PROVE UFFICIALI DEGLI ANNI PASSATI

IMAT 2019

PROVA UFFICIALE MUR

Con le risposte

ALLENATI SULL'APP TESTBUDDY

TESTBUDDY.IT

WHAT'S IN THIS DOCUMENT

Prova di ammissione IMAT 2019, 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	17 questions
Chemistry	12 questions
Physics and Mathematics	8 questions
Total	**59 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.

Ministero dell'Istruzione, dell'Università e della Ricerca

B10537

ADMISSION TEST FOR THE DEGREE COURSE IN MEDICINE AND SURGERY

Academic Year 2019/2020

Cambridge Assessment Admissions Testing

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1 A study involving a brain-training exercise was carried out on more than a thousand adults aged 65 and over, some of whom later developed dementia. Results showed that the benefits of the five-week mental agility course undertaken by some of the adults lasted for at least five years. This led to an improvement in everyday activities such as money management and the ability to do housework. If those with trained brains developed dementia, they did so later than those in the control group. The results also showed that, for those people in the study who developed dementia, after the diagnosis their mental decline occurred faster than for those who had not undertaken the training.

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

A Keeping the mind active delays the onset of dementia.

B All over-65s who undertake brain training live for at least five years afterwards.

C Older people do not perform mentally challenging tasks unless forced to do so.

D People do a decreasing amount of housework as they grow older.

E It is preferable to have swift mental decline once dementia develops.

2 Once again it has become fashionable for householders to replace their carpets with wooden floors. Sales of laminate and solid floors, such as oak, have seen a massive increase in the last ten years. This trend seems more in tune with our eco-friendly aspirations: carpets are often plastic-based and use vast quantities of underlying material, or underlay, made from petrochemicals. For this reason, it seems unlikely that wooden floors will go out of fashion in the near future.

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

A Most types of laminate and wood floors use petrochemicals in their manufacture.

B Not all wooden floors need a layer of underlay.

C Carpets can harbour dust mites and allergens.

D Sales of carpets made of synthetic materials have decreased in the last ten years while woollen carpets have seen an increase.

E Wooden floors may look longer-lasting but can be more easily damaged than carpets.

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3 According to the current mainstream scientific view, Near Death Experiences (NDEs) are explicable in purely physiological terms. Specifically, they are caused by cerebral anoxia (oxygen deficiency in brain tissue), which occurs in a dying brain. On the other hand, recent research on hundreds of successfully resuscitated cardiac patients found that only twenty per cent reported NDEs. If NDEs had purely medical causes then most of the patients should have experienced them, since they had all been clinically dead and experienced cerebral anoxia. NDEs therefore do not have purely physiological causes.

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

A NDEs are not necessarily caused by physical events alone.

B Not all clinically dead patients have NDEs.

C NDEs are a physical property of the human brain.

D NDEs are caused by oxygen deficiency in the brain.

E Not all successfully resuscitated cardiac patients have NDEs.

4 Increasingly, the quality of a teacher, and of his or her lessons, is to be judged by feedback from their pupils. This is dangerous, as pupils have a tendency to focus too much on whether or not they enjoyed the lesson, in other words, on how much 'fun' they found it. The purpose of education, however, is not to keep children entertained; it is not to make their lives more fun. Arguably, it is not even to make them happier, per se. The purpose of schools is to make their pupils better, more educated people. This is all that matters, and therefore it is whether the teacher succeeds at this – not at being a children's entertainer – that counts.

Which one of the following is a flaw in the above argument?

A It fails to consider that enjoying lessons could result in pupils ending up better educated.

B By simply asserting that the purpose of education is not even to make people happier, the argument rests on a questionable contention.

C It patronises young people by thinking that their judgement will be based solely on how much fun they found the lesson.

D It doesn't specify precisely what it means by making someone a better, more educated person.

E The comparison with being a children's entertainer is an unfair exaggeration of what a teacher tries to do by making lessons more fun.

5 Researchers have tried to establish reasons for a recent drop in the catch of marlin near the Madeira coast. This drop cannot be explained by environmental conditions; there was no significant change in the temperature or composition of the region's water. Nor could one blame the human factor, because the size of the fishing fleet, catch quotas and pollution levels have been strictly observed. The environmentalists then analysed the records of the fishing catch of marlin over the last six centuries. This research identified that regular five-year periods of significant decrease in the catch alternated with fifteen-year periods of gradual growth of the catch. In view of this, the study concluded that the current drop in the marlin catch is part of a long-term cycle related to fish migration and food-chain balance.

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

A The records provide accurate information about the catch of marlin off the Madeira coast.

B The change in fishing technology has affected the change in the fishing catch.

C There is no correlation between the fishing catch today and the deep-sea stock of marlin in the sixteenth century.

D The fishing catch of marlin around Madeira does not depend on the condition of the water around the island.

E Climate change did not affect the temperature of ocean water off the Madeira coast.

6 A student packs books into a box which is 20 cm high, 30 cm wide, and 40 cm long. She ties string around the box in the pattern shown. A further 20 cm of string is needed for a knot.



What length of string is needed to tie up her box?

A 3.8 m

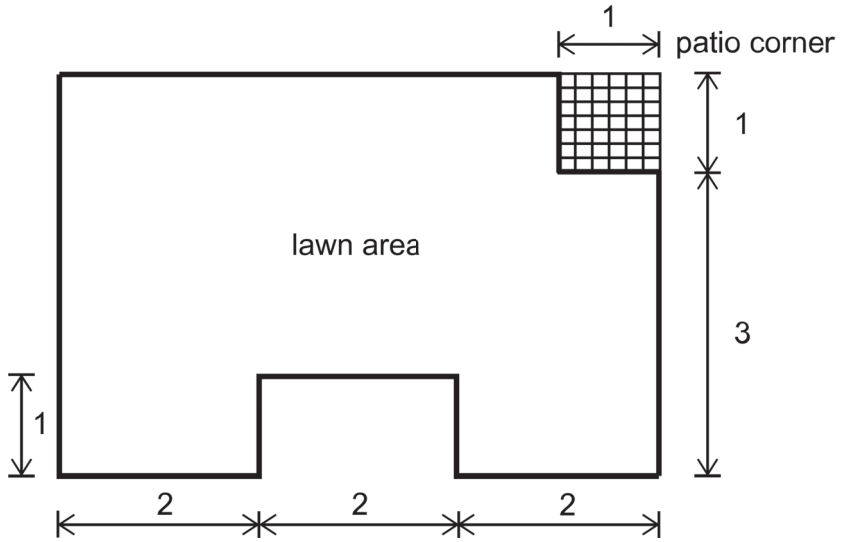
B 5.4 m

C 2.0 m

D 2.6 m

E 2.9 m

7 The plan of a domestic lawn with dimensions in metres is shown below.



The lawn area is to be reseeded. Seed must be applied at the rate of 50 grams per square metre.

Appropriate grass seed is available only in the following quantities:

grass seed packet prices	
1.6 kg	£20.00
1.2 kg	£16.50
1.0 kg	£14.00
500 g	£8.00
200 g	£3.00
100 g	£2.00

What is the least amount of money that needs to be spent to buy sufficient seed to reseed the lawn?

A £16.00

B £13.50

C £14.00

D £16.50

E £22.00

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8 Five girls competed in five events at their sports day. The following scoring system was used for each event:

1st place	6 points
2nd place	3 points
3rd place	1 point
4th/5th place	0 points

Before the events started, each girl nominated the event in which they wished to play their joker card – this doubled the number of points gained in that event. The table below shows the results of each event and the athletes' final points scores:

competitor	*800 m run*	*100 m hurdles*	*high jump*	*long jump*	*shot put*	*total points scored*
Tia	4th	1st	5th	3rd	3rd	14
Jessica	1st	3rd	1st	5th	4th	19
Carolina	3rd	4th	2nd	1st	2nd	14
Kelly	2nd	2nd	4th	2nd	5th	12
Helena	5th	5th	3rd	4th	1st	13

How many of the girls won the event in which they had elected to play their joker?

A 3

B 1

C 2

D 4

E 5

9 At the Shawilde Theatre, tickets are priced as follows:

Front stalls £35
Centre stalls £28
Rear stalls £20

Every row in the theatre contains 30 seats.

Last night's performance was a sell-out and the ticket sales were £21 000. Exactly 60% of this income came from tickets for the centre stalls, and the rest was split equally between the front stalls and the rear stalls.

How many rows of seats make up the centre stalls at the Shawilde Theatre?

A 15

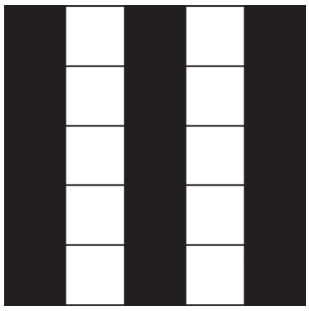
B 11

C 19

D 22

E 26

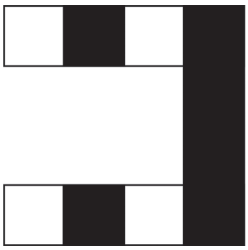
10



Four of the following five pieces can be fitted together to make the above pattern.

Which one of the pieces is NOT needed?

A



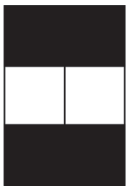
B



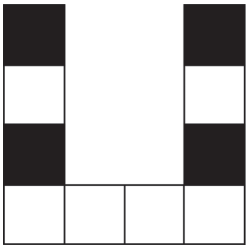
C



D



E



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11 Which one of the following literary works does NOT originate in the corresponding country?

A The Poems of Rumi – China

B The Tale of Genji – Japan

C Oedipus Rex – Greece

D The Divine Comedy – Italy

E Don Quixote – Spain

12 Which one of the following composed the opera *Madama Butterfly*?

A Giacomo Puccini

B Giuseppe Verdi

C Gioachino Rossini

D Georges Bizet

E Richard Wagner

13 Which one of the following plays by William Shakespeare is NOT set in Italy?

A A Midsummer Night's Dream

B Much Ado About Nothing

C Othello

D The Taming of the Shrew

E Romeo and Juliet

14 Which one of the following writers is the author of the novel *To Kill a Mockingbird*?

A Harper Lee

B Georges Simenon

C Iris Murdoch

D Elena Ferrante

E Ernest Hemingway

15 The 'prisoner's dilemma' is a common example analysed in the field of

A Game theory

B Chaos theory

C Asymptotic theory

D Network theory

E Quantum theory

16 Who was the first woman to be awarded a Nobel Prize?

A Marie Curie

B Mother Teresa

C Grazia Deledda

D Selma Lagerlöf

E Doris Lessing

17 Which one of these events in world history happened most recently?

A The October Revolution in the Russian Empire

B The fall of the Western Roman Empire

C The Taiping Rebellion in China

D The building of the Taj Mahal

E The crowning of Charlemagne

18 Which one of the following religions is NOT considered to have been revealed to or founded by an individual?

A Hinduism

B Confucianism

C Islam

D Christianity

E Buddhism

19 The governance of modern states is often based on the separation of which three powers?

A Legislative – executive – judicial

B Legislative – elective – jurisprudential

C Electoral – regulatory – jurisprudential

D Regulatory – executive – judicial

E Legislative – elective – executive

20 The Constitution of the Italian Republic was enacted on 22 December 1947 by

A The Constituent Assembly

B The Supreme Court

C The Ministry of Justice

D The Ministry of Defence

E The Government

21 Which one of the following is NOT a stated purpose of the United Nations?

A To encourage peaceful trade between nations

B To maintain international peace and security

C To develop friendly relations among nations

D To achieve international co-operation in solving international problems

E To be a centre for harmonizing the actions of nations

22 Which one of the following countries did NOT adopt the coins and banknotes of the Euro as its currency on 1 January 2002?

A Sweden

B Austria

C Portugal

D Luxembourg

E Finland

23 Which of the following rows are correct about these naturally occurring biological molecules?

	biological molecule	*presence of carboxylic acid groups*	*presence of 2 or more hydroxyl groups*
row 1	ALL amino acids	yes	no
row 2	glucose	no	yes
row 3	glycerol	no	no
row 4	ALL fatty acids	yes	no

A 1, 2 and 4 only

B 1, 2 and 3 only

C 1, 3 and 4 only

D 2, 3 and 4 only

E 1, 2, 3 and 4

24 Which of the following is/are tissues?

1 cartilage

2 skin

3 endothelium

A 1 and 3 only

B 1, 2 and 3

C 1 and 2 only

D 2 and 3 only

E 1 only

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25 Which of the following statements about the metabolism of plants is/are correct?

1 CO_2 is produced during the day.

2 CO_2 is produced at night.

3 The CO_2 produced can be used by the plant.

A 1, 2 and 3

B 1 only

C 2 only

D 2 and 3 only

E 1 and 2 only

26 Which one of the following occurs during anaphase of mitosis in a healthy human liver cell?

A Sister chromatids are pulled by the spindle fibres towards opposite poles of the cell.

B Chromatin condenses so that the chromosomes are visible under the microscope.

C Chromosomes move towards the equator of the cell and attach to the spindle fibres.

D DNA replicates so that each chromosome is made up of two sister chromatids.

E Centrioles migrate to opposite poles of the cell and help to assemble the spindle fibres.

27 Which row shows a correct component of each of the three structures listed?

	viral envelope	*capsid*	*genetic material*
row 1	glycogen	glycosidic bonds	adenine
row 2	glycosidic bonds	glycogen	ester bonds
row 3	phosphodiester bonds	hydrogen bonds	amino acids
row 4	fatty acids	amino acids	phosphodiester bonds
row 5	phosphate	phosphodiester bonds	cytosine

A row 4

B row 2

C row 3

D row 1

E row 5

28 Beetroot is a root vegetable with cells that contain a red pigment. Normally the pigment cannot pass out of the cells because it cannot diffuse through their cell surface membranes. An investigation was carried out into the effect of various chemicals on the permeability of the cell surface membranes of beetroot cells.

1 cm^3 samples were cut from the beetroot and washed in running water for 20 minutes to remove any pigment that was released from the damaged cells.

Five experiments were carried out. In each experiment, one cube of beetroot was placed in liquid P and one cube placed in liquid Q, and the results were observed.

Which row shows the correct results and conclusions?

Key
✓ does happen
x does not happen

		result	*conclusion*		*result*	*conclusion*
	liquid P	*liquid P turns red*	*phospholipids dissolve*	*liquid Q*	*liquid Q turns red*	*protein denatures*
row 1	dilute HCl	x	x	water at 20 °C	✓	✓
row 2	dilute HCl	✓	✓	ethanol	✓	✓
row 3	ethanol	✓	✓	dilute HCl	✓	✓
row 4	ethanol	x	x	water at 20 °C	✓	✓
row 5	water at 20 °C	✓	✓	dilute HCl	x	x

A row 3

B row 2

C row 1

D row 4

E row 5

29 If a cell divides by mitosis ten times, what is the number of cells at the end of the process?

[Assume that all cells remain alive.]

