PROVE UFFICIALI DEGLI ANNI PASSATI

IMAT

2018

A B ✓ D E

SVOLTA CON SOLUZIONI COMMENTATE

Il perché di ogni risposta

WHAT'S IN THIS DOCUMENT

Prova di ammissione IMAT 2018, 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	18 questions
Chemistry	12 questions
Physics and Mathematics	8 questions
Total	**60 questions**

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 **You want to buy a house in your local area with three bedrooms and a garage. However, you only want to spend €150,000. Houses in your local area with three bedrooms and a garage never sell for less than €200,000. You will have to spend more to get the house you want.**

Which one of the following most closely matches the logical structure of the above argument?

- **A** **You want a large powerful car that is fuel efficient. Large powerful cars are never fuel efficient, so you will have to spend more on fuel if you want a large powerful car.**
- B You want to study mathematics but you don't like numerical reasoning. Mathematics is essentially numerical reasoning, so you should choose a different subject.
- C You want to buy the painting at the auction. Lots of other people want to buy it, so you have to be prepared to bid a lot of money to be successful.
- D You want either the green jacket or the blue jacket. The green jacket looks good and the blue jacket is a bargain, so there are advantages in buying either one.
- E You want a well-paid job with lots of holiday and the chance to retire early. Such jobs do not exist, so you need to adjust your expectations.

Correct answer: A

The original argument states that a specific property type has a fixed minimum price higher than your budget. Acquiring the preferred house inevitably requires exceeding that initial spending limit. Option D mirrors this exact structure. It presents a desired vehicle category with a built-in trade-off regarding efficiency. Owning the target model forces acceptance of higher running costs.

Why the other answers are wrong

- **B) You want to study mathematics but you don't like numerical reasoning. Mathematics is essentially numerical reasoning, so you should choose a different subject.**: The original argument accepts the desired item while acknowledging a necessary extra expense. This option identifies a core incompatibility and recommends dropping the goal entirely rather than tolerating an additional burden.
- **C) You want to buy the painting at the auction. Lots of other people want to buy it, so you have to be prepared to bid a lot of money to be successful.**: The original argument relies on an inherent cost floor for a specific category. This option attributes the price increase to external market demand rather than a fixed structural limit.
- **D) You want either the green jacket or the blue jacket. The green jacket looks good and the blue jacket is a bargain, so there are advantages in buying either one.**: The original argument focuses on a single unattainable objective requiring financial adjustment. This option evaluates two separate items and lists independent benefits without highlighting a required compromise.
- **E) You want a well-paid job with lots of holiday and the chance to retire early. Such jobs do not exist, so you need to adjust your expectations.**: The original argument confirms the house exists but demands extra funding. This option concludes that the ideal position does not exist at all and suggests modifying goals instead of covering additional expenses.

2 **Competition between restaurants is fierce and restaurateurs are trying to gain recognition for the quality of their food. Research from Oxford University might just give them that edge over their competitors. More than a hundred people participated in a series of experiments to see if the taste of food was affected by the cutlery used to eat it. The study found that desserts tasted better when eaten using small spoons. Similarly yoghurt tasted creamier when eaten with a black spoon. Cheese cut with a heavy knife tasted more expensive than cheese cut with a lighter knife.**

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

A **Restaurants should think carefully about what cutlery they use.**
B Variety of cutlery is more important than quality of food.
C Customers pay attention to the cutlery they are using.
D Restaurants should pay less attention to food presentation.
E People choose restaurants only because of the quality of the food.

Correct answer: A

The study demonstrates that **utensil design** directly influences **food perception**, making desserts taste better with smaller spoons, yoghurt creamier with black spoons, and cheese appear more expensive with heavier knives. Since restaurateurs aim to enhance their **dining experience**, selecting appropriate serveware provides a measurable edge. Venues should therefore carefully evaluate their tools to match intended customer outcomes.

Why the other answers are wrong

- **B) Variety of cutlery is more important than quality of food.**: The experiment evaluates utensil impact on perception rather than weighing it against culinary standards, leaving any priority ranking completely unsubstantiated.
- **C) Customers pay attention to the cutlery they are using.**: Although cutlery altered subconscious sensory judgments, the research confirms no conscious awareness or deliberate observation of the utensils by diners.
- **D) Restaurants should pay less attention to food presentation.**: No information addresses visual arrangement or styling, so proposing reduced focus on plating introduces external suggestions absent from the passage.
- **E) People choose restaurants only because of the quality of the food.**: The text never states that meal quality is the sole factor driving restaurant selection, rendering this claim an unsupported assumption.

3 **Food manufacturers should reduce sugar levels in processed foods. This is because there are too many overweight and obese people. Since people are unable or unwilling to make sensible decisions for themselves, manufacturers must take responsibility for rectifying a problem to which they contribute.**

Which one of the following illustrates the principle used in the above argument?

A Power tools should have clear instructions in order to reduce the number of accidents caused by incorrect use.

B **To reduce the number of deaths caused by excessive speed, car manufacturers should incorporate speed limiters in vehicles.**

C Labelling on food should be improved so that consumers are clear about the level of sugar in a product.

D In order to reduce sugar intake, foods with high sugar content should be taxed more heavily.

E Cigarette packets should have plain packaging and display government health warnings.

Correct answer: B

The argument applies the principle of **manufacturer responsibility** when dealing with inherent **consumer limitations**. Companies must embed safety directly into products instead of expecting voluntary compliance. Speed limiters achieve this by physically capping vehicle performance.

Why the other answers are wrong

- **A) Power tools should have clear instructions in order to reduce the number of accidents caused by incorrect use.**: Detailed manuals shift the burden of caution onto operators who might disregard them, contradicting the need for foolproof design changes.
- **C) Labelling on food should be improved so that consumers are clear about the level of sugar in a product.**: Enhanced labeling provides transparency but still assumes buyers will use that information to adjust their diets responsibly.
- **D) In order to reduce sugar intake, foods with high sugar content should be taxed more heavily.**: This suggests a financial policy enforced by regulators rather than physical modifications made by producers.
- **E) Cigarette packets should have plain packaging and display government health warnings.**: Warning labels and neutral boxes aim to educate shoppers and trigger behavioral shifts rather than removing harmful additives.

4 **Action has to be taken now to stop the spread of bovine tuberculosis (TB). Experts agree that reducing the number of badgers in the most heavily infected areas will help to break the cycle of infection between badgers and cattle and begin to reduce TB in both species. Although badgers can be vaccinated, there is no vaccine available to protect our cattle, and best estimates suggest it will be ten years before one is available. The only way to stop bovine TB spreading is to kill badgers.**

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

A **Five annual vaccinations are necessary to protect a badger fully against bovine TB.**
B When efforts are made to remove badgers, many are injured rather than killed outright.
C In a trial, killing ten thousand badgers reduced the TB rate in cattle by only fifteen per cent.
D Shooting large numbers of badgers is more expensive than vaccinating them.
E Less than ten per cent of the dairy cows destroyed each year are destroyed because of bovine TB.

Correct answer: A

The argument claims culling is necessary because vaccination lacks immediate impact and a cattle vaccine remains unavailable. If fully protecting badgers requires five annual boosters, the vaccination program cannot deliver **rapid results**. This time gap strengthens the premise that **lethal control** is the only viable short-term measure.

Why the other answers are wrong

- **B) When efforts are made to remove badgers, many are injured rather than killed outright.**: Removal campaigns frequently injure rather than kill target animals, which casts doubt on the **effectiveness** of the proposed intervention.
- **C) In a trial, killing ten thousand badgers reduced the TB rate in cattle by only fifteen per cent.**: Trial data show that removing thousands of badgers cuts cattle infection rates by only fifteen percent, suggesting the intervention yields **limited results**.
- **D) Shooting large numbers of badgers is more expensive than vaccinating them.**: Financial comparisons showing higher shooting costs make the alternative method **economically superior**, which undermines the push for lethal control.
- **E) Less than ten per cent of the dairy cows destroyed each year are destroyed because of bovine TB.**: Current cow slaughter statistics focus on domestic herds rather than wild carriers, making the data **irrelevant** to the necessity of culling badgers.

5 **Sperm whales have the largest brains on the planet, although both humans and dolphins have larger brains relative to their body size. But why should relative brain size be important? If one thinks of a brain as a computer, there is no obvious reason why it must be sized in proportion to the body it lives in. Why for example should a whale need an especially large brain, when a hummingbird – which has complex tasks to perform – manages with a tiny one?**

Which one of the following is a conclusion that is supported by the above passage?

A Hummingbirds and whales have equally complex tasks to perform, despite huge difference in brain size.

B Whales need larger brains than either dolphins or humans because of their enormous size.

C **Brain size and the ability to perform complex tasks are not necessarily related.**

D There is no important difference between a brain and a computer.

E Dolphins are more intelligent than whales.

Correct answer: C

The passage explicitly states that a hummingbird performs **complex tasks** with a **tiny brain**. This example directly shows that organ volume does not strictly determine functional capability. Therefore, the text supports the conclusion that cognitive demand and physical size are not necessarily linked.

Why the other answers are wrong

- **A) Hummingbirds and whales have equally complex tasks to perform, despite huge difference in brain size.**: The passage explicitly discusses both species, but it never claims their daily routines involve equally demanding activities. The bird is merely cited to challenge the necessity of massive cerebral mass.
- **B) Whales need larger brains than either dolphins or humans because of their enormous size.**: The opening paragraph actively doubts whether neural volume requires direct scaling with physical dimensions. No evidence links massive marine anatomy to mandatory brain expansion.
- **D) There is no important difference between a brain and a computer.**: The software reference functions purely as an analogy to illustrate processing limits. The author clarifies this parallel without asserting functional identity between biology and machinery.
- **E) Dolphins are more intelligent than whales.**: The text acknowledges differences in relative proportions, yet it draws absolutely no conclusions about comparative intelligence between the two aquatic mammals.

6 **Recent research in the USA has found that areas with more dentists per person have much lower rates of obesity than neighbouring areas of similar population size. Clearly, public health authorities concerned with obesity rates should focus more resources on the provision of dental care. Dentists are a neglected asset in the struggle against the serious health problems associated with obesity.**

Which one of the following is the best statement of the flaw in the above argument?

- **A** **It assumes that a higher number of dentists causes lower obesity rates.**
- **B** It ignores the fact that help and advice concerning obesity can be delivered in a variety of ways.
- **C** It assumes dental care in the USA is somewhat similar to that found elsewhere.
- **D** It ignores factors that might prevent public health authorities from spending more on obesity and related conditions.
- **E** It assumes that obesity rates should be a priority concern for public health authorities.

Correct answer: A

The research identifies a **correlation** between higher dentist density and lower obesity rates, but it does not establish **causation**. Public health authorities wrongly assume that increasing dental care will directly reduce obesity, while ignoring a **third factor** that could drive both observed trends.

Why the other answers are wrong

- **B) It ignores the fact that help and advice concerning obesity can be delivered in a variety of ways.**: Pointing out alternative intervention methods does not address the flawed inference, as other approaches could still exist even if dental care proved effective.
- **C) It assumes dental care in the USA is somewhat similar to that found elsewhere.**: The recommendation relies exclusively on domestic regional data comparing neighboring areas, making any assumption about international dental system similarities irrelevant to the conclusion.
- **D) It ignores factors that might prevent public health authorities from spending more on obesity and related conditions.**: It focuses on potential financial or administrative barriers to increasing health spending, which misses the central logical error regarding whether dental care actually reduces obesity.
- **E) It assumes that obesity rates should be a priority concern for public health authorities.**: The argument explicitly acknowledges that authorities are already concerned with obesity rates, so it does not make the unstated assumption that these rates should be a priority.

7 **It's better for your children's health to give them a video game to play than to let them watch television. Researchers at Queensland University examined the effects of video gaming and watching television on children between the ages of two and five. They found that the children burned more calories when they were gaming than when they were watching television; higher blood pressure was associated with watching television, but not with video gaming. The scientists believe that the difference comes from two distinct kinds of screen time: passive screen time, where you are simply viewing programmes or films, and active screen time, where you are engaging both your mind and your body.**

Which one of the following is the main conclusion of the above argument?

A Playing video games helps to reduce children's blood pressure.

B Watching television does not stimulate children's minds.

C Video gaming engages both the mind and the body.

D Children burn more calories when they play video games than when they watch television.

E Video gaming is better for children's health than watching television.

Correct answer: E

The passage opens by claiming that video games are healthier than television for young children. This statement acts as the **main conclusion**. The calorie and blood pressure findings serve as evidence to support it. The distinction between passive and active screen time provides a scientific explanation for these differences.

Why the other answers are wrong

- **A) Playing video games helps to reduce children's blood pressure.**: The research states that gaming is simply unlinked to elevated blood pressure, not that it actively reduces it.
- **B) Watching television does not stimulate children's minds.**: Describing television viewing as passive does not mean it never engages a child's mind in any capacity.
- **C) Video gaming engages both the mind and the body.**: This outlines the proposed mechanism behind the results, acting as contextual explanation instead of the primary argument.
- **D) Children burn more calories when they play video games than when they watch television.**: This records a specific finding used to back up the claim, so it functions as a supporting premise rather than the final point.

8 **‘Internet addiction’ is about to be classified as a recognised psychiatric disorder. Internet addiction is characterised by a number of signs: excessive use of the internet; anger or depression if access is lost; isolation from friends and family; and, most significantly, poor educational achievement. This should make us cautious about incorporating computer-based learning into all aspects of education. Educationalists should consider the long-term problems associated with extensive internet use as well as its immediate attractions.**

Which one of the following is an assumption of the above argument?

