Cambridge Assessment
Admissions Testing

BioMedical Admissions Test

Section 2

November 2020

Explained Answers

1 Which two of the following statements about genetic variation are correct?

1 Asexual reproduction always produces genetic variation.

2 Gamete production is the only possible source of genetic variation in sexual reproduction.

3 The environment can cause genetic variation.

4 Mutations can produce genetic variation.

A 1 and 2 only

B 1 and 3 only

C 1 and 4 only

D 2 and 3 only

E 2 and 4 only

F 3 and 4 only

The answer is option **F**.

Asexual reproduction produces genetically identical offspring so it does not usually result in genetic variation. If a mutation occurs, it would result in genetic variation. Statement 1 is therefore not correct.

Gamete production does result in genetic variation within sexual reproduction. However, it is not the only source of genetic variation: for example, the particular sperm that fertilises an egg can be another source. Statement 2 is therefore not correct.

The environment can cause genetic variation: for example, carcinogens in cigarette smoke can cause genetic mutations that lead to genetic variation. Statement 3 is therefore correct.

A mutation affects the DNA sequence. A change in the DNA results in genetic variation. Statement 4 is therefore correct.

2 A sample of an element consists of two isotopes. The relative abundance of each isotope is shown in the table.

	number of protons	*number of neutrons*	*number of electrons*	*relative abundance*
isotope 1	31	38	31	60%
isotope 2	31	40	31	40%

What is the relative atomic mass of the element in this sample?

A 31.0

B 38.8

C 39.0

D 62.0

E 69.8

F 70.0

The answer is option **E**.

The relative mass of an isotope is determined by the total number of protons and neutrons, and so isotope 1 has a relative mass of 69 and isotope 2 has a relative mass of 71. The relative atomic mass is the average mass of these isotopes taking into account their relative abundance.

$$\text{Relative atomic mass} = \frac{(69 \times 60) + (71 \times 40)}{100} = 69.8$$

3 A supermarket has a large open-topped deep freezer to keep products frozen but still visible to customers.

Which statement about the air in this freezer explains why the products remain frozen, even though it is open-topped?

A The temperature difference between the air inside and outside the freezer is too large for heat to enter the freezer.

B The temperature difference between the air inside and outside the freezer is too small for heat to enter the freezer.

C The warm air above the freezer is denser than cold air inside the freezer.

D The cold air inside the freezer is denser than the hot air above the freezer.

E The products inside the freezer trap the cold air so it cannot escape.

The answer is option **D**.

The freezer cools the air inside it, and so the air falls to the bottom of the freezer by convection. The cold air is denser than the surrounding air and so is trapped in the freezer.

4 Which one of the following is a simplification of

$$2 - \frac{2x+1}{4x^2+4x+1}$$

A $\dfrac{4x+1}{2x+1}$

B $\dfrac{4x+3}{2x+1}$

C $\dfrac{4x+9}{2x+5}$

D $\dfrac{8x^2+4x+1}{4x^2+2x+1}$

E $\dfrac{8x^2+4x+1}{4x^2+2x+2}$

F 2

The answer is option **A**.

Factorise the denominator and the expression cancels to give:

$$2 - \frac{2x+1}{4x^2+4x+1} = 2 - \frac{2x+1}{(2x+1)(2x+1)}$$

$$= 2 - \frac{1}{2x+1}$$

$$= \frac{2(2x+1)-1}{2x+1}$$

$$= \frac{4x+2-1}{2x+1}$$

$$= \frac{4x+1}{2x+1}$$

5 Scientists are using human stem cells to develop treatments for a wide variety of health conditions.

Two types of stem cell that are available for this work are:

- stem cells collected from an early embryo
- bone marrow stem cells collected from an adult

Which of the following statements is/are correct?

(Assume that no mutations occur.)

1 Both of these types of stem cell can divide producing daughter cells. Each daughter cell will contain one haploid copy of the donor's genome.

2 The stem cells collected from an embryo are able to differentiate into a wider variety of specialised cells than the adult bone marrow stem cells.

3 The use of stem cell therapy to treat a medical condition can increase the risk of a person developing cancer.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The answer is option **G**.

All stem cells are undifferentiated cells which have the ability to differentiate into specialised cells and the ability to divide by mitosis in order to self-renew. However, stem cells are not gametes so they are diploid. So when a stem cell divides it will produce two diploid daughter cells. Statement 1 is therefore not correct.

The fertilised egg is the first cell of a new human life, and is a stem cell capable of differentiating into any cell type in the new developing life. As the human ages, the ability of stem cells to differentiate into all types of specialised human cells is lost. Stem cells in adults are only able to differentiate into a small number of cells associated with the tissue in which they are found. Therefore, stem cells from an embryo can differentiate into a wider variety of specialised cells than those from an adult. Statement 2 is therefore correct.

The use of stem cell therapy in humans can increase the risk of abnormal cell division, resulting in tumours and the development of cancer. Statement 3 is therefore correct.

6 Hot, concentrated aqueous sodium hydroxide and chlorine react as shown in the equation:

$$6NaOH + 3Cl_2 \rightarrow 5NaCl + NaClO_3 + 3H_2O$$

Which of the following statements is/are correct?