A 1024

B 10

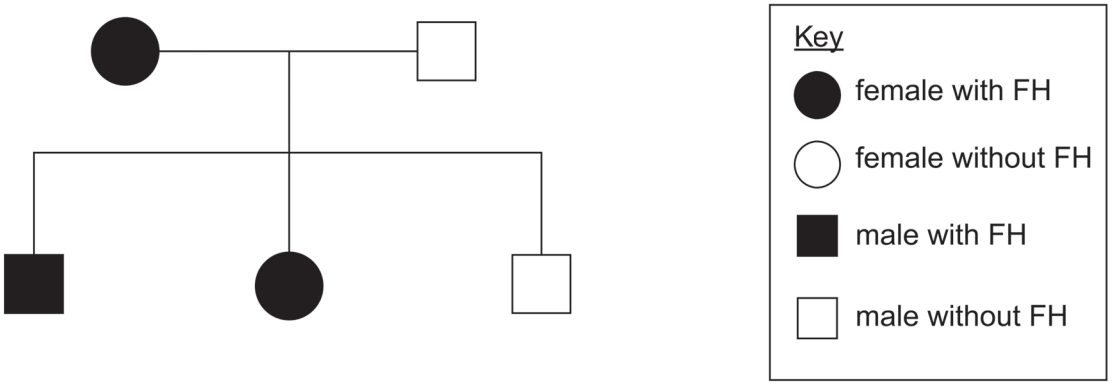
C 100

D 64

E 11

30 Familial hypercholesterolaemia (FH) is an inherited disease caused by a dominant allele. People with FH have high concentrations of cholesterol in the blood, which can lead to an increased risk of coronary heart disease.

The family tree shows the inheritance of this disease in one family.



Which row shows the number of individuals in the family tree with each genotype?

	genotype		
	homozygous dominant	*homozygous recessive*	*heterozygous*
row 1	3	2	0
row 2	2	3	0
row 3	0	2	3
row 4	0	3	2
row 5	3	0	2

A row 3

B row 2

C row 1

D row 4

E row 5

31 The diagrams show some pathways between the central nervous system and effector organs in a healthy human.

Which pathway is a possible route for impulses passing along a parasympathetic neuron?

A



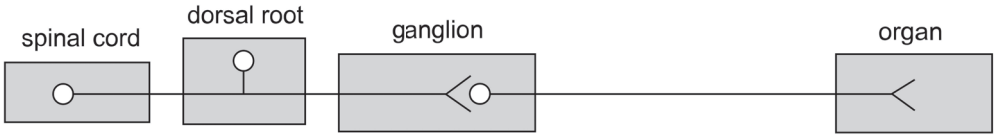
B



C



D



E



32 An electron microscope (EM) was used to view a cell.

The maximum dimension of the cell was observed at a magnification ×30 000. The image on the EM screen showed a maximum length of 30 mm.

Which of the following mature healthy cells was being magnified?

A one coccus bacterium in a Staphylococcus cluster

B one lymphocyte from a human

C one mature human red blood cell

D one sensory neuron from a human

E one palisade cell from a wheat plant

33 Which statement about an enzyme involved in genetic modification is correct?

A A restriction enzyme causes phosphodiester bonds to be broken.

B A ligase causes phosphodiester bonds to be broken.

C A restriction enzyme causes H-bonds to form between sticky ends.

D A restriction enzyme causes only H-bonds to be broken.

E A ligase causes H-bonds to form between sticky ends only.

34 Which statement is correct in healthy humans?

A In active tissues where the carbon dioxide concentration is high, haemoglobin has a low affinity for oxygen.

B Blood leaving active muscles that are respiring aerobically will contain hydrogencarbonate ions and raised levels of lactic acid.

C At a low partial pressure of oxygen, myoglobin is less saturated with oxygen than haemoglobin.

D Increasing the partial pressure of oxygen makes it more likely that haemoglobin will release its oxygen.

E The majority of carbon dioxide transported in the blood is in the form of carbaminohaemoglobin.

35 Which of the following regions within a sarcomere remain UNCHANGED in length when a healthy human muscle cell contracts?

1 A-band

2 I-band

3 H-zone / band

A 1 only

B 2 only

C 3 only

D 1 and 3 only

E 2 and 3 only

36 Which row is correct for the three given features of typical human B lymphocytes?

Key
✓ correct
x incorrect

	formed from bone marrow stem cells	*processed in the thymus*	*contain genes coding for antibodies*
row 1	✓	✓	✓
row 2	✓	✓	x
row 3	✓	x	✓
row 4	x	x	✓
row 5	x	✓	x

A row 3

B row 2

C row 1

D row 4

E row 5

37 Which of the following processes involve ions?

1 contraction of a muscle

2 transmission of a nerve impulse across a synapse

3 transfer of light energy into chemical energy in photosynthesis

4 oxidative phosphorylation in a mitochondrion

A 1, 2, 3 and 4

B 2 and 3 only

C 3 and 4 only

D 1, 2 and 3 only

E 1 and 2 only

38 An animal has a coat that has some patches of white hair and some patches of black hair. Cells that make up a hair follicle form a single hair, which is either white or black.

Assume that there are no mutations following formation of the zygote.

A student wrote the following statements:

1 The cells in all the hair follicles contain the same genes.

2 The alleles in a hair follicle forming a white hair are different from the alleles in the hair follicle forming a black hair.

3 Each white hair follicle cell contains two recessive alleles.

Which statement(s) is/are correct?

A 1 only

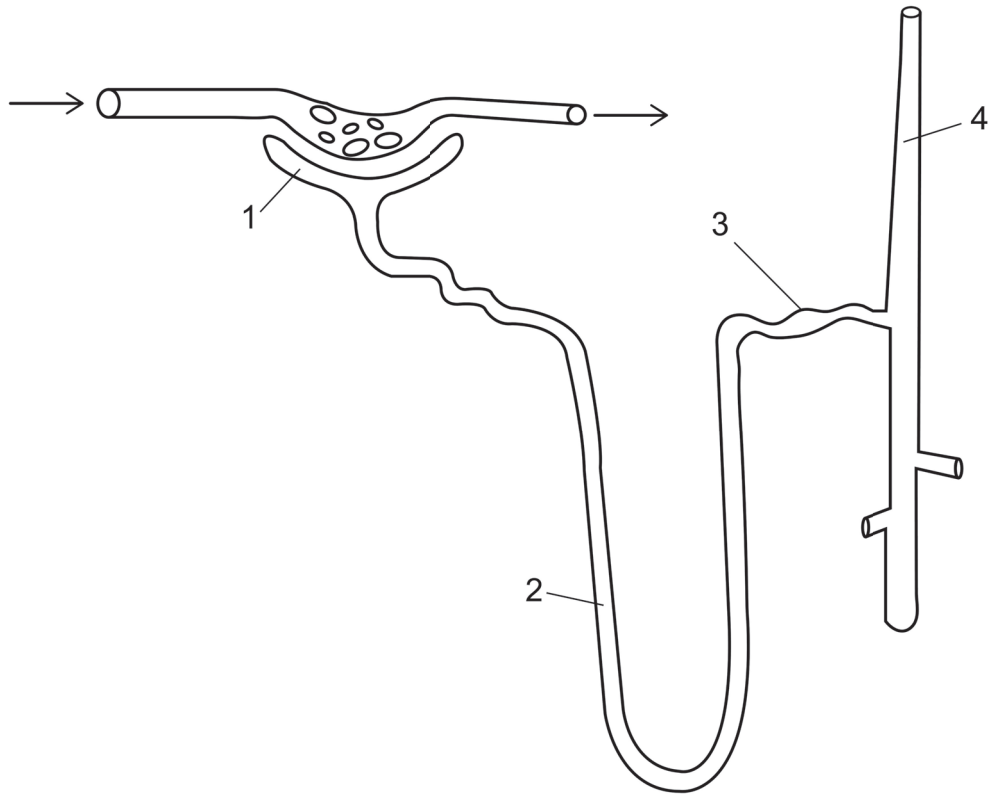
B 2 only

C 1 and 2 only

D 2 and 3 only

E 1, 2 and 3

39 The diagram shows a nephron with collecting duct from a healthy human.



Which of the regions (1-4) contain a liquid with no urea?

A none of them

B 1 only

C 1 and 2 only

D 2 and 3 only

E 2, 3 and 4 only

40 The same section of an allele coding for five amino acids from two different individuals, P and Q, is shown.

P	ATTCCGGGATTCCCT
Q	ATTCCGGATTGCACT

Which of the following types of mutation could explain the differences between P and Q?

1 addition

2 deletion

3 substitution

A 1, 2 and 3

B 1 only

C 1 and 3 only

D 2 and 3 only

E none of them

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41 Which statement about a positive ion explains why it is positively charged?

A The ion has more protons than electrons.

B The ion has more electrons than neutrons.

C The ion has more electrons than protons.

D The ion has more protons than neutrons.

E The ion has the same number of protons and neutrons.

42 A few drops of universal indicator solution were added to exactly 50 mL of sodium hydroxide solution, NaOH, of concentration 1 mol / L. Exactly 50 mL of hydrochloric acid, HCl, of concentration 1 mol / L, was added drop by drop to the sodium hydroxide solution containing the universal indicator solution.

What colour changes would be observed as the hydrochloric acid was added?

A violet → blue → green

B red → orange → yellow → green

C violet → blue → green → yellow → orange → red

D blue → red

E red → orange → yellow → green → blue → violet

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43 A student observed that when powdered sugar at $-1\,^{\circ}C$ was added to ice at $-1\,^{\circ}C$ all of the ice melted.

Which of the following statements explain this observation?

1 Sugar has given the water molecules energy.

2 The melting point of the mixture is higher.

3 The melting point of the mixture is lower.

A 3 only

B 2 only

C 1 only

D 1 and 2 only

E 1 and 3 only

44 Which of the following pairs of structural formulae represent structural isomers?

1 CH_3CH_2OH and CH_3OCH_3

2 $CH_3CH(CH_3)CH_2CH_2CH_3$ and $CH_3CH_2CH_2CH(CH_3)CH_3$

3 $CH(OH)=CHCH_2OH$ and CH_3CH_2COOH

A 1 and 3 only

B 2 only

C 1 only

D 2 and 3 only

E 1, 2 and 3

45 Element Z reacts with water at room temperature and hydrogen gas is released.

The oxide of element Z is a solid at room temperature and does not conduct electricity. The oxide reacts with acids and has the formula ZO.

To which group/part of the Periodic Table does element Z belong?

A Group II

B Group I

C Group III

D Transition metals

E Group VII

46 Which of the following equations represent(s) a redox reaction?

1 $4LiH + AlCl_3 \rightarrow 3LiCl + LiAlH_4$

2 $N_2O_3 + 3H_2O \rightarrow 2H_3O^+ + 2NO_2^-$

3 $NH_4NO_3 \rightarrow 2H_2O + N_2O$

A 3 only

B 2 only

C 1 and 2 only

D 1 and 3 only

E 1, 2 and 3

47 Which of the following molecules have an overall permanent dipole moment?

1 CO_2

2 H_2O

3 NH_3

[C is in Group IV, N is in Group V, O is in Group VI]

A 2 and 3 only

B 1 and 2 only

C 1 and 3 only

D none of them

E 1, 2 and 3

48 Why does hydrogen iodide (HI) have a higher boiling point than hydrogen bromide (HBr)?

[Atomic numbers: bromine = 35; iodine = 53]

A The induced dipole-induced dipole (dispersion) forces between HI molecules are stronger than those between HBr molecules.

B The permanent dipole-permanent dipole forces between HI molecules are stronger than those between HBr molecules.

C There are hydrogen bonds between HI molecules but not between HBr molecules.

D The H – I covalent bond is stronger than the H – Br covalent bond.

E The iodide ions in HI are larger than the bromide ions in HBr.

49 What is the minimum mass of sulfur dioxide needed to make 500 mL of a solution of concentration 3.0 mol / L?

[A_r values: O = 16; S = 32]

A 96 g

B 48 g

C 32 g

D 192 g

E 384 g

50 A compound consists of carbon, hydrogen and oxygen only.

8 g of this compound contains 3 g of carbon and 1 g of hydrogen.

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

[A_r values: C = 12; H = 1; O = 16]

A CH_4O

B CH_2O

C C_2H_4O

D C_2H_8O

E C_3HO_4

51 Hydrogen has a radioactive isotope called tritium. Tritium atoms have two neutrons.

The most abundant naturally occurring isotope of hydrogen has a relative atomic mass of 1.0.

What is the value for the relative atomic mass of a sample of hydrogen gas that has an equal amount of these two isotopes of hydrogen?

A 2.0

B 1.0

C 1.5

D 3.0

E 4.0

52 Consider the following reversible reaction at temperature *T*.

$$A + 2B \rightleftharpoons 2C + D$$

At equilibrium, there are 0.5 moles of A, 0.2 moles of B, 0.5 moles of C and 0.8 moles of D, all in a vessel of volume *V*.

What is the value of the equilibrium constant, K_c, at this temperature?

A 10

B 4

C 2

D 0.25

E 0.1

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53 Which of the following expressions is equal to $\frac{8^{2n} \times 4^{n}}{2^{n}}$ for all integers n?

A 2^{7n}

B 2^{6n}

C 2^{6n+1}

D 2^{2n+5}

E 2^{14n}

54 The mean mass of three babies is 2.1 kg. The range of their masses is 0.7 kg. The lightest baby has a mass of 1.8 kg.

What is the median mass of the three babies?

A 2.0 kg

B 1.95 kg

C 2.1 kg

D 2.15 kg

E 2.3 kg

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55 What is the highest common factor of 360, 500 and 700, given as the product of powers of its prime factors?

A $2^2 \times 5$

B 2×5

C $2^3 \times 5^3$

D $2^2 \times 3^2 \times 5 \times 7$

E $2^3 \times 3^2 \times 5^3 \times 7$

56 What is the sum of the solutions to the equation $\frac{3}{x} + \frac{2}{x-2} = 1$, where x is a real number and $x \neq 0$ and $x \neq 2$?

A 7

B 5

C -7

D 2.4

E -3

57 A car, which is initially stationary, accelerates for 5.0 seconds at 4.0 m / s^2 along a straight road. It then continues in the same direction for 20 seconds at a constant speed.

What is the maximum speed of the car, and what is the distance travelled by the car in the final 20 seconds of its motion?