A It is a bad idea to incorporate computer-based learning into education.

B Students are unable to regulate their internet use.

C Excessive internet use is the only cause of poor educational achievement.

D Classifiying internet addiction as a recognised psychiatric disorder will help lead to a cure.

E **All computer-based learning includes internet use.**

Correct answer: E

The argument warns against integrating computer-based learning because of the risks linked to heavy internet use. It requires a logical bridge between digital education tools and online access. Option A supplies this necessary connection without overstating the causal relationship.

Why the other answers are wrong

- **A) It is a bad idea to incorporate computer-based learning into education.**: The passage explicitly calls for careful consideration of long-term effects rather than complete opposition. Urging caution in policy implementation differs fundamentally from labeling the entire pedagogical method as harmful.
- **B) Students are unable to regulate their internet use.**: The stated danger targets problematic patterns observed in specific user groups. Generalizing this risk to universal self-regulation failure across all learners exceeds the intended scope.
- **C) Excessive internet use is the only cause of poor educational achievement.**: The logical structure only requires online activity to be a significant contributing factor to academic decline. The conclusion remains valid even when multiple overlapping variables influence student performance.
- **D) Classifiying internet addiction as a recognised psychiatric disorder will help lead to a cure.**: The provided text restricts its scope to academic impact and behavioral warnings. It introduces no information regarding clinical diagnosis pathways or therapeutic effectiveness.

9 **One of the populations with the highest life expectancy is Iceland. The people there are very healthy, as indicated by the low incidence of diabetes, obesity, heart disease and diet related cancers. Their diet is rich in good quality local fish, and meat and dairy products from grass fed animals. The fish and meat is all caught, produced and processed on a small scale. If we want to live long and healthy lives we should adopt the Icelanders' diet.**

Which one of the following is the best statement of the flaw in the above argument?

A There may be insufficient space in many countries to raise grass fed animals.

B People may not like being told what they should eat.

C Vegetarians may not be able to live on an Icelandic diet.

D The Icelandic diet may be prohibitively expensive elsewhere.

E There may be other reasons for the Icelanders' health and longevity.

Correct answer: E

The argument **confuses correlation with causation** by assuming the diet directly improves health and longevity. It overlooks that genetic factors, environmental conditions, or healthcare systems could equally explain these positive outcomes. Without ruling out **alternative explanations**, the evidence does not prove the diet is responsible.

Why the other answers are wrong

- **A) There may be insufficient space in many countries to raise grass fed animals.**: This notes a practical limitation for raising livestock while failing to challenge the claimed link between food consumption and well-being.
- **B) People may not like being told what they should eat.**: This addresses potential public resistance to dietary advice rather than evaluating whether the diet actually improves longevity.
- **C) Vegetarians may not be able to live on an Icelandic diet.**: This highlights feasibility issues for vegetarians instead of identifying the logical gap between habit and outcome.
- **D) The Icelandic diet may be prohibitively expensive elsewhere.**: This mentions financial barriers to implementation without demonstrating why the provided evidence fails to establish a causal relationship.

10 **A leaking undersea oil well in the USA caused massive damage to wildlife and was extremely expensive to clear up. Worst of all, it destroyed the livelihoods of poor people living in the area. Despite this, in the developed world we still don't take seriously the risks of deepwater drilling. Until we can be satisfied that regulation is effective and that oil companies are operating safely, deepwater drilling should be banned.**

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

A Alternatives to fossil fuels may eventually be able to meet our energy needs.

B Oil companies will operate more safely in future than they did before the accident in the USA.

C **A ban on deepwater drilling would cause oil prices to rise, which would affect poor people most.**

D Oil companies involved in the accident in the USA paid money to compensate the victims.

E The risks of deepwater drilling were known prior to the accident in the USA.

Correct answer: C

The argument proposes banning extraction activities to shield vulnerable communities from operational failures. If the restriction spikes global fuel prices, the financial strain falls heaviest on disadvantaged households. This outcome directly undercuts the stance by proving the policy would injure the very group it intends to protect.

Why the other answers are wrong

- **A) Alternatives to fossil fuels may eventually be able to meet our energy needs.**: Potential long-term substitutes do not eliminate the immediate dangers posed by active projects. Delayed technological progress leaves current safety gaps completely unresolved.
- **B) Oil companies will operate more safely in future than they did before the accident in the USA.**: Optimistic predictions of improved protocols lack verifiable enforcement mechanisms. Assurances of future caution cannot substitute for documented compliance required to lift restrictions.
- **D) Oil companies involved in the accident in the USA paid money to compensate the victims.**: Payments issued after the spill do not repair environmental destruction or verify that upcoming operations will remain secure. Financial reimbursements address historical losses rather than preventing new incidents.
- **E) The risks of deepwater drilling were known prior to the accident in the USA.**: Historical awareness of hazards does not lower the actual danger of extraction. Past foresight merely highlights regulatory gaps without proving that stricter oversight has been enforced.

11 **A train is travelling at 30 mph towards a terminus which is 120 miles away.**

At the same time, a pigeon starts flying from the terminus towards the train. When it meets the train, it turns and flies back towards the terminus and, when it arrives there, it turns and flies back towards the train again.

The pigeon flies at an average speed of 40 mph. The pigeon continues to do this until the train reaches the terminus.

Assuming that no time was lost in each turnaround, how far (to the nearest 10 miles) does the pigeon fly altogether?

A 120 miles
B 240 miles
C **160 miles**
D 140 miles
E 180 miles

Correct answer: C

Calculate the **arrival time** of the train with $t = 120\ \text{mi}/30\ \text{mph} = 4\ \text{h}$. The bird maintains **continuous** flight throughout this entire interval. **Multiply** the duration by its constant speed to find the total **distance**: $40\ \text{mph} \times 4\ \text{h} = 160\ \text{mi}$. Rounding to the nearest ten yields exactly this value.

Why the other answers are wrong

- **A) 120 miles**: Assumes the bird covers only $120\ \text{mi}$, either by miscalculating the flight duration as $3\ \text{h}$ or confusing the bird's range with the initial separation, thereby ignoring the full $4\ \text{h}$ of travel.
- **B) 240 miles**: Equals $2 \times 120\ \text{mi}$, chosen when assuming the pigeon completes a full round trip of $120\ \text{mi}$ out and back, forgetting that the train advances continuously so each shuttle leg progressively shortens.
- **D) 140 miles**: Results from incorrectly averaging the two velocities $\frac{30\ \text{mph}+40\ \text{mph}}{2} \times 4\ \text{h} \approx 140\ \text{mi}$, or simply rounding down $160\ \text{mi}$ without physical justification.
- **E) 180 miles**: Arises from adding the train's displacement $120\ \text{mi}$ to a single leg $40\ \text{mph} \times 1.5\ \text{h} = 60\ \text{mi}$, mistakenly treating the shuttle segments as independent rather than parts of a shrinking pattern.

12 **Mr and Mrs Massa's rectangular lawn measures 10 metres by 6 metres. They pay Giovanni to cut the grass and trim the edges. Giovanni charges a fixed rate per square metre of grass to be cut and another fixed rate per metre of edge to be trimmed. For Mr and Mrs Massa's lawn, this results in a charge of \$12 to cut the grass and \$8 to trim the edges.**

Now, Mr and Mrs Costa next door want Giovanni to do the same for them. Their lawn is also rectangular and measures 15 metres by 9 metres.

If he charges them at the same rate as the Massas, how much will Giovanni charge Mr and Mrs Costa, in total, for cutting their grass and trimming their edges?

A $36
B **$39**
C $30
D $45
E $35

Correct answer: B

Explanation of the correct method 1. Work out Giovanni's two separate rates from the Massa job. • Area of the Massa lawn = 10 m × 6 m = 60 m² Charge for cutting = $\$12 \Rightarrow Rate for cutting grass = \$12 \div 60m^2 = \$0.20 per m^2$ • $Perimeter of the Massa lawn = 2(10m + 6m) = 32m$ $Charge for trimming edges = \$8 \Rightarrow Rate for trimming edges =$ 8 ÷ 32 m = $0.25 per m 2. Apply the same rates to the Costa lawn. • Area of the Costa lawn = 15m \times 9m = 135m^2$ $Cost to cut grass = 135m^2 \times$ 0.20/m² = 27 • $Perimeter of the Costa lawn = 2(15m + 9m) = 48m$ $Cost to trim edges = 48m \times$ 0.25/m = 123. $Add the two parts of the bill. Total charge =$ 27 + \$12 = \$39 Therefore Giovanni will charge Mr and Mrs Costa \$39 in total, which is Answer E.

Why the other answers are wrong

13 **David normally takes 45 minutes to walk at a steady speed in a straight line from his house, past his friend Barry's house and then past a shop to reach his college.**

Today, however, he stopped at Barry's house on the way and had to wait 3 minutes for him to be ready to leave. They stopped at the shop to buy their lunch, which took another 3 minutes.

It normally takes David 20 minutes to walk from his home directly to the shop and Barry normally takes 32 minutes to walk directly from his home to the college and they both walk at the same steady speed.

How long does it take them to walk from Barry's house to the shop?

A 10 minutes
B **7 minutes**
C 13 minutes
D 4 minutes
E 1 minute

Correct answer: B

1. Assign A, B, and C to the walking segments House–Barry's, Barry's–Shop, and Shop–College respectively. 2. Translate the given durations into three equations using the **steady speed** assumption: $A + B + C = 45$, $A + B = 20$, and $B + C = 32$. 3. Solve the system by **subtracting** the shorter paths from the total route to isolate $C = 25\ \text{min}$ and $A = 13\ \text{min}$. 4. **Substitute** the value of A into $A + B = 20$ to calculate the target segment $B = 7\ \text{min}$.

Why the other answers are wrong

- **A) 10 minutes**: Picking $10\ \text{min}$ extends the Barry's–College travel time to $35\ \text{min}$, conflicting with the required $32\ \text{min}$.
- **C) 13 minutes**: Selecting $13\ \text{min}$ stems from subtracting 32 from 45, which actually yields A (the House to Barry's segment) rather than the requested Barry's to Shop distance.
- **D) 4 minutes**: Picking $4\ \text{min}$ reduces the House–Shop travel time to $17\ \text{min}$, which also violates the given condition.
- **E) 1 minute**: Picking $1\ \text{min}$ reduces the House–Shop travel time to $14\ \text{min}$, directly contradicting the stated $20\ \text{min}$.

14 **In a family, each of the six children has one packet of crisps on each weekday (Monday to Friday) for their packed lunch. The triplets have Cheese flavoured crisps, the twins have Paprika flavoured crisps, and the oldest child always has Chilli flavoured crisps. The exact number of packets of crisps needed are purchased at the same time for the four-week period.**

The table below shows the price of single packets of crisps and multipacks of crisps of the same flavour. A multipack is a discounted collection of a number of single packets of one flavour.

What is the most money that can be saved for the four weeks by purchasing the appropriate combination of multipacks and single packs of the different flavours rather than all single packs?

packet type	price
single packet	\$0.50
multipack of6	\$2.50
multipack of12	\$4.50
multipack of24	\$8.50
multipack of36	\$12.50

A £18.00
B £23.50
C **£16.50**
D £8.00
E £43.50

Correct answer: C

Over four weekdays, the children require 60 cheese, 40 paprika, and 20 chilli packets, totalling 120 individual items. Buying every packet separately costs $120 \times £0.50 = £60.00$. To maximise **savings**, each flavour demand is matched with an **exact fit** of discounted multipacks, topping up only with standard **singles** when an exact multipack combination is impossible. Cheese (60): one 36-pack and one 24-pack cost $£21.00$ ($£9.00$ saved). Paprika (40): one 36-pack and four singles cost $£14.50$ ($£5.50$ saved). Chilli (20): one 12-pack, one 6-pack, and two singles cost $£8.00$ ($£2.00$ saved). The optimal purchase totals $£43.50$, leaving a **total saving** of $£60.00 - £43.50 = £16.50$.

Why the other answers are wrong

- **A) £18.00**: This figure cannot be derived from any valid comparison between bulk multipack rates and standard single-unit pricing.
- **B) £23.50**: This amount stems from no logical packaging combination or mathematical comparison against the baseline cost.
- **D) £8.00**: It isolates the discount metric associated with a single flavour group instead of aggregating the reductions across all three types.
- **E) £43.50**: It reflects the final amount payable after applying discounts ($£43.50$) rather than the actual monetary reduction secured.

15 **The table below shows how to choose an appropriate glue for different materials you may want to bond together. For example, to bond cork and rubber you can use either rubber contact glue or epoxy glue.**

Key
B – acrylic cement
C – balsa cement
D – PVA glue
E – synthetic resin glue
F – cyanoacrylate (superglue)
G – rubber contact glue
H – latex glue
I – epoxy glue
J – polyester resin

Which one of the following statements is supported by the information in the table?

	balsa wood	*plywood*	*acrylic*	*card*	*fabric*	*polystyrene*	*metal*	*cork*	*glass*	*rubber*
rubber	G	G	I	F I	G	H	F I	G I	G I	F G
glass	I	I	F I	F I	G	D H	F I	G I	G I	
cork	G I	G I	F I	F I	G	D H	G I	D G J		
metal	I	I	F I	F I	G	D H	F I			
polystyrene	D	D	D H	D	D H	D H				
fabric	G H	G H	G	G	D H					
card	C D	C D	D F I	C D						
acrylic	F I	F I	B							
plywood	D E	D E								
balsa wood	C D									

A Balsa cement can only be used to glue balsa wood to another material.

