PROVE UFFICIALI DEGLI ANNI PASSATI

IMAT 2015

PROVA UFFICIALE MUR

Con le risposte

ALLENATI SULL'APP TESTBUDDY

TESTBUDDY.IT

WHAT'S IN THIS DOCUMENT

Prova di ammissione IMAT 2015, pubblicata dal Ministero dell'Università e della Ricerca (accessoprogrammato.mur.gov.it). Versioni, soluzioni e commenti di TestBuddy, che non è collegata al Ministero.

- Il testo della prova impaginato da TestBuddy, nell'ordine dell'ateneo
- The correct answers and the explained solutions, with the letters of the paper

General Knowledge and Logical Reasoning	22 questions
Biology	16 questions
Chemistry	10 questions
Physics and Mathematics	8 questions
Total	**56 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.

ADMISSION TEST FOR THE DEGREE COURSE IN MEDICINE AND SURGERY

Academic Year 2015/2016

General Knowledge and Logical Reasoning

1 Studies are taking place to assess the benefits to dental health of adding fluoride to drinking water, a process known as mass medication. The Health Minister has urged consideration of fluoridation, particularly in deprived areas where dental care is poor. Fluoride can occur naturally in the water because of fluoride containing minerals. Fluoride, if in the water, improves dental health by up to 50 percent. Even so, fluoridation should not take place. A campaign leader opposed to fluoridation has spoken of her experiences of living in a fluoridated area of the USA. She experienced feelings of apathy and depression; her 2 year old son showed autistic tendencies and had white flecks on his teeth. These symptoms disappeared when they returned home from the USA.

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

A The reported health symptoms were caused by fluoride in the water.

B Mass medication is always wrong.

C Fluoridation is cheaper than improving dental facilities.

D Fluoridation is only necessary in deprived areas.

E Fluoridation of water is a person's only source of fluoride.

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2 Climate scientists in Greenland studying patterns of plant growth have suggested that the early arrival of spring in the Arctic threatens to drive down populations of migrating animals such as caribou. However, comparable studies elsewhere show that their fears are unfounded. A recent study of great tits in Oxfordshire showed the birds are capable of adapting to climate change better than many scientists expected. Over the past half century, the birds have brought forward the date they lay their eggs by two weeks, so that young are born when plant-eating grubs are most plentiful.

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

A Migrating animals in the Arctic can adapt to climate change as successfully as great tits in Oxfordshire.

B Birds are more adaptable than large mammals such as caribou.

C Climate change in Greenland and climate change in Oxfordshire are of the same scale.

D The scientists working in Oxfordshire have greater expertise than those working in Greenland.

E Unless animals like the caribou produce their young earlier in the year, their population will fall.

3 Now, it might be thought an amazing coincidence if Earth were the only planet in the galaxy on which intelligent life evolved. If it happened here, the one planet we have studied closely, surely one would expect it to have happened on a lot of other planets in the galaxy – planets we have not yet had the chance to examine. This objection, however, rests on a fallacy: it overlooks what is known as an 'observation selection effect', so it wouldn't be such a coincidence. Whether intelligent life is common or rare, every observer is guaranteed to originate from a place where intelligent life did, in fact, arise. Since only the successes give rise to observers who can wonder about their existence, it would be a mistake to regard our planet as a randomly selected sample from all planets.

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

A There would be no amazing coincidence if we discovered that Earth were the only planet in the galaxy on which intelligent life evolved.

B If life had evolved here on Earth, it would probably have happened on a lot of other planets in the galaxy.

C It would be an amazing coincidence if Earth were the only planet in the galaxy on which intelligent life evolved.

D Our planet is not a randomly selected sample from all planets.

E However common intelligent life is, every observer will certainly originate from a place where intelligent life did, in fact, arise.

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4 Although it is sometimes suggested that the congestion caused by the bunching of cars on motorways could be eased by increasing the speed limit to 150 km/hr, such an increase would not be a good thing. An estimated 35 per cent of drivers exceed the speed limit by 20 km/hr and would continue to do so if the limit were raised. Since bunching is caused by speeding drivers trying to pass those who observe the speed limit, raising the limit to 150 km/hr would result in the same amount of congestion, but at an increased speed. Moreover, a higher speed limit would encourage all drivers to drive faster, and thus would increase the existing danger from those who drive too close to the car in front.

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

A It would not be a good thing to increase the speed limit to 150 km/hr.

B Raising the speed limit to 150 km/hr would not reduce congestion on motorways.

C A higher speed limit on motorways would encourage all drivers to drive faster.

D An increase in the speed limit would increase the existing danger from those drivers who drive too close.

E Congestion on motorways is caused by speeding drivers trying to pass those who observe the speed limit.

5 Food producers are resisting pressure to reduce still further the levels of salt in food. Although it is proven that salt intake must be reduced by those with hypertension, there is no evidence that reducing salt intake prevents hypertension. So why should we all be deprived of the pleasures of salt in food? We certainly need to identify those with hypertension and give them advice on their salt intake, but why should everyone else be deprived of salt? Food producers are right to resist the pressure.

Which one of the following best illustrates the principle underlying the argument above?

A Adding fluoride to drinking water has reduced tooth decay, but fluoride is unwelcome to some people. Instead, dentists should advise patients with tooth problems on better tooth care.

B The requirement to wear seatbelts has reduced deaths in car accidents but was unpopular when first introduced. People eventually accepted such changes even if it has not benefited them personally.

C Retailers cannot sell alcohol to people under 18 years, but providing more general advice on alcohol in schools would be better, as it would encourage young people to be self limiting in their consumption of alcohol.

D Advice to wear sun block to protect the skin from harmful rays is ignored by some people. Those people should be charged for medical treatment for skin cancer.

E Passive smoking is still a problem for people who share a home with a smoker. The law should be extended to make smoking illegal even in the home.

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6 Sports are played either as a means of getting exercise or as a competition with an opponent. Some sports, such as football, involve a large amount of running and some people are more motivated to run when it is part of a game. Other sports, such as pool, do not involve much physical activity and so it is unlikely that they would be played for the exercise.

Which one of the following conclusions is best supported by the passage above?

A People who play pool are more likely to be interested in the competition than those who play football.

B Since the main reason for playing sports is to get exercise, pool should not be classified as a sport.

C It is easier to exercise when it is as part of another activity, such as playing sport.

D Football is a better sporting activity than pool.

E There is no point in running as a hobby, since football is more fun.

7 Concern about the effects of chemicals upon the environment has led to calls for more research. But we should not wait for further research before we ban some of the chemicals used by industry. If anyone has a good reason to think something is harmful, it should not be used until, or unless, the risk is found to be zero. We know enough about past mistakes to be forewarned. Much of the harm to wildlife and humans is long-term, and the disturbing results we see today reflect the chemical environment 40 years ago. Thousands more chemicals have been released into the environment since then.

Which one of the following most closely matches the reasoning above?

A A suspected terrorist should be arrested at once. Waiting for conclusive evidence in the past has resulted in atrocities that could have been avoided by acting on suspicion, and the threat of terrorism has grown.

B People should not be able to adopt children until proper checks have been carried out. Serious consequences may follow if adoptive parents are unsuitable.

C Some homes for the elderly have been found to give dangerously substandard care. Therefore they should be closed down and the residents found acceptable alternatives.

D Some cars that have passed the annual roadworthiness test would not pass 6 months later. Cars should be tested more than once a year once they pass a certain age.

E Cyclists should not place too much confidence in the benefits of helmets, because there is no conclusive evidence as yet that helmets prevent serious injuries.

8 Children are being encouraged to take up gardening through special events at shows and activities in schools. It is hoped that an interest in gardening, and particularly growing one's own food, will make children more interested in learning about their food and they will therefore be deterred from eating junk food. The initiative should be supported and spread to more schools as quickly as possible.

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

A Most children have enjoyed the events provided, but have not gained an interest in gardening itself.

B The practical experience of gardening is not a traditional academic subject.

C It tends to be older people who are interested in gardening and growing their own food.

D Some schools do not have a garden.

E The events to encourage children to garden also included stands where junk food was for sale.

9 Although the Earth supports life, it has a mysterious carbon deficit. Compared with other bodies in the solar system the Earth has far less carbon than would be expected for a planet that supports life. Originally it was thought that in the inner region of the dust disc where the Earth formed, temperatures soared high enough for the carbon to boil away. However, observations of developing solar systems have now suggested that the temperature would not have been high enough. It is more likely that fire is to blame. Hot oxygen atoms would have readily combined with carbon, burning to produce carbon dioxide. There would have been fewer of these oxygen atoms further away from the Sun.

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

A The abundance of carbon in the asteroid belt surrounding the inner planets increases the further away you get from the Sun.

B There is no theoretical reason why life has to be carbon-based.

C At temperatures that are high enough for carbon to boil away, oxygen would also have boiled away.

D The carbon that is present on the Earth could have arrived at a later date from an asteroid.

E There are other solar systems with Earth-like planets that have an abundance of carbon on them.

10 Undercover police investigators sometimes commit 'crimes' in order to convince the 'real criminals' that they are on the same side as them. Some of these activities have victims, although in the main these are other criminals – rival gang members for example. In committing what are technically offences the officers are preventing many more serious crimes by helping to convict and imprison dangerous criminals who might otherwise remain at liberty. But that is not really the point. A breach of the law is a breach of the law, whoever commits it and for whatever reason. Preventing a crime does not make it right to commit another crime.

Which one of the following is the general principle underlying the above argument?

A The end does not justify the means.

B Serious crime must be prevented by any reasonable means.

C An act is criminal only if it is committed for criminal reasons.

D The police have a duty to protect law-abiding citizens from violence.

E There is no such thing as a victimless crime.

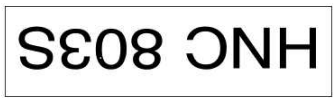
11 Looking in his rear-view mirror, Graham sensed that there was something wrong with the number plate of the car behind him. When the car overtook him and he saw its rear plate he realised that the front plate had been upside down.

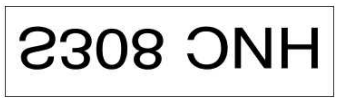


What had Graham seen in his rear-view mirror?

A


B


C


D


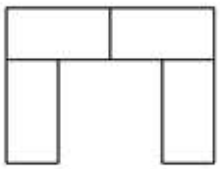
E


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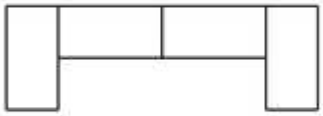
12 A local museum wishes to exhibit a collection of butterflies which is mounted in nine narrow (only 0.2 m wide) display cases, each 1.5 m long. The museum wants to arrange four tables, each 2 m long and 1 m wide, in such a way that all the display cases can be placed around the edges. The room for the exhibition is 6 m by 6 m and there must be at least 1 m of clear floor space around the outside of the tables.

Which one of the five arrangements shown would be satisfactory?

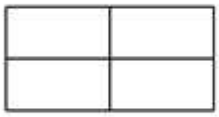
A



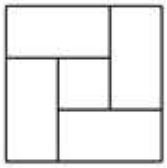
B



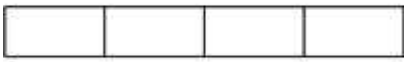
C



D



E



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13 Alberto has decided to paint his dining room. Paint comes in 1 litre cans. The paint in one can will cover an area of approximately 24 square metres. The dining room is 4 m x 6 m x 3.5 m high. There is just one window which is in one of the long walls and is 1.5 m x 2 m.

All of the walls, door and ceiling are to be painted with the same type of paint.

Approximately 20% of the wall area to be painted is wood which will need a second coat of paint.

What is the minimum number of cans of paint that Alberto should buy to have sufficient to complete the room?

A 5 cans

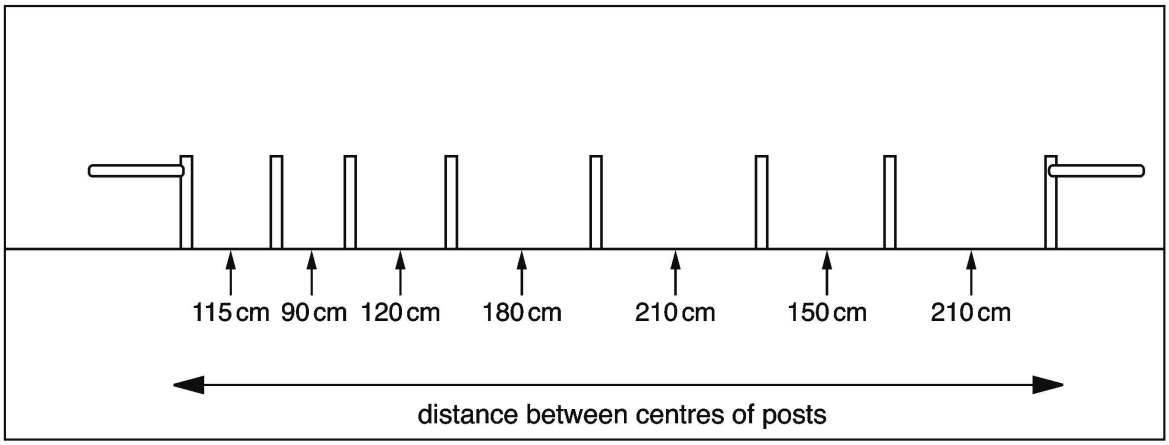
B 2 cans

C 3 cans

D 4 cans

E 6 cans

14 A farmer wishes to fix fencing rails to posts which are already in place. The posts are shown in the diagram. The farmer has a supply of rails, each one 2.4 m long. One rail or part of a rail is to be fixed between each pair of posts. (He can cut the rails into smaller lengths.)



What is the smallest number of rails that he could use?

A 5

B 3

C 4

D 6

E 7

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15 Tom is having a celebration and needs to send out 50 invitation cards. The cards must be at least 6 cm wide and at least 8 cm high and Tom wants to put a photo on the card. Each type of card has a standard version and a deluxe version. The prices (per card) that have been quoted to Tom are shown in the table below:

Width (cm)	*Height (cm)*	*Photo?*	*Personalised greeting?*	*Price (standard)*	*Price (deluxe)*
6	6	Y	N	€0.90	€1.65
6	10	N	Y	€1.00	€1.60
6	10	Y	Y	€1.75	€2.15
7	7	Y	N	€1.40	€1.90
7	10	Y	N	€1.50	€1.95
7	10	Y	Y	€1.60	€2.15
10	10	Y	N	€2.25	€2.95

Tom wants to buy the cheapest type of card possible but is willing to pay for the deluxe version instead of the standard.

What is the total extra that Tom would have to pay to buy the deluxe cards?

A €22.50

B €20.00

C €25.00

D €27.50

E €30.00

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16 The table below shows the average mass of the cerebellum, which is a part of the brain, and total body mass, for a number of animal species. The cerebellum of a cat has an average mass of 5.3 g, while a cat's average body mass is 3.5 kg.

Species	Cerebellum mass (g)	Body mass (g)
Mouse	0.09	58
Pigeon	0.4	500
Squirrel	1.5	350
Rabbit	1.9	1800
Dog	6.0	3500

For which of the species shown is the ratio of cerebellum to total body mass closest to that of the cat?

A Mouse

B Dog

C Pigeon

D Rabbit

E Squirrel

17 There are two services between Sandpoint and Genville: a fast hovercraft service which takes 50 minutes and a slow ferry which takes 1 hour 40 minutes. They both stop in port for 20 minutes at each end before starting the return journey. They start out from Sandpoint together at the same time each morning.

For how long has the slow ferry been sailing before it meets the hovercraft coming back? (Answer to the nearest minute if necessary.)

A 1 hour and 20 minutes

B 1 hour and 10 minutes

C 1 hour and 7 minutes

D 1 hour and 25 minutes

E 1 hour and 30 minutes

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18 Deanna keeps a record of the petrol she puts into her car and the current distance it has covered so she can estimate her fuel consumption. When she puts petrol in, sometimes the tank is filled completely and she marks 'FULL' beside the entry if this is so, otherwise the tank is only partly filled.

Her data for the last month is as follows:

Date	Total km	Fuel added	FULL?
2 June	23,508	5 litres	
6 June	23,805	37 litres	FULL
12 June	24,350	25 litres	
17 June	24,743	21 litres	
23 June	24,989	34 litres	FULL
27 June	25,454	18 litres	

Which one of the following is the best estimate of her fuel consumption?

