answers are wrong

- **A) none of these substances - it is not a redox reaction**: The reaction features definite changes in oxidation states, confirming it is a redox process.
- **B)** Cl_2: Chlorine **gains electrons** during the reaction rather than donating them.
- **C) C and** Cl_2: $\mathrm{Cl_2}$ undergoes reduction, which classifies it as an **oxidising agent**.
- **E)** TiO_2: Titanium does not change its oxidation state, remaining fixed at $+4$.

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46 **Iron is made by reduction of iron oxide using carbon monoxide.**

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

50 g of iron is made in a reaction from 80 g of iron oxide.

What is the percentage yield of iron in this reaction? (M_r Fe_2O_3 = 160, A_r Fe = 56)

A $\frac{50}{56} \times 100$

B $\frac{50/56}{80/160} \times 100$

C $\frac{25/112}{80/160} \times 100$

D $\frac{25}{80} \times 100$

E $\frac{50}{80} \times 100$

Correct answer: A

The balanced equation shows that 1 mole of $\mathrm{Fe_2O_3}$ produces 2 moles of Fe. Dividing 80 by 160 gives 0.5 moles of $\mathrm{Fe_2O_3}$. Applying the mole ratio yields 1 mole of Fe. This corresponds to a theoretical yield of $56\ \mathrm{g}$. The percentage calculation divides the actual yield of $50\ \mathrm{g}$ by $56\ \mathrm{g}$.

Why the other answers are wrong

- **B)** $\frac{50/56}{80/160} \times 100$: This expression compares the moles of produced iron directly to the moles of iron oxide. It omits the required multiplication by two from the stoichiometry.
- **C)** $\frac{25/112}{80/160} \times 100$: The fraction $\frac{25}{112}$ contains values that do not appear in the problem statement. It does not represent any measured or calculated quantity for this reaction.
- **D)** $\frac{25}{80} \times 100$: The value 25 has no basis in the provided data. It cannot substitute for either the experimental or theoretical amount of iron.
- **E)** $\frac{50}{80} \times 100$: This formula places the starting mass of the oxide in the denominator. Correct yield determination requires the predicted mass of the specific product instead.

47 **Which of these is a weak, diprotic acid?**

A $HO-S(=O)_2-OH$

B $HO-C(=O)-C(=O)-OH$

C $HO-CH_2-CH_2-OH$

D $H-C(=O)-OH$

E $H-C(=O)-C(=O)-H$

Correct answer: B

$HO-C(=O)-C(=O)-OH$ is oxalic acid. It contains two carboxyl groups that can donate protons, making it **diprotic**. It is classified as a **weak acid** because it does not completely dissociate in water.

Why the other answers are wrong

- **A)** $HO-S(=O)_2-OH$ is sulfuric acid. While it can donate two protons, its first dissociation is complete, which defines it as a **strong acid**.
- **C)** $HO-CH_2-CH_2-OH$ is ethylene glycol. It is an **alcohol**, not considered a diprotic acid in standard classifications.
- **D)** $H-C(=O)-OH$ is formic acid. Although it is a weak acid, it contains only one ionizable hydrogen, making it **monoprotic**.
- **E)** $H-C(=O)-C(=O)-H$ is glyoxal. It possesses two **aldehyde groups** instead of acidic carboxyl groups.

48 **Consider this function, defined for every $x > 1$ (where "ln" indicates the natural logarithm): $f(x) = 2\ln(x) - 2\ln(x-1)$. Which of these is an expression for its inverse function $f^{-1}(y)$?**

A $\frac{e^{y/2}}{e^{y/2}-1}, \quad y > 1$

B $\frac{e^{y/2}}{e^{y/2}-1}, \quad y > 0$

C $\frac{1}{e^{y/2}-1}, \quad y > 1$

D $\frac{1}{e^{y/2}-1}, \quad y > 0$

E $\frac{1}{e^{y/2}-1}, \quad y \neq 0$

Correct answer: B

We **combine** the logarithms to obtain $y = 2\ln\left(\frac{x}{x-1}\right)$. **Exponentiating** both sides yields $e^{y/2} = \frac{x}{x-1}$. Rearranging isolates x to give $x = \frac{e^{y/2}}{e^{y/2}-1}$. Since $x > 1$ implies the **fraction** exceeds unity, y must be **strictly positive**. The **inverse** is therefore valid for all $y > 0$.