A maximum speed = 20 m / s; distance = 400 m

B maximum speed = 20 m / s; distance = 80 m

C maximum speed = 9.0 m / s; distance = 180 m

D maximum speed = 9.0 m / s; distance = 200 m

E maximum speed = 24 m / s; distance = 480 m

58 A stone of density 5.20 g / cm^3 and volume 200 cm^3 is completely submerged in a liquid of density 1.20 g / cm^3.

What is the magnitude of the upthrust acting on the stone?

[gravitational field strength = 10.0 N / kg]

A 2.40 N

B 6.40 N

C 8.00 N

D 10.4 N

E 2.00 N

59 Two charged particles P and Q are 0.10 m apart. The charge on P is 1.50×10^{-7} C and the charge on Q is 1.50×10^{-7} C. Particle P experiences an electrostatic force of magnitude *F* because it is near to the charge on particle Q.

The distance between the two particles is increased to 0.20 m. The charge on P is increased to 4.50×10^{-7} C and the charge on Q is increased to 6.00×10^{-7} C.

What is the magnitude of the force that particle P experiences now?

A 3*F*

B 12*F*

C 6*F*

D $\frac{F}{4}$

E $\frac{3F}{4}$

60 A fixed mass of an ideal gas is compressed at constant temperature. The pressure is recorded continuously as the volume decreases. The pressure (y-axis) and volume (x-axis) are plotted on a linearly scaled graph.

Which statement describes the plotted line?

A a curved line with negative gradient of decreasing magnitude

B a straight line of positive gradient starting at the origin of the graph

C a straight line parallel to the pressure axis

D a straight line parallel to the volume axis

E a curved line of increasing positive gradient starting at the origin of the graph

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ANSWERS AND EXPLAINED SOLUTIONS

The letters are those of the official paper above.

1 **A study involving a brain-training exercise was carried out on more than a thousand adults aged 65 and over, some of whom later developed dementia. Results showed that the benefits of the five-week mental agility course undertaken by some of the adults lasted for at least five years. This led to an improvement in everyday activities such as money management and the ability to do housework. If those with trained brains developed dementia, they did so later than those in the control group. The results also showed that, for those people in the study who developed dementia, after the diagnosis their mental decline occurred faster than for those who had not undertaken the training.**

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

Correct answer: A · Keeping the mind active delays the onset of dementia.

The study found that individuals who completed the mental agility course **developed dementia later** than the control group. This evidence indicates that engaging in cognitive exercises can **delay disease onset**.

Why the other answers are wrong

- **B) All over-65s who undertake brain training live for at least five years afterwards.**: Benefit duration of at least five years does not imply universal survival for that period among all participants.
- **C) Older people do not perform mentally challenging tasks unless forced to do so.**: The text contains no information regarding whether older adults require external pressure to perform cognitively demanding tasks.
- **D) People do a decreasing amount of housework as they grow older.**: The passage states that training improved housework ability, but provides no data on how chores decrease with age.
- **E) It is preferable to have swift mental decline once dementia develops.**: Although trained individuals showed faster decline after diagnosis, the passage never claims this outcome is preferable.

2 **Once again it has become fashionable for householders to replace their carpets with wooden floors. Sales of laminate and solid floors, such as oak, have seen a massive increase in the last ten years. This trend seems more in tune with our eco-friendly aspirations: carpets are often plastic-based and use vast quantities of underlying material, or underlay, made from petrochemicals. For this reason, it seems unlikely that wooden floors will go out of fashion in the near future.**

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

Correct answer: A · Most types of laminate and wood floors use petrochemicals in their manufacture.

The argument predicts that wood flooring will stay popular because it appears more **eco-friendly** than traditional carpeting. Option C states that manufacturing laminate and solid wood products similarly depends on **petrochemicals**. This fact directly **undermines** the environmental justification used to forecast ongoing demand.

Why the other answers are wrong

- **B) Not all wooden floors need a layer of underlay.**: Noting that certain installations skip an underlay layer strengthens the claimed efficiency of hard surfaces rather than providing a valid critique.
- **C) Carpets can harbour dust mites and allergens.**: Reporting that carpets trap dust mites and allergens simply gives homeowners an additional practical motive to switch materials without challenging the ecological premise.
- **D) Sales of carpets made of synthetic materials have decreased in the last ten years while woollen carpets have seen an increase.**: Tracking rising wool carpet sales alongside falling synthetic ones documents market shifts without proving that wooden flooring loses its asserted environmental advantage.
- **E) Wooden floors may look longer-lasting but can be more easily damaged than carpets.**: Acknowledging that wood planks scratch more easily identifies a durability flaw but does not counter the specific sustainability reasoning that drives the current trend.

3 **According to the current mainstream scientific view, Near Death Experiences (NDEs) are explicable in purely physiological terms. Specifically, they are caused by cerebral anoxia (oxygen deficiency in brain tissue), which occurs in a dying brain. On the other hand, recent research on hundreds of successfully resuscitated cardiac patients found that only twenty per cent reported NDEs. If NDEs had purely medical causes then most of the patients should have experienced them, since they had all been clinically dead and experienced cerebral anoxia. NDEs therefore do not have purely physiological causes.**

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

Correct answer: A · NDEs are not necessarily caused by physical events alone.

The passage challenges the **mainstream view** that these phenomena stem solely from reduced blood flow to the brain. Clinical death induces widespread tissue oxygen loss, yet only a minority of survivors report such episodes. If **cerebral anoxia** triggered universal experiences, nearly all clinically dead patients would report them. The observed discrepancy proves that non-biological elements play a role. Consequently, the author concludes that physical mechanisms cannot exclusively explain **purely physiological causes**.

Why the other answers are wrong

- **B) Not all clinically dead patients have NDEs.**: This clause summarizes an empirical result drawn from resuscitation studies. Researchers employ this statistic to bolster their primary thesis instead of presenting it as the ending claim.
- **C) NDEs are a physical property of the human brain.**: The manuscript explicitly rejects the notion that biological triggers provide complete coverage. It highlights the explanatory gaps in current pathology models rather than assigning the phenomenon to fixed neural characteristics.
- **D) NDEs are caused by oxygen deficiency in the brain.**: This option states the orthodox medical hypothesis the text actively disputes. It reflects the initial premise under attack rather than the argument's final deduction.
- **E) Not all successfully resuscitated cardiac patients have NDEs.**: This phrase simply echoes the published data regarding heart attack survivors. The recorded low frequency operates as quantitative evidence proving that medical conditions fail to produce uniform outcomes.

4 **Increasingly, the quality of a teacher, and of his or her lessons, is to be judged by feedback from their pupils. This is dangerous, as pupils have a tendency to focus too much on whether or not they enjoyed the lesson, in other words, on how much 'fun' they found it. The purpose of education, however, is not to keep children entertained; it is not to make their lives more fun. Arguably, it is not even to make them happier, per se. The purpose of schools is to make their pupils better, more educated people. This is all that matters, and therefore it is whether the teacher succeeds at this – not at being a children's entertainer – that counts.**

Which one of the following is a flaw in the above argument?

Correct answer: A · It fails to consider that enjoying lessons could result in pupils ending up better educated.

The argument assumes that student **enjoyment** is irrelevant to learning outcomes. However, positive attitudes may increase classroom **engagement** and improve comprehension. Therefore, feedback about lessons could actually indicate teaching **effectiveness**.

Why the other answers are wrong

- **B) By simply asserting that the purpose of education is not even to make people happier, the argument rests on a questionable contention.**: The argument does not rely on excluding happiness as an aim of education.
- **C) It patronises young people by thinking that their judgement will be based solely on how much fun they found the lesson.**: The text states pupils tend to focus heavily on enjoyment, not that they base their evaluation exclusively on it.
- **D) It doesn't specify precisely what it means by making someone a better, more educated person.**: A precise definition of educational goals is unnecessary to identify the logical gap between enjoyment and academic progress.
- **E)** The comparison to an entertainer is exaggerated but does not address the core issue regarding how pupil feedback relates to educational value.

5 **Researchers have tried to establish reasons for a recent drop in the catch of marlin near the Madeira coast. This drop cannot be explained by environmental conditions; there was no significant change in the temperature or composition of the region's water. Nor could one blame the human factor, because the size of the fishing fleet, catch quotas and pollution levels have been strictly observed. The environmentalists then analysed the records of the fishing catch of marlin over the last six centuries. This research identified that regular five-year periods of significant decrease in the catch alternated with fifteen-year periods of gradual growth of the catch. In view of this, the study concluded that the current drop in the marlin catch is part of a long-term cycle related to fish migration and food-chain balance.**

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

Correct answer: A · The records provide accurate information about the catch of marlin off the Madeira coast.

The conclusion depends on **historical records** spanning six centuries to identify a repeating pattern. For that pattern to support the claim that the current decline belongs to a long term cycle, those records must **accurately reflect** actual catches near Madeira.

Why the other answers are wrong

- **B) The change in fishing technology has affected the change in the fishing catch.**: This points to **technological shifts** as an alternative cause for catch fluctuations. It contradicts the assumption that ecological cycles drive the changes.
- **C) There is no correlation between the fishing catch today and the deep-sea stock of marlin in the sixteenth century.**: The argument does not require a direct correlation between modern catches and sixteenth century fish stocks. It only needs consistent historical patterns overall.
- **D) The fishing catch of marlin around Madeira does not depend on the condition of the water around the island.**: The text states that recent water conditions remained stable. It does not assume that environmental factors never influence catches under different circumstances.
- **E) Climate change did not affect the temperature of ocean water off the Madeira coast.**: The reasoning rests on the absence of a recent temperature shift. It makes no claims about how climate change may have altered ocean temperatures over longer periods.

6 **A student packs books into a box which is 20 cm high, 30 cm wide, and 40 cm long. She ties string around the box in the pattern shown. A further 20 cm of string is needed for a knot.**

What length of string is needed to tie up her box?



Correct answer: A · 3.8 m

1. Identify the three distinct string **paths** wrapping around the box faces. 2. Calculate the **perimeter** of each path using the given dimensions: • Mid-height belt: $2 \times (40\ \text{cm} + 30\ \text{cm}) = 140\ \text{cm}$ • Front-to-back vertical loop: $2 \times (30\ \text{cm} + 20\ \text{cm}) = 100\ \text{cm}$ • Side-to-side vertical loop: $2 \times (40\ \text{cm} + 20\ \text{cm}) = 120\ \text{cm}$ 3. Sum the three lengths and add the extra material needed for the **knot**: $140\ \text{cm} + 100\ \text{cm} + 120\ \text{cm} + 20\ \text{cm} = 380\ \text{cm} = 3.8\ \text{m}$.

Why the other answers are wrong

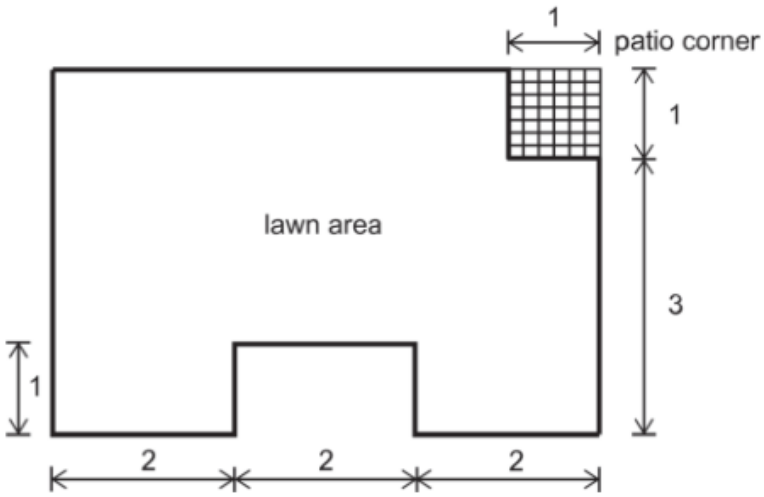
- **B) 5.4 m**: This value is far too large, as it roughly doubles the total required length instead of simply adding the three distinct paths once.
- **C) 2.0 m**: This length is far too short, representing roughly only a single loop rather than combining all required string segments.
- **D) 2.6 m**: This result occurs when only two of the three paths are counted, typically by adding both vertical loops while completely forgetting the horizontal mid-height belt.
- **E) 2.9 m**: This figure does not match any valid mathematical combination of the three calculated perimeters plus the mandatory knot allowance.

7 **The plan of a domestic lawn with dimensions in metres is shown below.**

The lawn area is to be reseeded. Seed must be applied at the rate of 50 grams per square metre.

Grass seed packet prices
1.6 kg = £20.00
1.2 kg = £16.50
1.0 kg = £14.00
500 g = £8.00
200 g = £3.00
100 g = £2.00

Appropriate grass seed is available only in the following quantities:
What is the least amount of money that needs to be spent to buy sufficient seed to reseed the lawn?



Correct answer: A · £16.00

1. The **lawn area** is $(2\ \text{m} \times 4\ \text{m}) + (2\ \text{m} \times 3\ \text{m}) + (2\ \text{m} \times 4\ \text{m}) - (1\ \text{m} \times 1\ \text{m}) = 21\ \text{m}^2$, subtracting the patio. 2. At a rate of $50\ \text{g}\,\text{m}^{-2}$, the **seed required** is $21\ \text{m}^2 \times 50\ \text{g}\,\text{m}^{-2} = 1{,}050\ \text{g}$. 3. The available packs are $1{,}600\ \text{g}$ for £20, $1{,}200\ \text{g}$ for £16.50, $1{,}000\ \text{g}$ for £14, $500\ \text{g}$ for £8, $200\ \text{g}$ for £3, and $100\ \text{g}$ for £2. The **cheapest sufficient combination** is $1{,}000\ \text{g} + 100\ \text{g} = 1{,}100\ \text{g}$ for £16. Combinations of smaller packs cost at least £17, and the larger single packs cost £16.50 or £20.

Why the other answers are wrong

- **B)** £13.50 is below the minimum cost of £16 for enough seed. For example, $500\ \text{g} + 500\ \text{g} + 100\ \text{g} = 1{,}100\ \text{g}$ costs £18; the single packs that provide enough seed cost £16.50 for $1{,}200\ \text{g}$ or £20 for $1{,}600\ \text{g}$.
- **C) £14.00**: A $1{,}000\ \text{g}$ pack costs £14, but it is $50\ \text{g}$ short of the $1{,}050\ \text{g}$ required.
- **D) £16.50**: A $1{,}200\ \text{g}$ pack costs £16.50 and is sufficient, but buying a $1{,}000\ \text{g}$ pack and a $100\ \text{g}$ pack provides $1{,}100\ \text{g}$ for £16.
- **E) £22.00**: £22 is more than necessary. For example, a $1{,}000\ \text{g}$ pack and a $200\ \text{g}$ pack provide $1{,}200\ \text{g}$ for £17, while the least-cost sufficient purchase is £16.