A 6.8 litres / 100 km

B 1.7 litres / 100 km

C 7.7 litres / 100 km

D 8.0 litres / 100 km

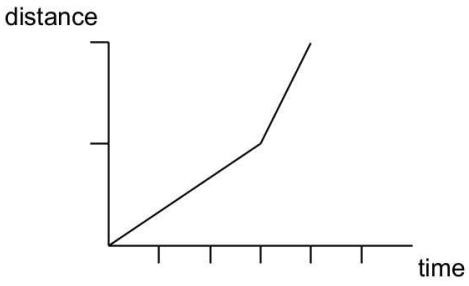
E 9.9 litres / 100 km

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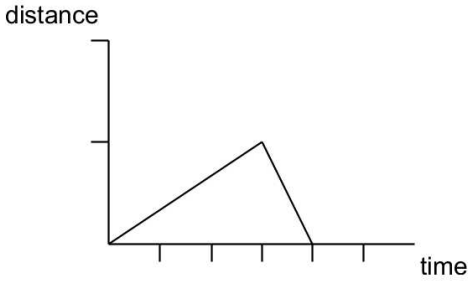
19 Leroy cycles to work each morning. The first half of his journey is uphill and he can manage only a steady 5 kilometres per hour. The second half, however, is downhill and he covers this at 15 kilometres per hour.

Which one of these graphs could show Leroy's journey?

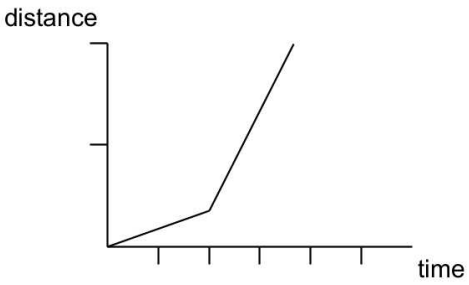
A



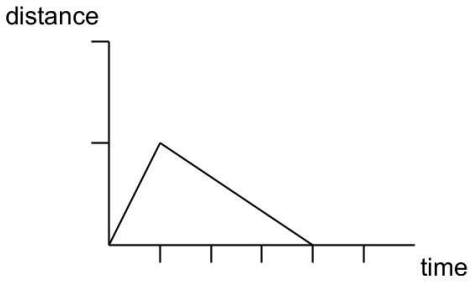
B



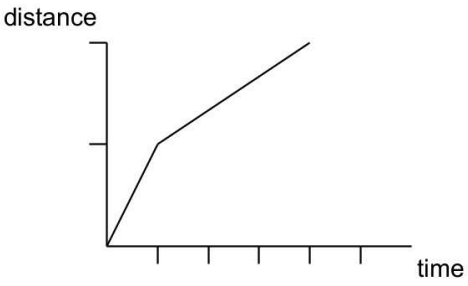
C



D



E



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20 When I made a hotel reservation online yesterday I was given an 8-digit booking reference which contained no zeros. It did, however, consist of three 2-digit odd numbers followed by the sum of these three numbers, and all eight digits were different.

The first digit of the booking reference was 4. What was the last digit?

A 7

B 1

C 3

D 5

E 9

21 Which one of the following pairs of scholar/field of study is NOT correct?

A Max Weber - Pedagogy

B Amartya Sen - Economics

C Ludwig Wittgenstein - Philosophy

D Konrad Lorenz - Ethology

E Doris Lessing - Literature

22 Which one of the following public figures was NOT awarded the Nobel Peace Prize?

A Mahatma Gandhi

B Willy Brandt

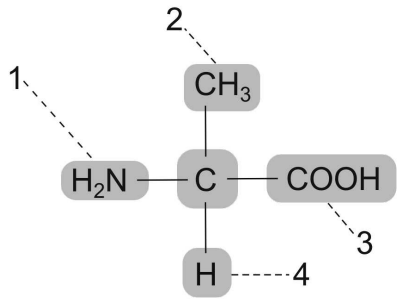
C Martin Luther King

D Nelson Mandela

E Aung San Suu Kyi

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23 The diagram below shows an amino acid.



Which option correctly identifies both the variable group (R group) and the acidic group?

A variable group = 2; acidic group = 3

B variable group = 1; acidic group = 2

C variable group = 4; acidic group = 3

D variable group = 3; acidic group = 1

E variable group = 2; acidic group = 4

24 In a prokaryote, transcription can occur in which of the following?

1. cytoplasm
2. mitochondria
3. ribosomes

A 1 only

B 2 only

C 3 only

D 1 and 2 only

E 1 and 3 only

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25 Which of the following are directly produced during photolysis of water?

1. oxygen
2. carbon dioxide
3. protons

A 1 and 3 only

B 1 and 2 only

C 2 and 3 only

D 1 only

E 2 only

26 The table shows some events of the normal eukaryotic cell cycle.

row 1	nuclear envelope disappears	DNA starts to condense	chromosomes line up at the equator	cytoplasm divides
row 2	chromosomes line up at the equator	spindle fibres shorten	DNA starts to condense	nuclear envelope reappears
row 3	chromosomes line up at the equator	spindle fibres shorten	nuclear envelope reappears	cytoplasm divides
row 4	DNA starts to condense	nuclear envelope disappears	spindle fibres shorten	chromosomes line up at the equator
row 5	nuclear envelope disappears	spindle fibres shorten	chromosomes line up at the equator	nuclear envelope reappears

Which row shows the correct sequence of events (left to right) as they occur during part of this cell cycle?

A row 3

B row 1

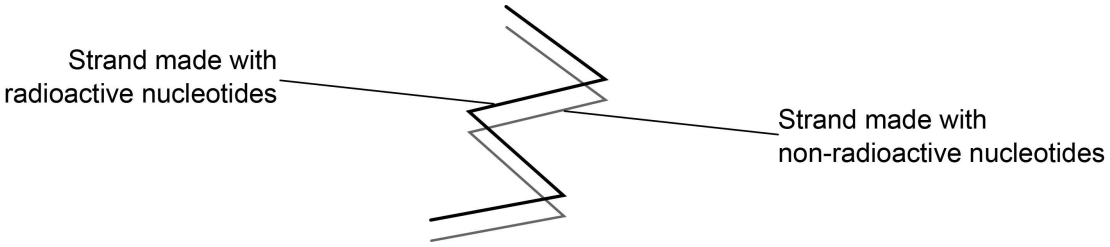
C row 2

D row 4

E row 5

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27 A double stranded DNA molecule is shown below:



This DNA molecule is allowed to replicate three times in a medium containing non-radioactive nucleotides .

Which answer shows the correct percentages of original DNA and completely non-radioactive DNA?

row	*Percentage original DNA*	*Percentage completely non-radioactive DNA*
1	12.5	87.5
2	25	75
3	50	50
4	87.5	12.5
5	75	25

[Assume all radioactive nucleotides remain radioactive throughout, and all non-radioactive nucleotides remain non-radioactive throughout].

A row 1

B row 2

C row 3

D row 4

E row 5

28 The genotype QqRr produces a certain phenotype. If two individuals with a genotype of QqRr reproduce, how many **different** possible phenotypes could be created, assuming all allele combinations are equally viable and the phenotypes are the result of complete dominance?

A 4

B 5

C 8

D 16

E 9

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29 A normal sequence of triplets in a section of DNA is given by: ATCGAACGG

The same section of DNA has been changed by mutation, and is given by: ATCTTGCGG

Some of the triplets below represent the tRNA triplets which code for amino acids.

Key:

triplet	amino acid	triplet	amino acid	triplet	amino acid
AUC	□	ATC	■	UAG	⊡
CAA	⊙	UUG	○	GAA	●
CGG	◇	GCC	◈	TTG	◆
AAC	▲	CUU	▽	ACC	△

Using the tRNA triplets, which amino acid sequence given below could be formed from the **mutated** DNA sequence?

A □–○–◇

B □–●–◇

C ■–●–◇

D ■–◆–◇

E ⊡–▲–◈

30 Which of the following could be the outcome of evolution?

1. speciation
2. a change in allele frequency
3. increased biodiversity

A 1, 2 and 3

B 1 and 2 only

C 2 and 3 only

D 1 and 3 only

E 1 only

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31 Where in a shoulder joint are osteocytes found?

A bone tissue

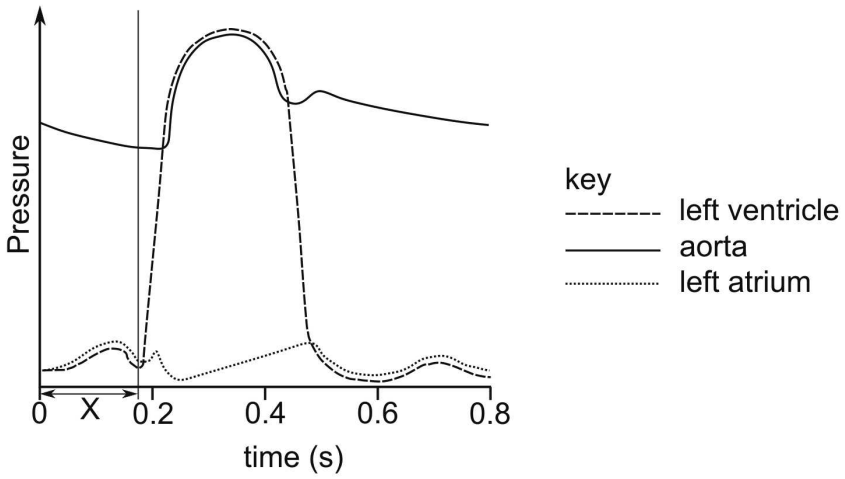
B muscle tissue

C skin

D ligament

E cartilage

32 The diagram shows how the pressure changes in the left atrium, left ventricle and the aorta during one heartbeat in a healthy human.



Which row shows the correct events during time period X?

row	*volume of blood in left atrium*	*semi-lunar valve in aorta*	*muscles of left ventricle wall*
1	decreases	closed	relax
2	decreases	open	relax
3	increases	closed	contract
4	decreases	open	contract
5	increases	closed	relax

A row 1

B row 2

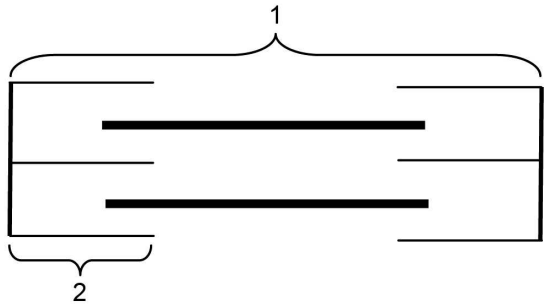
C row 3

D row 4

E row 5

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33 The diagram shows a single sarcomere in a relaxed state.



Which answer describes the changes when the sarcomere contracts?

A 1 gets smaller and 2 does not change.

B 1 gets smaller and 2 gets smaller.

C 1 gets longer and 2 gets wider.

D 1 gets longer and 2 gets smaller.

E 1 does not change and 2 gets wider.

34 Some local anaesthetics affect nervous impulse transmission by making it more difficult for voltage-gated sodium channels to open. In a human patient treated with these anaesthetics which of the following statements would be true?

A It would become harder to depolarise the neuron.

B The axon membrane would become more difficult to repolarise.

C The membrane potential of the neuron at rest would decrease below –90 mV.

D The sodium/potassium pump may need to work faster to maintain the resting potential.

E The threshold potential required to generate an action potential would be lowered.

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35 The changes in concentration of hormones in a healthy woman's blood were monitored during several menstrual cycles.

During which stage of the menstrual cycle was the concentration of oestrogen falling, the concentration of luteinising hormone (LH) and follicle-stimulating hormone (FSH) maximal and the progesterone concentration rising?

A four days before ovulation and the time of ovulation

B at the end of menstruation

C between the end of menstruation and four days before ovulation

D after ovulation but before the start of menstruation

E at the start of menstruation

36 The following events occur during a reflex response to a person placing a hand on a hot object.

1. Myosin binding sites on actin filaments uncovered.
2. ADP and phosphate ion released from myosin head.
3. Sodium voltage-gated channels open.
4. Myosin head detaches from binding site on actin.
5. Calcium ions released by sarcoplasmic reticulum.

Which of the following options places four of these events in the correct order (from left to right)?

A 5, 1, 2, 4

B 1, 2, 4, 3

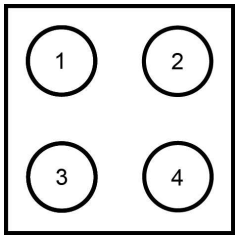
C 3, 1, 4, 2

D 3, 5, 4, 2

E 5, 2, 1, 4

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37 The picture below shows a DNA microarray. Each spot (labelled 1–4) contains a different DNA probe. A sample of fluorescently-labelled human DNA, with the sequence TGGTCAAGATTAT, is washed over the array.



spot	DNA probe
1	GATTAT
2	CTAATA
3	ACCAGT
4	TGGTCA

Which of the spots would show a positive signal because it fluoresces?

A 2 and 3 only

B 1 and 3 only

C 1 and 4 only

D 2 and 4 only

E 1, 2, 3 and 4

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38 In the nerve cells of a person, one gene has two alleles, 'A' and 'a', present. For this person, which row correctly shows the alleles present in all three different situations given in the table?

row	*Situation*		
	Stem cell starting to specialise into a liver cell	Cell at the start of mitosis	Cell at the start of meiosis I
1	Aa	AAaa	AAaa
2	AAaa	Aa	AAaa
3	AAaa	AAaa	Aa
4	Aa	Aa	A or a
5	A or a	A or a	Aa

A row 1

B row 2

C row 3

D row 4

E row 5

39 Place the following structures in a human sperm cell in descending order of size (left to right):

1. mitochondria
2. nucleus
3. ribosome

A 2, 1, 3

B 1, 2, 3

C 1, 3, 2

D 2, 3, 1

E 3, 1, 2

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40 Which one of the following is NOT a carbohydrate?

A glucagon

B maltose

C amylopectin

D ribose

E amylose

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41 What is the correct formula of propanal?

A CH_3CH_2CHO

B $CH_3CH_2CO_2H$

C $CH_3CH_2CH_2OH$

D $CH_3CH_2OCH_3$

E CH_3COCH_3

42 Which two of the following oxides would NOT give acidic solutions in water?

CO, CO_2, SO_2, NO

A CO and NO

B CO and CO_2

C CO and SO_2

D NO and CO_2

E NO and SO_2

43 Assume that the oxidation numbers are as shown below:

N = –3 H = +1 Cr = +6 O = –2

Which compound formula given below is correct?

A $(NH_4)_2CrO_4$

B $NH_4Cr_2O_7$

C $[\,(NH_4)_2CrO_4\,]^+$

D $(NH_4)_3CrO_4$

E $[\,(NH_4)_3CrO_4\,]^-$

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44 0.75 g of a hydrocarbon compound contains 0.60 g of carbon.

(A_r : C = 12.0; H = 1.0)

Which one of the following could be the molecular formula of the hydrocarbon compound?

A C_2H_6

B CH_4

C C_3H_8

D C_2H_4

E C_2H_3

45 The atomic number of aluminium is 13.

Which electron configuration given below corresponds to the Al^{2+} ion in its ground state?

A $ls^2 2s^2 2p^6 3s^1$

B $ls^2 2s^2 2p^5 3s^2$

C $ls^2 2s^2 2p^6 3s^2 3p^1$

D $ls^2 2s^2 2p^6 3s^2 3p^3$

E $ls^2 2s^2 2p^6$

46 When propan-1-ol is burnt in excess oxygen the only products formed are carbon dioxide and water.

In the balanced equation for this reaction what is the ratio of CO_2 : H_2O molecules formed?

A 3 : 4

B 3 : 8

C 4 : 7

D 5 : 12

E 2 : 7

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47 2,2 – dimethylpropane, $C(CH_3)_4$, is an isomer of pentane, $CH_3(CH_2)_3CH_3$.

Pentane has a boiling point of 36 °C whilst the boiling point of 2,2 – dimethylpropane is 10 °C.

Which statement below explains the difference in the boiling points for these two substances?

A Longer chain, less branched molecules have stronger spontaneous/induced dipoles.

B The molecules have different relative molecular masses.

C Isomers have different chemical properties.

D 2,2 – dimethylpropane has stronger intermolecular forces.

E Pentane has permanent dipoles.

48 Potassium nitrate was found to have a solubility of 120 g in 100 g of water at 80 °C and 50 g in 100 g of water at 25 °C.

50 g of water was heated to 80 °C and solid potassium nitrate added until the solution was just saturated.

The solution was then cooled to 25 °C when solid potassium nitrate separated out to leave a saturated solution.

