PROVE UFFICIALI DEGLI ANNI PASSATI

# IMAT 2021

## PROVA UFFICIALE MUR

Con le risposte

ALLENATI SULL'APP TESTBUDDY

TESTBUDDY.IT

# WHAT'S IN THIS DOCUMENT

**Prova di ammissione IMAT 2021, 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 | 21 questions |
| Biology | 18 questions |
| Chemistry | 10 questions |
| Physics and Mathematics | 4 questions |
| **Total** | **53 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

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## ADMISSION TEST FOR THE DEGREE COURSE IN MEDICINE AND SURGERY

**Academic Year 2021/2022**

Cambridge Assessment Admissions Testing

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**1** A young woman (A), knowing that she was dying, requested that her mother (B), who was awaiting a kidney transplant, should be allowed to receive her kidneys after her death. The request was not allowed, and A's kidneys were received by another patient (C), who was higher up the waiting list than B because his medical need for a transplant was more urgent. The committee overseeing transplant decisions argued that the system it used had to be administered solely in accordance with the rationale behind its waiting list. Their decision seemed to others unduly bureaucratic, especially as B will be left to care for A's young child.

Which one of the following best illustrates the principle behind the committee's decision?

**A** Decisions on transplants should focus on the medical need of the potential recipient.

**B** Decisions on transplants cannot be influenced by emotions.

**C** Donations between family members are not allowed.

**D** Decisions on transplants should include social considerations.

**E** The donor's wishes should not be considered.

**2** From ever younger ages, people are reporting symptoms of anxiety due to the pressure to be 'perfect' in all areas of life. It seems that, in many cultures, there is an increasing sense of competition in everything from school results to the job market to personal appearance and even how one's social life looks on social media. As a result, many people experience problems associated with low self-confidence. But rather than reach for a pill or a self-help book to tackle their problems, more of these individuals should just go outside for a run or a walk. While it sounds simplistic, this recommendation is supported by the research finding that people who do a lot of outdoor activities tend to have high self-esteem.

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

**A** It ignores the possibility that people with higher self-esteem might be more inclined to take part in outdoor activities.

**B** It assumes that high levels of self-confidence or self-esteem are all that are needed for a person to enjoy good mental health.

**C** It ignores the fact that not everyone with low self-esteem has the desire to go for a run or a walk outside.

**D** It assumes that people who manage to appear 'perfect' in the different parts of their lives will not suffer from problems with self-confidence.

**E** It ignores the likelihood that many people with varying levels of self-confidence would benefit from the advice of a mental health professional.

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**3** For many years, children and young people have been protected from exploitation by the entertainment industry. In recent years, however, the number of young people suddenly thrust into the limelight has increased, and many of them feel that they must seize any opportunity to achieve recognition before this window passes them by. Dealing with fame, performing in front of large audiences, the rigours of rehearsal and the general stresses of what is a difficult occupation take maturity and can rob children of their childhood. Rejection, disappointment and failure are felt more keenly by young people because they lack wider experience and this can make for a very unhappy childhood. These factors would indicate that young performers need further protection by law.

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

**A** Young performers need further protection by law.

**B** Young people can be suddenly thrust into the limelight.

**C** Young performers are robbed of their childhood by the demands of performing.

**D** Young people feel rejection, disappointment and failure more because they lack wider experience.

**E** Young people have been protected from exploitation by the entertainment industry for many years.

**4** Our three local universities have agreed that they will offer a place to everyone from our school who applies to them. Because you attend a different school, you are not guaranteed an offer from these universities.

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

**A** Everyone over the age of 60 is entitled to a bus pass, which gives them free travel on buses after 9:30 am. Since you are younger than 60, you are not entitled to free bus travel.

**B** Everyone who becomes a student at our college has achieved a high score in their high school examinations. You have a high score, and therefore you are sure to be accepted as a student at our college.

**C** Everyone who has a free bus pass is entitled to travel on buses after 9:30 am without payment. Since it is after 9:30 am and you have a free bus pass, you do not have to pay for this bus journey.

**D** In our country, everyone who becomes a teacher must have a university degree. Since you do not have a degree, you are not qualified to become a teacher.

**E** The only way to stand for election to Parliament is to be nominated by voters in a geographical constituency. Since you have not been nominated, you cannot stand for election.

**5** Of all the food we buy, bread suffers the worst fate when it comes to waste. 32% of it ends up being thrown away. We value other types of food a lot more, as the average for all food and drink being wasted is 15%. The proportion of meat and fish thrown away is below average (13%) and our most precious item is alcohol – we throw away just 6% of it.

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

**A** The main reason why we throw food away is that we do not value it much.

**B** Bread is a low-quality food.

**C** We should be more moderate when it comes to buying bread.

**D** The more expensive a food or drink is, the less likely it is that it will be wasted.

**E** Bread goes stale faster so is more likely to be thrown away.

**6** In a survey of cats' eating habits, 10% of the cats tested showed a clear preference for Moggiemeat, 20% preferred Fuss-a-Puss and 40% preferred Yummy Paws. An additional 6 cats did not seem to care at all which of the three foods they ate, while the remaining 27 cats in the survey would not touch any of these foods.

How many cats were involved in the survey?

**A** 110

**B** 33

**C** 63

**D** 90

**E** 103

**7** It is usual, when seating people round a table at a social function, to alternate males with females, but if there are unequal numbers of each, this is impossible.

At one party, 14 women and only 6 men were present. They were seated round a circular table so that as few women as possible had no male sitting directly next to them.

How many women had no male sitting directly next to them?

**A** 2

**B** 4

**C** 6

**D** 7

**E** 8

**8** Simon plans to send Christmas cards to 35 friends. He is going to choose a single design to send to them all and knows that some of the recipients really do not like glitter cards so he will not buy this type. He wants 2-fold cards so that he can write a letter on the inside for 5 of them.

The following table shows the possibilities that he is considering.

| *card type* | *no. in pack* | *glitter* | *1-fold* | *2-fold* | *pack price* |
|---|---|---|---|---|---|
| *religious* | 5 | no | | yes | £1.80 |
| *robins* | 8 | no | yes | | £1.95 |
| *village scene* | 20 | yes | | yes | £2.50 |
| *cartoon* | 12 | no | yes | | £2.20 |
| *father xmas* | 10 | no | | yes | £3.10 |

What is the lowest amount of money that Simon could spend on his cards?

**A** £12.40

**B** £12.60

**C** £5.00

**D** £6.00

**E** £9.75

**9** When I first woke up early this morning the display of my bedside digital clock showed:




I presumed that it was faulty, but, after drifting off to sleep again, when I next awoke and saw the clock I realised that someone must have turned the clock upside down and that it was exactly an hour and a half since I had looked at it before.

What did I see when I woke up the second time?

**A**




**B**




**C**




**D**




**E**




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**10** Teams from five US states have reached the final of a competition. The event organisers are trying to design a sign for each state. One idea involves the name, in capital letters, being placed vertically on a sign board which spins when one of the team presses their buzzer to answer a question. They want the sign to read correctly regardless of whether it is read from the front or the back.

Unfortunately they realise that most of the states for which this would have worked have not reached the final.

Which one of the following is the only state in the final for which this style of sign would work?

**A** Hawaii

**B** Alabama

**C** Idaho

**D** Montana

**E** Oklahoma

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

**A** Hans Jonas – medicine

**B** John Maynard Keynes – economics

**C** Maria Montessori – pedagogy

**D** Max Planck – physics

**E** B. F. Skinner – psychology

**12** Which one of the following writers is the author of the best-selling novel *My Brilliant Friend*?

**A** Elena Ferrante

**B** Khaled Hosseini

**C** Ian McEwan

**D** Paulo Coelho

**E** Kazuo Ishiguro

**13** What does the letter A stand for in the international organisation FAO?

**A** Agriculture

**B** Architecture

**C** Aerospace

**D** Automotive

**E** Aesthetics

**14** Which of the following pairs of theatre/city is the only correct one?

**A** Metropolitan Opera House – New York

**B** San Carlo – Venice

**C** The Bolshoi Theatre – Saint Petersburg

**D** La Fenice – Florence

**E** The Palais Garnier Opera House – Brussels

**15** The Rosetta Stone provided the key to decipher

**A** Egyptian hieroglyphs.

**B** characters of the Phoenician alphabet.

**C** characters of the Ancient Greek alphabet.

**D** the Code of Hammurabi.

**E** the Sumerian language.

**16** Which one of the following institutions of the European Union is elected by direct universal suffrage?

**A** European Parliament

**B** European Commission

**C** Court of Justice of the European Union

**D** European Economic and Social Committee

**E** Council of the European Union

**17** Which one of the following directors directed the films that make up *The Godfather* trilogy?

**A** Francis Ford Coppola

**B** Martin Scorsese

**C** Sergio Leone

**D** Brian De Palma

**E** Matteo Garrone

**18** Which one of the following pairs of scholar/scientific discovery is NOT correct?

**A** Niels Bohr – electron microscope

**B** Dmitri Mendeleev – periodic table of elements

**C** Wilhelm Conrad Röntgen – x-ray

**D** Hans Wilhelm Geiger – particle detector

**E** Evangelista Torricelli – mercury barometer

**19** Which one of the following treaties established the European Coal and Steel Community (ECSC)?

**A** Paris

**B** Lisbon

**C** Amsterdam

**D** Nice

**E** Rome

**20** Which one of the following global organisations sets and enforces rules of trade between nations?

**A** WTO

**B** World Bank

**C** IMF

**D** OECD

**E** World Economic Forum

**21** Which one of the following pairs of Russian writers/works is NOT correct?

**A** Mikhail Bulgakov – Uncle Vanya

**B** Vladimir Nabokov – Lolita

**C** Fyodor Dostoyevsky – The Brothers Karamazov

**D** Leo Tolstoy – Anna Karenina

**E** Boris Pasternak – Doctor Zhivago

**22** The expression ‘perfect bicameral system’ refers to

**A** the legislative procedure that assigns identical powers to the two chambers of a parliament.

**B** the judicial system whereby the first sentence must be confirmed by the first round of appeal.

**C** the form of government that assigns identical power to two institutional figures.

**D** the kind of parliamentary monarchy where monarch and parliament have the same powers.

**E** the perfect separation of the magistrate judge and public prosecutor.

**23** Which of the following types of nucleic acid is/are found in viruses?

**1** single-stranded DNA

**2** double-stranded DNA

**3** RNA

**A** 1, 2 and 3

**B** 1 and 2 only

**C** 2 only

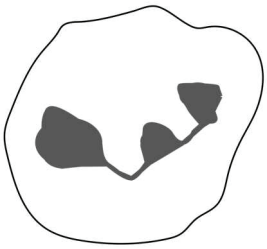
**D** 1 and 3 only

**E** 2 and 3 only

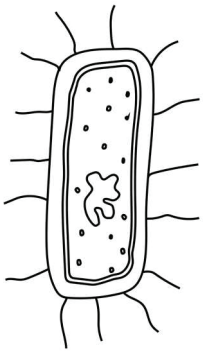
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**24** Which one of the diagrams (not drawn to scale) represents a structure that is formed by mitosis?

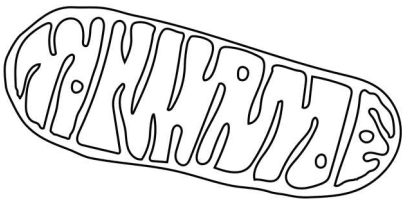
**A**



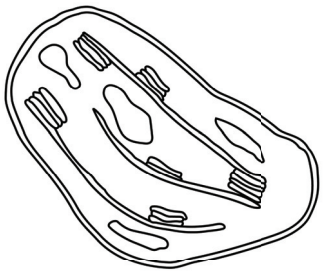
**B**



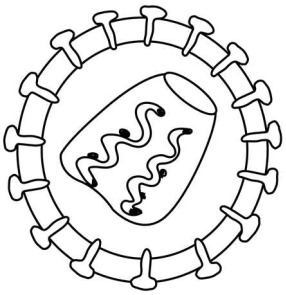
**C**



**D**



**E**



**25** Three fatty acids with the formula $C_8H_{16}O_2$ react with glycerol ($C_3H_8O_3$) to form a triglyceride.

Which of the following is the correct formula for the triglyceride?

**A** $C_{27}H_{50}O_6$

**B** $C_{27}H_{48}O_5$

**C** $C_{27}H_{48}O_6$

**D** $C_{27}H_{52}O_7$

**E** $C_{27}H_{56}O_9$

**26** Which of the following is correct for cholesterol in humans?

**A** It maintains the fluidity of the cell membrane.

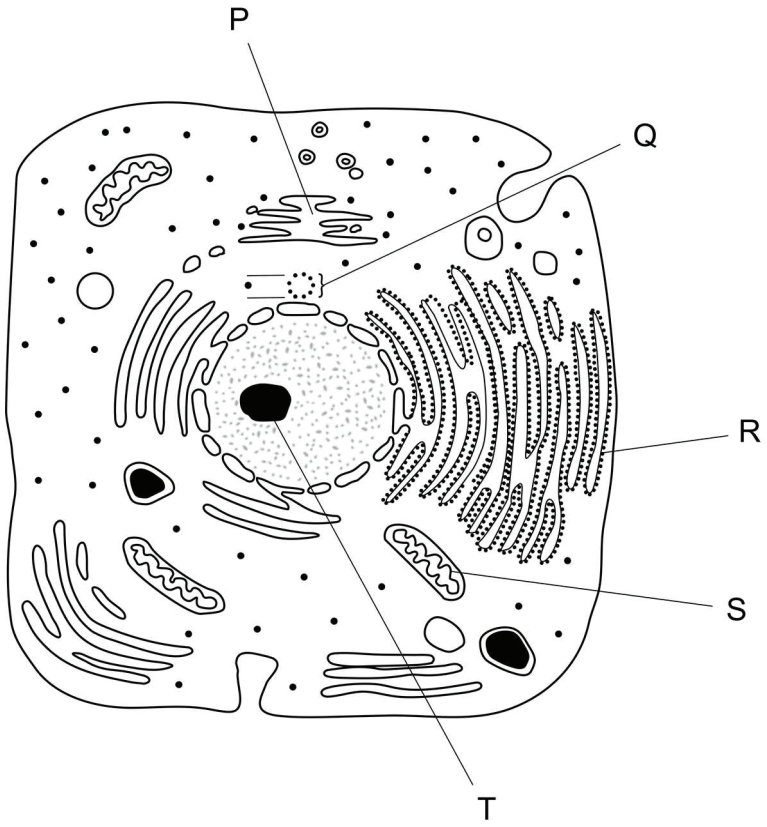
**B** It is used to make all hormones.

**C** It is a good source of energy because of the number of hydrogen atoms.

**D** It forms hydrogen bonds with water which stabilises the cell membrane.

**E** It transports fatty acids around the body.

**27** The diagram represents an animal cell with five organelles labelled P, Q, R, S and T.




Which row correctly matches the label with the name and function of the cell organelle?

| | *label* | *name of cell organelle* | *function of cell organelle* |
|---|---|---|---|
| row 1 | P | mitochondrion | protein synthesis |
| row 2 | Q | centrioles | holds sister chromatids together |
| row 3 | R | ribosome | formation of lysosomes |
| row 4 | S | Golgi apparatus | anaerobic respiration |
| row 5 | T | nucleolus | formation of ribosomal sub-units |

**A** row 5

**B** row 2

**C** row 3

**D** row 4

**E** row 1

**28** Which of the following cell structures contain(s) biological catalysts?

**1** cytoplasm

**2** nucleus

**3** mitochondria

**A** 1, 2 and 3

**B** 2 only

**C** 3 only

**D** 2 and 3 only

**E** 1 only

**29** Which of the following reactions or biological processes involves a redox reaction?

**A** $NAD^+ + H_2 \rightleftharpoons NADH + H^+$

**B** glucose + glucose ⇌ maltose + water

**C** a cytosine and guanine pairing

**D** polymerisation of amino acids

**E** depolarisation of a neuron

**30** The SRY gene is normally located on the human Y chromosome. This gene initiates the development of male characteristics.

