PROVE UFFICIALI DEGLI ANNI PASSATI

IMAT

2020

A B D E

SVOLTA CON SOLUZIONI COMMENTATE

Il perché di ogni risposta

WHAT'S IN THIS DOCUMENT

Prova di ammissione IMAT 2020, 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

General Knowledge and Logical Reasoning	22 questions
Biology	17 questions
Chemistry	12 questions
Physics and Mathematics	6 questions
Total	**57 questions**

This version has **57 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.

GENERAL KNOWLEDGE AND LOGICAL REASONING

1 **Thousands of books and blogs – and quite a bit of legitimate science – sing the praises of positivity. Optimistic, happy people tend to be healthier, more physically active and more successful. They may even live longer. But as shown by research, positivity, when deployed at the wrong time or in the wrong amount, can have negative effects. For example, when it comes to waiting for the results of an exam or a job interview, 'being prepared for the worst' is shown to be a better strategy for protecting ourselves than categorical optimism. When it comes to health, negative thinking spurs people into seeking information and engaging in healthy behaviour. Finally, relentlessly positive people may seem dismissive or insensitive to friends who are having difficulties, seeming to make light of their problems.**

Which one of the following best expresses the main conclusion of the above argument?

A Negative thinking about health can be beneficial.
B People who think positively live longer.
C Research into positivity has so far ignored its potential downsides.
D **Positive thinking is not always helpful.**
E Being overly positive can damage our relationships with friends.

Correct answer: D

The passage acknowledges the benefits of optimism but argues that **positivity** can cause negative effects when applied at the **wrong time** or in the **wrong amount**. Scenarios involving exam results, personal health, and social interactions provide supporting evidence for this broader claim.

Why the other answers are wrong

- **A) Negative thinking about health can be beneficial.**: This statement reflects only a single illustrative detail about how cautious thoughts motivate healthy actions, rather than serving as the central thesis of the paragraph.
- **B) People who think positively live longer.**: This choice merely reports an initial advantage of optimistic mindsets that the author subsequently qualifies by introducing their potential limitations.
- **C) Research into positivity has so far ignored its potential downsides.**: The text explicitly cites studies demonstrating the potential drawbacks of excessive positivity, directly contradicting the claim that academic research ignores these issues.
- **E) Being overly positive can damage our relationships with friends.**: This option highlights just one interpersonal consequence described in the text, failing to capture the broader critique that applies across multiple life domains.

2 **Although the idea of a driverless vehicle seems like the stuff of science fiction, we are moving very close to the reality of self-driving cars. But we are so engrossed in the technology that we are ignoring the legal implications – and legislating for new scenarios takes time. A whole new set of questions is raised by the development of these machines. One example is the question of who takes responsibility when an accident happens. Given that the vast majority of crashes are caused in part at least by human error, self-driving cars should have the capacity to save lives. But they will not be perfect. So if an accident happens, who is responsible? The owner of the car, or the manufacturer of the car? The car itself cannot be prosecuted or made to pay damages.**

Which one of the following can be drawn as a conclusion from the above passage?

A It will be impossible to determine liability for accidents involving driverless cars.

B All the technology needed to create a self-driving car is already available.

C **New laws are needed to determine liability for accidents involving driverless cars.**

D We should not continue to develop self-driving cars.

E The design of driverless cars will continue to improve with time.

Correct answer: C

The passage states that driverless cars could reduce accidents caused by human error but remain imperfect. Because the vehicle itself cannot be prosecuted, determining **liability** falls on either the **owner** or the **manufacturer**. This legal gap indicates a clear need for **new laws** to assign responsibility when crashes occur.

Why the other answers are wrong

- **A) It will be impossible to determine liability for accidents involving driverless cars.**: The passage claims responsibility is currently unclear due to the lack of legislation, but this ambiguity does not make determining liability an insurmountable or impossible task.
- **B) All the technology needed to create a self-driving car is already available.**: Stating that society is moving close to self-driving reality only indicates technological progress, not that every required component is fully ready and deployed.
- **D) We should not continue to develop self-driving cars.**: The text explicitly notes that self-driving cars have the potential to save lives, so it does not support halting their development.
- **E) The design of driverless cars will continue to improve with time.**: The author focuses strictly on current legal and ethical questions, offering no forecasts regarding how the engineering or performance will evolve.

3 **In 1938 the Dutch artist Piet Mondrian left Paris to escape the threat of German invasion and went to live in London, where he painted what are now regarded as his best works. Mondrian had the option of moving to a more rural area in England, but chose London because of his love of the diverse and vibrant culture of big cities. This explains why London has more artists living in it than any other city in England.**

Which one of the following is an underlying assumption of the above passage?

A There is less inspiration for artists in rural areas.

B Artists can only create great works if they are happy and relaxed.

C London is a big city because all the artists who live there boost its size and population.

D Other big cities in England have the same attractive features as London.

E **Other artists make the same choice as Mondrian for the same reasons.**

Correct answer: E

The author explains London's high artist population by citing Mondrian's move for the **urban cultural environment**. This logic only holds if other artists followed the **same reasoning**. Without this connection, the leap from one individual to an entire city remains unsupported.

Why the other answers are wrong

- **A) There is less inspiration for artists in rural areas.**: Mondrian's personal preference does not require rural areas to lack **creative stimulation**. The passage only highlights his attraction to cities, ignoring countryside settings entirely.
- **B) Artists can only create great works if they are happy and relaxed.**: The conclusion focuses on where artists reside, not on the emotional states needed for **artistic production**. Psychological conditions fall outside the stated demographic scope.
- **C) London is a big city because all the artists who live there boost its size and population.**: The argument treats London's size as a reason artists choose it, not as a result of their living there. This confuses cause with effect through **reversed causality**.
- **D) Other big cities in England have the same attractive features as London.**: Claiming other cities share comparable traits would undermine the original argument instead of supporting it. Equal attractiveness would fail to explain why London specifically draws the largest number.

4 **In some countries, prisoners may purchase books with the money they earn by working. Hence receiving gifts of books may discourage prisoners from undertaking paid work while in prison. This work is important in building self-esteem and encouraging a work ethic among prisoners. In any case, prisoners have access to books through the prison library. Therefore prisoners should not be allowed to receive parcels containing books from friends or relatives while they are serving their sentence.**

Which one of the following, if true, most strengthens the above argument?

A **Many parcels of books sent by relatives or friends have been found to contain illegal drugs.**

B The range of books available in prison libraries is limited.

C Many prisoners have difficulty finding work when they are released because of their low level of literacy.

D Prisoners often read detective stories which may encourage them to glamorise crime.

E Prisoners have to purchase a range of items from their wages, including a television licence.

Correct answer: A

The argument recommends banning **book parcels** to prevent inmates from skipping **paid work** for free reading material. If these parcels frequently contain **illegal drugs**, the prohibition would also eliminate a serious **security threat**. This provides an independent justification that strongly supports the proposal beyond the original economic logic.

Why the other answers are wrong

- **B) The range of books available in prison libraries is limited.**: Restricted library collections directly contradict the premise that institutional archives can fully replace personal deliveries. This factual gap weakens the core rationale for implementing the ban.
- **C) Many prisoners have difficulty finding work when they are released because of their low level of literacy.**: Low literacy rates severely restrict future job prospects upon release. This indicates that book access holds significant rehabilitative value and does not support restricting external mail.
- **D) Prisoners often read detective stories which may encourage them to glamorise crime.**: Specific literary genres may promote criminal glorification, but this observation targets content selection alone. It fails to address the procedural distinction between accepting mailed volumes versus utilizing facility libraries or maintaining labor participation.
- **E) Prisoners have to purchase a range of items from their wages, including a television licence.**: Inmates require wages to purchase mandatory items such as television licences. Receiving complimentary books would therefore be less likely to reduce their incentive to earn money through prison employment.

5 **People who take their holidays in Las Vegas love to gamble. Gerry will be going to France for his holiday so he must not like gambling.**

Which one of the following most closely parallels the reasoning used in the above argument?

A You have to find the password to complete the game. You haven't finished the game yet so you can't have found the password.

B People who eat a lot of sweets have rotten teeth. You eat a lot of sweets, so your teeth must be rotten.

C **People who live in the city hate traffic jams. You live in the country so you must like traffic jams.**

D You always walk when you are visiting your sister. You are not visiting your sister so that's why you are taking the car.

E In England cars are driven on the left side of the road. We are driving on the left, so we must be in England.

Correct answer: C

The premise identifies a trait for visitors to a location, then wrongly assumes that going elsewhere forces the opposite view. Option B follows this exact **structure** by claiming that living outside the city guarantees loving traffic jams. Both arguments commit the same **converse** error by dismissing neutral alternatives.

Why the other answers are wrong

- **A) You have to find the password to complete the game. You haven't finished the game yet so you can't have found the password.**: This outlines a sequential requirement for finishing a task rather than attributing conflicting attitudes based on geography.
- **B) People who eat a lot of sweets have rotten teeth. You eat a lot of sweets, so your teeth must be rotten.**: This properly extends a generalization to an individual who satisfies the stated condition instead of speculating about someone outside the set.
- **D) You always walk when you are visiting your sister. You are not visiting your sister so that's why you are taking the car.**: This supplies a direct cause for choosing transportation instead of deducing a personal stance from a circumstance.
- **E) In England cars are driven on the left side of the road. We are driving on the left, so we must be in England.**: This reverses directionality by moving from observable conduct back to geographical location, whereas the prompt travels from place to preference.

6 **LoCost sells three different types of washing powder: Zoom, Zap and Ownbrand. Zoom is a double concentrate brand needing only half the amount of powder used by the other two brands.**

Which one of the boxes of powder below represents best value for money?

A **<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e218x128xe81281e2.png?alt=media&token=37f03e22-7a6b-4f1d-90a0-2f6ea2727000<i>**

B <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e21i21j12xe.png?alt=media&token=5493737d-84f6-4299-8ca0-b512f1848c24<i>

C <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc8e1u28cu1ce12.png?alt=media&token=2c712c6a-f646-4c7b-a99c-f00c24c46525<i>

D <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fce81u28ue181c2e.png?alt=media&token=76c25553-5449-4a4c-a040-693ed7d76922<i>

E <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc1e2121yu12u8c1.png?alt=media&token=6a5651dd-dd78-4d90-b717-93dcdcdc8da2<i>

Correct answer: A

To compare value correctly, first convert all packages to an **equivalent strength weight**. Since Zoom is double concentrate, its mass must be multiplied by 2 before pricing. Next, divide the adjusted weight by the price to find the **cost per kilogram** for each box. Selecting the lowest unit cost identifies the true best value.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e21i21j12xe.png?alt=media&token=5493737d-84f6-4299-8ca0-b512f1848c24<i>**: The Zap box contains $1.50\ \text{kg}$ for £3.30. Dividing gives a unit cost of $£2.20\ \text{kg}^{-1}$, which is significantly higher than option A. The larger pack size does not justify the increased price.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc8e1u28cu1ce12.png?alt=media&token=2c712c6a-f646-4c7b-a99c-f00c24c46525<i>**: The smallest Ownbrand box offers only $1.00\ \text{kg}$ for £2.00. Its direct division results in $£2.00\ \text{kg}^{-1}$. The attractive shelf price hides a steep per-unit rate compared to the concentrated formula.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fce81u28ue181c2e.png?alt=media&token=76c25553-5449-4a4c-a040-693ed7d76922<i>**: The Ownbrand package weighs $1.80\ \text{kg}$ and costs £3.20. The calculation yields roughly $£1.78\ \text{kg}^{-1}$, making it cheaper than Zap but still notably more expensive than the adjusted Zoom price.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc1e2121yu12u8c1.png?alt=media&token=6a5651dd-dd78-4d90-b717-93dcdcdc8da2<i>**: The larger Zap box holds $2.00\ \text{kg}$ at £4.40. This produces the identical unit price of $£2.20\ \text{kg}^{-1}$. Scaling up quantity here only scales the total cost proportionally without improving efficiency.