Using the information provided in this question, what is the minimum mass of water that must now be added to the mixture of the solution and the solid in order to make this solid potassium nitrate redissolve at 25 °C?

A 70 g

B 20 g

C 120 g

D 140 g

E 190 g

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49 Pure water self-ionises. This endothermic reaction is represented by the equation:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

Which of the following statements is true for pure water between the temperatures of 0 °C and 100 °C?

1. The concentrations of H^+(aq) and OH^-(aq) are equal between 0 °C and 100 °C.
2. An increase in temperature causes the pH to fall.
3. An increase in temperature causes the electrical conductivity to decrease.

A 1 and 2 only

B 1 only

C 2 only

D 3 only

E 1 and 3 only

50 Which one of the following 0.01 M aqueous solutions has a pH > 7.0?

A Na_2CO_3

B $AlBr_3$

C NH_4Cl

D NaI

E CH_3CO_2H

51 Atoms X and Y form an **ionic** compound with formula XY_2.

Which option below could give the correct atomic numbers for X and Y?

A X = 12; Y = 9

B X = 3; Y = 17

C X = 6; Y = 16

D X = 11; Y = 16

E X = 14; Y = 8

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52 In the reaction

$$C_3H_7Br + KOH \rightarrow C_3H_7OH + KBr$$

24.6 g of 1-bromopropane reacts with excess potassium hydroxide to produce 8.00 g of propan-1-ol.

M_r : C_3H_7Br = 123

A_r : H = 1.0; C = 12.0; O = 16.0

What is the percentage yield of this reaction?

A 66.7%

B 32.5%

C 33.3%

D 57.1%

E 93.0%

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53 The variables x and y satisfy the following two equations:

$x + 3y = 13$

$2x - y = 5$

What is the value of $x + y$?

A 7

B 6

C 8

D 9

E 10

54 Evaluate:

$(27^2 - 23^2) + (14^2 - 6^2)$

A 360

B 80

C 40

D 840

E 1680

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55 Given that $2 \log_{10}(x) - 3 = \log_{10}(y)$

Express y in terms of x.

A $y = \frac{x^2}{1000}$

B $y = \frac{2x}{1000}$

C $y = \frac{2x}{3}$

D $y = \frac{x^2}{3}$

E $y = x^2 - 3$

56 The arithmetic mean of the three numbers a, b, c is 8.

Find the arithmetic mean of the four numbers: $a + 1$, $b + 2$, $c + 6$, 3.

A 9

B 7

C 5

D 11

E 27

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57 An aluminium block of mass 2.5 kg is supplied with 9000 J of thermal energy. This causes its temperature to rise by 4 K. Which expression gives the specific heat capacity of this aluminium, from this data?

[Assume that the block remains solid throughout, and that no additional energy is exchanged between the block and the surroundings.]

A $\frac{9000}{2.5 \times 4}\ \mathrm{J\,kg^{-1}K^{-1}}$

B $9000 \times 2.5 \times 4\ \mathrm{J\,kg^{-1}K^{-1}}$

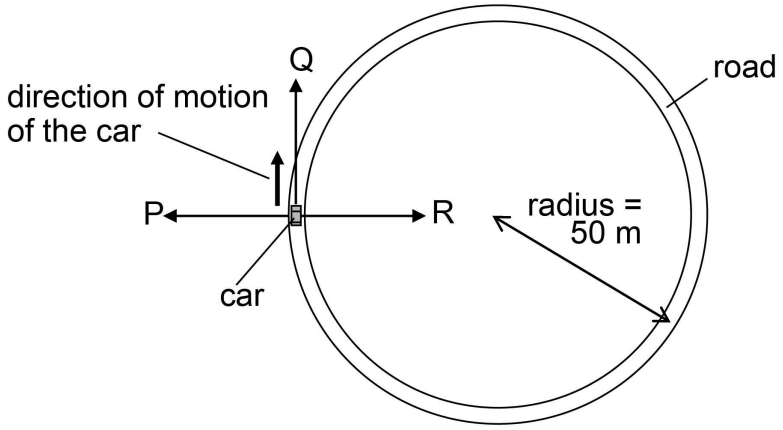
C $\frac{2.5 \times 4}{9000}\ \mathrm{J\,kg^{-1}K^{-1}}$

D $\frac{9000 \times 2.5}{4}\ \mathrm{J\,kg^{-1}K^{-1}}$

E $\frac{9000 \times 4}{2.5}\ \mathrm{J\,kg^{-1}K^{-1}}$

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58 The diagram shows a car of mass 1000 kg travelling at a constant speed of 30 m/s in the direction shown along a flat, level road which forms a circle of radius 50 m.



Which row in the table gives both the magnitude of the resultant force on the car and the direction of the acceleration of the car at the instant shown?

row	*magnitude of resultant force (kN)*	*direction of acceleration*
1	0	R
2	18	Q
3	18	R
4	30	Q
5	30	P

A row 3

B row 2

C row 1

D row 4

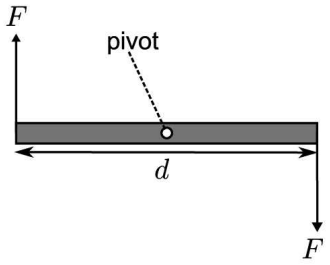
E row 5

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59 Two forces F of equal magnitude act on a beam. Which diagram shows a couple acting and states the magnitude of the torque (moment) of the couple about the pivot?

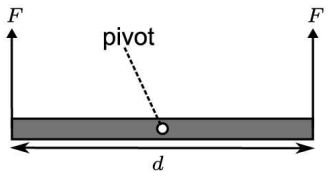
[The pivot is at the centre of the beam]

A



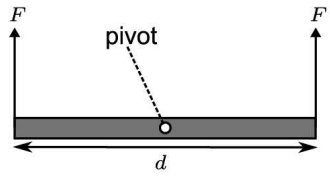
torque $= (F \times d)$

B



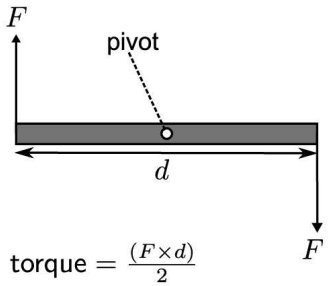
torque $= \frac{(F \times d)}{2}$

C



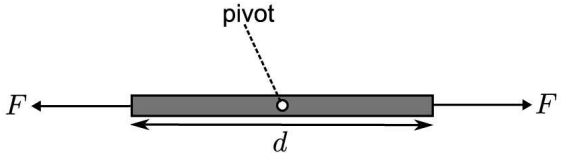
torque $= (F \times d)$

D



torque $= \frac{(F \times d)}{2}$

E



torque $= (F \times d)$

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60 Which one of the following equations is dimensionally consistent (has consistent units)?

[All the symbols have their usual meanings:

v = velocity; F = force; m = mass; t = time; V = voltage; Q = charge; R_1, R_2, R_3, R_4 = resistance]

A electrical current = $(V/R_1) + (Q/t)$

B acceleration = $(\frac{1}{2}vt^2) + (F/m)$

C energy = $(\frac{1}{2}mv^2) + Fv$

D resistance = $R_1 + R_2 + (1/R_3) + (1/R_4)$

E temperature change = energy × m × specific heat capacity

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ANSWERS AND EXPLAINED SOLUTIONS

The letters are those of the official paper above.

1 **Studies are taking place to assess the benefits to dental health of adding fluoride to drinking water, a process known as mass medication. The Health Minister has urged consideration of fluoridation, particularly in deprived areas where dental care is poor. Fluoride can occur naturally in the water because of fluoride containing minerals. Fluoride, if in the water, improves dental health by up to 50 percent. Even so, fluoridation should not take place. A campaign leader opposed to fluoridation has spoken of her experiences of living in a fluoridated area of the USA. She experienced feelings of apathy and depression; her 2 years old son showed autistic tendencies and had white flecks on his teeth. These symptoms disappeared when they returned home from the USA.**

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

Correct answer: A · The reported health symptoms were caused by fluoride in the water.

The argument opposes water fluoridation based on reported health issues during residence in a fluoridated region. For this observation to justify rejecting the practice, the reasoning must assume a direct **causal link** between the treated water and those symptoms. If the water did not cause the problems, the anecdotal evidence cannot support the final **conclusion**.

Why the other answers are wrong

- **B) Mass medication is always wrong.**: The opposition targets only water fluoridation rather than all medical interventions. The logic does not require a blanket rejection of every mass medication method.
- **C) Fluoridation is cheaper than improving dental facilities.**: The argument contains no discussion regarding the financial aspects of public health policies. Cost comparisons are completely absent from the provided reasoning.
- **D) Fluoridation is only necessary in deprived areas.**: Deprived areas are highlighted as priority zones due to poor dental care access. The argument never restricts potential fluoridation exclusively to these locations.
- **E) Fluoridation of water is a person's only source of fluoride.**: Fluoride exposure can occur through multiple pathways beyond drinking water. The validity of the stance does not rely on water being the exclusive source.

2 **Climate scientists in Greenland studying patterns of plant growth have suggested that the early arrival of spring in the Arctic threatens to drive down populations of migrating animals such as caribou. However, comparable studies elsewhere show that their fears are unfounded. A recent study of great tits in Oxfordshire showed the birds are capable of adapting to climate change better than many scientists expected. Over the past half century, the birds have brought forward the date they lay their eggs by two weeks, so that young are born when plant eating grubs are most plentiful.**

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

Correct answer: A · Migrating animals in the Arctic can adapt to climate change as successfully as great tits in Oxfordshire.

The argument claims that fears of caribou decline in Greenland are unfounded based on great tits adjusting their breeding season in Oxfordshire. This conclusion relies on migrating Arctic animals possessing a **capacity to adapt** their life cycles to shifting conditions. Without **similar behavioral flexibility**, the avian example cannot logically support the claim that caribou will also maintain stable populations.

Why the other answers are wrong

- **B) Birds are more adaptable than large mammals such as caribou.**: If small birds consistently exceeded large mammals in plasticity, the tit data would actually weaken the argument for caribou recovery. Proven adaptation in one group does not guarantee parallel results in another without assuming equivalent adaptability.
- **C) Climate change in Greenland and climate change in Oxfordshire are of the same scale.**: The comparison requires matched biological resilience rather than identical warming intensity. Geographic variations in temperature trends do not undermine the cross-species inference.
- **D) The scientists working in Oxfordshire have greater expertise than those working in Greenland.**: The proof depends on documented **reproductive shifts** rather than academic backgrounds. Researcher qualifications do not establish biological feasibility in this context.
- **E) Unless animals like the caribou produce their young earlier in the year, their population will fall.**: The text does not treat advanced birth timing as the only possible survival route. Caribou could preserve their numbers through different ecological mechanisms.

3 **Now, it might be thought an amazing coincidence if Earth were the only planet in the galaxy on which intelligent life evolved. If it happened here, the one planet we have studied closely, surely one would expect it to have happened on a lot of other planets in the galaxy – planets we have not yet had the chance to examine. This objection, however, rests on a fallacy: it overlooks what is known as an 'observation selection effect', so it wouldn't be such a coincidence. Whether intelligent life is common or rare, every observer is guaranteed to originate from a place where intelligent life did, in fact, arise. Since only the successes give rise to observers who can wonder about their existence, it would be a mistake to regard our planet as a randomly selected sample from all planets.**

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

Correct answer: A · There would be no amazing coincidence if we discovered that Earth were the only planet in the galaxy on which intelligent life evolved.

The argument states that **only successful evolution produces** observers. Because this **guarantees our origin** regardless of frequency, we cannot treat Earth as a random sample. Therefore, Earth being the sole host of intelligent life would not constitute an **amazing coincidence**.

Why the other answers are wrong

- **B) If life had evolved here on Earth, it would probably have happened on a lot of other planets in the galaxy.**: This repeats the initial presumption the author challenges and considers flawed based on the observation selection effect.
- **C) It would be an amazing coincidence if Earth were the only planet in the galaxy on which intelligent life evolved.**: This expresses the intuitive counterargument that the passage explicitly identifies as a fallacy and dismisses.
- **D) Our planet is not a randomly selected sample from all planets.**: This explains why Earth is not a random sample and prevents using our existence to infer that intelligent life is common. It functions as evidence for the main conclusion.
- **E) However common intelligent life is, every observer will certainly originate from a place where intelligent life did, in fact, arise.**: This statement is a premise that supports the main conclusion rather than being the conclusion itself. It establishes a necessary condition for observation.

4 **Although it is sometimes suggested that the congestion caused by the bunching of cars on motorways could be eased by increasing the speed limit to 150 km/hr, such an increase would not be a good thing. An estimated 35 per cent of drivers exceed the speed limit by 20 km/hr and would continue to do so if the limit were raised. Since bunching is caused by speeding drivers trying to pass those who observe the speed limit, raising the limit to 150 km/hr would result in the same amount of congestion, but at an increased speed. Moreover, a higher speed limit would encourage all drivers to drive faster, and thus would increase the existing danger from those who drive too close to the car in front.**

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

Correct answer: A · It would not be a good thing to increase the speed limit to 150 km/hr.

The argument **explicitly states** that raising the limit **would not be a good thing**. This sentence functions as the **main conclusion** because every following statement supports it. The author argues that traffic volume stays high and collision risks rise if the policy changes.

Why the other answers are wrong

- **B) Raising the speed limit to 150 km/hr would not reduce congestion on motorways.**: Drivers who already speed by twenty kilometres per hour will simply match the new limit, leaving traffic patterns unchanged. This observation explains why the proposed change fails but serves as a supporting detail rather than the primary claim.
- **C) A higher speed limit on motorways would encourage all drivers to drive faster.**: All motorists would likely accelerate under a stricter regime, compounding close-following hazards. This point supplies further justification for the risk assessment while remaining subordinate to the core verdict.
- **D) An increase in the speed limit would increase the existing danger from those drivers who drive too close.**: Faster driving speeds amplify the threat posed by tailgaters when limits are raised. This safety warning strengthens the overall stance against the policy without replacing the central thesis.
- **E) Congestion on motorways is caused by speeding drivers trying to pass those who observe the speed limit.**: Vehicles attempting to overtake rule-following motorists create the characteristic car bunching on highways. This background fact clarifies the mechanics of traffic flow instead of delivering the final recommendation.

5 **Food producers are resisting pressure to reduce still further the levels of salt in food. Although it is proven that salt intake must be reduced by those with hypertension, there is no evidence that reducing salt intake prevents hypertension. So why should we all be deprived of the pleasures of salt in food? We certainly need to identify those with hypertension and give them advice on their salt intake, but why should everyone else be deprived of salt? Food producers are right to resist the pressure.**

Which one of the following best illustrates the principle underlying the argument above?

Correct answer: A · Adding fluoride to drinking water has reduced tooth decay, but fluoride is unwelcome to some people. Instead, dentists should advise patients with tooth problems on better tooth care.

The argument establishes that **targeted medical advice** should replace **universal restrictions** when preventive evidence remains insufficient. Option E mirrors this logic by supporting **individualized dental care** over mandatory water supplementation.

Why the other answers are wrong

- **B) The requirement to wear seatbelts has reduced deaths in car accidents but was unpopular when first introduced. People eventually accepted such changes even if it has not benefited them personally.**: Supports accepting a general safety measure for public benefit, whereas the passage explicitly resists imposing it universally.
- **C) Retailers cannot sell alcohol to people under 18 years, but providing more general advice on alcohol in schools would be better, as it would encourage young people to be self limiting in their consumption of alcohol.**: Favors broader preventive advice in educational settings rather than clinical guidance targeted at people with an identified condition.
- **D) Advice to wear sun block to protect the skin from harmful rays is ignored by some people. Those people should be charged for medical treatment for skin cancer.**: Concerns the financial consequences of ignoring health advice, not whether a public policy should apply to the entire population.
- **E) Passive smoking is still a problem for people who share a home with a smoker. The law should be extended to make smoking illegal even in the home.**: Proposes extending existing restrictions into private homes, representing the direct opposite of resisting an unnecessary general limitation.

6 **Sports are played either as a means of getting exercise or as a competition with an opponent. Some sports, such as football, involve a large amount of running and some people are more motivated to run when it is part of a game. Other sports, such as pool, do not involve much physical activity and so it is unlikely that they would be played for the exercise.**

Which one of the following conclusions is best supported by the passage above?

Correct answer: A · People who play pool are more likely to be interested in the competition than those who play football.