Using this information, which of the following statements about the SRY gene is/are correct?

**1** Insertion of the SRY gene into an X chromosome of a female zygote could give it male characteristics.

**2** A sperm cell arising from incorrect division, which has a functional SRY gene, could give rise to a female with a sex chromosome trisomy following fertilisation with a normal ova.

**3** During meiosis, crossing over could result in the formation of 'X' sperm with the SRY gene, which could cause male characteristics after fertilisation.

**A** 1 and 3 only

**B** 2 only

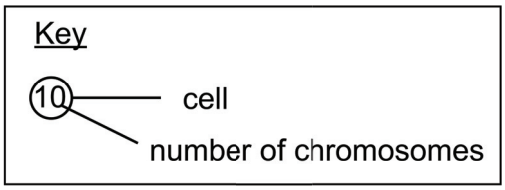
**C** 3 only

**D** 1 and 2 only

**E** 1 only

**31** A cell containing four pairs of homologous chromosomes divides by meiosis.

Which row shows the cells produced and the number of chromosomes that they contain?




| *row* | *parent cell* | *end of meiosis I* | *after meiosis II* |
|---|---|---|---|
| 1 | (4) | (2) (2) | (2) (2) (2) (2) |
| 2 | (4) | (4) (4) | (2) (2) (2) (2) |
| 3 | (8) | (4) (4) | (4) (4) (4) (4) |
| 4 | (8) | (8) (8) | (4) (4) (4) (4) |
| 5 | (8) | (16) (16) | (8) (8) (8) (8) |

**A** row 3

**B** row 2

**C** row 1

**D** row 4

**E** row 5

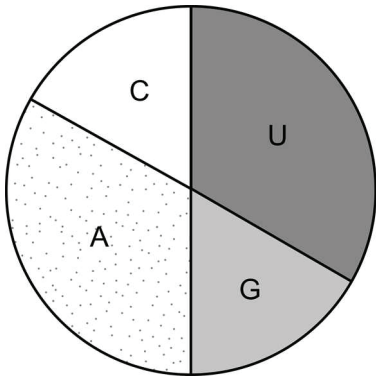
**32** The sequence of bases in part of a DNA strand is:

TATGATCTTAGGCAACAT

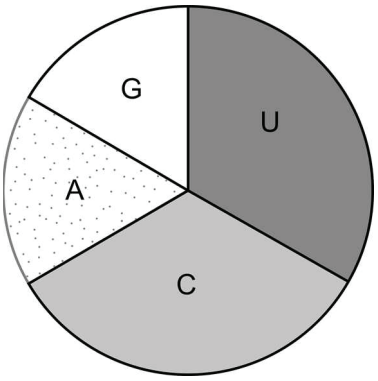
A strand of mRNA is transcribed using this sequence of bases.

Which one of the following charts shows the correct proportions of the bases in the mRNA?

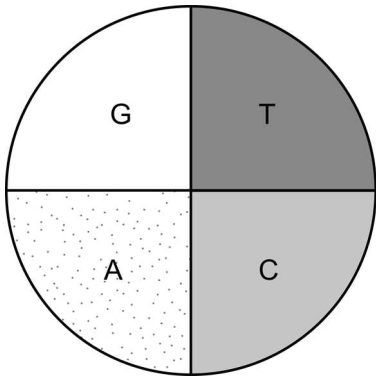
**A**



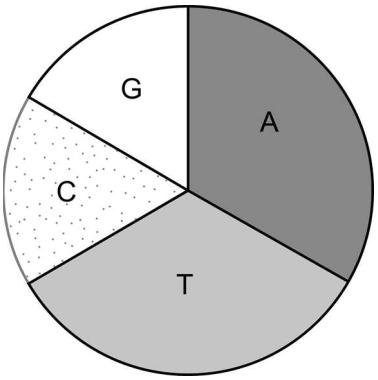

**B**



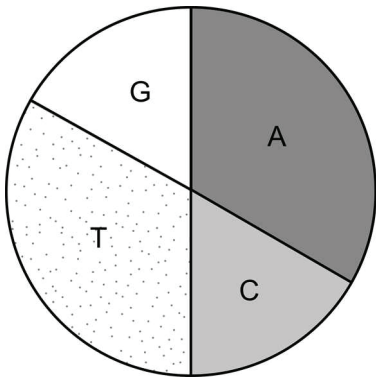

**C**




**D**

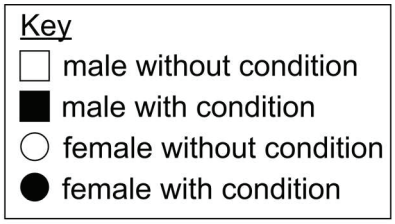



**E**

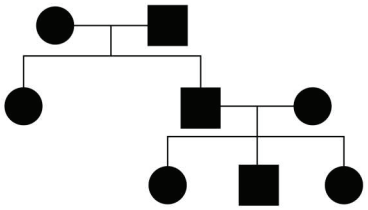


**33** Polydactyly is a condition caused by a gene mutation. Animals affected by polydactyly have extra digits on one or more limbs.

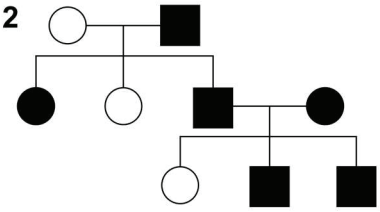
Five inheritance patterns of polydactyly in a species are shown in the diagrams.



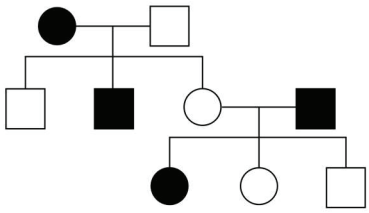

**1**



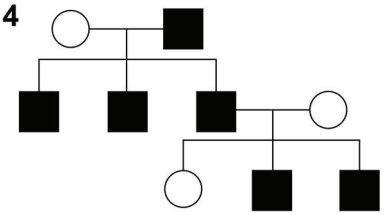
**2**



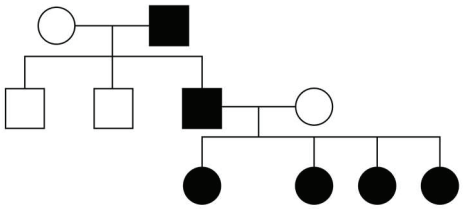
**3**



**4**



**5**



Which inheritance pattern can ONLY occur when polydactyly is caused by an autosomal dominant allele and NOT when it is caused by an autosomal recessive allele?

[Assume normal cell divisions in all individuals.]

**A** 2

**B** 1

**C** 3

**D** 4

**E** 5

**34** In which of the following places are proton pumps found?

**1** the chloroplast stroma

**2** the gap between the thylakoid membranes

**3** the membrane of the granum

**A** 3 only

**B** 2 only

**C** 1 only

**D** 1 and 2 only

**E** 1 and 3 only

**35** Which row could be correct for directional selection?

| Key | |
|---|---|
| ✓ | yes |
| x | no |

| | *a low-frequency phenotype is selected* | *a predator could be the cause* | *the frequency of a recessive allele increases* |
|---|---|---|---|
| row 1 | ✓ | x | x |
| row 2 | x | ✓ | x |
| row 3 | x | x | ✓ |
| row 4 | x | ✓ | ✓ |
| row 5 | ✓ | ✓ | ✓ |

**A** row 5

**B** row 2

**C** row 3

**D** row 4

**E** row 1

**36** Which one of the following statements is correct about the cardiac cycle of a healthy human?

**A** When the left ventricle relaxes, the aortic valve closes.

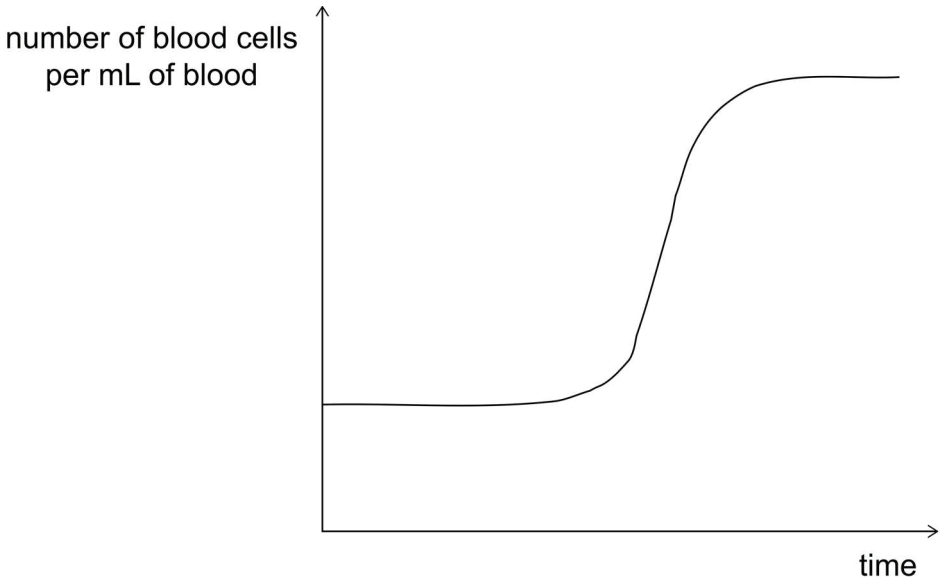
**B** When the left atrium contracts, the aortic valve opens.

**C** When the right atrio-ventricular valve closes, the left atrio-ventricular valve opens.

**D** When the right atrium contracts, the left ventricle contracts.

**E** When the right ventricle contracts, the right atrio-ventricular valve opens.

**37** The graph below shows the change in blood cell count of a human over time.




Which of the following could explain the shape of the above graph?

**1** a reduction in the concentration of oxygen in the atmosphere

**2** a response to a bacterial infection

**3** increased differentiation of bone marrow stem cells

**A** 1, 2 and 3

**B** 1 and 2 only

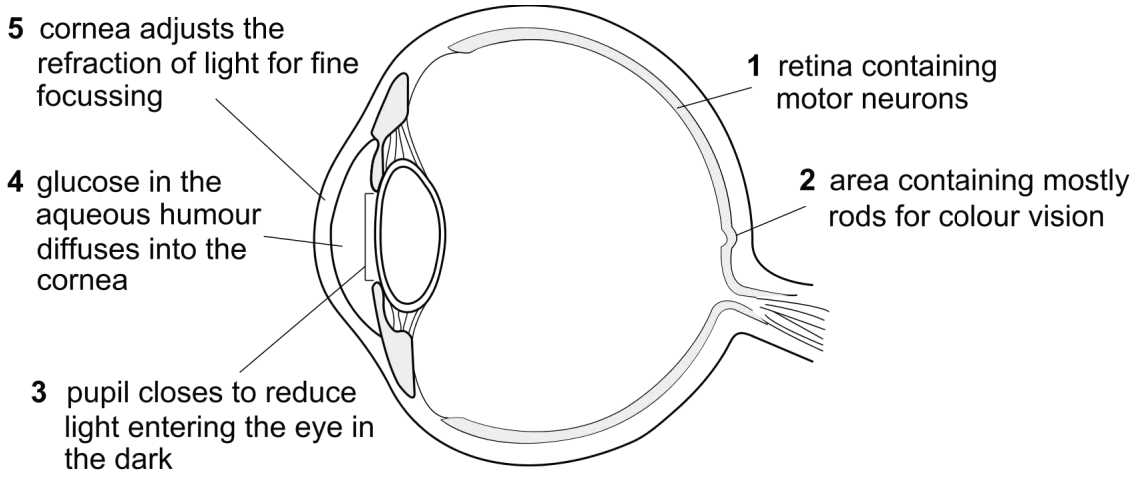
**C** 2 and 3 only

**D** 1 only

**E** 2 only

**38** The diagram shows a cross section through a human eye. Some parts of the eye are labelled 1 to 5 with notes.

Which one of the following notes is correct?




**A** note 4

**B** note 2

**C** note 3

**D** note 1

**E** note 5

**39** Organ or tissue transplants normally require that the donor's antigens must be closely matched to those of the recipient.

Which one of the following types of transplant can typically be carried out WITHOUT the need for a match between donor and recipient?

**A** cornea

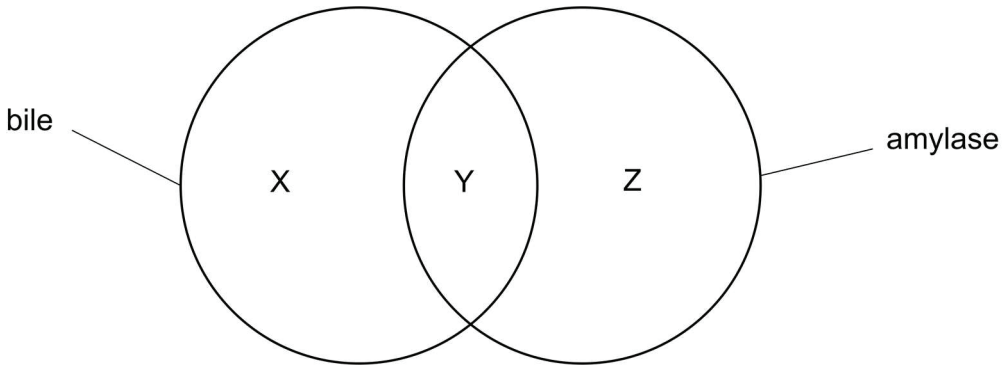
**B** liver

**C** lung

**D** heart

**E** kidney

**40** The diagram shows the relationship between the features of two substances involved in digestion: bile and amylase.




Which of the following rows is correct for X, Y and Z?

| | *X* | *Y* | *Z* |
|---|---|---|---|
| row 1 | assimilates lipid | stored in the gall bladder | digests maltose |
| row 2 | digests lipid | works in the small intestine | digests starch |
| row 3 | digests lipid | produced by the pancreas | produces maltose |
| row 4 | emulsifies lipid | produced by the pancreas | digests maltose |
| row 5 | emulsifies lipid | works in the small intestine | digests starch |

**A** row 5

**B** row 2

**C** row 3

**D** row 4

**E** row 1

**41** As Group VII of the Periodic Table (F to I) is descended, which of the following properties of the elements DECREASE?

**1** melting points

**2** electronegativities

**3** first ionisation energies

**A** 2 and 3 only

**B** 2 only

**C** 1 only

**D** 1 and 3 only

**E** 1, 2 and 3

**42** An atom has a mass number of 18 and contains 10 neutrons.

A common ion of this atom has a charge of $-2$.

What is the electron configuration of this ion in its lowest energy state?

**A** $1s^2 2s^2 2p^6$

**B** $1s^2 2s^2 2p^4$

**C** $1s^2 2s^2 2p^2$

**D** $1s^2 2s^2 2p^6 3s^2$

**E** $1s^2 2s^2 2p^6 3s^2 3p^4$

**43** Which of the following changes is/are correct?

**1** The addition of 1 g of salt to 100 g water will increase the freezing point.

**2** A change in temperature from 150 °C to 120 °C will increase the average kinetic energy of water molecules.

**3** A change in the surrounding air pressure from 100 kPa to 120 kPa will increase the boiling point of water.

**A** 3 only

**B** 2 only

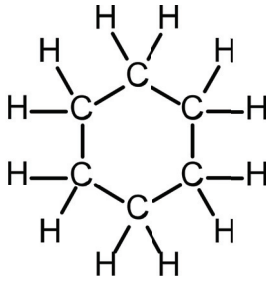
**C** 1 only

**D** 1 and 3 only

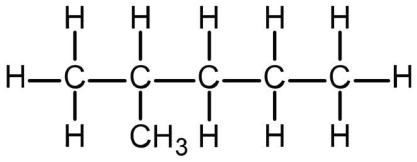
**E** 1, 2 and 3

**44** Which of the following hydrocarbons are structural isomers of hexane?

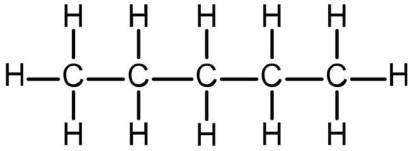
**1**



**2**



**3**



**A** 2 only

**B** 1 only

**C** 3 only

**D** 1 and 2 only

**E** 1 and 3 only

**45** Which of the following equations is associated with the first electron affinity of chlorine?

**A** $Cl(g) + e^- \rightarrow Cl^-(g)$

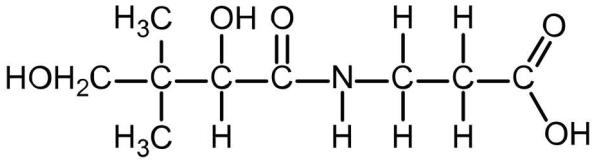
**B** $Cl(g) \rightarrow Cl^-(g) + e^-$

**C** $Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

**D** $2Cl^-(g) - 2e^- \rightarrow Cl_2(g)$

**E** $Cl^-(g) + e^- \rightarrow Cl(g)$

**46** Vitamin B5 has the structure:



Which of the following functional groups are contained in a molecule of vitamin B5?