8 **Five girls competed in five events at their sports day. The following scoring system was used for each event:**

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/IMAT%2FIMAT_Quizzes%2F2023-06-21%2015_31_56-2019_IMAT-TaxiTest-mixsol.pdf%20-%20Foxit%20PDF%20Editor.png?alt=media&token=82034267-7883-4e1b-9091-f8c8b8cc55a6<i>

Before the events started, each girl nominated the event in which they wished to play their joker card – this doubled the number of points gained in that event. The table below shows the results of each event and the athletes' final points scores:

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/IMAT%2FIMAT_Quizzes%2F2023-06-21%2015_32_07-2019_IMAT-TaxiTest-mixsol.pdf%20-%20Foxit%20PDF%20Editor.png?alt=media&token=c8b31838-2562-4001-b8fd-fdc11af3f248<i>

How many of the girls won the event in which they had elected to play their joker?

Correct answer: A · 3

1. Each event awards **fixed points** based on finishing order: $1^{\text{st}} = 6$, $2^{\text{nd}} = 3$, $3^{\text{rd}} = 1$, and $4^{\text{th}}/5^{\text{th}} = 0$. 2. Adding each athlete's standard points yields a **baseline total** before the joker is applied: Tia 8, Jessica 13, Carolina 13, Kelly 9, Helena 7. 3. Subtracting these baselines from the published finals reveals the **base points** of the jokered event: Tia 6, Jessica 6, Carolina 1, Kelly 3, Helena 6. 4. A 6-point difference indicates the athlete doubled a **first-place finish**, confirming a win. Three athletes show this gap, while Carolina and Kelly doubled lower values from third and second places respectively. Event placement cross-checks confirm this distribution is fully **consistent**.

Why the other answers are wrong

- **B) 1**: Assuming only one victory leaves too few high-point doublers to cover the calculated gaps for Jessica, Helena, and others. The numerical discrepancies require multiple athletes to have doubled higher values.
- **C) 2**: Limiting wins to two athletes leaves an unresolved point discrepancy for the third competitor who recorded a 6-point gap. The arithmetic strictly demands exactly three successful jokers to align all totals simultaneously.
- **D) 4**: Four victories would necessitate four separate 6-point joker boosts. Since exactly three athletes exhibit a 6-point difference between baseline and final scores, the remaining participant's gap cannot be resolved through a first-place result.
- **E) 5**: Doubling a winning 6-point finish for all five competitors would push every baseline total above the published finals. The data proves that two participants actually doubled lower point values, making a perfect outcome mathematically impossible.

9 **At the Shawilde Theatre, tickets are priced as follows:**

Front stalls £35
Centre stalls £28
Rear stalls £20

Every row in the theatre contains 30 seats. Last night's performance was a sell-out and the ticket sales were £21 000. Exactly 60% of this income came from tickets for the centre stalls, and the rest was split equally between the front stalls and the rear stalls.

How many rows of seats make up the centre stalls at the Shawilde Theatre?

Correct answer: A · 15

1. Calculate the **income** distributed across each seating zone. Centre stalls earned 60% of £21 000, totaling £12 600. The remaining 40% (£8 400) divides evenly, giving £4 200 for both front and rear sections. 2. Convert each monetary total into the corresponding number of **tickets** by applying the specific **ticket prices**. Centre stalls account for $12\,600 \div 28 = 450$ tickets. Front and rear stalls yield $4\,200 \div 35 = 120$ and $4\,200 \div 20 = 210$ tickets respectively. 3. Translate ticket counts into rows using the fixed seat capacity of 30 per row. Centre stalls occupy $450 \div 30 = 15$ rows.

Why the other answers are wrong

- **B) 11**: Multiplying 11 rows by 30 seats and the £28 price gives £9 240, which falls short of the required centre-stall income.
- **C) 19**: Calculating revenue for 19 rows results in £15 960, exceeding the actual earnings for that section.
- **D) 22**: Scaling up to 22 rows produces £18 480, again surpassing the correct financial target.
- **E) 26**: Extending to 26 rows generates £21 840, an amount that actually exceeds the entire evening's gross revenue.

10 **Four of the following five pieces can be fitted together to make the above pattern. Which one of the pieces is NOT needed?**



Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F12xe81e1885855.png?alt=media&token=ab265a6c-66f9-47dc-890c-79e817fde35c<i>

The pattern is **4 columns** wide and **5 units** tall. The two outer columns are solid black bars, while each of the two middle columns is white and divided by four horizontal lines into five panels. B and E fill the outer columns, and C and D fill the middle columns, so A is not needed.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e1287181ije.png?alt=media&token=cb0b46e2-f71e-4610-81fd-480c14d571ce<i>**: It is a 1×5 solid-black bar, needed for one of the outer columns.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fcr9818r128cr818cur.png?alt=media&token=f33221d4-1ce2-4ec9-a3a8-4caa6a42edae<i>**: It is a 1×5 white bar with four horizontal lines, filling one of the middle columns.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fc8128e218eu2je1.png?alt=media&token=b32e7e14-84ab-4b5b-b505-cf9555c0f1cb<i>**: It is another 1×5 white bar with four horizontal divisions, filling the other middle column.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e121812821e.png?alt=media&token=077c453f-8fdb-40ae-a47d-7aac9227f4c7<i>**: It is a second 1×5 solid-black bar, filling the remaining outer column.

11 Which one of the following literary works does NOT originate in the corresponding country?

Correct answer: A · The Poems of Rumi – China

Jalāl al-Dīn Rūmī was a Persian poet and Sufi mystic active in Khorāsān, a historical region spanning modern Afghanistan, Iran, and Turkey. He composed his major works, including the *Masnavi* and various *ghazals*, entirely in classical Persian. Pairing his poetry with China is therefore historically inaccurate. **Why the other options are not the answer Answer A**: Dante Alighieri wrote the text in early fourteenth-century Florence, establishing it as a foundational cornerstone of Italian literature. **Answer B**: Attributed to Murasaki Shikibu in the early eleventh century, the narrative is written in classical Japanese and is widely recognized as the world's first novel. **Answer C**: Authored by the ancient Greek playwright Sophocles during the fifth century BCE, this tragedy firmly belongs to the classical Greek literary canon. **Answer E**: Miguel de Cervantes originally published the work in Spanish across two volumes in 1605 and 1615, cementing its reputation as Spain's greatest literary classic.

Why the other answers are wrong

12 Which one of the following composed the opera Madama Butterfly?

Correct answer: A · Giacomo Puccini

Giacomo Puccini began work in 1901 after David Belasco's stage play. He **premiered at La Scala in 1904** and revised it for modern stages. His **late-Romantic harmony**, **lyrical vocal writing**, and **rich orchestration** align with mature works like La Bohème. This direct association confirms him as the sole author.

Why the other answers are wrong

- **B)** Giuseppe Verdi composed Rigoletto, La Traviata, and Aida. His death in 1901 occurred before the new work was written.
- **C)** Gioachino Rossini belonged to an early 19th-century generation known for The Barber of Seville and William Tell. He had already retired from opera decades before this score appeared.
- **D)** Georges Bizet was a French composer famous for Carmen who died in 1875. This predates the premiere by nearly 30 years, so he never addressed this subject.
- **E)** Richard Wagner created German music dramas like Tristan und Isolde and the Ring cycle. His distinct musical language and thematic focus differ entirely from Puccini's approach, and he did not write this opera.

13 Which one of the following plays by William Shakespeare is NOT set in Italy?

Correct answer: A · A Midsummer Night's Dream

A Midsummer Night's Dream is set in ancient **Athens** and its surrounding woods. Because this location is in **Greece**, it is the only play in the list that lacks an Italian setting.

Why the other answers are wrong

- **B)** Much Ado About Nothing takes place in Messina on Sicily in southern **Italy**.
- **C)** Othello opens in Venice and centers on Venetian society, so it qualifies as an Italy-set play even though part of the action moves to Cyprus.
- **D)** The Taming of the Shrew unfolds in Padua with mentions of Verona, both cities in northern **Italy**.
- **E)** Romeo and Juliet happens entirely in Verona and briefly in Mantua, keeping the entire story within **Italy**.

14 **Which one of the following writers is the author of the novel To Kill a Mockingbird?**

Correct answer: A · Harper Lee

Harper Lee published **To Kill a Mockingbird** in **1960**. The book won the **Pulitzer Prize for Fiction** and became a classic of modern American literature. It remained her most famous work for decades.

Why the other answers are wrong

- **B)** Georges Simenon was a Belgian author famous for his Inspector Maigret detective series and never wrote this novel.
- **C)** Iris Murdoch was a British novelist and philosopher recognized for works such as The Sea, the Sea and Under the Net.
- **D)** Elena Ferrante is the pseudonymous Italian writer known for the Neapolitan Novels, including My Brilliant Friend.
- **E)** Ernest Hemingway was an American Nobel laureate celebrated for novels like The Old Man and the Sea and A Farewell to Arms.

15 **The 'prisoner's dilemma' is a common example analysed in the field of**

Correct answer: A · Game theory

The prisoner's dilemma is a foundational model in **Game theory** used to study **strategic interaction** among rational decision-makers. It frames a scenario where players must choose to **cooperate or defect**, revealing the tension between personal incentives and collective benefit. The analysis centers on concepts like **Nash equilibrium** and **dominant strategies**.

Why the other answers are wrong

- **B)** Chaos theory examines nonlinear dynamical systems that exhibit sensitive dependence on initial conditions. It models deterministic but unpredictable physical behavior rather than deliberate choice-making between agents.
- **C)** Asymptotic theory focuses on the behavior of mathematical functions or statistical estimators as a parameter approaches infinity. It does not model interactive payoff structures or strategic decision processes.
- **D)** Network theory investigates the architecture and flow within interconnected systems like social or communication grids. The classic dilemma relies on isolated two-person encounters rather than graph topology or node degree.
- **E)** Quantum theory deals with subatomic particles and probabilistic wave behaviors. While researchers have developed quantum extensions of the puzzle, the original framework predates and operates completely outside particle physics.

16 Who was the first woman to be awarded a Nobel Prize?

Correct answer: A · Marie Curie

Marie Curie shared the Nobel Prize in **Physics** in 1903 with Pierre Curie and Henri Becquerel for their research on **radioactivity**. This achievement made her the first woman to receive any major international award. She later secured a second Nobel Prize in **Chemistry** in 1911.

Why the other answers are wrong

- **B)** Mother Teresa received the Peace Prize in 1979, which occurred more than seven decades after the 1903 award.
- **C)** Grazia Deledda was honored with the Literature prize in 1926, placing her long after the first female laureate.
- **D)** Selma Lagerlöf became the first woman to win the Literature prize in 1909, yet Marie Curie had already claimed the overall first female honor in 1903.
- **E)** Doris Lessing won the Literature Nobel in 2007, making her one of the oldest recipients rather than the pioneering female laureate.

17 Which one of these events in world history happened most recently?

Correct answer: A · The October Revolution in the Russian Empire

The October Revolution occurred in **November 1917** during the twentieth century. This places it centuries later than all other listed historical events. It follows the fall of Rome, the construction of the Taj Mahal, and the Taiping Rebellion by significant time gaps.

Why the other answers are wrong

- **B)** The fall of the Western Roman Empire took place in 476 CE. This event occurred more than **fourteen hundred years** before the October Revolution.
- **C)** The Taiping Rebellion lasted from 1850 to 1864. It ended over **fifty years** before the twentieth-century revolution.
- **D) The building of the Taj Mahal**: The Taj Mahal was constructed between 1632 and 1653. This seventeenth-century project predates the 1917 event by roughly **two hundred eighty years**.
- **E) The crowning of Charlemagne**: Charlemagne was crowned Emperor in 800 CE. His coronation happened more than **eleven hundred years** earlier than the October Revolution.

18 **Which one of the following religions is NOT considered to have been revealed to or founded by an individual?**

Correct answer: A · Hinduism

Hinduism lacks a **single** historical founder or a specific moment of divine revelation. It developed through organic growth over centuries of Indian religious practice, Vedic rituals, diverse philosophies, and local traditions. Scholars treat it as a cumulative cultural tradition rather than a personally founded faith.

Why the other answers are wrong

- **B)** Confucianism takes its name from the Chinese sage Confucius (Kong Fuzi, 6th–5th century BCE). The Analects preserve his sayings and the school explicitly traces its origin to him.
- **C) Islam**: Muslims believe God directly **revealed** the Qur'an to the Prophet Muhammad in the 7th century CE. The religion's existence is inseparable from this historical figure and his recorded revelations.
- **D)** Christianity centers on the life, death, and resurrection of Jesus of Nazareth. His identity as the Christ makes him the indispensable founding figure, even though his disciples expanded the movement.
- **E)** Buddhism was **established** by Siddhārtha Gautama (the Buddha, 5th–4th century BCE). Core teachings like the Four Noble Truths and the Noble Eightfold Path stem directly from his enlightenment and subsequent instructions.

19 **The governance of modern states is often based on the separation of which three powers?**

Correct answer: A · Legislative – executive – judicial

The **separation of powers** doctrine divides state authority into three independent branches: **legislative** bodies create statutes, the **executive** implements them, and the **judicial** resolves disputes. This functional division prevents power concentration and safeguards civil liberties. Option D accurately names these three components.

Why the other answers are wrong

- **B) Legislative – elective – jurisprudential**: Legislative is valid, but elective describes democratic voting processes rather than a state function. Jurisprudential maps to the judiciary, yet the inclusion of elective breaks the classical triad.
- **C) Electoral – regulatory – jurisprudential**: It omits the executive branch and falsely inserts regulatory authority. Electoral designates election management instead of a governing power, leaving only jurisprudential correct.
- **D) Regulatory – executive – judicial**: It retains executive and judicial roles but substitutes legislative with regulatory. Regulations enforce established statutes rather than drafting them, making the foundational lawmaking branch absent.
- **E) E Legislative – elective – executive**: It pairs legislative and executive roles but substitutes judicial with elective. Elections function as participation tools rather than an independent power, effectively removing the court system.

20 The Constitution of the Italian Republic was enacted on 22 December 1947 by

Correct answer: A · The Constituent Assembly

After World War II Italians elected the **Constituent Assembly** with the sole mission to draft a republican constitution. The body debated and approved the final text on 22 December 1947 with 453 votes in favour and 62 against. This assembly performed the definitive act of enactment before the provisional Head of State formally issued it.

Why the other answers are wrong

- **B) The Supreme Court**: Italy's Court of Cassation lacks any legislative power and only interprets existing laws. It exercised no authority during the constitutional drafting process.
- **C)** The Ministry of Justice belongs to the executive branch and cannot perform a constituent act. It may have assisted only with technical implementing legislation after the Constitution took effect.
- **D)** The Ministry of Defence operates as an executive office without constituent authority. It participated neither in drafting nor in voting the constitutional text.
- **E) The Government**: The post-war government could propose political ideas but held no power to draft the fundamental law. The constituent task was deliberately reserved for the elected assembly rather than ordinary ministers.