7 **36% of the contents of a tin of sweets have been eaten. Today, 25% of the remaining sweets will be eaten. The same number of sweets will be eaten on each of the following 2 days.**

What % of its original contents will it then contain?

A 25
B 15
C **16**
D 9
E 24

Correct answer: C

1. Assume 100 initial sweets. 2. Eating 36% leaves 64 sweets. 3. Daily consumption takes 25% of 64, calculated as $0.25 \times 64 = 16$ sweets. 4. The next two days remove the same **fixed quantity** of 16 sweets each time. 5. Subtracting twice more gives 16 sweets left, which matches 16% of the original total.

Why the other answers are wrong

- **A) 25**:
- **B) 15**:
- **D) 9**:
- **E) 24**:

8 **As part of a maths project, a class of 30 children conduct a survey amongst themselves of how many brothers and sisters they have. They each write their name in the appropriate space on the chart below.**
No one in the class has a brother or sister who is also in the class.

How many of the 30 families involved in the survey have a total of 3 or more children?

		BROTHERS			
		0	1	2	3
SISTERS	0	Sara Jordan Ben Ellie	Kylie Gita Tamsin Sam Adam Bethany Craig	Leroy Gemma	Callum
	1	Kate Jessica Robin Vikram Sally Scott Chloe Oliver	Rajiv Emily Fatima	Paul	
	2	Aruna	Candice Marvin		
	3		Phoebe		

A 8
B 10
C **11**
D 6
E 7

Correct answer: C

Each child represents a **distinct family** because no siblings attend the same class. The total family size equals the student plus their **sisters and brothers**. We require a **total of three or more** members, meaning the sibling sum must be two or higher. Filtering the chart for matching cells and counting the names results in $2 + 1 + 3 + 1 + 1 + 2 + 1 = 11$.

Why the other answers are wrong

- **A) 8**: Eight remains insufficient since it excludes valid families like Rajiv, Emily, and Fatima who appear at the one sister and one brother coordinate, as well as Phoebe at the three sisters and zero brothers coordinate.
- **B) 10**: Ten falls exactly one unit below the verified total of eleven, indicating a simple counting oversight during the selection process.
- **D) 6**: Six is too small because it omits several families with exactly two siblings, such as Candice, Marvin, and Aruna, along with the three students located at the intersection of one sister and one brother.
- **E) 7**: Seven also undercounts the data by potentially focusing only on combinations with two sisters and zero brothers alongside zero sisters and two brothers, while completely ignoring the other valid cells.

9 **Jeff is looking to buy a new car. He will only be using it for commuting to his workplace for 1 year and will have a total annual mileage of 20 000. He wants to buy the car which would make his total spend over the year, including the initial cost of the car, the lowest.**

Using the table above, which type of car should he buy?

type of car	*cost to fill or charge tank* ($)	*distance on full tank or charge* (miles)	*car cost* ($)
autogas	30	200	10 000
diesel	50	500	12 000
petrol	50	400	10 000
hydrogen	50	200	9500
electric	5	200	12 500

A hydrogen
B **petrol**
C diesel
D autogas
E electric

Correct answer: B

Calculate the **number of fills** by dividing 20,000 miles by the range per fill. Multiply by the cost per fill to find **fuel cost**, then add the purchase price to get the **total cost**. Petrol's total is 12,500 dollars, the **lowest** of the five. | Type | Cost per fill (dollars) | Range per fill (miles) | Number of fills | Fuel cost (dollars) | Car cost (dollars) | Total cost (dollars) | |---|---:|---:|---:|---:|---:|---:| | Autogas | 30 | 200 | $20\,000 \div 200 = 100$ | $100 \times 30 = 3\,000$ | 10,000 | 13,000 | | | Diesel | 50 | 500 | $20\,000 \div 500 = 40$ | $40 \times 50 = 2\,000$ | 12,000 | 14,000 | | | Hydrogen | 50 | 200 | $20\,000 \div 200 = 100$ | $100 \times 50 = 5\,000$ | 9,500 | 14,500 | | | Electric | 5 | 200 | $20\,000 \div 200 = 100$ | $100 \times 5 = 500$ | 12,500 | 13,000 | | | Petrol | 50 | 400 | $20\,000 \div 400 = 50$ | $50 \times 50 = 2\,500$ | 10,000 | 12,500 |

Why the other answers are wrong

- **A) hydrogen**: Its total is 14,500 dollars, the highest of all five options and 2,000 dollars more than petrol's 12,500 dollars.
- **C) diesel**: Its total is 14,000 dollars, which is 1,500 dollars more than petrol's 12,500 dollars.
- **D) autogas**: Its total is 13,000 dollars, which is 500 dollars more than petrol's 12,500 dollars.
- **E) electric**: Its total is 13,000 dollars, which is 500 dollars more than petrol's 12,500 dollars.

10 **A piece of paper is laid on a table in landscape orientation (i.e. the longer side running left to right and the shorter side running top to bottom). This piece of paper is then folded in half four times, alternately by moving the left hand side across over the right hand side and folding, and by moving the top half down over the bottom half and then folding. After each fold a dot is made with a pen in the centre of the face showing on the table.**
After the four folds and four dots, the paper is unfolded in the reverse sequence and is then turned over so that the four dots are showing.

What is the pattern of the dots on the paper?
(Dotted lines represent the fold marks)

A <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F38rcu1cr21u.png?alt=media&token=9197164a-b31e-46b6-9dbd-5321f4af297b<i>

B <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1c2e1i2e12cj12.png?alt=media&token=61575656-a6b0-41cd-9296-6c0ed42c81f1<i>

C <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fr8cu82uc218rc.png?alt=media&token=8600a42f-cd90-4cb7-8463-45329f55fb92<i>

D <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F9e129c1212c.png?alt=media&token=b52bfe4c-58a3-4ab1-83cc-607e30c48913<i>

E **<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc12e89128cu8ce.png?alt=media&token=ca609033-97db-4d5a-8bd1-94eacc0ba514<i>**

Correct answer: E

1. The first fold leaves the **right half** of the sheet, so the first dot unfolds to $\left(\frac{3}{4}W, \frac{1}{2}H\right)$. 2. The second fold leaves the lower half of that part, placing the second dot at $\left(\frac{3}{4}W, \frac{3}{4}H\right)$. 3. The third and fourth folds place the remaining dots at $\left(\frac{7}{8}W, \frac{3}{4}H\right)$ and $\left(\frac{7}{8}W, \frac{7}{8}H\right)$. After unfolding and turning the paper over, only diagram A shows all four positions.

Why the other answers are wrong

- **A) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F38rcu1cr21u.png?alt=media&token=9197164a-b31e-46b6-9dbd-5321f4af297b<i>**: The two lower-right dots are correct, but the other two are a whole square too far to the left. They would require folding the right edge over the left, which never happens.
- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1c2e1i2e12cj12.png?alt=media&token=61575656-a6b0-41cd-9296-6c0ed42c81f1<i>**: One dot is shown on the $\frac{1}{4}$ fold line and another too high up. That arrangement cannot be produced by the given folding order.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fr8cu82uc218rc.png?alt=media&token=8600a42f-cd90-4cb7-8463-45329f55fb92<i>**: The pattern is shown one row too high. The first dot should lie on the $\frac{1}{2}$-height fold, not in the centre of the upper strip.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F9e129c1212c.png?alt=media&token=b52bfe4c-58a3-4ab1-83cc-607e30c48913<i>**: The right-hand pair is correct, but the

remaining two positions are swapped, placing one above instead of to the left. That swap would require the first fold to be top-over-bottom, contrary to the instructions.

11 **Which of the following languages is not a member of the 'Romancè language family?**

A Romanian
B Bulgarian
C Catalan
D Spanish
E French

Correct answer: B

The Romance language family consists of tongues that evolved directly from **Vulgar Latin**. Bulgarian developed from **Proto-Slavic** instead and belongs to the **South Slavic** branch, which means it has a distinct grammatical structure and core vocabulary. It is therefore the only option that does not belong to the Romance group.

Why the other answers are wrong

- **A)** Romanian represents the Eastern Romance subgroup derived from Latin in the Balkans, and despite notable Slavic influences its foundational structure and vocabulary remain Latin-based.
- **C)** Catalan descended directly from Latin and is spoken across northeastern Spain, Andorra, southern France, and northern Italy while staying firmly within the Romance classification.
- **D)** Spanish is a West-Iberian Romance language that grew out of Latin in the Iberian Peninsula and remains a major member of the family.
- **E)** French developed as a Gallo-Romance language from Latin spoken in ancient Gaul and serves as another principal member of the group.

12 **Which of these people did NOT win the Nobel Prize in Literature?**

A Pablo Neruda
B Thomas Mann
C Harold Pinter
D Bob Dylan
E Charles Dickens

Correct answer: E

The **Nobel Prize** was first awarded in **1901**, decades after **Charles Dickens** died in 1870. Because the award did not exist during his lifetime, he was never eligible to receive it.

Why the other answers are wrong

- **A)** Pablo Neruda is a Chilean poet who received the award in 1971.
- **B)** Thomas Mann is a German novelist who was honored with the Nobel Prize in Literature in 1929.
- **C)** Harold Pinter is a British playwright who won the prize in 2005.
- **D)** Bob Dylan is an American songwriter and author who received the award in 2016.

13 **Which one of the following is the director of the film Amarcord ?**

A Alfred Hitchcock
B **Federico Fellini**
C Francis Ford Coppola
D François Truffaut
E Stanley Kubrick

Correct answer: B

Amarcord (1973) is an autobiographical Italian film about a year in a small Adriatic town viewed through a teenage boy. Written and directed by **Federico Fellini**, it features his signature **episodic structure**, **surreal humor**, and blend of **nostalgia** and fantasy. The director earned the **1975 Academy Award** for Best Foreign-Language Film for this exact work.

Why the other answers are wrong

- **A) Alfred Hitchcock**: He earned the nickname master of suspense and directed classic thrillers like *Psycho*, *Vertigo*, and *Rear Window*. He never worked on an Italian coming-of-age movie.
- **C) Francis Ford Coppola**: He is an American filmmaker best known for *The Godfather* trilogy and *Apocalypse Now*. He did not direct or contribute to this film.
- **D) François Truffaut**: He was a leading figure of the French New Wave who directed *The 400 Blows* and *Jules and Jim*. He had no creative involvement with this Italian production.
- **E) Stanley Kubrick**: He built his career around movies like *2001: A Space Odyssey*, *A Clockwork Orange*, and *The Shining*. His cinematic style and filmography are entirely unrelated to this project.