**1** alcohol

**2** aldehyde

**3** amide

**4** amine

**5** carboxylic acid

**6** ketone

**A** 1, 3 and 5 only

**B** 1, 2 and 4 only

**C** 1, 3 and 6 only

**D** 2, 4 and 6 only

**E** 4, 5 and 6 only

**47** X is 50.0 mL of a 0.050 mol $L^{-1}$ aqueous solution of nitric acid ($HNO_3$).

Y is 100 mL of a 0.050 mol $L^{-1}$ aqueous solution of sulfuric acid ($H_2SO_4$).

Which of the following statements about these solutions is/are correct?

**1** The hydrogen ion concentration in Y is four times greater than the hydrogen ion concentration in X.

**2** Only the acid in Y will be completely dissociated into ions.

**3** Y has a pH value of less than 2 at 25 °C.

**A** 3 only

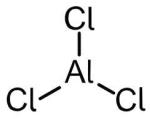
**B** none of them

**C** 1 only

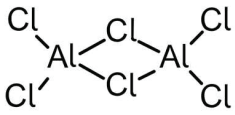
**D** 1 and 3 only

**E** 2 and 3 only

**48** Which row gives the correct shapes around the aluminium centres in $AlCl_3$ and $Al_2Cl_6$ molecules?




$AlCl_3$




$Al_2Cl_6$

| | $AlCl_3$ | $Al_2Cl_6$ |
|---|---|---|
| row 1 | trigonal planar | square planar |
| row 2 | trigonal pyramidal | tetrahedral |
| row 3 | tetrahedral | square planar |
| row 4 | trigonal planar | tetrahedral |
| row 5 | trigonal pyramidal | square planar |

[atomic numbers: Al = 13; Cl = 17]

**A** row 4

**B** row 2

**C** row 3

**D** row 1

**E** row 5

**49** At room temperature and pressure, which of the following substances has the strongest hydrogen bonds between their molecules?

**A** ethanoic acid, $CH_3COOH$

**B** propanal, $CH_3CH_2CHO$

**C** fluoromethane, $CH_3F$

**D** trimethylamine, $(CH_3)_3N$

**E** hydrogen sulfide, $H_2S$

© UCLES

**50** 100 mL of a solution contained 3.2 g of potassium nitrate.

25 mL of this solution was added to an empty 250 mL volumetric flask. Distilled water was added up to the 250 mL mark and the flask was shaken to ensure that mixing was complete.

A pipette was used to transfer 25 mL of the resulting solution from the volumetric flask to an empty conical flask.

What is the concentration of the potassium nitrate solution, in $g\,L^{-1}$, in the conical flask?

**A** $3.20\,g\,L^{-1}$

**B** $0.80\,g\,L^{-1}$

**C** $0.32\,g\,L^{-1}$

**D** $8.00\,g\,L^{-1}$

**E** $0.08\,g\,L^{-1}$

**51** The general formula of an oxoacid is $H_m XO_n$

Which of the following expressions gives the oxidation state of element X?

**A** $2n - m$

**B** $m - 2n$

**C** $m + 2n$

**D** $2m - n$

**E** $n - 2m$

**52** A sample of an oxide of iron contains 1.68 g of iron and 0.64 g of oxygen only.

What is the formula of this oxide?

[$A_r$ values: Fe = 56; O = 16]

**A** $Fe_3O_4$

**B** $Fe_4O_3$

**C** $Fe_2O_3$

**D** $Fe_3O_2$

**E** FeO

**53** Which one of the following is a simplification of

$$\frac{(x+2)^2}{x^2+x-2}$$

**A** $\dfrac{x+2}{x-1}$

**B** $\dfrac{(x+2)^2}{(x-2)(x+1)}$

**C** $\dfrac{4x+4}{x-2}$

**D** $\dfrac{x+2}{x-2}$

**E** $-4$

**54** Find the complete set of values of $x$ which satisfy the inequality

$$\tfrac{1}{2}(2x+3)-\tfrac{2}{3}(x+1) < 2x$$

**A** $x > \frac{1}{2}$

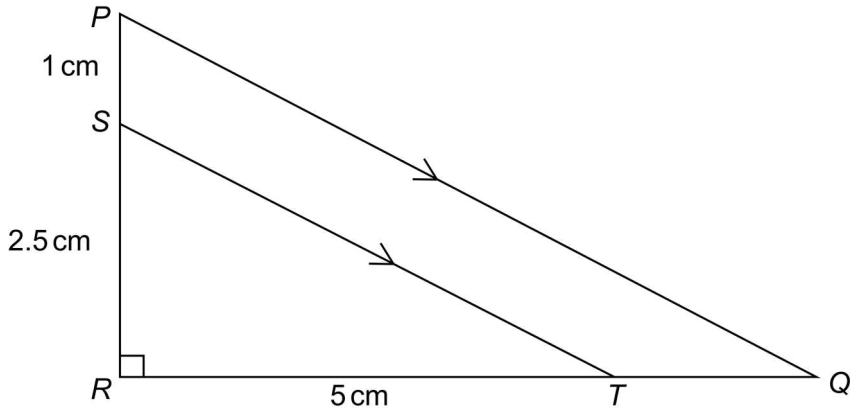
**B** $x > \frac{5}{14}$

**C** $x > \frac{7}{8}$

**D** $x > \frac{5}{4}$

**E** $x < -5$

**55**




[diagram not to scale]

$PQR$ is a right-angled triangle with angle $PRQ$ equal to 90°.

Point $S$ is on the side $PR$.

Point $T$ is on the side $RQ$.

The line $ST$ is parallel to the line $PQ$.

$RS = 2.5\,\text{cm}$

$PS = 1\,\text{cm}$

$RT = 5\,\text{cm}$

What is the perimeter of the trapezium $PQTS$ in cm?

**A** $3\left(1+2\sqrt{5}\right)$

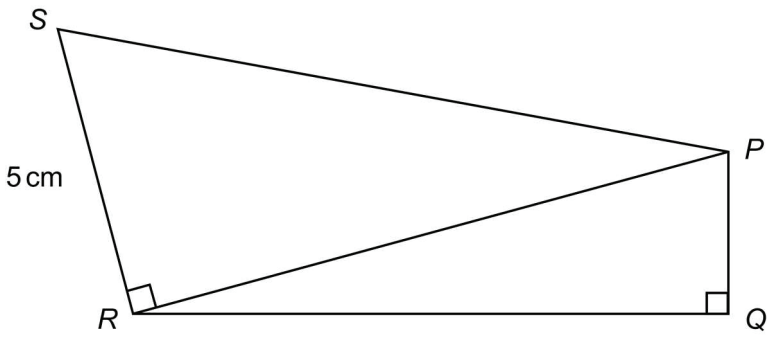
**B** $2\left(1+3\sqrt{3}\right)$

**C** $3\left(1+2\sqrt{3}\right)$

**D** $2\left(1+3\sqrt{5}\right)$

**E** $2\left(1+3\sqrt{6}\right)$

**56**




[diagram not to scale]

*PQR* and *PRS* are right-angled triangles.

Angle *PRS* = Angle *PQR* = 90°

*RS* = 5 cm

The area of triangle *PQR* is 14 $\text{cm}^2$ and $\tan PRQ = \frac{1}{7}$

What is the value of $\cos RPS$?

**A** $\frac{2\sqrt{2}}{3}$

**B** $\frac{\sqrt{2}}{4}$

**C** $\frac{\sqrt{2}}{2}$

**D** $\frac{\sqrt{6}}{3}$

**E** $\frac{1}{3}$

**57** At an athletics competition, a hammer thrower swings a hammer in a horizontal circle.

Immediately before releasing the hammer, the ball at the end of the hammer is moving at a constant angular velocity of 10 rad / s in a horizontal circular path of radius 2.5 m.

Which row in the table gives the speed and the magnitude of the acceleration of the ball just before release?

| | *speed* (m / s) | *acceleration* (m / s²) |
|---|---|---|
| row 1 | 25 | 250 |
| row 2 | 25 | 40 |
| row 3 | 15 | 50 |
| row 4 | 10 | 40 |
| row 5 | 10 | 0 |

**A** row 1

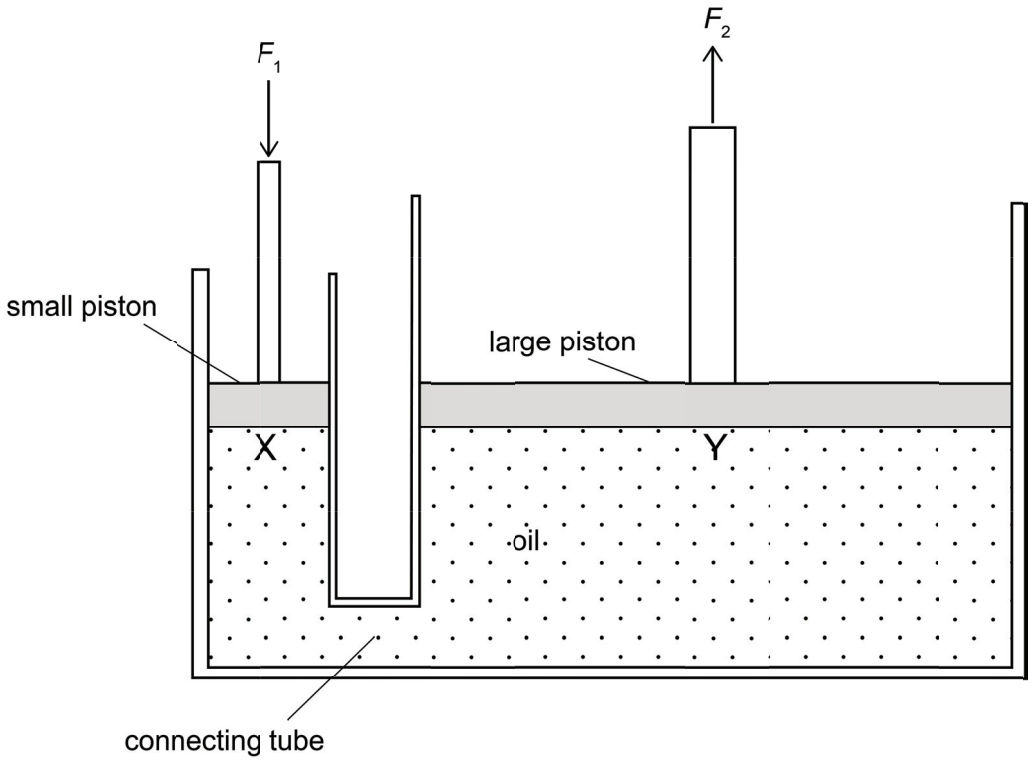
**B** row 2

**C** row 3

**D** row 4

**E** row 5

**58** A hydraulic jack consists of a piston with a small cross-sectional area connected by a tube to a piston with a larger cross-sectional area. The cylinders of the pistons and the tube contain oil.




A downward force $F_1$ is applied to the smaller piston, which results in an upwards resultant force $F_2$ being exerted on the larger piston. Points X and Y are in the oil, immediately underneath the pistons, which are at the same height.

Which of the following statements about the pressure and forces in the hydraulic jack is/are correct?

**1** The pressure at Y is less than the pressure at X.

**2** The pressure at Y is equal to the pressure at X.

**3** $F_2$ is greater than $F_1$.

**4** $F_2$ is less than $F_1$.

**A** 2 and 3 only

**B** 3 only

**C** 1 only

**D** 2 and 4 only

**E** 1 and 4 only

**59** A metal has a specific heat capacity of 500 J / (kg °C). A block of this metal has a mass of 1.20 kg and is provided with thermal energy by a heater for 5.00 minutes. The temperature of the block increases from 40.0 °C to 90.0 °C without a phase change.

What is the power of the heater?

[Assume that no thermal energy is lost to or gained from the surroundings and that the metal is at a uniform temperature at all times.]

**A** 100 W

**B** 6000 W

**C** 180 W

**D** 10 800 W

**E** 80 W

**60** Which of the following expressions gives a quantity that can be measured in joules (J)?

[Assume that all quantities are magnitudes.]

**A** momentum × velocity

**B** $(\text{charge})^2 \times \text{resistance}$

**C** $(\text{mass})^2 \times \text{velocity}$

**D** $\dfrac{\text{specific heat capacity}}{\text{mass} \times \text{temperature change}}$

**E** $\dfrac{\text{voltage}}{\text{current} \times \text{time}}$

# ANSWERS AND EXPLAINED SOLUTIONS

The letters are those of the official paper above.

**1** **A young woman (A), knowing that she was dying, requested that her mother (B), who was awaiting a kidney transplant, should be allowed to receive her kidneys after her death. The request was not allowed, and A's kidneys were received by another patient (C), who was higher up the waiting list than B because his medical need for a transplant was more urgent. The committee overseeing transplant decisions argued that the system it used had to be administered solely in accordance with the rationale behind its waiting list. Their decision seemed to others unduly bureaucratic, especially as B will be left to care for A's young child.**

**Which one of the following best illustrates the principle behind the committee's decision?**

**Correct answer: A · Decisions on transplants should focus on the medical need of the potential recipient.**

The committee followed the waiting list based on **medical urgency**. Patient C received the organs because his clinical need was higher than B's. The donor's request and the recipient's family situation did not alter this **priority**.

**Why the other answers are wrong**

- **B) Decisions on transplants cannot be influenced by emotions.**: This option is overly broad. The committee's actual standard is limited to adhering to the established criteria rather than making decisions free of emotional influence.
- **C) Donations between family members are not allowed.**: The passage never mentions a general rule banning family donations. The outcome depends entirely on the specific ranking system used.
- **D) Decisions on transplants should include social considerations.**: The committee deliberately excluded external circumstances. B's duty to raise A's child was not factored into her medical ranking.
- **E) The donor's wishes should not be considered.**: Although A's preference was overridden, the guiding principle targets recipient selection. It defines how waiting lists operate, not a universal mandate regarding donor input.

**2** **From ever younger ages, people are reporting symptoms of anxiety due to the pressure to be 'perfect' in all areas of life. It seems that, in many cultures, there is an increasing sense of competition in everything from school results to the job market to personal appearance and even how one's social life looks on social media. As a result, many people experience problems associated with low self-confidence. But rather than reach for a pill or a self-help book to tackle their problems, more of these individuals should just go outside for a run or a walk. While it sounds simplistic, this recommendation is supported by the research finding that people who do a lot of outdoor activities tend to have high self-esteem.**

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

**Correct answer: A · It ignores the possibility that people with higher self-esteem might be more inclined to take part in outdoor activities**

The argument mistakes **correlation** for **causation** using observational data. Research indicates an association between outdoor exercise and strong self-esteem. The actual causal direction could be **reversed**. People who already possess higher confidence are more **motivated** to engage in physical activity. This alternative explanation undermines the recommendation to treat low confidence through running.