B The only materials that are suitable for bonding together with three different types of glue are cork with cork.

C Acrylic can be bonded to polystyrene using cyanoacrylate.

D Polystyrene and card can only be bonded with rubber contact glue.

E Synthetic resin glue can only be used to glue wood materials together.

Correct answer: E

Synthetic resin glue is code E. It appears only for plywood–balsa wood and plywood–plywood, so every listed use bonds two wood materials. Therefore, the statement is supported by the table.

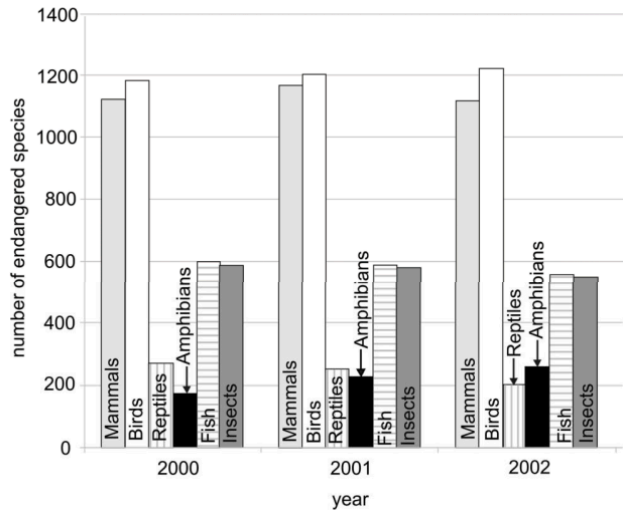
Why the other answers are wrong

- **A) Balsa cement can only be used to glue balsa wood to another material.**: Balsa cement is code C. Although C appears in balsa-wood rows or columns, it also appears for card–plywood, as well as card–balsa wood. The card–plywood bond does not involve balsa wood, so C is not limited to bonding balsa wood to another material.
- **B) The only materials that are suitable for bonding together with three different types of glue are cork with cork.**: Cork–cork has three glue options, D, G, and J, but it is not the only material pair with three options. Card–card also has three, D, F, and I.

- **C) Acrylic can be bonded to polystyrene using cyanoacrylate.**: Cyanoacrylate is code F. At the acrylic–polystyrene intersection, in either orientation, F does not appear; the table lists only D, PVA glue.
- **D) Polystyrene and card can only be bonded with rubber contact glue.**: Rubber contact glue is code G. The table lists D, PVA glue, at the polystyrene–card intersection, not G. Thus G is not the only glue listed for that pair.

16 **The bar chart below shows the number of endangered species between 2000 and 2002 per animal class**

Which one of the following pieces of information can be inferred from the bar chart above?



A The number of endangered species of mammals remained constant over the three-year period.

B The number of endangered species of reptiles increased over the three-year period while that of amphibians decreased.

C More species of bird became endangered over the three-year period than any other animal class.

D **The number of species of insects that were endangered was almost equal to the number of species of fish that were endangered over the three-year period.**

E In 2001, there were exactly four times as many endangered species of birds as there were endangered species of reptiles.

Correct answer: D

The bars for Fish and Insects maintain a similar height across all three years. Numerical estimates show minimal variation between the two groups (roughly 600 versus 580 in 2000, 580 versus 575 in 2001, and 560 versus 550 in 2002). This consistent proximity indicates that their endangered population counts were virtually equivalent throughout the observed period.

Why the other answers are wrong

- **A) The number of endangered species of mammals remained constant over the three-year period.**: The mammal bars clearly fluctuate instead of remaining level. The recorded values shift from approximately 1120 in 2000 to 1175 in 2001, before dropping back to around 1115 in 2002.
- **B) The number of endangered species of reptiles increased over the three-year period while that of amphibians decreased.**: While reptile numbers experience a slight rise, amphibian populations do not follow a steady decline. Amphibian counts actually climb during 2001 before falling again in 2002, which contradicts a continuous downward trend.
- **C) More species of bird became endangered over the three-year period than any other animal class.**: Although the bird population shows a modest upward movement, the total gain remains lower than the growth observed for reptiles and fish. Consequently, birds do not represent the largest increase among all categories.
- **E) In 2001, there were exactly four times as many endangered species of birds as there were endangered species of reptiles.**: The data for 2001 disproves the exact multiple. Bird species number approximately 1205 while reptiles reach about 320, making four times the reptile count equal to 1280 rather than the actual bird total.

17 **A 300g packet of Scottish oatcakes has the following information on the side of the packet: How many oatcakes are there in the packet?**

typical values	per100 g	per oatcake
energy	462kcal	60kcal
protein	10.78 g	1.4 g
carbohydrate - total	56.0 g	7.27 g
carbohydrate - sugars	2.31 g	0.3 g
fat - total	20.79 g	2.7 g
fat - saturates	5.4 g	0.7 g
fibre	6.9 g	0.9 g

A 21
B 29
C **23**
D 24
E 18

Correct answer: C

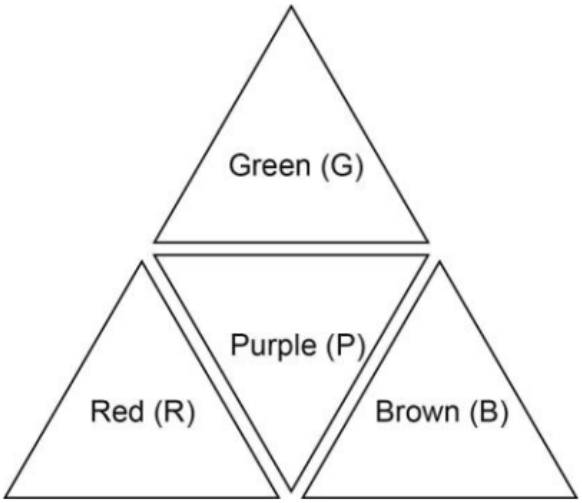
1. Calculate the **mass** of one oatcake using the **energy ratio** on the label. Since $100\ \text{g}$ provide $462\ \text{kcal}$ and one cake provides $60\ \text{kcal}$, the calculation is $60\ \text{kcal} \div (462\ \text{kcal}/100\ \text{g}) \approx 12.99\ \text{g}$. 2. Divide the **total** packet weight by the single unit weight. $300\ \text{g} \div 12.99\ \text{g} \approx 23.1$. 3. Apply the **integer** rule for discrete items. You cannot have a fraction of a pre-made oatcake, so the exact count must be 23.

Why the other answers are wrong

- **A) 21**: Assuming 21 cakes requires a weight of $300\ \text{g} \div 21 \approx 14.3\ \text{g}$ per piece. This remains significantly heavier than the ~13 g consistent with the stated energy content.
- **B) 29**: Assuming 29 cakes suggests a mass of roughly $300\ \text{g} \div 29 \approx 10.3\ \text{g}$. Such a light cake could not possibly deliver the full $60\ \text{kcal}$ when the reference ratio is $462\ \text{kcal}$ per $100\ \text{g}$.
- **D) 24**: Assuming 24 cakes calculates to $300\ \text{g} \div 24 \approx 12.5\ \text{g}$ each. This value falls below the 12.99 g strictly required to match the calorie count per cake.
- **E) 18**: Assuming 18 cakes would require each to weigh $300\ \text{g} \div 18 \approx 16.7\ \text{g}$. This directly contradicts the ~13 g figure derived from the nutritional label.

18 **A regular tetrahedron is made by fastening together four triangles made from card coloured on one side only, as shown in the diagram below.**

Which one of the following is NOT a possible view of this tetrahedron when looked at from above?



A <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1xe22121eie21i12exixe21.png?alt=media&token=d0c02880-4321-46b6-836d-2429179022e0<i>

B <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e11288e218e12ei121e2k.png?alt=media&token=0cf28924-5fe1-4ecc-821b-e25a7c14a156<i>

C <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e2198e1e2x9ex2eke2.png?alt=media&token=c4285604-6199-43c2-8e19-a16c42dde61b<i>

D **<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1eio29x191e9ox2e.png?alt=media&token=1df1f4c8-df3b-46c9-b5f1-b1c539b96547<i>**

E <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e12eu1ajhaja.png?alt=media&token=2ccc7232-1d2a-4af9-9926-83a4404e4ca3<i>

Correct answer: D

The **purple face** lies flat on the table and stays completely hidden from above. The three coloured triangles fold upward to meet at the apex, exposing their painted sides. Their spatial arrangement creates a **fixed cyclic order** of red, green, and blue that allows only physical **rotations** but forbids any mirroring. Diagram A violates this rule by displaying the reversed sequence.

Why the other answers are wrong

- **A) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1xe22121eie21i12exixe21.png?alt=media&token=d0c02880-4321-46b6-836d-2429179022e0<i>**: The layout shows a B → R → G arrangement. Starting the established cycle at a different starting face produces this exact configuration, confirming its consistency with the original net.
- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e11288e218e12ei121e2k.png?alt=media&token=0cf28924-5fe1-4ecc-821b-e25a7c14a156<i>**: Here the faces appear exactly in the R

→ G → B sequence. It matches the mandatory geometric progression regardless of how the drawing is oriented.

- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e2198e1e2x9ex2eke2.png?alt=media&token=c4285604-6199-43c2-8e19-a16c42dde61b<i>**: This view arranges the colours in a G → B → R pattern around the centre. It simply shifts the required cycle forward, so it emerges naturally when the solid is turned slightly.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e12eu1ajhaja.png?alt=media&token=2ccc7232-1d2a-4af9-9926-83a4404e4ca3<i>**: This diagram presents a G → B → R cycle around the top point. It corresponds to a different turning angle of the same folded shape, proving it remains a valid projection.

19 **Alpha, Beta and Gamma are the three political parties in the Parliament. There are 360 seats in the Parliament. Before last week's General Election, each party held 120 seats. In last week's election:**

There was no change in 216 seats.
Alpha gained 15 seats from Beta and 23 seats from Gamma.
Beta gained 31 seats from Alpha and 41 seats from Gamma.
Gamma gained 24 seats from Alpha and 10 seats fom Beta.

Which pie chart, suitably labelled, shows the current state of the parties in the Parliament?

A <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2eu8u1ueww1.png?alt=media&token=0bd8d8fa-e07b-412b-9ba0-2fe64b21e347<i>

B <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1ex21e8e21e81e1k.png?alt=media&token=962146d2-7e8b-47e2-b467-f2ef6d0b3b70<i>

C **<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e21u1uuia.png?alt=media&token=e3923edd-26f6-440f-8791-2b50379f549e<i>**

D <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e21ieiaii1i.png?alt=media&token=1df75568-a0e3-4ff3-a429-5f128ba8e25a<i>

E <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12eie21iei212e.png?alt=media&token=d248f284-be34-4091-aee3-e82c7292c86b<i>

Correct answer: C

1. Calculate the **net seat change** for each party: Alpha $+38 - 55 = -17$, Beta $+72 - 25 = +47$, Gamma $+34 - 64 = -30$. 2. Apply these adjustments to the starting 120 seats: Alpha becomes 103, Beta becomes 167, and Gamma becomes 90. 3. Confirm the total remains 360 seats. 4. Convert the final counts into **percentages**: Alpha $\approx 28.6\ \%$, Beta $\approx 46.4\ \%$, Gamma $= 25.0\ \%$. 5. Identify the pie chart where **Beta** covers just under half, **Alpha** is slightly above a quarter, and **Gamma** is exactly a quarter.

Why the other answers are wrong

- **A) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2eu8u1ueww1.png?alt=media&token=0bd8d8fa-e07b-412b-9ba0-2fe64b21e347<i>**: Displays three nearly equal slices representing one-third each, which matches the initial pre-election distribution of 120 seats per party rather than the updated totals.
- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1ex21e8e21e81e1k.png?alt=media&token=962146d2-7e8b-47e2-b467-f2ef6d0b3b70<i>**: Incorrectly positions **Gamma** as larger than **Alpha** and comparable to Beta, while the calculations prove Gamma is the smallest group with 90 seats and Alpha is larger with 103 seats.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e21ieiaii1i.png?alt=media&token=1df75568-a0e3-4ff3-a429-5f128ba8e25a<i>**: Shows **Beta** as exactly half the pie with the remainder split equally between Alpha and Gamma, implying roughly 180 seats for Beta and 90 each for the others instead of the actual 103 seats for Alpha.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12eie21iei212e.png?**

alt=media&token=d248f284-be34-4091-aee3-e82c7292c86b<i>: Assigns the largest slice to **Gamma** and places **Alpha** last, reversing the actual outcome where Gamma is the smallest party and Beta holds the largest share with 167 seats.

20 **A puzzle is made up of these three pieces.**
The pieces can be flipped and rotated, but they cannot overlap.

Which one of the following shapes CANNOT be made using these three pieces?