Why the other answers are wrong

- **A)** $\frac{e^{y/2}}{e^{y/2}-1}, \quad y > 1$: The algebraic form matches the correct derivation, yet the stated interval $y > 1$ is too restrictive since the function reaches all $y > 0$.
- **C)** $\frac{1}{e^{y/2}-1}, \quad y > 1$: The formula produces $x - 1$ instead of x, and the condition $y > 1$ wrongly discards valid outputs between 0 and 1.
- **D)** $\frac{1}{e^{y/2}-1}, \quad y > 0$: This expression calculates $x - 1$ rather than x, despite correctly noting the range $y > 0$.
- **E)** $\frac{1}{e^{y/2}-1}, \quad y \neq 0$: It relies on the incorrect $x - 1$ formula, and permitting negative values contradicts the fact that the inverse only maps to $y > 0$.

49 **Find the set of real solutions of this inequation:**
$2x^2 - 6x + 5 > 0$

A $\{1, 2\}$
B $(1, 2)$
C $(-\infty, 1) \cup (2, +\infty)$
D $\varnothing$
E $\mathbb{R}$

Correct answer: E

Completing the square rewrites the quadratic as $2(x - \frac{3}{2})^2 + \frac{1}{2}$. The squared part stays **non-negative**, guaranteeing the expression is **strictly positive** for any real input. The inequality is satisfied across the **entire domain**.

Why the other answers are wrong

- **A)** $\{1, 2\}$: Isolates discrete points, yet the mathematical relationship continues uninterrupted throughout the graph.
- **B)** $(1, 2)$: Restricts the outcome to a specific interval, while the condition applies everywhere beyond those bounds.
- **C)** $(-\infty, 1) \cup (2, +\infty)$: Excludes a central portion, even though every value inside that range still fulfills the original requirement.
- **D)** $\varnothing$: Proposes an empty set, but the function never drops below zero anywhere on the number line.

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50 **The ratio of sugar to flour in a mixture is $1 : 5$. After 1kg of sugar and 2kg of flour are added to the mixture, the ratio has changed to $2 : 5$.**
A further 1kg of sugar and 2kg of flour are added to the mixture.
What is the new ratio of sugar to flour?

A $3 : 5$
B $4 : 7$
C $3 : 7$
D $11 : 25$
E $14 : 25$

Correct answer: D

1. Define the **initial amounts** as x kg of sugar and $5x$ kg of flour. 2. Apply the **first change condition** $\frac{x+1}{5x+2} = \frac{2}{5}$. 3. Cross-multiply to get $5x + 5 = 10x + 4$ and **solve** for $x = 0.2$. 4. Compute the **final totals** by adding both batches: $0.2 + 2 = 2.2$ kg of sugar and $1 + 4 = 5$ kg of flour. 5. Reduce the fraction to find the **resulting ratio** $11 : 25$.

Why the other answers are wrong

- **A)** $3 : 5$: Incorrect because $3 : 5$ represents a larger proportion than the verified $11 : 25$.
- **B)** $4 : 7$: Incorrect because $4 : 7$ also exceeds the calculated ratio derived from the balanced additions.
- **C)** $3 : 7$: Incorrect because $3 : 7$ corresponds to a smaller proportion than the actual masses of 2.2 kg and 5 kg.
- **E)** $14 : 25$: Incorrect because the combined ingredient weights simplify strictly to $11 : 25$ rather than $14 : 25$.

51 **Two standard six-sided dice numbered 1 to 6 are rolled. What is the probability that the product of the two numbers obtained is the square of a prime?**

- **A** $5/36$
- **B** $7/36$
- **C** $4/36$
- **D** $6/36$
- **E** $3/36$

Correct answer: A

The possible **squares of primes** are $4, 9$ and 25. The matching **ordered outcomes** are $(1,4)$, $(4,1)$, $(2,2)$, $(3,3)$ and $(5,5)$. There are 5 favourable results among 36 total rolls, so the probability is $5/36$.

Why the other answers are wrong

- **B)** $7/36$ contradicts the fact that there are only five favourable ordered outcomes.
- **C)** $4/36$ **misses one** of the five favourable ordered outcomes.
- **D)** $6/36$ asserts there are six distinct favourable rolls, which is incorrect because only five match the prime squares.
- **E)** $3/36$ fails to recognise that each ordering of 1 and 4 counts as a **separate outcome**.

