UNIVERSITY OF CAMBRIDGE

**NATURAL SCIENCES
ADMISSIONS ASSESSMENT**

D568/12

2023

60 minutes

SECTION 2

INSTRUCTIONS TO CANDIDATES

Please read these instructions carefully, but do not open this question paper until you are told that you may do so. This paper is Section 2 of 2.

A separate answer sheet is provided for this paper. Please check you have one. You also require a soft pencil and an eraser.

Please complete the answer sheet with your candidate number, centre number, date of birth, and name.

This paper contains **three** parts: **X**, **Y** and **Z**.

All candidates should complete only **one** part chosen from:

Part X   Physics
Part Y   Chemistry
Part Z   Biology

Each part has 20 multiple-choice questions. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt **all** 20 questions in your chosen part. Each question is worth one mark.

For each question, choose the **one** option you consider correct and record your choice on the separate answer sheet. If you make a mistake, erase thoroughly and try again.

You **must** complete the answer sheet within the time limit.

You can use the question paper for rough working, but **no extra paper** is allowed. Only your responses on the answer sheet will be marked.

A Periodic Table is included.

Dictionaries and calculators are NOT permitted.

Please wait to be told you may begin before turning this page.

This question paper consists of 70 printed pages and 10 blank pages.

BLANK PAGE

Paper content

BLANK PAGE

Periodic Table

Legend:
symbol
atomic number

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 1																	**He** 2
Li 3	**Be** 4											**B** 5	**C** 6	**N** 7	**O** 8	**F** 9	**Ne** 10
Na 11	**Mg** 12											**Al** 13	**Si** 14	**P** 15	**S** 16	**Cl** 17	**Ar** 18
K 19	**Ca** 20	**Sc** 21	**Ti** 22	**V** 23	**Cr** 24	**Mn** 25	**Fe** 26	**Co** 27	**Ni** 28	**Cu** 29	**Zn** 30	**Ga** 31	**Ge** 32	**As** 33	**Se** 34	**Br** 35	**Kr** 36
Rb 37	**Sr** 38	**Y** 39	**Zr** 40	**Nb** 41	**Mo** 42	**Tc** 43	**Ru** 44	**Rh** 45	**Pd** 46	**Ag** 47	**Cd** 48	**In** 49	**Sn** 50	**Sb** 51	**Te** 52	**I** 53	**Xe** 54
Cs 55	**Ba** 56	*Lanthanoids* 57-71	**Hf** 72	**Ta** 73	**W** 74	**Re** 75	**Os** 76	**Ir** 77	**Pt** 78	**Au** 79	**Hg** 80	**Tl** 81	**Pb** 82	**Bi** 83	**Po** 84	**At** 85	**Rn** 86
Fr 87	**Ra** 88	*Actinoids* 89-103	**Rf** 104	**Db** 105	**Sg** 106	**Bh** 107	**Hs** 108	**Mt** 109	**Ds** 110	**Rg** 111	**Cn** 112	**Nh** 113	**Fl** 114	**Mc** 115	**Lv** 116	**Ts** 117	**Og** 118

Lanthanoids	**La** 57	**Ce** 58	**Pr** 59	**Nd** 60	**Pm** 61	**Sm** 62	**Eu** 63	**Gd** 64	**Tb** 65	**Dy** 66	**Ho** 67	**Er** 68	**Tm** 69	**Yb** 70	**Lu** 71
Actinoids	**Ac** 89	**Th** 90	**Pa** 91	**U** 92	**Np** 93	**Pu** 94	**Am** 95	**Cm** 96	**Bk** 97	**Cf** 98	**Es** 99	**Fm** 100	**Md** 101	**No** 102	**Lr** 103

BLANK PAGE

PART X Physics

1 A block of weight W slides down a rough plane at a constant speed.

The plane is at an angle of 30° to the horizontal.

The block is now pulled by a force of $3W$ acting parallel to and up the plane. The block has constant acceleration.

Which expression gives the acceleration of the block?

(gravitational field strength $= g$)

A $2g$

B $\dfrac{5}{2}g$

C $3g$

D $\left(3 - \sqrt{3}\right)g$

E $\left(3 - \dfrac{1}{\sqrt{3}}\right)g$

F $\left(3 - \dfrac{\sqrt{3}}{2}\right)g$

G $\left(3 - \dfrac{2}{\sqrt{3}}\right)g$

2 The speed v of an object moving in a straight line is related to time t by the equation

$$v = kt^2$$

where k is a constant.

At $t = 10\,\text{s}$ the speed of the object is $48\,\text{m}\,\text{s}^{-1}$ and the resultant force on the object is $24\,\text{N}$.

What is the mass of the object?

A $0.15\,\text{kg}$

B $0.40\,\text{kg}$

C $1.2\,\text{kg}$

D $2.5\,\text{kg}$

E $6.7\,\text{kg}$

3 Two waves P and Q, which superpose, are shown in the diagram in a particular region at time $t = 0$.
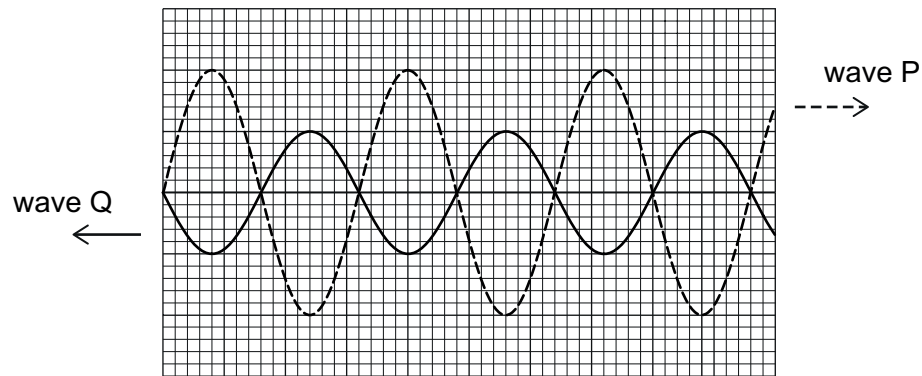
Both waves have period T and are moving in the directions shown by the arrows. Wave P has amplitude 2.0 cm and wave Q has amplitude 1.0 cm.

Which diagram represents the resultant wave formed in the same region by waves P and Q at time $t = \dfrac{T}{2}$?

A 3.0 cm

B 3.0 cm

C 3.0 cm

D 3.0 cm

E 3.0 cm

F 3.0 cm

G 3.0 cm
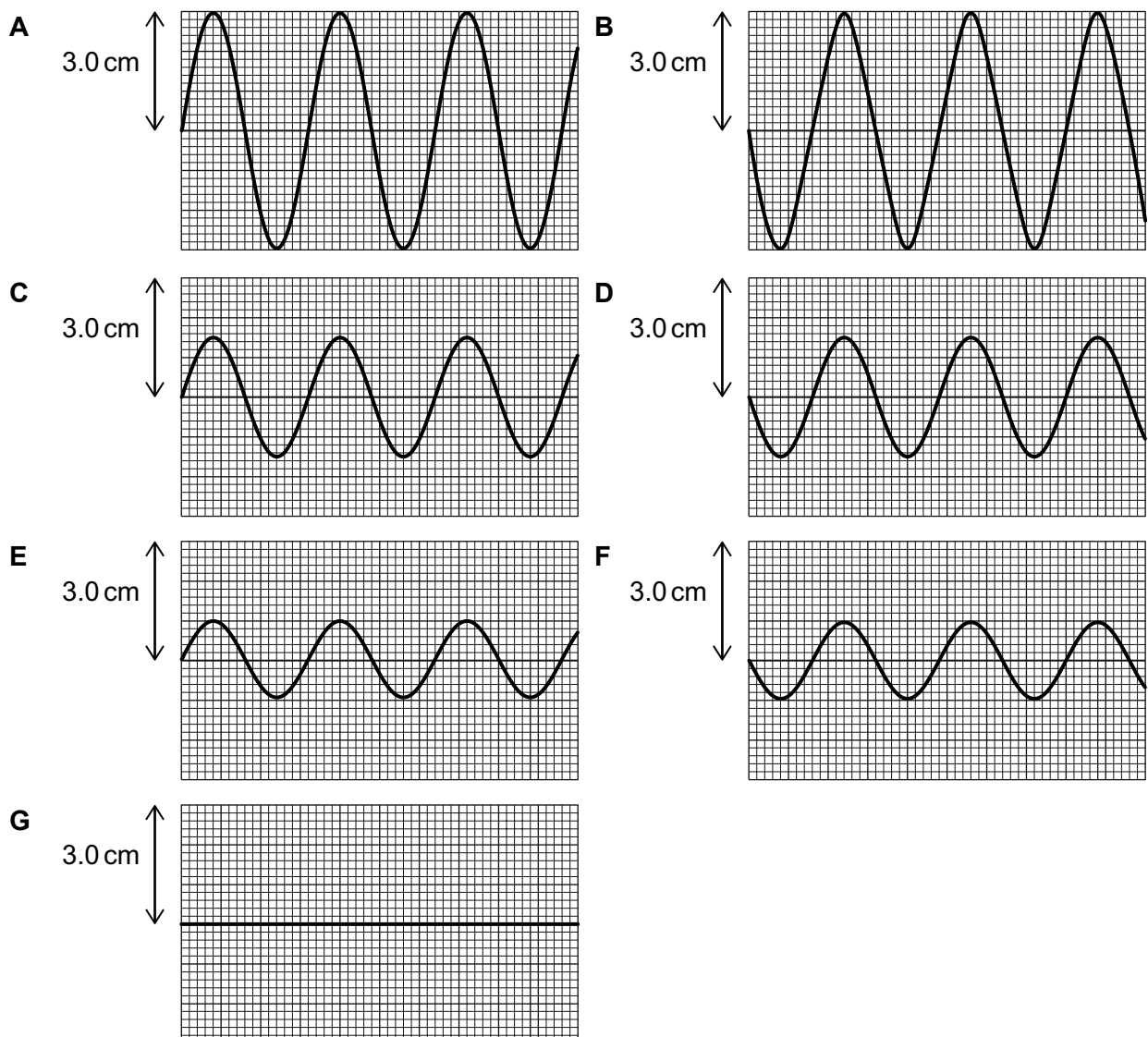
4   Four identical springs are arranged as shown and suspended from a support.
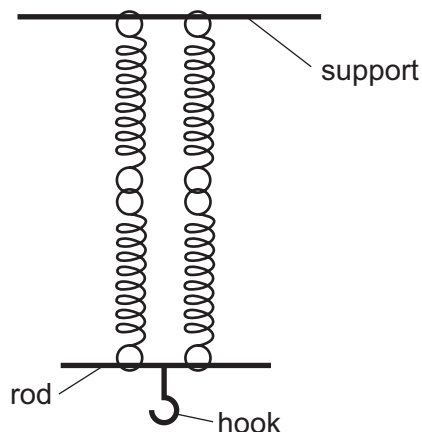
The mass of the springs, rod and hook are negligible.

A load of weight 8.4 N is attached to the hook at the lower end of the springs and this causes a total extension of the system of 24 mm.