A <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F12xe12iei128e8.png?alt=media&token=d5d5ae37-a45d-454b-85da-7386192c5e62<i>

B <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e22e1iemss.png?alt=media&token=bdcb38f2-3f50-42b3-a1d3-ce8d77a64162<i>

C <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fe1c2ikskzk1k.png?alt=media&token=eae80d3b-ded9-4be4-88ac-e653318dcdda<i>

D **<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x21e781288e2112.png?alt=media&token=2effb2bb-48e4-42e9-a47e-6ff8312bad7c<i>**

E <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1xe2e12818eissi.png?alt=media&token=b8141a72-3116-4805-a49d-3a527589682a<i>

Correct answer: D

Shape B cannot be formed because its outline requires **oblique edges** at 30° and 150°, while all puzzle pieces only feature edges at 0°, 90°, or $45^\circ/135^\circ$. Counting the grid squares confirms that shape B also lacks the **correct total area** compared to the three pieces. These geometric mismatches make B impossible to construct. **Why the other answers are possible Answer A**: Its border consists exclusively of **horizontal**, **vertical**, and 45° **segments**, and its area perfectly matches the combined pieces. Construct it by positioning the **tall right-triangle** on the left, inserting the **small right-triangle** into the bottom corner, and flipping the **quadrilateral** to fit on the right. **Answer C**: This shape uses only the allowed **edge orientations** and maintains the **required area**. Place the **trapezoidal quadrilateral** flat as a base, stand the **skinny triangle** vertically against one side, and complete the figure by adding the **small right triangle** in the empty corner. **Answer D**: It satisfies both the **slope requirements** and the **area constraint**. Rotate the **quadrilateral** by 180°, balance the **skinny triangle** upright on its longest edge, and slide the **small triangle** into the remaining space. **Answer E**: The notches and protrusions align at 45° **increments**, allowing every part to rotate or flip into position without gaps. All boundary lines follow the permitted 0°, 45°, or 90° directions, and the **sum of the areas** exactly equals the original three shapes.

Why the other answers are wrong

21 **The Almagest is the common title of a mathematical and astronomical treatise written by**

A Aristotle
B Pythagoras
C Nicolaus Copernicus
D **Claudius Ptolemy**
E Johannes Kepler

Correct answer: D

Claudius Ptolemy synthesized Greek mathematical astronomy in the second century CE into a thirteen-volume work. The original title Mathematical Compilation was translated by Arab scholars into **al-Majisṭī** meaning the greatest. Latin translators rendered this term as Almagest. The treatise detailed the **geocentric model** utilizing **epicycles** and deferents alongside comprehensive star catalogs. It remained the authoritative astronomical framework for nearly fourteen centuries.

Why the other answers are wrong

- **A)** Aristotle composed foundational cosmological texts like On the Heavens and Meteorology in the fourth century BCE. His theories shaped medieval science but he died about five hundred years before the Almagest was compiled.
- **B)** Pythagoras was a sixth century BCE philosopher famous for mathematical theory and mystical numerology. He left no surviving astronomical treatise and predates the Almagest by roughly seven hundred years.
- **C)** Nicolaus Copernicus published De revolutionibus orbium coelestium in 1543 to displace the Ptolemaic system. He lived over a millennium after the text was written and contributed nothing to it.
- **E)** Johannes Kepler formulated his three laws of planetary motion in the early seventeenth century. His principal works include Astronomia Nova and Harmonices Mundi instead of the Almagest.

22 **Which of these pairs of nation and national newspaper name is wrong?**

A **Denmark – De Telegraaf**
B Germany – Süddeutsche Zeitung
C France – Le Monde
D United Kingdom – The Times
E Slovakia – Nový Čas

Correct answer: A

De Telegraaf is a major **Dutch** newspaper based in Amsterdam, creating a clear **mismatch** with **Denmark**. It lacks any editorial ties to that Nordic country, which instead publishes leading national dailies like Politiken, Berlingske, and Jyllands-Posten.

Why the other answers are wrong

- **B) Germany – Süddeutsche Zeitung**: Süddeutsche Zeitung stands as one of Germany's largest national newspapers and is permanently headquartered in Munich.
- **C) France – Le Monde**: Le Monde operates as a leading French daily based in Paris and remains widely regarded as a flagship national newspaper of France.
- **D) United Kingdom – The Times**: The Times functions as a well-known national newspaper published in London and is fully distributed throughout the United Kingdom.
- **E) Slovakia – Nový Čas**: Nový Čas ranks as the highest-circulation daily newspaper in Slovakia and its title directly translates to New Time.

BIOLOGY

23 **Reverse transcriptase is mainly found in retroviruses such as HIV. Four nucleotides are needed for the reaction catalysed by this enzyme.**

A group of molecules may inhibit this enzyme. These molecules are structurally similar to the nucleotides but slightly altered so that bonds normally formed in the reaction cannot be made. Which of the following statements may be correct?

1. The four inhibitor molecules will resemble adenine, thymine, guanine and cytosine.
2. The inhibitor molecules can prevent the formation of phosphodiester bonds.
3. The inhibitor molecules can result in a reduction in the number of new virus particles produced.

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

Correct answer: A

Reverse transcriptase copies viral RNA into complementary DNA using four deoxyribonucleoside triphosphates (dATP, dTTP, dGTP, dCTP). Effective inhibitors undergo **substrate mimicry** to enter the active site but lack the $3'\text{-}\mathrm{OH}$ group required for phosphodiester bond formation. This causes **chain termination** before integration occurs, which ultimately restricts **viral replication**.

Why the other answers are wrong

- **B) 1 and 2 only**: Excludes statement 3, but inhibiting polymerisation directly prevents the assembly of complete genomes, which unquestionably lowers the yield of progeny virions.
- **C) 2 and 3 only**: Excludes statement 1, although competitive inhibition strictly requires the analogues to structurally resemble adenine, thymine, guanine and cytosine to bypass substrate selectivity.
- **D) 1 and 3 only**: Excludes statement 2, yet modified nucleotide analogues physically lack the reactive hydroxyl group needed for the enzyme to catalyze the next phosphodiester linkage.
- **E) 3 only**: Excludes both statements 1 and 2, ignoring that accurate base matching ensures enzyme acceptance while the altered sugar moiety guarantees premature strand elongation arrest.

24 **The enzyme HIV-1 protease is produced by the HIV virus.**

The enzyme is formed from two identical chains of 99 amino acids.
In each chain, amino acids 25, 26 and 27 in the sequence form part of the active site.

Which levels of structure control the shape of the active site of the HIV protease?

A secondary and tertiary only
B **primary, secondary, tertiary and quaternary**
C quaternary only
D primary and quaternary only
E primary, secondary and tertiary only

Correct answer: B

The **primary structure** fixes the sequence, including Asp-Thr-Gly at positions 25–27. **Secondary and tertiary structure** orient these residues and fold each chain to form half of the active-site pocket. **Quaternary structure** brings the two identical chains together in an obligate homodimer; each contributes an Asp25 and neighboring residues to the catalytic site. All four structural levels therefore determine the active-site shape.

Why the other answers are wrong

- **A) secondary and tertiary only**: It ignores the primary sequence, which supplies the catalytic residues, and quaternary structure, which is required for the dimer interface.
- **C) quaternary only**: It neglects the correct amino-acid sequence and folding within each monomer. A dimer of improperly folded chains would not have an active site.
- **D) primary and quaternary only**: It leaves out secondary and tertiary structure. Without correct local and overall folding of each monomer, the catalytic residues would not be oriented properly, even if the dimer forms.
- **E) primary, secondary and tertiary only**: It omits quaternary structure. The active site is not fully formed until the two subunits dimerise.

25 **A section of unmutated double-stranded DNA contains 100 nucleotides and 38% of these nucleotides contain thymine.**

Which one of the following correctly identifies the number of hydrogen (H) bonds and phosphodiester bonds present in this section of DNA?

A 112 H bonds present and 99 phosphodiester bonds present

B 138 H bonds present and 98 phosphodiester bonds present

C 138 H bonds present and 99 phosphodiester bonds present

D 224 H bonds present and 98 phosphodiester bonds present

E **112 H bonds present and 98 phosphodiester bonds present**

Correct answer: E

1. 38% of 100 nucleotides are **thymine** (38), meaning **adenine** also equals 38 per Chargaff's rule. 2. The remaining 24 nucleotides split evenly into 12 **guanine** and 12 **cytosine**. 3. **Hydrogen bonds** total 38×2 (A-T) $+12 \times 3$ (G-C) $= 112$. 4. Each 50-nucleotide strand contains 49 **phosphodiester bonds**, yielding $49 \times 2 = 98$ total.

Why the other answers are wrong

- **A) 112 H bonds present and 99 phosphodiester bonds present**: 112 hydrogen bonds are correct, but 99 phosphodiester bonds require 50 bonds in one strand and 49 in the other, or treat the molecule as a single strand, which is impossible for two complementary 50-nucleotide strands.
- **B) 138 H bonds present and 98 phosphodiester bonds present**: 98 phosphodiester bonds are correct, but 138 hydrogen bonds incorrectly assume all 62 non-thymine nucleotides form G-C pairs, calculating $38 \times 2 + 62 \times 3$, which ignores Chargaff's rule that adenine must equal thymine.
- **C) 138 H bonds present and 99 phosphodiester bonds present**: Combines the hydrogen bond error from Answer B with the phosphodiester bond error from Answer A, making both numerical results incorrect.
- **D) 224 H bonds present and 98 phosphodiester bonds present**: Lists 98 phosphodiester bonds correctly, but doubles the accurate hydrogen bond count ($112 \times 2 = 224$), likely confusing the total bonds per base pair with the contribution expected from each individual strand.

26 **Which of the following statements about a neurone in a healthy human is/are correct?**

1. Transport across its cell membrane can occur by exocytosis.
2. It contains the gene that codes for insulin.
3. It contains circular DNA.

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

Correct answer: E

Neurons transmit signals using **exocytosis** at synaptic terminals. Every **nucleated cell** retains a full copy of the human genome, so the insulin gene sits in the nucleus even when silent. Aerobic metabolism also requires **mitochondria**, which store their own circular DNA.

Why the other answers are wrong

- **A) 1 only**: Dismisses statements 2 and 3 based on a flawed assumption about cellular specialization. Complete nuclear diploidy and functional mitochondrial networks are universal traits shared by all viable human somatic cells.
- **B) 1 and 2 only**: Omits statement 3 because it incorrectly assumes neurons lack internal genetic material. Neural cells actively perform oxidative phosphorylation and therefore host numerous organelles that maintain their own compact circular DNA copies.
- **C) 1 and 3 only**: Misses statement 2 by confusing gene presence with gene activity. The insulin coding sequence remains fully integrated into the neuronal nuclear DNA on chromosome 11 despite being transcriptionally inactive in this tissue.
- **D) 2 and 3 only**: Ignores statement 1 by underestimating vesicular dynamics. Synaptic communication depends on presynaptic vesicle docking and fusion, making exocytosis the mandatory mechanism for neurotransmitter discharge.

27 **Squamous epithelium, ciliated epithelium and cartilage are tissues found in healthy humans.**

Which one of the following structures is made up of at least TWO of these tissues?

A alveoli
B **trachea**
C oviduct
D capillaries
E Bowman's capsule

Correct answer: B

The tracheal wall is lined by **ciliated epithelium** that sweeps mucus upward. Structural support comes from C-shaped rings of **hyaline cartilage** to keep the **airway** open. Because it contains both tissues, it meets the requirement.

Why the other answers are wrong

- **A) alveoli**: Alveolar walls consist almost entirely of thin squamous epithelium mixed with elastic tissue and capillaries. They contain neither ciliated epithelium nor cartilage.
- **C) oviduct**: The mucosa features ciliated columnar epithelium designed to transport the ovum toward the uterus. It lacks cartilage and shows only occasional non-ciliated columnar cells instead of squamous epithelium.
- **D) capillaries**: Capillary walls are a single layer of squamous endothelial cells supported by a basement membrane. They completely lack both motile cilia and structural cartilage.
- **E) Bowman's capsule**: The parietal layer uses simple squamous epithelium while the visceral surface consists of specialized podocytes. Neither component contains ciliated epithelium or cartilage.

28 **Which of the following contain peptide bonds?**

1. ribosomes in human liver cells
2. antibodies in human plasma
3. cilia on human bronchial cells
4. cholesterol in the membrane of human kidney cells

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

Correct answer: E

Peptide bonds ($-\mathrm{CO}-\mathrm{NH}-$) link amino-acid residues in proteins. Ribosomes contain rRNA and **ribosomal proteins**, antibodies consist of four **polypeptide chains**, and cilia contain **tubulin** microtubules arranged in a $9+2$ array. Cholesterol is a **sterol lipid**, not made of amino acids, so only 1, 2 and 3 contain peptide bonds.

Why the other answers are wrong

- **A) 2, 3 and 4 only**: Antibodies and cilia contain proteins with peptide bonds. Cholesterol does not contain peptide bonds, and this option omits ribosomes, which contain ribosomal proteins.
- **B) 2 and 4 only**: Antibodies are proteins and contain peptide bonds, but cholesterol is a sterol lipid and contains none. This option also omits ribosomes and cilia, both of which contain proteins.
- **C) 1 and 4 only**: Ribosomes contain proteins with peptide bonds, but cholesterol is not made of amino acids and contains none. This option also omits antibodies and cilia, both of which contain proteins.
- **D) 1 and 3 only**: Ribosomes contain ribosomal proteins, and cilia contain tubulin microtubules, so both have peptide bonds. This option omits antibodies, which are proteins made of four polypeptide chains.

29 **An organism, in bright sunlight, has the following features:**
- Consists of some cells with organelles which contain grana.
- All cells contain molecules of ATP, ADP and NAD.
- Some cells release carbon dioxide by diffusion all the time.

Which one of the following statements about the organism is correct?

- **A** **It is photosynthetic but has some cells which only respire.**
- **B** It is an anaerobic organism which only releases carbon dioxide.
- **C** It is eukaryotic and all cells carry out photosynthesis.
- **D** It is made up of cells which all contain mitochondria and chloroplasts.
- **E** It is prokaryotic and only carries out respiration.