21 Which one of the following is NOT a stated purpose of the United Nations?

Correct answer: A · To encourage peaceful trade between nations

Only option **peaceful trade** is absent from the founding text. Article 1 of the Charter lists four specific purposes but treats economic cooperation only in general terms. Actual trade regulation falls under specialized agencies like the WTO or UNCTAD rather than the primary mandate.

Why the other answers are wrong

- **B) To maintain international peace and security**: This matches the exact wording of Article 1(1). It establishes the primary mandate for the **Security Council** and peacekeeping operations. Since it is explicitly defined, it cannot be the correct choice.
- **C) To develop friendly relations among nations**: Article 1(2) mandates the development of friendly relations grounded in respect for equal rights and the **self-determination** of peoples. This direct reference confirms its status as an official objective.
- **D) To achieve international co-operation in solving international problems**: Article 1(3) outlines the commitment to international cooperation in resolving economic, social, and humanitarian challenges while advancing human rights. The statement reproduces this clause accurately.
- **E) To be a center for harmonizing the actions of nations**: Article 1(4) designates the organization as a centre for **harmonizing** national actions to achieve shared objectives. This phrasing aligns precisely with the Charter's fourth stated purpose.

22 Which one of the following countries did NOT adopt the coins and banknotes of the Euro as its currency on 1 January 2002?

Correct answer: A · Sweden

Sweden joined the European Union in 1995 but **deliberately avoided** adopting the euro. It continues to circulate the **Swedish krona** (SEK) instead of euro cash. The 2003 referendum rejected euro membership, and the country remains outside the Exchange-Rate Mechanism II by choice. This prevented it from issuing euro coins and banknotes on 1 January 2002 alongside the other listed nations.

Why the other answers are wrong

- **B) Austria**: This country belonged to the original twelve euro-area states. It converted from the national schilling to electronic euros in 1999 and issued physical euro money on 1 January 2002.
- **C) Portugal**: This member was part of the first wave of euro adopters. It exchanged the local escudo for the euro and placed euro banknotes and coins into circulation on 1 January 2002.
- **D) Luxembourg**: This jurisdiction participated in the monetary union from the start. It abandoned the national franc and accepted euro cash as legal tender on 1 January 2002.
- **E) Finland**: This territory entered the initial euro group simultaneously. The domestic markka lost official status after the transitional two-currency phase that began when euro notes and coins were launched on 1 January 2002.

23 Which of the following rows are correct about these naturally occurring biological molecules?

	biological molecule	presence of carboxylic acid groups	presence of 2 or more hydroxyl groups
row 1	ALL amino acids	yes	no
row 2	glucose	no	yes
row 3	glycerol	no	no
row 4	ALL fatty acids	yes	no

Correct answer: A · 1, 2 and 4 only

All amino acids contain a $-\mathrm{COOH}$ group but possess fewer than two $-\mathrm{OH}$ groups. Glucose is an aldose with five $-\mathrm{OH}$ groups and lacks a **carboxyl** group. **Glycerol** has three $-\mathrm{OH}$ groups, making the corresponding table entry false. Every **fatty acid** contains exactly one $-\mathrm{COOH}$ group and no additional **hydroxyl** groups, so **rows 1, 2, and 4** are accurate.

Why the other answers are wrong

- **B) 1, 2 and 3 only**: Includes row 3, but glycerol actually possesses three $-\mathrm{OH}$ groups, contradicting the table.
- **C) 1, 3 and 4 only**: Relies on the incorrect row 3 regarding glycerol and mistakenly excludes row 2, which correctly identifies glucose features.
- **D) 2, 3 and 4 only**: Depends on the false entry for row 3 and omits row 1, which accurately states amino acid properties.
- **E) 1, 2, 3 and 4**: Accepts row 3 as valid despite glycerol having multiple hydroxyls, leading to the conclusion that all rows are correct when only three are.

24 **Which of the following is/are tissues?**

1. cartilage
2. skin
3. endothelium

Correct answer: A · 1 and 3 only

A biological tissue consists of structurally similar **cells** and their secreted **extracellular material** working together to perform a specific function. **Cartilage** is a connective tissue made of chondrocytes in a collagen and proteoglycan matrix that provides support and absorbs shock. **Endothelium** is a simple squamous epithelium forming a continuous cellular lining of blood and lymphatic vessels with a unified selective permeability function. **Skin** does not qualify as a single tissue because it is a complex organ integrating multiple distinct tissue types.

Why the other answers are wrong

- **B) 1, 2 and 3**: Incorrect because it classifies skin as a tissue despite it being a composite organ containing epithelial, connective, nervous, and muscular components.
- **C) 1 and 2 only**: Incorrect because it includes skin which is an organ and excludes endothelium which clearly meets the structural and functional criteria of a tissue.
- **D) 2 and 3 only**: Incorrect because it omits cartilage which is a definitive connective tissue and incorrectly counts skin as a single tissue type.
- **E) 1 only**: Incorrect because it overlooks endothelium which functions as a specialized epithelial tissue lining vascular systems.

25 **Which of the following statements about the metabolism of plants is/are correct?**

1. CO_2 is produced during the day.
2. CO_2 is produced at night. 2
3. The CO_2 produced can be used by the plant. 2

Correct answer: A · 1, 2 and 3

Plant cells carry out **continuous aerobic respiration**, producing CO_2 both during the day and at night. Daylight photosynthesis normally masks this output, yet respiratory and photorespiratory pathways still release CO_2 internally. This gas diffuses through leaf spaces and remains available for **immediate refixation** in the Calvin cycle or temporary storage in CAM species. All three statements therefore accurately describe plant carbon metabolism.

Why the other answers are wrong

- **B) 1 only**: Incorrect because it ignores nocturnal CO_2 release from ongoing mitochondrial activity and fails to recognize that respiratory gas remains available for immediate photosynthetic recycling.
- **C) 2 only**: Incorrect because daytime CO_2 production occurs alongside photosynthesis via respiration and photorespiration, and dismissing reuse contradicts how chloroplasts readily fix internally generated carbon.
- **D) 2 and 3 only**: Incorrect because omitting daytime production overlooks that mitochondrial respiration runs concurrently with light reactions, ensuring constant CO_2 generation even when net atmospheric uptake is observed.
- **E) 1 and 2 only**: Incorrect because excluding recapture ignores the physical trapping of metabolically produced gas within leaf tissues, which guarantees its availability for subsequent dark or light phase fixation pathways.

26 Which one of the following occurs during anaphase of mitosis in a healthy human liver cell?

Correct answer: A · Sister chromatids are pulled by the spindle fibres towards opposite poles of the cell.

During anaphase, the **centromeres** split and allow the **sister chromatids** to separate. Each chromatid becomes an independent chromosome pulled by the **spindle** fibers toward opposite **cell poles**.

Why the other answers are wrong

- **B)** Chromatin condensation begins in prophase to make chromosomes visible under the microscope. By anaphase, the chromosomes are already fully condensed.
- **C) Chromosomes move towards the equator of the cell and attach to the spindle fibres.**: Attachment to spindle fibers occurs in prometaphase and alignment at the equator defines metaphase. Anaphase involves movement away from the equator toward the poles.
- **D) DNA replicates so that each chromosome is made up of two sister chromatids.**: DNA replication that creates sister chromatids takes place during the S phase of interphase. No new DNA synthesis occurs during anaphase or any mitotic stage.
- **E) Centrioles migrate to opposite poles of the cell and help to assemble the spindle fibres.**: Centriole migration and spindle assembly happen in early prophase. By anaphase, the spindle is already fully formed and actively functioning.

27 Which row shows a correct component of each of the three structures listed?

	viral envelope	capsid	genetic material
row 1	glycogen	glycosidic bonds	adenine
row 2	glycosidic bonds	glycogen	ester bonds
row 3	phosphodiester bonds	hydrogen bonds	amino acids
row 4	fatty acids	amino acids	phosphodiester bonds
row 5	phosphate	phosphodiester bonds	cytosine

Correct answer: A · row 4

Row 4 lists **fatty acids** for the viral envelope, **amino acids** for the capsid, and **phosphodiester bonds** for the genetic material. Viral envelopes contain a phospholipid bilayer with fatty acid tails, capsids are made of proteins, and nucleotides in DNA or RNA are joined by phosphodiester bonds.

Why the other answers are wrong

- **B) row 2**: Glycosidic bonds and glycogen are carbohydrate-related, but viral envelopes are lipid-based and capsids are protein-based, so neither is a main structural component of those structures. Ester bonds occur in lipids, not in nucleic acids, so that entry is also incorrect for the genetic material.
- **C) row 3**: Phosphodiester bonds belong in nucleic acids, not in viral envelopes. Hydrogen bonds help stabilize protein secondary structure, but capsids are built from amino acids, not from hydrogen bonds themselves. Amino acids are appropriate for proteins, but they are listed here under genetic material.
- **D) row 1**: Glycogen and glycosidic bonds are carbohydrate-related; neither is a lipid component of the envelope nor a protein component of the capsid. Adenine is a nucleobase and is valid for genetic material, but the other two entries are incorrect.
- **E) row 5**: A phosphate group is part of a phospholipid head, but phosphate alone is an incomplete description of the envelope, which consists of a phospholipid bilayer. Phosphodiester bonds are appropriate for nucleic acid backbones, but are misplaced under the capsid. Cytosine is a valid base in genetic material.

29 **If a cell divides by mitosis ten times, what is the number of cells at the end of the process?**

[Assume that all cells remain alive.]

Correct answer: A · 1024

Each mitotic division splits one parent cell into two identical daughter cells. This means the population **doubles** with every round. Starting from a single cell, the total after n divisions follows the formula 2^n. Applying this to ten rounds gives $2^{10} = 1024$.

Why the other answers are wrong

- **B) 10**: Assumes each division simply adds one new cell. It overlooks the **exponential** nature of cellular replication.
- **C) 100**: Calculates 10×10 instead of raising two to the power of ten. Mitosis produces **geometric** growth, not a linear decimal increase.
- **D) 64**: Equals 2^6, meaning it applies the correct formula to only six rounds. This reflects a **miscalculation** of how many divisions actually occur.
- **E) 11**: Adds the original cell to ten new ones $(1 + 10)$ instead of counting successive generations. This treats the process as **linear** accumulation rather than repeated splitting.

30 **Familial hypercholesterolaemia (FH) is an inherited disease caused by a dominant allele. People with FH have high concentrations of cholesterol in the blood, which can lead to an increased risk of coronary heart disease.**

The family tree shows the inheritance of this disease in one family.

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e128e8218ee8282e82e.png?alt=media&token=e27c0b4f-90c1-48f6-a0aa-c68f94e9942b<i>

Which row shows the number of individuals in the family tree with each genotype?

<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/IMAT%2FIMAT_Quizzes%2F2023-06-21%2015_17_46-IMAT%202019%20TB%20COMMENTATO.pdf%20-%20Foxit%20PDF%20Editor.png?alt=media&token=d75c8f46-c0c5-4522-b97f-61061e7d5a1f<i>

Correct answer: A · row 3

Familial hypercholesterolaemia follows a **dominant** inheritance pattern where the allele F determines the affected phenotype. Unshaded symbols represent homozygous recessive ff individuals, while shaded symbols carry at least one F allele. Because every affected parent has at least one unaffected child, each affected individual must be **heterozygous** Ff. Counting the family tree gives zero FF, five Ff, and three ff, which matches row 3.

Why the other answers are wrong

- **B) row 2**: Row 2 lists one FF individual. Because the pedigree proves that no one can be homozygous dominant, since every affected person transmits the recessive allele to an unaffected child, any row containing a non-zero value in the FF column is impossible.
- **C) row 1**: Row 1 lists one FF individual. Because the pedigree proves that no one can be **homozygous** dominant, since every affected person transmits the recessive allele to an unaffected child, any row containing a non-zero value in the FF column is impossible.
- **D) row 4**: Row 4 lists two FF individuals. Because the pedigree proves that no one can be homozygous dominant, since every affected person transmits the recessive allele to an unaffected child, any row containing a non-zero value in the FF column is impossible.
- **E) row 5**: Row 5 correctly lists zero FF individuals but incorrectly counts four Ff and four ff individuals. The actual pedigree contains five affected members and three unaffected ones, making this distribution inconsistent with the visual data.

31 **The diagrams show some pathways between the central nervous system and effector organs in a healthy human.**

Which pathway is a possible route for impulses passing along a parasympathetic neuron?

Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e18e18e8a8a.png?alt=media&token=f5381795-a181-4442-a200-9ae6ad62ce51<i>

The **parasympathetic pathway** originates from the brain stem or sacral region. It contains a **long pre-ganglionic fibre** that synapses near the target organ, followed by a **short post-ganglionic fibre**. Neurotransmission relies on **Acetylcholine** at both synapses. Diagram A correctly illustrates this anatomical and chemical arrangement.

Why the other answers are wrong

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F21exx9812e28ak.png?alt=media&token=7ccb5ac3-2e44-42a5-bca5-c8ad898b790c<i>**: Shows a short pre-ganglionic fibre terminating in a paravertebral ganglion alongside the spinal cord. This configuration generates a long post-ganglionic fibre targeting the effector, matching the standard sympathetic architecture instead of the parasympathetic one.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e128a88aa.png?alt=media&token=55758227-b56c-401e-b4c9-19dfc4f62568<i>**: Depicts a single neurone projecting directly from the central nervous system to skeletal muscle. This linear connection bypasses any peripheral ganglion and characterizes the voluntary somatic motor circuit rather than an autonomic pathway.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e288x1888ss.png?alt=media&token=9e660e9c-c461-4cfa-996a-baa20a00f9f7<i>**: Represents the unique sympathetic innervation of the adrenal medulla where a short pre-ganglionic fibre directly contacts chromaffin cells. The absence of a second neurone occurs because neurotransmitter exposure causes immediate hormone secretion into circulation.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e8a888q82.png?alt=media&token=5d23bec0-6149-4671-8e9a-a08ba78022e5<i>**: Outlines the conventional sympathetic route to internal organs featuring a short initial segment and a ganglion positioned close to the vertebral column. A lengthy post-ganglionic segment then delivers noradrenaline to the tissue, which contrasts with cholinergic parasympathetic signaling.

32 **An electron microscope (EM) was used to view a cell.**

The maximum dimension of the cell was observed at a magnification ×30 000.

The image on the EM screen showed a maximum length of 30 mm.

Which of the following mature healthy cells was being magnified?

Correct answer: A · one coccus bacterium in a Staphylococcus cluster

The **actual** size is determined by **dividing** the image measurement by the magnification factor. $\text{Size} = \frac{30\ \text{mm}}{30\,000} = 1\ \mu\text{m}$ This value **matches** the standard diameter of a spherical bacterium. Every other cellular type listed operates at a substantially greater scale and would yield proportionally larger projections.