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52 **How many solutions are there in the range $0^\circ \leq x \leq 360^\circ$ to the equation $\sin^4\left(\frac{x+90^\circ}{10}\right) = \frac{1}{16}$?**

- **A** 40
- **B** 20
- **C** 4
- **D** **1**
- **E** 2

Correct answer: D

Substitute $t = \frac{x+90^\circ}{10}$. The domain $0^\circ \leq x \leq 360^\circ$ restricts t to $9^\circ \leq t \leq 45^\circ$. The equation reduces to $|\sin t| = \frac{1}{2}$. Only $t = 30^\circ$ satisfies this condition in the **allowed range**. Back-substitution yields $x = 210^\circ$, proving a **single solution**.

Why the other answers are wrong

- **A) 40**: Computing 40 erroneously includes angles outside the permitted interval. The transformation compresses the domain, so extraneous periodic branches must be removed.
- **B) 20**: Arriving at 20 relies on counting **periodic** repeats that fall outside the valid range. Any candidate generating t outside $9^\circ \leq t \leq 45^\circ$ is invalid and must be discarded.
- **C) 4**: The power of 4 does not multiply the number of valid angles within the restricted interval. Trigonometric mapping preserves the count of valid roots per period.
- **E) 2**: Expecting two solutions ignores the explicit bound check. The relation $\sin t = \frac{1}{2}$ produces exactly one root between 9° and 45°, eliminating the second possibility.

QUESTIONS

53 **What is the complete set of values of x for which $100 - 99x \leq 98 - 97x$ and $96 + 95x > 94 + 93x$?**

A $x > 1$
B $x > -1$
C $-1 < x \leq 1$
D $x \geq 1$
E $x \leq -1$ or $x > 1$

Correct answer: D

Solving the first inequality **simplifies** to $x \geq 1$. The second inequality reduces to $x > -1$. The **intersection** of these conditions yields $x \geq 1$.

Why the other answers are wrong

- **A)** $x > 1$: This option **excludes** $x = 1$, even though substituting 1 works in both expressions.
- **B)** $x > -1$: This range covers values below 1 that fail the first inequality.
- **C)** $-1 < x \leq 1$: This interval includes invalid values under 1 while cutting off every number larger than 1 .
- **E)** $x \leq -1$ **or** $x > 1$: This interval contains numbers that violate the system and incorrectly removes $x = 1$, which satisfies both.

54 **What is the minimum distance of the circle given by the equation $x^2 - 10x + y^2 + 12y + 57 = 0$ from the coordinate axes?**

A **3**
B 1
C 5
D 4
E 2

Correct answer: A

Completing the square yields $(x - 5)^2 + (y + 6)^2 = 4$. The **center** is at $(5, -6)$ and the **radius** is 2. The distance to the x-axis is 6 and to the y-axis is 5. Subtracting the radius gives 4 and 3. The smallest gap is therefore 3.

Why the other answers are wrong

- **B) 1**: Both coordinate axes remain further away than one unit from the curve.
- **C) 5**: This number represents the distance from the center to the y-axis before removing the boundary. Forgetting to subtract the size leads to an incorrect result.
- **D) 4**: This figure corresponds to the shortest path toward the x-axis, but the curve approaches the y-axis more closely.
- **E) 2**: This value equals the radius length rather than the actual distance to an axis.

55 **The expression $\sqrt{\frac{16^x+8^x}{4^x+2^x}}$ simplifies to which of the following?**

A 2^{2x}
B $(\sqrt{2})^x$
C 2
D $\sqrt{2^x}$
E 2^x

Correct answer: E

Substitute $t = 2^x$. This implies $t > 0$, $16^x = t^4$, $8^x = t^3$, $4^x = t^2$, and $2^x = t$. Replace these terms to obtain $\sqrt{\frac{t^4+t^3}{t^2+t}}$. **Factor** out t^3 in the numerator and t in the denominator. **Simplify** the fraction by canceling the common factor $(t + 1)$. The expression reduces to $\sqrt{t^2}$. Apply the condition $t > 0$ to **result** in $t = 2^x$.