**Why the other answers are wrong**

- **B) It assumes that high levels of self-confidence or self-esteem are all that are needed for a person to enjoy good mental health**: The author does not claim that self-esteem is the sole requirement for psychological wellness. The focus remains strictly on activity levels and personal worth.
- **C) It ignores the fact that not everyone with low self-esteem has the desire to go for a run or a walk outside**: Hesitation to follow the proposed lifestyle change does not invalidate the empirical link between exercise and improved self-perception.
- **D) It assumes that people who manage to appear 'perfect' in the different parts of their lives will not suffer from problems with self-confidence**: The passage never suggests that social perfection shields individuals from confidence struggles. It explicitly states that striving for perfection creates anxiety.
- **E) It ignores the likelihood that many people with varying levels of self-confidence would benefit from the advice of a mental health professional**: Receiving professional mental health guidance might be beneficial, but this possibility does not refute the flawed logical jump from the study findings.

**3** **For many years, children and young people have been protected from exploitation by the entertainment industry. In recent years, however, the number of young people suddenly thrust into the limelight has increased, and many of them feel that they must seize any opportunity to achieve recognition before this window passes them by. Dealing with fame, performing in front of large audiences, the rigours of rehearsal and the general stresses of what is a difficult occupation take maturity and can rob children of their childhood. Rejection, disappointment and failure are felt more keenly by young people because they lack wider experience and this can make for a very unhappy childhood. These factors would indicate that young performers need further protection by law.**

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

**Correct answer: A · Young performers need further protection by law.**

The passage outlines the intense **pressures** of fame and the emotional toll on young performers. These factors demonstrate that current safeguards are insufficient. The author therefore concludes that young performers require **legal protection**.

**Why the other answers are wrong**

- **B) Young people can be suddenly thrust into the limelight.**: Sudden public exposure establishes the **context** for the debate, but it does not express the author's ultimate recommendation.
- **C) Young performers are robbed of their childhood by the demands of performing.**: Performing demands can rob children of their childhood, but this point functions as a **premise** rather than the central claim.
- **D) Young people feel rejection, disappointment and failure more because they lack wider experience.**: Heightened sensitivity to rejection stems from limited life experience, yet this observation provides evidence for new legislation.
- **E) Young people have been protected from exploitation by the entertainment industry for many years.**: Previous industry safeguards offer historical background, whereas the passage specifically argues for expanding regulations.

**4** **Our three local universities have agreed that they will offer a place to everyone from our school who applies to them. Because you attend a different school, you are not guaranteed an offer from these universities.**

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

**Correct answer: A · Everyone over the age of 60 is entitled to a bus pass, which gives them free travel on buses after 9:30 am. Since you are younger than 60, you are not entitled to free bus travel.**

The argument promises a benefit to a **specific group** and assumes outsiders cannot access it. This structure contains a logical flaw because the promise does not block alternative paths to the same outcome. Option A mirrors this pattern by tying eligibility strictly to age limits.

**Why the other answers are wrong**

- **B) Everyone who becomes a student at our college has achieved a high score in their high school examinations. You have a high score, and therefore you are sure to be accepted as a student at our college.**: **Reverses logic** regarding exam results and college admission. It incorrectly elevates a basic standard into an absolute guarantee.
- **C) Everyone who has a free bus pass is entitled to travel on buses after 9:30 am without payment. Since it is after 9:30 am and you have a free bus pass, you do not have to pay for this bus journey.**: Applies a regulation to a case that fulfills every condition. It produces a valid deduction rather than exhibiting the target fallacy.
- **D) In our country, everyone who becomes a teacher must have a university degree. Since you do not have a degree, you are not qualified to become a teacher**: Defines a degree as a mandatory prerequisite. It properly denies teaching status when the requirement is **missing a prerequisite**.
- **E) The only way to stand for election to Parliament is to be nominated by voters in a geographical constituency. Since you have not been nominated, you cannot stand for election.**: Recognizes candidate nomination as a required step. It accurately concludes that lacking the step blocks electoral participation.

**5** **Of all the food we buy, bread suffers the worst fate when it comes to waste. 32% of it ends up being thrown away. We value other types of food a lot more, as the average for all food and drink being wasted is 15%. The proportion of meat and fish thrown away is below average (13%) and our most precious item is alcohol - we throw away just 6% of it.**

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

**Correct answer: A · The main reason why we throw food away is that we do not value it much.**

The passage highlights that bread faces a higher disposal rate than meat, fish, and alcohol, leading to the conclusion that people value it less. This logical leap depends on treating **disposal rates** as direct indicators of **perceived worth**.

**Why the other answers are wrong**

- **B) Bread is a low-quality food.**: The comparison relies exclusively on quantitative waste data without referencing the actual quality tier of the products.
- **C) We should be more moderate when it comes to buying bread.**: Suggesting purchase moderation outlines a practical step forward rather than identifying a necessary hidden premise.
- **D) The more expensive a food or drink is, the less likely it is that it will be wasted.**: Market price plays no role in the text, which contrasts waste statistics using subjective importance rather than financial cost.
- **E) Bread goes stale faster so is more likely to be thrown away.**: Rapid staleness functions as a separate cause for bread loss instead of validating the proposed connection between low regard and high waste.

**6** **In a survey of cats' eating habits, 10% of the cats tested showed a clear preference for Moggiemeat, 20% preferred Fuss-a-Puss and 40% preferred Yummy Paws. An additional 6 cats did not seem to care at all which of the three foods they ate, while the remaining 27 cats in the survey would not touch any of these foods.**

**How many cats were involved in the survey?**

**Correct answer: A · 110**

Let $N$ represent the **total number** of cats. Definite preferences cover $10\% + 20\% + 40\% = 70\%$, leaving $30\%$ for the remainder. The non-preferent group consists of $6$ indifferent cats and $27$ who refuse the food, totaling $33$. Therefore $0.30N = 33$, which gives $N = 110$.

**Why the other answers are wrong**

- **B) 33**: This value matches only the $6$ indifferent cats plus the $27$ refusers. It completely ignores the $70\%$ that showed a preference, making it too small for the total.
- **C) 63**: This stems from an **arithmetic slip** during division. Dividing the constant $33$ by an incorrect decimal like $0.525$ produces roughly $63$ instead of the required $110$.
- **D) 90**: This happens if you commit an **omission** by excluding the $6$ indifferent cats. Solving $0.30N = 27$ instead of using the correct sum yields $N = 90$.
- **E) 103**: This arises from a faulty **addition** of the fixed groups. Treating $6 + 27$ as $31$ leads to $0.30N = 31$, which incorrectly calculates the total as approximately $103$.

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**7** **It is usual, when seating people round a table at a social function, to alternate males with females, but if there are unequal numbers of each, this is impossible. At one party, 14 women and only 6 men were present. They were seated round a circular table so that as few women as possible had no male sitting directly next to them.**

**How many women had no male sitting directly next to them?**

**Correct answer: A · 2**

The 6 men can have at most $2 \times 6 = 12$ distinct women sitting directly beside them. Since there are 14 women, at least $14 - 12 = 2$ must have no male neighbour. This minimum is attainable by arranging the women in six gaps as four groups of 2 and two groups of 3, so only the middle woman in each group of 3 has no male beside her.

**Why the other answers are wrong**

- **B) 4**: The men can sit next to 12 women, so at most 2 need to miss out. Four is not the minimum.
- **C) 6**: This would mean only 8 women sit next to men, leaving four of the 12 available seats beside men unused. A better arrangement is possible.
- **D) 7**: The same reasoning applies as for 6, and seven is even less optimal. With thoughtful spacing of the men, seven women need not be isolated.
- **E) 8**: This could happen if the men were clumped together, leaving long runs of women between them. Since the seating is arranged to minimise the number of women without a male neighbour, 8 is far from optimal.

**8** **Simon plans to send Christmas cards to 35 friends. He is going to choose a single design to send to them all and knows that some of the recipients really do not like glitter cards so he will not buy this type. He wants 2-fold cards so that he can write a letter on the inside for 5 of them.**

**The following table shows the possibilities that he is considering.**

**What is the lowest amount of money that Simon could spend on his cards?**

| card type | no. in pack | glitter | 1-fold | 2-fold | pack price |
|---|---|---|---|---|---|
| religious | 5 | no | | yes | $1.80 |
| robins | 8 | no | yes | | $1.95 |
| village scene | 20 | yes | | yes | $2.50 |
| cartoon | 12 | no | yes | | $2.20 |
| father xmas | 10 | no | | yes | $3.10 |

**Correct answer: A · £12.40**

1. Occorrono 35 biglietti di un unico tipo, non lucidi e piegati a metà. Dal tavolo si identificano solo le **cartoline religiose** e quelle del **Babbo Natale**. 2. Con quelle religiose (5 pezzi a $£1.80$) servono $35 \div 5 = 7$ pacchetti per un totale di $7 \times 1.80 = £12.60$. 3. Con quelle del Babbo Natale (10 pezzi a $£3.10$) ne bastano 4 confezioni per coprire gli 35 destinatari, portando la spesa a $4 \times 3.10 = £12.40$. 4. Il prezzo minore conferma la scelta finale.

**Why the other answers are wrong**

- **B) £12.60**: Rappresenta il costo calcolato scegliendo esclusivamente le cartoline religiose ($7$ confezioni $\times$ $£1.80$), superando però la alternativa del Babbo Natale.
- **C) £5.00**: La cifra indicata è irrealisticamente bassa per acquistare 35 biglietti rispettando i vincoli di formato e finitura richiesti.
- **D) £6.00**: Nessuna combinazione valida di biglietti piegati a metà e privi di glitter scende sotto la soglia dei $£12$ per l'intero lotto.
- **E) £9.75**: Corrisponde esattamente a $5$ confezioni di biglietti con i merli ($5 \times £1.95 = £9.75$), ma questo modello presenta un tipo di piega errato. Inoltre, considerando le dimensioni dei pacchetti, comprarne 5 fornisce 40 biglietti, eccedendo la quantità necessaria senza rispettare tutti i criteri.

**10** **Teams from five US states have reached the final of a competition. The event organisers are trying to design a sign for each state. One idea involves the name, in capital letters, being placed vertically on a sign board which spins when one of the team presses their buzzer to answer a question. They want the sign to read correctly regardless of whether it is read from the front or the back.**

**Unfortunately they realise that most of the states for which this would have worked have not reached the final.**

**Which one of the following is the only state in the final for which this style of sign would work?**

**Correct answer: A · Hawaii**

When the signboard rotates 180 degrees along a **vertical axis**, the reverse side displays a **mirrored** view. To remain legible, every uppercase letter must possess **left-right symmetry**. The only capitals that preserve their identity under this transformation are A, H, I, M, O, T, U, V, W, X, and Y.

**Why the other answers are wrong**

- **B) Alabama**: ALABAMA contains L and B, which lack vertical symmetry and distort beyond recognition when flipped.
- **C) Idaho**: IDAHO includes D, which is not symmetric across a vertical axis and fails the reflection test.
- **D) Montana**: MONTANA features N, which breaks the symmetry requirement and produces an illegible reverse side.
- **E) Oklahoma**: OKLAHOMA combines K and L, neither of which preserves its shape under vertical reflection.

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

**Correct answer: A · Hans Jonas - medicine**

Hans Jonas was a **philosopher** rather than a medical professional. His academic contributions centered on ethics and the philosophy of biology, making the association with medicine incorrect.

**Why the other answers are wrong**

- **B)** John Maynard Keynes was a British economist who founded modern macroeconomics through his development of Keynesian economic theory.
- **C)** Maria Montessori was an Italian physician and educator who created the Montessori method of education, representing a major advancement in pedagogy.
- **D) Max Planck - physics**: Max Planck was a German theoretical physicist who originated quantum theory and received the Nobel Prize in Physics in 1918.
- **E) B. F. Skinner - psychology**: B. F. Skinner was an American psychologist known for his foundational work on behaviorism and operant conditioning.

## 12 Which one of the following writers is the author of the best-selling novel My Brilliant Friend?

**Correct answer: A · Elena Ferrante**

The novel was published in 2011 as the opening volume of the Neapolitan Novels cycle. It achieved global success by following the lives of two women in Naples. The narrative was crafted by an Italian author who writes under the pseudonym Elena Ferrante.

**Why the other answers are wrong**

- **B)** Khaled Hosseini is an Afghan-American novelist recognized for The Kite Runner and A Thousand Splendid Suns. His complete bibliography remains entirely separate from the Neapolitan series.
- **C) Ian McEwan**: Ian McEwan is a British author known for Atonement and Amsterdam. He has never produced a manuscript bearing that specific title.
- **D)** Paulo Coelho is a Brazilian writer celebrated for The Alchemist. His published works contain no volumes from the Neapolitan cycle.
- **E) Kazuo Ishiguro**: Kazuo Ishiguro is a Nobel prize-winning novelist behind The Remains of the Day and Never Let Me Go. He holds no authorship credit for this particular book.

## 13 What does the letter A stand for in the international organisation FAO?

**Correct answer: A · Agriculture**

The acronym **FAO** stands for the Food and Agriculture Organization, a United Nations agency founded in 1945 to combat hunger and promote sustainable farming. Therefore, the letter A explicitly denotes Agriculture.

**Why the other answers are wrong**

- **B) Architecture**: The institution deals with crop production and distribution rather than architectural planning or construction management.
- **C) Aerospace**: Operations do not involve aircraft development, space exploration, or any aerospace engineering sectors.
- **D) Automotive**: Policies are unrelated to automobile manufacturing, transportation networks, or mechanical vehicle systems.
- **E) Aesthetics**: Goals prioritize practical food security over abstract theories concerning artistic expression or visual beauty.

## 14 Which of the following pairs of theatre/city is the only correct one?

**Correct answer: A · Metropolitan Opera House - New York**

The **Metropolitan Opera House** stands at Lincoln Center in New York City. This geographical match makes it the only fully accurate option.

**Why the other answers are wrong**

- **B) San Carlo - Venice**: The Teatro di San Carlo is the historic opera house of Naples. Venice features La Fenice as its main venue.
- **C)** The Bolshoi Theatre is located in Moscow. Saint Petersburg hosts the Mariinsky Theatre instead.
- **D) La Fenice - Florence**: Teatro La Fenice belongs to Venice, not Florence. Florence is known for Teatro della Pergola.
- **E)** The Palais Garnier Opera House is the celebrated 19th-century venue in Paris. Brussels relies on La Monnaie for performances.

## 15 The Rosetta Stone provided the key to decipher

**Correct answer: A · Egyptian hieroglyphs**

The Rosetta Stone carries a trilingual inscription featuring Egyptian hieroglyphs, Demotic script, and Ancient Greek. Scholars already knew how to read the Greek portion, so they could match those familiar words to the unknown Egyptian symbols. This cross-referencing approach revealed the phonetic values embedded in the carvings. Jean-François Champollion subsequently applied these findings to fully decipher ancient Egyptian hieroglyphs.

**Why the other answers are wrong**

- **B) characters of the Phoenician alphabet**: The Phoenician alphabet had already been reconstructed using classical historical records. It never appeared on the Rosetta Stone and played no role in its linguistic breakthrough.
- **C) characters of the Ancient Greek alphabet**: Researchers could read Ancient Greek long before the stone's 1799 discovery. The Greek section simply acted as a translation key for the Egyptian scripts rather than requiring new decoding.
- **D) the Code of Hammurabi**: The Code of Hammurabi consists of Babylonian cuneiform carved around the 18th century BCE. Experts decoded it by analyzing parallel Mesopotamian tablets and bilingual Akkadian texts, unrelated to the Rosetta Stone.
- **E) the Sumerian language**: Sumerian used a cuneiform system that required comparison between thousands of Mesopotamian clay tablets and later Akkadian translations. The Egyptian monument contained no data useful for unraveling this early language.

## 16 Which one of the following institutions of the European Union is elected by direct universal suffrage?

**Correct answer: A · European Parliament**

The **European Parliament** is the only EU institution whose representatives are chosen through **direct elections** held every five years across all member states. Eligible voters cast ballots directly for their candidates, establishing a system of **direct universal suffrage** that distinguishes this body from all others.