14 **Which of the following books was NOT written by Primo Levi?**

A The Truce
B **Beyond Good and Evil**
C The Drowned and the Saved
D If Not Now, When?
E If This Is a Man

Correct answer: B

Beyond Good and Evil is a philosophical treatise by **Friedrich Nietzsche**, published in **1886**, decades before the Italian writer was born. All remaining titles belong to his bibliography and explore his camp imprisonment alongside post-war ethical reflections.

Why the other answers are wrong

- **A) The Truce**: Released in 1963 as a direct sequel tracking his arduous transit home immediately following his liberation.
- **C) The Drowned and the Saved**: Completed in 1986 as a final essay collection examining the moral dilemmas and psychological remnants of the genocide.
- **D) If Not Now, When?**: Written in 1982 as a historical novel centering on a partisan group battling occupying forces across Eastern Europe.
- **E) If This Is a Man**: Appears in 1947 as a memoir regarding his imprisonment at Auschwitz and circulates under the variant title *Survival in Auschwitz*.

15 **The name of the German mathematician Carl Friedrich Gauss is famously associated with**

A the law of supply and demand
B the uncertainty principle
C **the normal distribution curve**
D Bayes' theorem
E the sine function

Correct answer: C

Carl Friedrich Gauss advanced **probability theory** while analyzing **measurement errors** in astronomy and geodesy. He proved that combining numerous independent random errors produces a characteristic **bell-shaped curve**. This statistical pattern is universally recognized as the **normal distribution** or Gaussian distribution because of his foundational work.

Why the other answers are wrong

- **A) the law of supply and demand**: The law of supply and demand is an economic principle rather than a mathematical one. It traces its development to classical economists like Adam Smith and Alfred Marshall and shares no connection with Gauss's research.
- **B) the uncertainty principle**: The uncertainty principle was established by Werner Heisenberg in 1927 as a core tenet of quantum mechanics. This physical discovery occurred nearly a century after Gauss's death and falls completely outside his scientific domain.
- **D)** Bayes' theorem is named after theologian Thomas Bayes and was later formalized by Pierre-Simon Laplace. While Gauss utilized statistical approaches resembling Bayesian inference in certain problems, the formal theorem remains strictly attributed to Bayes.
- **E) the sine function**: Sine and cosine functions predate Gauss by centuries and originate from ancient Greek and Indian mathematics. Gauss routinely applied trigonometric methods in his calculations, but the sine function itself bears no historical attribution to him.

16 **Which one of the following was the first human to complete an orbit of the Earth in 1961?**

A John Glenn
B **Yuri Gagarin**
C Valentina Tereshkova
D Neil Armstrong
E Buzz Aldrin

Correct answer: B

On April 12, 1961, Soviet cosmonaut **Yuri Gagarin** flew aboard Vostok 1. His spacecraft completed one full revolution around the **Earth**. This **108-minute flight** marked the first successful human **orbital mission**.

Why the other answers are wrong

- **A)** John Glenn orbited Earth aboard Friendship 7 in February 1962 as the first American. Gagarin had already secured the first human orbital flight the previous year.
- **C)** Valentina Tereshkova launched on Vostok 6 in 1963 as the first woman in space. She successfully orbited Earth but flew two years after the initial human milestone.
- **D)** Neil Armstrong became known for walking on the Moon during Apollo 11 in 1969. He did not reach Earth orbit first, as that achievement occurred eight years earlier.
- **E)** Buzz Aldrin served as the second astronaut to walk on the Moon with Armstrong. He did not fly in space until 1966 aboard Gemini 12 and missed the first Earth orbit record.

17 **Which one of the following pairs of archipelago/country is NOT correct?**

A Canary Islands – Spain
B Azores – Portugal
C Hawaii – United States of America
D Galapagos Islands – Ecuador
E Cape Verde – Brazil

Correct answer: E

Cape Verde is an **independent nation** in the Atlantic Ocean located about 600 km off the coast of West Africa. It gained independence from **Portugal** in 1975 and has never been a territory or dependency of **Brazil**. Pairing these two creates the only incorrect match, making it the correct choice.

Why the other answers are wrong

- **A) Canary Islands – Spain**: The Canary Islands are an autonomous community of Spain located off the northwest coast of Africa. Their historical and current governance under Spanish sovereignty validates the match.
- **B) Azores – Portugal**: The Azores are an **autonomous region** of Portugal situated in the North Atlantic. Their direct administrative ties to Lisbon confirm the validity of this pairing.
- **C) Hawaii – United States of America**: Hawaii has maintained its status as a US state since **1959**. Its long political integration into the United States confirms the correct association.
- **D) Galapagos Islands – Ecuador**: The Galápagos Islands act as a province of Ecuador lying in the Pacific Ocean roughly 1,000 km west of the mainland. This territorial arrangement aligns perfectly with the option.

18 **Which one of the following international organisations maintains a list of the World Heritage Sites of outstanding cultural or natural importance?**

A OECD
B WTO
C WHO
D UNICEF
E UNESCO

Correct answer: E

Under the 1972 Convention concerning the Protection of the World Cultural and Natural Heritage, UNESCO establishes and manages the **World Heritage List**. The agency recognizes locations based on their **outstanding universal value**, regardless of whether they are cultural or natural monuments. It coordinates nomination procedures, evaluates proposals via independent advisory commissions, and monitors ongoing preservation strategies.

Why the other answers are wrong

- **A) OECD**: This institution functions as an economic policy discussion platform for advanced industrialized nations. Its mandates involve fiscal coordination and statistical analysis rather than artifact or landscape conservation.
- **B) WTO**: This entity arbitrates cross-border commerce regulations and adjudicates tariff disagreements between contracting parties. It exercises no oversight capacity over geographic or archaeological registers.
- **C) WHO**: This specialized agency directs global public health initiatives, epidemic surveillance, and medical research programs. It possesses no authority regarding heritage documentation or landmark designation.
- **D) UNICEF**: This fund prioritizes infant mortality reduction, childhood vaccination campaigns, and primary schooling access. It operates entirely outside the scope of historical or environmental site management.

19 **Which one of the following pairs of currency/country is NOT correct?**

A Peso – Argentina
B Rand – South Africa
C **Euro – Hungary**
D Rupee – India
E Baht – Thailand

Correct answer: C

This pair does not match a country with its actual national currency. Hungary's legal tender is the **Hungarian forint** (HUF), not the euro. The nation belongs to the European Union but has not fulfilled the convergence requirements to enter the **eurozone**. Domestic trade therefore continues exclusively with the local currency. **Why the other answers are not the answer Answer A**: Argentina officially adopts the **Argentine peso** (ARS) as its legal currency. **Answer B**: Thailand circulates the **Thai baht** (THB) for all official payments. **Answer C**: South Africa operates with the **South African rand** (ZAR) nationwide. **Answer E**: India maintains the **Indian rupee** (INR) as its sole monetary unit.

Why the other answers are wrong

20 **Which of the following institutions of the Republic of Italy is democratically elected by direct universal suffrage?**

A High Council of the Judiciary
B Government
C **Senate of the Republic**
D President of the Republic
E President of the Council of Ministers

Correct answer: C

The **Senate of the Republic** is elected by eligible voters through **direct universal suffrage**. Citizens cast ballots for party lists or individual candidates. Electoral law distributes seats among winning coalitions. Senators assume office immediately without intermediate bodies.

Why the other answers are wrong

- **A) High Council of the Judiciary**: The High Council of the Judiciary combines ex officio members with elected judges and parliamentarians. Magistrates select their peers while lawmakers choose lay members. Citizens do not vote for this body directly.
- **B) Government**: The Government requires **parliamentary confidence** to function. The President of the Republic appoints a Prime Minister-designate who selects the ministers. General elections do not directly choose the executive branch.
- **D) President of the Republic**: The President of the Republic is chosen by an indirect **electoral college**. This assembly includes both parliamentary chambers and regional delegates. Popular votes cannot directly determine this office.
- **E) President of the Council of Ministers**: The President of the Council of Ministers is appointed by the President of the Republic. They must secure legislative approval before governing. Electoral results may indicate a likely leader but provide no constitutional path for direct selection.

21 **Which one of the following is NOT a principle of the sharing economy?**

A Access is preferable to ownership.

B **Competition is dangerous.**

C Stranger danger can be overcome.

D Transparent and open data increases innovation.

E Unused value is wasted value.

Correct answer: B

The sharing economy matches idle resources with demand through digital platforms. Rival marketplaces engage in **healthy competition** to deliver better pricing, higher service quality, and continuous innovation. Treating competition as dangerous directly contradicts this established operational model.

Why the other answers are wrong

- **A)** Access is preferable to ownership. Consumers shift their focus from acquiring permanent assets like cars or drills to renting them on demand. This preference for temporary utility over possession remains the foundational consumer promise.
- **C)** Stranger danger can be overcome. Integrated **trust mechanisms** including identity checks, reciprocal rating systems, and financial protections neutralize traditional safety fears. These structured safeguards replace personal familiarity with verifiable accountability.
- **D)** Transparent and open data increases innovation. Visible usage metrics, reputation scores, and transaction records allow participants to evaluate opportunities accurately. Engineers use these public datasets to iterate quickly and deploy improved platform features.
- **E)** Unused value is wasted value. Assets left idle represent dormant economic potential until they enter an active marketplace. Peer-to-peer networks efficiently transform these **underutilized resources** into revenue-generating transactions.

22 **The Fields medal is a prestigious award in the field of**

A Economics

B Psychology

C Biology

D Music

E **Mathematics**

Correct answer: E

The **Fields Medal** is frequently called the Nobel Prize of mathematics. Awarded **every four years** by the **International Mathematical Union**, it recognizes up to four individuals **under age forty** for exceptional contributions. It stands as the highest international honor specifically devoted to **mathematics**.

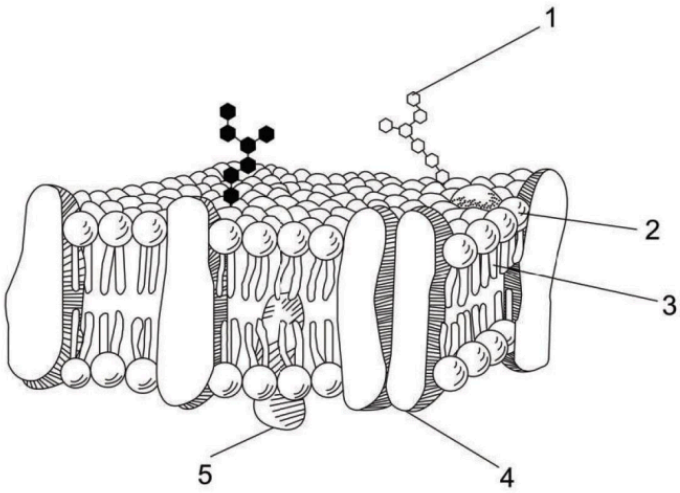
Why the other answers are wrong

- **A) Economics**: Economists are usually honoured by the Nobel Memorial Prize in Economic Sciences or the John Bates Clark Medal. The Fields Medal does not cover economic disciplines.
- **B) Psychology**: Prestigious recognitions in psychology come from the American Psychological Association or the Grawemeyer Award. The Fields Medal is completely unrelated to psychological research.
- **C) Biology**: Biological researchers typically receive the Lasker Award or the Nobel Prize in Physiology or Medicine. This medal shares no ties with the life sciences.
- **D)** Musical accomplishments are celebrated via the Grammy Awards or the Pulitzer Prize for Music. The award is strictly limited to mathematical achievements.