The arrangement is then changed to:
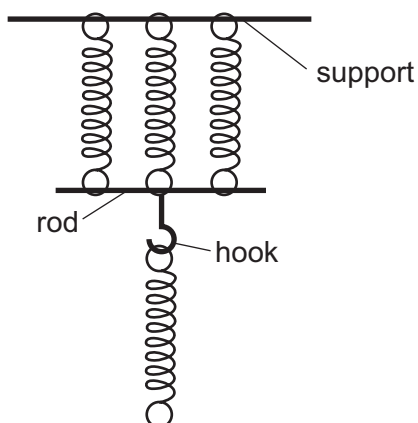
The load of 8.4 N is attached to the bottom of the lower spring.

What is the total extension of the system at equilibrium in the second arrangement?

(The springs obey Hooke's law.)

A   3 mm

B   12 mm

C   16 mm

D   24 mm

E   32 mm

F   48 mm

G   64 mm

5 A student and a child are standing on trolleys X and Y, respectively, which are close to each other but not touching. The trolleys are initially stationary on a straight, horizontal frictionless track. The student is initially holding a ball of mass 5.0 kg.

The total mass of the student, the ball and trolley X is 80 kg.

The total mass of the child and trolley Y is 20 kg.

The student on trolley X throws the ball to the child on trolley Y. The ball travels at a horizontal speed of 12 m s^{-1} relative to the ground. The child then catches the ball.

What is the speed of separation of the trolleys after the child has caught the ball?

(Assume that air resistance is negligible.)

A 1.6 m s^{-1}

B 2.4 m s^{-1}

C 3.2 m s^{-1}

D 3.8 m s^{-1}

E 24 m s^{-1}

6 The variation of the acceleration with time of an object moving in a straight line is shown on the graph.

At time $= 0\,$s the velocity of the object is $8.0\,\text{m s}^{-1}$.
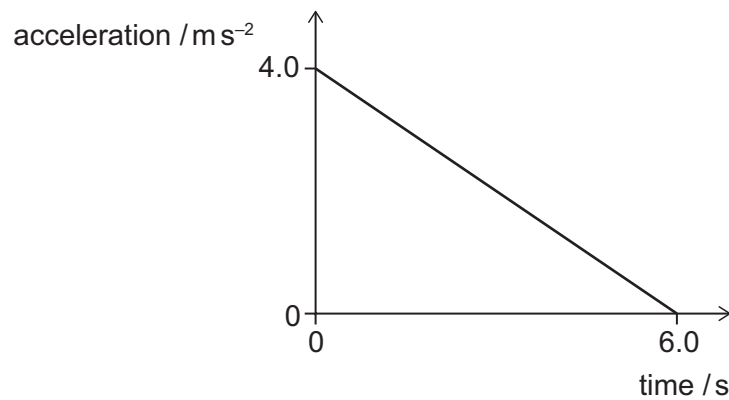
What is the maximum velocity of the object between time $= 0\,$s and time $= 6\,$s?

A $5.0\,\text{m s}^{-1}$

B $8.0\,\text{m s}^{-1}$

C $12\,\text{m s}^{-1}$

D $20\,\text{m s}^{-1}$

E $32\,\text{m s}^{-1}$

F $44\,\text{m s}^{-1}$

7 The diagram shows a circuit that includes a battery with an emf of 18 V and internal resistance r.
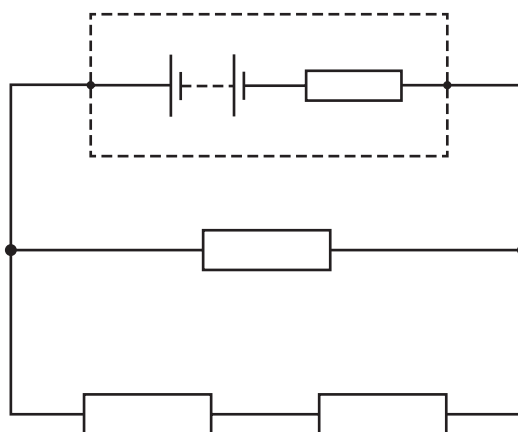
The three identical resistors in the external circuit each have resistance R.

The terminal potential difference across the battery is 16 V.

Which expression gives R in terms of r?

A $R = \dfrac{10r}{3}$

B $R = \dfrac{16r}{3}$

C $R = 6r$

D $R = 12r$

E $R = \dfrac{27r}{2}$

F $R = 24r$

G $R = \dfrac{51r}{2}$

8 Three identical bar magnets, each of mass m, and two identical trolleys, X and Y, also each of mass m, are arranged with the bar magnets fixed to the trolleys as shown. The trolleys are held at rest a short distance apart on a smooth horizontal track.

The trolleys are released at the same time. They move towards each other and collide.

Find the value of the ratio

$$\frac{\text{kinetic energy of X immediately before collision}}{\text{kinetic energy of Y immediately before collision}}$$

A $\dfrac{4}{9}$

B $\dfrac{1}{2}$

C $\dfrac{2}{3}$

D   1

E $\dfrac{3}{2}$

F   2

G $\dfrac{9}{4}$

9 A uniform rod XY of length 3.0 m has a weight of 20 N. The rod is supported by two light wires, P and Q, as shown. P and Q are attached 0.50 m from ends X and Y, respectively.
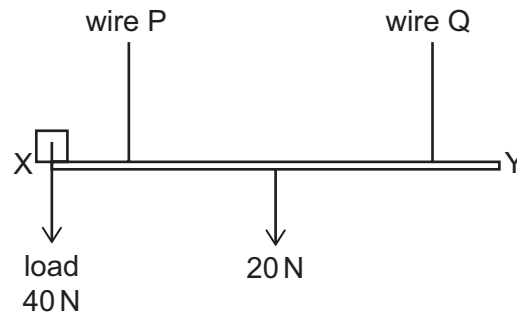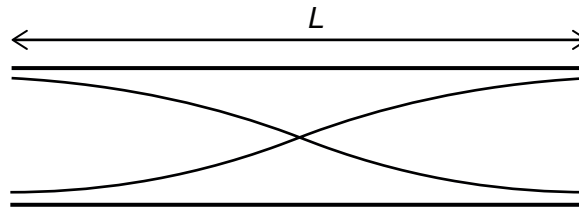

A 40 N load is moved from end X to end Y. The rod remains horizontal at all times.

Which graph shows the variation of the tension T in wire P with the position of the load as it is moved along the rod?
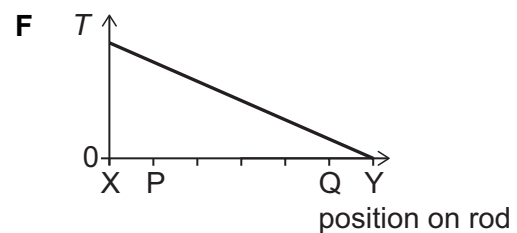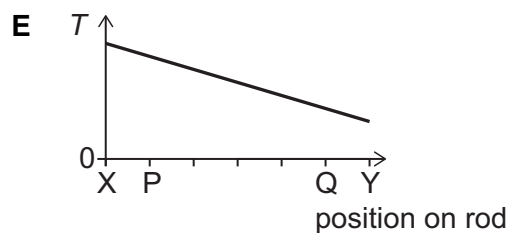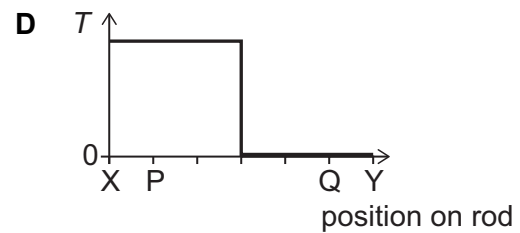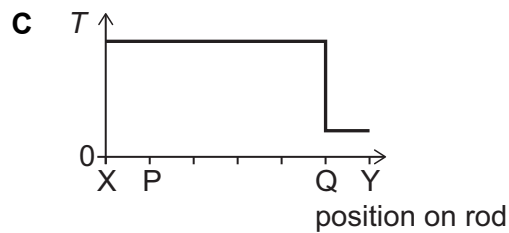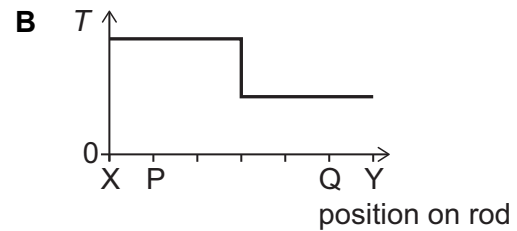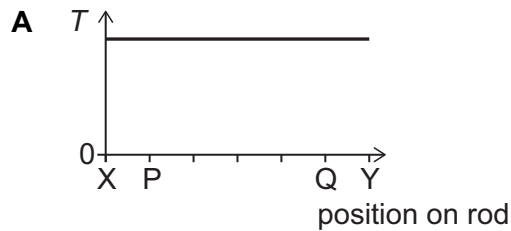
10 A pipe of length *L* open at both ends contains a stationary sound wave with 1 node, as shown in the diagram.

The frequency of the stationary wave in this pipe is 4*f*.

A second pipe is open at one end and closed at the other end. A stationary sound wave in this pipe contains one more node than the stationary wave shown in the diagram.

The frequency of the stationary wave in the second pipe is *f*.
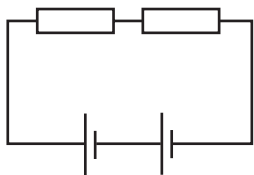
The speed of sound is the same in both pipes.
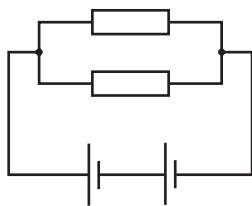
What is the length of the second pipe?

A 4*L*

B 6*L*

C 8*L*

D 10*L*

E 12*L*

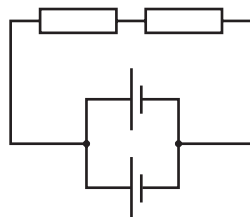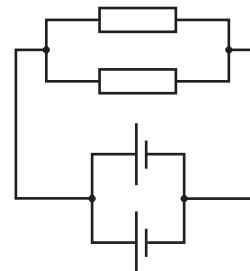**11** The resistors in the following four circuits are identical.

The cells are identical and have no internal resistance. Each cell can supply the same total amount of energy at a constant voltage before becoming exhausted.

t_1, t_2, t_3 and t_4 are the lengths of time after which the cells in circuits **1**, **2**, **3** and **4**, respectively, become exhausted.

Which comparison of t_1, t_2, t_3 and t_4 is correct?

A $t_1 = t_2 < t_3 = t_4$

B $t_1 = t_3 < t_2 = t_4$

C $t_2 < t_1 = t_4 < t_3$

D $t_2 = t_4 < t_1 = t_3$

E $t_3 < t_1 = t_4 < t_2$

F $t_3 = t_4 < t_1 = t_2$

12 A particle of mass m is accelerated from rest by a resultant force of varying magnitude that acts in a constant direction. The kinetic energy E of the particle increases with time t according to the equation

$$E = kt$$

where k is a constant.

Which expression gives the resultant force on the particle at time T?

A k

B $2mk$

C $\sqrt{2mkT}$

D $\sqrt{\dfrac{mk}{2T}}$

E $\sqrt{\dfrac{mk}{8T}}$

F $\sqrt{\dfrac{2mk}{T}}$

G $\sqrt{\dfrac{k}{2mT}}$

13 A light horizontal wire of cross-sectional area *A* is fixed at two points a distance 2*L* apart. The initial tension in the wire is zero.