The passage outlines **two motivations** for athletic participation: fitness and rivalry. Games like pool demand minimal **physical exertion**, making health goals improbable. Since rivalry remains the stated alternative, players focus on strategy and winning. Football requires sustained movement and serves dual purposes. This supports the inference that pool participants prioritize competition significantly more than runners do.

Why the other answers are wrong

- **B) Since the main reason for playing sports is to get exercise, pool should not be classified as a sport.**: Premises establish fitness and rivalry as **parallel objectives**, contradicting claims of dominance, and provide no classification criteria.
- **C) It is easier to exercise when it is as part of another activity, such as playing sport.**: Authors highlight increased **motivation** during gameplay but draw no conclusions about reduced difficulty in fitness routines.
- **D) Football is a better sporting activity than pool.**: The text maintains a descriptive tone without evaluating relative value or declaring superiority.
- **E) There is no point in running as a hobby, since football is more fun.**: Writers never assess personal hobby viability or compare entertainment factors across disciplines.

7 **Concern about the effects of chemicals upon the environment has led to calls for more research. But we should not wait for further research before we ban some of the chemicals used by industry. If anyone has a good reason to think something is harmful, it should not be used until, or unless, the risk is found to be zero. We know enough about past mistakes to be forewarned. Much of the harm to wildlife and humans is long term, and the disturbing results we see today reflect the chemical environment 40 years ago. Thousands more chemicals have been released into the environment since then.**

Which one of the following most closely matches the reasoning above?

Correct answer: A · A suspected terrorist should be arrested at once. Waiting for conclusive evidence in the past has resulted in atrocities that could have been avoided by acting on suspicion, and the threat of terrorism has grown.

We should take action based on a **reasonable suspicion** of harm instead of waiting for **conclusive evidence**. Historical delays caused severe **long-term damage** to ecosystems and human health. The overall threat has also **grown** considerably since those past mistakes occurred.

Why the other answers are wrong

- **B) People should not be able to adopt children until proper checks have been carried out. Serious consequences may follow if adoptive parents are unsuitable.**: This insists on completing background verification before authorizing adoptions. It opposes the core premise by demanding full confirmation prior to any decision instead of acting on present concerns.
- **C) Some homes for the elderly have been found to give dangerously substandard care. Therefore they should be closed down and the residents found acceptable alternatives.**: This supports closing facilities only after documented deficiencies are proven. It misses the intended logic because it rejects early intervention while threats remain unconfirmed.
- **D) Some cars that have passed the annual roadworthiness test would not pass 6 months later. Cars should be tested more than once a year once they pass a certain age.**: This recommends increasing test frequency rather than intervening immediately on suspicion. It does not support taking preventive measures before additional evidence is collected.
- **E) Cyclists should not place too much confidence in the benefits of helmets, because there is no conclusive evidence as yet that helmets prevent serious injuries.**: This advises limiting trust in a possible benefit rather than opposing an established practice. It does not advocate restricting a tool due to potential risks.

8 **Children are being encouraged to take up gardening through special events at shows and activities in schools. It is hoped that an interest in gardening, and particularly growing one's own food, will make children more interested in learning about their food and they will therefore be deterred from eating junk food. The initiative should be supported and spread to more schools as quickly as possible.**

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

Correct answer: A · Most children have enjoyed the events provided, but have not gained an interest in gardening itself.

The argument assumes that school events will actually **generate interest** in gardening among children. If participants enjoy the activities but do not develop a lasting hobby, they will not seek knowledge about food sources or abandon junk food. The entire chain of **cause and effect** collapses without this initial shift in attitude.

Why the other answers are wrong

- **B) The practical experience of gardening is not a traditional academic subject.**: Gardening is not classified as a core academic discipline. This classification does not prevent students from gaining practical skills or influencing **dietary preferences** through hands-on experiences.
- **C) It tends to be older people who are interested in gardening and growing their own food.**: Demographic trends show higher engagement among adults. Statistical patterns regarding age groups prove nothing about the potential success of youth-focused interventions.
- **D) Some schools do not have a garden.**: Physical facilities are lacking in certain locations. Infrastructure gaps might slow program expansion but do not invalidate the intended behavioral impact on enrolled participants.
- **E) The events to encourage children to garden also included stands where junk food was for sale.**: Commercial vendors operated alongside educational booths. Offering tempting snacks during demonstrations creates momentary confusion but does not erase the long-term educational value of cultivating crops.

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9 **Although the Earth supports life, it has a mysterious carbon deficit. Compared with other bodies in the solar system the Earth has far less carbon than would be expected for a planet that supports life. Originally it was thought that in the inner region of the dust disc where the Earth formed, temperatures soared high enough for the carbon to boil away. However, observations of developing solar systems have now suggested that the temperature would not have been high enough. It is more likely that fire is to blame. Hot oxygen atoms would have readily combined with carbon, burning to produce carbon dioxide. There would have been fewer of these oxygen atoms further away from the Sun.**

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

Correct answer: A · The abundance of carbon in the asteroid belt surrounding the inner planets increases the further away you get from the Sun.

The argument suggests that **high oxygen** combined with carbon near the Sun. **Scarcer atoms** remained at greater distances. An increasing **carbon concentration** moving outward matches this predicted pattern.

Why the other answers are wrong

- **B) There is no theoretical reason why life has to be carbon based.**: The lack of biological necessity does not clarify the planetary shortage.
- **C) At temperatures that are high enough for carbon to boil away, oxygen would also have boiled away.**: This weakens the previous temperature theory without proving how oxygen removed the carbon.
- **D) The carbon that is present on the Earth could have arrived at a later date from an asteroid.**: This addresses the later arrival of existing carbon rather than explaining the initial deficit.
- **E) There are other solar systems with Earth like planets that have an abundance of carbon on them.**: Unknown formation locations and oxygen levels prevent this from supporting the proposed mechanism.

10 **Undercover police investigators sometimes commit 'crimes' in order to convince the 'real criminals' that they are on the same side as them. Some of these activities have victims, although in the main these are other criminals – rival gang members for example. In committing what are technically offences the officers are preventing many more serious crimes by helping to convict and imprison dangerous criminals who might otherwise remain at liberty. But that is not really the point. A breach of the law is a breach of the law, whoever commits it and for whatever reason. Preventing a crime does not make it right to commit another crime.**

Which one of the following is the general principle underlying the above argument?

Correct answer: A · The end does not justify the means.

The argument's principle is that a **good outcome** does not justify **unlawful means**. Preventing more serious crimes does not make it right for officers to commit other offences.

Why the other answers are wrong

- **B) Serious crime must be prevented by any reasonable means.**: The argument rejects committing crimes as a means of preventing other crimes, even when the crimes being prevented are more serious.
- **C) An act is criminal only if it is committed for criminal reasons.**: The passage says a breach of the law remains a breach regardless of the offender's reason. The officers' motives therefore do not make their acts non-criminal.
- **D) The police have a duty to protect law abiding citizens from violence.**: Protecting law-abiding citizens from violence is not the principle used to judge the officers' actions.
- **E) There is no such thing as a victimless crime.**: The passage mentions that some of the officers' activities have victims, often other criminals such as rival gang members. It does not claim that every crime has a victim.

11 **Looking in his rear view mirror, Graham sensed that there was something wrong with the number plate of the car behind him. When the car overtook him and he saw its rear plate he realised that the front plate had been upside down.**

What had Graham seen in his rear view mirror?



Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx8w8wi1ixi1w82626hcncnc.png?alt=media&token=4644f636-50bf-4760-97df-d149ae3ba42f<i>

The car's actual rear plate was CNH 803S. The front plate was **upside down**, and Graham saw it in a mirror. Rotating the plate by 180° and then reflecting it produces S308 CNH, as shown in A.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx1di21iiwdi333n444.png?alt=media&token=7fceb880-d86a-40d9-a1d3-7423290954ea<i>**: Whatever letters and numbers the image shows, rotating it by 180° and then reflecting it in a mirror does not yield CNH 803S. These transformations do not produce any other valid UK-style plate either.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1ex2121m12j21u2727.png?alt=media&token=a99121c3-b434-4624-9bd8-4a78b3ed9ad3<i>**: Rotating this image by 180° and then viewing it in a mirror produces garbled characters, not a recognisable UK number plate, and certainly not CNH 803S.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx2e18e1281x8281dkdkkdfkdd.png?alt=media&token=23d3fe58-3f09-47c7-b140-3f00bf163437<i>**: The mixture of letters and numbers in this image does not map to CNH 803S when turned upside down and mirror-reflected. It does not produce any valid plate either.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx21ee2i12i8s7f77ffhhg.png?alt=media&token=cab0d8c1-b058-4c23-a6b8-e735f3e7f7d5<i>**: Inverting and mirroring this image produces invalid or mismatched characters, not the genuine rear plate CNH 803S.

12 **A local museum wishes to exhibit a collection of butterflies which is mounted in nine narrow (only 0.2 m wide) display cases, each 1.5 m long. The museum wants to arrange four tables, each 2 m long and 1 m wide, in such a way that all the display cases can be placed around the edges. The room for the exhibition is 6 m by 6 m and there must be at least 1 m of clear floor space around the outside of the tables.**

Which one of the five arrangements shown would be satisfactory?

Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fxode2o1ox1o1x2o2122.png?alt=media&token=525fce21-9ed6-49e1-91ca-7933ad3d0508<i>

The nine display cases need a total of $9 \times 1.5 = 13.5\ \mathrm{m}$ of edge length. The tables must fit within a $4\ \mathrm{m} \times 4\ \mathrm{m}$ footprint to leave at least $1\ \mathrm{m}$ of clear space around them in the $6\ \mathrm{m} \times 6\ \mathrm{m}$ room. Only arrangement C satisfies both conditions.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fdwuddjdjddjjdj2j2.png?alt=media&token=db308e9e-3fe4-43ac-8af9-d512aa162441<i>**: This arrangement does not provide enough usable edge length for all nine cases while also meeting the required clearance.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fe12i2eie21i1e2ixxxxxxx2.png?alt=media&token=baa57858-44a9-46f6-9a84-325a5ca5f1e3<i>**: This arrangement fails at least one of the two constraints: the tables do not fit within the available footprint, or there is not enough usable edge length for all nine cases.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2ei12ie2ie282xnmmc.png?alt=media&token=df07d8bb-2aa9-448e-9c49-afeb61b060eb<i>**: This arrangement does not provide enough usable edge length for all nine cases while also meeting the required clearance.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F128ex12ixk27367363y43.png?alt=media&token=35b6c7de-b53d-47cf-be03-b8964555fc22<i>**: This arrangement fails at least one of the two constraints: the tables do not fit within the available footprint, or there is not enough usable edge length for all nine cases.

13 **Alberto has decided to paint his dining room. Paint comes in 1 litre cans. The paint in one can will cover an area of approximately 24 square metres. The dining room is 4 m x 6 m x 3.5 m high. There is just one window which is in one of the long walls and is 1.5 m x 2 m.**

All of the walls, door and ceiling are to be painted with the same type of paint.

Approximately 20% of the wall area to be painted is wood which will need a second coat of paint.

What is the minimum number of cans of paint that Alberto should buy to have sufficient to complete the room?

Correct answer: A · 5 cans

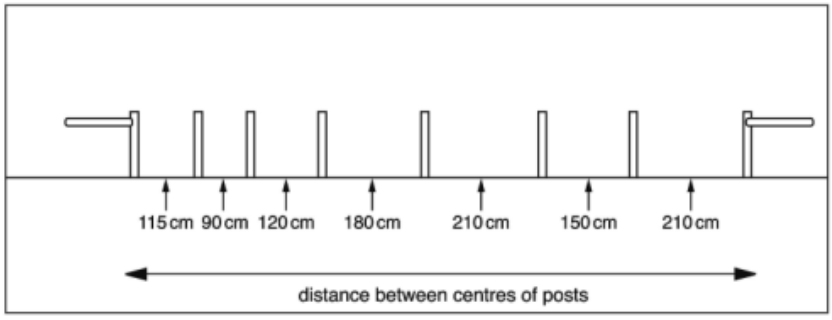
1. The four walls have area $2(4 \times 3.5) + 2(6 \times 3.5) = 70\ \text{m}^2$. Subtracting the $3\ \text{m}^2$ window gives a **wall area** of $67\ \text{m}^2$ to paint. The ceiling adds $4 \times 6 = 24\ \text{m}^2$, so the **first coat** covers $91\ \text{m}^2$. 2. The wood needs a second coat over $0.20 \times 67 = 13.4\ \text{m}^2$. The total coverage needed is $91 + 13.4 = 104.4\ \text{m}^2$. 3. At $24\ \text{m}^2$ per can, $104.4 \div 24 \approx 4.35$, so Alberto must **round up** and buy 5 cans.

Why the other answers are wrong

- **B) 2 cans**: Two cans cover $2 \times 24 = 48\ \text{m}^2$, less than half the area that needs painting.
- **C) 3 cans**: Three cans cover $3 \times 24 = 72\ \text{m}^2$, which is still far short of the required $104.4\ \text{m}^2$.
- **D) 4 cans**: Four cans cover $4 \times 24 = 96\ \text{m}^2$, which is closer but still not enough for the required $104.4\ \text{m}^2$.
- **E) 6 cans**: Six cans cover $6 \times 24 = 144\ \text{m}^2$, which is sufficient but more than the minimum, so it would mean unnecessary extra cost.

14 **A farmer wishes to fix fencing rails to posts which are already in place. The posts are shown in the diagram. The farmer has a supply of rails, each one 2.4 m long. One rail or part of a rail is to be fixed between each pair of posts. (He can cut the rails into smaller lengths.)**

What is the smallest number of rails that he could use?



Correct answer: A · 5

1. Convert the measurements: available rails are $\mathbf{240}$ cm long and the gaps measure 210, 210, 180, 150, 120, 115, and 90 cm. 2. This creates a **bin-packing** scenario where each supply holds pieces summing to at most the limit. 3. The three largest gaps cannot share a rail with any other segment, as adding even the shortest piece exceeds $\mathbf{240}$ cm. 4. The remaining four segments pair efficiently: $150 + 90 = 240$ cm and $120 + 115 = 235$ cm, each fitting on one rail. 5. Combining three dedicated rails with two paired rails reaches the minimum of **five**.

Why the other answers are wrong

- **B) 3**: Three rails cannot cover seven segments, and the three largest gaps each require a separate rail since they exceed the capacity when combined with any other piece.
- **C) 4**: Four rails remain insufficient because the three isolated large gaps already consume three supplies, leaving only one rail for the remaining four segments which do not fit together.
- **D) 6**: Six rails functionally work but fail to achieve the minimum, as the layout can be optimized to pack all segments into fewer supplies.
- **E) 7**: Seven rails simply assign one unit per gap, ignoring the possibility of cutting longer supplies to join multiple segments into shared units.

15 **Tom is having a celebration and needs to send out 50 invitation cards. The cards must be at least 6 cm wide and at least 8 cm high and Tom wants to put a photo on the card. Each type of card has a standard version and a deluxe version. The prices (per card) that have been quoted to Tom are shown in the table below:**

Tom wants to buy the cheapest type of card possible but is willing to pay for the deluxe version instead of the standard.

What is the total extra that Tom would have to pay to buy the deluxe cards?

Width (cm)	*Height (cm)*	*Photo?*	*Personalised greeting?*	*Price (standard)*	*Price (deluxe)*
6	6	Y	N	€0.90	€1.65
6	10	N	Y	€1.00	€1.60
6	10	Y	Y	€1.75	€2.15
7	7	Y	N	€1.40	€1.90
7	10	Y	N	€1.50	€1.95
7	10	Y	Y	€1.60	€2.15
10	10	Y	N	€2.25	€2.95

Correct answer: A · € 22.50

Filtering the catalog for width ≥ $6\ \text{cm}$, height ≥ $8\ \text{cm}$, and photo inclusion leaves four viable candidates. The cheapest **standard** tier costs $€1.50$ for the $7 \times 10\ \text{cm}$ photo card without greetings. Upgrading to **deluxe** raises the price to $€1.95$, creating a per-unit **surplus** of $€0.45$. Multiplying this margin by the required 50 cards yields a total extra cost of $€22.50$.