Correct answer: A

Grana are membrane stacks located exclusively within **chloroplasts**. This structural detail confirms that **photosynthesis** occurs in a specific fraction of the organism's cells. Additional cells continuously release carbon dioxide even under bright sunlight, which proves they depend entirely on **respiration**. The combination of these two metabolic pathways aligns precisely with the description of mixed cell types.

Why the other answers are wrong

- **B) It is an anaerobic organism which only releases carbon dioxide.**: Photosynthesis inherently generates oxygen, which directly contradicts a strictly anaerobic classification. The organism consumes carbon dioxide during photosynthesis instead of releasing it exclusively.
- **C) It is eukaryotic and all cells carry out photosynthesis.**: The stem explicitly restricts grana possession to some cells, ruling out universal photosynthesis. Cells without chloroplasts emit carbon dioxide constantly, confirming they perform respiration alone.
- **D) It is made up of cells which all contain mitochondria and chloroplasts.**: Evidence shows only a portion of the cells contain chloroplasts, making a universal presence incorrect. The prompt provides no data regarding the mitochondrial composition of every cell.
- **E) It is prokaryotic and only carries out respiration.**: Grana and chloroplasts are exclusive to eukaryotes, which invalidates a prokaryotic classification. The visible photosynthetic structures also contradict the assertion that respiration is the sole metabolic activity.

30 **Which of the following can be a result of exercise in a healthy human?**

1. a decrease in muscle pH
2. an increase in blood pH
3. more blood flows to certain organs

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

Correct answer: B

During intense activity, skeletal muscle relies on $\text{anaerobic glycolysis}$, which generates excess H^+ that lowers intracellular pH. Systemic acid production rises concurrently, but compensatory hyperventilation maintains stable circulating pH or causes a minor decline rather than an increase. The cardiovascular system boosts cardiac output significantly, prioritizing perfusion toward working tissues and the skin for thermoregulation.

Why the other answers are wrong

- **A) 2 and 3 only**: Relies on the incorrect assumption of rising circulating alkalinity, which directly contradicts the balanced interplay between metabolic acid generation and breath exchange.
- **C) 3 only**: Recognizes targeted vascular redistribution but completely omits the documented proton-driven drop in fibre acidity during strenuous contraction.
- **D) 1, 2 and 3**: Groups all claims together while retaining the factually unsupported notion that resting thresholds are exceeded, violating fundamental biological stability.
- **E) 1 and 2 only**: Combines the valid intracellular acidification with the impossible systemic alkalinization, ignoring how respiratory mechanisms keep arterial levels neutral or slightly acidic.

31 **Which of the following could explain why the phenotype of a healthy female child may show differences from her healthy biological brother (apart from the gender)?**

1. independent assortment after the formation of the female zygote
2. crossing over between a chromosome from the sperm and a chromosome from the egg
3. random alignment of homologous chromosomes at the equator of the cell during metaphase I

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

Correct answer: B

Random alignment of homologous chromosomes at metaphase I creates genetic variation through **independent assortment**. This meiotic event in parental germ cells determines which chromosomes enter each gamete. Different gametes combine to form unique offspring. The siblings inherit distinct chromosomal sets that produce visible phenotypic differences.

Why the other answers are wrong

- **A) 2 and 3 only**: This option pairs a correct mechanism with an incorrect one. Statement 3 accurately describes meiotic random alignment. Statement 2 wrongly locates recombination between sperm and egg chromosomes. The combination fails because statement 2 remains false.
- **C) 2 only**: Statement 2 incorrectly claims crossing over happens between sperm and egg chromosomes after fertilisation. **Recombination** actually occurs during **prophase I** within a single parent's germ cell. Paternal and maternal chromosomes never exchange DNA segments during early embryonic divisions.
- **D) 1 and 2 only**: This option combines two biologically impossible scenarios. Independent assortment cannot occur after the zygote forms. Genetic recombination does not bridge separate parental gametes post-fertilisation. Both claims lack scientific validity.
- **E) 1 only**: Statement 1 incorrectly attributes chromosomal rearrangement to post-zygotic events. Meiotic shuffling is strictly confined to parental gonads. Chromosomes simply replicate through **mitosis** inside the developing embryo.

32 **The genes P, Q, R and S occur on the same chromosome.**
The COV (crossover values) for the pairs of genes are:

- P and Q 35%
- P and R 5%
- R and Q 40%
- Q and S 10%
- R and S 30%

Which one of the following sequences of letters represents a correct order of genes on the chromosome?

A PQSR
B **RPSQ**
C RSQP
D PQRS
E PRSQ

Correct answer: B

1. Locate the minimum crossover value (**P-R = 5**$\%$) to fix two adjacent loci. 2. Use additive distances (**P-Q = 35**$\%$ plus **R-Q = 40**$\%$) to place Q on the opposite side of P from R. 3. Fit S between P and Q using **Q-S = 10**$\%$ and **R-S = 30**$\%$, verifying that all pairwise recombination frequencies remain consistent.

Why the other answers are wrong

- **A) PQSR**: The segments **P-Q = 35**$\%$, **Q-S = 10**$\%$, and **R-S = 30**$\%$ align with the provided data, yet extending the chain to include R pushes the **P-R** interval to $35 + 10 + 30 = 75\%$. The map cannot accommodate a discrepancy of this magnitude against the stated 5%.
- **C) RSQP**: Values for **R-S = 30**$\%$, **Q-S = 10**$\%$, and **R-Q = 40**$\%$ remain internally consistent, but positioning P at the terminal end inflates the **P-R** span to $30 + 10 + 35 = 75\%$. Such a large separation is incompatible with the actual genetic distance.
- **D) PQRS**: This sequence correctly matches **P-Q = 35**$\%$ and **R-S = 30**$\%$, but placing R between Q and S expands the **P-R** distance to $35 + 40 = 75\%$. The experimental data strictly demands a much shorter linkage interval of 5%.
- **E) PRSQ**: The layout preserves **P-R = 5**$\%$ and **Q-S = 10**$\%$, but inserting S between P and Q forces the total **P-Q** distance to sum to $5 + 30 + 10 = 45\%$. This calculation directly contradicts the required 35% recombination frequency.

33 **A eukaryotic cell undergoes division.**
At one point it has pairs of chromosomes being separated by spindle fibres and moving towards the poles of the cell.

What stage of division is this?

A anaphase in Mitosis
B metaphase in Mitosis
C metaphase in Meiosis II
D telophase in Meiosis I
E anaphase in Meiosis I

Correct answer: E

During Anaphase I of meiosis, **spindle fibers** contract to pull **homologous pairs** toward opposite cell poles. Each chromosome moves as a complete unit still containing two sister chromatids. This specific type of **separation** directly matches the described cellular activity.

Why the other answers are wrong

- **A) anaphase in Mitosis**: Mitotic anaphase divides sister chromatids into independent chromosomes. The scenario explicitly describes homologous pairs moving apart. This pairing behavior identifies meiosis I uniquely.
- **B) metaphase in Mitosis**: Metaphase involves chromosomes aligning at the metaphase plate. No movement toward the poles occurs during this phase. Mitosis organizes individual duplicated chromosomes rather than homologous pairs.
- **C) metaphase in Meiosis II**: Metaphase II positions single chromosomes along the equatorial plate. The chromosomes do not separate yet. Meiosis II handles sister chromatids instead of homologous pairs.
- **D) telophase in Meiosis I**: Telophase I begins after chromosomes have already reached the poles. They stop moving and nuclear envelopes start to reform. Cytokinesis typically follows this stage.

34 **A condition caused by the dominant allele of a gene on the X chromosome is passed down through a family.**
Individual Z inherits the condition.

For this family, which of the following statements must be correct, assuming no spontaneous mutations have occurred?

1. If Z is a boy, then he must have inherited the dominant allele from his father.
2. If Z is a boy, then one of his mother's parents must have also had the condition.
3. If Z is a girl, then both of her parents must have had the allele.
4. If Z is a boy, and has children, then all of his daughters will have the condition.

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

Correct answer: E

This scenario involves an **X-linked dominant** gene where males inherit their single X chromosome exclusively from their **mother**. Since the trait is dominant, possession of one allele guarantees expression of the condition. Statement 2 is necessarily true because an affected mother must have inherited the allele from one of her own parents. Statement 4 is also true because an affected male passes his only X chromosome to every **daughter**. Only statements 2 and 4 are invariably correct.

Why the other answers are wrong

- **A) 1 and 4 only**: Includes statement 1 and statement 4. Statement 4 is valid since an affected father transmits his disease-carrying X chromosome to all his girls while giving his Y chromosome to sons. Statement 1 is entirely incorrect because boys receive their sole X chromosome from their mother, making paternal transmission impossible for male offspring.
- **B) 1, 3 and 4 only**: Includes statement 1, statement 3, and statement 4. Statement 4 remains accurate as affected men guarantee transmission to every daughter via their single X chromosome. Statements 1 and 3 persist as logical errors regarding maternal chromosome origin and single-parent allele sufficiency.
- **C) 2 and 3 only**: Includes statement 2 and statement 3. Statement 2 correctly traces the allele back to a grandparent under strict no-mutation conditions. Statement 3 falsely requires both parents to carry the allele. A daughter needs only one dominant copy and can inherit it exclusively from an affected mother or an affected father alone, so dual parental involvement is unnecessary.
- **D) 1 and 3 only**: Includes statement 1 and statement 3. Both claims contradict basic inheritance patterns. Males cannot receive X-linked genes from their fathers. Additionally, the dominant mechanism ensures that only one parent needs to possess the mutant allele for a daughter to develop the phenotype, regardless of parental sex.

35 **Part of a polypeptide sequence consists of four amino acids -1-2-3-4-.**

The tRNA anticodons for each amino acid are:

Which one of the following is the correct sequence, in a 3′ to 5′ direction, for the bases on the template strand of the DNA?

amino acid	anticodon
1	GCA
2	ACA
3	UUG
4	GGU

A GCAACAUUCCCU
B CGTTGTAAGCCA
C ATGGTGCCTTTC
D **GCAACATTGGGT**
E CGUUGUAAGCCA

Correct answer: D

1. The tRNA **anticodon** (3′→5′) pairs with the mRNA codon (5′→3′) through standard complementary base pairing. 2. Converting each anticodon produces the mRNA sequence 5′–CGU UGU AAC CCA–3′. 3. The DNA **template** strand is **antiparallel** and **complementary** to the mRNA, substituting uracil with thymine, which results in the 3′–GCAACATTGGGT–5′ sequence.

Why the other answers are wrong

- **A) GCAACAUUCCCU**: Also preserves uracil (U), confirming it is an RNA sequence, and the nucleotide arrangement does not correspond to the required DNA template complement.
- **B) CGTTGTAAGCCA**: Employs the correct DNA alphabet (thymine instead of uracil) but places the bases in an incorrect order, matching neither the original codons nor their complementary strand.
- **C) ATGGTGCCTTTC**: Shows both an incorrect length and a faulty base-pair complement to the mRNA, with its nucleotide blocks failing to align with the expected CGU UGU AAC CCA pattern.
- **E) CGUUGUAAGCCA**: This string matches the mRNA transcript exactly, which is evident because it still contains uracil (U) rather than the DNA base thymine.

36 **Mutations in the CFTR gene cause cystic fibrosis (CF). The non-mutated allele of the gene can be obtained and then introduced into the lung cells of a person with CF using liposomes as a vector. This treatment gives only short-term relief from the symptoms of CF.**

Which of the following statements would be a correct explanation of this treatment?

1. Genes are unstable and break down over time in the cell.
2. Lung cells are constantly being replaced and new cells will have the faulty allele.
3. The non-mutated allele is recessive.

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

Correct answer: C

Lung epithelial cells are **continuously replaced** by new cells derived from basal stem populations. The liposome-delivered CFTR DNA remains extra-chromosomal and does not integrate into these progenitor genomes. As treated surface cells senesce and detach, daughter cells begin **inheriting** only the original mutated alleles, which restricts clinical improvement to a few weeks.

Why the other answers are wrong

- **A) 1 and 2 only**: This option incorrectly merges statement 2 with the false claim in statement 1. Nucleic acids maintain chemical integrity over time, so the limited therapeutic window results exclusively from physiological tissue renewal rather than spontaneous DNA degradation.
- **B) 1 and 3 only**: Both statements 1 and 3 contain factual errors. Statement 1 misrepresents DNA persistence, while statement 3 inverts the actual mode of inheritance. Cystic fibrosis is an **autosomal recessive** disease that requires homozygous loss-of-function variants, directly contradicting the assertion that the functional allele is recessive.
- **D) 2 and 3 only**: Statement 2 correctly identifies the cellular mechanism, but statement 3 falsely describes allele behavior. The wild-type CFTR channel shows complete **allelic dominance** over the defective counterpart, since a single functional copy suffices for baseline chloride secretion. Pairing this accurate mechanism with an inverted dominance model renders the combination invalid.
- **E) 1 only**: Statement 1 is false because genomic DNA is structurally stable and does not spontaneously decompose inside viable cells. While non-integrated plasmids may dilute during repeated mitotic cycles, they do not undergo chemical breakdown, ruling out genetic instability as the cause of transient efficacy.

37 **A Petri dish contains populations of two different species of bacteria (V and W). Both are growing and reproducing at the same rate, using the same resources. The conditions are then changed and the rate of growth and reproduction of the population of species V increases.**

Which of the following, acting independently, could cause this increase in growth and reproduction rate?

1. a decrease in temperature
2. a change in pH
3. the addition of an antibiotic

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

Correct answer: A

Each environmental shift can independently move conditions toward V's physiological **optimum**. Dropping the temperature may align better with V's thermal tolerance than with W's. Altering pH can specifically match V's enzymatic range. Introducing an **antibiotic** triggers **selective inhibition** of W, which releases resource **competition** and allows V to multiply faster. Because every listed factor alone can plausibly drive this outcome, all three must be included.