An object of weight *W* is fixed directly to the centre of the wire. The wire stretches so that the object rests in equilibrium at a vertical distance of $\dfrac{3L}{4}$ below the original position of the wire.

What is the Young modulus of the wire?

(Assume that the wire does not exceed its limit of proportionality.)

A $\dfrac{2W}{A}$

B $\dfrac{4W}{A}$

C $\dfrac{5W}{2A}$

D $\dfrac{2W}{3A}$

E $\dfrac{10W}{3A}$

F $\dfrac{20W}{3A}$

G $\dfrac{5W}{6A}$

14 A triangular ramp with angles to the horizontal of 60° and 30° is placed with its largest face horizontal. A block of mass 1.5 kg and a block of mass m are joined by a light, inextensible string and placed on the ramp as shown.
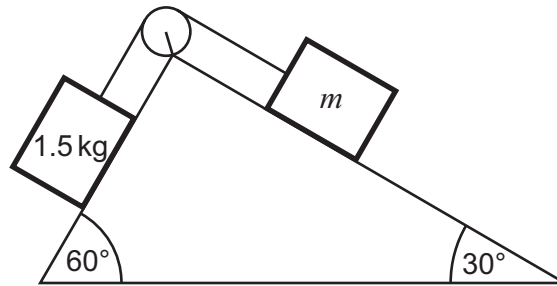
The string passes over a light, frictionless pulley.

The maximum force of friction between the block of mass 1.5 kg and the surface of the ramp is 3.5 N.

The maximum force of friction between the block of mass m and the surface of the ramp is 5.0 N.

What is the maximum value of m that allows the blocks to remain stationary on the surfaces?

(gravitational field strength $= 10\,\text{N}\,\text{kg}^{-1}$)

A   1.5 kg

B   1.65 kg

C   2.35 kg

D $\left(\dfrac{16\sqrt{3}}{15}\right)\text{kg}$

E $(0.60\sqrt{3})\,\text{kg}$

F $(0.30 + 1.5\sqrt{3})\,\text{kg}$

G $(1.7 + 1.5\sqrt{3})\,\text{kg}$

15 A sound wave travels through medium J, reaches a boundary, and then travels through medium K as shown. The thickness of each medium is *L*.

[diagram not to scale]
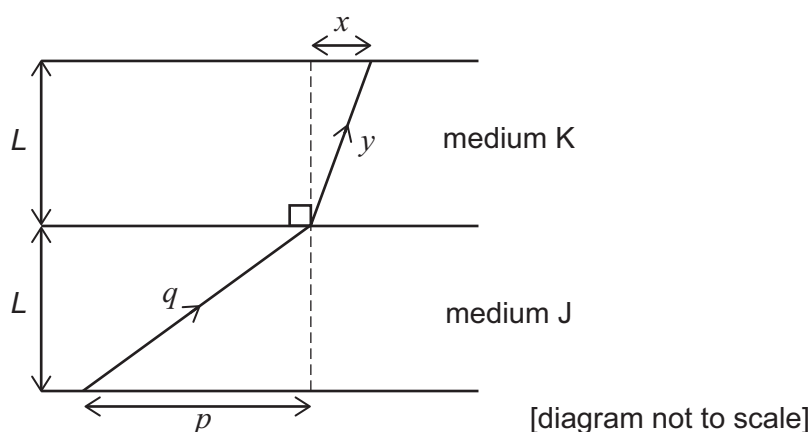
The wave travels a distance q in medium J and a distance y in medium K.

The horizontal distance travelled in medium J is p. The horizontal distance travelled in medium K is x.

The wave travels at speed v in medium J. The graph shows how the speed of the wave varies with time t as it travels distances q and y, and that the wave leaves medium K at $t = 2.75$ ms.
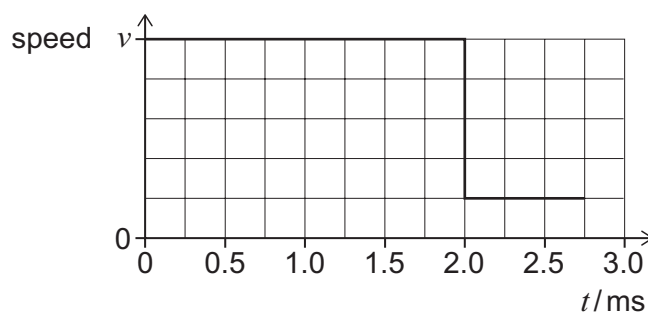
What is the value of $\dfrac{x}{p}$?

A $\dfrac{3}{200}$

B $\dfrac{3}{40}$

C $\dfrac{8}{75}$

D $\dfrac{3}{8}$

E $\dfrac{8}{15}$

F $\dfrac{8}{3}$

G $\dfrac{200}{3}$

16 The drag force F acting on a sphere of radius r falling at constant speed v though air is given by

$$F = krv$$

where k is a constant.

For a sphere of uniform density and mass m falling at a constant speed, the drag force heats the surrounding air at a constant rate P.

Another sphere of the same material but with mass $8m$ falls through the air at a different constant speed.

What is the rate at which the drag force on the heavier sphere heats the surrounding air?

A $2P$

B $4P$

C $8P$

D $16P$

E $32P$

F $64P$

17 A projectile is launched from an inclined plane.

The graphs show the variation of the horizontal and vertical components of the velocity of the projectile with time from when it is launched until it hits the plane at time *T*.
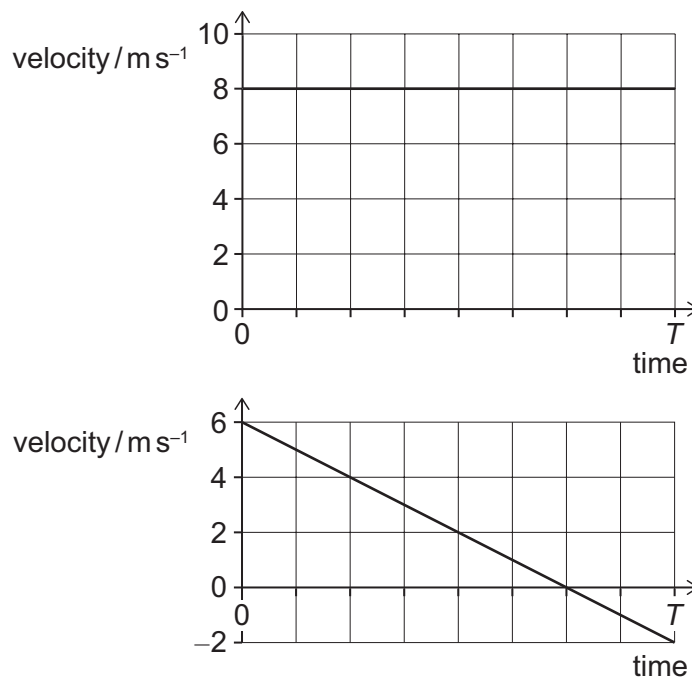

What is the angle of the plane to the horizontal?

(gravitational field strength $= 10\,\text{N}\,\text{kg}^{-1}$)

A $\tan^{-1}\dfrac{1}{32}$

B $\tan^{-1}\dfrac{1}{8}$

C $\tan^{-1}\dfrac{1}{4}$

D $\tan^{-1}\dfrac{5}{16}$

E $\tan^{-1}\dfrac{1}{3}$

F $\tan^{-1}\dfrac{4}{3}$

18 A tennis ball of mass 0.060 kg travels horizontally and strikes a vertical wall at $30\,\text{m}\,\text{s}^{-1}$. It leaves the wall in the opposite direction at $20\,\text{m}\,\text{s}^{-1}$.

The graph shows how the resultant horizontal force acting on the ball varies with time during this collision.
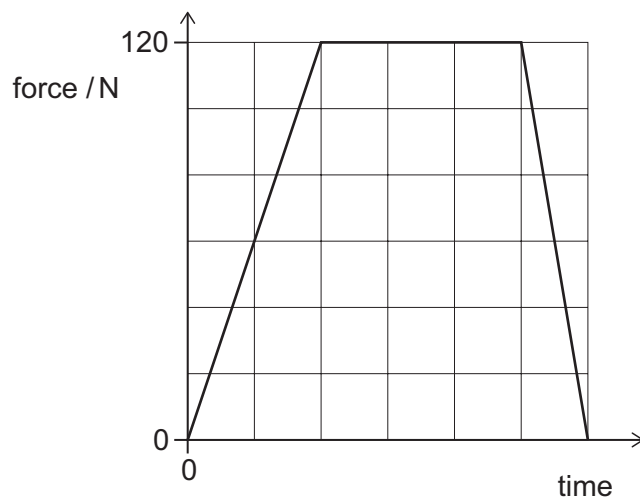
What is the duration of the collision?

A $\dfrac{1}{200}\,\text{s}$

B $\dfrac{1}{150}\,\text{s}$

C $\dfrac{1}{100}\,\text{s}$

D $\dfrac{1}{40}\,\text{s}$

E $\dfrac{1}{30}\,\text{s}$

F $\dfrac{1}{20}\,\text{s}$

19 A battery with an emf of 8.0 V and internal resistance R and another battery with an emf of 4.0 V and internal resistance 2.0 Ω are connected to a cell with an emf of 2.0 V and internal resistance 4.0 Ω in the circuit shown.

The current in the 2.0 V cell is 0.50 A in the direction shown in the diagram.
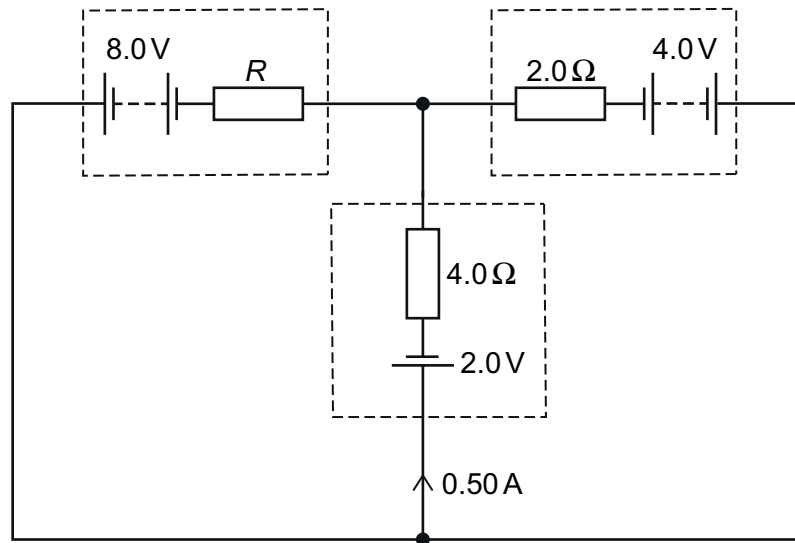
What is the resistance R?

A 1.6 Ω

B 2.7 Ω

C 3.2 Ω

D 8.0 Ω

E 16 Ω

20 A model for how the resistivity ρ of damp soil varies with depth x from the surface is given by

$$\rho = \rho_0\left(1 - \frac{kx^2}{h^2}\right)$$

where h is the maximum depth, and k and ρ_0 are other constants.

What is the resistance of a vertical column of damp soil of cross-sectional area A and depth h?