Why the other answers are wrong

- **B) € 20.00**: This figure assumes the premium is calculated on the $6 \times 10\ \text{cm}$ photo card. The difference between its deluxe price ($€2.15$) and standard price ($€1.75$) equals $€0.40$. Scaling this to 50 cards produces $€20.00$, but this base card costs more than the minimum selected option.
- **C) € 25.00**: No eligible card generates a price **gap** of $€0.50$ between tiers. Dividing the stated amount by 50 confirms this differential does not match any listed pair.
- **D) € 27.50**: This value matches the $7 \times 10\ \text{cm}$ photo card including a personalized greeting. Its standard rate is $€1.60$ while the upgraded version costs $€2.15$, leaving a $€0.55$ margin. Applying the 50 cards multiplier leads to $€27.50$, yet the initial selection exceeds the lowest base price.
- **E) € 30.00**: Reaching $€30.00$ requires a markup of $€0.60$ per unit. None of the qualified designs feature this exact increase between their pricing tiers.

16 **The table below shows the average mass of the cerebellum, which is a part of the brain, and total body mass, for a number of animal species. The cerebellum of a cat has an average mass of 5.3 g, while a cat's average body mass is 3.5 kg**

For which of the species shown is the ratio of cerebellum to total body mass closest to that of the cat?

Species	Cerebellum mass(g)	Body mass (g)
Mouse	0.09	58
Pigeon	0.4	500
Squirrel	1.5	350
Rabbit	1.9	1800
Dog	6.0	3500

Correct answer: A · Mouse

Convert the cat's body mass to grams: $3.5\ \text{kg} = 3500\ \text{g}$. Compute the baseline cerebellum ratio using the given masses: $\frac{5.3\ \text{g}}{3500\ \text{g}} \approx 0.00151$. Compare this to the mouse data by calculating $\frac{0.09\ \text{g}}{58\ \text{g}} \approx 0.00155$. The absolute difference is roughly 0.00004, which is the smallest deviation among all listed species.

Why the other answers are wrong

- **B) Dog**: The dog's calculation $\frac{6.0\ \text{g}}{3500\ \text{g}}$ yields approximately 0.00171. This creates a gap of about 0.00020 from the feline benchmark, showing a proportionally larger organ.
- **C) Pigeon**: Dividing the pigeon's measurements gives $\frac{0.4\ \text{g}}{500\ \text{g}} = 0.00080$. The resulting spread of 0.00071 indicates a significantly lower relative mass.
- **D) Rabbit**: Evaluating the rabbit figures produces $\frac{1.9\ \text{g}}{1800\ \text{g}} \approx 0.00106$. With a deviation near 0.00045, the cerebellum accounts for less of the total weight than expected.
- **E) Squirrel**: Processing the squirrel values results in $\frac{1.5\ \text{g}}{350\ \text{g}} \approx 0.00429$. This generates a large discrepancy of 0.00278, reflecting a much higher ratio.

17 **There are two services between Sandpoint and Genville: a fast hovercraft service which takes 50 minutes and a slow ferry which takes 1 hour 40 minutes. They both stop in port for 20 minutes at each end before starting the return journey. They start out from Sandpoint together at the same time each morning.**

For how long has the slow ferry been sailing before it meets the hovercraft coming back? (Answer to the nearest minute if necessary.)

Correct answer: A · 1 hour and 20 minutes

Let the route length be D. The two vessels have constant **speeds** of $v_{\mathrm{h}} = D/50\ \mathrm{min}$ and $v_{\mathrm{f}} = D/100\ \mathrm{min}$. Both depart at $t = 0$, but the hovercraft reaches Genville after $50\ \mathrm{min}$, pauses for $20\ \mathrm{min}$, and resumes traveling toward Sandpoint at $t = 70\ \mathrm{min}$. By that moment the ferry has sailed for $70\ \mathrm{min}$ and covered $0.7D$, leaving a **gap** of $0.3D$ between them. Their opposing rates sum to $\frac{3D}{100}\ \mathrm{min}^{-1}$, requiring a **closing time** of exactly $10\ \mathrm{min}$ to intersect. Adding this to the initial $70\ \mathrm{min}$ gives a total sailing duration of $80\ \mathrm{min}$, or 1 hour 20 minutes.

Why the other answers are wrong

- **B) 1 hour and 10 minutes**: This corresponds to the exact moment the hovercraft departs Genville ($t = 70\ \mathrm{min}$). It overlooks the extra time needed for the two boats to approach each other and eliminate the remaining distance.
- **C) 1 hour and 7 minutes**: This figure results from arithmetic errors like subtracting the $50\ \mathrm{min}$ travel time from the ferry's $100\ \mathrm{min}$ duration or mishandling average speeds. Such miscalculations leave the vessels separated by a fractional portion of the route instead of crossing paths.
- **D) 1 hour and 25 minutes**: This option extends the correct $70\ \mathrm{min}$ baseline by $15\ \mathrm{min}$ instead of $10\ \mathrm{min}$. The inflation usually stems from applying only the ferry's speed or a flawed relative speed during the approach phase.
- **E) 1 hour and 30 minutes**: This value often comes from incorrectly summing both port stops with the outbound journey ($50 + 20 + 20 = 90\ \mathrm{min}$). This mistake assumes the second stop happens before the return trip, whereas it actually occurs at Genville after the hovercraft has already turned around.

18 **Deanna keeps a record of the petrol she puts into her car and the current distance it has covered so she can estimate her fuel consumption. When she puts petrol in, sometimes the tank is filled completely and she marks 'FULL' beside the entry if this is so, otherwise the tank is only partly filled.**

Her data for the last month is as follows:

Which one of the following is the best estimate of her fuel consumption?

Date	Total km	Fuel added	FULL?
2 June	23, 508	5 litres	
6 June	23, 805	37 litres	FULL
12 June	24, 350	25 litres	
17 June	24, 743	21 litres	
23 June	24, 989	34 litres	FULL
27 June	25, 454	18 litres	

Correct answer: A · 6.8 litres / 100 km

To estimate fuel consumption accurately, rely on **consecutive full refills** so the **exact volume burned** over a measured stretch is clear. Between 6 June and 23 June the tank reached full twice. The pump records show a **total fuel added** of $25\ \mathrm{L} + 21\ \mathrm{L} + 34\ \mathrm{L} = 80\ \mathrm{L}$. The odometer indicates an **actual distance** of $24\,989\ \mathrm{km} - 23\,805\ \mathrm{km} = 1\,184\ \mathrm{km}$. Converting to standard units yields $\frac{80\ \mathrm{L}}{1\,184\ \mathrm{km}} \times 100\ \mathrm{km} \approx 6.8\ \mathrm{L}/100\,\mathrm{km}$.

Why the other answers are wrong

- **B) 1.7 litres / 100 km**: This value is unrealistically low and would imply the vehicle could travel over 5000 km on 80 L, which directly contradicts the recorded odometer readings and fuel volumes.
- **C) 7.7 litres / 100 km**: This figure is too high and usually stems from using an incorrect denominator, such as dividing 80 L by roughly 1000 km instead of the verified 1184 km.
- **D) 8.0 litres / 100 km**: A rate of 8.0 L per 100 km would require approximately 95 L to cover 1184 km, whereas the log confirms only 80 L were consumed between the two full tanks.
- **E) 9.9 litres / 100 km**: This estimate implies nearly 120 L consumed for the journey, which vastly exceeds the 80 L actually pumped into the tank to restore it to full capacity.

19 **Leroy cycles to work each morning. The first half of his journey is up hill and he can manage only a steady 5 kilometres per hour. The second half, however, is downhill and he covers this at 15 kilometres per hour.**

Which one of these graphs could show Leroy's journey?

Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fd1i1ii1d1.png?alt=media&token=04a15ff6-dff0-41d1-b6f2-618f71703847<i>

On a distance-time graph, the **gradient** represents speed. The first half of the distance is covered at 5 kilometres per hour and the second half at 15, so the first half takes three times as long. Graph A shows a long, shallow straight section covering half the distance, followed by a shorter, three-times-steeper section.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fxwq1iwei1ikdkdsmmss.png?alt=media&token=bbcb5e17-a651-48b0-9c56-7b606b41ccae<i>**: It starts with a very steep slope and then flattens out, which would mean Leroy is fast first and slow later, the opposite of the journey described.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fsd81811c81cchhsjhs.png?alt=media&token=942e32cc-1ada-4577-95b0-094e0c00078a<i>**: It shows a single straight line with a constant slope, which would mean Leroy travels the whole distance at one speed. The question gives two different steady speeds.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1ex12w8wudjsdjdjd2.png?alt=media&token=2a74ddc8-00d0-4ff5-9e30-37469a5df970<i>**: After the gentle first section, the graph is horizontal for a while before rising again. A horizontal section means Leroy has stopped completely, which the description does not mention.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1xe2128wisaksk.png?alt=media&token=8a0930dc-315e-4a5d-a8ef-a7278df2d787<i>**: Both sections are curved, indicating that Leroy's speed is continuously changing. The question specifies two steady speeds, 5 kilometres per hour and 15 kilometres per hour, so the sections should be straight lines.

20 **When I made a hotel reservation online yesterday I was given an 8 digit booking reference which contained no zeros. It did, however, consist of three 2 digit odd numbers followed by the sum of these three numbers, and all eight digits were different.**

The first digit of the booking reference was 4. What was the last digit?

Correct answer: A · 7

The eight-digit reference consists of three two-digit odd numbers N_1, N_2, N_3 followed by their sum $S = N_1 + N_2 + N_3$. Since the **first digit is 4**, testing possible values reveals that **only** $N_1 = 49$ **works** without forcing digit repetition or exceeding a two-digit sum. The remaining numbers must draw from small odd candidates, leaving $\{13, 25\}$ **or** $\{15, 23\}$ **as the only valid pairs**. Both combinations yield a total sum of $S = 87$, so the **final digit is necessarily 7**.

Why the other answers are wrong

- **B) 1**: The digit 1 is already required in the second or third number to keep the total under 100, so it cannot also be the last digit due to the distinct digit rule.
- **C) 3**: A final digit of 3 would require the sum to end in 3, but constructing such a total with the available non-repeating odd numbers inevitably forces a duplicate 3 in the addends.
- **D) 5**: A final digit of 5 would repeat the digit 5, which must already appear in 15 or 25 to satisfy the sum constraint.
- **E) 9**: The digit 9 is already used as the second digit of the first number, violating the rule that all eight digits must be different.

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21 **Which one of the following pairs of scholar/field of study is NOT correct?**

Correct answer: A · Max Weber - Pedagogy

This question requires identifying the mismatched scholar and discipline pair. **Max Weber** is incorrectly linked to **pedagogy** because his foundational contributions belong to **sociology**, **economics**, and political theory rather than education science. **Why the other answers are not the answer Answer A**: Amartya Sen is a Nobel laureate recognized for his work in welfare economics, social choice theory, and development studies, making the Economics match accurate. **Answer B**: Ludwig Wittgenstein remains a central figure in twentieth century thought, widely credited with major contributions to analytic philosophy through works like the Tractatus Logico-Philosophicus. **Answer D**: Konrad Lorenz earned the 1973 Nobel Prize for his research on animal behavior and imprinting, which directly established the scientific field of ethology. **Answer E**: Doris Lessing was awarded the 2007 Nobel Prize for her outstanding fiction, confirming Literature as her correct disciplinary affiliation.

Why the other answers are wrong

22 **Which one of the following public figures was NOT awarded the Nobel Peace Prize?**

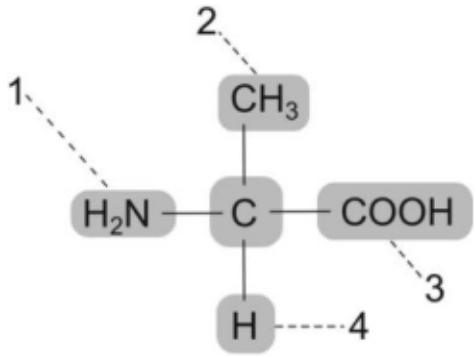
Correct answer: A · Mahatma Gandhi

Mahatma Gandhi was never awarded the **Nobel Peace Prize** despite several nominations. His assassination in January 1948 occurred just before the committee finalized that year's selection. The foundation enforced a strict posthumous rule that barred retroactive honors. His philosophy of nonviolence heavily influenced future laureates.

Why the other answers are wrong

- **B)** Willy Brandt served as Chancellor of West Germany when he received the 1971 prize. He was honored for his Ostpolitik strategy. This diplomatic approach promoted détente and reconciliation with Eastern Europe.
- **C) Martin Luther King**: Dr. Martin Luther King Jr. won the 1964 prize for leading the non-violent Civil Rights Movement. He advanced legal equality across the United States through peaceful activism.
- **D)** Nelson Mandela shared the 1993 prize with F.W. de Klerk for peacefully dismantling institutionalized segregation. Their joint negotiations established a democratic framework in South Africa.
- **E)** Aung San Suu Kyi earned the 1991 prize for advocating fundamental liberties under military rule. She organized a sustained peaceful campaign for democracy and human rights in Myanmar.

23 **The diagram below shows an amino acid.**
Which option correctly identifies both the variable group (R group) and the acidic group?



Correct answer: A · variable group = 2; acidic group = 3

The central α-carbon bonds to four distinct components: an amino group, a carboxyl group, a hydrogen atom, and a variable group. 1. Label 2 identifies the $\mathrm{CH_3}$ fragment, which functions as the unique **side chain**. 2. Label 3 marks the COOH fragment, which acts as the acidic center because it releases protons. This alignment matches option A precisely.

Why the other answers are wrong

- **B) variable group = 1; acidic group = 2**: Label 1 points to the $\mathrm{NH_2}$ group, which constitutes a constant structural backbone rather than a mutable region. Label 2 designates a hydrocarbon fragment that maintains electrical neutrality and cannot donate protons.
- **C) variable group = 4; acidic group = 3**: Label 4 indicates a hydrogen atom bound to the central carbon, meaning all standard protein building blocks share this specific feature. The identification of the acidic moiety remains accurate, but the variable designation fails.
- **D) variable group = 3; acidic group = 1**: Label 3 corresponds to the COOH moiety, which belongs to the universal framework instead of the distinctive appendage. Label 1 marks the nitrogen-containing group, functioning as a proton acceptor instead of a **proton donor**.
- **E) variable group = 2; acidic group = 4**: The classification of label 2 as the variable appendage stands correct. Label 4 highlights a hydrogen atom, which stays chemically inert regarding acid-base behavior under physiological conditions.

24 **In a prokaryote, transcription can occur in which of the following?**

1. cytoplasm
2. mitochondria
3. ribosomes

Correct answer: A · 1 only

Prokaryotic cells lack a membrane-bound nucleus, so their genetic material rests directly in the **cytoplasm**. **RNA polymerase** binds to this DNA and performs **transcription** without needing a separate compartment.

Why the other answers are wrong

- **B) 2 only**: **Organelles** like mitochondria are complex structures found only in eukaryotic cells. Prokaryotes entirely lack them, making internal RNA synthesis impossible.
- **C) 3 only**: Ribosomes are dedicated machines for protein production. They perform **translation** using pre-existing mRNA and never participate in building new RNA strands.
- **D) 1 and 2 only**: This choice wrongly links the valid cellular location with non-existent compartments. Since true prokaryotes possess zero mitochondria, this pairing cannot exist.
- **E) 1 and 3 only**: This option incorrectly adds structural sites to the actual RNA synthesis zone. While ribosomes float freely in bacteria, their sole role decodes messages, not writes them.

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25 **Which of the following are directly produced during photolysis of water?**

1. oxygen
2. carbon dioxide
3. protons

Correct answer: A · 1 and 3 only

During the light-dependent reactions, the oxygen-evolving complex of **Photosystem II** splits water molecules according to the reaction $2\,\mathrm{H_2O} \rightarrow \mathrm{O_2} + 4\,\mathrm{H^+} + 4\,\mathrm{e^-}$. The direct products are **oxygen** and **protons**. The released protons accumulate in the thylakoid lumen to build a gradient for ATP synthesis. **Carbon dioxide** is not generated in this process and instead acts as a substrate for the Calvin cycle.

Why the other answers are wrong

- **B) 1 and 2 only**: Oxygen is correctly identified, but carbon dioxide is never produced during photolysis. This choice combines a true product with a false one.
- **C) 2 and 3 only**: Protons are indeed released, but carbon dioxide does not appear in the reaction. The option also omits oxygen, which makes it incorrect on two counts.
- **D) 1 only**: This choice acknowledges the production of oxygen but ignores the simultaneous generation of protons. It therefore presents an incomplete picture of the photolysis outputs.
- **E) 2 only**: Carbon dioxide is not formed during water photolysis. This option lists only a substance that is irrelevant to the step.