BIOLOGY

23 **The diagram represents the fluid mosaic model of a cell membrane.**

Which one of the labels 1-5 shows a hydrophobic region of a molecule?



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

Correct answer: A

Phospholipid molecules consist of polar **hydrophilic heads** and nonpolar **hydrophobic tails**. In the diagram, label 3 points to the **fatty-acid chains** that face the **interior of the bilayer**. These regions repel water and define the membrane's central hydrophobic zone.

Why the other answers are wrong

- **B) 5**: Label 5 highlights a cholesterol molecule embedded within the lipid layers. Although its steroid ring system is largely nonpolar, the question specifically requests the hydrophobic region of a phospholipid, not an adjacent sterol.
- **C) 1**: Label 1 indicates a carbohydrate chain attached to a glycoprotein. Sugars are highly polar and readily interact with water, making this surface region strictly hydrophilic.
- **D) 2**: Label 2 marks the phosphate-glycerol head group of a phospholipid. This portion carries partial charges and remains exposed to the extracellular or cytosolic fluid, confirming it is hydrophilic.
- **E) 4**: Label 4 designates an integral membrane protein that spans the entire lipid layer. While certain transmembrane segments contain hydrophobic amino acids, the label identifies the complete protein structure rather than a phospholipid tail.

25 **Which of the following statements about healthy living organisms are correct?**

1) They are made up of one or more cells.
2) They have DNA as the genetic material.
3) They use energy to stay alive when their surroundings change.
4) They undergo phases of growth.

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

Correct answer: D

All four statements define universal traits of living systems. **Cells** form the basic structural units. **DNA** stores genetic information in all cellular life. **Energy** drives metabolism during environmental shifts. **Growth** occurs in distinct developmental phases.

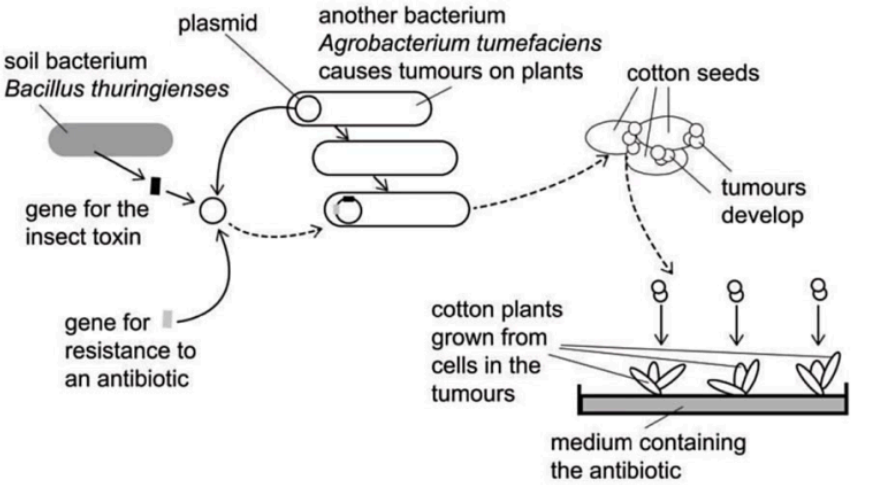
Why the other answers are wrong

- **A) 1, 2 and 3 only**: Excludes the fourth point. Structural and functional expansion through growth is a mandatory biological requirement.
- **B) 2, 3 and 4 only**: Excludes the first point. Being composed of at least one cell establishes the fundamental boundary of life.
- **C) 1, 3 and 4 only**: Excludes the second point. Hereditary instructions are universally encoded in DNA for viable organisms.
- **E) 1, 2 and 4 only**: Excludes the third point. Metabolic processes require continuous energy input to maintain homeostasis when surroundings fluctuate.

26 **The diagram shows how recombinant DNA can be used to make cotton plants produce an insect toxin. The insect toxin kills any insect that can damage the cotton crop.**

What are the TWO functions of the Agrobacterium tumefaciens bacteria in this process?

1) They stimulate cell division in cotton plant seeds.
2) They supply the plasmid vector.
3) They are the source of the gene for the production of the insect toxin.
4) They are the source of the gene for antibiotic resistance.



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

Correct answer: E

Agrobacterium tumefaciens naturally transfers T-DNA into plant cells, which triggers rapid **cell division** to form galls. Researchers exploit this mechanism to deliver engineered genes directly into cotton cells. The bacterium also provides the Ti **plasmid** that serves as a molecular shuttle for **foreign DNA**. Both processes are essential steps in creating **transgenic crops**.

Why the other answers are wrong

- **A) 1 and 3 only**: Combines the first statement with the third, but the insect toxin gene originates from Bacillus thuringiensis rather than the bacteria itself.
- **B) 2 and 4 only**: Joins the second statement with the fourth, while the fourth describes an artificially inserted selectable marker rather than a natural bacterial function.
- **C) 2 and 3 only**: Links the second statement with the third, but the third statement remains factually incorrect regarding the toxin source.
- **D) 1 and 4 only**: Pairs the first statement with the fourth, yet the antibiotic resistance marker is artificially engineered into the plasmid for selection.

27 **Which one of the structures listed is NOT involved in the reabsorption of water in a healthy human?**

A distal convoluted tubule

B **glomerulus**

C collecting duct

D proximal convoluted tubule

E loop of Henle

Correct answer: B

The glomerulus **filters** plasma into Bowman's capsule to create primary urine. It moves fluid out of the bloodstream but does not **reclaim** it back into circulation. Functional reabsorption requires specialized downstream epithelia that actively transport water toward peritubular capillaries. Consequently, the glomerulus contributes nothing to water conservation. **Why the other answers are not the answer Answer B**: The distal convoluted tubule actively reabsorbs water under **hormonal regulation**. Aldosterone and antidiuretic hormone coordinate this variable recovery phase. **Answer C**: The collecting duct serves as a major pathway for controlled water uptake. Antidiuretic hormone increases epithelial permeability to reclaim excess fluid based on physiological needs. **Answer D**: The loop of Henle generates the **osmotic gradient** required for later water recovery. Its descending limb remains highly permeable to pass large fluid volumes into the interstitium. **Answer E**: The proximal convoluted tubule executes obligatory water reabsorption alongside sodium, glucose, and amino acids. It systematically retrieves approximately sixty-five to seventy percent of the initial filtered volume.

Why the other answers are wrong

28 **Which of the following statements about bile in the digestive system are correct?**

1) It emulsifies fat globules.
2) It dilutes the contents of the small intestine.
3) It lowers the activation energy of lipase.
4) It helps to reduce the acidity of the contents leaving the stomach.

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

Correct answer: B

Bile salts **emulsify** fat globules into small droplets (1). Bile is mostly water, so it also **dilutes** the contents of the small intestine (2). Bile is **alkaline**: together with pancreatic juice, it helps to **reduce the acidity** of the chyme leaving the stomach (4). Statement 3 is false: bile is not an enzyme and does not lower the activation energy of lipase; it only increases the surface area on which lipase can act.

Why the other answers are wrong

- **A) 1, 2 and 3 only**: It includes statement 3: bile increases the surface area of the fat but does not lower the activation energy of lipase.
- **C) 1 and 2 only**: It leaves out statement 4: alkaline bile does help to reduce the acidity of the contents leaving the stomach.
- **D) 2 and 3 only**: It includes statement 3, which is false, and leaves out statements 1 and 4, which are correct.
- **E) 1 and 4 only**: It leaves out statement 2, which is correct: the large volume of bile dilutes the intestinal contents.

29 **The heart of a developing human fetus normally has a hole in the septum. The septum separates the right atrium and the left atrium.**

Which one of the statements about the circulation in the developing fetus with a hole in the septum is correct?

A The atrioventricular node will not cause ventricular systole.

B Blood in the pulmonary artery will go directly to the aorta.

C Blood in the right atrium may return directly to the vena cava.

D Blood entering the right atrium can bypass the lungs and go to the rest of the body.

E The maximum pressure in the aorta is the same as the maximum pressure in the contracting

Correct answer: D

In the fetus, the lungs are not yet functioning, so blood is diverted away from the pulmonary circulation. The **foramen ovale** connects the right atrium to the left atrium. Blood from the placenta can pass through it to the left atrium, left ventricle and aorta, reaching the body and placenta without passing through the pulmonary capillaries. Thus A is correct.

Why the other answers are wrong

- **A) The atrioventricular node will not cause ventricular systole.**: The electrical conduction system, including the AV node, functions in the fetus as it does after birth. The foramen ovale does not prevent the AV node from initiating the conduction that leads to ventricular contraction, so this statement is unrelated to the septal opening.
- **B) Blood in the pulmonary artery will go directly to the aorta.**: This describes the **ductus arteriosus**, which connects the pulmonary artery to the aorta. The foramen ovale connects the atria, not the pulmonary artery and aorta, so this does not describe the opening in the septum.
- **C) Blood in the right atrium may return directly to the vena cava.**: Blood in the venae cavae normally flows toward the heart, and there is no normal route for blood in the right atrium to return directly to them. The foramen ovale opens into the left atrium, not either vena cava.
- **E) The maximum pressure in the aorta is the same as the maximum pressure in the contracting**: Even in the fetus, peak aortic pressure is slightly lower than the peak pressure generated in the contracting left ventricle, because some pressure is lost across the aortic valve and the aorta is distensible. In any case, the foramen ovale does not determine the relationship between ventricular and aortic pressures.

30 **Which row shows three structures found in a healthy human male liver cell, in order of size from largest to smallest?**
[Assume that there are no mutations in the cell.]

row	*structures from largest to smallest*				
1	Y chromosome	→	nucleosome	→	histone
2	nucleosome	→	X chromosome	→	Y chromosome
3	histone	→	nucleosome	→	X chromosome
4	Y chromosome	→	X chromosome	→	histone
5	X chromosome	→	histone	→	nucleosome

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

Correct answer: E

Row 1 correctly orders the structures by decreasing size. The **Y chromosome** spans approximately $50–60$ million base pairs. The **nucleosome** follows at about $11\ \mathrm{nm}$ in diameter. Individual **histone** proteins measure roughly $5–6\ \mathrm{nm}$ and form the core of each nucleosome.

Why the other answers are wrong

- **A) row 2**: Lists the nucleosome before the chromosomes. This reverses the actual size hierarchy since a nucleosome is far smaller than a complete chromosome. Placing the Y chromosome last also incorrectly implies it is smaller than the X chromosome in this comparison.
- **B) row 4**: Claims the Y chromosome is larger than the X chromosome. This is biologically inaccurate as the X chromosome contains significantly more DNA and physical mass.
- **C) row 5**: Places the histone protein above the nucleosome. This reverses their actual dimensions because nucleosomes consist of DNA wrapped around histone octamers.
- **D) row 3**: Arranges the structures from smallest to largest. The biological size progression is valid but the directional order contradicts the explicit requirement.

31 **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 2, 3, 1
B 3, 2, 1
C 1, 3, 2
D 1, 2, 3
E **2, 1, 3**

Correct answer: E

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) 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.
- **B) 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) 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.
- **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.

32 **Which of the following is/are features of HIV?**

1) It has a capsid.
2) It contains DNA.
3) It has ribosomes.