Why the other answers are wrong

- **A)** 2^{2x} represents the unsimplified ratio before the square root. The radical operator halves the exponent, making this value incorrect.
- **B)** $(\sqrt{2})^x$ also rewrites as $2^{x/2}$. It shares the same exponential mismatch as option D and does not equal 2^x.
- **C) 2**: The simplified form contains x in the exponent. It varies as x changes instead of remaining a constant value.
- **D)** $\sqrt{2^x}$ converts to $2^{x/2}$. This exponent differs from x and fails to match the target expression generally.

56 **A point mass A with mass m moves at a constant speed v on a horizontal frictionless plane and collides with another point mass B with mass 2m that is at rest. The collision is elastic. After the collision, point mass A is moving with a speed v_A and point mass B with a speed v_B.**
What are v_A and v_B, in terms of v?

A $v_A = \frac{1}{3}v; \quad v_B = \frac{1}{2}v$
B $v_A = \frac{1}{2}v; \quad v_B = \frac{1}{3}v$
C $v_A = \frac{1}{2}v; \quad v_B = \frac{1}{2}v$
D $v_A = \frac{2}{3}v; \quad v_B = \frac{1}{3}v$
E $v_A = \frac{1}{3}v; \quad v_B = \frac{2}{3}v$

Correct answer: E

Apply **conservation of momentum** and **kinetic energy** to the isolated system. The initial state satisfies $mv = mu_A + 2mu_B$ and $\frac{1}{2}mv^2 = \frac{1}{2}mu_A^2 + \frac{1}{2}(2m)u_B^2$. Solving this pair of equations yields $u_A = -\frac{1}{3}v$ and $u_B = \frac{2}{3}v$. Mass A rebounds while mass B advances forward. Since the question asks for **speeds**, we report the absolute values of these signed velocities.

Why the other answers are wrong

- **A)** $v_A = \frac{1}{3}v; \quad v_B = \frac{1}{2}v$: Substituting these values into the energy equation produces a final total less than the initial one, violating elastic collision rules.
- **B)** $v_A = \frac{1}{2}v; \quad v_B = \frac{1}{3}v$: These magnitudes similarly break energy conservation and do not match the theoretical velocity ratio for an elastic impact.
- **C)** $v_A = \frac{1}{2}v; \quad v_B = \frac{1}{2}v$: This pair reduces the total kinetic energy and fails to balance the initial linear momentum.
- **D)** $v_A = \frac{2}{3}v; \quad v_B = \frac{1}{3}v$: The numerical results are swapped between the objects, contradicting the mass-dependent outcome and failing both conservation laws.

57 **An ideal gas is trapped in a metal cylinder by a free-moving piston and is at equilibrium in a room at $25^{\circ}\mathrm{C}$.**
The piston is pulled slowly to the right so that the volume of the trapped gas increases isothermally. The piston is now fixed in position.
The metal cylinder is then placed in a location where thermal energy is transferred from the trapped gas until the pressure of the gas is halved.
To the nearest degree Celsius, what is the final temperature of the gas?

A $25^{\circ}\mathrm{C}$
B $-124^{\circ}\mathrm{C}$
C $-149^{\circ}\mathrm{C}$
D $13^{\circ}\mathrm{C}$
E $50^{\circ}\mathrm{C}$

Correct answer: B

The isothermal expansion keeps the gas at $25^{\circ}\mathrm{C} = 298.15\ \mathrm{K}$. Fixing the piston maintains a **constant volume**, making **pressure directly proportional to absolute temperature**. Halving the pressure halves the Kelvin value to $149.075\ \mathrm{K}$. Converting back yields $-124^{\circ}\mathrm{C}$.

Why the other answers are wrong

- **A)** $25^{\circ}\mathrm{C}$: Incorrectly assumes the temperature remains unchanged, ignoring the necessary cooling when pressure drops at fixed volume.
- **C)** $-149^{\circ}\mathrm{C}$: Mistakes the halved Kelvin value of $149\ \mathrm{K}$ for a negative Celsius reading.
- **D)** $13^{\circ}\mathrm{C}$: Results from halving $25^{\circ}\mathrm{C}$ directly without converting to Kelvin for the pressure temperature relationship.
- **E)** $50^{\circ}\mathrm{C}$: Implies a rise in thermal energy, whereas decreasing pressure requires the absolute temperature to fall.