Why the other answers are wrong

- **B) one lymphocyte from a human**: A human lymphocyte typically measures 8–$12\ \mu\text{m}$. Scaling this dimension by thirty thousand times produces an image spanning 240–$360\ \text{mm}$, which drastically exceeds the recorded screen length.
- **C) one mature human red blood cell**: A mature red blood cell spans roughly 7–$8\ \mu\text{m}$. The applied magnification would stretch this width to approximately 210–$240\ \text{mm}$, contradicting the observed $30\ \text{mm}$ projection.
- **D) one sensory neuron from a human**: A sensory neuron possesses a cell body measuring tens of micrometers alongside axons extending meters. Multiplying these physical lengths by the magnification factor generates a virtual image far beyond $30\ \text{mm}$.
- **E) one palisade cell from a wheat plant**: A wheat palisade cell characteristically grows to 40–$100\ \mu\text{m}$ in length. Subjecting this range to the specified zoom level expands the visible span to 1.2–$3.0\ \text{m}$, ruling out compatibility with the micrograph data.

33 **Which statement about an enzyme involved in genetic modification is correct?**

Correct answer: A · A restriction enzyme causes phosphodiester bonds to be broken.

A **restriction enzyme** recognizes specific sequences in double-stranded DNA. It cuts the molecule by hydrolyzing **phosphodiester bonds** in the sugar-phosphate backbone. This direct cleavage mechanism confirms the statement.

Why the other answers are wrong

- **B) A ligase causes phosphodiester bonds to be broken.**:
- **C) A restriction enzyme causes H-bonds to form between sticky ends.**:
- **D) A restriction enzyme causes only H-bonds to be broken.**:
- **E) A ligase causes H-bonds to form between sticky ends only.**:

34 Which statement is correct in healthy humans?

Correct answer: A · In active tissues where the carbon dioxide concentration is high, haemoglobin has a low affinity for oxygen.

In active tissues high $\mathrm{pCO_2}$ and elevated $\mathrm{H^+}$ concentration occur from carbonic acid formation. These acidic conditions reduce **affinity** for oxygen and shift the equilibrium right via the **Bohr effect**. Tissue oxygen delivery therefore improves under these conditions.

Why the other answers are wrong

- **B) Blood leaving active muscles that are respiring aerobically will contain hydrogencarbonate ions and raised levels of lactic acid.**: Aerobic respiration generates $\mathrm{CO_2}$ that converts mainly to hydrogencarbonate ions. Lactate production follows **anaerobic** metabolism when oxygen supply is insufficient. Actively respiring aerobic muscles maintain baseline lactate levels.
- **C) At a low partial pressure of oxygen, myoglobin is less saturated with oxygen than haemoglobin.**: **Myoglobin** exhibits a substantially higher oxygen affinity than haemoglobin. Its dissociation curve positions far left relative to the haemoglobin curve. Myoglobin retains bound oxygen while haemoglobin unloads it.
- **D) Increasing the partial pressure of oxygen makes it more likely that haemoglobin will release its oxygen.**: Increased partial pressure of oxygen drives binding rather than release. The **sigmoid** saturation relationship confirms rising loading with elevated pressure. Oxygen detachment requires decreased pressure alongside metabolic shifts.
- **E) The majority of carbon dioxide transported in the blood is in the form of carbaminohaemoglobin.**: Approximately 70–75 \% of systemic carbon dioxide circulates as dissolved bicarbonate. Carbaminohaemoglobin accounts for roughly 20–25 \% of total transport capacity. Remaining gas molecules dissolve freely in plasma fluid.

35 Which of the following regions within a sarcomere remain UNCHANGED in length when a healthy human muscle cell contracts?

1. A-band
2. I-band
3. H-zone/band

Correct answer: A · 1 only

During contraction the **sliding filaments** move past each other without altering their **fixed length**. The A-band covers the entire structural span of the thick fiber so its measurement stays constant throughout the cycle.

Why the other answers are wrong

- **B) 2 only**: The I-band holds only non-overlapping thin filament sections. Contraction pulls actin inward increasing overlap and causing this space to narrow significantly.
- **C) 3 only**: The H-zone marks the central thick-filament-only area. Growing actin insertion reduces this clearance so the region continuously diminishes.
- **D) 1 and 3 only**: Although the A-band dimension is stable the H-zone shrinks dynamically making this combination invalid.
- **E) 2 and 3 only**: Both listed regions contract simultaneously as filaments interdigitate further confirming that neither preserves its baseline width.

36 **Which row is correct for the three given features of typical human B lymphocytes?**

Key:

✓ correct
x incorrect

	formed from bone marrow stem cells	processed in the thymus	contain genes coding for antibodies
row 1	✓	✓	✓
row 2	✓	✓	×
row 3	✓	x	✓
row 4	x	✓	✓
row 5	x	✓	×

Correct answer: A · row 3

Human B lymphocytes develop from **hematopoietic stem cells** in the **bone marrow** and retain **immunoglobulin genes** throughout their life cycle. Their final maturation occurs locally without migration to the **thymus**. This sequence produces the exact combination shown in row 3.

Why the other answers are wrong

- **B) row 2**: Row 2 marks the gene feature as incorrect. This contradicts the established fact that B cells actively maintain the genetic code for antibody synthesis.
- **C) row 1**: Row 1 incorrectly assigns thymic processing to B cells. While the first and third features match, the second must be rejected because thymic development applies exclusively to T lymphocytes.
- **D) row 4**: Row 4 wrongly denies bone marrow formation and confirms thymic processing. Both the origin and the maturation site descriptions conflict with the standard developmental pathway of B lymphocytes.
- **E) row 5**: Row 5 fails on all three points. B cells originate in the bone marrow instead of being absent there, they do not mature in the thymus, and they definitely possess antibody coding sequences.

37 **Which of the following processes involve ions?**

1. contraction of a muscle
2. transmission of a nerve impulse across a synapse
3. transfer of light energy into chemical energy in photosynthesis
4. oxidative phosphorylation in a mitochondrion

Correct answer: A · 1, 2, 3 and 4

1. Muscle contraction involves Na^+ and K^+ flux during action potentials along the sarcolemma and T-tubules, which opens voltage-gated Ca^{2+} channels in the sarcoplasmic reticulum. Released Ca^{2+} binds to troponin and initiates actin-myosin sliding. 2. At a **synapse**, an arriving action potential opens presynaptic voltage-gated Ca^{2+} channels, and the influx triggers neurotransmitter vesicle fusion. Neurotransmitters open postsynaptic ligand-gated Na^+, K^+ or Cl^- channels, producing an excitatory or inhibitory potential. 3. In photosynthesis, light-driven electrons in the electron transport chain support H^+ pumping across the thylakoid membrane; the resulting **proton gradient** drives H^+ through ATP synthase into the stroma, enabling ATP production from ADP. 4. In oxidative phosphorylation, complexes I, III and IV pump H^+ from the mitochondrial matrix into the intermembrane space. The proton-motive force drives H^+ back through **ATP synthase**, generating ATP.

Why the other answers are wrong

- **B) 2 and 3 only**: It omits muscle contraction and oxidative phosphorylation, which rely on Ca^{2+} and H^+ gradients, respectively.
- **C) 3 and 4 only**: It omits muscle contraction and synaptic transmission, which depend on the ionic basis of action potentials, Ca^{2+} release, and ion movement across the synapse.
- **D) 1, 2 and 3 only**: It excludes oxidative phosphorylation, in which a proton gradient drives ATP synthesis.
- **E) 1 and 2 only**: It ignores the fundamental roles of ions in photosynthesis and oxidative phosphorylation.

38 **An animal has a coat that has some patches of white hair and some patches of black hair. Cells that make up a hair follicle form a single hair, which is either white or black.**

Assume that there are no mutations following formation of the zygote. A student wrote the following statements:

1. The cells in all the hair follicles contain the same genes.
2. The alleles in a hair follicle forming a white hair are different from the alleles in the hair follicle forming a black hair.
3. Each white hair follicle cell contains two recessive alleles.

Which statement(s) is/are correct?

Correct answer: A · 1 only

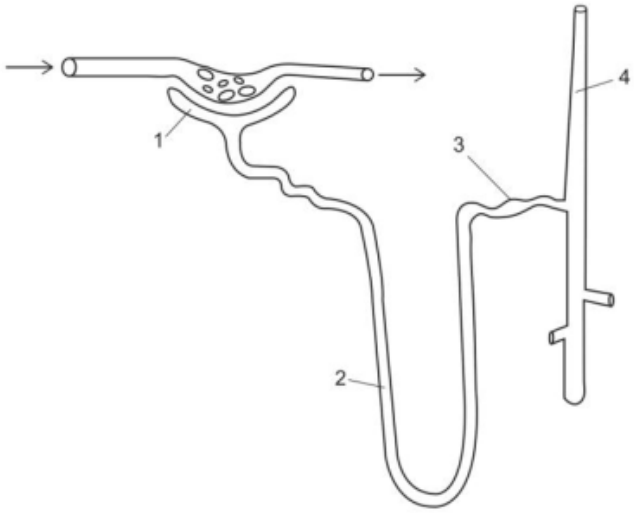
All hair follicle cells descend from the same zygote without subsequent mutations, so they retain the **identical set of genes**. Coat color variation arises from **differential gene expression**, meaning pigment pathways are activated in some follicles and suppressed in others. Consequently only the first statement correctly describes the genetic uniformity of somatic cells.

Why the other answers are wrong

- **B) 2 only**: This option relies on statement 2, which falsely claims that white and black follicles carry different alleles. In reality somatic cells maintain uniform genetic material and color differences stem solely from regulated expression.
- **C) 1 and 2 only**: This combination includes statement 2, which is incorrect. Follicles producing opposite colors possess identical alleles throughout their development. Phenotypic variation is controlled by whether pigment genes are switched on or off.
- **D) 2 and 3 only**: Both statements 2 and 3 are false. The follicles do not harbor distinct alleles, and white hair does not necessitate a homozygous recessive genotype. The animal may carry a homozygous dominant, heterozygous, or homozygous recessive background while expressing color patches through biological regulation.
- **E) 1, 2 and 3**: This choice adds statement 3 to the already false statement 2. There is no evidence supporting a requirement for two recessive alleles, as coat patterns result from spatial control of gene activity rather than fixed allelic configurations.

39 **The diagram shows a nephron with collecting duct from a healthy human.**

Which of the regions (1-4) contain a liquid with no urea?



Correct answer: A · none of them

Urea is freely filtered from blood plasma into the glomerulus. Once inside **Bowman's capsule** (region 1), it passes through the **loop of Henle** (region 2), **distal convoluted tubule** (region 3), and **collecting duct** (region 4) without complete elimination. Although selective reabsorption alters concentrations, no nephron segment purifies the fluid entirely. Therefore, every region retains **urea**.

Why the other answers are wrong

- **B) 1 only**: Incorrect. Bowman's capsule holds the initial filtrate which already contains urea.
- **C) 1 and 2 only**: Incorrect. Both Bowman's capsule and the loop of Henle transport fluid that consistently retains urea.
- **D) 2 and 3 only**: Incorrect. The loop of Henle and distal convoluted tubule continue carrying urea alongside water and ions, just like region 1.
- **E) 2, 3 and 4 only**: Incorrect. Urea concentration varies in the collecting duct but never reaches zero, and region 1 cannot be excluded from the pathway.

40 **The same section of an allele coding for five amino acids from two different individuals, P and Q, is shown.**

P ATTCCGGGATTCCCT
Q ATTCCGGATTGCACT

Which of the following types of mutation could explain the differences between P and Q?

1. addition
2. deletion
3. substitution

Correct answer: A · 1, 2 and 3

Both sequences encode five amino acids, meaning the displayed 15 bases form exactly five triplets. Four bases differ between P and Q at positions 8, 9, 11 and 13. Direct **substitution** can account for these changes. A prior **deletion** or **addition** upstream would shift the **reading frame**, altering **downstream** codons to match Q. Without extra genomic data, all three mechanisms remain valid.

Why the other answers are wrong

- **B) 1 only**: Incorrect because it restricts the cause to addition alone. A standalone base loss elsewhere would shift the reading frame and produce identical codon alterations, making pure addition an insufficient explanation.
- **C) 1 and 3 only**: Incorrect because it excludes deletion. A single nucleotide loss upstream would reorganize the triplet grouping downstream, generating the exact base pattern seen in Q without requiring substitution or addition events.
- **D) 2 and 3 only**: Incorrect because it removes substitution from consideration. Four independent base replacements directly convert the P sequence into Q, and discarding this straightforward mechanism ignores the verified position-specific differences at bases 8, 9, 11 and 13.
- **E) none of them**: Incorrect because it denies any genetic change. The sequences show multiple distinct nucleotide positions, confirming that at least one mutation type must have occurred to generate the observed variation.

41 **Which statement about a positive ion explains why it is positively charged?**

Correct answer: A · The ion has more protons than electrons.

A neutral atom maintains equal numbers of **protons** and **electrons**, yielding a net charge of zero. When the atom loses **electrons**, the remaining **protons** outnumber them. Each **proton** contributes a $+1$ charge while each **electron** contributes a -1 charge. This **imbalance** results in an overall **positive charge**, matching option A.

Why the other answers are wrong

- **B) The ion has more electrons than neutrons.**: Neutrons carry no electric charge. Comparing the number of electrons to neutrons provides no information about the net electrical charge. A surplus of electrons relative to neutrons does not generate a positive charge.
- **C) The ion has more electrons than protons.**: Having more electrons than protons creates a net negative charge. This condition describes an anion rather than the cation requested by the question.
- **D) The ion has more protons than neutrons.**: Neutrons are electrically neutral particles. The ratio between protons and neutrons influences nuclear stability, not the electrical charge of the ion.
- **E) The ion has the same number of protons and neutrons.**: An equal count of protons and neutrons reveals nothing about the relationship between protons and electrons. You cannot determine the ion's electrical charge from this comparison alone.

42 **A few drops of universal indicator solution were added to exactly 50 mL of sodium hydroxide solution, NaOH, of concentration 1 mol/L. Exactly 50 mL of hydrochloric acid, HCl, of concentration 1 mol/L, was added drop by drop to the sodium hydroxide solution containing the universal indicator solution.**

What colour changes would be observed as the hydrochloric acid was added?

Correct answer: A · violet → blue → green

The initial sodium hydroxide solution has a concentration of $1\ \mathrm{mol\,L^{-1}}$, corresponding to a pH of approximately 14. At this strongly basic value, the universal indicator appears **violet**. Adding hydrochloric acid triggers the reaction $\mathrm{HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)}$. The pH decreases smoothly until equal amounts of acid and base are mixed, reaching neutrality at pH 7. With no excess acid present, the final observed colour is **green**.