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

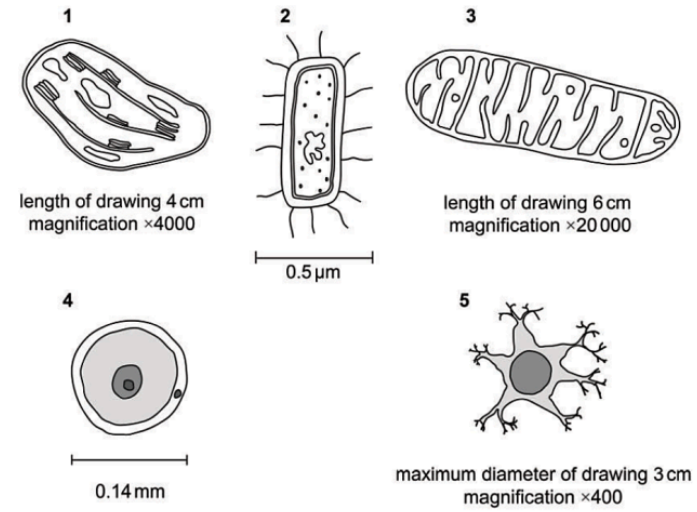
Correct answer: D

The pathogen is an enveloped retrovirus that shields its genetic blueprint inside a protein **capsid**. Its infectious particle exclusively stores two identical strands of single-stranded positive-sense **RNA**, each measuring approximately $9.7\ \mathrm{kb}$. Being non-cellular organisms, it completely lacks metabolic machinery such as **ribosomes**.

Why the other answers are wrong

- **A) 1 and 2 only**: Incorrect because it incorrectly couples a valid structural trait with a false genomic statement. The protective shell built chiefly from p24 protein ensures stability during entry and uncoating, yet the nucleic acid payload remains purely RNA until intracellular reverse transcription.
- **B) 2 and 3 only**: Incorrect because it erroneously attributes both internal genetics and cellular organelles to the virus. Neither integrated DNA nor independent protein factories exist in the free-floating infectious unit.
- **C) 3 only**: Incorrect because viruses cannot synthesize proteins autonomously. HIV depends entirely on host translation networks to replicate, confirming that ribosomal structures are never packaged inside the particle.
- **E) 2 only**: Incorrect because the mature extracellular **virion** contains zero DNA. Viral genome conversion into proviral DNA only triggers after successful cellular invasion, leaving the free virus strictly RNA-based.

33 **The diagrams show five different microscopic structures.**
The structures are not drawn to the same scale.
Which of these structures is the smallest?



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

Correct answer: E

Structure 2 has a stated actual length of $0.5\ \mu\text{m}$, which is smaller than all other options.

Why the other answers are wrong

- **A) 1**: The drawing measures $4\ \text{cm}$ at $\times 4\,000$ magnification, so the **real length** is $4\ \text{cm} \div 4\,000 = 0.001\ \text{cm} = 10\ \mu\text{m}$.
- **B) 5**: The drawing is $3\ \text{cm}$ at $\times 400$ magnification, so the **real diameter** equals $3\ \text{cm} \div 400 = 0.0075\ \text{cm} = 75\ \mu\text{m}$.
- **C) 4**: It shows a **scale bar** of $0.14\ \text{mm}$ $(140\ \mu\text{m})$, making it much larger than $0.5\ \mu\text{m}$.
- **D) 3**: The drawing is $6\ \text{cm}$ at $\times 20\,000$ magnification, giving a **real length** of $6\ \text{cm} \div 20\,000 = 0.0003\ \text{cm} = 3\ \mu\text{m}$.

34 **Which of the following healthy cells contain circular DNA?**

1) Escherichia coli
2) Saccharomyces cerevisiae (yeast)
3) human liver cell

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

Correct answer: A

The question tests whether each cell type contains at least one **circular DNA** molecule, regardless of its primary genome structure. *Escherichia coli* possesses a closed **bacterial chromosome** and frequently carries extra plasmids. *Saccharomyces cerevisiae* has linear **nuclear genomes** but maintains its own **mitochondrial DNA** and can host plasmids. Human liver cells also contain linear nuclear genomes but are packed with mitochondria housing a 16.6-kb circular mtDNA. Since all three healthy cell types harbor these molecules, option A is correct.

Why the other answers are wrong

- **B) 1 only**: Recognizes circular DNA in *E. coli* but ignores the mitochondrial DNA present in yeast and human cells.
- **C) 2 only**: Selects yeast while overlooking both the classic bacterial circular chromosome and human mitochondrial DNA.
- **D) 1 and 2 only**: Includes *E. coli* and yeast but incorrectly excludes humans, who clearly possess circular mitochondrial DNA.
- **E) 2 and 3 only**: Accepts yeast and human cells but mistakenly omits *E. coli*, whose circular chromosome serves as a fundamental textbook example.

35 **The occurrence of which of the following could allow you to distinguish between the processes of DNA replication and transcription?**
1) The breaking of hydrogen bonds.
2) The formation of hydrogen bonds.
3) The formation of phosphodiester bonds.

A **none of them**
B 1 only
C 1 and 2 only
D 3 only
E 2 only

Correct answer: A

Both DNA replication and transcription require identical basic chemical steps. Strand separation breaks hydrogen bonds, template-directed base pairing forms new hydrogen bonds, and polymerases catalyze phosphodiester bonds to extend the chain. Since every listed event occurs in both pathways, none can distinguish them.

Why the other answers are wrong

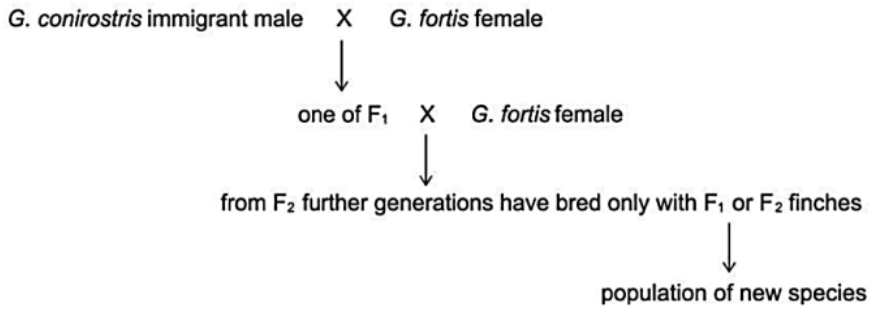
- **B) 1 only**: Incorrect. Breaking hydrogen bonds to unwind the double helix is a universal initiation step performed by helicases before template reading begins.
- **C) 1 and 2 only**: Incorrect. Both initial strand unwinding and subsequent template-directed base pairing are mandatory sequential requirements in both biological processes.
- **D) 3 only**: Incorrect. Phosphodiester bond formation is actively catalyzed by DNA polymerase during replication and by RNA polymerase during transcription to link nucleotides.
- **E) 2 only**: Incorrect. Complementary base pairing through hydrogen bonds is fundamental to both replication and transcription, making it a non-diagnostic shared step.

36 **In 1981, an immature male finch (Geospiza conirostris) arrived on an island in the Galapagos. This male finch was similar to finches of the species (G. fortis) living on the island. However, G. conirostris was 70% larger than G. fortis and had a distinctly different song.**

The diagram shows how, after observing further generations, a new species has evolved.

The success of the new species is due to its larger bill and body size and its unique song. Which of the following terms is/are illustrated by this information?

1) sympatric speciation
2) reproductive isolation
3) post-zygotic isolation



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

Correct answer: E

The founding male belonged to a different species and successfully interbred with resident birds. Their descendants inherited a larger body and a distinct mating call. These traits function as prezygotic barriers that stop interbreeding with the original population. This clearly demonstrates **reproductive isolation**. The scenario does not show **sympatric speciation** because a new lineage did not diverge from a single local gene pool. **Post-zygotic isolation** is also absent because the hybrid offspring remain completely healthy and fertile.

Why the other answers are wrong

- **A) 3 only**: This option incorrectly isolates term 3. The evolutionary timeline shows that hybrid generations survive and reproduce successfully. Post-zygotic isolation would require genetic incompatibilities that cause hybrid sterility or death after fertilization.
- **B) 2 and 3 only**: This option pairs terms 2 and 3. Term 2 correctly identifies the behavioral and morphological barriers that maintain species boundaries. Term 3 is invalid because the observed **hybrid viability** proves that fertilization barriers alone are responsible for the isolation.
- **C) 1 and 2 only**: This option pairs terms 1 and 2. While term 2 accurately describes the barrier to gene flow, term 1 remains false. The presence of reproductive isolation does not automatically mean sympatric speciation occurred, since the founding individuals came from a different geographical source.
- **D) 1 only**: This option incorrectly isolates term 1. The diagram does not depict sympatric speciation because the lineage originated from an external colonizer that already belonged to a distinct species. Sympatric speciation requires a single ancestral population to split into two groups without geographic separation.

37 **A single base mutation occurs in a gene.**

Which of the following is/are possible effects on the protein produced as a result of this mutation?

1) The protein has an altered tertiary structure.
2) The protein is shorter in length.
3) The protein is unchanged.

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

Correct answer: A

A single base substitution alters the coding sequence in three possible ways. A change that swaps one amino acid for another creates a missense mutation which can disrupt folding and yield an **altered tertiary structure**. A change that generates a premature termination signal creates a nonsense mutation that cuts translation short and produces a **shorter protein**. A change that codes for the same amino acid due to codon redundancy creates a silent mutation that leaves the final product **unchanged**. All three mechanisms are valid biological outcomes of a point mutation.

Why the other answers are wrong

- **B) 1 and 2 only**: It acknowledges missense and nonsense mechanisms but overlooks synonymous substitutions that preserve the original polypeptide.
- **C) 1 and 3 only**: It accepts missense and silent scenarios but excludes premature stop codons that reduce the final chain length.
- **D) 1 only**: It fails to recognize nonsense mutations that truncate translation and silent mutations where the sequence remains identical.
- **E) 2 and 3 only**: It considers nonsense and silent variants but ignores point substitutions that swap amino acids and modify protein folding.

38 **Which one of the following is an example of catabolism in healthy human cells?**

A formation of RuBisCo

B attachment of tRNA to mRNA

C ATP made during glycolysis

D replication of DNA

E oxidation of NADH

Correct answer: E

Catabolism breaks down molecules to release stored energy. In mitochondria, NADH is **oxidised** to $\mathrm{NAD^+}$ as electrons flow through the electron transport chain to reduce $\mathrm{O_2}$ to $\mathrm{H_2O}$. This exergonic reaction releases free energy that ultimately drives ATP production. The process is directly **energy-yielding** and fits the catabolic definition.

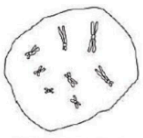
Why the other answers are wrong

- **A) formation of RuBisCo**: RuBisCo is a protein synthesised through transcription and translation. These steps assemble complex enzymes from amino acids using GTP and ATP. The pathway is **biosynthetic** and consumes cellular energy.
- **B) attachment of tRNA to mRNA**: This step occurs during translation, a process that requires energy to build a polypeptide chain. Peptide bonds form instead of large molecules breaking down. The pathway is strictly **anabolic** because it constructs proteins.
- **C) ATP made during glycolysis**: Glucose breakdown is catabolic, but ATP synthesis from ADP and phosphate stores chemical energy. Creating high-energy bonds requires input, making it **endergonic**. The actual catabolic event is the oxidative cleavage of glucose.
- **D) replication of DNA**: DNA polymerase joins deoxyribonucleotides into a growing double helix. This assembly process uses nucleotide triphosphates to build genetic material. The construction relies on energy consumption, confirming it as an anabolic pathway.