26 **The table shows some events of the normal eukaryotic cell cycle.**

Which row shows the correct sequence of events (left to right) as they occur during part of this cell cycle?

row 1	nuclear envelope disappears	DNA starts to condense	chromosomes line up at the equator	cytoplasm divides
row 2	chromosomes line up at the equator	spindle fibres shorten	DNA starts to condense	nuclear envelope reappears
row 3	chromosomes line up at the equator	spindle fibres shorten	nuclear envelope reappears	cytoplasm divides
row 4	DNA starts to condense	nuclear envelope disappears	spindle fibres shorten	chromosomes line up at the equator
row 5	nuclear envelope disappears	spindle fibres shorten	chromosomes line up at the equator	nuclear envelope reapears

Correct answer: A · row 3

Row 3 lists mitotic stages in exact chronological order. **Chromosome alignment** at the equator initiates metaphase. **Spindle shortening** drives chromatid separation during anaphase. The nuclear envelope reforms in telophase. Cytokinesis concludes division by splitting the cytoplasm.

Why the other answers are wrong

- **B) row 1**: **DNA condensation** begins in prophase alongside nuclear envelope breakdown, not afterward. Starting with envelope disappearance reverses early mitotic timing. Cytokinesis must remain the final step, leaving intermediate alignment and contraction steps misplaced.
- **C) row 2**: Condensation is a prophase prerequisite that must precede metaphase alignment. Inserting condensation after spindle contraction inverts the stage progression. Envelope reformation logically follows both early condensation and late separation, making the middle sequence impossible.
- **D) row 4**: Spindle shortening belongs to anaphase and cannot precede metaphase alignment. Chromatids require prior equatorial attachment before segregation forces act. Swapping these stages contradicts spindle mechanics and breaks the required assembly sequence.
- **E) row 5**: Spindle contraction cannot trigger before chromosomes reach the equator. Nuclear envelope breakdown depends on initial prophase condensation, which this sequence omits. Early and late division phases are scattered, removing the linear cause-effect chain of mitosis.

28 **The genotype QqRr produces a certain phenotype.**
If two individuals with a genotype of QqRr reproduce, how many different possible phenotypes could be created, assuming all allele combinations are equally viable and the phenotypes are the result of complete dominance?

Correct answer: A · 4

The cross involves two independent loci (Q/q and R/r) governed by **complete dominance**. Each locus yields two observable outcomes, dominant and recessive, which combine mathematically as $2 \times 2 = 4$. Multiple genetic makeups map to the same outward trait, so the total number of **genotypes** does not change the count of distinct **phenotypes**.

Why the other answers are wrong

- **B) 5**: This selects five by incorrectly treating the heterozygous QqRr pairing as a unique trait. Under strict dominance, heterozygotes express the identical characteristic as homozygous dominants and never expand the phenotype total.
- **C) 8**: Eight likely stems from confusing parental gamete permutations with offspring traits or misapplying an exponential rule like 2^3. With only two segregating chromosomes, the observable categories cap at four.
- **D) 16**: Sixteen equals the precise number of genetic combinations inside a standard 4×4 Punnett grid. Dominant alleles hide recessive variants, meaning many distinct codes resolve into fewer visible states.
- **E) 9**: Nine marks only the leading class of the standard dihybrid ratio. Treating individual proportion numbers as separate physical forms or summing them to sixteen ignores that the full distribution groups strictly into the four established trait pairs.

30 **Which of the following could be the outcome of evolution?**

1. speciation
2. a change in allele frequency
3. increased biodiversity

Correct answer: A · 1, 2 and 3

Evolution involves heritable genetic changes across generations, producing several distinct outcomes. At the population level, it fundamentally requires a **change in allele frequency** driven by forces like selection or drift. Over longer timescales, accumulated divergence causes lineages to split into **speciation**. These mechanisms collectively generate new species and ecological networks, driving **increased biodiversity**. Because all three statements accurately describe evolutionary results, option A is the only complete choice.

Why the other answers are wrong

- **B) 1 and 2 only**: This omits increased biodiversity. Speciation and allele frequency shifts actively contribute to expanding biodiversity, so excluding statement 3 makes the selection incomplete.
- **C) 2 and 3 only**: This excludes speciation. While allele frequency changes and biodiversity gains are accurate, speciation remains a primary macroevolutionary endpoint that must be included.
- **D) 1 and 3 only**: This leaves out the change in allele frequency. That shift defines evolution at the population level and provides the necessary foundation for both speciation and long-term biodiversity increases.
- **E) 1 only**: This lists only speciation. It ignores the underlying allele frequency mechanisms and the broader consequence of increased biodiversity, rendering the explanation incomplete.

31 Where in a shoulder joint are osteocytes found?

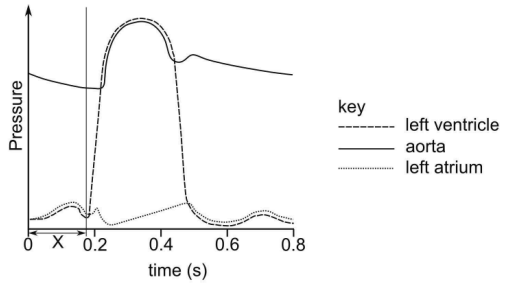
Correct answer: A · bone tissue

Osteocytes are mature bone cells embedded in small cavities called **lacunae**. They reside exclusively within the **mineralized extracellular matrix** of osseous tissue to maintain skeletal structure. Therefore, they are only present in the bone components of the shoulder joint.

Why the other answers are wrong

- **B) muscle tissue**: Skeletal muscle tissue contains **myocytes** specialized for contraction, not bone cells.
- **C) skin**: Skin is composed of **epithelial cells** and dermal connective tissue, which do not produce or house osteocytes.
- **D) ligament**: Ligaments consist of dense regular connective tissue built by **fibroblasts** secreting collagen fibers for joint stability.
- **E) cartilage**: Cartilage supports articular surfaces but contains **chondrocytes** within a flexible, avascular matrix instead of bone cells.

32 The diagram shows how the pressure changes in the left atrium, left ventricle and the aorta during one heartbeat in a healthy human. Which row shows the correct events during time period X?



Which row shows the correct events during time period X?

row	*volume of blood in left atrium*	*semi-lunar valve in aorta*	*muscles of left ventricle wall*
1	decreases	closed	relax
2	decreases	open	relax
3	increases	closed	contract
4	decreases	open	contract
5	increases	closed	relax

Correct answer: A · row 1

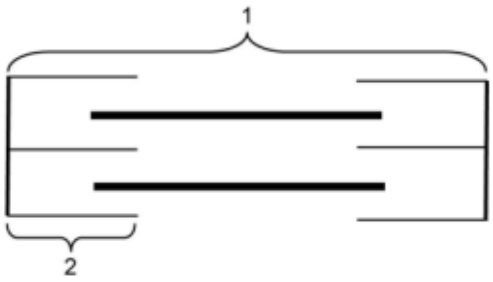
During **atrial systole** the left atrium actively empties blood into the ventricle so its **volume decreases**. The heart chamber remains **relaxed** while waiting for the next contraction. **Semilunar valves** stay **closed** because ventricular pressure has not yet exceeded aortic pressure. Row 1 matches these three conditions exactly.

Why the other answers are wrong

- **B) row 2**: Row 2 pairs an open semilunar valve with a relaxing ventricle. This physiological combination never occurs in the normal cardiac cycle because the valve closes as soon as ventricular pressure drops below aortic pressure.
- **C) row 3**: Row 3 describes isovolumetric contraction where the ventricle contracts with all valves closed. The atrium volume increases during this phase but it happens after period X when pressure rises sharply.
- **D) row 4**: Row 4 describes ventricular ejection with the semilunar valve open and muscles contracting. During ejection the atrium fills passively so its volume increases instead of decreasing.
- **E) row 5**: Row 5 corresponds to isovolumetric relaxation early in diastole. The ventricle relaxes with closed semilunar valves while the atrium fills, but the timing and pressure values do not match period X.

33 **The diagram shows a single sarcomere in a relaxed state.**

Which answer describes the changes when the sarcomere contracts?



Correct answer: A · 1 gets smaller and 2 does not change

Label 1 marks the **sarcomere length** measured from one **Z-line** to the next. Label 2 marks the **A-band** width determined by the **thick filaments**. During contraction **thin filaments** slide past thick ones pulling the boundary anchors inward. This shortens the first region while the second region remains constant.

Why the other answers are wrong

- **B) 1 gets smaller and 2 gets smaller**: It suggests both measurements decrease, which incorrectly implies the thick filaments themselves shorten. The sliding filament mechanism only moves thin filaments inward. Thick filaments remain constant in length throughout the process.
- **C) 1 gets longer and 2 gets wider**: It describes the sarcomere stretching and the A-band expanding. This reverses the actual mechanics since contraction pulls structural boundaries closer. The muscle fiber actively generates force to reduce the gap between anchor points.
- **D) 1 gets longer and 2 gets smaller**: It claims the sarcomere stretches while simultaneously stating the dark band shrinks. Both assertions contradict the contraction phase. The sarcomere definitely shortens and the A-band maintains its original span.
- **E) 1 does not change and 2 gets wider**: It asserts the overall length stays static while the thick zone widens. Active contraction forces the Z-lines toward the center. The structural integrity of the myosin bundle prevents any change in diameter.

34 **Some local anaesthetics affect nervous impulse transmission by making it more difficult for voltage gated sodium channels to open. In a human patient treated with these anaesthetics which of the following statements would be true?**

Correct answer: A · It would become harder to depolarise the neuron

Voltage-gated Na^{+} channels mediate the rapid sodium influx that drives neuronal depolarisation. Local anaesthetics bind to these proteins and stabilise their closed state. This significantly reduces the **inward sodium current**, meaning the cell requires a much stronger stimulus to initiate an action potential. Therefore, it becomes harder to depolarise the neuron.

Why the other answers are wrong

- **B) The axon membrane would become more difficult to repolarise**: Repolarisation relies mainly on the opening of **voltage-gated K^{+} channels** and the inactivation of sodium channels. Blocking sodium channels does not impede potassium efflux, leaving the repolarisation phase functionally intact.
- **C) The membrane potential of the neuron at rest would decrease below –90 mV**: The **resting membrane potential** is determined by passive potassium permeability and active ion transport. Voltage-gated sodium channels are fully closed at rest, so their pharmacological blockade cannot hyperpolarise the membrane below $-90\ \mathrm{mV}$.
- **D) The sodium/potassium pump may need to work faster to maintain the resting potential**: Because fewer sodium channels open, significantly less sodium actually crosses the membrane. With a reduced intracellular sodium accumulation, the **sodium-potassium pump** faces a lower transport demand rather than needing to work faster.
- **E) The threshold potential required to generate an action potential would be lowered**: Neuronal excitability depends on the number of available sodium channels for the regenerative feedback loop. When channel availability drops, a larger depolarisation is required to trigger enough openings simultaneously, effectively raising the **threshold potential** instead of lowering it.

35 **The changes in concentration of hormones in a healthy woman's blood were monitored during several menstrual cycles.**

During which stage of the menstrual cycle was the concentration of oestrogen falling, the concentration of luteinising hormone (LH) and follicle stimulating hormone (FSH) maximal and the progesterone concentration rising?

Correct answer: A · four days before ovulation and the time of ovulation

During the **ovulatory window**, dominant follicles secrete high levels of **estrogen**. This concentration triggers positive feedback on the pituitary gland, causing a surge in **LH** and **FSH** to reach their cycle maximums. Immediately after this peak, estrogen declines while the transforming follicle begins producing **progesterone**. These concurrent changes align exactly with option A.

Why the other answers are wrong

- **B) at the end of menstruation**: At the end of menstruation, estrogen remains low and continues its upward trend. LH and FSH maintain baseline levels without surging. Progesterone secretion is virtually absent until after ovulation.
- **C) between the end of menstruation and four days before ovulation**: The period between menstruation and four days before ovulation marks the mid-follicular phase. Estrogen steadily increases as follicles mature. LH and FSH stay at resting concentrations. Progesterone production remains negligible.
- **D) after ovulation but before the start of menstruation**: The timeframe after ovulation and before menstruation represents the luteal phase. Progesterone dominates the profile and remains elevated throughout. LH and FSH are suppressed to minimal levels by negative feedback. Estrogen does not exhibit the sharp initial drop seen at the follicular peak.
- **E) at the start of menstruation**: Menstruation begins when ovarian hormone support collapses. Estrogen and progesterone concentrations hit their lowest cycle values. LH and FSH also drop to baseline, apart from a minor rise that primes the next cycle. No matching hormone pattern exists at this stage.

36 **The following events occur during a reflex response to a person placing a hand on a hot object.**

1. Myosin binding sites on actin filaments uncovered
2. ADP and phosphate ion released from myosin head
3. Sodium voltage gated channels open
4. Myosin head detaches from binding site on actin
5. Calcium ions released by sarcoplasmic reticulum

Which of the following options places four of these events in the correct order (from left to right)?

Correct answer: A · 5, 1, 2, 4

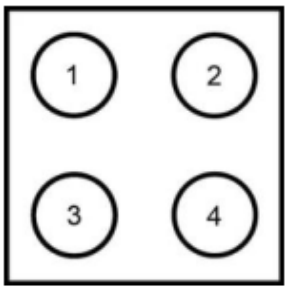
The withdrawal reflex triggers a precise sequence in the muscle fibers: first Ca^{2+} **release** from the sarcoplasmic reticulum opens access to the thin filament. Next, tropomyosin shifts to expose the actin **binding sites**. Then the energized myosin head attaches and undergoes the **power stroke**, releasing ADP and phosphate. Finally, ATP binding causes the myosin head to detach for the next cycle. Option B correctly lists steps 5, 1, 2, and 4 in this order.

Why the other answers are wrong

- **B) 1, 2, 4, 3**: Step 1 cannot occur without the preceding Ca^{2+} release in step 5. It also places Na^{+} channel opening last, while neural depolarization actually initiates the entire reflex pathway.
- **C) 3, 1, 4, 2**: It reverses the contractile cycle by placing myosin detachment before ADP and phosphate release. Cross bridge cycling requires force generation before the head can let go.
- **D) 3, 5, 4, 2**: It again positions detachment before the power stroke. It also omits the critical step of exposing binding sites entirely.
- **E) 5, 2, 1, 4**: It orders the power stroke before binding sites are available. Myosin heads cannot generate tension until calcium makes the actin sites accessible.

37 **The picture below shows a DNA microarray.**
Each spot (labelled 1–4) contains a different DNA probe. A sample of fluorescently labelled human DNA, with the sequence TGGTCAAGATTAT, is washed over the array.

Which of the spots would show a positive signal because it fluoresces?



spot	DNA probe
1	GATTAT
2	CTAATA
3	ACCAGT
4	TGGTCA

Correct answer: A · 2 and 3 only

DNA microarrays detect binding via precise **hybridization** between the fluorescent sample and immobilized **complement** probes. The target strand contains two distinct regions that satisfy these pairing rules. Spot 2 carries CTAATA, which aligns with the GATTAT segment at positions 8–13. Spot 3 holds ACCAGT, which pairs with the initial TGGTCA region at positions 1–6. Only these two locations generate a measurable **fluorescence** signal.

Why the other answers are wrong

- **B) 1 and 3 only**: Spot 1 utilizes probe GATTAT, requiring CTAATA to initiate base pairing. This complementary string is completely absent from the sample, so no reaction occurs despite the validity of spot 3.
- **C) 1 and 4 only**: Neither candidate probe achieves binding. Spot 1 seeks CTAATA while spot 4 searches for ACCAGT within the provided DNA, and both potential anchors are missing.
- **D) 2 and 4 only**: This selection erroneously includes spot 4 next to the operational spot 2. Spot 4 presents TGGTCA, which fails to attach because its necessary counterpart ACCAGT does not exist in the mixture.
- **E) 1, 2, 3 and 4**: This claim assumes blanket binding across every location. Precise molecular pairing restricts successful detection to exactly two sites, invalidating the assumption of universal emission.

38 **In the nerve cells of a person, one gene has two alleles, 'A' and 'a', present. For this person, which row correctly shows the alleles present in all three different situations given in the table?**

row	*Situation*		
	Stem cell starting to specialise into a liver cell	Cell at the start of mitosis	Cell at the start of meiosis I
1	Aa	AAaa	AAaa
2	AAaa	Aa	AAaa
3	AAaa	AAaa	Aa
4	Aa	Aa	A or a
5	A or a	A or a	Aa

Correct answer: A · row 1

1. The differentiating stem cell remains **diploid** with an unreplicated genotype of Aa. 2. Prior to mitosis and meiosis I, complete **DNA replication** creates two sister chromatids per chromosome, shifting the genotype to $AAaa$ for both stages. 3. Row 1 accurately tracks this transition from unreplicated to replicated cellular phases.