Why the other answers are wrong

- **B) red → orange → yellow → green**: Reverses the actual sequence by starting with an acidic colour. The experiment begins with a strong base, so the initial colour cannot be red.
- **C) violet → blue → green → yellow → orange → red**: Correctly shows the transition up to green, but extends into yellow, orange, and red. These shifts require adding more acid than the stoichiometric amount, which the problem explicitly rules out.
- **D) blue → red**: Uses an incorrect starting colour by listing blue instead of violet. It omits the intermediate green stage at the equivalence point and falsely ends at red, a colour unreachable here.
- **E) red → orange → yellow → green → blue → violet**: Displays the exact reverse progression, which describes titrating an acid with a base rather than a base with an acid. The observed changes must follow the direction of decreasing pH.

43 **A student observed that when powdered sugar at –1°C was added to ice at –1°C all of the ice melted.**

Which of the following statements explain this observation?

1. Sugar has given the water molecules energy.
2. The melting point of the mixture is higher.
3. The melting point of the mixture is lower.

Correct answer: A · 3 only

When sugar contacts ice, it dissolves in the surface moisture. This process triggers **freezing-point depression**, which **lowers** the melting point of the water below $0\ ^\circ\mathrm{C}$. At $-1\ ^\circ\mathrm{C}$, the system is now above its new melting point. The resulting thermodynamic shift makes the ice unstable and causes it to melt until equilibrium is reached.

Why the other answers are wrong

- **B) 2 only**: Incorrect because statement 2 claims the melting point rises, but adding a solute always depresses the freezing point. If the melting point increased, ice would remain stable at $-1\ ^\circ\mathrm{C}$.
- **C) 1 only**: Incorrect because statement 1 suggests sugar provides thermal energy. Sugar merely alters the phase boundary and does not supply heat, as any required energy is absorbed from the surroundings.
- **D) 1 and 2 only**: Incorrect because it combines two false claims. Sugar neither transfers thermal energy nor elevates the phase transition temperature.
- **E) 1 and 3 only**: Incorrect because it pairs the correct observation with a faulty mechanism. The melting occurs due to colligative properties changing the stability of the solid phase, not because sugar delivers energy.

44 **Which of the following pairs of structural formulae represent structural isomers?**

1. $\mathrm{CH_3CH_2OH}$ and $\mathrm{CH_3OCH_3}$
2. $\mathrm{CH_3CH\left(CH_3\right)CH_2CH_2CH_3}$ and $\mathrm{CH_3CH_2CH_2CH\left(CH_3\right)CH_3}$
3. $\mathrm{CH(OH)=CHCH_2OH}$ and $\mathrm{CH_3CH_2COOH}$

Correct answer: A · 1 and 3 only

Structural isomers share the same **molecular formula** but differ in atomic **connectivity**. Pair 1 contains $\mathrm{CH_3CH_2OH}$ and $\mathrm{CH_3OCH_3}$, both with $\mathrm{C_2H_6O}$ but distinct oxygen placement. Pair 3 includes $\mathrm{CH(OH)=CHCH_2OH}$ and $\mathrm{CH_3CH_2COOH}$, both possessing $\mathrm{C_3H_6O_2}$ yet showing different bonding arrangements. Thus, only these two pairs represent structural isomers.

Why the other answers are wrong

- **B) 2 only**: Pair 2 displays $\mathrm{CH_3CH(CH_3)CH_2CH_2CH_3}$ and $\mathrm{CH_3CH_2CH_2CH(CH_3)CH_3}$. Reading the second structure backwards reproduces the first, proving they are the **identical** compound 2-methylpentane.
- **C) 1 only**: This option misses pair 3, which correctly fulfills the isomer criteria by sharing $\mathrm{C_3H_6O_2}$ with an alternative atomic arrangement.
- **D) 2 and 3 only**: This selection incorrectly accepts pair 2 as valid isomers while wrongly excluding pair 1.
- **E) 1, 2 and 3**: This choice falsely treats pair 2 as isomers despite both representations describing the exact same molecule.

45 **Element Z reacts with water at room temperature and hydrogen gas is released.**

The oxide of element Z is a solid at room temperature and does not conduct electricity.

The oxide reacts with acids and has the formula ZO.

To which group/part of the Periodic Table does element Z belong?

Correct answer: A · Group II

Elements that react with cold water to release hydrogen are mainly **alkali metals** and **alkaline-earth metals** from calcium downward. The oxide formula ZO indicates a **divalent cation**, matching the stable **+2 oxidation state** of Group II elements. A **non-conducting basic solid** that dissolves in acid is characteristic of **ionic oxides** such as MgO or CaO. All experimental data align exclusively with the chemistry of **Group II**.

Why the other answers are wrong

- **B) Group I**: Alkali metals form oxides with the stoichiometry M_2O, contradicting the given formula ZO. Their valence electrons yield a +1 oxidation state instead of +2.
- **C)** Group III elements do not liberate hydrogen gas upon contact with liquid water at ambient conditions. Their predominant oxide exhibits the formula M_2O_3.
- **D) Transition metals**: Most transition metals resist reaction with cold water or proceed at negligible rates. Their oxide species display diverse stoichiometries and frequently possess metallic or semiconducting electrical properties.
- **E) Group VII**: Halogen elements act as non-metals and undergo hydrolysis reactions that produce halide and hypohalite ions rather than hydrogen gas. Their oxide derivatives are discrete molecular compounds that remain unstable and lack basic reactivity.

46 **Which of the following equations represent(s) a redox reaction?**

1. $4LiH + AlCl_3 \rightarrow 3LiCl + LiAlH_4$
2. $N_2O_3 + 3H_2O \rightarrow 2H_3O^+ + 2NO_2^-$
3. $NH_4NO_3 \rightarrow 2H_2O + N_2O$

Correct answer: A · 3 only

A **redox** reaction requires at least one element to change its **oxidation number**. In reaction 1, Li, H, Al, and Cl maintain their initial states (+1, –1, +3, and –1), classifying it as a simple **hydride transfer**. In reaction 2, N stays +3 while O and H remain –2 and +1, making it an **acid–base** equilibrium. In reaction 3, the **nitrogen** in NH_4^+ starts at –3 and the nitrogen in NO_3^- starts at +5, both converting to +1 in N_2O, which confirms simultaneous oxidation and reduction.

Why the other answers are wrong

- **B) 2 only**: Claims reaction 2 is redox, but tracking every atom reveals no electron exchange since formal charges remain identical on both sides of the equation.
- **C) 1 and 2 only**: Groups reactions 1 and 2 together, yet both lack any shift in oxidation states and therefore fail the core requirement for electron transfer.
- **D) 1 and 3 only**: Selects reaction 1 alongside reaction 3, but reaction 1 only redistributes ions without altering their original values, which contradicts redox definitions.
- **E) 1, 2 and 3**: Treats all three equations as redox, ignoring that only reaction 3 actually features two nitrogen atoms undergoing opposite changes from –3 and +5 to +1.

47 **Which of the following molecules have an overall permanent dipole moment?**

1. CO_2
2. H_2O
3. NH_3

[C is in Group IV, N is in Group V, O is in Group VI]

Correct answer: A · 2 and 3 only

A molecule exhibits a **permanent dipole** when the vector sum of its bond dipoles is non-zero. Molecular **geometry** dictates whether these vectors cancel or **reinforce** each other. CO_2 is linear, so equal bond dipoles point oppositely and cancel completely. H_2O has a bent shape due to lone pairs, causing polar bonds to reinforce. NH_3 is trigonal pyramidal, so its polar bonds also yield a net dipole.

Why the other answers are wrong

- **B) 1 and 2 only**: Incorrectly includes the non-polar CO_2 and excludes the polar NH_3.
- **C) 1 and 3 only**: Commits the same error regarding CO_2 and omits H_2O, which possesses a net dipole due to its asymmetrical charge distribution.
- **D) none of them**: Overlooks the definitive polarity of both H_2O and NH_3 caused by their distinct molecular shapes.
- **E) 1, 2 and 3**: Confuses bond polarity with molecular polarity. Bond polarity is necessary but not sufficient, since linear **symmetry** causes complete cancellation in CO_2.

48 **Why does hydrogen iodide (HI) have a higher boiling point than hydrogen bromide (HBr)?**

[Atomic numbers: bromine = 35; iodine = 53]

Correct answer: A · The induced dipole-induced dipole (dispersion) forces between HI molecules are stronger than those between HBr molecules.

HI and HBr cannot form **hydrogen bonds**, so their physical properties depend on **permanent dipole–dipole forces** and **London dispersion forces**. Electronegativity decreases down the group, which reduces the permanent dipole moment from HBr to HI. Meanwhile, iodine contains significantly more electrons (53 versus 35), substantially increasing its **polarisability**. The enlarged electron cloud generates stronger instantaneous dipoles that enhance dispersion interactions. This dispersion enhancement outweighs the dipole weakening and raises the boiling point of HI above HBr.

Why the other answers are wrong

- **B)** The permanent dipole–dipole attractions are actually weaker in HI because the H–I bond exhibits a smaller electronegativity difference than H–Br. Dispersion forces consistently dominate the intermolecular profile for heavier hydrogen halides regardless of dipole magnitude.
- **C) There are hydrogen bonds between HI molecules but not between HBr molecules.**: True hydrogen bonding occurs only when hydrogen is directly attached to nitrogen, oxygen, or fluorine. Bromine and iodine fall short in both electronegativity and atomic compactness required for this specific interaction.
- **D) The H–I covalent bond is stronger than the H–Br covalent bond.**: Vaporisation demands overcoming the forces separating adjacent molecules, not rupturing the internal covalent framework. The thermal stability of the H–I bond ($\approx 299\ \mathrm{kJ\ mol^{-1}}$) is also experimentally lower than that of H–Br ($\approx 366\ \mathrm{kJ\ mol^{-1}}$).
- **E) The iodide ions in HI are larger than the bromide ions in HBr**: Liquid-phase HI and HBr consist of neutral molecular entities rather than dissociated charged species. Describing them as ionic assemblies contradicts their actual bonding character and cannot account for vaporisation temperatures.

49 **What is the minimum mass of sulfur dioxide needed to make 500 mL of a solution of concentration 3.0 mol/L?**
[A values: O = 16; S = 32]

Correct answer: A · 96 g

1. Convert the **volume**: $500\ \text{mL} = 0.500\ \text{L}$. 2. Calculate the **moles** required: $n = cV = (3.0\ \text{mol L}^{-1})(0.500\ \text{L}) = 1.5\ \text{mol}$ of SO_2. 3. The **molar mass** is $M(\text{SO}_2) = 32 + 2(16) = 64\ \text{g mol}^{-1}$. 4. The mass needed is $m = nM = (1.5\ \text{mol})(64\ \text{g mol}^{-1}) = 96\ \text{g}$.

Why the other answers are wrong

- **B) 48 g**: This mass gives $0.75\ \text{mol}$ of SO_2. That could result from incorrectly converting $500\ \text{mL}$ to $0.250\ \text{L}$, which halves the volume, or from accidentally calculating $1.5\ \text{mol} \div 2$.
- **C) 32 g**: This mass gives $0.50\ \text{mol}$ of SO_2. It treats the solution as having a concentration of $1\ \text{mol L}^{-1}$ instead of $3\ \text{mol L}^{-1}$, or assumes the molar mass of SO_2 is $32\ \text{g mol}^{-1}$ by forgetting the two oxygen atoms.
- **D) 192 g**: This corresponds to $3.0\ \text{mol}$ of SO_2, the amount required for $1.0\ \text{L}$ of a $3\ \text{mol L}^{-1}$ solution. The error is using $1\ \text{L}$ instead of the given $0.500\ \text{L}$.
- **E) 384 g**: This is twice the amount in D. It results from treating the volume as $2\ \text{L}$ or repeating the error, giving $6\ \text{mol}$ of SO_2 instead of $1.5\ \text{mol}$.

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50 **A compound consists of carbon, hydrogen and oxygen only.**

8 g of this compound contains 3 g of carbon and 1 g of hydrogen.

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

[A_r values: C = 12; H = 1; O = 16] r

Correct answer: A · CH_4O

Determine the **mass** of oxygen by subtraction: $8\ \text{g} - 3\ \text{g} - 1\ \text{g} = 4\ \text{g}$. Convert each component to **moles** using the given atomic weights: $3\ \text{g} \div 12\ \text{g mol}^{-1} = 0.25\ \text{mol}$, $1\ \text{g} \div 1\ \text{g mol}^{-1} = 1\ \text{mol}$, $4\ \text{g} \div 16\ \text{g mol}^{-1} = 0.25\ \text{mol}$. Divide all values by the smallest quantity to find the simplest whole-number **ratio**: $1 : 4 : 1$. This establishes the **empirical** formula as CH_4O. The molecular formula must be this base unit or an exact integer **multiple**. Only option A corresponds to the calculated composition.

Why the other answers are wrong

- **B)** CH_2O: CH_2O contains a hydrogen-to-carbon ratio of $2 : 1$ instead of $4 : 1$. This deviation from the experimental data eliminates it immediately.
- **C)** $\text{C}_2\text{H}_4\text{O}$: $\text{C}_2\text{H}_4\text{O}$ reduces to a ratio of $1 : 2 : 0.5$ when divided by two. Non-integer values indicate it cannot represent the fundamental building blocks of the molecule.
- **D)** $\text{C}_2\text{H}_8\text{O}$: $\text{C}_2\text{H}_8\text{O}$ simplifies to $1 : 4 : 0.5$ after division by two. The oxygen deficiency contradicts the required stoichiometry derived from the sample masses.
- **E)** C_3HO_4: C_3HO_4 follows a completely unrelated distribution of $3 : 1 : 4$. Both carbon and oxygen counts deviate significantly from the measured proportions.

51 **Hydrogen has a radioactive isotope called tritium. Tritium atoms have two neutrons.**

The most abundant naturally occurring isotope of hydrogen has a relative atomic mass of 1.0.

What is the value for the relative atomic mass of a sample of hydrogen gas that has an equal amount of these two isotopes of hydrogen?

Correct answer: A · 2.0

The **relative atomic mass** represents the abundance-weighted average of all isotopes present. **Protium** has a standard mass of $1\ \mathrm{u}$. **Tritium** contains one proton and two neutrons, giving it a mass of $3\ \mathrm{u}$. With equal atom counts, each isotope contributes exactly 50%. Computing the **weighted sum** yields $(0.50 \times 1\ \mathrm{u}) + (0.50 \times 3\ \mathrm{u}) = 2.0\ \mathrm{u}$.