**Why the other answers are wrong**

- **B) European Commission**: Commissioners are nominated by national governments and subject to parliamentary approval rather than originating from public elections.
- **C) Court of Justice of the European Union**: Judges and Advocates-General are appointed by joint agreement of member-state governments for renewable terms without any popular vote.
- **D) European Economic and Social Committee**: Members represent employers, workers, and interest groups through government proposals and Council appointments instead of direct voter choice.
- **E) Council of the European Union**: The Council comprises national ministers who participate by virtue of their domestic roles, meaning citizens never elect these representatives for their EU functions.

**17** **Which one of the following directors directed the films that make up The Godfather trilogy?**

**Correct answer: A · Francis Ford Coppola**

Francis Ford Coppola conceived, co-wrote, and directed all three films: *The Godfather* (1972), *The Godfather Part II* (1974), and *The Godfather Part III* (1990). He oversaw their casting, visual style, and thematic throughline, making him the **director of the trilogy**.

**Why the other answers are wrong**

- **B)** Martin Scorsese is a celebrated filmmaker of Italian-American crime dramas, including *Mean Streets*, *Goodfellas*, and *Casino*, but he had no creative role in any of *The Godfather* films.
- **C)** Sergio Leone is best known for his "Spaghetti Westerns," such as *The Good, the Bad and the Ugly* and *Once Upon a Time in the West*. He was never involved with *The Godfather* franchise.
- **D)** Brian De Palma directed crime and gangster films such as *Scarface* and *The Untouchables*, but he did not direct, write, or produce any of *The Godfather* movies.
- **E)** Matteo Garrone is a contemporary Italian director known for *Gomorrah* and *Dogman*. He was not connected with the *Godfather* films produced between 1970 and 1990.

**18** **Which one of the following pairs of scholar/scientific discovery is NOT correct?**

**Correct answer: A · Niels Bohr - electron microscope**

Niels Bohr formulated the **quantum model of the atom** and laid the groundwork for atomic physics. He never designed imaging equipment for microscopic analysis. The first practical **electron microscope** was assembled in **1931** by Ernst Ruska and Max Knoll. This historical mismatch identifies D as the invalid pair.

**Why the other answers are wrong**

- **B)** Dmitri Mendeleev organized known substances into a structured layout. His classification successfully predicted unknown properties and established the periodic law through systematic atomic weight ordering.
- **C)** Wilhelm Conrad Röntgen discovered penetrating electromagnetic waves in 1895 during cathode ray experiments. This observation directly triggered the inaugural Nobel Prize in Physics in 1901.
- **D)** Hans Wilhelm Geiger co-developed a specialized gas-filled detection tube. The instrument registers ionizing radiation types including alpha particles, beta particles, and gamma rays through measurable electrical discharges.
- **E)** Evangelista Torricelli proved that air exerts physical force capable of supporting liquid columns in 1643. His mercury glass tube design calculated atmospheric weight and established the principles of fluid statics.

**19** **Which one of the following treaties established the European Coal and Steel Community (ECSC)?**

**Correct answer: A · Paris**

The **Treaty of Paris** was signed on 18 April 1951 by six founding states. It entered into force in 1952 and **pooled coal and steel production** under a supranational authority. This agreement created the first institutional foundations for European integration.

**Why the other answers are wrong**

- **B) Lisbon**: The Treaty of Lisbon took effect in 2009 and **amended existing EU treaties**. It streamlined decision making and created a permanent Council president without founding any early community.
- **C) Amsterdam**: The Treaty of Amsterdam entered into force in 1999 and **revised Maastricht provisions** on justice and security. It prepared institutions for enlargement rather than establishing the ECSC.
- **D) Nice**: The Treaty of Nice became active in 2003 and **adjusted voting weights** in the Council for eastern expansion. It focused solely on procedural updates unrelated to the ECSC creation.
- **E) Rome**: The Treaties of Rome were signed in 1957 and **established the EEC and Euratom** instead. They advanced integration six years after the Paris agreement and targeted different economic sectors.

**20** **Which one of the following global organisations sets and enforces rules of trade between nations?**

**Correct answer: A · WTO**

The **World Trade Organization (WTO)** creates, administers and enforces rules governing international trade in goods, services and intellectual property. It does so through multilateral agreements, a binding dispute-settlement mechanism and periodic trade-policy reviews.

**Why the other answers are wrong**

- **B) World Bank**: The World Bank provides long-term loans and technical assistance for development projects and poverty reduction. It does not write or enforce trade rules among nations.
- **C) IMF**: The International Monetary Fund focuses on monetary stability, exchange-rate surveillance and short-term balance-of-payments support. It may advise on trade-related policies, but it does not set or enforce trade rules.
- **D) OECD**: The OECD is a forum of mostly high-income countries that conducts research and issues policy recommendations on economic matters. Its guidelines are voluntary, and it has no authority to impose or enforce global trade rules.
- **E) World Economic Forum**: The World Economic Forum is a non-governmental organisation best known for its annual Davos meeting, which brings together business, political and civil-society leaders to discuss global issues. It has no formal rule-making or enforcement powers in trade.

## 21 Which one of the following pairs of Russian writers/works is NOT correct?

**Correct answer: A · Mikhail Bulgakov - Uncle Vanya**

**Mikhail Bulgakov** never wrote the play **Uncle Vanya**. That title belongs to **Anton Chekhov**, who published it in 1897. Bulgakov is instead famous for satirical novels like *The Master and Margarita* and *Heart of a Dog*. This clear mismatch makes option A the only incorrect pairing.

**Why the other answers are wrong**

- **B)** Vladimir Nabokov published *Lolita* in 1955. He was a Russian-American novelist whose work remains a classic of twentieth-century literature.
- **C)** Fyodor Dostoyevsky completed *The Brothers Karamazov* in 1880. It is widely regarded as his magnum opus and deeply explores themes of faith and morality.
- **D) Leo Tolstoy - Anna Karenina**: Leo Tolstoy serialized *Anna Karenina* between 1873 and 1877. The novel is considered one of the foundational pillars of realist fiction.
- **E)** Boris Pasternak wrote *Doctor Zhivago*, first published in 1957. The novel earned him the 1958 Nobel Prize in Literature, which he declined due to political pressure.

## 22 The expression 'perfect bicameral system' refers to

**Correct answer: A · the legislative procedure that assigns identical powers to the two chambers of a parliament**

A **bicameral** legislature consists of two separate chambers. The system functions properly when both houses possess **identical powers** and must approve every bill in exactly the same manner. Neither chamber can override the other, making mutual consent mandatory for all legislation.

**Why the other answers are wrong**

- **B) the judicial system whereby the first sentence must be confirmed by the first round of appeal**: This choice confuses legislative structure with court appeals and judicial review, processes that belong entirely to the **judiciary** rather than the lawmaking branch.
- **C) the form of government that assigns identical power to two institutional figures**: This option describes a **dual executive** setup such as a diarchy or collegial presidency, while bicameralism specifically governs chambers within a single parliament.
- **D) the kind of parliamentary monarchy where monarch and parliament have the same powers**: This selection misplaces the focus on monarchical versus parliamentary authority instead of internal parliamentary division. Constitutional frameworks never grant equal governing power to a sovereign and a legislative assembly.
- **E) the perfect separation of the magistrate judge and public prosecutor**: Court administration and prosecutor independence involve judicial functions that operate completely outside the legislative decision making process.

**23** **Which of the following types of nucleic acid is/are found in viruses?**

**1) single-stranded DNA**
**2) double-stranded DNA**
**3) RNA**

**Correct answer: A · 1, 2 and 3**

Viruses exhibit **remarkable genetic diversity** across different taxonomic families. Verified genomes include **single-stranded DNA** (parvoviruses), **double-stranded DNA** (herpesviruses, adenoviruses, poxviruses), and **RNA** (influenza, reoviruses, retroviruses, coronaviruses). Virological evidence confirms the presence of all three structural types. Option A correctly lists every valid category.

**Why the other answers are wrong**

- **B) 1 and 2 only**: Removes RNA from the available genetic pools. Well-established viral groups like influenza, HIV, and SARS-CoV-2 depend entirely on RNA. Omitting RNA creates an incomplete selection.
- **C) 2 only**: Restricts viral genetics exclusively to double-stranded DNA. This excludes both single-stranded DNA lineages and the extensive RNA virus classification. The assertion becomes unnecessarily narrow.
- **D) 1 and 3 only**: Omits double-stranded DNA. Clinically significant pathogens such as herpes simplex virus and variola virus utilize dsDNA. Excluding dsDNA invalidates the choice.
- **E) 2 and 3 only**: Leaves out single-stranded DNA viruses. Recognized families like parvoviruses naturally harbor ssDNA. Failing to acknowledge ssDNA produces an incomplete answer.

**24** **Which one of the diagrams (not drawn to scale) represents a structure that is formed by mitosis?**

**Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12ee12e121n2ee2.png?alt=media&token=87886f97-4f5a-4ca1-b7fc-f939bdda4e69<i>**

Mitosis preserves the chromosome number, so the daughter cells are **diploid**, like the parent cell. The two daughter cells are genetically identical and usually the same size. Diagram A shows one parent cell producing two identical cells with the full diploid complement.

**Why the other answers are wrong**

- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e1e12uu12u1e2.png?alt=media&token=10cfe167-0725-4912-ab92-c6b6277750c2<i>**: The diagram shows four equal-sized cells arising from one parent cell. This is characteristic of the two divisions of meiosis, not a single mitotic division; each cell also has half the original chromosome set, as in meiosis.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2F1x2e21j21j12j12ee.png?alt=media&token=a13484e9-bf04-428f-93b7-d8a1a9f279f1<i>**: The diagram shows a tetrad of spores or pollen grains inside a sac. A tetrad is produced when one diploid cell undergoes meiosis, and each spore is haploid.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx2e1ejh12j12ee12.png?alt=media&token=b3a5c140-1826-4108-a56b-982beace7335<i>**: The chromosomes are shown as homologous pairs that have already split into single chromatids. This is a stage of the second meiotic division, anaphase II, so the structure is associated with meiosis, not mitosis.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e1je21j21ej1e2.png?alt=media&token=96f53c92-5999-4fc5-ae01-f46facbc4397<i>**: The diagram shows one cell with homologous chromosome pairs about to separate, as in metaphase I of meiosis. It shows a meiotic stage, and no daughter cells have yet been produced.

**25** **Three fatty acids with the formula $C_8H_{16}O_2$ react with glycerol $(C_3H_8O_3)$ to form a triglyceride.**

**Which of the following is the correct formula for the triglyceride?**

**Correct answer: A · $C_{27}H_{50}O_6$**

To synthesize a triglyceride, three fatty acid molecules undergo **esterification** with one glycerol molecule. This condensation reaction forms **three ester bonds**, releasing **three water molecules**. Summing the reactant atoms yields $C_{27}H_{56}O_9$, which decreases to $C_{27}H_{50}O_6$ after subtracting $H_6O_3$.

**Why the other answers are wrong**

- **B)** $C_{27}H_{48}O_5$: This formula requires removing $H_8O_4$, which corresponds to four water molecules. Triglyceride synthesis only creates three ester bonds and eliminates exactly three water molecules.
- **C)** $C_{27}H_{48}O_6$: This composition maintains the correct oxygen count for three lost waters but reduces hydrogen by eight atoms. Relative to the initial sum, this would mean removing $H_8O_3$, which does not match the fixed stoichiometry of water.
- **D)** $C_{27}H_{52}O_7$: This result stems from eliminating only two water molecules. This incomplete removal indicates partial esterification rather than complete triglyceride formation.
- **E)** $C_{27}H_{56}O_9$: This value represents the raw sum of all reactant atoms before any chemical change. It completely ignores the dehydration step where three water molecules are expelled during bond formation.

**26** **Which of the following is correct for cholesterol in humans?**

**Correct answer: A · It maintains the fluidity of the cell membrane**

Cholesterol is an **amphipathic** molecule inserted between phospholipids in animal cell membranes. At low temperatures it prevents tight packing of lipid tails, avoiding rigidity. At high temperatures it restricts excessive movement, preventing over-fluidity. This dual action buffers membrane integrity across varying temperatures.

**Why the other answers are wrong**

- **B) It is used to make all hormones**: Cholesterol is only the precursor for **steroid hormones** (e.g. oestrogen, testosterone, cortisol). Most human hormones are peptide or amino-acid derivatives (e.g. insulin, ADH, adrenaline). They are not synthesised from cholesterol.
- **C) It is a good source of energy because of the number of hydrogen atoms**: Its fused ring structure is not readily **oxidised** during normal metabolism. Unlike fatty acids or glucose, it cannot be catabolised to release ATP. It is never used as an energy store.
- **D) It forms hydrogen bonds with water which stabilises the cell membrane**: Only its single hydroxyl group forms hydrogen bonds with water. The remainder is highly hydrophobic. Stabilisation derives from its placement among phospholipids. Water interactions do not stabilise the membrane.
- **E) It transports fatty acids around the body**: Transport relies on lipoproteins (e.g. LDL, HDL) and plasma albumin. Cholesterol simply acts as a **passenger** within these particles. It does not function as a transporter.

**27** **The diagram represents an animal cell with five organelles labelled P, Q, R, S and T.**

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**Which row correctly matches the label with the name and function of the cell organelle?**

**<i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Immagini_TestBuddy_2025_Quesiti_ENG%2FScreenshot%202025-07-29%20082206.png?alt=media&token=9f12af07-1a4c-4acb-90fa-1cea6697f589<i>**

**Correct answer: A · row 5**

T points to the **nucleolus**, which produces ribosomal RNA and combines it with proteins to form ribosomal subunits. Therefore, row 5 correctly matches the label, organelle and function.

**Why the other answers are wrong**

- **B) row 2**: Q indicates the centrioles, but they do not hold sister chromatids together. They help organize microtubules and the mitotic spindle during cell division; sister chromatids are held together mainly by cohesin proteins.
- **C) row 3**: R indicates the rough endoplasmic reticulum rather than a single ribosome. Ribosomes carry out protein synthesis, while lysosomes are formed through the endomembrane system, particularly with processing and packaging by the Golgi apparatus.
- **D) row 4**: S points to a mitochondrion, not the Golgi apparatus. Mitochondria are principally associated with aerobic respiration, while anaerobic glycolysis occurs in the cytosol, not in the Golgi apparatus.
- **E) row 1**: P indicates the Golgi apparatus, not a mitochondrion. The Golgi modifies, sorts and packages proteins, whereas mitochondria principally produce ATP through aerobic respiration. Protein synthesis is performed by ribosomes, including those attached to the rough endoplasmic reticulum.

**28** **Which of the following cell structures contain(s) biological catalysts?**

**1. cytoplasm**
**2. nucleus**
**3. mitochondria**

**Correct answer: A · 1, 2 and 3**

Biological catalysts are **enzymes**. The cytoplasm hosts metabolic pathways like glycolysis powered by soluble or ribosome-bound proteins. The nucleus contains DNA and RNA polymerases, helicases, and ligases. The mitochondria house Krebs cycle and oxidative phosphorylation catalysts. All three structures therefore contain biological catalysts.

**Why the other answers are wrong**

- **B) 2 only**: Identifies nuclear catalysts but ignores the extensive enzymatic activity in the cytoplasm and mitochondria.
- **C) 3 only**: Includes mitochondrial catalysts but omits both cytoplasmic and nuclear proteins.
- **D) 2 and 3 only**: Acknowledges nuclear and mitochondrial sites but incorrectly excludes the cytoplasm where most cellular reactions occur.
- **E) 1 only**: Recognises cytoplasmic catalysts yet overlooks the complete enzyme sets present in the nucleus and mitochondria.