1 Chlorine has oxidation state +5 in $NaClO_3$.

2 This is an example of a disproportionation reaction.

3 Some of the oxygen in the hydroxide ions is oxidised.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The answer is option **E**.

The chlorine in the reactants is in oxidation state 0. Two of the products contain chlorine.

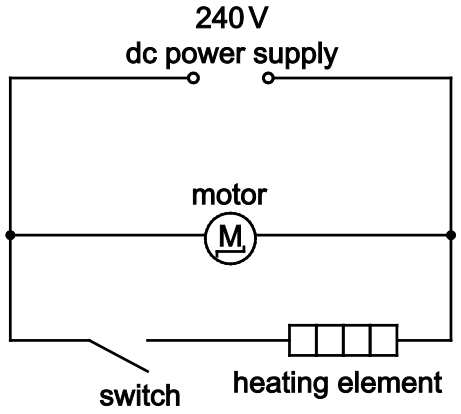
In NaCl, the chlorine is in oxidation state −1 and has therefore been reduced.

In $NaClO_3$, the chlorine is in oxidation state +5 and has therefore been oxidised. Statement 1 is correct.

The reaction is a redox reaction. Cl_2 has been both reduced and oxidised, and so it is a disproportionation reaction. Statement 2 is correct.

The oxygen atoms in the hydroxide ions are in oxidation state −2. They do not change oxidation state and remain in the oxidation state −2 in the water molecule. Statement 3 is not correct.

7 An electric fan heater contains a heating element and a motor that drives the fan. The circuit diagram is shown.



At first, the switch is open and the current in the motor is 0.40 A.

The switch is then closed.

Which of the following statements is/are correct after the switch is closed?

1 The current in the heating element added to the current in the motor is 0.40 A.

2 The voltage across the heating element is 240 V.

3 The resistance of the circuit is smaller than it is with the switch open.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The answer is option **G**.

When the switch is closed, the motor remains connected directly to the power supply and so the voltage across it is 240 V, which means that the current in the motor remains 0.40 A.

Since there is a voltage across the heating element, there is a current in it. The current in the heating element (which is greater than zero) added to the current in the motor (0.40 A) is greater than 0.40 A, and so statement 1 is not correct.

The heating element is connected directly to the power supply and so the voltage across it is 240 V. Statement 2 is correct.

Initially, the resistance of the circuit is equal to the resistance of the motor. When the switch is closed the two components constitute a parallel arrangement of resistors. The resistance of the circuit is now equal to the resistance of the parallel combination. The resistance of any parallel combination is less than the resistance of any individual component. It follows that the resistance of this parallel combination (which is the new resistance of the circuit) is less than the resistance of the motor on its own. Hence the resistance of the circuit has decreased and statement 3 is correct.

8 In a sale, the normal price of a camera is reduced by 20%.

The sale price of the camera is £180.

Which expression gives the normal price of the camera?

A $0.8 \times £180$

B $1.02 \times £180$

C $1.2 \times £180$

D $\frac{£180}{0.8}$

E $\frac{£180}{0.2}$

F $\frac{£180}{0.08}$

The answer is option **D**.

80% = 0.8

normal price × 80% = sale price

normal price × 0.8 = 180

normal price = $\frac{180}{0.8}$

9 Some rabbits have a genetic condition. The dominant allele codes for this condition.

A homozygous dominant rabbit mated with a rabbit that did not have the condition.

They had three offspring.

One of the offspring then mated with a rabbit that did not have the condition and they also produced three offspring. Two of the offspring had the condition and one did not.

One body cell that is in early interphase is taken from each of the rabbits in these three generations.

What is the total number of copies of the allele for the condition in this collection of cells?

A 6

B 7

C 8

D 11

E 12

F 14

The answer is option **B**.

The genetic condition is coded for by a dominant allele (H), and therefore only one allele is required for the condition to be expressed.

A homozygous dominant rabbit (HH) was mated with a rabbit that did not have the condition (hh).

Therefore the Punnett square for the first cross is:

	H	H
h	Hh	Hh
h	Hh	Hh

As all of the offspring are heterozygous, the three offspring all have the condition and have the genotype Hh.

One of these offspring then mated with a rabbit that did not have the condition (hh).

Therefore the Punnett square for the second cross is:

	H	h
h	Hh	hh
h	Hh	hh

Two of the offspring had the condition, so would contain the dominant allele (Hh), and one did not, so would be homozygous recessive (hh).

Both generations had three offspring.

The number of dominant alleles in the whole family is calculated:

$1 \times$ original parent = HH

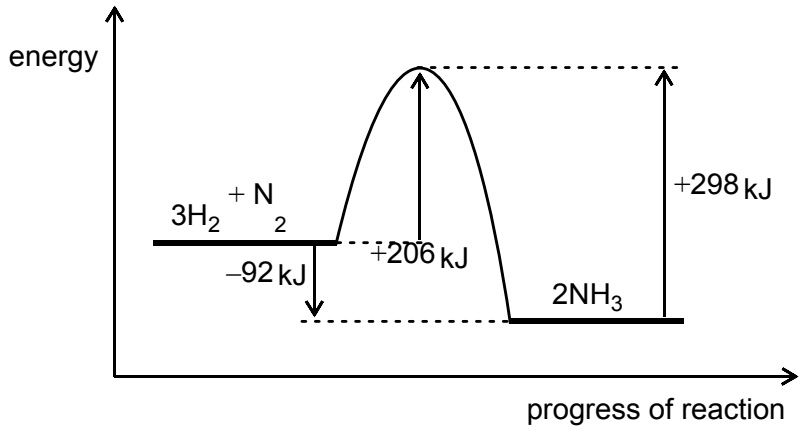
$3 \times$ offspring with the condition = Hh + Hh + Hh

$2 \times$ offspring with the condition = Hh + Hh

Therefore there are 7 dominant alleles (H) in total.