58 **A metal jug of negligible thermal capacity contains a mass M of water at a temperature T_1. A dry block of ice (specific latent heat of fusion = L_f) of mass m at $0\ ^\circ\mathrm{C}$ is dropped into the water (specific heat capacity = c) and begins to melt. At thermal equilibrium, there is no ice in the jug and the temperature of all the water is T_2.**
There is no thermal energy transfer between the atmosphere and the water or between the atmosphere and the ice.
Which expression is used to calculate m?

A $\frac{McT_1}{L_f+cT_2}$
B $\frac{Mc(T_1-T_2)}{L_f+cT_1}$
C $\frac{Mc(T_1-T_2)}{L_f}$
D $\frac{McT_1}{L_f}$
E $\frac{Mc(T_1-T_2)}{L_f+cT_2}$

Correct answer: E

The system follows an energy conservation principle where the heat lost by the warm water equals the heat gained by the ice. The initial water cools from T_1 to T_2, releasing $Mc(T_1 - T_2)$. The ice absorbs latent heat mL_f to melt at $0\ ^\circ\mathrm{C}$ and then requires sensible heat mcT_2 to reach the final temperature. Equating these quantities yields $Mc(T_1 - T_2) = m(L_f + cT_2)$, which rearranges directly to the target expression.

Why the other answers are wrong

- **A)** $\frac{McT_1}{L_f+cT_2}$: Uses T_1 rather than the original water's temperature drop $T_1 - T_2$.
- **B)** $\frac{Mc(T_1-T_2)}{L_f+cT_1}$: Warms the melted ice to T_1 instead of the final equilibrium temperature T_2.
- **C)** $\frac{Mc(T_1-T_2)}{L_f}$: Accounts only for the melting process and neglects the energy required to raise the temperature of the melted water to T_2.
- **D)** $\frac{McT_1}{L_f}$: Uses the wrong temperature change for the cooling phase and omits the energy needed to warm the melted ice.

59 **A vehicle travels east for 6km, then south for 8km without stopping. If the trip takes 15 minutes, what is the magnitude of the average velocity in km/h?**

A 20
B 56
C 8
D 14
E **40**

Correct answer: E

Average velocity depends on net **displacement**, not total distance. The two movement directions form a **right angle**, so we determine the net path using the **hypotenuse**. Calculation yields $\sqrt{6^2 + 8^2} = 10\ \mathrm{km}$. The duration converts to $0.25\ \mathrm{h}$. Dividing displacement by time gives $40\ \mathrm{km/h}$.

Why the other answers are wrong

- **A) 20**: The displacement divided by the travel time equals $40\ \mathrm{km/h}$.
- **B) 56**: This figure does not result from dividing the displacement by the travel time.
- **C) 8**: The value $8\ \mathrm{km}$ is only the southward segment length, representing neither the net displacement nor the average velocity.
- **D) 14**: Summing the two legs produces $14\ \mathrm{km}$, which is the total distance travelled rather than the displacement.

60 **Two perfectly insulating spheres charged respectively with Q_1 and Q_2 and with a respective radius of R_1 and R_2 are placed in contact.**
What will the charge on the sphere of radius R_1 now be?

A $\frac{Q_1R_1^2+Q_2R_2^2}{R_1^2+R_2^2}$

B Q_1

C Q_2

D 0

E $\frac{Q_1R_1+Q_2R_2}{R_1+R_2}$

Correct answer: B

Insulating materials prevent any transfer of electric charge between objects. When the spheres touch, the charges remain fixed on their respective volumes. Thus, the sphere of radius R_1 maintains its **original charge** Q_1.

Why the other answers are wrong

- **A)** $\frac{Q_1R_1^2+Q_2R_2^2}{R_1^2+R_2^2}$: This formula implies charge splits proportionally to surface area, which describes how **conductors** share electrons to reach electrostatic equilibrium. Insulators block such redistribution entirely.
- **C)** Q_2: This choice suggests physical contact instantly overwrites the first sphere's state with the second's value. Touching separate dielectric bodies never swaps or copies stored energy.
- **D) 0**: This result would occur only if opposite charges met and cancelled out, leading to complete **neutralization**. Isolated insulating spheres retain their independent net values regardless of proximity.
- **E)** $\frac{Q_1R_1+Q_2R_2}{R_1+R_2}$: This expression assumes splitting follows linear radius ratios, a model applicable only to connected metallic bodies that allow charge migration. It fails here because the material properties stop **charge transfer**.

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