## 29 Which of the following reactions or biological processes involves a redox reaction?

**Correct answer: A** · $\mathrm{NAD^+ + H_2 \longleftrightarrow NADH + H^+}$

In the reaction $\mathrm{NAD^+ + H_2 \longleftrightarrow NADH + H^+}$, molecular hydrogen loses electrons and undergoes **oxidation** while $\mathrm{NAD^+}$ accepts a **hydride ion** and undergoes **reduction**. The direct **electron transfer** between reactants satisfies the redox definition and serves as the primary mechanism for cellular energy harvesting.

**Why the other answers are wrong**

- **B) glucose + glucose ↔ maltose + water**: This is a condensation reaction that links two glucose molecules into maltose by removing water. The **oxidation state** of carbon, hydrogen, and oxygen remains constant throughout the process, so no net electron transfer occurs.
- **C) a cytosine and guanine pairing**: Base pairing relies entirely on **hydrogen bonding** and $\pi$-$\pi$ stacking interactions. The atoms involved maintain their initial oxidation states, meaning neither oxidation nor reduction takes place.
- **D) polymerisation of amino acids**: Peptide bond formation during protein polymerisation is also a dehydration condensation reaction. Although cellular energy carriers like ATP fuel the overall synthesis, the actual bond-forming step does not alter the oxidation states of the amino acid atoms.
- **E) depolarisation of a neuron**: Neuronal depolarisation depends on the diffusion of $\mathrm{Na^+}$ and $\mathrm{K^+}$ ions through membrane channels. These ions preserve their original charge and oxidation state; only their spatial distribution changes, making this an electrochemical ion movement rather than an electron transfer.

**30** **The SRY gene is normally located on the human Y chromosome. This gene initiates the development of male characteristics.**

**Using this information, which of the following statements about the SRY gene is/are correct?**

**1. lnsertion of the SRY gene into an X chromosome of a female zygote could give it male characteristics**
**2. A sperm cell arising from incorrect division, which has a functional SRY gene, could give rise to a female with a sex chromosome trisomy following fertilisation with a normal ova**
**3. During meiosis, crossing over could result in the formation of 'X' sperm with the SRY gene, which could cause male characteristics after fertilisation**

**Correct answer: A · 1 and 3 only**

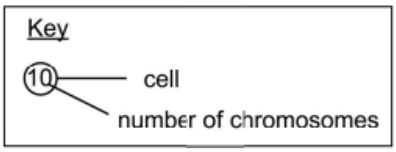
The $SRY$ gene acts as the primary molecular trigger for gonadal sex determination. Statement 1 is accurate because transferring an active copy of the gene to an $X$ **chromosome** forces an otherwise female $XX$ embryo to differentiate testes. Statement 2 is incorrect since any gamete delivering functional $SRY$ inevitably produces phenotypic males rather than a female with a sex-chromosome trisomy. Statement 3 holds true because **aberrant recombination** during meiosis can detach the $SRY$ locus from the $Y$ chromosome and attach it to the $X$, creating sperm capable of inducing male traits after fertilisation.

**Why the other answers are wrong**

- **B) 2 only**: This option isolates statement 2, which is factually invalid. A sperm carrying $SRY$ would yield either an $XY$ or an $SRY$-positive $XX$ zygote, both committing to male development and completely unable to form a triple-$X$ ($XXX$) female karyotype.
- **C) 3 only**: This choice discards the validated statement 1. Clinical observations and experimental models consistently demonstrate that a single translocated $SRY$ cassette on an $X$ chromosome provides all necessary instructions to drive the entire male embryonic programme.
- **D) 1 and 2 only**: This combination erroneously pairs a correct premise with a false one. Any fertilisation event involving an $SRY$-carrying sperm guarantees a male developmental trajectory, thereby contradicting the claim that such a gamete could produce a sex-chromosome trisomy female.
- **E) 1 only**: This selection neglects the chromosomal mechanics outlined in statement 3. Improper alignment at the pseudoautosomal regions during prophase I can physically relocate $SRY$ onto the $X$ chromosome, yielding viable $X$-bearing sperm that trigger testicular formation in their offspring.

**31** **A cell containing four pairs of homologous chromosomes divides by meiosis.**

**Which row shows the cells produced and the number of chromosomes that they contain?**




| *row* | *parent cell* | *end of meiosis I* | *after meiosis II* |
|---|---|---|---|
| 1 | (4) | (2) (2) | (2) (2) (2) (2) |
| 2 | (4) | (4) (4) | (2) (2) (2) (2) |
| 3 | (8) | (4) (4) | (4) (4) (4) (4) |
| 4 | (8) | (8) (8) | (4) (4) (4) (4) |
| 5 | (8) | (16) (16) | (8) (8) (8) (8) |

**Correct answer: A · row 3**

A cell with four homologous pairs is **diploid** and contains $2n = 8$ chromosomes. During meiosis I, **homologous chromosomes** separate to produce two intermediate cells with $4$ chromosomes each. Meiosis II then splits the **sister chromatids**, generating four **haploid** daughter cells with $4$ chromosomes. Row 3 correctly tracks this sequence from $8$ to two cells of $4$, and finally four cells of $4$.

**Why the other answers are wrong**

- **B) row 2**: This option starts with a parent cell containing only $4$ chromosomes instead of $8$. It describes meiosis for a $2n = 4$ organism, so the final chromosome counts do not match the starting condition given in the question.
- **C) row 1**: This choice also uses an incorrect starting number of $4$ chromosomes. It ignores the initial specification of four homologous pairs, leading to mismatched gamete sizes.
- **D) row 4**: This row fails to show chromosome reduction after meiosis I. Listing both intermediate cells as having $8$ chromosomes contradicts the essential halving of genetic material that occurs when homologous pairs separate.
- **E) row 5**: This option incorrectly shows the chromosome count doubling to $16$ after meiosis I. Chromosome numbers never increase during meiotic divisions; the process is designed to reduce, not multiply, the genomic content.

**32** **The sequence of bases in part of a DNA strand is:**

**TATGATCTTAGGCAACAT A strand of mRNA is transcribed using this sequence of bases.**

**Which one of the following charts shows the correct proportions of the bases in the mRNA?**

**Correct answer: A · <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e12uj1212eje1j1e2.png?alt=media&token=f84facee-2a33-4548-89c8-d166fdf1b158<i>**

Count the bases in the provided DNA strand: $\mathrm{T} = 6$, $\mathrm{A} = 6$, $\mathrm{G} = 3$, and $\mathrm{C} = 3$. During **transcription**, each template base follows strict **complementary** rules to form the messenger RNA. This conversion generates an mRNA molecule with $\mathrm{A} = 6$, $\mathrm{U} = 6$, $\mathrm{G} = 3$, and $\mathrm{C} = 3$. The calculated **proportions** place adenine and uracil at $33\frac{1}{3}\ \%$ and guanine and cytosine at $16\frac{2}{3}\ \%$. Only **Chart A** accurately represents these balanced segments.

**Why the other answers are wrong**

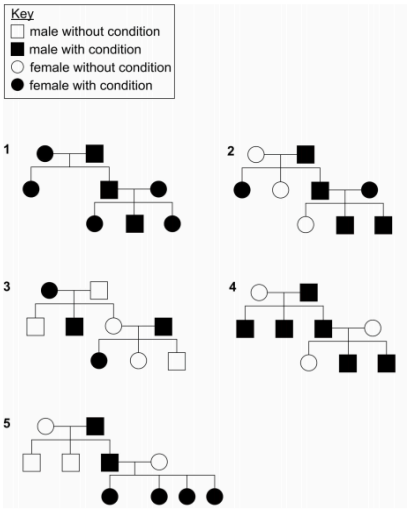
- **B) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx1e21ne121e21ne21e.png?alt=media&token=cc7754f6-db9b-4268-866b-7534e0d4fccf<i>**: Depicts unequal sections for $\mathrm{A}$ and $\mathrm{U}$. This mismatch would only occur if the DNA strand contained different quantities of $\mathrm{T}$ and $\mathrm{A}$, which contradicts the actual count.
- **C) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fx12e2112h12eh12he2e.png?alt=media&token=58fa008f-99b5-4dfb-bc07-1bdb56198fcb<i>**: Distributes the total equally among all four nucleotides. The original genetic sequence clearly shows uneven base frequencies, making an equal split impossible for the transcribed molecule.
- **D) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fcju1ej2u1e12u12e2.png?alt=media&token=30d52db0-fba5-455e-823a-f52ec1963501<i>**: Fails to replace thymine with uracil during the synthesis step. This oversight artificially inflates the remaining category while shrinking the corresponding $\mathrm{A}$ segment, violating standard nucleic acid composition rules.
- **E) <i>https://firebasestorage.googleapis.com/v0/b/e2-ms01.appspot.com/o/Assets%2FImages%2FQuizzes%2Fu1ec1huh12ue121e2.png?alt=media&token=384bc062-ec4e-49fc-afd7-c547b4753b63<i>**: Reverses the expected values for guanine and cytosine. A larger cytosine section would demand more $\mathrm{C}$ than $\mathrm{G}$ in the coding region, contradicting the observed three-to-three ratio.

**33** **Polydactyly is a condition caused by a gene mutation. Animals affected by polydactyly have extra digits on one or more limbs.**

**Five inheritance patterns of polydactyly in a species are shown in the diagrams..**

**Which inheritance pattern can ONLY occur when polydactyly is caused by an autosomal dominant allele and NOT when it is caused by an autosomal recessive allele?**

**[Assume normal cell divisions in all individuals.]**




**Correct answer: A · 2**

With an **autosomal recessive** allele, affected individuals are homozygous recessive ($aa$): two affected parents can only have affected children. In pedigree 2 an affected man and an affected woman have an **unaffected daughter**: this is possible only if the allele is **dominant** and both parents are heterozygous ( $Aa \times Aa$ can give $aa$).

**Why the other answers are wrong**

- **B) 1**: In pedigree 1 every child of affected parents is affected: this also fits a recessive allele ($aa \times aa$ gives only $aa$).
- **C) 3**: In pedigree 3 every cross is affected × unaffected: with a recessive allele the unaffected partner can be a carrier, so it fits both kinds of inheritance.
- **D) 4**: In pedigree 4 every cross is affected × unaffected: with a recessive allele the unaffected partner can be a carrier, so it fits both kinds of inheritance.
- **E) 5**: In pedigree 5 every cross is affected × unaffected: with a recessive allele the unaffected partner can be a carrier, so it fits both kinds of inheritance.

**34** **In which of the following places are proton pumps found?**

**1 the chloroplast stroma**
**2 the gap between the thylakoid membranes**
**3 the membrane of the granum**

**Correct answer: A · 3 only**

The photosynthetic electron-transport chain operates within the **thylakoid membrane**. The **cytochrome $b_6f$ complex** actively transports $\mathrm{H}^+$ ions out of the stroma. **ATP synthase** subsequently enables $\mathrm{H}^+$ backflow to generate ATP. Both proteins are embedded directly in the **granum membrane**, making it the only valid location.

**Why the other answers are wrong**

- **B) 2 only**: Statement 2 refers to the thylakoid lumen, which acts as a reservoir for accumulated protons. The pumping machinery itself requires a lipid bilayer anchor and cannot exist in an empty aqueous gap.
- **C) 1 only**: Statement 1 describes the chloroplast stroma, an aqueous phase rich in dissolved Calvin-cycle enzymes and ribosomes. Proton pumps are strictly transmembrane structures and do not float freely in this solvent.
- **D) 1 and 2 only**: This choice incorrectly pairs statements 1 and 2. Both refer to fluid compartments that lack the essential hydrophobic core needed to house ion-translocating protein complexes.
- **E) 1 and 3 only**: This selection mixes a correct location with an incorrect one. Statement 3 accurately identifies the membrane site, but statement 1 wrongly assigns the pumps to the soluble stromal matrix.

**35** **Which row could be correct for directional selection?**

**Key:**
✓ yes
**x** no

| | a low-frequency phenotype is selected | a predator could be the cause | the frequency of a recessive allele increases |
|---|---|---|---|
| row 1 | ✓ | x | x |
| row 2 | x | ✓ | x |
| row 3 | x | x | ✓ |
| row 4 | x | ✓ | ✓ |
| row 5 | ✓ | ✓ | ✓ |

**Correct answer: A · row 5**

**Directional selection** occurs when an external agent like a **predator** consistently favors one **extreme phenotype**, driving up the frequency of the underlying **allele**. Row 5 satisfies all three required conditions: a **low-frequency phenotype** is selected, the causal agent fits, and the recessive allele frequency increases over time.

**Why the other answers are wrong**

- **B) row 2**: Row 2 mentions a predator as a potential cause, but it does not involve selecting a low-frequency phenotype nor does it show the recessive allele increasing. Without matching the core definition, it cannot represent directional selection.
- **C) row 3**: Row 3 shows an increase in the recessive allele frequency, yet it lacks selection of a low-frequency phenotype and involves no predator. This combination misses the unidirectional evolutionary push required.
- **D) row 4**: Row 4 includes both a predatory cause and an increase in the recessive allele frequency, but it fails to select a low-frequency phenotype. The model specifically requires favoring an initially rare extreme trait.
- **E) row 1**: Row 1 selects a low-frequency phenotype, but neither implicates a predator nor shows an increase in the recessive allele frequency. These missing factors suggest frequency-dependent or random mechanisms instead.

**36** **Which one of the following statements is correct about the cardiac cycle of a healthy human?**

**Correct answer: A · When the left ventricle relaxes, the aortic valve closes**

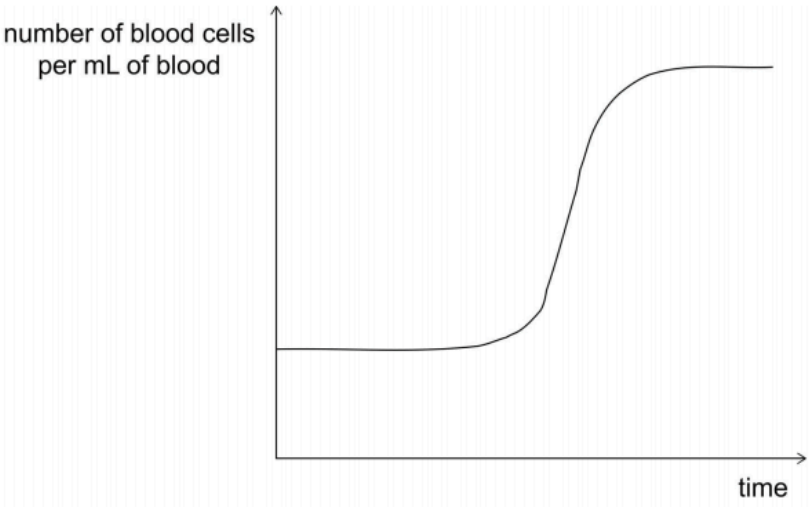
During **ventricular relaxation**, pressure in the left ventricle falls rapidly below aortic pressure. This pressure gradient forces the semilunar valve cusps together, sealing the aortic valve. The closure prevents backflow and marks the end of systole.

**Why the other answers are wrong**

- **B) When the left atrium contracts, the aortic valve opens**: Left atrial contraction occurs during late ventricular diastole, while the aortic valve remains closed. The valve only opens later during ventricular systole, once intraventricular pressure exceeds aortic pressure.
- **C) When the right atrio-ventricular valve closes, the left atrio-ventricular valve opens**: The right and left atrioventricular valves function synchronously. Both close simultaneously at the start of ventricular systole and open together during early diastole. One never closes while the other opens.
- **D) When the right atrium contracts, the left ventricle contracts**: Atrial and ventricular contractions follow a strict sequence rather than occurring simultaneously. Both atria contract first, then a brief conduction delay allows both ventricles to contract next. Right atrial contraction therefore precedes, rather than coincides with, left ventricular contraction.
- **E) When the right ventricle contracts, the right atrio-ventricular valve opens**: Ventricular contraction raises intraventricular pressure above atrial pressure. This gradient forces the tricuspid valve to close firmly, blocking retrograde flow into the right atrium. Opening it would cause regurgitation.