Why the other answers are wrong

- **B) 1.0**: This value assumes the sample contains only ordinary hydrogen without any tritium, contradicting the stated presence of both isotopes.
- **C) 1.5**: An average of $1.5\ \mathrm{u}$ would require a specific non-equal distribution, specifically a $3:1$ ratio of protium to tritium.
- **D) 3.0**: This corresponds to the pure tritium mass, which would only occur if ordinary hydrogen were completely absent.
- **E) 4.0**: This value does not match any hydrogen isotope and cannot be produced as an average of $1\ \mathrm{u}$ and $3\ \mathrm{u}$ in any proportion.

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52 **Consider the following reversible reaction at temperature T.**

$$A + 2B \rightleftharpoons 2C + D$$

At equilibrium, there are 0.5 moles of A, 0.2 moles of B, 0.5 moles of C and 0.8 moles of D, all in a vessel of volume V.

Using the equilibrium-constant expression for this reaction, what is the value of K at this temperature?

Correct answer: A · 10

The value of the **equilibrium constant expression** depends on product and reactant concentrations raised to their **stoichiometric coefficients**. For this reaction, $K_c = \frac{[C]^2[D]}{[A][B]^2}$. The calculation proceeds as follows: 1. Express each concentration as moles divided by the common volume V: $[A] = \frac{0.5}{V}$, $[B] = \frac{0.2}{V}$, $[C] = \frac{0.5}{V}$, $[D] = \frac{0.8}{V}$. 2. Substitute these terms into the formula: $K_c = \frac{(0.5/V)^2(0.8/V)}{(0.5/V)(0.2/V)^2}$. 3. Cancel the identical **volume terms** and evaluate the remaining **numerical ratio** to obtain 10.

Why the other answers are wrong

- **B) 4**: The result 4 typically appears when an exponent is missing in the calculation or the numbers are simplified incorrectly during substitution.
- **C) 2**: This value often results from ignoring the stoichiometric coefficients, which removes the squared terms from the concentration products and reactants.
- **D) 0.25**: The figure 0.25 comes from an incorrect ratio of the given amounts rather than applying the proper power rules for the equilibrium formula.
- **E) 0.1**: The value 0.1 reflects an inverse-type error where the positions of reactants and products are swapped in the division.

53 Which of the following expressions is equal to $\frac{8^{2n} \times 4^n}{2^n}$ for all integers n?

Correct answer: A · 2^{7n}

Convert all **bases** to **powers** of 2 using exponent rules. Rewrite 8^{2n} as 2^{6n} and 4^n as 2^{2n}. **Multiply** the numerators by adding exponents to get 2^{8n}. **Divide** by the denominator and subtract n to obtain 2^{7n}.

Why the other answers are wrong

- **B)** 2^{6n}: Represents only the first factor 8^{2n} without applying the remaining operations. It completely omits the multiplication by 4^n and the division by 2^n.
- **C)** 2^{6n+1}: Results from adding 1 to the exponent during multiplication or incorrectly assuming division by 2^n reduces the exponent by just 1. The correct operation requires adding $2n$ and then subtracting n.
- **D)** 2^{2n+5}: Incorrectly treats 8^{2n} as a **constant** value like $2^5 = 32$ rather than an exponential expression. This mistake fails to scale the exponent by n and introduces an unrelated numerical term.
- **E)** 2^{14n}: Occurs when reversing the **sign** of the denominator exponent, effectively multiplying by 2^n instead of dividing. Adding $6n + 2n + 6n$ produces $14n$ instead of correctly subtracting n to reach $7n$.

54 The mean mass of three babies is 2.1 kg. The range of their masses is 0.7 kg. The lightest baby has a mass of 1.8 kg.

What is the median mass of the three babies?

Correct answer: A · 2.0 kg

The **total mass** equals $3 \times 2.1\ \text{kg} = 6.3\ \text{kg}$. Given the **range** of $0.7\ \text{kg}$ and the lightest mass of $1.8\ \text{kg}$, the **heaviest** is $1.8 + 0.7 = 2.5\ \text{kg}$. Subtracting these from the sum leaves the **middle** value: $6.3 - 4.3 = 2.0\ \text{kg}$. In a set of three, this center number is the **median**.

Why the other answers are wrong

- **B) 1.95 kg**: Substituting $1.95\ \text{kg}$ changes the total sum to $6.25\ \text{kg}$. This results in a calculated mean of $2.083\ \text{kg}$, which contradicts the stated average.
- **C) 2.1 kg**: Substituting $2.1\ \text{kg}$ changes the total sum to $6.4\ \text{kg}$. This results in a calculated mean of $2.133\ \text{kg}$, which exceeds the required average.
- **D) 2.15 kg**: Substituting $2.15\ \text{kg}$ changes the total sum to $6.45\ \text{kg}$. This results in a calculated mean of $2.15\ \text{kg}$, which deviates significantly from the stated mean.
- **E) 2.3 kg**: Substituting $2.3\ \text{kg}$ changes the total sum to $6.6\ \text{kg}$. This results in a calculated mean of $2.2\ \text{kg}$, representing the largest numerical error among the choices.

55 **What is the highest common factor of 360, 500 and 700, given as the product of powers of its prime factors?**

Correct answer: A · $2^2 \times 5$

1. Decompose each number into **prime factors**: $360 = 2^3 \times 3^2 \times 5^1$, $500 = 2^2 \times 5^3$, $700 = 2^2 \times 5^2 \times 7^1$. 2. Select only primes appearing in **all three** lists. 3. Apply the **lowest exponent** found for each selected prime. This procedure yields $2^2 \times 5^1 = 20$.

Why the other answers are wrong

- **B) 2 × 5**: Contains the right primes but applies an insufficient exponent to 2. It divides the inputs yet falls short of the maximum possible divisor.
- **C)** $2^3 \times 5^3$: Requires 2^3 and 5^3, which surpass the available powers in 500 and 700. These excess values prevent the expression from dividing every number.
- **D)** $2^2 \times 3^2 \times 5 \times 7$: Introduces 3^2 and 7, which are absent from at least one original integer. The presence of these exclusive primes breaks the simultaneous divisibility requirement.
- **E)** $2^3 \times 3^2 \times 5^3 \times 7$: Combines the exclusion flaw of option D with excessively large exponents for 2 and 5. It ignores the lowest-exponent rule and fails to act as a common divisor.

56 **What is the sum of the solutions to the equation $\frac{3}{x} + \frac{2}{x-2} = 1$, where x is a real number and $x \neq 0$ and $x \neq 2$?**

Correct answer: A · 7

1. Multiply both sides by $x(x-2)$ to clear denominators, yielding $3(x-2) + 2x = x(x-2)$. 2. Expand and rearrange terms to obtain the **quadratic** equation $x^2 - 7x + 6 = 0$. 3. Factor into $(x-1)(x-6) = 0$, giving two **valid roots** $x = 1$ and $x = 6$ that respect $x \neq 0, 2$. 4. Add the solutions to compute the **sum** as $1 + 6 = 7$.

Why the other answers are wrong

- **B) 5**: The value 5 typically stems from arithmetic slips like subtracting the roots instead of adding them, or from mistakenly combining coefficients. It ignores the requirement to include both admissible solutions in the final total.
- **C) -7**: This negative sum originates from a **sign error** during rearrangement, which incorrectly yields $x^2 + 7x - 6 = 0$. That flipped middle term generates false roots whose sum is wrong.
- **D) 2.4**: The decimal 2.4 suggests an **averaging** attempt of the initial constants or solving $5x = 12$ through invalid cross-multiplication. This isolated value does not represent the required sum and fails to satisfy the original equation.
- **E) -3**: This figure appears if one mistakenly cancels denominators to get $3 + 2 = x - 2$, then applies arbitrary corrections. Neither –3 nor its **incorrect simplification** relates to the verified roots.

57 **A car, which is initially stationary, accelerates for 5.0 seconds at 4.0 m/s^2 along a straight road. It then continues in the same direction for 20 seconds at a constant speed.**

What is the maximum speed of the car, and what is the distance travelled by the car in the final 20 seconds of its motion?

Correct answer: A · maximum speed = 20 m/s; distance = 400 m

1. The car starts from rest, so the initial speed is zero. 2. It accelerates uniformly for $5.0\ \mathrm{s}$ at $4.0\ \mathrm{m\,s^{-2}}$, giving $v = u + at = 0 + (4.0\ \mathrm{m\,s^{-2}})(5.0\ \mathrm{s}) = 20\ \mathrm{m\,s^{-1}}$. 3. This value is the **maximum speed**. 4. The vehicle travels at this **constant speed** for $20\ \mathrm{s}$, covering $s = vt = (20\ \mathrm{m\,s^{-1}})(20\ \mathrm{s}) = 400\ \mathrm{m}$.

Why the other answers are wrong

- **B) maximum speed = 20 m/s; distance = 80 m**: The maximum speed is correctly identified, but $80\ \mathrm{m}$ results from using $4\ \mathrm{m\,s^{-1}}$ instead of $20\ \mathrm{m\,s^{-1}}$. This error likely stems from confusing the numerical value of the acceleration ($4.0\ \mathrm{m\,s^{-2}}$) with the final speed.
- **C) maximum speed = 9.0 m/s; distance = 180 m**: The quoted speed of $9.0\ \mathrm{m\,s^{-1}}$ would only require about $2.25\ \mathrm{s}$ of acceleration at $4.0\ \mathrm{m\,s^{-2}}$, not the given $5.0\ \mathrm{s}$. The distance $180\ \mathrm{m}$ follows directly from incorrectly multiplying $9.0\ \mathrm{m\,s^{-1}}$ by $20\ \mathrm{s}$.
- **D) maximum speed = 9.0 m/s; distance = 200 m**: It repeats the incorrect maximum speed from option C. The distance $200\ \mathrm{m}$ implies multiplication by $10\ \mathrm{m\,s^{-1}}$ rather than the stated $9.0\ \mathrm{m\,s^{-1}}$, making the figures internally inconsistent.
- **E) maximum speed = 24 m/s; distance = 480 m**: A speed of $24\ \mathrm{m\,s^{-1}}$ assumes an acceleration period of $6\ \mathrm{s}$ instead of $5\ \mathrm{s}$. The corresponding distance $480\ \mathrm{m}$ is simply $24\ \mathrm{m\,s^{-1}} \times 20\ \mathrm{s}$, so it scales linearly from the wrong velocity.

58 **A stone of density 5.20 g/$\mathrm{cm^3}$ and volume 200 $\mathrm{cm^3}$ is completely submerged in a liquid of density 1.20 g/$\mathrm{cm^3}$.**

What is the magnitude of the upthrust acting on the stone?

[gravitational field strength = 10.0 N/kg]

Correct answer: A · 2.40 N

1. Apply **Archimedes' principle** to state that the upthrust equals the **weight of displaced liquid**. 2. Convert measurements to SI units: $\rho = 1.20 \times 10^3\ \mathrm{kg\,m^{-3}}$ and $V = 2.0 \times 10^{-4}\ \mathrm{m^3}$. 3. Calculate the **mass** of displaced fluid using $m = \rho V$, which yields $0.24\ \mathrm{kg}$. 4. Compute the **upthrust** by multiplying by gravitational acceleration: $F = mg = 0.24 \times 10.0 = 2.40\ \mathrm{N}$.

Why the other answers are wrong

- **B)** 6.40 N comes from mistakenly subtracting densities or misaligning units, producing neither the buoyant force nor the net weight.
- **C)** 8.00 N corresponds to the apparent weight, found by removing the correct upthrust value from the true gravitational weight.
- **D)** 10.4 N is the actual weight in air, derived from the stone's own density and volume instead of the liquid properties.
- **E)** 2.00 N appears when approximating the liquid density to pure water or applying early rounding during intermediate steps.

59 **Two charged particles P and Q are 0.10 m apart. The charge on P is $1.50 \times 10^{-7} C$ and the charge on Q is 1.50×10^{-7}. Particle P experiences an electrostatic force of magnitude F because it is near to the charge on particle Q.**

The distance between the two particles is increased to 0.20 m.
The charge on P is increased to 4.50×10^{-7} and the charge on Q is increased to $6.00 \times 10^{-7} C$.

What is the magnitude of the force that particle P experiences now?

Correct answer: A · 3F

Based on **Coulomb's law**, the electrostatic force scales with the product of the charges and inversely with the square of the distance. To find the new force, we evaluate the **ratio** between the final and initial states: 1. Particle P's charge **triples** ($4.50 \times 10^{-7}\ \mathrm{C} / 1.50 \times 10^{-7}\ \mathrm{C} = 3$). 2. Particle Q's charge **quadruples** ($6.00 \times 10^{-7}\ \mathrm{C} / 1.50 \times 10^{-7}\ \mathrm{C} = 4$). 3. The separation distance **doubles** ($0.20\ \mathrm{m} / 0.10\ \mathrm{m} = 2$), applying a factor of $(1/2)^2 = 1/4$. $3 \times 4 \times \frac{1}{4} = 3$ The combined effect confirms that the new force equals $3F$.

Why the other answers are wrong

- **B) 12F**: Multiplies the charge increases correctly ($3 \times 4 = 12$) but ignores the distance increase. Doubling the gap reduces the force by a factor of four, which this option omits.
- **C) 6F**: Notes that stronger charges raise the force, but mistakenly applies the doubled distance as a linear factor of two rather than squared, or drops one of the charge multipliers.
- **D)** $\frac{F}{4}$: Accounts only for the increased separation ($1/2^2 = 1/4$) and follows the inverse square relationship, while completely disregarding the multiplicative effect of the larger charges.
- **E)** $\frac{3F}{4}$: Applies the threefold charge increase and the quarter-distance reduction, but fails to include the fourfold increase from particle Q.

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60 **A fixed mass of an ideal gas is compressed at constant temperature.**
The pressure is recorded continuously as the volume decreases.
The pressure (y-axis) and volume (x-axis) are plotted on a linearly scaled graph.
Which statement describes the plotted line?

Correct answer: A · a curved line with negative gradient of decreasing magnitude

For an ideal gas at constant temperature, **Boyle's law** gives $pV = \text{constant}$. On linear axes this plots as a **rectangular hyperbola** with an **inverse relationship** between variables. The curve shows a **negative gradient** that **decreases in magnitude** because $|dp/dV| = k/V^2$.

Why the other answers are wrong

- **B) a straight line of positive gradient starting at the origin of the graph**: Requires direct proportionality $p \propto V$, contradicting the inverse relationship. It also incorrectly places the line through the origin.
- **C) a straight line parallel to the pressure axis**: Describes a vertical line implying fixed volume. The experiment actively changes volume, making a constant value impossible.
- **D) a straight line parallel to the volume axis**: Indicates constant pressure throughout the process. This models an isobaric change instead of the specified isothermal condition.
- **E) a curved line of increasing positive gradient starting at the origin of the graph**: Claims a positive slope that grows steeper over time. The physical curve actually slopes downward and flattens out as volume increases.

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