10 The reaction between hydrogen and nitrogen in the presence of an iron catalyst is known as the Haber process. It is a reversible reaction.

The energy profile for this reaction is shown.



What is the energy change when one mole of ammonia is decomposed into its component elements?

A 46 kJ is absorbed

B 46 kJ is released

C 57 kJ is absorbed

D 57 kJ is released

E 92 kJ is absorbed

F 92 kJ is released

G 149 kJ is absorbed

H 149 kJ is released

The answer is option **A**.

In the forward direction, the energy change is determined by the relative energy of the reactants and the products. The energy change for the formation of **two** moles of ammonia is shown as −92 kJ.

This means that the energy change for the formation of **one** mole of ammonia is −46 kJ. The negative sign indicates that energy is released during the formation (an exothermic reaction).

The decomposition of one mole of ammonia is the reverse process for the formation, and so the energy change is +46 kJ. The positive sign indicates that the energy is absorbed (an endothermic reaction).

11 A 'gold medal' used in events such as the Olympic Games is made from a silver–nickel alloy with a coating of a gold–silver alloy.

The mass of the medal is 256 g, of which 24.0 g is the mass of the coating.

The density of the silver–nickel alloy is 10.0 g cm^{-3} and the density of the gold–silver alloy is 16.0 g cm^{-3}.

What is the volume of the medal?

A 16.0 cm^3

B 16.9 cm^3

C 23.2 cm^3

D 24.7 cm^3

E 25.6 cm^3

F 27.1 cm^3

The answer is option **D**.

The mass of the medal is 256 g, of which 24.0 g is the gold–silver alloy coating, leaving 232 g of silver–nickel alloy.

The volume of the medal is the sum of the individual alloy volumes.

The volume of the gold–silver alloy coating is given by its mass divided by its density:

$$\frac{24.0}{16.0} = 1.5\,\text{cm}^3$$

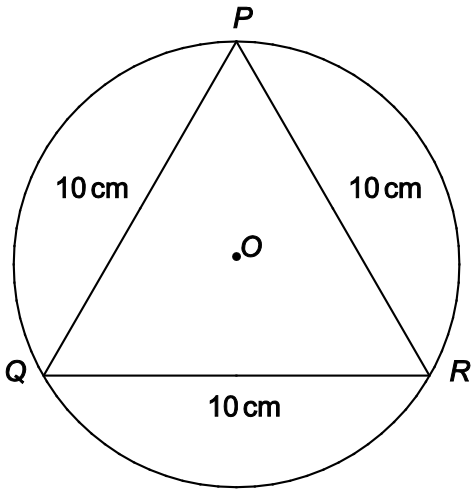
The volume of the silver–nickel alloy is given by its mass divided by its density:

$$\frac{232}{10.0} = 23.2\,\text{cm}^3$$

The volume of the medal is therefore $1.5 + 23.2 = 24.7\,\text{cm}^3$

12 Triangle PQR is equilateral with sides of length 10 cm.

P, Q, and R are points on the circumference of a circle with centre O.



[diagram not to scale]

Which one of the following is an expression, in centimetres, for the radius of the circle?

A $5\cos 60°$

B $\dfrac{5}{\tan 60°}$

C $5\sin 60°$

D $\dfrac{5}{\sin 60°}$

E $5\tan 60°$

F $\dfrac{5}{\cos 60°}$

The answer is option **D**.

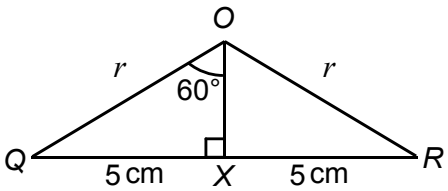
Join *R* and *Q* to *O* to make isosceles triangle *OQR*.

Angle *QOR* = 120° because of the symmetry of the equilateral triangle.

A perpendicular line from *O* to *X* bisects angle *QOR* and side *QR*.

Triangle *OQR* is isosceles, and so angle *QOX* = 60° and $QX = \frac{10}{2} = 5\,\text{cm}$.

QO is the radius r :



$\sin 60° = \frac{5}{r}$

Therefore $r = \frac{5}{\sin 60°}$

13 Several processes can change the proportion of gases in the atmosphere by adding or removing carbon dioxide or oxygen.

Which row is correct?

	adds carbon dioxide	*removes carbon dioxide*	*adds oxygen*	*removes oxygen*
A	combustion	aerobic respiration in animals	photosynthesis	activity of decomposers
B	anaerobic respiration in animals	activity of decomposers	aerobic respiration in plants	combustion
C	activity of decomposers	photosynthesis	anaerobic respiration in animals	aerobic respiration in animals
D	aerobic respiration in plants	photosynthesis	photosynthesis	activity of decomposers
E	photosynthesis	activity of decomposers	aerobic respiration in plants	combustion
F	aerobic respiration in animals	aerobic respiration in plants	anaerobic respiration in animals	aerobic respiration in animals

The answer is option **D**.