A $\dfrac{\rho_0 h}{A}$

B $\dfrac{\rho_0 h}{A}(1 - k)$

C $\dfrac{\rho_0 h}{2A}(2 - k)$

D $\dfrac{\rho_0 h}{A}(1 - 3k)$

E $\dfrac{\rho_0 h}{A}\left(1 - \dfrac{k}{3}\right)$

F $\dfrac{\rho_0}{A}\left(1 - \dfrac{kh}{3}\right)$

G $\dfrac{\rho_0 h^2}{A}\left(\dfrac{1}{2} - \dfrac{k}{4}\right)$

BLANK PAGE

PART Y Chemistry

21 The following organic reactions are carried out:

    1 1-Chloropropane is warmed with aqueous sodium hydroxide.

    2 Propan-1-ol is heated under reflux with excess acidified potassium dichromate(VI).

    3 Propan-2-ol is heated under reflux with excess acidified potassium dichromate(VI).

    4 Propene is heated with hydrogen gas over a nickel catalyst.

What is the order of boiling points of the major organic product from each of these reactions, from lowest to highest boiling point?

	lowest → highest *boiling point*
A	1, 2, 3, 4
B	1, 4, 3, 2
C	2, 1, 3, 4
D	2, 3, 4, 1
E	3, 4, 2, 1
F	3, 1, 2, 4
G	4, 3, 1, 2
H	4, 3, 2, 1

22 The equations for the complete combustion of ethanol (Reaction 1) and the complete combustion of propan-1-ol (Reaction 2) are:

Reaction 1: $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Reaction 2: $C_3H_7OH + 4.5O_2 \rightarrow 3CO_2 + 4H_2O$
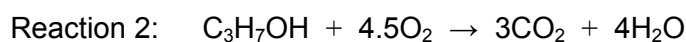
The standard energy change for Reaction 2 is $650\,kJ\,mol^{-1}$ more exothermic than the standard energy change for Reaction 1.
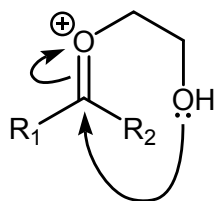
Assume the following bond energy data:

bond	bond energy / $kJ\,mol^{-1}$
C–C	350
C–H	400
O–H	450
O=O	500

Using this data, what is the value of the bond energy for the C=O bond?

A $175\,kJ\,mol^{-1}$

B $425\,kJ\,mol^{-1}$

C $450\,kJ\,mol^{-1}$

D $650\,kJ\,mol^{-1}$

E $825\,kJ\,mol^{-1}$

F $900\,kJ\,mol^{-1}$

G $1050\,kJ\,mol^{-1}$
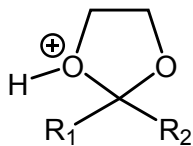
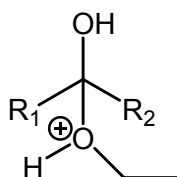**H** $1650\,kJ\,mol^{-1}$

23   Part of an organic reaction mechanism is shown:
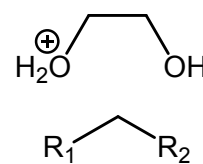

What is produced by this part of the mechanism?
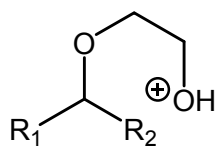
A

B

C

D
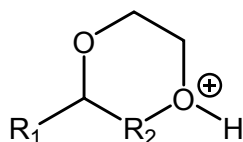
E
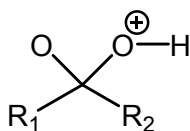
F
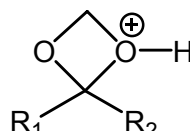
G
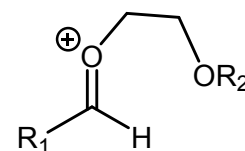
H

24 Ibuprofen is a common pain relief and anti-inflammatory drug. It is often sold in tablet form, each tablet containing 200 mg of the drug.

Ibuprofen can be synthesised from isobutylbenzene in a 3-stage process with the percentage yields for each step shown on the arrows:
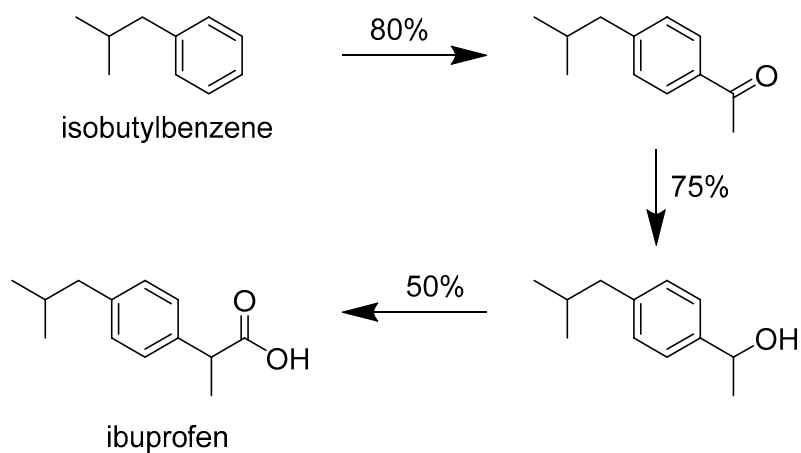
6.7 g of isobutylbenzene is converted to ibuprofen to trial this process.

What is the maximum number of 200 mg ibuprofen tablets that can be manufactured?

(A_r values: H = 1; C = 12; O = 16)

A 10

B 15

C 20

D 33

E 40

F 50

25 The enthalpy change for neutralisation of one mole of sulfuric acid was determined experimentally.

Solutions of sodium hydroxide ($2.00\,\text{mol}\,\text{dm}^{-3}$) and sulfuric acid ($4.00\,\text{mol}\,\text{dm}^{-3}$) were used in the experiment. The initial temperature of both solutions was $20.0\,°\text{C}$.

$40.0\,\text{cm}^3$ of the sodium hydroxide solution was placed into a well-insulated container. The sulfuric acid was added to the alkali until the solution was neutral. The maximum temperature reached was $40.0\,°\text{C}$.

Assume that the specific heat capacity of all aqueous solutions is $x\,\text{J}\,\text{g}^{-1}\,°\text{C}^{-1}$, and that the density of all solutions is $1.0\,\text{g}\,\text{cm}^{-3}$.

What is the value for the enthalpy change, in $\text{kJ}\,\text{mol}^{-1}$, for neutralisation of one mole of sulfuric acid?

(Assume that all heat is transferred to the solution and no heat is lost to the surroundings.)

A $-5.0x\,\text{kJ}\,\text{mol}^{-1}$

B $-10.0x\,\text{kJ}\,\text{mol}^{-1}$

C $-12.5x\,\text{kJ}\,\text{mol}^{-1}$

D $-15.0x\,\text{kJ}\,\text{mol}^{-1}$

E $-20.0x\,\text{kJ}\,\text{mol}^{-1}$

F $-25.0x\,\text{kJ}\,\text{mol}^{-1}$

G $-50.0x\,\text{kJ}\,\text{mol}^{-1}$

H $-100x\,\text{kJ}\,\text{mol}^{-1}$

26 An object is electroplated with a thin layer of chromium with a mass of 0.26 g, using a solution made up of CrO_3 dissolved in acid.

Assume that 1 mole of electrons carries a charge of **96 000** coulombs.

How long does it take, in minutes, to electroplate the object using a 12 A current?

(1 ampere (A) is a current of 1 coulomb per second. A_r value: Cr = 52)

A $\dfrac{2}{3}$ minutes

B 2 minutes

C 4 minutes

D $6\dfrac{2}{3}$ minutes

E 20 minutes

F 40 minutes

G 120 minutes

H 240 minutes

27 Water is classified as hard or soft depending on the concentration of calcium ions from dissolved salts. Water with a calcium ion concentration of less than $0.60 \, \text{mmol dm}^{-3}$ is soft.

Hard water, which has a calcium ion concentration greater than $0.60 \, \text{mmol dm}^{-3}$, can be softened by the addition of washing soda, sodium carbonate decahydrate ($Na_2CO_3 \cdot 10H_2O$), to precipitate calcium carbonate.

A $10 \, \text{dm}^3$ sample of water contains a total of $15 \, \text{mmol}$ calcium ions from dissolved salts.

What is the minimum mass of washing soda required to change the classification of this sample from hard to soft?

(A_r values: H = 1; C = 12; O = 16; Na = 23; Ca = 40. Assume that the only metal ions present in solution are calcium ions and there is no change of volume on the addition of the washing soda.)

A 0.26 g

B 0.41 g

C 0.95 g

D 1.1 g

E 2.6 g

F 4.1 g

28 Triiodomethane is a pale-yellow solid with the formula CHI_3. It is formed when some organic compounds react with alkaline aqueous iodine.

When an alcohol reacts, the series of steps that take place during the reaction to produce the triiodomethane are:
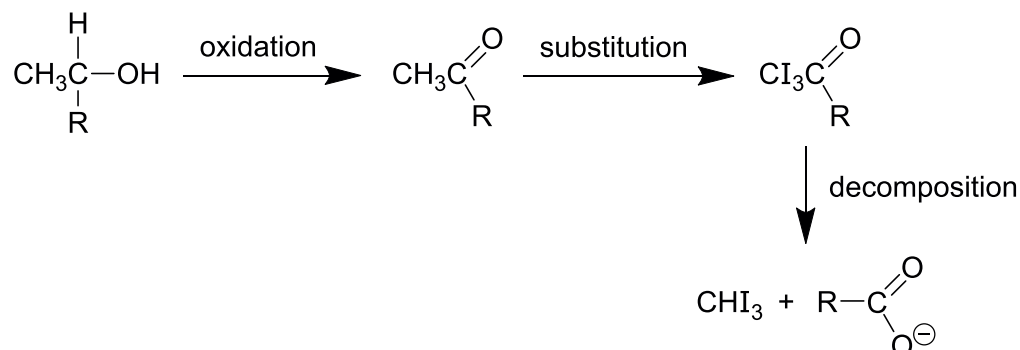
A compound with the following structural formula is completely reacted with excess alkaline aqueous iodine and the reaction mixture is then acidified with an excess of a dilute acid.
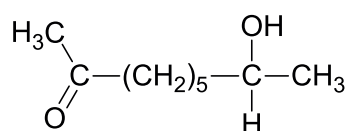
What is the final organic compound that is produced along with the triiodomethane?

A

B

C

D

E

F
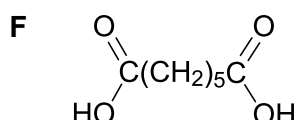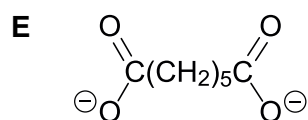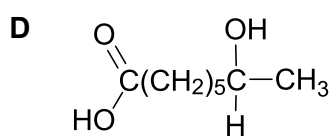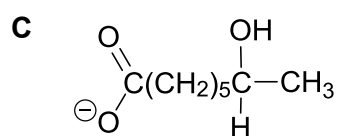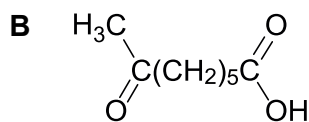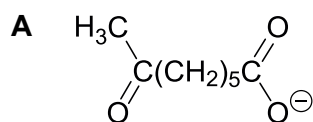
29 Ethanethiol, CH_3CH_2SH, is a foul-smelling gas that is added to natural gas to enable humans to detect gas leaks, which would otherwise not be noticed.
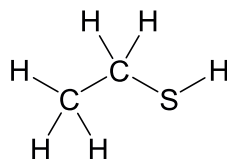
The minimum concentration of ethanethiol that a person can detect is 1.8×10^{-7} mg per cm^3 of air.