Why the other answers are wrong

- **B) row 2**: Row 2 incorrectly labels the initial differentiating cell as already replicated and misplaces the unreplicated state at the start of mitosis, violating the established timeline of **DNA synthesis**.
- **C) row 3**: Row 3 falsely claims the differentiating stem cell underwent prior duplication and incorrectly reduces the meiosis I genotype to single-copy Aa, ignoring pre-meiotic chromosomal doubling.
- **D) row 4**: Row 4 fails to account for obligatory replication before mitosis, retaining Aa, and erroneously applies the post-meiotic "A or a" outcome to meiosis I instead of a finalized **haploid gamete**.
- **E) row 5**: Row 5 inappropriately uses the terminal single-allele notation for both early developmental and mitotic stages, which must maintain paired allelic copies until nuclear division concludes.

39 **Place the following structures in a human sperm cell in descending order of size (left to right):**

1. mitochondria
2. nucleus
3. ribosome

Correct answer: A · 2, 1, 3

Descending order requires ranking cellular components from largest to smallest physical dimension. The **nucleus** fills the sperm head and reaches approximately 4–$5\ \mu\text{m}$. Individual **mitochondria** wrapping the axoneme measure about 0.5–$1\ \mu\text{m}$. **Ribosomes** are nanoscale complexes requiring **electron microscopy** to resolve at 20–$30\ \text{nm}$. This hierarchy confirms the sequence $2 > 1 > 3$.

Why the other answers are wrong

- **B) 1, 2, 3**: Positions the mitochondria before the nucleus despite the size difference. The nucleus spans several micrometres while an individual mitochondrion approaches only one micrometre, directly reversing the largest structures.
- **C) 1, 3, 2**: Assigns the first position to mitochondria and places ribosomes second. This misorders both comparisons since mitochondria exceed ribosomes in size and neither surpasses the nucleus.
- **D) 2, 3, 1**: Begins correctly with the nucleus but exchanges the middle and last positions. Ribosomes remain significantly smaller than mitochondria and must occupy the final spot.
- **E) 3, 1, 2**: Starts with the smallest component and ends with the largest. This completely inverts the required descending sequence without respecting any pairwise size relationship.

40 Which one of the following is NOT a carbohydrate?

Correct answer: A · glucagon

Glucagon is a **peptide hormone** synthesized by pancreatic α-cells. It consists of a chain of **amino acids** and completely lacks sugar units, so it belongs to proteins rather than carbohydrates.

Why the other answers are wrong

- **B) maltose**: Maltose is a **disaccharide** containing two glucose molecules joined by an α-1,4-glycosidic bond. As a molecule composed exclusively of saccharide units, it functions as a digestible sugar.
- **C) amylopectin**: Amylopectin is a highly branched **polysaccharide** that makes up a major part of plant starch. Its structure relies on thousands of glucose residues connected primarily through α-1,4 linkages with occasional α-1,6 branch points, defining it as a complex carbohydrate.
- **D) ribose**: Ribose is a five-carbon **monosaccharide** classified as a pentose sugar. It acts as a fundamental backbone for nucleic acids like RNA and energy carriers like ATP, leaving no doubt about its carbohydrate nature.
- **E) amylose**: Amylose represents the linear fraction of starch and avoids branching entirely. It forms long chains of glucose units linked strictly by α-1,4 bonds, which categorizes it firmly as a complex carbohydrate.

41 What is the correct formula of propanal?

Correct answer: A · CH_3CH_2CHO

The prefix prop- indicates a **three-carbon** chain. The suffix -al designates an **aldehyde** family with a terminal $-CHO$ group. Combining these features produces the condensed structural formula CH_3CH_2CHO. Option E matches both requirements perfectly.

Why the other answers are wrong

- **B)** $CH_3CH_2CO_2H$: Contains three carbons but ends with a carboxyl group ($-CO_2H$). This structure defines propanoic acid instead of an aldehyde.
- **C)** $CH_3CH_2CH_2OH$: Features three carbons but terminates with a hydroxyl group ($-OH$). It represents 1-propanol, which belongs to the alcohol class.
- **D)** CH_3COCH_3: Includes three carbons but places the carbonyl center between two alkyl groups. It identifies propanone, a ketone compound.
- **E)** $CH_3CH_2OCH_3$: Keeps three carbons total but arranges them around a central oxygen atom ($R-O-R$). This configuration yields methoxyethane, an ether compound.

42 **Which two of the following oxides would NOT give acidic solutions in water?**

CO, CO_2, SO_2, NO

Correct answer: A · CO and NO

CO and NO act as **neutral oxide** because carbon and nitrogen share a $+2$ **oxidation state**. Neither compound hydrolyses in pure water and therefore releases no H^+ or OH^- ions. Nitric oxide only converts to NO_2 when exposed to atmospheric oxygen, and only then hydrolyses into acids, but in isolated water it remains completely inert. Both gases thus maintain a neutral pH.

Why the other answers are wrong

- **B) CO and CO_2:** CO_2 reacts directly with water to **form carbonic acid** through the equilibrium $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightarrow H^+ + HCO_3^-$. Because it generates protons, this pair fails the neutral requirement.
- **C) CO and SO_2:** SO_2 hydrates readily to **form sulfurous acid** via $SO_2 + H_2O \rightleftharpoons H_2SO_3 \rightarrow H^+ + HSO_3^-$. Its tendency to acidify water invalidates this choice.
- **D) NO and CO_2:** This option contains CO_2, which behaves exactly as described in Answer A. Including any acid-producing oxide automatically makes the combination incorrect.
- **E) NO and SO_2:** This option contains SO_2, which follows the same acid-generating mechanism outlined in Answer B. Any mixture including an acidic oxide cannot satisfy the condition.

43 **Assume that the oxidation numbers are as shown below:**

N = –3 ; H = +1 ; Cr = +6 ; O = –2

Which compound formula given below is correct?

Correct answer: A · $(NH_4)_2\,CrO_4$

An ionic compound must be **neutral**. The given oxidation numbers assign a $+1$ charge to the NH_4^+ group and a -2 charge to the CrO_4^{2-} ion. Two ammonium ions are required to **balance** the charge of one chromate ion. The summation follows $2 \times (+1) + (-2) = 0$.

Why the other answers are wrong

- **B)** $NH_4Cr_2O_7$: The $Cr_2O_7^{2-}$ ion carries a -2 charge but only one NH_4^+ cation is listed. The calculation yields $(+1) + (-2) = -1$. A proper salt needs two ammonium ions.
- **C)** $[(NH_4)_2\,CrO_4]^+$: The bracketed formula already yields a zero net charge. Attaching a $+1$ suffix **contradicts** the internal calculation. No extra positive species appear in the notation.
- **D)** $(NH_4)_3\,CrO_4$: Three NH_4^+ units contribute $+3$ while the single CrO_4^{2-} anion provides -2. The result follows $3 \times (+1) + (-2) = +1$. This violates electrical neutrality.
- **E)** $[(NH_4)_3\,CrO_4]^-$: The interior composition holds a $+1$ net charge. Marking the whole entity with a -1 charge implies **missing** electrons. The notation remains internally inconsistent.

44 **0.75 g of a hydrocarbon compound contains 0.60 g of carbon.**
(A_r : C = 12.0; H = 1.0)

Which one of the following could be the molecular formula of the hydrocarbon compound?

Correct answer: A · C_2H_6

1. Subtract the carbon mass from the total sample to find **hydrogen**: $0.75\ \text{g} - 0.60\ \text{g} = 0.15\ \text{g}$. 2. Convert both masses to **moles** using atomic weights: $n(\text{C}) = 0.60\ \text{g}/12.0\ \text{g mol}^{-1} = 0.050\ \text{mol}$ and $n(\text{H}) = 0.15\ \text{g}/1.0\ \text{g mol}^{-1} = 0.150\ \text{mol}$. 3. Simplify the **ratio** to $1:3$, establishing an empirical **formula** of CH_3 and 80% **carbon** by mass. 4. Verify the options against these constraints. Only C_2H_6 matches both criteria.

Why the other answers are wrong

- **B)** CH_4: Molar mass is $16\ \text{g mol}^{-1}$ with $12\ \text{g}$ carbon, yielding 75% carbon. The atom ratio is $1:4$, which contradicts the calculated $1:3$.
- **C)** C_3H_8: Molar mass is $44\ \text{g mol}^{-1}$ with $36\ \text{g}$ carbon, giving approximately 81.8% carbon. The $\text{H}:\text{C}$ ratio is $8:3$ $(2.67:1)$, not matching the data.
- **D)** C_2H_4: Molar mass is $28\ \text{g mol}^{-1}$ with $24\ \text{g}$ carbon, resulting in approximately 85.7% carbon. The $\text{H}:\text{C}$ ratio is $2:1$, indicating too little hydrogen.
- **E)** C_2H_3: Molar mass is $27\ \text{g mol}^{-1}$ with $24\ \text{g}$ carbon, leading to approximately 88.9% carbon. The $\text{H}:\text{C}$ ratio is $1.5:1$, making it chemically unlikely and far from the target values.

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46 **When propan 1 ol is burnt in excess oxygen the only products formed are carbon dioxide and water.**

In the balanced equation for this reaction what is the ratio of $CO_2 : H_2O$ molecules formed?

Correct answer: A · 3 : 4

The combustion of **propan-1-ol** requires balancing its constituent elements first. Three **carbon atoms** yield three CO_2 molecules and eight **hydrogen atoms** produce four H_2O molecules. Balancing **oxygen** on the reactant side demands $4.5\ O_2$ to match the ten oxygen atoms on the product side. Doubling all coefficients removes the fraction and gives $6\ CO_2$ and $8\ H_2O$. The final **ratio** of $6:8$ simplifies to the correct value.

Why the other answers are wrong

- **B) 3 : 8**: This option keeps the doubled count of eight H_2O molecules but fails to double the CO_2 amount, leaving the carbon atoms unbalanced.
- **C) 4 : 7**: No integer-balanced combustion equation yields this pair because forcing these coefficients makes both carbon and hydrogen counts contradict the starting molecule.
- **D) 5 : 12**: Twelve H_2O molecules correspond to twenty-four hydrogen atoms, which cannot originate from any whole-number multiple of C_3H_8O while still producing exactly five CO_2.
- **E) 2 : 7**: An odd number of water molecules creates an odd hydrogen total on the product side, directly conflicting with the fixed even number of eight hydrogens present in every C_3H_8O unit.

47 **2,2 – dimethylpropane, $\mathrm{C\,(CH_3)_4}$, is an isomer of pentane, $\mathrm{CH_3\,(CH_2)_3\,CH_3}$.**

Pentane has a boiling point of 36 °C whilst the boiling point of 2,2 – dimethylpropane is 10 °C.

Which statement below explains the difference in the boiling points for these two substances?

Correct answer: A · Longer chain, less branched molecules have stronger spontaneous/induced dipoles

Pentane and 2,2-dimethylpropane have the same molecular formula, $\mathrm{C_5H_{12}}$, and are nonpolar, so their main intermolecular attractions are **London dispersion forces**. Pentane's **less-branched, extended shape** allows greater contact between molecules, strengthening these attractions and raising its boiling point to 36 °C, compared with 10 °C for 2,2-dimethylpropane.

Why the other answers are wrong

- **B) The molecules have different relative molecular masses**: Both substances have the same relative molecular mass, $72.15\ \mathrm{g\,mol^{-1}}$, because both have the formula $\mathrm{C_5H_{12}}$. Their boiling-point difference is not due to a difference in mass.
- **C) Isomers have different chemical properties**: Isomers can have different chemical reactivity, but boiling point is a physical property governed by intermolecular forces. This statement does not explain the specific difference in boiling points.
- **D) 2,2 – dimethylpropane has stronger intermolecular forces**: The opposite is true: 2,2-dimethylpropane has weaker intermolecular forces, which is why its boiling point is lower.
- **E) Pentane has permanent dipoles**: Pentane is **nonpolar**. Its $\mathrm{C-C}$ and $\mathrm{C-H}$ bonds have electronegativity differences too small to produce permanent dipoles, so its molecules have dispersion forces but no dipole-dipole forces.

48 **Potassium nitrate was found to have a solubility of 120 g in 100 g of water at 80 °C and 50 g in 100 g of water at 25 °C.**

50 g of water was heated to 80 °C and solid potassium nitrate added until the solution was just saturated.

The solution was then cooled to 25 °C when solid potassium nitrate separated out to leave a saturated solution.

Using the information provided in this question, what is the minimum mass of water that must now be added to the mixture of the solution and the solid in order to make this solid potassium nitrate redissolve at 25 °C?

Correct answer: A · 70 g

1. At $80^{\circ}\mathrm{C}$ the **solubility** is $120\ \mathrm{g}\ \mathrm{KNO_3}$ per $100\ \mathrm{g}\ \mathrm{H_2O}$. This yields $60\ \mathrm{g}$ **dissolved** in the initial $50\ \mathrm{g}$ of water. 2. Cooling to $25^{\circ}\mathrm{C}$ drops the limit to $50\ \mathrm{g}$ per $100\ \mathrm{g}\ \mathrm{H_2O}$ ($0.5\ \mathrm{g\ g^{-1}}$). 3. Only $25\ \mathrm{g}$ remain in solution, creating $35\ \mathrm{g}$ of **precipitate**. 4. The **additional water** needed to redissolve the solid follows $x = 35 \div 0.5 = 70\ \mathrm{g}$.

Why the other answers are wrong

- **B) 20 g**: Adding $20\ \mathrm{g}$ creates $70\ \mathrm{g}$ total water. The concentration becomes $60 \div 70 = 0.86\ \mathrm{g\ g^{-1}}$ ($86\ \mathrm{g}$ per $100\ \mathrm{g}$), exceeding the saturation limit. Solid remains because the mixture is oversaturated.
- **C) 120 g**: Adding $120\ \mathrm{g}$ results in $170\ \mathrm{g}$ total water. The concentration calculates to $60 \div 170 = 0.35\ \mathrm{g\ g^{-1}}$ ($35\ \mathrm{g}$ per $100\ \mathrm{g}$), which dissolves everything. This quantity works but provides excess solvent, violating the minimum requirement.
- **D) 140 g**: Following the same logic, $140\ \mathrm{g}$ of added water yields an unsaturated mixture. It successfully redissolves the solid but supplies significantly more solvent than necessary.
- **E) 190 g**: Like the previous options, $190\ \mathrm{g}$ of water guarantees complete dissolution through heavy dilution. This guess ignores the precise saturation threshold and drastically overshoots the target.

49 **Pure water self ionises. This endothermic reaction is represented by the equation:**

$$\mathrm{H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)}$$

Which of the following statements is true for pure water between the temperatures of 0 °C and 100 °C?

1. The concentrations of $\mathrm{H^+(aq)}$ and $\mathrm{OH^-(aq)}$ are equal between 0 °C and 100 °C
2. An increase in temperature causes the pH to fall
3. An increase in temperature causes the electrical conductivity to decrease

Correct answer: A · 1 and 2 only

1. Pure water dissociates into equal amounts of $\mathrm{H^+(aq)}$ and $\mathrm{OH^-(aq)}$ due to $1:1$ stoichiometry, so their concentrations remain identical at every temperature between $0\ ^\circ\mathrm{C}$ and $100\ ^\circ\mathrm{C}$. 2. The autoionisation reaction is **endothermic**; raising the temperature shifts the **equilibrium** to the right, increasing both ion concentrations and the ionic product K_w. 3. Because $\mathrm{pH} = -\log[\mathrm{H^+}]$, the higher hydrogen ion concentration directly causes the **pH** to decrease as temperature rises. 4. Electrical **conductivity** depends on the total ion concentration; since more ions are produced at higher temperatures, conductivity increases rather than decreases.

Why the other answers are wrong

- **B) 1 only**: Incorrect because it accepts statement 1 but rejects statement 2, ignoring that higher temperatures genuinely lower the neutral pH.
- **C) 2 only**: Incorrect because it accepts statement 2 but rejects statement 1, overlooking the fundamental stoichiometric equality of ions in pure water.
- **D) 3 only**: Incorrect because statement 3 is factually reversed; conductivity rises with temperature due to greater ionic dissociation.
- **E) 1 and 3 only**: Incorrect because it pairs the valid statement 1 with the false statement 3 regarding conductivity.

51 **Atoms X and Y form an ionic compound with formula XY_2.**

Which option below could give the correct atomic numbers for X and Y?