Combustion, the activity of decomposers, and aerobic respiration in both plants and animals add carbon dioxide to the atmosphere. These are in options **A**, **C**, **D** and **F**.

The only process to remove carbon dioxide is photosynthesis. This is in options **C** and **D**.

The only process to add oxygen to the atmosphere is photosynthesis. This is in options **A** and **D**.

The activity of decomposers, combustion and aerobic respiration all remove oxygen from the atmosphere, so all of the options in the final column are correct.

The only row that has all columns correct is option **D**.

14 Four metals, labelled R, T, X and Z, have the following characteristics:

- R fizzes when added to dilute hydrochloric acid.
- T is precipitated when R reacts with an aqueous solution of a compound of T.
- X is the only one of these metals that occurs naturally on Earth uncombined with other elements.
- Z is the only one of these metals manufactured commercially by electrolysis of one of its molten compounds, whereas R and T can be manufactured by heating their oxides with carbon.

What is the order of reactivity of these metals, from most to least reactive?

A R, Z, T, X

B R, T, X, Z

C T, X, R, Z

D X, R, T, Z

E X, T, R, Z

F Z, R, T, X

G Z, T, R, X

H Z, R, X, T

The answer is option **F**.

Highly reactive metals are manufactured by the electrolysis of their melted compounds. So Z must be the most reactive of the four metals. (Z could be sodium.)

Metals having medium reactivity fizz with dilute acids, giving off hydrogen, and are manufactured by reducing their oxide ores with carbon in a furnace. (R could be zinc.)

X occurs uncombined in nature, so it must be the most unreactive metal of the four. (X could be silver.)

T is displaced from its aqueous salts by R, so T is less reactive than R. (T could be lead.)

The correct order of reactivity, from most to least reactive, is Z, R, T, X.

15 Thorium-232 ($^{232}_{90}\text{Th}$) is an unstable nuclide that decays through a sequence of radioactive emissions to form a stable nuclide of lead.

All of the emissions during this sequence are either alpha or beta (β^-) particles.

One of the intermediate nuclides, reached after four alpha and two beta decays, is a nuclide of an element labelled X.

What is the symbol for this nuclide of X?

A $^{214}_{80}\text{X}$

B $^{216}_{80}\text{X}$

C $^{216}_{84}\text{X}$

D $^{216}_{88}\text{X}$

E $^{224}_{84}\text{X}$

F $^{224}_{88}\text{X}$

G $^{224}_{90}\text{X}$

H $^{228}_{88}\text{X}$

The answer is option **C**.

Alpha particles consist of two protons and two neutrons, so they have mass number 4 and atomic number 2. An alpha reduces the mass number of the nucleus by 4 and the atomic number by 2.

Beta particles are electrons, so they do not affect the mass number of the nucleus. However, they have an atomic number of -1, so when they are emitted from a nucleus the atomic number increases by 1.

The emission of 4 alpha particles and 2 beta particles will change the mass number A and atomic number Z in the following way:

$$A = 232 - (4 \times 4) - 0 = 216$$

$$Z = 90 - (4 \times 2) + (2 \times 1) = 84$$

The isotope of X has a mass number $A = 216$ and atomic number $Z = 84$.

The symbol for the isotope is therefore $^{216}_{84}\text{X}$.

16 The graphs of the following functions are drawn:

1 $y = 2x - 1$

2 $y = 1 - x^2$

3 $y = (1 - x)^2$

4 $y = 2 - x$

Which two graphs do **not** intersect?

A 1 and 2

B 1 and 3

C 1 and 4

D 2 and 3

E 2 and 4

F 3 and 4

The answer is option **E**.

This item is best approached by sketching four graphs:

Line 1 $y = 2x - 1$ is a straight line with a gradient of 2.

It intersects the y-axis at $(0, -1)$.

Line 2 $y = 1 - x^2$ is an upside-down parabola because of the $-x^2$.

When $x = 0$, $y = 1$.

Line 3 $y = (1 - x)^2$ is a positive quadratic and so also a parabola.

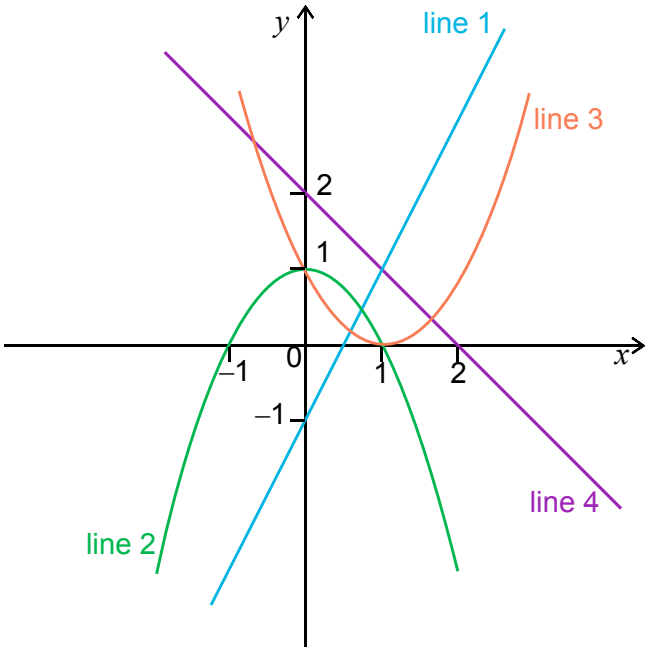
It intersects the y-axis at $(0, 1)$ and the x-axis at $(1, 0)$.