Why the other answers are wrong

- **B) 2 and 3 only**: It omits the temperature decrease, ignoring that shifting thermal conditions toward V's preferred range can directly elevate its reproductive rate regardless of chemical or pH adjustments.
- **C) 1 and 3 only**: It leaves out the pH change, failing to recognize that modifying acidity or alkalinity constitutes another plausible mechanism that specifically optimizes V's metabolic efficiency and cell division.
- **D) 2 only**: It considers only a single mechanism, disregarding both the independent thermal effect and the selective antibiotic effect, both of which could individually produce the observed growth increase.
- **E) 1 and 2 only**: It excludes the antibiotic addition, which remains a valid independent trigger because differential susceptibility removes competitive pressure and accelerates V's reproduction, making the selection incomplete.

38 **Which one of the following statements is correct when the pressure in the ventricles of a healthy human heart is at its highest?**

- **A** **The atria of the heart will be filling.**
- **B** The atrioventricular valves will be open.
- **C** The semi-lunar valves will be closed.
- **D** A wave of electrical activity will be reaching the atrioventricular node.
- **E** The heart will be in atrial systole.

Correct answer: A

When ventricular pressure peaks, the heart is in mid-to-late **ventricular systole** as the chambers contract to eject blood. During this phase, the atria remain relaxed and passively receive venous return, meaning they are actively **filling**. This physiological state aligns exactly with option A.

Why the other answers are wrong

- **B) The atrioventricular valves will be open.**: High intraventricular pressure forcefully closes the atrioventricular valves to prevent regurgitation back into the atria. These valves remain shut throughout ejection and only open again when ventricular pressure falls during passive filling.
- **C) The semi-lunar valves will be closed.**: The semilunar valves (aortic and pulmonary) are forced open by rising ventricular pressure to allow forward ejection into the great arteries. They only close later when ventricular pressure drops below arterial pressure during early diastole.
- **D) A wave of electrical activity will be reaching the atrioventricular node.**: The electrical impulse arrives at and passes through the atrioventricular node early in the cardiac cycle, shortly after the P-wave on an ECG. By peak ventricular pressure, the signal has already exited the AV node, conducted down the bundle branches, and triggered complete ventricular muscle contraction.
- **E) The heart will be in atrial systole.**: Atrial systole occurs just before ventricular contraction to complete ventricular filling while ventricular pressure is still low. By the time ventricular pressure reaches its maximum, atrial contraction has already finished and the atria are in diastole.

39 **Which of the following structures make a solution that can raise the pH in the digestive system of a healthy human?**

1. gall bladder
2. pancreas
3. stomach

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

Correct answer: D

The exocrine **pancreas** produces fluid rich in **bicarbonate** ions $\mathrm{HCO_3^-}$. This secretion enters the duodenum and **neutralises** incoming acidic chyme. The chemical balance shifts the intestinal pH from 2 to $7–8$. Only this organ synthesises a liquid that raises digestive tract acidity.

Why the other answers are wrong

- **A) 1 only**: Suggests the gall bladder alone is responsible. This organ does not manufacture bile but only **stores** and concentrates hepatic secretions, so it fails the production criterion.
- **B) 2 and 3 only**: Combines the pancreas with the stomach. The presence of acid secretion in this pairing directly contradicts the requirement to increase pH.
- **C) 3 only**: Points only to the stomach. Gastric glands secrete **hydrochloric acid** HCl which drops the luminal environment to $1–2$ instead of elevating it.
- **E) 1 and 2 only**: Links the gall bladder with the correct organ. While the pancreas raises pH, the gall bladder contributes neither synthesis nor significant buffering capacity.

40 **B lymphocytes are involved in the human immune response to a bacterial infection.**

Which of the following processes would TYPICALLY be carried out by these lymphocytes in response to the infection?

1. cell division by mitosis
2. transcription producing mRNA
3. engulfing and digesting bacteria

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

Correct answer: D

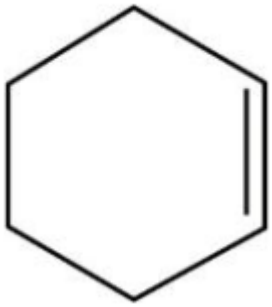
Upon activation by a bacterial antigen, B-lymphocytes undergo clonal expansion through **mitosis**, creating plasma cells and memory cells. These effector cells drive **transcription** of immunoglobulin genes to generate mRNA for rapid **antibody synthesis**. Engulfing whole bacteria is not a standard lymphocyte function; that **phagocytosis** occurs mainly in macrophages, neutrophils, and dendritic cells. While B-cells can internalize bound antigens for presentation on MHC II molecules, they do not digest intact pathogens.

Why the other answers are wrong

- **A) 2 and 3 only**: Includes RNA synthesis but wrongly associates bacterial ingestion with B-cells, while overlooking the proliferative phase needed for an effective immune response.
- **B) 3 only**: Selects only bacterial engulfment, which is incorrect for B-cells, and ignores the critical roles of mitotic proliferation and genetic transcription.
- **C) 1 only**: Recognizes cellular division but fails to include transcription, which is indispensable for producing the high volumes of antibodies required during infection.
- **E) 1 and 3 only**: Combines cell division with pathogen engulfment, omitting the necessary transcription step and misattributing phagocytic activity to lymphocytes instead of myeloid leukocytes.

CHEMISTRY

41 **What is the molecular formula of the compound shown below?**



- **A** C_6H_{10}
- **B** C_6H_{14}
- **C** C_6H_6
- **D** C_6H_{12}
- **E** C_6H_8

Correct answer: A

Start from the fully **saturated** alkane C_6H_{14}. The structure contains one **ring** and one **double bond**. Each element reduces the hydrogen count by two. Removing four hydrogens yields C_6H_{10}.

Why the other answers are wrong

- **B)** C_6H_{14}: Represents hexane, an open-chain alkane lacking both rings and multiple bonds. The given compound is cyclic and unsaturated.
- **C)** C_6H_6: Matches benzene, featuring three alternating double bonds in a six-membered ring. Our structure possesses only one double bond.
- **D)** C_6H_{12}: Describes cyclohexane, which has a six-membered ring with zero double bonds. The target molecule includes one double bond, requiring two fewer hydrogens.
- **E)** C_6H_8: Indicates a ring plus two double bonds or one triple bond. The drawing clearly shows a single double bond only.

42 **Five atoms are shown below. The letters are NOT chemical symbols.**

Which one of the following atoms has the highest first ionisation energy?

A $^{23}_{11}Z$

B $^{21}_{9}X$

C $^{22}_{11}\mathrm{Y}$

D $^{20}_{10}\mathrm{W}$

E $^{19}_{9}\mathrm{V}$

Correct answer: D

Ionisation energy rises across a period as increasing **nuclear charge** pulls outer electrons tighter. Atom A exhibits the highest proton number in its row and possesses a **closed-shell** arrangement. Disrupting this stable configuration demands substantially more energy than removing electrons from incomplete shells or higher energy levels.

Why the other answers are wrong

- **A)** $^{23}_{11}Z$: Replicates the outer configuration and periodic location of option C. Neutron quantity variations exert negligible influence on electrostatic forces or ionisation energy.
- **B)** $^{21}_{9}X$: Maintains identical electron distribution and chemical properties to option E. Altered neutron counts produce isotopes that share indistinguishable ionisation thresholds.
- **C)** $^{22}_{11}\mathrm{Y}$: Valence electron resides in a higher principal energy level, positioning it farther from the nucleus. Enhanced inner-shell **electron shielding** and expanded atomic radius diminish effective nuclear attraction despite additional protons. Actual sodium requires $496\ \mathrm{kJ\,mol^{-1}}$ versus neon's $2080\ \mathrm{kJ\,mol^{-1}}$.
- **E)** $^{19}_{9}\mathrm{V}$: Lower proton count weakens electrostatic attraction to electrons occupying the same principal shell. An incomplete valence subshell allows electron ejection with reduced energy input compared to a fully filled outer layer.

43 **Which of the following species have the same number and arrangement of electrons in their lowest energy states?**

$19\ \mathrm{K}_{+} \quad 11\mathrm{Na} + {}_{8}\mathrm{O}_{-} \quad {}_{8}\mathrm{O}_{2} - {}_{16}\ \mathrm{S}_{-}$

A ${}_{19}\ \mathrm{K}^{+} \mathrm{and}_{16}\ \mathrm{S}^{-}$

B ${}_{8}\mathrm{O}^{-} \mathrm{and}_{8}\mathrm{O}^{2-}$

C ${}_{11}\mathrm{Na}^{+} \mathrm{and}_{8}\mathrm{O}^{2-}$

D ${}_{8}\mathrm{O}^{-} \mathrm{and}_{16}\ \mathrm{S}^{-}$

E ${}_{19}\ \mathrm{K}^{+} \mathrm{and}_{11}\mathrm{Na}^{+}$

Correct answer: C

To share the same number and arrangement of electrons in their lowest energy states, two species must be **isoelectronic**. Na^{+} has $11 - 1 = 10$ electrons and O^{2-} has $8 + 2 = 10$ electrons. Both fill the orbitals as $1s^2 2s^2 2p^6$. They therefore possess identical totals and matching **ground-state configurations**.

Why the other answers are wrong

- **A)** ${}_{19}\ \mathrm{K}^{+} \mathrm{and}_{16}\ \mathrm{S}^{-}$: K^{+} possesses 18 electrons matching argon, while S^{-} possesses 17 electrons with a $3p^5$ end state. A single electron gap results in distinct energy level distributions.
- **B)** ${}_{8}\mathrm{O}^{-} \mathrm{and}_{8}\mathrm{O}^{2-}$: O^{-} holds $8 + 1 = 9$ electrons ($1s^2 2s^2 2p^5$) and O^{2-} holds 10 electrons ($1s^2 2s^2 2p^6$). The difference in electron count leaves a p subshell incomplete in the anion.
- **D)** ${}_{8}\mathrm{O}^{-} \mathrm{and}_{16}\ \mathrm{S}^{-}$: O^{-} has 9 electrons restricted to the second principal shell, whereas S^{-} has $16 + 1 = 17$ electrons occupying up to the third shell. They originate from different elements and lack structural correspondence.
- **E)** ${}_{19}\ \mathrm{K}^{+} \mathrm{and}_{11}\mathrm{Na}^{+}$: K^{+} contains $19 - 1 = 18$ electrons with configuration $[\mathrm{Ar}]$, while Na^{+} contains 10 electrons with configuration $[\mathrm{Ne}]$. Mismatched totals produce different orbital fills.

44 **Which of the following statements, if any, are correct for the properties of Group I elements?**

1. They form hydrides where the hydrogen has an oxidation state of –1.
2. They can reduce iodine to iodide.
3. Their outer electrons are delocalised when in the liquid state.

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

Correct answer: C

Alkali metals form ionic hydrides (MH) where the metal exists as M^+ and **hydrogen is –1**. These metals act as powerful **reducing agents** because their standard electrode potentials drop below +0.54 V for the I_2/I^- couple. In both solid and molten phases, the outer ns^1 electrons stay **delocalised** throughout the structure, preserving metallic bonding and electrical conductivity.

Why the other answers are wrong

- **A) 1 and 2 only**: Omits statement 3, despite the fact that valence electrons remain fully delocalised in the liquid phase, maintaining metallic character.
- **B) none of them**: Contradicts verified experimental data, as all three described behaviours are fundamental and well-documented properties of Group I elements.
- **D) 2 and 3 only**: Excludes statement 1, yet alkali metals consistently produce ionic hydrides with hydrogen fixed at an oxidation state of –1.
- **E) 1 and 3 only**: Misses statement 2, ignoring that alkali metals spontaneously reduce iodine to iodide due to their highly negative standard electrode potentials.

45 **Compounds of chlorine include:**

Cl_2O KCl $KClO$ $KClO_3$ $KClO_4$ Cl_2O_7

Which one of the following options correctly lists the oxidation states of chlorine that are shown in these compounds?

- **A** **–1, +1, +5 and +7 only**
- **B** –1, 0 and +1 only
- **C** –1, 0, +1, +5 and +7 only
- **D** –1 only
- **E** –1, +1, +3, +5 and +7 only

Correct answer: A

Apply the rules that **oxygen** is -2, **potassium** is $+1$, and the **net charge** is zero. Calculate each compound to find the chlorine values: 1. Cl_2O: $2x - 2 = 0 \Rightarrow x = +1$ 2. KCl: $+1 + x = 0 \Rightarrow x = -1$ 3. $KClO$: $+1 + x - 2 = 0 \Rightarrow x = +1$ 4. $KClO_3$: $+1 + x - 6 = 0 \Rightarrow x = +5$ 5. $KClO_4$: $+1 + x - 8 = 0 \Rightarrow x = +7$ 6. Cl_2O_7: $2x - 14 = 0 \Rightarrow x = +7$ The actual **oxidation states** are -1, $+1$, $+5$ and $+7$, which matches option A.

Why the other answers are wrong

- **B) –1, 0 and +1 only**: Includes zero, which only occurs in elemental chlorine (Cl_2). It also omits the $+5$ and $+7$ states present in the chlorate and perchlorate compounds.
- **C) –1, 0, +1, +5 and +7 only**: Adds zero to the correct set, repeating the mistake of assuming molecular chlorine exists. This value does not match any compound listed.
- **D) –1 only**: Recognizes only the -1 state in KCl. It fails to account for the positive values required to balance the oxygen atoms in the other formulas.
- **E) –1, +1, +3, +5 and +7 only**: Introduces $+3$, a state that belongs to species like the chlorite ion (ClO_2^-) or dichlorine trioxide. Neither of these substances appears in the provided group.