Correct answer: A · X = 12; Y = 9

In an ionic compound, the **total charges must balance**. Atomic number 12 is magnesium, which forms $\mathrm{Mg^{2+}}$, and atomic number 9 is fluorine, which forms $\mathrm{F^-}$. One magnesium ion balances two fluoride ions, giving $\mathrm{MgF_2}$, which has the formula XY_2.

Why the other answers are wrong

- **B) X = 3; Y = 17**: Lithium forms $\mathrm{Li^+}$ and chlorine forms $\mathrm{Cl^-}$. Their charges balance in a $1:1$ ratio, giving LiCl rather than XY_2.
- **C) X = 6; Y = 16**: Carbon and sulfur do not normally form simple monatomic ions that make an ionic solid. They bond covalently to form $\mathrm{CS_2}$, not an ionic XY_2 lattice.
- **D) X = 11; Y = 16**: Sodium forms $\mathrm{Na^+}$ and sulfur forms $\mathrm{S^{2-}}$. Two sodium ions are needed for each sulfide ion, giving $\mathrm{Na_2S}$, or X_2Y, rather than XY_2.
- **E) X = 14; Y = 8**: Formal charges of $\mathrm{Si^{4+}}$ and $\mathrm{O^{2-}}$ would give the $1:2$ ratio in $\mathrm{SiO_2}$. However, $\mathrm{SiO_2}$ is a **covalent network solid**, not an ionic compound.

52 **In the reaction**

$$\mathrm{C_3H_7Br + KOH \rightarrow C_3H_7OH + KBr}$$

24.6 g of 1 bromopropane reacts with excess potassium hydroxide to produce 8.00 g of propan 1 ol.

$M_\mathrm{r}: \mathrm{C_3H_7Br} = 123$
$A_\mathrm{r}: \mathrm{H} = 1.0; \mathrm{C} = 12.0; \mathrm{O} = 16.0$

What is the percentage yield of this reaction?

Correct answer: A · 0.667

1. Calculate the **moles** of 1-bromopropane: $n = \frac{24.6\ \mathrm{g}}{123\ \mathrm{g\,mol^{-1}}} = 0.200\ \mathrm{mol}$. 2. The 1:1 **stoichiometry** dictates that the theoretical amount of propan-1-ol is also $0.200\ \mathrm{mol}$. 3. Compute the molar mass of propan-1-ol: $M_\mathrm{r} = (3 \times 12.0) + (8 \times 1.0) + 16.0 = 60.0\ \mathrm{g\,mol^{-1}}$. 4. Determine the **theoretical mass**: $0.200\ \mathrm{mol} \times 60.0\ \mathrm{g\,mol^{-1}} = 12.0\ \mathrm{g}$. 5. Evaluate the **percentage yield** using the actual mass: $\frac{8.00\ \mathrm{g}}{12.0\ \mathrm{g}} \times 100\% = 66.7\%$, or 0.667.

Why the other answers are wrong

- **B)** 0.325 divides the product mass directly by the reactant mass ($8.00 \div 24.6$), which ignores both molar masses and the reaction stoichiometry.
- **C)** 0.333 repeats this mass-ratio error but rounds the initial values to integers first ($8 \div 24$), introducing additional rounding mistakes.
- **D) 0.5710000000000001**: 0.571 arises from assigning an incorrect molar mass to propan-1-ol, such as $70.0\ \mathrm{g\,mol^{-1}}$, which calculates a higher theoretical mass of $14.0\ \mathrm{g}$ and yields $\frac{8.00}{14.0} \approx 0.571$.
- **E)** 0.93 appears when the product molar mass is calculated incompletely, for instance by omitting oxygen and using $43.0\ \mathrm{g\,mol^{-1}}$, resulting in a theoretical mass near $8.6\ \mathrm{g}$ and a ratio of $\frac{8.00}{8.6} \approx 0.93$.

53 **The variables x and y satisfy the following two equations:**

x + 3y = 13

2x – y = 5

What is the value of x + y?

Correct answer: A · 7

1. Set up the **system** of equations: $x + 3y = 13$ and $2x - y = 5$. 2. Rearrange the second equation to express y as $2x - 5$. 3. Apply **substitution** in the first equation: $x + 3(2x - 5) = 13$, which simplifies to $7x - 15 = 13$. 4. Solve for **x = 4** and compute **y = 3**. 5. The required sum is $x + y = 4 + 3 = 7$.

Why the other answers are wrong

- **B) 6**: This number appears if you derive $y = 2$ instead of 3, typically caused by a sign mistake when isolating y in the second equation.
- **C) 8**: This choice occurs if the values of x and y are accidentally swapped, or stems from incorrectly adding the constant terms during variable elimination.
- **D) 9**: It follows a straightforward arithmetic slip after expansion, such as treating $7x - 15 = 13$ as $7x - 15 = 14$, which yields a non-integer value that gets miscopied as 9.
- **E) 10**: It results from blindly adding both left-hand sides to get $3x + 2y = 18$ and then falsely assuming this combined expression equals the target sum $x + y$.

54 **Evaluate:** $(27^2 - 23^2) + (14^2 - 6^2)$

Correct answer: A · 360

Apply the **difference of squares** identity $a^2 - b^2 = (a - b)(a + b)$ to each grouped term. Compute $(27 - 23)(27 + 23) = 4 \times 50 = 200$. Compute $(14 - 6)(14 + 6) = 8 \times 20 = 160$. Add the products to reach $200 + 160 = 360$.

Why the other answers are wrong

- **B) 80**: Evaluates $(27 - 23)^2 + (14 - 6)^2 = 16 + 64 = 80$. This reverses the operation sequence by squaring the differences instead of calculating the difference of the squares.
- **C) 40**: Calculates $200 - 160 = 40$. A **sign error** replaces the required addition with a subtraction between the two partial results.
- **D) 840**: Combines the factors prematurely as $(4 + 8)(50 + 20) = 12 \times 70 = 840$. This **invalid grouping** alters the algebraic structure of the expression.
- **E) 1680**: Multiplies the previous result by two to get 1680. This introduces a **redundant factor** that doubles the value without justification.

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55 **Given that $2\log_{10}(x) - 3 = \log_{10}(y)$**
Express y in terms of x.

Correct answer: A · $y = \frac{x^2}{1000}$

To express y in terms of x, apply logarithmic identities step by step: 1. **Move the constant** 3 to the right side: $2\log_{10} x = \log_{10} y + 3$. 2. Rewrite 3 as $\log_{10} 10^3 = \log_{10} 1000$: $2\log_{10} x = \log_{10} y + \log_{10} 1000$. 3. Apply the **product rule** ($\log a + \log b = \log ab$): $2\log_{10} x = \log_{10}(1000y)$. 4. Use the power rule ($k \log a = \log a^k$): $\log_{10} x^2 = \log_{10}(1000y)$. 5. Drop the logarithms and **solve for y** by dividing both sides by 1000, yielding $y = \frac{x^2}{1000}$.

Why the other answers are wrong

- **B)** $y = \frac{2x}{1000}$: Retains the factor 2 as a linear multiplier of x instead of converting it into an exponent, revealing a misapplication of the power rule.
- **C)** $y = \frac{2x}{3}$: Mishandles both the coefficient 2 and the constant 3 as straightforward algebraic divisors, ignoring their logarithmic roles entirely.
- **D)** $y = \frac{x^2}{3}$: Fails to convert the constant 3 into $\log_{10} 1000$, incorrectly placing the raw number 3 in the denominator.
- **E)** $y = x^2 - 3$: Tries to retain the subtraction of 3 after removing the logarithm, which violates the rule that additive constants inside logarithms become multiplicative factors upon exponentiation.

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56 **The arithmetic mean of the three numbers a, b, c is 8.**
Find the arithmetic mean of the four numbers: a + 1, b + 2, c + 6, 3.

Correct answer: A · 9

1. The mean of a, b, and c is 8, so their **combined sum equals 24**. 2. The new set includes $a + 1$, $b + 2$, $c + 6$, and the **additional value 3**. 3. Their total is: $(a + b + c) + 1 + 2 + 6 + 3 = 36$ 4. Dividing this **total sum 36** by the count of 4 numbers yields 9.

Why the other answers are wrong

- **B) 7**: Missing the extra term 3 leads to an incomplete average like 28 divided by 4.
- **C) 5**: Applying the raw formula $(8 + 1 + 2 + 6 + 3)/4$ ignores the established **base sum 24**.
- **D) 11**: Counting the constant adjustments as 11 instead of 12 creates a flawed intermediate result.
- **E) 27**: Skipping the final division step leaves the raw accumulated total instead of the requested mean.

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57 **An aluminium block of mass 2.5 kg is supplied with 9000 J of thermal energy. This causes its temperature to rise by 4 K.**

Which expression gives the specific heat capacity of this aluminium, from this data?

[Assume that the block remains solid throughout, and that no additional energy is exchanged between the block and the surroundings.]

Correct answer: A · $\frac{9000}{2.5\times4}\ \mathrm{J\ kg^{-1}\ K^{-1}}$

The equation linking **thermal energy**, **mass**, and **temperature rise** is $Q = mc\Delta T$. Rearranging for **specific heat capacity** gives $c = \frac{Q}{m\Delta T}$. Substituting the data places the energy in the **numerator** and both remaining variables in the **denominator**, yielding $900\ \mathrm{J\,kg^{-1}\,K^{-1}}$.

Why the other answers are wrong

- **B)** $9000 \times 2.5 \times 4\ \mathrm{J\ kg^{-1}\ K^{-1}}$: Multiplies the energy by mass and temperature rise instead of dividing, creating a value 100 times too large. This operation fails dimensional analysis by producing $\mathrm{J^3\,kg\,K}$ units.
- **C)** $\frac{2.5\times4}{9000}\ \mathrm{J\ kg^{-1}\ K^{-1}}$: Inverts the fraction by placing energy in the denominator and the physical quantities in the numerator. This yields the reciprocal value $\frac{1}{100}$ of the correct result and generates $\mathrm{kg\,K\,J^{-1}}$ units.
- **D)** $\frac{9000\times2.5}{4}\ \mathrm{J\ kg^{-1}\ K^{-1}}$: Fails to divide by mass while incorrectly including it in the numerator. The scaling error results in a value 2.5 times too large and breaks dimensional consistency with $\mathrm{J^2\,kg^{-1}}$ units.
- **E)** $\frac{9000\times4}{2.5}\ \mathrm{J\ kg^{-1}\ K^{-1}}$: Correctly uses mass in the denominator but erroneously multiplies by the temperature rise. This arithmetic mistake increases the result by a factor of 4 and produces invalid units of $\mathrm{J^2\,K\,kg^{-1}}$.

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58 **The diagram shows a car of mass 1000 kg travelling at a constant speed of 30 m/s in the direction shown along a flat, level road which forms a circle of radius 50 m.**

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx2188d1818.png?alt=media&token=81270162-3368-49a4-9fe8-e8f9b4c17f94<i>

Which row in the table gives both the magnitude of the resultant force on the car and the direction of the acceleration of the car at the instant shown?

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/IMAT%2FIMAT_Quizzes%2F83333f43a5850013b1e7f1dd269dc83201ec952a.png?alt=media&token=423c0441-d4dc-409c-89da-d3c84bfd8f54<i>

Correct answer: A · row 3

The car undergoes uniform circular motion, so the net force acts as a **centripetal force** calculated with $F = \frac{mv^2}{r}$. Substituting the given values yields $F = \frac{1000\ \mathrm{kg}\times(30\ \mathrm{m/s})^2}{50\ \mathrm{m}} = 18\,000\ \mathrm{N}$, which equals **18 kN**. The acceleration vector is always **directed towards the centre** of the path, corresponding to R in the diagram. Row 3 matches both the correct magnitude and direction.

Why the other answers are wrong

- **B) row 2**: Row 2 lists the correct force magnitude but points Q vertically instead of horizontally towards the centre.
- **C) row 1**: Row 1 claims a zero resultant force, which would imply no acceleration, contradicting the required centripetal acceleration.
- **D) row 4**: Row 4 gives an incorrect magnitude of 30 kN and an incorrect vertical direction Q.
- **E) row 5**: Row 5 also uses the wrong magnitude of 30 kN and indicates P, which points outward opposite to the required inward force.

59 **Two forces F of equal magnitude act on a beam.**
Which diagram shows a couple acting and states the magnitude of the torque (moment) of the couple about the pivot?

[The pivot is at the centre of the beam]

Correct answer: D · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2esuudaquduw1d%C3%B9.png?alt=media&token=850c202b-cf3f-4510-8084-40a3dc8f50c0<i>

A couple requires two forces that are **equal** in magnitude and **opposite** in direction, separated by a perpendicular distance d. The resultant translational force vanishes while the system generates a **torque** of magnitude $F \times d$. Diagram D places both forces at distance a from the centre, making the perpendicular separation $2a$. The calculated moment $F \times 2a = 2Fa$ matches the diagram label exactly.

Why the other answers are wrong

- **A) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Facd139c9dkack.png?alt=media&token=716aa31a-5450-4dc8-b554-55912f387f41<i>**: The forces point in the same direction, producing a **resultant** force of $2F$. A single directional pull cannot satisfy the opposing force requirement for a couple.
- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F8scccj1ccc.png?alt=media&token=2ddb6b8e-1830-4576-b3d0-5527330c3bc7<i>**: The opposing forces sit at different distances from the pivot, creating unequal clockwise and anticlockwise moments. This asymmetry prevents a pure rotational effect.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fcxjcqucquuc1c.png?alt=media&token=55f5318f-0309-47c5-8234-2b4fe0844a80<i>**: Identical force directions combine into a translational push of $2F$. Since a couple must have zero net force, the arrangement remains invalid regardless of the stated value.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fdw1w881c8c1.png?alt=media&token=5ee580ed-cfcc-4980-a43f-8cc9217c384b<i>**: The geometric arrangement correctly forms a couple, but the diagram lists the moment as $F \times a$ instead of $F \times 2a$. The written magnitude is therefore exactly half the correct turning effect.

60 **Which one of the following equations is dimensionally consistent (has consistent units)?**

[All the symbols have their usual meanings:

$v =$ velocity; $F =$ force; $m =$ mass; $t =$ time; $V =$ voltage; $Q =$ charge; $R_1, R_2, R_3, R_4 =$ resistance**]**

Correct answer: A · electrical current $= (V/R_1) + (Q/t)$

Every term in a valid equation must share identical physical dimensions. The left-hand side represents **current**. This quantity dimensionally equals charge per second ($[\mathrm{C\,s^{-1}}]$). The first right-hand term derives from Ohm's law (V/R). It matches this dimension exactly. The second right-hand term defines current as charge divided by time (Q/t). Both additions share the same units as the left-hand side. Therefore the equation is consistent.

Why the other answers are wrong

- **B) acceleration** $= \left(1/2vt^2\right) + (F/m)$: The left-hand side requires acceleration ($[\mathrm{L\,T^{-2}}]$). The first right-hand term multiplies velocity by time squared ($v\,t^2$). This produces length times time ($[\mathrm{L\,T}]$). This value does not match the target dimension. The second right-hand term divides force by mass (F/m). This correctly yields acceleration. Adding it to the first term mixes incompatible units. The two operands lack a common dimension.
- **C) energy** $= \left(1/2mv^2\right) + Fv$: The left-hand side demands energy ($[\mathrm{M\,L^2\,T^{-2}}]$). The kinetic energy term ($\frac{1}{2}mv^2$) correctly provides this dimension. The second term multiplies force by velocity ($F\,v$). This results in power ($[\mathrm{M\,L^2\,T^{-3}}]$). Energy and power possess distinct dimensions. Their sum cannot equal the left-hand side quantity.
- **D) resistance** $= R_1 + R_2 + (1/R_3) + (1/R_4)$: The left-hand side specifies resistance (Ω). The first two addends are valid resistances (R_1, R_2). They measure in ohms. The last two addends represent conductance ($1/R_3$, $1/R_4$). They measure in siemens (Ω^{-1}). Physical quantities with inverse units cannot be algebraically summed. The expression becomes dimensionally invalid.
- **E) temperature change = energy × m × specific heat capacity**: The left-hand side tracks temperature change (K). The right-hand side multiplies energy (J). It also multiplies mass (kg). Finally it multiplies specific heat capacity ($\mathrm{J\,kg^{-1}\,K^{-1}}$). This product evaluates to joules squared per kelvin ($\mathrm{J^2\,K^{-1}}$). An extra energy factor remains. The result does not reduce to a temperature scale.

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