A gas leak happens in an empty room that has dimensions $20\,m \times 20\,m \times 3\,m$. Assume that the ethanethiol is spread evenly throughout the room.

If a person detected the gas leak, what is the minimum number of molecules of ethanethiol in the room to 1 significant figure?

(A_r values: H = 1; C = 12; S = 32. Avogadro's number = 6×10^{23})

A 2×10^{18}

B 2×10^{19}

C 2×10^{20}

D 2×10^{21}

E 2×10^{22}

F 2×10^{23}

G 2×10^{24}

H 2×10^{25}

30 Compounds P and T are isomeric hydrocarbons containing six carbon atoms. Compound T decolourises bromine water in a 1 : 1 molar ratio, whereas compound P does not react at all.

Compounds P and T both undergo free radical substitution reactions with chlorine in the presence of ultraviolet light to produce a number of mono-chlorinated products. One of these products is compound Q, formed from hydrocarbon P, and another is compound V, formed from hydrocarbon T.

- Q undergoes a substitution reaction with aqueous sodium hydroxide to form compound R. Compound R is oxidised with acidified potassium dichromate to form compound S which does not react with either Tollens' reagent or sodium carbonate solution.

- V undergoes a substitution reaction with aqueous sodium hydroxide to form compound W. Compound W is oxidised with acidified potassium dichromate to form compound X which causes bubbling when added to sodium carbonate solution.

Compound R reacts with compound X, in the presence of an acid catalyst, to form compound Y.

What is the relative molar mass (M_r) of compound Y?

(A_r values: H = 1; C = 12; O = 16)

A 180

B 184

C 196

D 200

E 210

F 214

31 Calcium and element X are two elements from Group 2 of the Periodic Table. Element X is one place above or one place below calcium in the group.

Some information about these two elements is:

element	solubility of the element's anhydrous sulfate / mol per 100 g of water
calcium	1.51×10^{-3}
X	7.11×10^{-5}

1.0 mol of XCO_3 is completely thermally decomposed. The solid residue is then completely reacted with dilute nitric acid, and the salt produced when in its anhydrous form has a mass of y.

Which row in the following table is correct?

(A_r values: N = 14; O = 16; Mg = 24; Ca = 40; Sr = 88)

	thermal stability of XCO_3	value of y
A	more thermally stable than $CaCO_3$	$y < 150\,g$
B	less thermally stable than $CaCO_3$	$y < 150\,g$
C	more thermally stable than $CaCO_3$	$y = 150\,g$
D	less thermally stable than $CaCO_3$	$y = 150\,g$
E	more thermally stable than $CaCO_3$	$y > 150\,g$
F	less thermally stable than $CaCO_3$	$y > 150\,g$

32 0.125 mol of a hydrocarbon undergoes complete combustion to form 22 g of carbon dioxide and 9 g of water.

What is the total number of isomers that can be represented by the molecular formula of this hydrocarbon?

(A_r values: H = 1; C = 12; O = 16)

A 2

B 4

C 5

D 6

E 7

F 8

G 13

33 Unsaturation of fatty acids and lipids is measured by the iodine number.

The iodine number is the mass, in g, of iodine required to saturate all the C=C bonds in 100 g of the substance.

The structures of lipid P and fatty acid Q are shown:

lipid P ($M_r = 1000$)	
fatty acid Q ($M_r = 278$)	
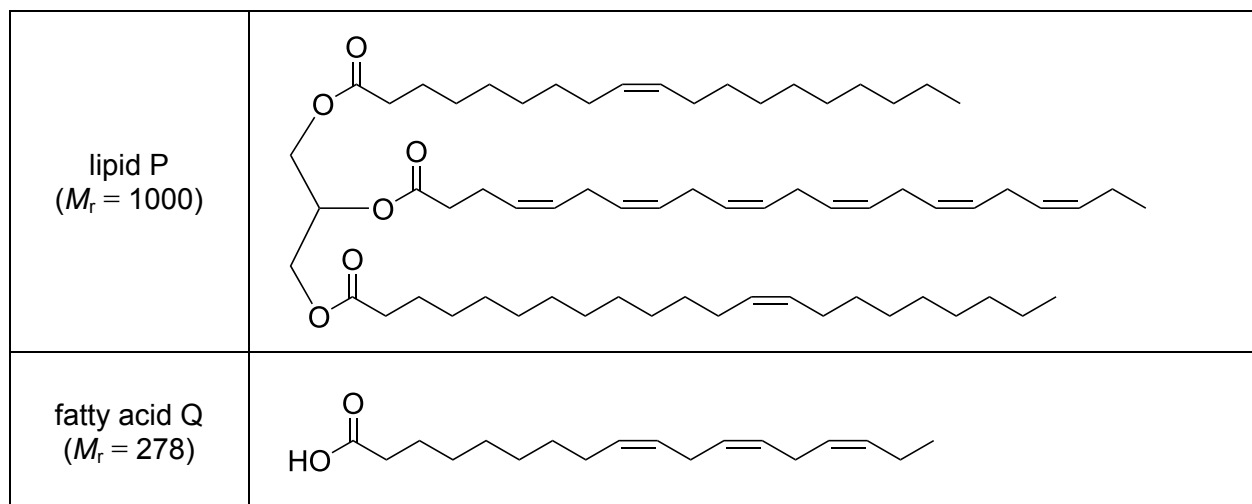
Which of the following statements is/are correct?

1 One molecule of lipid P contains 112 hydrogen atoms.

2 The iodine number of lipid P is 203.2.

3 The iodine number of lipid P is greater than the iodine number of fatty acid Q.

(A_r value: I = 127)

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

34 A sample of copper(II) oxide is added to an excess of dilute sulfuric acid and warmed until no solid remains.

The solution is then electrolysed using inert electrodes.

During the first t_1 minutes, no bubbling is observed at the cathode, but the mass of the cathode increases by 0.635 g.

During the next t_2 minutes, bubbling is observed at the cathode. The volume of gas produced at the cathode is 120 cm^3.

Bubbling is observed at the anode throughout the electrolysis. The gas is collected and measured.

Which row identifies the gas produced at the **cathode**, and the total volume of gas produced at the **anode**, measured at room temperature and pressure?

(A_r value: Cu = 63.5. Assume that the volume of one mole of a gas is 24 dm^3 at room temperature and pressure.)

	gas formed at the cathode	total volume of gas produced at the **anode** / cm^3
A	hydrogen	360
B	hydrogen	300
C	hydrogen	240
D	hydrogen	180
E	oxygen	360
F	oxygen	300
G	oxygen	240
H	oxygen	180

35 Concentrated sulfuric acid reacts with sodium iodide in three possible redox reactions, all of which produce iodine.

In these reactions, sulfuric acid is reduced to either $SO_2(g)$, or $S(s)$ or $H_2S(g)$.

In an experiment, 0.3 g of sodium iodide reacts with excess concentrated sulfuric acid.

If exactly 0.1 g of this sodium iodide reacts in each of the three redox reactions, what is the total volume of sulfur-containing gases that are formed?

(A_r values: Na = 23; I = 127. Assume that one mole of a gas occupies 24 dm³ at room temperature and pressure, and that none of the gases dissolve in the reaction mixture.)

A 10.0 cm³

B 12.7 cm³

C 16.0 cm³

D 20.0 cm³

E 24.0 cm³

F 25.3 cm³

G 32.0 cm³

H 48.0 cm³

36 The relative atomic mass of bromine is 80.0. Bromine has only two stable isotopes containing 44 and 46 neutrons.

The relative atomic mass of chlorine is 35.5. Chlorine has only two stable isotopes containing 18 and 20 neutrons.

Bromine and chlorine can form a compound $BrCl_3$. A sample of $BrCl_3$ was studied by mass spectrometry.

Which row in the table gives correct information about the low-resolution mass spectrum of $BrCl_3$?

(atomic numbers: Cl = 17; Br = 35)

	number of isotopic molecular ion peaks	mass-to-charge ratio of the *most intense* peak(s)
A	5	184
B	8	184
C	4	both 184 and 186
D	5	both 184 and 186
E	5	186
F	4	186.5
G	8	186.5
H	8	192

37 $36\,dm^3$ of oxygen gas reacts completely with excess water and arsenic to form an acid only. This acid contains a single arsenic in oxidation state $+3$.
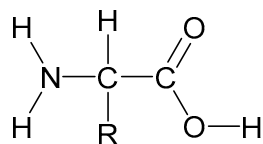
What mass of arsenic would be required?

(A_r values: As = 74.9; H = 1.0; O = 16. Assume that one mole of gas at room temperature and pressure occupies $24\,dm^3$.)

A 74.9 g

B 84.3 g

C 112.4 g

D 149.8 g

E 224.7 g

F 449.4 g

47

BLANK PAGE

38   The general structure of an amino acid is:

The R group determines the identity of the amino acid.

The equation for the reaction between three amino acids to make a tripeptide is shown.
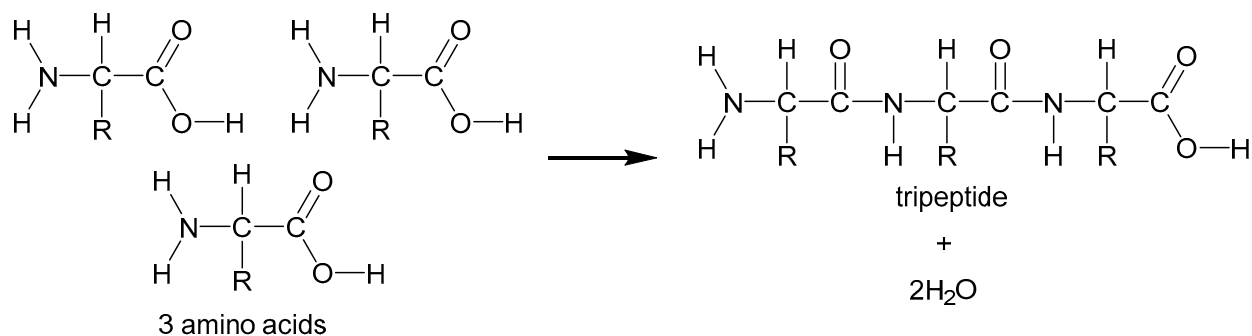
The three amino acids may be the same or different.

A tripeptide is broken down into its three component amino acids and analysed using chromatography.