39 **The diagrams show animal cells from organisms that sexually reproduce. Each diagram shows a single cell containing chromosomes during cell division.**
Which one of the following diagrams has a correct description for a cell from an organism with a haploid number of 4?

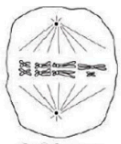
[Assume that the sex of the organism is inherited in the same way as in humans.]

A



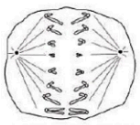
Cell from a male organism with 16 chromatids during prophase of meiosis.

B



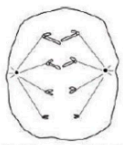
Cell from a female organism with 8 chromosomes during metaphase of mitosis.

C



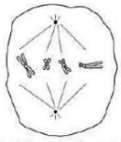
Cell from a male organism with a diploid number of 8 during anaphase of first division of meiosis.

D



Cell has a diploid number of 8 showing the chromosomes during anaphase of mitosis.

E



Cell from a female organism with 4 chromatids during metaphase of mitosis.

A E
B B
C **A**
D C
E D

Correct answer: C

For an organism with a haploid number of $n = 4$, the diploid number is $2n = 8$. During **prophase I** of meiosis, chromosomes replicate, creating **eight replicated chromosomes** with **16 chromatids** total. Homologous chromosomes form **bivalents**, and an **XY pair** confirms a male. The diagram aligns perfectly with these parameters.

Why the other answers are wrong

- **A) E**: A diploid cell with $n = 4$ must exhibit $2n = 8$ replicated chromosomes during metaphase of mitosis, accounting for 16 chromatids. Displaying only four chromatids equals half the haploid number and contradicts the baseline ploidy.
- **B) B**: Metaphase of mitosis in a $2n = 8$ cell displays eight replicated chromosomes aligned at the plate, meaning 16 chromatids are present rather than 8. Homologous pairing never occurs in mitosis, and sex chromosomes do not form distinguishable pairs under these conditions.
- **D) C**: Anaphase I moves homologous chromosomes to opposite poles while sister chromatids remain attached, resulting in 16 chromatids distributed in two groups. The image depicts **sister chromatid separation**, which belongs to anaphase II or mitosis.
- **E) D**: In mitotic anaphase for a $2n = 8$ cell, identical sister chromatids detach and migrate to opposite poles, producing 16 distinct chromatids total. The illustration contains significantly fewer fragments than required for this phase.

40 **Which one of the following will be caused by an appropriate stimulus of a rod cell in the retina of a healthy human eye?**

A an opsin and retinal will form rhodopsin

B **rhodopsin will form an opsin and retinal**

C an opsin and retinol will form rhodopsin

D rhodopsin will form opsonin and retinol

E rhodopsin will form an opsin and retinol

Correct answer: B

When light hits a rod cell, it causes the **isomerisation** of 11-cis-retinal to all-trans-retinal. The change of shape makes **rhodopsin split** into opsin and **retinal**: this is the direct effect of the stimulus and starts the signal to the brain.

Why the other answers are wrong

- **A) an opsin and retinal will form rhodopsin**: The joining of opsin and retinal regenerates rhodopsin after the stimulus, in the dark: it is not caused by the stimulus itself.
- **C) an opsin and retinol will form rhodopsin**: It describes the formation of rhodopsin, which happens in the dark during regeneration, not as an effect of the stimulus; and it uses retinol instead of retinal.
- **D) rhodopsin will form opsonin and retinol**: Opsonin is a plasma protein that helps phagocytosis, not a part of rhodopsin; and the product is retinal, not retinol.
- **E) rhodopsin will form an opsin and retinol**: Rhodopsin splits into opsin and retinal, not retinol: retinol is the alcohol form of vitamin A, from which retinal is made.

CHEMISTRY

41 **What does the formula $\mathrm{Br_2}$ represent?**

A a molecule of the compound bromine

B a compound of the element bromine

C two bromide ions

D two separate atoms of the element bromine

E a molecule of the element bromine

Correct answer: E

The symbol Br identifies the element bromine. The subscript 2 shows that two identical atoms are **covalently bonded**. This structure forms a diatomic molecule containing only one type of atom. Because it lacks multiple elements, it is classified as an elemental molecule.

Why the other answers are wrong

- **A) a molecule of the compound bromine**: This substance exists as an element in molecular form. Labeling it a compound molecule applies an **incorrect classification** to a pure substance.
- **B) a compound of the element bromine**: A compound must contain at least two **different elements**. This formula holds only bromine atoms, so it cannot be a compound.
- **C) two bromide ions**: A bromide ion carries a **negative charge** and is written as $\mathrm{Br^-}$. The absence of charge notation in the original formula indicates neutral atoms rather than ions.
- **D) two separate atoms of the element bromine**: The subscript confirms the atoms are joined in a single **bonded particle**. Isolated atoms would use the coefficient notation $2\ \mathrm{Br}$.

42 **Sucrose, $C_{12}H_{22}O_{11}$, is added to water at 20 °C until no more sucrose will dissolve. Four statements are made about sucrose and the solution that is produced:**

1) A saturated solution of sucrose is produced.
2) The freezing point of the solution is 0 °C.
3) Sucrose is a non-polar substance.
4) Sucrose is the solute.

Which two statements are correct?

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

Correct answer: D

Adding sucrose until dissolution stops produces a **saturated** mixture where dissolved concentration matches the maximum solubility limit. Water functions as the solvent. Sucrose acts as the **solute** because it is the component being dispersed.

Why the other answers are wrong

- **A) 3 and 1 only**: Incorrect because statement 3 is false. Numerous $-OH$ groups generate dipole interactions. These features confirm a polar nature instead of a non-polar one. This structural detail directly explains aqueous solubility.
- **B) 2 and 3 only**: Incorrect because both statement 2 and statement 3 are false. The solution does not freeze at zero. Molecular structure prevents non-polar classification. Multiple hydroxyl groups create strong hydrogen bonds with water. These interactions establish a highly polar character.
- **C) 1 and 2 only**: Incorrect because statement 2 contradicts colligative properties. Pure water freezes at $0\ ^{\circ}C$. Dissolving sucrose triggers **freezing point** depression. This effect lowers the transition temperature below zero.
- **E) 3 and 4 only**: Incorrect because statement 3 remains false despite the validity of statement 4. Extensive hydrogen bonding capacity defines a polar compound. This characteristic rules out non-polar behavior.

43 **Which of the following is the equation for the reaction of magnesium with excess cold water?**

A $2Mg + 2H_2O \rightarrow 2MgOH + H_2CMg + H_2O$

B $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

C $2Mg + H_2O \rightarrow Mg_2O + H_2$

D $Mg + H_2O \rightarrow Mg(OH)_2 + H_2$

E $MgO + H_2$

Correct answer: B

Magnesium reacts slowly with cold water, **oxidizing** to Mg^{2+} while **reducing** water to hydrogen gas. The equation $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$ properly **balances** mass and charge. An insoluble $Mg(OH)_2$ layer coats the metal surface, naturally limiting the reaction rate.

Why the other answers are wrong

- **A)** $2Mg + 2H_2O \rightarrow 2MgOH + H_2CMg + H_2O$: Introduces the non-existent $MgOH$ unit and appends a chemically meaningless fragment. It violates standard valency rules and fails basic atom counting.
- **C)** $2Mg + H_2O \rightarrow Mg_2O + H_2$: Relies on the impossible compound Mg_2O and employs only one water molecule. Oxygen and hydrogen atoms remain strictly unbalanced across the reaction arrow.
- **D)** $Mg + H_2O \rightarrow Mg(OH)_2 + H_2$: Breaks stoichiometric rules because a single water molecule lacks the necessary atoms to form both hydroxide groups and dihydrogen gas. The total oxygen and hydrogen counts do not match on both sides.
- **E)** $MgO + H_2$: Omits water from the reactant side and incorrectly substitutes the expected product with an oxide. Direct metal oxidation in aqueous environments yields hydroxides rather than oxides.

44 **Which of the following substances has the weakest overall intermolecular forces?**

[atomic numbers: H = 1; C = 6; N = 7; O = 8; F = 9]

A H_2O
B CH_4
C NH_3
D HF
E CO_2

Correct answer: B

Intermolecular forces follow a predictable strength order: **London dispersion attractions** are the weakest tier, **permanent dipole–dipole interactions** occupy the middle level, and **hydrogen bonding** represents the strongest category. CH_4 is a symmetrical non-polar molecule that relies entirely on London dispersion forces. Its compact size and low number of electrons minimize polarizability, resulting in very feeble molecular attractions. This makes it the substance with the weakest overall intermolecular forces among the options provided.

Why the other answers are wrong

- **A)** H_2O: Water possesses two $O-H$ bonds that enable every molecule to donate and accept hydrogen bonds simultaneously. This capability builds a robust three-dimensional hydrogen-bond network that elevates the boiling point to $100\ ^\circ C$. These strong cohesive forces vastly exceed the weak interactions in CH_4.
- **C)** NH_3: Ammonia contains $N-H$ bonds that facilitate hydrogen bonding, though the network is less extensive than in water because each molecule can donate only one hydrogen bond. Even with this limitation, the hydrogen bonds remain considerably stronger than the pure London dispersion forces found in methane.
- **D) HF**: The highly polar $H-F$ bond positions hydrogen directly on fluorine, allowing extensive hydrogen bonding between molecules. Hydrogen bonding operates at a much higher energy level than the dispersion forces in methane, leading to significantly stronger overall attractions.
- **E)** CO_2 is also non-polar and depends exclusively on London dispersion forces. It has a greater molar mass ($44\ g\,mol^{-1}$ versus $16\ g\,mol^{-1}$ for CH_4) and contains more electrons. The expanded electron cloud becomes more easily polarized, which strengthens the dispersion forces above those in methane.

45 **An atom has atomic number x and a mass number of 2x + 6 How many neutrons are in the nucleus of this atom?**

A x - 3
B x - 6
C **x + 6**
D x + 3
E 6

Correct answer: C

The **atomic number** equals $Z = x$, representing the proton count. The **mass number** equals $A = 2x + 6$. Neutron count follows the difference between them. Substituting the values yields $n = (2x + 6) - x = x + 6$.

Why the other answers are wrong

- **A) x - 3**: It stacks the previous mistakes by halving the mass number and then subtracting 3, with no basis in the standard nucleon definition.
- **B) x - 6**: It subtracts 6 instead of adding it, implying a neutron count smaller than the proton count. This contradicts typical nuclear behavior and does not follow the given formula.
- **D) x + 3**: It takes half of the mass number, yielding $\frac{1}{2}(2x + 6) = x + 3$, and mistakenly treats this value as the neutron count. This actually calculates the average of protons and neutrons.
- **E) 6**: It ignores the variable x and assumes all extra mass comes solely from neutrons. This overlooks the requirement to subtract the proton contribution from the total mass.