46 **Which row correctly shows the shape of each molecule and whether the molecule is polar (i.e. has a permanent dipole moment) or non-polar?**

[Atomic numbers: H = 1; B = 5; C = 6; N = 7; O = 8; F = 9; P = 15; Cl = 17]

	molecule	*shape*	*polar or non-polar*
1	BF_3	trigonal planar	polar
2	CH_2Cl_2	tetrahedral	non-polar
3	CO_2	linear	polar
4	NH_3	trigonal planar	polar
5	PCl_5	trigonal bipyramidal	non-polar

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

Correct answer: A

PCl_5 features five bonding pairs and zero lone pairs around phosphorus, establishing a **trigonal bipyramidal** geometry via **VSEPR** theory. The symmetric placement of identical $P-Cl$ bonds causes all bond **dipoles** to cancel exactly, rendering the molecule **non-polar**.

Why the other answers are wrong

- **B) row 4**: NH_3 possesses three bonding pairs plus one lone pair on nitrogen, which dictates a trigonal pyramidal geometry instead of trigonal planar. The stated shape is therefore incorrect despite the molecule being polar.
- **C) row 1**: BF_3 forms a trigonal planar structure with three identical $B-F$ bonds arranged symmetrically. Perfect symmetry ensures the bond dipoles cancel out, so the molecule is non-polar.
- **D) row 2**: CH_2Cl_2 adopts a tetrahedral shape but contains two $C-H$ and two $C-Cl$ bonds. The stronger polarity of $C-Cl$ compared to $C-H$ prevents dipole cancellation, so the molecule is polar.
- **E) row 3**: CO_2 is linear with two equal $C=O$ bond vectors oriented 180° apart. Their opposing directions lead to complete vector cancellation, making the molecule non-polar.

47 **Which one of the following substances has the highest solubility in the specified liquid at a temperature of 298 K and 1 atm pressure?**

A sodium chloride in liquid cyclohexane

B hydrogen in liquid water

C **bromine in liquid hexane**

D silicon dioxide in liquid water

E potassium bromide in liquid tetrachloromethane

Correct answer: C

Bromine ($\mathrm{Br_2}$) and hexane ($\mathrm{C_6H_{14}}$) are both **nonpolar** substances. They interact through **matching intermolecular forces** based on the "like dissolves like" principle. This compatibility allows a solubility of tens of grams per $100\ \mathrm{g}$ of solvent at $298\ \mathrm{K}$.

Why the other answers are wrong

- **A) sodium chloride in liquid cyclohexane**: Sodium chloride (NaCl) is an ionic solid held together by strong electrostatic attractions. Cyclohexane ($\mathrm{C_6H_{12}}$) is nonpolar and supplies only weak dispersion forces. The energy required to break the crystal lattice cannot be compensated by the solvent. Solubility remains negligible at approximately $10^{-6}\ \mathrm{g}$ per $100\ \mathrm{g}$ solvent.
- **B) hydrogen in liquid water**: Molecular hydrogen ($\mathrm{H_2}$) is nonpolar while water is highly polar and extensively hydrogen bonded. Only weak dispersion forces operate between $\mathrm{H_2}$ and water molecules. Consequently the solubility stays extremely low at about $0.0016\ \mathrm{g}$ per $100\ \mathrm{g}$ water at $298\ \mathrm{K}$.
- **D) silicon dioxide in liquid water**: Silicon dioxide ($\mathrm{SiO_2}$) forms a rigid **covalent network** with an enormous lattice enthalpy. Breaking the three-dimensional bond structure requires prohibitive energy that water cannot offset. The solid therefore exhibits no appreciable dissolution.
- **E) potassium bromide in liquid tetrachloromethane**: Potassium bromide (KBr) consists of ions whereas carbon tetrachloride ($\mathrm{CCl_4}$) is a nonpolar liquid. The severe mismatch between strong ion-ion interactions and weak solvent forces prevents dissolution. Solubility is again restricted to roughly $10^{-6}\ \mathrm{g}$ per $100\ \mathrm{g}$ solvent.

48 **When nitrogen and hydrogen are mixed under suitable conditions of temperature and pressure, and in the presence of a catalyst, an equilibrium state is attained:**

$$\mathrm{N_2(\,g) + 3H_2(\,g) \rightleftharpoons 2NH_3(\,g)} \quad \Delta \mathrm{H \text{ is negative}}$$

Which of the following statements explain(s) why, when the pressure on a mixture of nitrogen and hydrogen is increased while the temperature remains constant, the time taken to attain equilibrium is decreased?

1. The molecules have a higher collision frequency.
2. The yield of ammonia $(\mathrm{NH_3(\,g)})$ decreases.
3. A greater proportion of molecules in the mixture have energy greater than the activation energy.

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

Correct answer: C

Increasing **pressure at constant temperature** reduces the gas volume, which directly raises reactant concentration. Higher concentration increases **collision frequency**, accelerating both forward and reverse reaction rates. Consequently, the mixture reaches the new equilibrium composition in less time. Statement 1 correctly identifies this kinetic effect.

Why the other answers are wrong

- **A) 2 only**: This option relies solely on statement 2. Statement 2 is incorrect because **Le Chatelier's principle** dictates that higher pressure shifts equilibrium toward the side with fewer gas moles. The reaction consumes four moles of reactants to produce two moles of product, so the ammonia yield actually increases rather than decreases.
- **B) 3 only**: This option relies solely on statement 3. Statement 3 is incorrect because the fraction of molecules possessing energy above the activation threshold follows the **Maxwell-Boltzmann distribution**. This statistical distribution depends strictly on temperature, not pressure, so the energetic proportion remains unchanged when temperature is held constant.
- **D) 1, 2 and 3**: This option combines all three statements. Although statement 1 accurately describes the rate acceleration mechanism, statements 2 and 3 present chemically inaccurate claims regarding equilibrium yield and molecular energy profiles, rendering the full set incorrect.
- **E) 1 and 3 only**: This combination incorrectly pairs statement 1 with statement 3. Since statement 3 falsely claims that pressure alters molecular energy distribution at fixed temperature, including it alongside the valid kinetic explanation makes the option invalid.

49 **Consider this ionic equation in aqueous solution:**

$$CH_3O^- + H_2O \rightarrow CH_3OH + OH^-$$

Which statement about this reaction is correct?

A The final mixture of solutions would have a pH below 7.

B Water is acting as a Brønsted–Lowry base.

C The CH_3O^- ion is a Lewis acid. 3

D The hydroxide ion is the conjugate acid of the water.

E **CH_3OH is the conjugate acid of CH_3O^-**

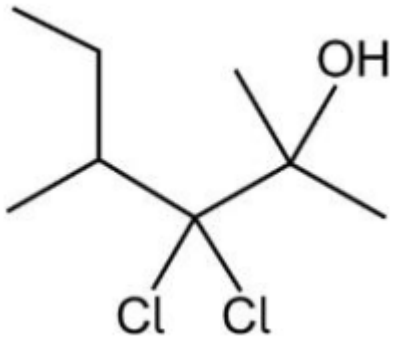
Correct answer: E

In this proton-transfer equilibrium, methoxide (CH_3O^-) accepts a proton from water to form methanol (CH_3OH), which is its conjugate acid. Water acts as an acid by donating the proton, **producing hydroxide ions** (OH^-) that make the solution basic.

Why the other answers are wrong

- **A) The final mixture of solutions would have a pH below 7.**: The reaction generates hydroxide ions, shifting the equilibrium toward a basic environment with a pH above 7.
- **B) Water is acting as a Brønsted–Lowry base.**: Water functions as a Brønsted–Lowry acid since it gives up a proton rather than accepting one.
- **C) The CH_3O^- ion is a Lewis acid. 3**: Methoxide acts as a Lewis base because it donates an electron pair to bond with the proton, whereas a Lewis acid must accept an electron pair.
- **D) The hydroxide ion is the conjugate acid of the water.**: Hydroxide is the conjugate base of water because it forms when water loses a proton, not gains one.

50 **What is the correct IUPAC name of this compound?**



A 4,4-dichloro-3,5-dimethylhexan-5-ol
B 3,3-dichloro-4-ethyl-2-methylpentan-2-ol
C 3,3-chloro-2-ethyl-4-methylpentan-4-ol
D **3,3-dichloro-2,4-dimethylhexan-2-ol**
E 3,3-chloro-4-ethyl-2-methylpentan-2-ol

Correct answer: D

Choose the longest chain that contains the hydroxyl group: it has six carbons. Number it from the end that gives the hydroxyl group the **lowest locant**, 2. The substituents are two chlorines at C-3 and methyl groups at C-2 and C-4, giving 3,3-dichloro-2,4-dimethylhexan-2-ol.

Why the other answers are wrong

- **A) 4,4-dichloro-3,5-dimethylhexan-5-ol**: It places the hydroxyl group at C-5, but the alcohol carbon is closer to one end and must be numbered C-2 to give the hydroxyl group the lowest locant. It also mislocates the chlorines and methyl groups.
- **B) 3,3-dichloro-4-ethyl-2-methylpentan-2-ol**: It uses a five-carbon parent chain, but including one of the ethyl-like branches on the hydroxyl-bearing carbon gives the longer six-carbon chain. That ethyl group belongs in the parent chain, so the substituents are methyl groups, not an ethyl group.
- **C) 3,3-chloro-2-ethyl-4-methylpentan-4-ol**: It uses a five-carbon parent instead of the six-carbon chain. It places the hydroxyl group at C-4 rather than C-2 in the longest chain, and it lists only one chlorine instead of two.
- **E) 3,3-chloro-4-ethyl-2-methylpentan-2-ol**: It uses a five-carbon parent instead of the six-carbon chain and lists only one chlorine instead of two.

51 **A sealed container contains 1.00 mol of hydrogen gas, which behaves as an ideal gas.**

Which of the following changes increase(s) the total kinetic energy of the hydrogen gas molecules initially within the container?
1. Changing the amount of hydrogen from 1.0 mol to 1.2 mol whilst keeping the pressure and volume constant.
2. Changing the pressure from 1.0 atm to 1.2 atm whilst keeping the volume and number of moles constant.
3. Changing the volume from 1.0 L to 1.2 L whilst keeping the pressure and number of moles constant.

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

Correct answer: E

For an ideal gas, $K_{\text{orig}} = \frac{3}{2} n_{\text{orig}} RT$, and the amount of the **original molecules** is fixed, so their total kinetic energy increases only if the **temperature** rises. From $PV = nRT$, increasing n from 1.0 to 1.2 mol at fixed P and V lowers the temperature, while increasing P or V by 20% at fixed values of the other variables raises it by 20%. Therefore, only statements 2 and 3 increase the kinetic energy.

Why the other answers are wrong

- **A) 1, 2 and 3**: It includes statement 1, which does not increase the kinetic energy. Increasing the amount from 1.0 to 1.2 mol at fixed pressure and volume lowers the temperature.
- **B) 1 only**: Statement 1 actually decreases the kinetic energy: increasing the amount at fixed pressure and volume lowers the temperature. It also omits statements 2 and 3, both of which increase the temperature and kinetic energy.
- **C) 3 only**: It omits statement 2. Raising the pressure from 1.0 to 1.2 atm at fixed volume and amount increases the temperature by 20%, so the original molecules' kinetic energy also increases.
- **D) 1 and 2 only**: Statement 1 lowers the temperature and kinetic energy because the amount increases from 1.0 to 1.2 mol while pressure and volume stay constant. Statement 3 should be included: increasing the volume from 1.0 to 1.2 L at fixed pressure and amount raises the temperature and kinetic energy by 20%.

52 **Consider a fixed volume and amount of an ideal gas at 10°C.**

What temperature would it have to be changed to in order for the pressure to be doubled?

A 20°C
B 566°C
C 5°C
D 278°C
E **293°C**

Correct answer: E

1. Convert the starting condition to the thermodynamic scale: $10\,^{\circ}\mathrm{C} + 273.15 = 283.15\ \mathrm{K}$ 2. Apply the **direct proportionality** between pressure and **absolute temperature**: $2 \times 283.15\ \mathrm{K} = 566.3\ \mathrm{K}$ 3. Transform the result back to the familiar scale: $566.3\ \mathrm{K} - 273.15 = 293.15\,^{\circ}\mathrm{C} \approx 293\,^{\circ}\mathrm{C}$

Why the other answers are wrong

- **A) 20°C**: Adding only ten degrees raises the Kelvin baseline by roughly $3.5\,\%$, which generates a nearly identical minor pressure increase rather than the **two-fold** expansion.
- **B) 566°C**: This choice stems from scaling the Celsius value directly instead of converting to the **Kelvin scale** first. Converting $566\,^{\circ}\mathrm{C}$ gives $839\ \mathrm{K}$, creating a ratio of $839/283 \approx 2.97$ that nearly triples the pressure.
- **C) 5°C**: Decreasing the thermal energy reduces molecular collisions against the container walls, so the pressure drops instead of rising.
- **D) 278°C**: This setting corresponds to $551\ \mathrm{K}$, yielding a temperature ratio of $551/283 \approx 1.95$. The gas pressure reaches approximately 1.95 times the initial value and stops short of the requirement.