Line 4 $y = 2 - x$ is a straight line with a gradient of -1.

It intersects the y-axis at $(0, 2)$ and the x-axis at $(2, 0)$.

A sketch of these two curves and two lines shows that the line $y = 2 - x$ is always above the curve $y = 1 - x^2$

This means that lines 2 and 4 do not intersect.



17 Six test tubes were set up. Two different solutions were added to each test tube as shown in the table.

The temperature, pH and all concentrations were optimal.

Which three mixtures would lead to the presence of amino acids in the test tube?

test tube	*mixture of solutions*
1	lipase and lipid
2	lipase and boiled protein
3	protease and lipase
4	boiled protease and protein
5	protease and boiled protein
6	protease and protein

A 1, 2 and 6 only

B 1, 4 and 6 only

C 2, 3 and 4 only

D 2, 4 and 5 only

E 3, 4 and 6 only

F 3, 5 and 6 only

G 4, 5 and 6 only

The answer is option **F**.

In order to produce amino acids, a protease enzyme needs to be mixed with a protein substrate.

In test tube 1, the lipase will break down the lipids into fatty acids. This will not result in any amino acids being present.

In test tube 2, the lipase will not have any effect on the boiled protein. This will not result in any amino acids being present.

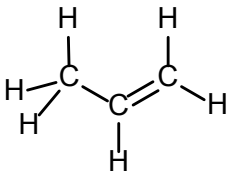
In test tube 3, the protease will break down the lipase. Although lipase is an enzyme, it is also a protein, so in this case it is also a substrate for the protease. This will result in amino acids being present.

In test tube 4, the protease has been boiled, and this has caused it to become denatured. A denatured enzyme does not break down a substrate, even if it is present. Therefore amino acids will not be present.

In test tube 5, the protease will break down the boiled protein into amino acids. Boiling a substrate does not prevent it from being broken down by an appropriate enzyme. This will result in amino acids being present.

In test tube 6, the protease will break down the protein into amino acids. This will result in amino acids being present.

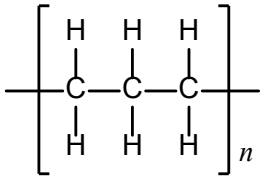
18 Propene is an alkene. The structural formula of propene is shown.



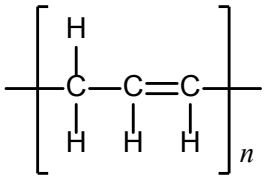
A polymer can be made from propene.

What is the correct structural formula of this polymer?

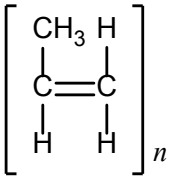
A



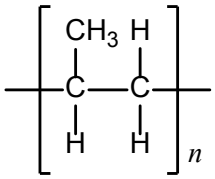
B



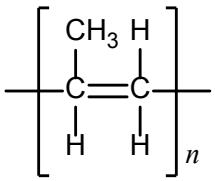
C



D



E

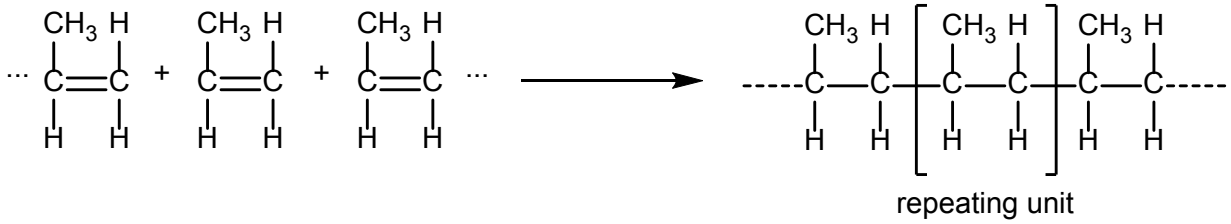


The answer is option **D**.

Polymerisation is the chemical bonding of many monomers (small molecules with covalent bonds) to form large single molecules.

For the monomer given, the chemical bond between monomers occurs between the carbon atoms that were previously double bonded (and in some cases this is also possible with triple-bonded monomers).

It is often convenient to redraw the monomer with the double bond horizontally orientated, with another monomer either side, and then change the double bond to a single bond, thereby making one electron from each carbon available to bond with the next monomer:



19 A diver of mass 45 kg jumps from a diving board and reaches a maximum height of 10 m above the surface of the water in a swimming pool.

Assume Earth's gravitational field strength is 10 N kg^{-1}, that air resistance is negligible, and that the diver is treated as a point particle.