The chromatogram is shown. Only two spots are present.
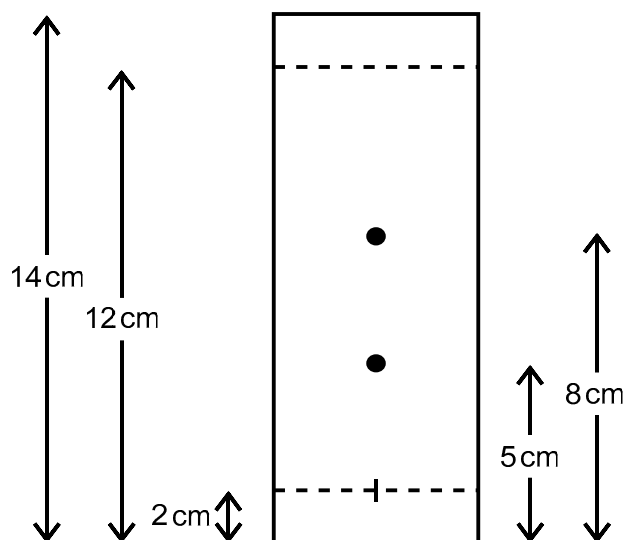
The R_f values in this solvent and the M_r values for some amino acids, including all those that make up the tripeptide, are given in the table.

R group on the amino acid	R_f	M_r of amino acid
-CH$_3$	0.30	89
-CH(CH$_3$)$_2$	0.42	117
-CH$_2$COOH	0.60	133
-CH$_2$CH$_2$COOH	0.67	147

The constituent amino acids from 0.0100 mol of tripeptide are reacted separately with aqueous sodium hydroxide.

In total, 40.0 cm^3 of 1.00 mol dm^{-3} of aqueous sodium hydroxide is required to exactly neutralise the acid groups on the amino acids.

Which row identifies M_r of the tripeptide and the number of different tripeptides (as structural isomers) with this M_r that can be made from the amino acids present?

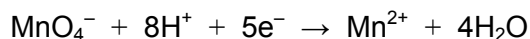(A_r values: H = 1; C = 12; N = 14; O = 16)

	M_r of tripeptide	number of different tripeptides possible
A	275	3
B	311	3
C	319	3
D	345	3
E	275	6
F	311	6
G	319	6
H	345	6

39 An organic compound X shows the following characteristics:

- X contains only carbon, hydrogen and oxygen. It has only one functional group.

- 0.148 g of X reacts with a small excess of sodium, producing 24.0 cm^3 of hydrogen, measured at room temperature and pressure.

- 0.148 g of X is oxidised completely by 16.0 cm^3 of acidified 0.100 mol dm^{-3} potassium manganate(VII) solution.

The half-equation for the reduction of manganate(VII) ions is:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Which statement about X is correct?

(A_r values: H = 1; C = 12; O = 16. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A   X must be propanoic acid

B   X must be methylpropan-1-ol

C   X must be methylpropan-2-ol

D   X must be butan-1-ol

E   X must be butan-2-ol

F   X could be either butan-1-ol or butan-2-ol

G   X could be either butan-1-ol or methylpropan-1-ol

H   X could be either butan-2-ol or methylpropan-2-ol

40   Lawn sand is used to remove moss and enhance the green colour of grass.

Lawn sand is a mixture of three compounds:

- silicon dioxide.

- an ionic salt, X. One mole of this salt contains 7 moles of water of crystallisation.

- a second ionic salt that provides the grass with nitrogen and is not hydrated.

Both salts contain one cation and one anion and are soluble in water. The anion in both salts is the same.

Excess water is stirred with 10.00 g of lawn sand, and the mixture then filtered. 8.12 g of dry silicon dioxide is obtained.

Excess acidified aqueous barium chloride is added to all of the filtrate. A white precipitate is formed. This mixture is filtered and all of this second filtrate is used in the next step.

Excess sodium hydroxide is now added to the filtrate. A green precipitate is formed.

When this mixture is heated, 480 cm^3 of ammonia, measured at room temperature and pressure, is produced.

Which of the following is an expression for the number of moles of X present in 10.00 g of lawn sand?

A_r values: H = 1; C = 12; N = 14; O = 16; Si = 28;
S = 32; Cl = 35.5; Br = 80; I = 127;
Mg = 24; Ca = 40; Fe = 56; Cu = 63.5; Ba = 137

(Assume that one mole of a gas occupies 24.0 dm^3 at room temperature and pressure.)

A $\dfrac{0.28}{76}$ mol

B $\dfrac{0.28}{139}$ mol

C $\dfrac{0.28}{167}$ mol

D $\dfrac{0.28}{200}$ mol

E $\dfrac{0.28}{244}$ mol

F $\dfrac{0.28}{263}$ mol

G $\dfrac{0.28}{278}$ mol

H $\dfrac{0.28}{306}$ mol

BLANK PAGE

PART Z Biology

41 Images of ribosomes from the cells of two different organisms were made using a transmission electron microscope (TEM) and a scanning electron microscope (SEM).

The image of the ribosome V using the TEM was 20 mm diameter at a magnification of $\times 1\,000\,000$.

The image of the ribosome W using the SEM was 15 mm diameter at a magnification of $\times 500\,000$.

Which row about the ribosomes and the microscopes used to obtain images of them is correct?

	actual diameter of ribosome	source of ribosome	microscope that can resolve more detail	one function of ribosomes in this cell
A	V = 30 nm	eukaryotic cell	SEM	to make proteins for the nuclear envelope
B	V = 30 µm	eukaryotic cell	SEM	to make components of flagellum
C	V = 20 nm	prokaryotic cell	TEM	to make proteins for the nuclear envelope
D	V = 20 nm	prokaryotic cell	TEM	to make components of flagellum
E	W = 30 µm	eukaryotic cell	TEM	to make components of flagellum
F	W = 30 nm	eukaryotic cell	SEM	to make proteins for the nuclear envelope
G	W = 30 µm	prokaryotic cell	TEM	to make components of flagellum
H	W = 20 nm	prokaryotic cell	SEM	to make proteins for the nuclear envelope

42 The following two molecules join to form a disaccharide.
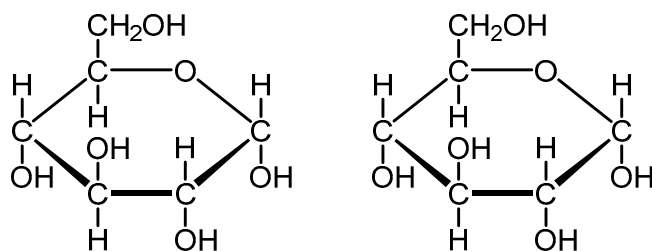
Which row is correct?

|	reaction type when molecules join	disaccharide formed	number of hydroxyl groups in disaccharide formed
A	condensation	maltose	8
B	condensation	sucrose	8
C	condensation	maltose	9
D	condensation	sucrose	9
E	hydrolysis	maltose	8
F	hydrolysis	sucrose	8
G	hydrolysis	maltose	9
H	hydrolysis	sucrose	9

43 The table gives some information about the inner membrane and outer membrane of mitochondria isolated from human liver cells.

	mean surface area of the membrane / μm^2	mean surface area of the membrane per 1×10^{-12} g of protein / μm^2
inner membrane	6	450
outer membrane	2	150

Which of the following statements is/are correct?

1 The rate of diffusion of oxygen into a mitochondrion is affected by the thickness of the mitochondrial cell wall.

2 The mean total mass of protein in the inner membrane is equal to the mean total mass of protein in the outer membrane of the mitochondria.

3 All cellular respiration takes place in mitochondria.

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

44 A research team has designed a cell-free miniature digestive system. The diagram outlines the system the scientists designed. A sample is introduced, and it is mixed with artificial digestive juices as it flows through the digestive system. The digested material, or chyme, flows out of the system.
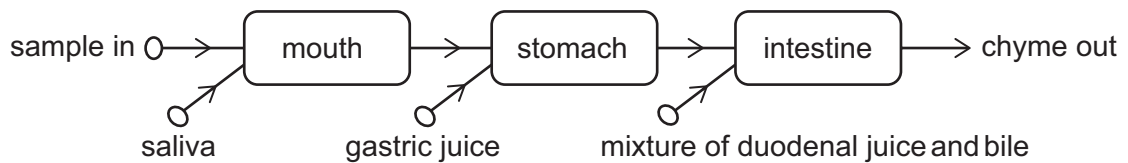
The research team prepared a series of control experiments using artificial digestive juices. They adjusted the pH of buffers for the mouth, stomach, and intestines. Next, they added the enzymes to the saliva, gastric juice and mixture of duodenal juice and bile. Before introducing their artificial juices, they warmed them to 37 °C.

Pepsin and trypsin are both proteases.

Which row shows the correct combination of enzyme(s) and pH that will produce chyme that is most like chyme produced during healthy human digestion?

	artificial digestive juices		
	saliva	*gastric juice*	*mixture of duodenal juice and bile*
A	amylase + pepsin pH 4.3	pepsin pH 2.7	trypsin + lipase + amylase pH 10.3
B	amylase pH 5.5	pepsin pH 6	trypsin + lipase only pH 6.5
C	amylase pH 6.8	pepsin pH 1.3	trypsin + lipase + amylase pH 8.2
D	amylase + pepsin pH 8.5	pepsin pH 2.5	trypsin + amylase only pH 7.5
E	amylase pH 4.3	pepsin pH 5.5	trypsin + lipase + amylase pH 8.1
F	amylase pH 7.2	pepsin pH 14	trypsin + lipase only pH 6.5
G	amylase pH 6.9	pepsin pH 13	trypsin + lipase + amylase pH 8.2

45 A student investigated the penetration of a blue dye solution into agar cubes of differing size. Each cube was placed into a beaker of blue dye for the same period of time.

The cubes were then removed and cut into sections to measure the depth of penetration of the dye.

For a cube of side 20 mm, the depth of penetration of the dye was 4 mm.

Which row is correct for this cube?

	total volume penetrated by the dye / mm^3	process by which the dye penetrated the agar
A	1.536×10^3	diffusion only
B	1.536×10^3	osmosis only
C	1.728×10^3	diffusion only
D	1.728×10^3	osmosis only
E	3.904×10^3	diffusion only
F	3.904×10^3	osmosis only
G	6.272×10^3	diffusion only
H	6.272×10^3	osmosis only

46 The vegetation of the Galapagos islands contains 15 different species of a plant belonging to the group *Scalesia*.

The diagram below shows the relationship between the number of *Scalesia* species found and the relative age and size of the different Galapagos islands. Each island is represented by a different pair of letters.
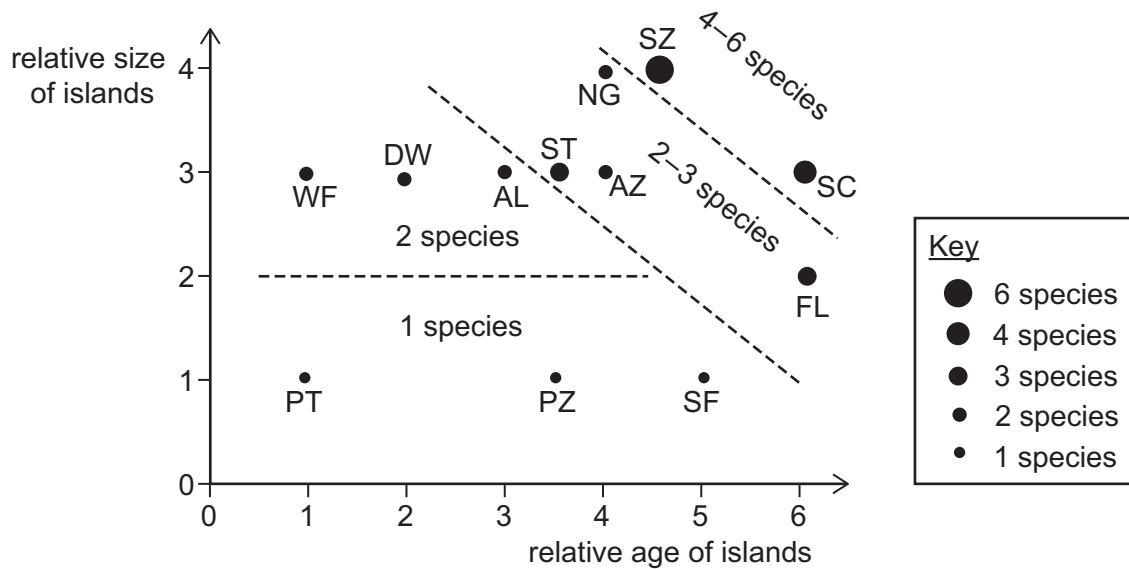

Which of the following statements is/are correct?