53 **Evaluate** $\left(3 \times 10^{3}\right)^{3} \times \left(2 \times 10^{-5}\right)$

A 5.4×10^{-1}
B 5.4×10^{2}
C 5.4×10^{4}
D 5.4×10^{5}
E 5.4×10^{1}

Correct answer: D

1. Apply the cube to each **factor** inside the parenthesis to get 27×10^{9}. 2. Multiply the coefficients and add the **exponents** to obtain 54×10^{4}. 3. Move the **decimal point** one place left to convert the value into proper scientific notation.

Why the other answers are wrong

- **A)** 5.4×10^{-1}: A sign error combines the exponents or discards the positive power entirely. Adding 9 and -5 correctly gives $+4$, while a mistaken subtraction or omitted factor produces a negative exponent like -1.
- **B)** 5.4×10^{2}: This option misses one power of ten during the final conversion. The value 54×10^{4} requires shifting the decimal to get 5.4, which should yield 10^{5} instead of 10^{2}.
- **C)** 5.4×10^{4}: The intermediate product 54×10^{4} is numerically correct, but the coefficient was not reduced below ten. Keeping 54 leaves the exponent one step too high.
- **E)** 5.4×10^{1}: This result loses four powers of ten. It typically occurs when the base ten is not cubed and remains 10^{3} instead of becoming 10^{9}.

54 **Which one of the following is an equation of the line that passes through (4, 3) and is perpendicular to the line y = 2x + 4?**

A 2y – x = 2

B **2y + x = 10**

C 2y + x = 11

D 2x – y = 5

E 2x + y = 11

Correct answer: B

The given line $y = 2x + 4$ has a **slope of** 2. A **perpendicular line requires a negative reciprocal slope**, which is $-\frac{1}{2}$. Using the point-slope form with $(4, 3)$ gives $y - 3 = -\frac{1}{2}(x - 4)$. Multiplying by 2 and rearranging results in $2y + x = 10$.

Why the other answers are wrong

- **A) 2y – x = 2**: The slope equals $\frac{1}{2}$, which is only the reciprocal instead of the negative reciprocal. It contains the required point but fails the perpendicularity requirement.
- **C) 2y + x = 11**: The slope equals $-\frac{1}{2}$, satisfying the angle condition. Substituting $(4, 3)$ into the left side of the equation yields $10 \neq 11$, proving the point does not belong to this line.
- **D) 2x – y = 5**: The slope equals 2, making the lines parallel rather than perpendicular. The point $(4, 3)$ lies on it, but the orientation does not match the perpendicular condition.
- **E) 2x + y = 11**: The slope equals -2, so the lines are not perpendicular. The equation passes through $(4, 3)$, but the incorrect slope violates the geometric condition.

55 **A pentagon has one line of symmetry. All five sides are 6 cm, and the interior angles, in anticlockwise order, are 60°, 150°, 90°, 90° and 150°.**

What is the area of this pentagon?

A $3(4+\sqrt{3})\text{cm}^2$
B $3(12+\sqrt{3})\text{cm}^2$
C $3(5+\sqrt{3})\text{cm}^2$
D $9(2+\sqrt{3})\text{cm}^2$
E $9(4+\sqrt{3})\text{cm}^2$

Correct answer: E

The interior angles determine the **exterior angles** $120^\circ, 30^\circ, 90^\circ, 90^\circ, 30^\circ$, which sum to 360°. Placing the first vertex at the origin and applying side vectors of length $6\ \text{cm}$ yields the **coordinates** $(0,0)$, $(6,0)$, $(3, 3\sqrt{3})$, $(3-3\sqrt{3}, 3\sqrt{3}+3)$, and $(-3\sqrt{3}, 3)$. Applying the **Shoelace formula** to these points gives $\frac{1}{2}|18(\sqrt{3}+1)+54| = 9(4+\sqrt{3})\ \text{cm}^2$. This matches the geometric **decomposition** into an equilateral triangle and a symmetric **trapezium**.

Why the other answers are wrong

- **A)** $3(4+\sqrt{3})\ \text{cm}^2$ ($\approx 17.2\ \text{cm}^2$) is exactly one third of the correct value. It occurs if the determinant factor of 2 from the Shoelace method is dropped, or if only the upper equilateral triangle is computed while discarding the remaining polygon portion.
- **B)** $3(12+\sqrt{3})\ \text{cm}^2$ ($\approx 41.2\ \text{cm}^2$) arises from incorrectly assuming the bottom base measures $12\ \text{cm}$. This doubles the actual horizontal width while retaining the standard area multiplier, introducing an extra $18\ \text{cm}^2$ to the total.
- **C)** $3(5+\sqrt{3})\ \text{cm}^2$ ($\approx 20.2\ \text{cm}^2$) appears when the lower region is mishandled after isolating the triangle. The calculation uses the correct $3\ \text{cm}$ height only once instead of accounting for both equal halves of the symmetric lower shape.
- **D)** $9(2+\sqrt{3})\ \text{cm}^2$ ($\approx 33.6\ \text{cm}^2$) results from substituting 4 with 2 in the final term. This error stems from performing a subtraction instead of an addition during coordinate cross-products, or from assigning a reduced trapezium height of $3\ \text{cm}$ rather than the full vertical span.

56 **The equation below has two roots.**

$\frac{x+4}{x+1} = x$

What is the sum of the two roots?

A 4
B **0**
C -2
D 2
E -4

Correct answer: B

1. Apply the **restriction** $x \neq -1$ before simplifying. 2. **Multiply** both sides by $x + 1$ to clear the fraction and obtain $x + 4 = x^2 + x$. 3. **Rearrange** all terms to reach the quadratic form $x^2 - 4 = 0$. 4. **Factor** the expression to determine the roots $x = 2$ and $x = -2$. 5. Calculate the **sum** $2 + (-2) = 0$, verifying both values remain valid.

Why the other answers are wrong

- **A) 4**: Calculates the sum of absolute values instead of performing the required algebraic addition.
- **C) -2**: Returns only the negative root without including the positive counterpart needed for the total sum.
- **D) 2**: Considers only the positive root while ignoring the second valid solution.
- **E) -4**: Incorrectly adds the numerator zero at $x = -4$ and the excluded denominator value at $x = -1$, neither of which solves the equation.

57 **Three spherical particles have the following diameters: 1650 pm, 1.5 nm and 0.0036 µm.**

What is their order of diameter (smallest first)?

A 1650 pm, 1.5 nm, 0.0036 µm
B 1.5 nm, 0.0036 µm, 1650 pm
C 0.0036 µm, 1.5 nm, 1650 pm
D 0.0036 µm, 1650 pm, 1.5 nm
E 1.5 nm, 1650 pm, 0.0036 µm

Correct answer: E

To compare the diameters, **convert** all measurements to a **common** unit. Since $1\ \text{pm} = 10^{-3}\ \text{nm}$, $1650\ \text{pm}$ becomes $1.65\ \text{nm}$. Because $1\ \mu\text{m} = 10^{3}\ \text{nm}$, $0.0036\ \mu\text{m}$ equals $3.6\ \text{nm}$. The third value remains $1.5\ \text{nm}$. Sorting these converted values in **increasing** order gives $1.5\ \text{nm} < 1.65\ \text{nm} < 3.6\ \text{nm}$.

Why the other answers are wrong

- **A) 1650 pm, 1.5 nm, 0.0036 µm**: It swaps the first two entries by placing $1.65\ \text{nm}$ before $1.5\ \text{nm}$, failing to recognise that $1.5\ \text{nm}$ is numerically smaller.
- **B) 1.5 nm, 0.0036 µm, 1650 pm**: It places $3.6\ \text{nm}$ ($0.0036\ \mu\text{m}$) ahead of $1.65\ \text{nm}$ ($1650\ \text{pm}$), incorrectly treating the **largest** diameter as the middle entry.
- **C) 0.0036 µm, 1.5 nm, 1650 pm**: It starts with $3.6\ \text{nm}$ ($0.0036\ \mu\text{m}$), mistakenly identifying the largest diameter as the smallest and reversing the entire sequence.
- **D) 0.0036 µm, 1650 pm, 1.5 nm**: It begins with the largest value and ends with the smallest, putting $0.0036\ \mu\text{m}$ first instead of following an ascending arrangement.

58 **An electric train is travelling on a straight, horizontal track.**
A constant resultant force (greater than zero) acts on the train in the direction of the train's motion.

What happens to the magnitude of the acceleration and to the magnitude of the velocity of the train while this force is acting?

A The acceleration increases and the velocity remains constant.
B The acceleration decreases and the velocity increases.
C The acceleration remains constant and the velocity remains constant.
D **The acceleration remains constant and the velocity increases.**
E The acceleration increases and the velocity increases.

Correct answer: D

The resultant force acting on the train is stated to be constant. According to Newton's second law $a = F/m$, a constant force and invariant mass produce a constant acceleration. A non-zero acceleration directed along the motion causes the velocity to increase steadily over time.

Why the other answers are wrong

- **A)** The acceleration does not increase because both force and mass remain unchanged. A non-zero acceleration inherently requires a change in velocity, making constant speed physically impossible.
- **B) The acceleration decreases and the velocity increases.**: Acceleration cannot decrease since the problem specifies a constant resultant force. Any reduction in acceleration would imply a diminishing net force, which contradicts the premise.
- **C)** The acceleration description is correct, but a non-zero acceleration always alters the kinematic state. Constant velocity fundamentally demands a zero net force, violating the given condition.
- **E) The acceleration increases and the velocity increases.**: While the velocity indeed increases, the acceleration stays fixed due to the unchanging force and mass. An increasing acceleration would require a progressively larger net force acting on the train.

59 **The Earth's atmosphere contains oxygen and nitrogen.**
The mass of an oxygen molecule is greater than the mass of a nitrogen molecule.
The temperature of air in a room on a particular day is 300 K.

Below are four statements about the motion of the two types of molecule in this room.

1. They have an equal mean square velocity $\left(\overline{v^2}\right)$.
2. A nitrogen molecule has a greater mean square velocity $\left(\overline{v^2}\right)$ than an oxygen molecule.
3. A nitrogen molecule has a greater mean kinetic energy than an oxygen molecule.
4. An oxygen molecule has a greater mean kinetic energy than a nitrogen molecule.

Which of the statements is/are correct?

A statement 1 only
B statement 1 and 3 only
C **statement 2 only**
D statement 2 and 4 only
E none of them

Correct answer: C

At a fixed **temperature** every gas molecule shares the same mean translational **kinetic energy** defined by $\langle E_k \rangle = \frac{3}{2}kT$. This leads to $\langle v^2 \rangle = \frac{3kT}{m}$, proving that **mean square speed** varies inversely with molecular **mass**. Nitrogen molecules weigh approximately 4.65×10^{-26} kg while oxygen weighs 5.31×10^{-26} kg, so nitrogen moves faster on average. Only statement 2 accurately reflects these thermodynamic relations.

Why the other answers are wrong

- **A) statement 1 only**: Incorrectly assumes speed equality follows energy equality. The heavier oxygen molecules must travel slower to maintain the same thermal energy as the lighter nitrogen molecules.
- **B) statement 1 and 3 only**: Combines the correct observation with a false energy claim. Translational kinetic energy depends exclusively on temperature, so neither gas type possesses a larger value.
- **D) statement 2 and 4 only**: Reverses the incorrect energy comparison while keeping the valid speed relation. Molecular identity does not alter the $\frac{3}{2}kT$ energy floor established by thermal equilibrium.
- **E) none of them**: Dismisses the correct statement despite the direct proof from $\langle v^2 \rangle = \frac{3kT}{m}$. The precise mass difference clearly dictates the higher speed for nitrogen.

60 **A wire made of a metal of uniform resistivity $1.0 \times 10^{-6} \Omega$ m is 2.0 m long and has a diameter of 2.0 × 10^{-3} m.**

What is the electrical resistance of this length of the wire?

A $\frac{1.0}{2\pi}\Omega$
B $\frac{2.0}{\pi}\Omega$
C $5.0 \times 10^{-13}\pi\Omega$
D $\frac{2.0\times10^{-3}}{\pi}\Omega$
E $2.0 \times 10^{-12}\pi\Omega$

Correct answer: B

The electrical **resistance** of a uniform wire follows $R = \rho L/A$. The cross-sectional **area** requires the radius $r = d/2 = 1.0 \times 10^{-3}$ m, yielding $A = \pi r^2 = \pi \times 10^{-6}$ m^2. Substituting the given values gives $R = (1.0 \times 10^{-6}\ \Omega\,\text{m})(2.0\ \text{m})/(\pi \times 10^{-6}\ \text{m}^2)$. The 10^{-6} factors **cancel** completely, leaving $2.0/\pi\ \Omega$.

Why the other answers are wrong

- **A)** $\frac{1.0}{2\pi}\Omega$: Treats the **diameter** as the radius value, which quadruples the actual geometric area. This division by four reduces the calculated value to $1.0/(2\pi)\ \Omega$.
- **C)** $5.0 \times 10^{-13}\pi\Omega$: Accidentally multiplies the 10^{-6} components from resistivity and area instead of dividing them. This arithmetic mistake compounds with an extra decimal shift, producing a result thirteen orders of magnitude too low.
- **D)** $\frac{2.0\times10^{-3}}{\pi}\Omega$: Keeps the correct symbolic layout but skips the **squaring** operation for the radius measurement. It leaves a single 10^{-3} factor standing where the area formula demands 10^{-6}.
- **E)** $2.0 \times 10^{-12}\pi\Omega$: Places π in the numerator contrary to the division layout and mixes up the power-of-ten handling during substitution. The flawed exponent combination generates a numerically impossible value.

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