What is the diver's kinetic energy as she hits the water, and at what speed does she hit the water?

	kinetic energy / J	*speed* / m s^{-1}
A	450	$\sqrt{10}$
B	450	$2\sqrt{5}$
C	450	10
D	4500	10
E	4500	$10\sqrt{2}$
F	4500	100

The answer is option **E**.

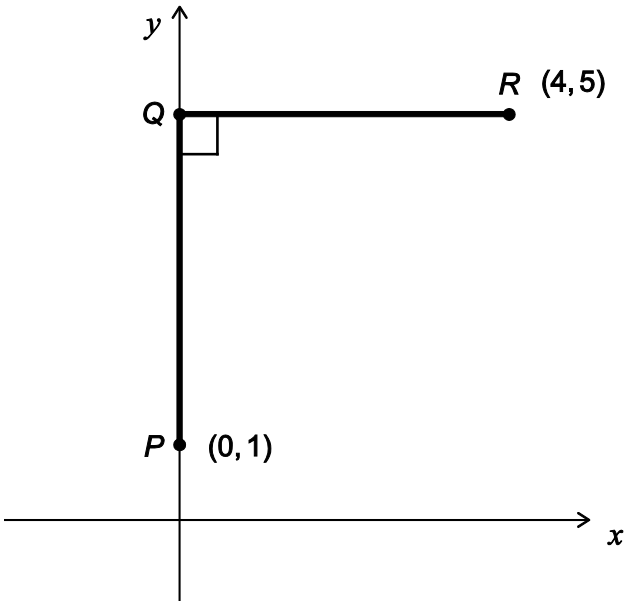
Kinetic energy gained = gravitational potential energy lost = $mgh = 45 \times 10 \times 10 = 4500$ J

Kinetic energy = $\frac{1}{2}mv^2$

so $\quad 4500 = \frac{1}{2} \times 45 \times v^2$

so $\quad v = \sqrt{\frac{2 \times 4500}{45}} = \sqrt{2 \times 100} = 10\sqrt{2}$ m s^{-1}

20



PQRS is a kite. Points *P*, *Q* and *R* are plotted on the diagram.

P is the point (0, 1) and *R* is the point (4, 5).

angle *PQR* = 90°

The point *Q* lies on the y-axis.

The line *PS* is a segment of the line $2y + x = 2$

The coordinates of *S* are (l, m).

What is $2l + m$?

A -3

B 1

C 2

D 10

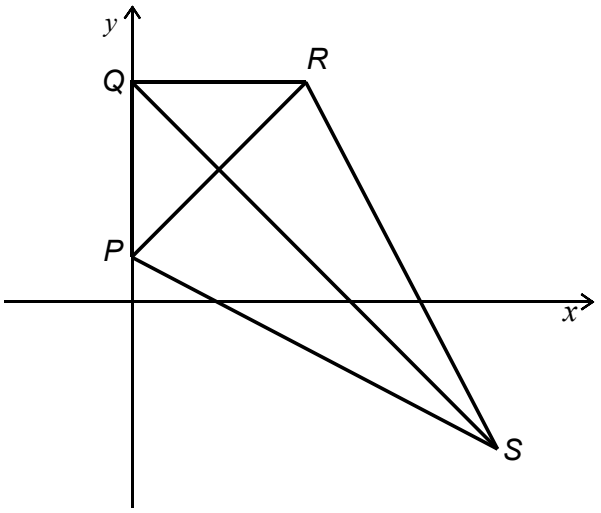
E 12

F 13

The answer is option **F**.

Q is the point (0 , 5).

PR has gradient $\frac{5-1}{4-0} = 1$



QS is perpendicular to *PR* (diagonals of a kite) so has gradient -1.

The gradient can be used to find the equation of *QS* as $\frac{y-5}{x-0} = -1$

so $y - 5 = -x$

or $x = 5 - y$

PS and *QS* intersect at *S*, so $2 - 2y = 5 - y$

Therefore $y = -3$ and $x = 5 - (-3) = 8$

$l = 8$ and $m = -3$

Therefore $2l + m = 13$

21 The table below gives some information about the number and biomass of organisms in the food chain:

rose bush → aphid → ladybird

organism	*number of organisms*	*biomass at each level* (arbitrary units)
rose bush	1	800
aphid	4000	200
ladybird	50	10

What percentage of the biomass in the producer is transferred into the biomass of each individual secondary consumer, in this food chain?

A 0.025

B 0.0625

C 0.1

D 1.25

E 5.0

F 25.0

The answer is option **A**.

Ladybirds are the secondary consumers and each ladybird has a biomass of:

$$\frac{10}{50} = 0.2 \text{ arbitrary units}$$

The producer is the rosebush, so the percentage of biomass that is transferred to each ladybird is:

$$\frac{0.2}{800} \times 100 = 0.025\%$$

22 The compounds BrCl and BrI melt at −66 °C and 42 °C, respectively.

What is the best explanation for this difference in melting points?

A The Br − I covalent bond is stronger than the Br − Cl covalent bond.

B Chlorine is more reactive than iodine so chlorine breaks away from bromine more readily than iodine.

C The forces between BrI molecules are stronger than the forces between BrCl molecules.

D Iodide ions are larger than chloride ions so bromide ions form stronger ionic bonds with iodide ions than with chloride ions.