**37** **The graph below shows the change in blood cell count of a human over time.**

**Which of the following could explain the shape of the above graph?**
**1. a reduction in the concentration of oxygen in the atmosphere**
**2. a response to a bacterial infection**
**3. increased differentiation of bone marrow stem cells**




**Correct answer: A · 1, 2 and 3**

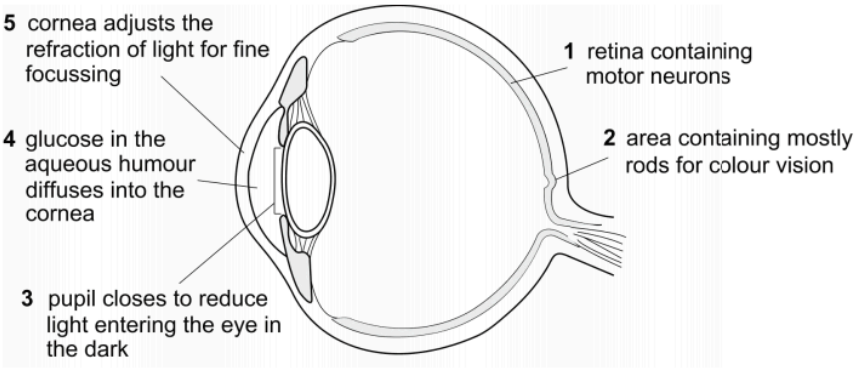
The flat baseline represents normal homeostasis. A reduction in atmospheric $O_2$ can cause tissue hypoxia, prompting the kidneys to release more **erythropoietin (EPO)** and the bone marrow to produce more red blood cells. A bacterial infection triggers cytokines and interleukins, which recruit white blood cells from circulation, possibly causing an initial dip, and then stimulate the marrow to increase white-cell production. Increased **stem-cell differentiation** can explain the sharp rise, while the transient dip or lag may reflect cell deployment or slight depletion. The final **plateau** represents a new balance between production and clearance.

**Why the other answers are wrong**

- **B) 1 and 2 only**: It includes hypoxia and infection but omits statement 3, the increased stem-cell differentiation that the solution identifies as the mechanism needed to produce the rise in cell count.
- **C) 2 and 3 only**: It omits statement 1, even though reduced atmospheric oxygen is another independent stimulus for increased blood-cell production.
- **D) 1 only**: It omits the contribution of bacterial infection and the increased bone-marrow stem-cell differentiation needed to explain the rise in the graph.
- **E) 2 only**: It omits both the hypoxia stimulus in statement 1 and the increased stem-cell differentiation in statement 3, which helps explain the rise in cell count.

**38** **The diagram shows a cross section through a human eye. Some parts of the eye are labelled 1 to 5 with notes.**

**Which one of the following notes is correct?**




**Correct answer: A · note 4**

The avascular tissue absorbs nutrients through **diffusion** from nearby fluids. This passive exchange sustains cellular metabolism while preserving optical clarity.

**Why the other answers are wrong**

- **B) note 2**: Light-sensitive rods lack chromatic discrimination. Colour processing depends entirely on specialized cone clusters concentrated in the central retina.
- **C) note 3**: Low illumination forces the aperture to dilate for greater photon capture. Brightness triggers constriction to limit exposure and protect internal structures.
- **D) note 1**: Retinal tissue hosts photoreceptors, bipolar interneurons, and ganglion cell projections. True motor neurons localize solely to the iris and ciliary body.
- **E) note 5**: The anterior surface performs primary light bending yet cannot alter its geometry. Accommodation requires the adjustable lens manipulated by ciliary muscle contraction.

**39** **Organ or tissue transplants normally require that the donor's antigens must be closely matched to those of the recipient.**

**Which one of the following types of transplant can typically be carried out WlTHOUT the need for a match between donor and recipient?**

**Correct answer: A · cornea**

The **cornea** is an **immune-privileged** tissue that lacks blood vessels and contains minimal antigen-presenting cells. This structural isolation prevents donor antigens from triggering widespread immune activation. The anterior chamber further protects grafts using inhibitory molecules like $\mathrm{TGF}$-$\beta$. These mechanisms allow successful transplantation without strict $\mathrm{HLA}$ or blood group compatibility.

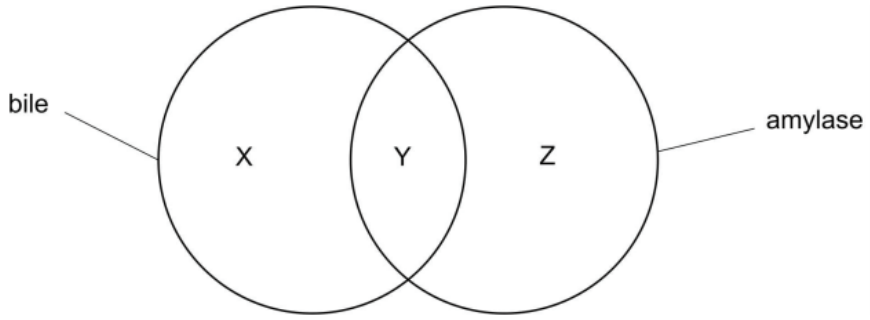
**Why the other answers are wrong**

- **B) liver**: Liver grafts tolerate some immunological differences but major $\mathrm{ABO}$ or $\mathrm{HLA}$ mismatches significantly raise rejection risks. Standard practice still requires careful crossmatching and lifelong antirejection medication.
- **C) lung**: Lung tissue is highly vascularized and densely packed with immune cells. Mismatched donors trigger severe acute rejection and chronic bronchiolitis obliterans syndrome without strict compatibility protocols.
- **D) heart**: Hearts rapidly provoke strong allo-immune responses due to extensive vascularity. Mandatory $\mathrm{ABO}$ matching and precise $\mathrm{HLA}$ typing are essential to prevent rapid graft failure.
- **E) kidney**: Renal function depends heavily on $\mathrm{HLA}$ compatibility at specific loci. Incompatible pairs face high rates of hyperacute, acute, and chronic rejection requiring intensive prophylaxis.

**40** **The diagram shows the relationship between the features of two substances involved in digestion: bile and amylase.**

**Which of the following rows is correct for X, Y and Z?**

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**Correct answer: A · row 5**

1. Bile contains no digestive enzymes; it only **emulsifies lipids**, breaking large fat globules into smaller droplets to increase their surface area. 2. Both bile and amylase reach and function in the **small intestine**. 3. Amylase specifically **digests starch** into simpler sugars like maltose. Row 5 correctly aligns these three biological facts.

**Why the other answers are wrong**

- **B) row 2**: Row 2 incorrectly claims that bile digests lipids; bile acts solely through physical emulsification rather than chemical breakdown. This fundamental error invalidates the entire row.
- **C) row 3**: Row 3 falsely states that bile digests lipids and that both substances are produced by the pancreas, while bile is exclusively synthesized by the liver. It also inaccurately reduces amylase's function to merely producing maltose instead of digesting starch.
- **D) row 4**: Row 4 correctly identifies that bile emulsifies lipids, but erroneously attributes bile production to the pancreas instead of the liver. It also incorrectly states that amylase targets maltose as its substrate rather than starch.
- **E) row 1**: Row 1 wrongly uses the term assimilates for bile, which only emulsifies lipids without nutrient uptake. It mistakenly places both substances in the gallbladder, an organ that only stores bile. It further misidentifies amylase's target as maltose instead of starch.

**41** **As Group VII of the Periodic Table (F to I) is descended, which of the following properties of the elements DECREASE?**

**1. melting points**
**2. electronegativities**
**3. first ionization energies**

**Correct answer: A · 2 and 3 only**

Descending Group VII from fluorine to iodine adds electron shells, increasing atomic radius and internal **shielding**. The outer electrons sit farther from the nucleus and feel less nuclear pull, so **electronegativity** and **first ionisation energy** both decrease. **Melting points** instead increase because larger halogen molecules develop stronger **London dispersion forces**, requiring more thermal energy to overcome. Only properties 2 and 3 show a downward trend, making option A correct.

**Why the other answers are wrong**

- **B) 2 only**: Recognises the drop in electronegativity but incorrectly excludes first ionisation energy, which declines for the same structural reasons.
- **C) 1 only**: Incorrectly claims melting point decreases, while the actual trend is an increase caused by growing molecular mass and stronger instantaneous dipole interactions.
- **D) 1 and 3 only**: Pairs a correct decreasing property with an incorrect one and omits electronegativity, breaking the requirement to identify all properties that fall.
- **E) 1, 2 and 3**: Assumes all three values drop, ignoring that intermolecular attraction strengthens down the group and forces the melting point upward.

**42** **An atom has a mass number of 18 and contains 10 neutrons.**

**A common ion of this atom has a charge of - 2.**

**What is the electron configuration of this ion in its lowest energy state?**

**Correct answer: A · $1s^2 2s^2 2p^6$**

1. Calculate the **proton number**: $Z = 18 - 10 = 8$, identifying the element as oxygen. 2. Determine the **electron count**: a neutral oxygen atom has $8$ electrons, and a $-2$ charge adds two more, totaling $10$ electrons. 3. Follow the standard **orbital filling order**: the first ten electrons occupy the available slots in $1\mathrm{s}^2 2\mathrm{s}^2 2\mathrm{p}^6$.

**Why the other answers are wrong**

- **B)** $1s^2 2s^2 2p^4$: This configuration holds $8$ electrons and corresponds to a neutral oxygen atom, missing the two extra electrons needed for the $\mathrm{O}^{2-}$ ion.
- **C)** $1s^2 2s^2 2p^2$: It contains only $6$ electrons, which would represent a $\mathrm{C}^{4+}$ ion rather than any oxygen species.
- **D)** $1s^2 2s^2 2p^6 3s^2$: This arrangement accounts for $12$ electrons, matching neutral magnesium, and exceeds the $10$ electrons present in the actual anion.
- **E)** $1s^2 2s^2 2p^6 3s^2 3p^4$: It lists $18$ electrons, identical to argon, which is far too many for an oxygen-derived ion.

**43** **Which of the following changes is/are correct?**

**1. The addition of 1 g of salt to 100g water will increase the freezing point.**
**2. A change in temperature from 150 °C to 120 °C will increase the average kinetic energy of water molecules.**
**3. A change in the surrounding air pressure from 100 kPa to 120 kPa will increase the boiling point of water.**

**Correct answer: A · 3 only**

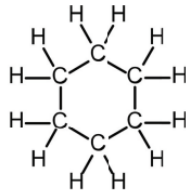
Boiling occurs when the **vapour pressure** of a liquid equals the external pressure. Raising the ambient pressure from $100\ \mathrm{kPa}$ to $120\ \mathrm{kPa}$ requires a higher temperature to achieve that match, so the boiling point increases. Only statement 3 describes this correctly.

**Why the other answers are wrong**

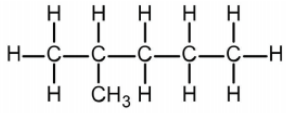
- **B) 2 only**: Targets statement 2, which claims cooling from $150\ ^{\circ}\mathrm{C}$ ($423\ \mathrm{K}$) to $120\ ^{\circ}\mathrm{C}$ ($393\ \mathrm{K}$) increases molecular **kinetic energy**. Average translational kinetic energy scales directly with **absolute temperature**, so it actually decreases during cooling.
- **C) 1 only**: Targets statement 1, claiming added salt raises the freezing point. Dissolving a non-volatile solute like $\mathrm{NaCl}$ causes **freezing-point depression** by lowering the chemical potential of liquid water, requiring a lower temperature for ice formation.
- **D) 1 and 3 only**: Combines statements 1 and 3. Statement 3 is valid, but statement 1 is false for the reason explained above, making this pairing incorrect.
- **E) 1, 2 and 3**: Groups statements 1, 2, and 3 together. It incorrectly validates two false statements alongside the single true one, so the full set is wrong.

**44** **Which of the following hydrocarbons are structural isomers of hexane?**

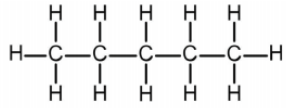
**1**



**2**



**3**



**Correct answer: A · 2 only**

Structural isomers must possess the **same molecular formula** while exhibiting **different connectivity**. n-Hexane corresponds to $C_6H_{14}$. Structure 2 is a branched six-carbon chain that maintains this exact formula, confirming its status as a structural isomer. Thus, only structure 2 satisfies the condition.

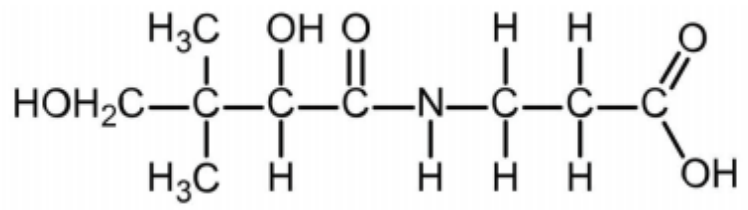
**Why the other answers are wrong**

- **B) 1 only**: Structure 1 is cyclohexane ($C_6H_{12}$), not $C_6H_{14}$, so it cannot be an isomer of hexane.
- **C) 3 only**: Structure 3 is heptane ($C_7H_{16}$), not $C_6H_{14}$, so it is not an isomer of hexane.
- **D) 1 and 2 only**: Although structure 2 is correct, structure 1 is cyclohexane ($C_6H_{12}$) and thus not an isomer of hexane.
- **E) 1 and 3 only**: Neither structure 1 nor structure 3 has the formula $C_6H_{14}$. Only structure 2 matches it.

**46** **Vitamin B5 has the structure:**

**Which of the following functional groups are contained in a molecule of vitamin B5?**

**1. alcohol**
**2. aldehyde**
**3. amide**
**4. amine**
**5. carboxylic acid**
**6. ketone**



**Correct answer: A · 1, 3 and 5 only**

The molecule contains a secondary **alcohol** group, a central **amide** linkage, and a terminal **carboxylic acid** moiety. The two $\mathrm{C}=\mathrm{O}$ bonds belong exclusively to the acid and amide functions, while the nitrogen forms part of the amide bond. Therefore, the structure does not include any **aldehyde** or **ketone** groups.

**Why the other answers are wrong**

- **B) 1, 2 and 4 only**: Suggests an aldehyde and an amine, which are absent. There is no terminal $-\mathrm{CHO}$ group, and the nitrogen atom is incorporated into the amide functionality rather than existing as a free amine.
- **C) 1, 3 and 6 only**: Incorrectly includes a ketone. Both carbonyl bonds in the structure are attached to heteroatoms (oxygen or nitrogen), so neither qualifies as a ketone where the carbon would bond to two other carbons.
- **D) 2, 4 and 6 only**: Lists only aldehyde, amine, and ketone. None of these three functionalities appear in the molecule, as the actual composition consists solely of the alcohol, amide, and acid groups.
- **E) 4, 5 and 6 only**: Combines a free amine and a ketone with the correct acid. This is invalid because the nitrogen is restricted to the amide linkage and the carbonyls are already assigned to the acid and amide, leaving no structural space for ketones or unbound amines.

**47** **X is 50.0 mL of a $1.0\ \text{mol L}^{-1}$ aqueous solution of nitric acid $(\text{HNO}_3)$.**

**Y is 100 mL of a 0.050 mol $\text{L}^{-1}$ aqueous solution of sulfuric acid $(\text{H}_2\text{SO}_4)$.**

**Which of the following statements about these solutions is/are correct?**

**1. The hydrogen ion concentration in Y is four times greater than the hydrogen ion concentration in X.**
**2. Only the acid in Y will be completely dissociated into ions.**
**3. Y has a pH value of less than 2 at 25 °C.**

**Correct answer: A · 3 only**

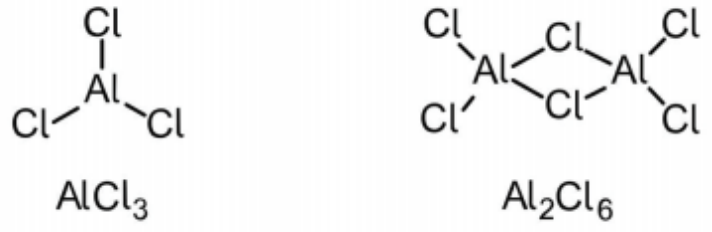
1. Nitric acid acts as a **strong monoprotic acid**, dissociating completely to give $[\text{H}^+]_\text{X} = 1.0\ \text{mol L}^{-1}$. 2. Sulfuric acid releases its first proton fully, but undergoes **partial dissociation** for the second proton at this concentration, placing $[\text{H}^+]_\text{Y}$ between $0.050$ and $0.10\ \text{mol L}^{-1}$. 3. Statement 1 is false because $[\text{H}^+]_\text{X}$ is at least ten times larger than $[\text{H}^+]_\text{Y}$. Statement 2 is false since $\text{HNO}_3$ remains **completely ionised** while $\text{H}_2\text{SO}_4$ does not fully split. Statement 3 is true because even ignoring the second ionisation, $\text{pH} = -\log(0.050) \approx 1.30$, confirming **pH < 2**.