46 **In which of the following pairs of species does the vanadium, V, have the same oxidation state? –**

A V_2O_5 and VO^{2+}
B VO_2 and V_2O_5
C VO_2 and VO_3^-
D VCl_4 and VO^{2+}
E VCl_4 and VO_3^-

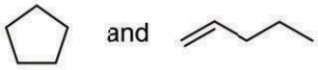
Correct answer: D

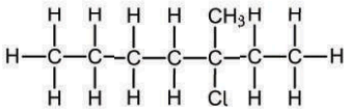
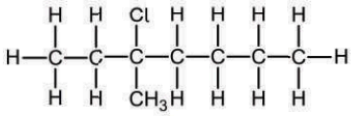
Assign **oxygen** as -2 and **chlorine** as -1, then balance each formula so the algebraic sum matches its net charge. 1. VO_2: $x + 2(-2) = 0 \Rightarrow x = +4$ 2. VO_3^-: $x + 3(-2) = -1 \Rightarrow x = +5$ 3. V_2O_5: $2x + 5(-2) = 0 \Rightarrow x = +5$ 4. VO^{2+}: $x - 2 = +2 \Rightarrow x = +4$ 5. VCl_4: $x + 4(-1) = 0 \Rightarrow x = +4$ Only VCl_4 and VO^{2+} share the same **+4** oxidation state.

Why the other answers are wrong

- **A)** V_2O_5 and VO^{2+}: V_2O_5 places vanadium at $+5$, whereas VO^{2+} leaves it at $+4$.
- **B)** VO_2 and V_2O_5: VO_2 has vanadium at $+4$, but V_2O_5 requires it at $+5$.
- **C)** VO_2 and VO_3^-: VO_2 contains vanadium at $+4$, while VO_3^- requires it at $+5$.
- **E)** VCl_4 and VO_3^-: VCl_4 holds vanadium at $+4$, contrasting with VO_3^- which needs it at $+5$.

47 **Which of the following pairs of molecules are structural isomers?**

1  and

2  and 

3 $CH_3CH_2CH_2CN$ and $CH_2{=}C{=}CHCH_2NH_2$

A 3 only

B **1 and 3 only**

C 2 only

D 2 and 3 only

E 1, 2 and 3

Correct answer: B

Structural isomers share the **same molecular formula** but exhibit **different connectivity**. Pair 1 features C_5H_{10} isomers that differ between a **ring structure** and an open chain. Pair 3 features C_4H_8N isomers distinguished by their **functional group** placement. Pair 2 shows the **identical compound** drawn with reversed numbering. Therefore only pairs 1 and 3 are true isomers.

Why the other answers are wrong

- **A) 3 only**: Incorrect because it omits pair 1, which correctly represents two structural isomers sharing the C_5H_{10} formula despite differing in ring versus chain connectivity.
- **C) 2 only**: Incorrect because pair 2 depicts the exact same molecule renumbered from opposite ends, making it identical rather than isomeric, while this option also ignores pairs 1 and 3.
- **D) 2 and 3 only**: Incorrect because it retains pair 2, which does not constitute an isomeric relationship since the drawings show the same structural backbone with swapped substituent labels.
- **E) 1, 2 and 3**: Incorrect because it counts pair 2 as an isomeric pair when careful inspection reveals both drawings map to a single linear hexane chain with a methyl and chlorine substituent.

48 **Which of the following functional groups is present in cysteine?**



cysteine

- **A** **thiol**
- **B** amide
- **C** ester
- **D** alcohol
- **E** ketone

Correct answer: A

Cysteine contains a side chain with the structure $\mathrm{CH_2SH}$. The terminal $-\mathrm{SH}$ group is chemically classified as a **sulfhydryl** or **thiol**. None of the other listed options correspond to this functionality.

Why the other answers are wrong

- **B) amide**: An amide consists of a carbonyl carbon directly bonded to a nitrogen atom ($-\mathrm{C(=O)\text{-}NH_2}$). The nitrogen in cysteine exists as a primary amine ($-\mathrm{NH_2}$) attached to the α-carbon, without an adjacent carbonyl.
- **C) ester**: An ester is defined by a $-\mathrm{C(=O)\text{-}O\text{-}R}$ linkage. Cysteine possesses a free carboxylic acid group rather than an ester bond connecting to another alkyl chain.
- **D) alcohol**: An alcohol requires a hydroxyl group ($-\mathrm{OH}$) attached to a carbon atom. In cysteine, the only $-\mathrm{OH}$ is incorporated into the carboxylic acid moiety ($-\mathrm{COOH}$), which does not constitute a standalone alcohol side chain.
- **E) ketone**: A ketone features a $\mathrm{C=O}$ double bond positioned between two carbon chains ($\mathrm{R\text{-}C(=O)\text{-}R'}$). Cysteine lacks this internal carbonyl arrangement and terminates with a carboxyl group instead.

49 **P, Q and R represent substances involved in a gaseous reaction. The equilibrium constant (K_c) and the sign of the enthalpy change for the reaction are:**

$$K_c = \frac{[P]^2}{[Q][R]^3} \quad \Delta H \text{ is negative}$$

Assuming that all other conditions remain constant, a change in which factor results in an increase of the value of the equilibrium constant, K_c?

A an increase in pressure
B a decrease in pressure
C an increase in temperature
D **a decrease in temperature**
E use of a suitable catalyst

Correct answer: D

The equilibrium constant depends exclusively on **temperature**. Since ΔH is negative, the forward reaction is **exothermic** and releases heat. Cooling the system removes thermal energy and triggers a **shift** toward the products. This increases the concentration of P relative to Q and R, thereby raising the value of $K_c = \frac{[P]^2}{[Q][R]^3}$.

Why the other answers are wrong

- **A) an increase in pressure**: Increasing pressure compresses the gaseous mixture and changes partial concentrations. While this can displace the reaction quotient, it leaves the thermodynamic equilibrium constant completely unaffected.
- **B) a decrease in pressure**: Changes in pressure modify the equilibrium position when gas mole numbers differ across the reaction stoichiometry. These variations alter instantaneous concentrations but do not change the fundamental constant.
- **C) an increase in temperature**: Raising the temperature adds heat to an exothermic system. The equilibrium moves toward the reactants to absorb the excess energy. This reduction in products and increase in reactants lowers the numerical value of the constant.
- **E) use of a suitable catalyst**: A suitable **catalyst** accelerates both forward and reverse reaction rates equally. It shortens the time to reach equilibrium without modifying the final state or the constant itself.

50 **Which of the following molecules has a permanent overall dipole moment?**

[C is in Group IV; N and P are in Group V; O and S are in Group VI; F and Cl are in Group VII]

A PCl_5
B CCl_4
C CO_2
D SF_6
E NF_3

Correct answer: E

Fluorine has higher electronegativity than nitrogen, making each $N\text{-}F$ bond strongly **polar**. The central atom possesses three bonding pairs and one lone pair, which produces a **trigonal pyramidal** molecular shape. This **asymmetric** geometry prevents the individual bond **dipoles** from canceling out, generating a **permanent** overall resultant moment.

Why the other answers are wrong

- **A)** PCl_5: The PCl_5 molecule assumes a trigonal bipyramidal geometry with two axial and three equatorial $P\text{-}Cl$ bonds. Although the bond lengths differ between positions, the high symmetry guarantees complete cancellation of all five dipoles. The final net dipole moment is $0\ D$.
- **B)** CCl_4: The CCl_4 molecule features a tetrahedral geometry surrounded by four identical $C\text{-}Cl$ bonds. The spatial symmetry ensures that the vector sum of all bond dipoles equals zero. Consequently, the molecule exhibits no permanent dipole moment.
- **C)** CO_2: The CO_2 molecule is strictly linear. The two polar $C{=}O$ bonds lie at a 180° angle and oppose each other perfectly. Their vector sum cancels exactly, resulting in a net dipole moment of $0\ D$.
- **D)** SF_6: The SF_6 molecule adopts an octahedral geometry with six equivalent $S\text{-}F$ bonds pointing toward the vertices. The symmetrical arrangement forces all bond dipoles to cancel mutually. The calculated net dipole moment remains $0\ D$.

51 **X and Y are acidic solutions.**
X has a pH of 2 and Y has a pH of 4
Which of the following statements about the hydrogen ion concentrations of X and Y is correct?

A X has a hydrogen ion concentration 2 times greater than Y.
B Y has a hydrogen ion concentration 100 times greater than X.
C Y has a hydrogen ion concentration 2 times greater than X.
D **X has a hydrogen ion concentration 100 times greater than Y.**
E X has a hydrogen ion concentration 4 times greater than Y.

Correct answer: D

The pH scale is **logarithmic**, meaning each unit difference represents a **ten-fold** change in $[\mathrm{H}^+]$. A gap of two units corresponds to $10^2 = 100$. Because X has the **lower pH**, it maintains a **higher** hydrogen ion concentration than Y. Thus, X is exactly 100 times greater than Y.

Why the other answers are wrong

- **A) X has a hydrogen ion concentration 2 times greater than Y.**: Also correctly identifies X as higher, yet ignores the logarithmic progression. The two-step difference produces a 10^2 ratio, not a simple $2\times$ value.
- **B) Y has a hydrogen ion concentration 100 times greater than X.**: Applies the correct numerical factor of 100 from the pH difference, but flips the inequality. The more acidic solution with the lower pH always holds the greater $[\mathrm{H}^+]$.
- **C) Y has a hydrogen ion concentration 2 times greater than X.**: States the opposite relationship, as Y has the higher pH and lower $[\mathrm{H}^+]$. It also incorrectly uses a linear factor of 2 instead of the required 100.
- **E) X has a hydrogen ion concentration 4 times greater than Y.**: Correctly places X above Y, but misapplies a linear multiplier. Two pH units require exponential scaling, yielding 100 rather than 4.

52 **40 cm^3 of a solution of sodium hydroxide is exactly neutralised by 25 cm^3 of 0.40 mol L–1 sulfuric acid.**

$$2\mathrm{NaOH} + \mathrm{H_2SO_4} \rightarrow \mathrm{Na_2SO_4} + 2\mathrm{H_2O}$$

What is the concentration, in g L^{-1}, of the sodium hydroxide solution? [M_r value: NaOH = 40] r –1

A 5 g L^{-1}
B 0.5 g L^{-1}
C **20 g L^{-1}**
D 10 g L^{-1}
E 0.25 g L^{-1}

Correct answer: C

The amount of **acid** is calculated from concentration and volume. The balanced equation provides the **ratio** between reactants. This yields the **moles** of base present in the sample. Dividing by the solution **volume** gives the molarity. Multiplying by the molecular **mass** converts it to grams per litre.

Why the other answers are wrong

- **A) 5 g L^{-1}**: This corresponds to $0.125\ \mathrm{mol\ L}^{-1}$ and results from skipping the stoichiometric ratio while also dividing by an incorrect volume like $0.080\ \mathrm{L}$ or the combined total of both solutions.
- **B) 0.5 g L^{-1}**: This corresponds to $0.0125\ \mathrm{mol\ L}^{-1}$ and typically arises from converting $40\ \mathrm{cm}^3$ to $0.4\ \mathrm{L}$ instead of $0.040\ \mathrm{L}$, compounded by ignoring the mole ratio.
- **D) 10 g L^{-1}**: This corresponds to $0.25\ \mathrm{mol\ L}^{-1}$ and comes from treating the reaction as a 1 NaOH : 1 $\mathrm{H_2SO_4}$ stoichiometry instead of 2:1.
- **E) 0.25 g L^{-1}**: This corresponds to $0.00625\ \mathrm{mol\ L}^{-1}$ and occurs when both the decimal placement error in the volume and the missing stoichiometric factor are applied simultaneously.