1 Older Galapagos islands always have more species.

2 Island SZ is similar in size to island NG but the number of *Scalesia* species is 200% larger.

3 The biotic and abiotic factors affecting *Scalesia* plants must be the same on PT, PZ and SF.

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

47 The diagram shows information about cell membranes.

Which option correctly identifies the following information?

- the solubility in water of the different parts of a cell membrane
- the effect of cholesterol on membrane fluidity as temperature decreases
- the units for the horizontal axis

PART Z Biology
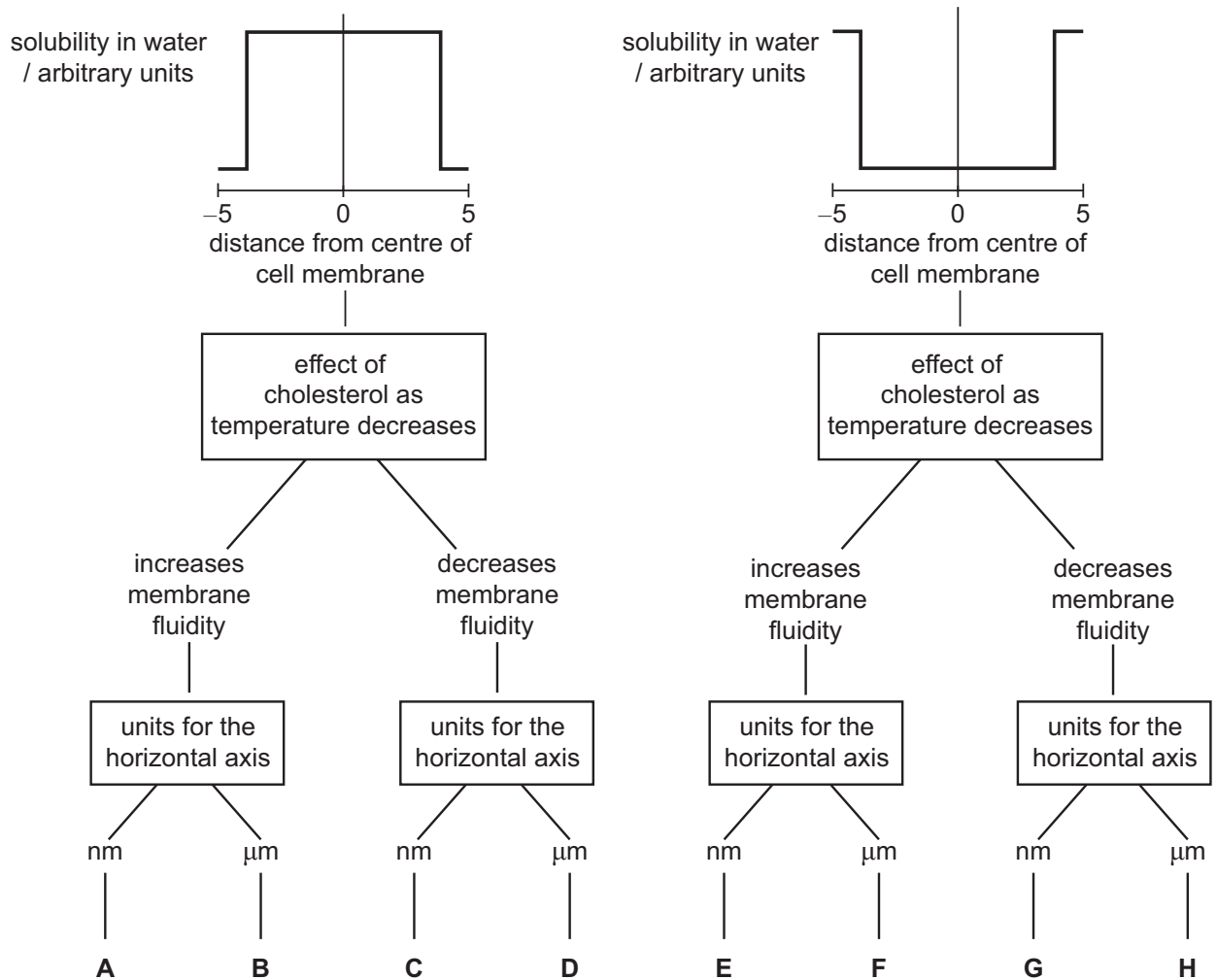
48   The table shows the diameters of four different structures in the lungs of a healthy human: an alveolus, a bronchus, a bronchiole and the trachea (but not necessarily in this order).

| structure	diameter
1	240 µm
2	2.00 cm
3	1.00 mm
4	1.20 cm

Which row is correct for these structures?

	ratio of trachea diameter to bronchiole diameter	a structure where gas exchange occurs	a structure where cilia are present	a structure where cartilage is present
A	200 : 1	3	1	1
B	200 : 1	3	2	2
C	20 : 1	1	4	3
D	20 : 1	1	4	4
E	20 : 1	3	3	4
F	2 : 1	1	2	4
G	2 : 1	1	3	3
H	2 : 1	3	3	2

61

49 Scientists tested the effect of protein P on the survival of bacterial cell populations. They tested this with, and without, the presence of chemical Q. Chemical Q disrupts the formation of disulfide bonds. The results are shown on the chart.

All other factors were kept constant.

Assume that rates of cell division are constant and so do not affect population size.
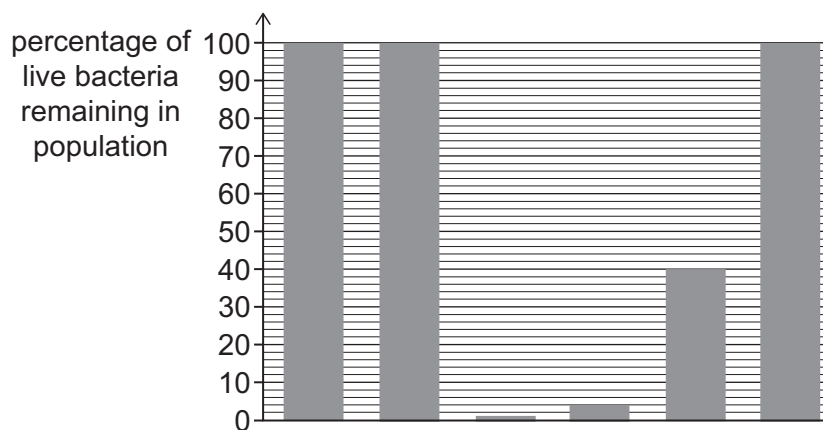
experiment	1	2	3	4	5	6
concentration of protein P / μM	0	0	5	5	5	5
concentration of chemical Q / μM	0	50	0	10	25	50

Which row in the table is correct?

	protein P kills bacterial cells	percentage increase in number of live bacteria remaining from experiment 4 to experiment 5	which level of protein structure differs between P in experiments 3 and 6?
A	yes	900	primary
B	yes	1000	tertiary
C	yes	900	tertiary
D	yes	1000	secondary
E	no	900	tertiary
F	no	1000	primary
G	no	900	secondary
H	no	1000	tertiary

BLANK PAGE

50 Scientists found that water loss rates varied between plants of the same species, even when kept in identical conditions.

To investigate this, they used one species of plant to produce plant Q. This contained a mutation that deleted the whole of gene X. The scientists also produced a version of plant Q with an unmutated copy of gene X reinserted into the plant genome. They confirmed that the new copy of gene X allowed the plant to produce functional protein X from the gene.

The mutation in Q is shown in the table with the other plants used in the investigation.

| plant	description
P	contains unmutated version of gene X
Q	contains a deletion of the whole of gene X from plant DNA
R	plant Q with an unmutated copy of gene X reinserted into the genome

[Other than the differences mentioned, all plants are genetically identical and grow normally. The rate of photosynthesis is the same in all three plants.]

The water use efficiencies of the plants were compared.

For a given rate of photosynthesis, plant water use efficiency is inversely proportional to the rate of transpiration.

The reactions were carried out at 21 °C in 10 hours of constant light intensity and 40% humidity. The plants were also supplied with a constant carbon dioxide concentration to ensure constant photosynthesis rates. These conditions were the same for all plants.

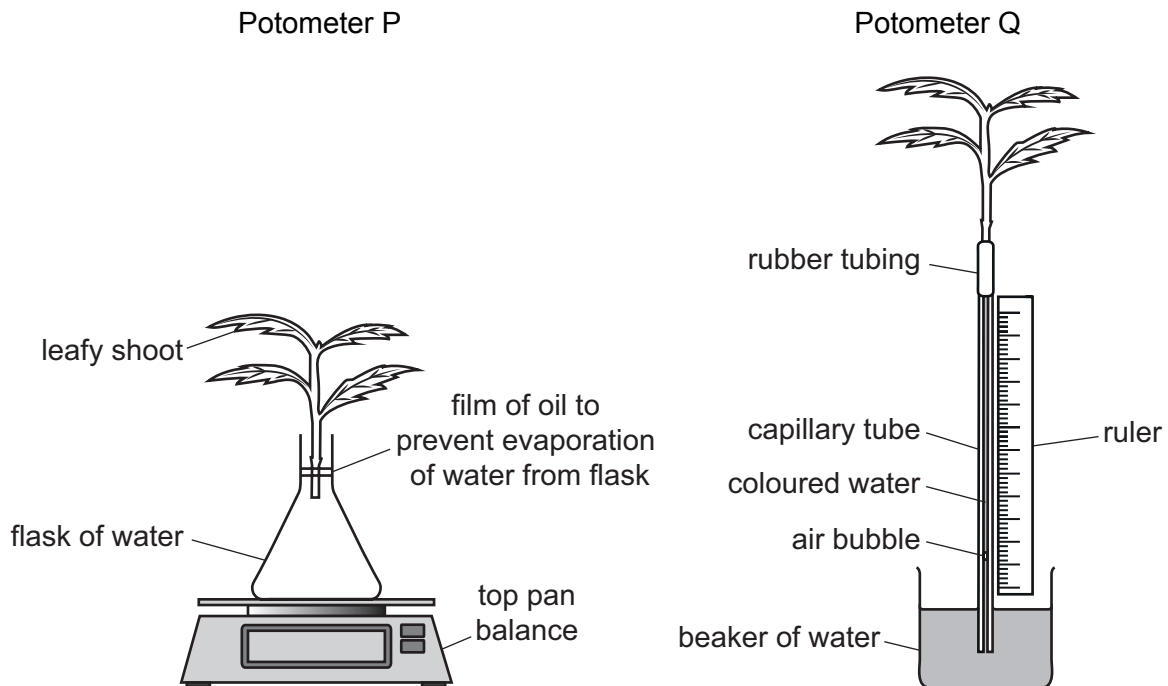The results of the experiment are shown in the chart.
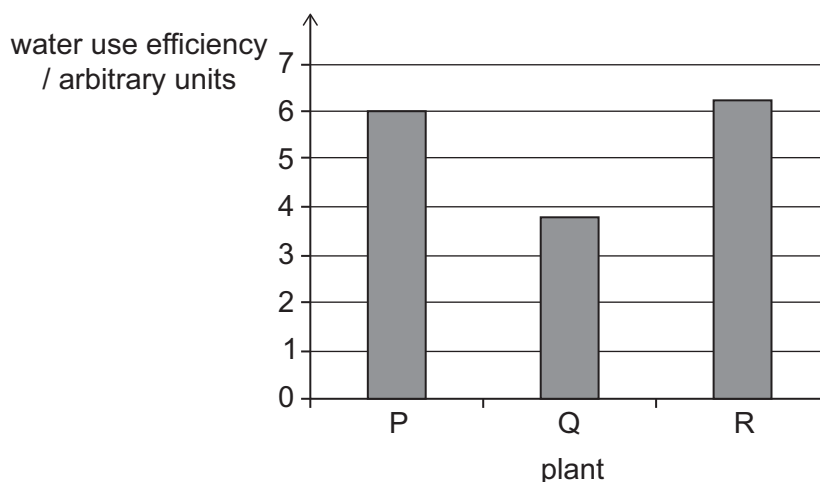
Which row is correct?