E Iodine atoms are larger than chlorine atoms so the BrI giant covalent lattice is more difficult to break up than the BrCl giant covalent lattice.

The answer is option **C**.

Chlorine, bromine and iodine are elements in Group 17 (the halogens). As typical non-metals, they form simple covalently bonded molecules. So options **D** and **E** are not correct.

When simple molecular compounds melt it is the forces between the molecules that are overcome, not the covalent bonds within the molecules. So options **A** and **B** are not correct.

Atomic radius increases down a Group as more electron shells are filled, so iodine atoms are much larger than chlorine atoms. This means that BrI molecules are larger than BrCl molecules. Therefore the temporary dipole–induced dipole interactions would be greater between BrI molecules as these molecules have more electrons and a larger surface area than BrCl molecules. So option **C** is correct.

23 A submarine uses sound of frequency 6000 Hz to locate obstructions ahead of it in the sea.

A pulse of this sound reflects off an object that is 750 m in front of the submarine. The pulse returns to the submarine 1.00 s after it is transmitted.

What is the wavelength of this sound in the sea water?

A 12.5 cm

B 25.0 cm

C 4.00 m

D 8.00 m

E 4.50 km

F 9.00 km

The answer is option **B**.

The sound travels to the obstruction and reflects back.

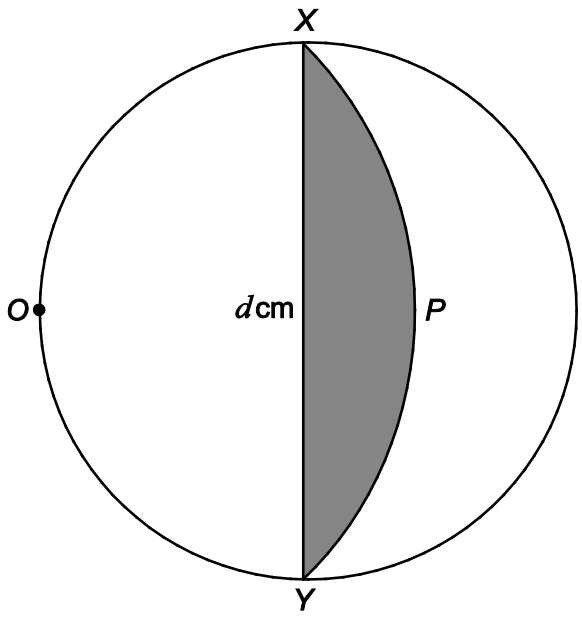
This is a distance of $2 \times 750\,\text{m} = 1500\,\text{m}$

The time taken is 1.00 s and so the speed of the sound in seawater is $\frac{1500}{1.00} = 1500\,\text{m s}^{-1}$

The frequency is 6000 Hz.

$$\text{wavelength} = \frac{\text{wave speed}}{\text{frequency}} = \frac{1500}{6000} = 0.250\,\text{m} = 25.0\,\text{cm}$$

24 The diameter *XY* of a circle has length d cm.



O is a point on the circumference of this circle such that a new circle with centre *O* passes through points *X* and *Y*.

P is a point on the new circle and the arc *XPY* is shown in the diagram.

Which of the following is an expression for the **perimeter**, in cm, of the shaded region?

A $\frac{d(2+\pi)}{2}$

B $\frac{d\left(2+\sqrt{2}\pi\right)}{2}$

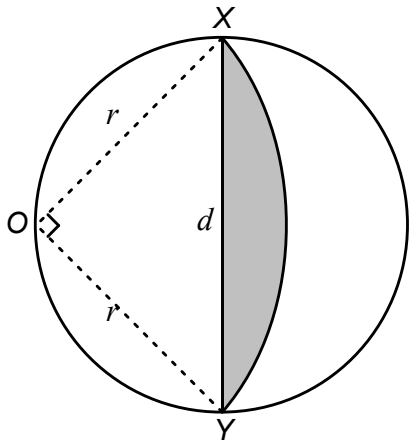
C $\frac{d(4+\pi)}{4}$

D $\frac{d\left(4+\sqrt{2}\pi\right)}{4}$

E $\frac{d(8+\pi)}{8}$

F $\frac{d\left(8+\sqrt{2}\pi\right)}{8}$

The answer is option **D**.



$OX = OY = r$ where r is the radius of the circle with centre O.

Angle $XOY = 90°$ as it is the angle in a semicircle.