**Why the other answers are wrong**

- **B) none of them**: Rejected because statement 3 is factually correct based on the calculated acidity.
- **C) 1 only**: Rejected because statement 1 misstates the concentration ratio and overlooks the validity of statement 3.
- **D) 1 and 3 only**: Rejected because it incorrectly includes the false statement 1 alongside the true statement 3.
- **E) 2 and 3 only**: Rejected because statement 2 contradicts the dissociation behaviour; $\text{HNO}_3$ fully ionises while $\text{H}_2\text{SO}_4$ only partially releases its second proton.

**48** **Which row gives the correct shapes around the aluminium centres in $AlCl_3$ and $Al_2Cl_6$ molecules?**

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**Correct answer: A · row 4**

In $AlCl_3$ the aluminium atom forms three bonds with chlorine and carries zero lone pairs, producing three electron domains that adopt a **trigonal planar** geometry. In $Al_2Cl_6$ each aluminium atom bonds to two terminal chlorines and two bridging chlorines, yielding four bonding domains that arrange in a **tetrahedral** shape. Row 4 correctly reports both molecular structures.

**Why the other answers are wrong**

- **B) row 2**: Proposes a trigonal pyramidal shape for $AlCl_3$, which requires a lone pair that aluminium lacks. The structure remains planar because no lone pair pushes the bonding pairs downward. The dimer geometry listed in this row is actually correct, but the monomer description violates VSEPR principles.
- **C) row 3**: Incorrectly assigns a tetrahedral geometry to $AlCl_3$, contradicting the fact that the monomer contains only three attached groups. It also claims a square planar arrangement for $Al_2Cl_6$, ignoring how four single bonds minimize repulsion through a three-dimensional tetrahedral layout instead of a flat square.
- **D) row 1**: Accurately identifies the monomer as trigonal planar but mislabels the dimer as square planar. The bridging chloride ions enforce a three-dimensional tetrahedral coordination environment around each aluminium centre rather than a two-dimensional plane.
- **E) row 5**: Lists both shapes incorrectly by assigning trigonal pyramidal to the monomer and square planar to the dimer. Neither configuration matches the actual bond counts or electron domain arrangements found in these compounds.

**49** **At room temperature and pressure, which of the following substances has the strongest hydrogen bonds between their molecules?**

**Correct answer: A · ethanoic acid, $CH_3COOH$**

Hydrogen bonding requires a molecule to act as both a **donor** (with an $H$ atom bonded to $F$, $O$, or $N$) and an **acceptor** (with a lone pair on an electronegative atom). Ethanoic acid contains a $-OH$ group that donates $H$ atoms and a carbonyl oxygen that accepts them. Two molecules link head-to-tail to form a cyclic **dimer** stabilized by **two** simultaneous $O-H\cdots O$ hydrogen bonds. This dual interaction creates significantly stronger intermolecular forces than single bonds, explaining its high boiling point of $118\ ^\circ C$.

**Why the other answers are wrong**

- **B) propanal, $CH_3CH_2CHO$**: Propanal possesses a carbonyl oxygen that can accept hydrogen bonds, but lacks any $O-H$, $N-H$, or $F-H$ bond to donate them. Consequently, propanal molecules interact only through dipole-dipole attractions, which are much weaker.
- **C) fluoromethane, $CH_3\ F$**: Fluoromethane has $C-H$ bonds rather than $F-H$ bonds, making its hydrogen atoms unsuitable donors for strong hydrogen bonding. Furthermore, fluorine bonded to carbon acts as a poor electron-pair acceptor, rendering intermolecular forces negligible.
- **D) trimethylamine, $(CH_3)_3\ N$**: Trimethylamine contains a nitrogen atom with a lone pair that can accept hydrogen bonds, but all hydrogen atoms are attached to carbon, preventing the molecule from acting as a donor. Any potential $C-H\cdots N$ contacts remain extremely weak compared to true hydrogen bonds.
- **E) hydrogen sulfide, $H_2\ S$**: Sulfur exhibits lower electronegativity than oxygen, making $S-H$ bonds considerably less polar than $O-H$ bonds. Although hydrogen sulfide can function as both a donor and an acceptor, its $S-H\cdots S$ interactions are fundamentally weaker than the robust $O-H\cdots O$ bonds found in carboxylic acids.

**51** **The general formula of an oxoacid is $H_mXO_n$**

**Which of the following expressions gives the oxidation state of element X?**

**Correct answer: A · 2n - m**

Assign the standard **oxidation numbers** of $+1$ for hydrogen and $-2$ for oxygen. Apply the **charge balance** rule requiring the sum to equal zero. Construct the **algebraic sum** $m(+1)+x+n(-2)=0$ and solve for $x$. The **correct result** is $x=2n-m$. Substituting $m=2$ and $n=4$ for $H_2SO_4$ confirms $+6$ for sulfur.

**Why the other answers are wrong**

- **B) m - 2n**: Produces the negative of the expected value. It stems from a **sign reversal** of the oxygen contribution while keeping hydrogen positive.
- **C) m + 2n**: Treats both elements as positively charged. It overlooks the $-2$ state of oxygen, causing an inflated magnitude and wrong sign whenever $n > m/2$.
- **D) 2m - n**: Features a **swapped roles** approach for hydrogen and oxygen. It erroneously uses $+2$ and $-1$ instead of their established oxidation values.
- **E) n - 2m**: Mixes the magnitude distortion of B with an incorrect oxygen sign. Evaluating $H_2SO_4$ gives $4-4=0$, contradicting experimental data.

**52** **A sample of an oxide of iron contains 1.68 g of iron and 0.64 g of oxygen only.**

**What is the formula of this oxide?**

**[$A_r$ values: Fe = 56; O = 16]**

**Correct answer: A** · $Fe_3O_4$

1. Convert the given masses to **moles** using the atomic masses, yielding $0.0300\ mol$ for iron and $0.0400\ mol$ for oxygen. 2. Divide both amounts by the smaller value to find the initial proportion, which gives $Fe : O = 1.00 : 1.33$. 3. Multiply by 3 to convert the decimal ratio into whole numbers, producing the **empirical formula** $Fe_3O_4$.

**Why the other answers are wrong**

- **B)** $Fe_4O_3$: Requires an $Fe : O$ mole ratio of $4 : 3$, which contradicts the experimental $0.75 : 1$ proportion.
- **C)** $Fe_2O_3$: Corresponds to a $2 : 3$ ratio, inconsistent with the calculated $3 : 4$ proportion.
- **D)** $Fe_3O_2$: Implies a $3 : 2$ mole ratio, which does not match the experimental data.
- **E) FeO**: Suggests a $1 : 1$ ratio, whereas the measured composition shows an excess of oxygen relative to iron.

**57** **At an athletics competition, a hammer thrower swings a hammer in a horizontal circle.**

**lmmediately before releasing the hammer, the ball at the end of the hammer is moving at a constant angular velocity of 10 rad / s in a horizontal circular path of radius 2.5 m.**

**Which row in the table gives the speed and the magnitude of the acceleration of the ball just before release?**

| | speed(m/s) | acceleration ($m/s^2$) |
|---|---|---|
| row 1 | 25 | 250 |
| row 2 | 25 | 40 |
| row 3 | 15 | 50 |
| row 4 | 10 | 40 |
| row 5 | 10 | 0 |

**Correct answer: A · row 1**

Calculate **linear speed** using $v = \omega r$. Calculate **centripetal acceleration** using $a = v^2/r$. Substitute $\omega = 10\ \mathrm{rad/s}$ and $r = 2.5\ \mathrm{m}$. The results match row 1.

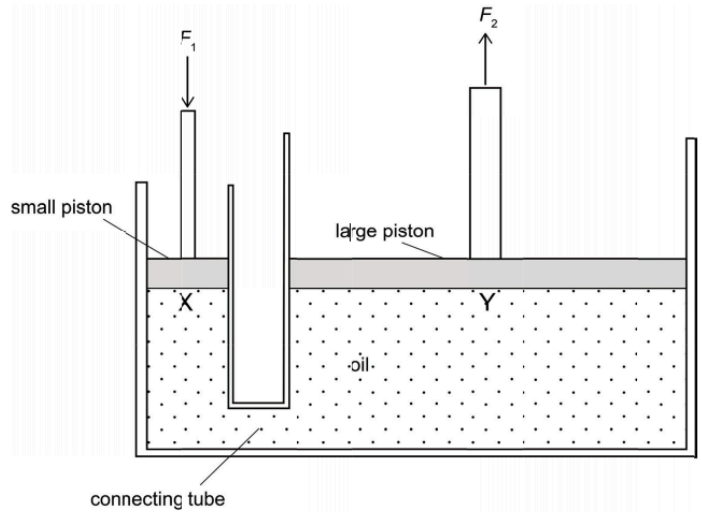
**Why the other answers are wrong**

- **B) row 2**: Row 2 lists speed $25\ \mathrm{m/s}$ and acceleration $40\ \mathrm{m/s^2}$. The speed is correct but acceleration must use $a = v^2/r$ to obtain $250\ \mathrm{m/s^2}$.
- **C) row 3**: Row 3 lists speed $15\ \mathrm{m/s}$ and acceleration $50\ \mathrm{m/s^2}$. Both numbers are off because speed equals $\omega r = 25\ \mathrm{m/s}$ and the correct acceleration is $250\ \mathrm{m/s^2}$.
- **D) row 4**: Row 4 lists speed $10\ \mathrm{m/s}$ and acceleration $40\ \mathrm{m/s^2}$. This mistakes **angular velocity** for linear speed. Speed equals $\omega r$, not just $\omega$. The acceleration value also relies on a wrong formula.
- **E) row 5**: Row 5 lists speed $10\ \mathrm{m/s}$ and acceleration $0\ \mathrm{m/s^2}$. This treats the motion as having **zero acceleration**. Constant speed does not eliminate centripetal acceleration directed toward the circle center.

**58** **A hydraulic jack consists of a piston with a small cross-sectional area connected by a tube to a piston with a larger cross-sectional area. The cylinders of the pistons and the tube contain oil.**

**A downward force $F_1$ is applied to the smaller piston, which results in an upwards resultant force $F_2$ being exerted on the larger piston. Points X and Y are in the oil, immediately underneath the pistons, which are at the same height.**

**Which of the following statements about the pressure and forces in the hydraulic jack is/are correct?**
**1. The pressure at Y is less than the pressure at X.**
**2. The pressure at Y is equal to the pressure at X.**
**3. $F_2$ is greater than $F_1$.**
**4. $F_2$ is less than $F_1$.**




**Correct answer: A · 2 and 3 only**

By **Pascal's principle**, points X and Y, at the same height in connected oil, have equal pressure, so statement 2 is true and statement 1 is false. Since the larger piston has a greater area, $A_2 > A_1$, the forces satisfy $F_2 = F_1(A_2/A_1) > F_1$. Thus statement 3 is true and statement 4 is false.

**Why the other answers are wrong**

- **B) 3 only**: It includes statement 3 but ignores statement 2, which is also true because the pressure is equal at X and Y.
- **C) 1 only**: Statement 1 is false: in connected oil, points at the same height have equal pressure, not a lower pressure at Y than at X.
- **D) 2 and 4 only**: It correctly includes statement 2, but statement 4 is false. The larger piston has a greater area, so it experiences a greater force than the smaller piston.
- **E) 1 and 4 only**: Both statements are false: the pressure at Y is not less than at X, and $F_2$ is not less than $F_1$.

**59** **A metal has a specific heat capacity of 500 J / (kg °C). A block of this metal has a mass of 1.20 kg and is provided with thermal energy by a heater for 5.00 minutes.**
**The temperature of the block increases from 40.0 °C to 90.0 °C without a phase change.**

**What is the power of the heater?**

**[Assume that no thermal energy is lost to or gained from the surroundings and that the metal is at a uniform temperature at all times.]**

**Correct answer: A · 100 W**

The energy transferred equals the product of **mass**, **specific heat**, and **temperature difference**. Applying the formula $Q = mc\Delta T$ yields $30000\ \mathrm{J}$. Converting the heating time to seconds requires multiplying by $60$, which gives $300\ \mathrm{s}$. Dividing the total energy by this duration provides the **power** of $100\ \mathrm{W}$.

**Why the other answers are wrong**

- **B) 6000 W**: Uses the raw minute value $5$ instead of the converted $300\ \mathrm{s}$. This skips the necessary unit conversion step.
- **C) 180 W**: Stems from calculating with an incorrect temperature change like $30\ ^{\circ}\mathrm{C}$ or approximating the time to $170\ \mathrm{s}$. It indicates a simple calculation or reading error.
- **D) 10800 W**: Replaces the temperature change with the final temperature $90\ ^{\circ}\mathrm{C}$ while also treating minutes as seconds. These two mistakes compound to produce an excessive result.
- **E) 80 W**: Substitutes the initial temperature $40\ ^{\circ}\mathrm{C}$ directly into the formula instead of finding the difference first. This confuses absolute readings with the actual change.

**60** **Which of the following expressions gives a quantity that can be measured in joules (J)?**

**[Assume that all quantities are magnitudes.]**

**Correct answer: A ·** $\mathrm{momentum} x\ \mathrm{velocity}$

The SI base units for energy correspond to **joules**, defined as $1\ \mathrm{J} = \mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-2}$. Multiplying the dimensions of **momentum** ($\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-1}$) by those of **velocity** ($\mathrm{m} \cdot \mathrm{s}^{-1}$) yields exactly $\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-2}$. This dimensional equivalence confirms the product represents an energy quantity.

**Why the other answers are wrong**

- **B)** $(\ \mathrm{charge})^2$ **x resistance**: Squared charge provides $\mathrm{A}^2 \cdot \mathrm{s}^2$ while resistance contributes $\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-3} \cdot \mathrm{A}^{-2}$, resulting in $\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-1}$. This combination carries an extra time dimension and equals energy multiplied by seconds.
- **C)** $(\ \mathrm{mass})^2\ \mathrm{x\ velocity}$: Squaring the mass retains $\mathrm{kg}^2$ instead of $\mathrm{kg}^1$, and combining it with velocity produces $\mathrm{kg}^2 \cdot \mathrm{m} \cdot \mathrm{s}^{-1}$. The presence of two mass powers breaks the required dimensional balance for energy.
- **D) specific heat capacity/mass x temperature change**: Specific heat capacity has units of $\mathrm{J} \cdot \mathrm{kg}^{-1} \cdot \mathrm{K}^{-1}$, so dividing by mass creates $\mathrm{J} \cdot \mathrm{kg}^{-2} \cdot \mathrm{K}^{-1}$. Multiplying by the temperature change removes the kelvin scale but leaves an unrecoverable $\mathrm{kg}^{-2}$ factor.
- **E) voltage/current x time**: Dividing voltage by current defines electrical **resistance** in ohms, expressed as $\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-3} \cdot \mathrm{A}^{-2}$. Multiplying this value by time adds a second to the denominator exponent, yielding $\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-2} \cdot \mathrm{A}^{-2}$ and introducing an invalid current term.

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