PHYSICS AND MATHEMATICS

53 **Given that:**

$8^{2x+3} \times \frac{1}{4^{3x}} = 2^{x+3}$

What is the value of x?

A $\frac{3}{2}$
B 0
C $\frac{1}{2}$
D 3
E **6**

Correct answer: E

1. Esprimi ogni fattore come potenza di base 2. $8 = 2^3$ e $4 = 2^2$ trasformano il membro sinistro in $(2^3)^{2x+3} \times (2^2)^{-3x}$. 2. Semplifica applicando le proprietà delle potenze: $2^{6x+9} \times 2^{-6x} = 2^{(6x+9)-6x} = 2^9$. 3. Uguaglia il risultato al secondo membro: $2^9 = 2^{x+3}$. Le **basi identiche** impongono che gli **esponenti coincidano**. 4. Risolvi l'equazione $9 = x + 3$ ricavando x = 6.

Why the other answers are wrong

- **A)** $\frac{3}{2}$: Inserendo $x = \frac{3}{2}$ il calcolo fornisce $2^{4.5} \approx 22.6$, che non corrisponde alla costante sinistra.
- **B) 0**: Mettendo $x = 0$ si ricava $2^3 = 8$, che non soddisfa l'uguaglianza proposta.
- **C)** $\frac{1}{2}$: Sostituendo $x = \frac{1}{2}$ nel membro destro si ottiene $2^{3.5} \approx 11.3$, valore incompatibile con 512.
- **D) 3**: Per $x = 3$ appare $2^6 = 64$, quantità inferiore al valore reale dell'equazione.

54 **Which of the following is equal to**

$\frac{2}{2+\sqrt{3}}$

A $4-2\sqrt{3}$

B $\frac{4}{7}+\frac{2\sqrt{3}}{7}$

C $\frac{4}{7}-\frac{2\sqrt{3}}{7}$

D $4+2\sqrt{3}$

E $1-\frac{\sqrt{3}}{2}$

Correct answer: A

Multiply the numerator and denominator by the **conjugate** $2-\sqrt{3}$ to **rationalise** the expression. The denominator product follows the difference of squares pattern: $(2+\sqrt{3})(2-\sqrt{3})=2^2-(\sqrt{3})^2=1$. The numerator becomes $2(2-\sqrt{3})=4-2\sqrt{3}$. The fraction **simplifies** directly to $4-2\sqrt{3}$.

Why the other answers are wrong

- **B)** $\frac{4}{7}+\frac{2\sqrt{3}}{7}$: Inherits the false denominator calculation from option C, while also introducing a sign error by adding $\sqrt{3}$ rather than subtracting it in the numerator.
- **C)** $\frac{4}{7}-\frac{2\sqrt{3}}{7}$: This value equals $\frac{4-2\sqrt{3}}{7}$. It stems from applying the correct conjugate multiplication while mistakenly believing the denominator evaluates to 7 instead of 1, which incorrectly scales the final result.
- **D)** $4+2\sqrt{3}$: Features an incorrect positive sign before the radical term. This occurs when the numerator is calculated as $2(2+\sqrt{3})$ instead of using the subtraction mandated by the conjugate.
- **E)** $1-\frac{\sqrt{3}}{2}$: Arises from invalidly distributing division across the sum in the denominator. Splitting $\frac{2}{2+\sqrt{3}}$ into separate fractions breaks the original ratio and produces a numerically unrelated value.

55 **What are the coordinates of the turning point of the graph of the quadratic equation**

$y = 2x^2 + 5x - 2$

A $\left(\frac{5}{4}, -\frac{41}{16}\right)$

B $\left(-\frac{5}{2}, -\frac{41}{8}\right)$

C $\left(-\frac{5}{4}, -\frac{41}{8}\right)$

D $\left(-\frac{5}{4}, -\frac{41}{16}\right)$

E $\left(-\frac{5}{2}, -\frac{41}{16}\right)$

Correct answer: C

1. Identify the **coefficients** $a = 2$ and $b = 5$ in $y = 2x^2 + 5x - 2$. 2. Apply the **formula** $x = -b/(2a)$ to obtain $x = -5/4$. 3. **Substitute** $x = -5/4$ into the original equation. 4. Calculate $y = 2(-5/4)^2 + 5(-5/4) - 2$, which reduces to $25/8 - 50/8 - 16/8 = -41/8$. The coordinates are $\left(-\frac{5}{4}, -\frac{41}{8}\right)$.

Why the other answers are wrong

- **A)** $\left(\frac{5}{4}, -\frac{41}{16}\right)$: Contains a sign error in the x-coordinate which should be negative. The y-value is also half of the correct value.
- **B)** $\left(-\frac{5}{2}, -\frac{41}{8}\right)$: Shares the same incorrect x-coordinate as A. Substituting $x = -5/2$ actually yields $y = -2$, making both coordinates wrong.
- **D)** $\left(-\frac{5}{4}, -\frac{41}{16}\right)$: Has the correct x-coordinate but the y-coordinate is halved, giving $-41/16$ instead of $-41/8$.
- **E)** $\left(-\frac{5}{2}, -\frac{41}{16}\right)$: Used $-b/a$ instead of $-b/2a$ for the x-coordinate. The y-value is consequently incorrect.

56 **39 male students and 36 female students were asked how many meals they had eaten in the school cafeteria during the first week of the term. The results are shown in the table:**

What is the value of x?

	male	female	all students
mean number of meals eaten	2	x	$3\frac{1}{5}$

A $4\frac{2}{5}$
B $3\frac{4}{5}$
C $4\frac{1}{2}$
D $2\frac{3}{5}$
E $4\frac{2}{3}$

Correct answer: C

The overall mean follows a **weighted mean** calculation. Let $M = 39$ be the number of males, $F = 36$ the females, and $T = 75$ the total. The equation is $(39 \cdot 2 + 36x)/75 = 3.2$. Multiply by 75 to get $78 + 36x = 240$. Subtract 78 to find $36x = 162$. Divide by 36 to obtain $x = 4.5$, which equals $4\frac{1}{2}$.

Why the other answers are wrong

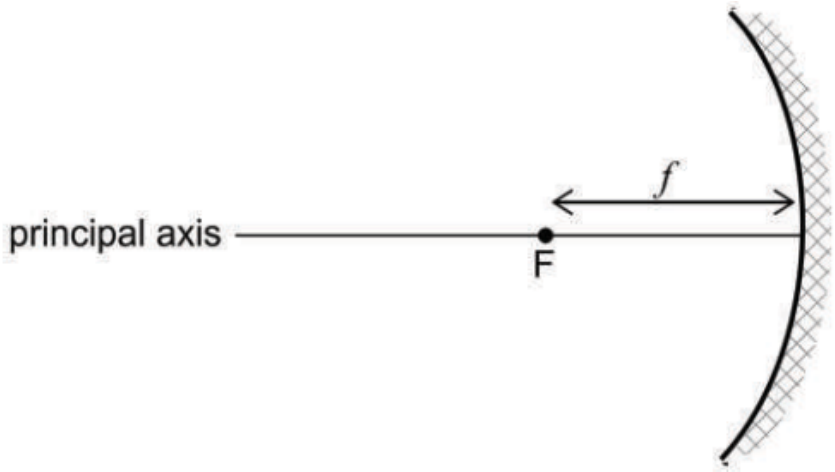
- **A)** $4\frac{2}{5}$: This stems from a **wrong divisor** in the division step. Verification shows $36 \cdot 4.4 + 39 \cdot 2 = 236.4$, which falls short of the required total sum of 240.
- **B)** $3\frac{4}{5}$: A student may have **garbled arithmetic** during rearrangement. Plugging the value into the check yields $(39 \cdot 2 + 36 \cdot 3.8)/75 \neq 3.2$.
- **D)** $2\frac{3}{5}$: This relies on a **plain average** of 2 and 3.2 while ignoring that more males than females attended. Substituting it gives $(39 \cdot 2 + 36 \cdot 2.6)/75 = 2.32$, not 3.2.
- **E)** $4\frac{2}{3}$: A **miscomputation** turns $162 \div 36$ into $168 \div 36$. Checking this value produces $36 \cdot (168/36) + 39 \cdot 2 = 246$, which divides to 3.28 instead of 3.2.

57 **The diagram represents a concave mirror, where F is the principal focus and f is the focal length.**

The mirror is used to produce an image of an object.

Which of the following statements are correct?
[Assume the mirror is parabolic.]

1. Incident rays travelling parallel to the principal axis always pass through F after reflection.
2. Incident rays passing through F always travel parallel to the principal axis after reflection.
3. The image formed is always inverted.
4. The image formed is always real.
5. The image formed is always larger than the object.



A 1 and 3 only
B 2 and 4 only
C 1, 3 and 4 only
D **1 and 2 only**
E 3, 4 and 5 only

Correct answer: D

For a **parabolic** concave mirror, rays parallel to the principal axis reflect through F, and rays passing through F reflect parallel to the axis. Therefore, statements 1 and 2 are always true.

Why the other answers are wrong

- **A) 1 and 3 only**: Statement 3 is not always true. For an object at distance $d > f$, the image is real and **inverted**; when $d < f$, it is **virtual** and upright.
- **B) 2 and 4 only**: Statement 4 is not always true. When the object is inside the focal length, so $d < f$, the image is virtual rather than real.
- **C) 1, 3 and 4 only**: Statements 3 and 4 can both fail when the object lies between the mirror and F: the image is virtual and upright. For an object beyond the focus, $d > f$, the image is real and inverted.
- **E) 3, 4 and 5 only**: None of statements 3, 4 or 5 holds for every object-mirror configuration. When $d > 2f$, the real image is **reduced**; for $f < d < 2f$, the real image is larger than the object; and when $d < f$, the virtual image is also larger.

58 **A beaker contains 1000 g of a liquid that is stirred at its boiling point.**
A 100 W electric heater is completely immersed in the liquid.
The heater provides the liquid with thermal energy, and 200 g of the liquid changes to vapour in 1600 s.

What is the specific latent heat of evaporation of the liquid?
[Assume that no thermal energy is transferred to or from the surroundings, and no vapour condenses.]

A 3200 J / g
B 16 000 J / g
C **800 J / g**
D 160 J / g
E 12.5 J / g

Correct answer: C

1. The **total energy supplied** by the heater is $E = P \times t = 100\ \text{W} \times 1600\ \text{s} = 1.60 \times 10^5\ \text{J}$. 2. All thermal energy converts directly to phase change under the given assumptions. 3. Dividing by the **evaporated mass** gives the **specific latent heat** $L = 1.60 \times 10^5\ \text{J}/200\ \text{g} = 800\ \text{J}\,\text{g}^{-1}$.

Why the other answers are wrong

- **A) 3200 J / g**: This is four times the correct value. It originates from a faulty unit conversion that treats $200\ \text{g}$ as $0.05\ \text{kg}$.
- **B) 16 000 J / g**: This is twenty times too large. It would result from multiplying instead of dividing or from erroneously dividing by a much smaller mass like $10\ \text{g}$.
- **D) 160 J / g**: This equals one fifth of the correct result. It appears when dividing the total energy by the initial $1000\ \text{g}$ in the beaker rather than the $200\ \text{g}$ that actually turned into vapour.
- **E) 12.5 J / g**: This value comes from using power instead of total energy or dividing incorrectly. Typical latent heats range from hundreds to thousands of $\text{J}\,\text{g}^{-1}$, so this result is far too small.

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