$d^2 = r^2 + r^2$ so $d^2 = 2r^2$

$d = \sqrt{2}\,r$

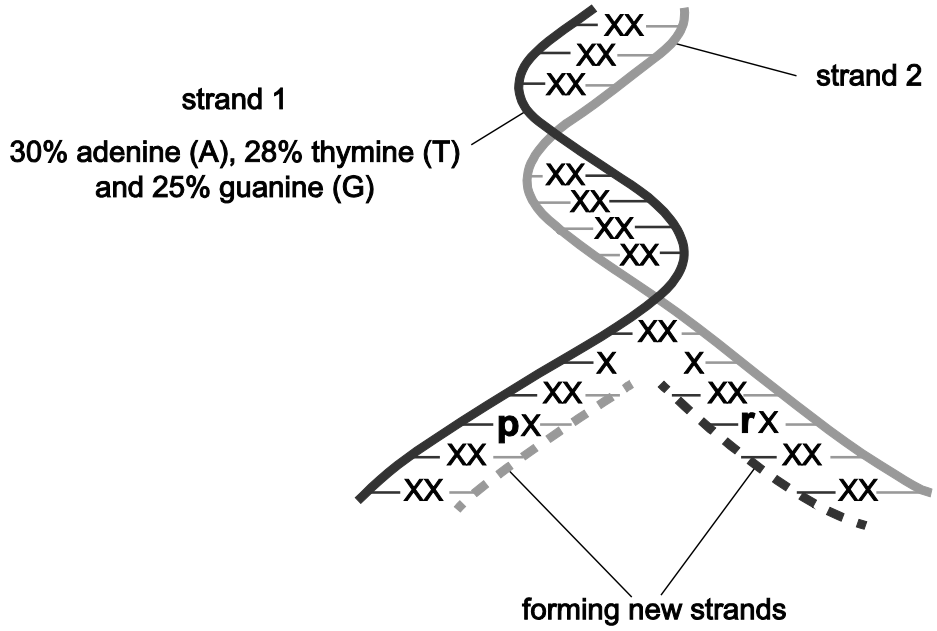
$r = \dfrac{d}{\sqrt{2}} = \dfrac{\sqrt{2}\,d}{2}$

So, the arc length (curve XY) $= \dfrac{90}{360} \times 2 \times \pi \times r = \dfrac{90}{360} \times 2 \times \pi \times \dfrac{\sqrt{2}\,d}{2} = \dfrac{\sqrt{2}\,\pi d}{4}$

Total perimeter of shaded area $= d + \dfrac{\sqrt{2}\,\pi d}{4} = \dfrac{4d}{4} + \dfrac{\sqrt{2}\,\pi d}{4} = \dfrac{d(4 + \sqrt{2}\,\pi)}{4}$

25 The diagram shows part of a DNA double helix being copied.

Key
X = unnamed bases
XX = unnamed base pairs



Which of the following statements, considered independently, is/are correct?

1 The probability of any base in strand 2 being guanine (G) is 0.17.

2 If **p** is guanine and **r** cytosine, a mutation must have taken place.

3 The copying process shown is taking place during mitosis.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The answer is option **E**.

The percentage of bases that are cytosine (C) on strand 1 is (100 – (30 + 25 + 28)) = 17%.

As guanine (G) is the complementary base to cytosine, the percentage of bases that are guanine in the complementary strand 2 will also be 17%, or a probability of 0.17. Statement 1 is therefore correct.

The diagram shows DNA being copied. As **r** is on the newly forming strand in the place of **p** they should both be the same base. As it is stated that **p** is guanine and **r** is cytosine, a mutation must have happened to cause **p** and **r** to be different bases. Statement 2 is therefore correct.

DNA copying takes place in interphase before mitosis begins. Statement 3 is therefore not correct.

26 Diammonium hydrogen phosphate, $(NH_4)_2HPO_4$, can be used as a fertiliser.

The following equation shows how it can be synthesised:

$$2NH_3(g) + H_3PO_4(aq) \rightarrow (NH_4)_2HPO_4(s)$$

What is the mass of diammonium hydrogen phosphate that is produced when 3.40 kg of ammonia is reacted with phosphoric acid (H_3PO_4), in excess, with a yield of 80%?

(M_r values: $NH_3 = 17.0$; $H_3PO_4 = 98.0$; $(NH_4)_2HPO_4 = 132$)

A 5.28 kg

B 10.6 kg

C 13.2 kg

D 15.8 kg

E 21.1 kg

F 26.4 kg

The answer is option **B**.

Mass of ammonia = 3.4 kg × 1000 = 3400 g

Number of moles of ammonia (M_r = 17) = $\frac{3400}{17}$ = 200 mol

From the equation, the reacting ratio of ammonia to diammonium hydrogen phosphate is 2 : 1.

Number of moles of $(NH_4)_2HPO_4$ (M_r = 132) = 100 mol

Mass of $(NH_4)_2HPO_4$ (M_r = 132) = 100 × 132 = 13 200 g

80% yield is therefore: 0.8 × 13 200 = 10 560 g = 10.6 kg (to 3 significant figures)

27 A bar magnet is rotating at a constant rate of 120 revolutions per minute inside a circular coil of wire, causing an induced voltage across the coil.

Which of the following statements is/are correct?

1 Increasing the number of turns of wire on the coil would increase both the maximum value and the frequency of the induced voltage.

2 The direction of the induced voltage in this coil reverses every 0.25 seconds.

3 There is always an induced current in a conductor which is experiencing a change in magnetic field.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The answer is option **C**.

Increasing the number of turns of wire increases the maximum value of the induced voltage, so the first part of the statement is correct. However, it does not change the rate at which the coil rotates and so the frequency of the induced voltage does not change. Statement 1 is not correct.

The magnet is rotating 120 times every minute, so takes $\frac{60}{120} = 0.50$ seconds to make one complete turn; the current reverses every half-turn. Statement 2 is correct.

There is always a voltage induced across a conductor that is experiencing a change in magnetic field, but there is only a current if the conductor is part of a complete circuit. Statement 3 is not correct.

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