	effect of protein X on transpiration rates	effect of increasing humidity on the water use efficiency of plant Q
A	decrease	decreases
B	decrease	stays the same
C	decrease	increases
D	increase	decreases
E	increase	stays the same
F	increase	increases

51 A student identified the position of xylem vessels in the root and stem of a plant.

Two different types of potometer, P and Q, were used to study transpiration.

Potometer P   Potometer Q

leafy shoot

film of oil to prevent evaporation of water from flask

flask of water

top pan balance

rubber tubing

capillary tube

coloured water

air bubble

ruler

beaker of water

When the plant shoot was set up in potometer P, it lost 11.55 g of water in 1 hour.

The same shoot was then set up in potometer Q, which had a capillary of internal diameter 7 mm.
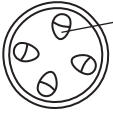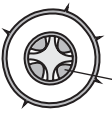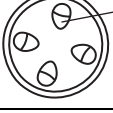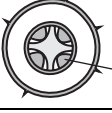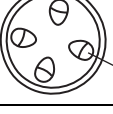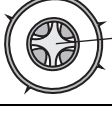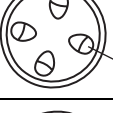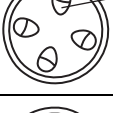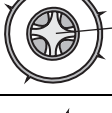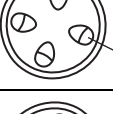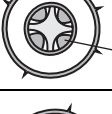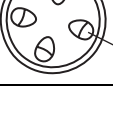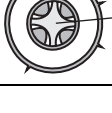
All other conditions were the same for both pieces of apparatus.

Assume that water lost by the shoot is the same as that taken up.

1 g of water has a volume of 1 cm^3.

The table shows possible distances that the air bubble would travel up the capillary tube in one minute and diagrams of a plant stem and plant root.

Which row is correct? (Approximate π as $\dfrac{22}{7}$)

	distance travelled by bubble in one minute / mm	position of xylem	
		in stem	in root
A	0.50		
B	0.50		
C	1.25		
D	1.25		
E	5.00		
F	5.00		
G	8.75		
H	8.75		

52 DNA replication is an enzyme-catalysed reaction. Experiments were performed at different temperatures using double-stranded DNA (dsDNA), with different percentages of guanine and cytosine base pairs (GC), as the substrate.

The graph shows how the relative rates of DNA replication vary with both temperature and the base composition of the substrate. The enzyme is thermally stable at all temperatures in the range.
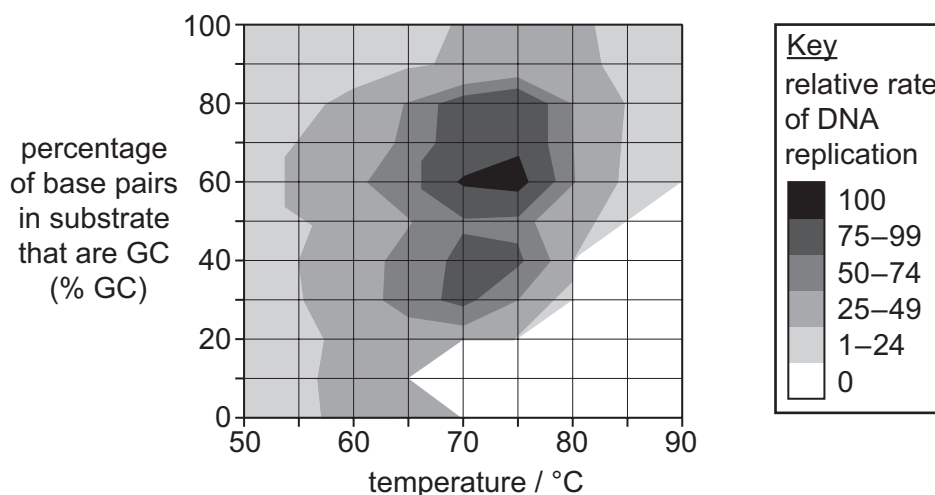
The temperature coefficient (Q_{10}) can be used to analyse the effect of increasing temperature on the rate of DNA replication. Q_{10} can be calculated as follows:

$$Q_{10} = \frac{\text{rate of reaction at } (x+10)^{\circ}\text{C}}{\text{rate of reaction at } x^{\circ}\text{C}}$$

For the temperatures investigated, which of the following statements is/are correct?

1 Q_{10} can be zero if the substrate has only adenine and thymine base pairs.

2 Q_{10} is always greater than one for substrates with 60% GC.

3 At any single temperature below the optimum for this enzyme, Q_{10} is always less for a substrate with 60% GC than for a substrate with 100% GC.

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

53 The affinity of haemoglobin for oxygen can be expressed as a p50 value. This represents the partial pressure of oxygen (in mmHg), pO_2, at which the haemoglobin is 50% saturated with oxygen.

In healthy humans, there is some variation in the p50 value between individuals, between sexes and with different fitness levels.

Scientists measured the affinity of haemoglobin in men and women volunteers. They separated the volunteers into groups of trained and untrained individuals. A trained individual runs for a minimum of one hour, three times a week and has done so for at least one year.

The results are shown in the table.

group of individuals tested	mean p50 value for this group in the study / mmHg
untrained women	28.7
trained women	29.1
untrained men	28.2
trained men	27.8

Which row of the table is correct?

	group with haemoglobin that has the highest mean affinity for oxygen	expected change in p50 value in muscles whilst running
A	trained men	increase
B	trained men	decrease
C	trained women	increase
D	trained women	decrease
E	untrained men	increase
F	untrained men	decrease
G	untrained women	increase
H	untrained women	decrease

54 Lipids are carried in the blood in combination with protein (lipoproteins). The enzyme lipoprotein lipase (LPL) is produced by endothelial cells lining the capillaries in muscle, heart and fatty tissues. This extracellular enzyme attaches to the capillary wall so that it is in contact with the blood.

Mutations in the gene for LPL can result in LPL deficiency and the accumulation of triglycerides in blood.

LPL deficiency is a recessive genetic condition and the gene coding for LPL is not carried on a sex chromosome.

One common mutation leads to the amino acid glycine being replaced by the amino acid glutamic acid at one position in the enzyme. This mutation is written as Gly188Glu.

Which of the statements is/are correct?

1 In healthy humans, the LPL gene is transcribed and translated in the nucleus of endothelial cells and then the protein is packaged by the Golgi apparatus for secretion from the cells.

2 In humans who are homozygous for the LPL mutation Gly188Glu, the mutated LPL gene is transcribed but not translated.

3 With parents who are both heterozygous for the LPL gene, the probability of a child without LPL deficiency being heterozygous is 50%.

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

55   The diagram shows the inheritance of an autosomal recessive genetic condition.

Key
- ■ male with condition
- □ male without condition
- ○ female without condition
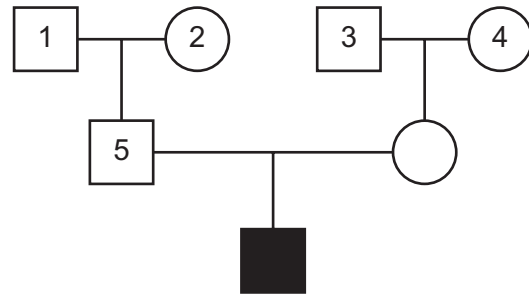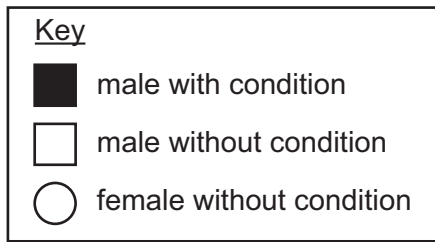
Which of the following statements is/are correct?

(Assume no mutations)

1   Among individuals 1, 2, 3 and 4, there must be 4 recessive alleles.

2   The probability of individual 5 having gained the recessive allele from individual 1 is 25% because each parent has two alleles.

3   If one body cell is taken from each of the seven individuals, the difference between the theoretical maximum number of recessive alleles present and the theoretical minimum number is two.

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

PART Z Biology

56 The diagram shows an electrocardiogram (ECG) trace from a healthy human. The cardiac output was 5000 $cm^3\,min^{-1}$.
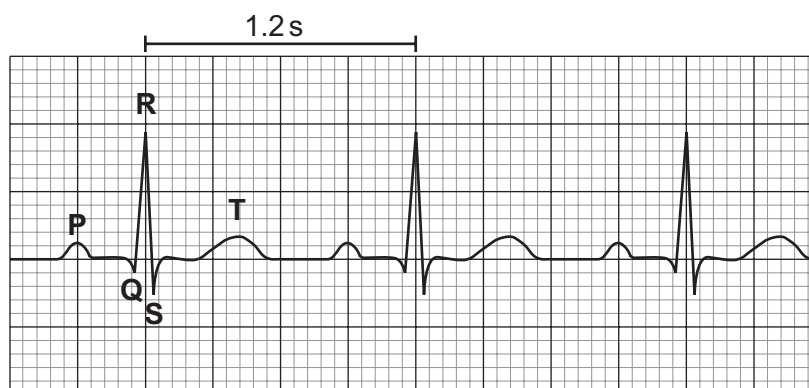
Which row in the table gives the stroke volume and the approximate duration of ventricular systole?

	stroke volume / cm^3	approximate duration of ventricular systole / s
A	50	0.1
B	50	0.5
C	100	0.1
D	100	0.5
E	2.5×10^5	0.1
F	2.5×10^5	0.5

57 Scientists investigated the effect of different chemicals on the rate of osmosis using frog egg cells.

Frog egg cells were injected with mRNA of a specific gene, or with non-coding mRNA as a control. The gene codes for a channel protein that allows water to pass through the cell membrane.

The cells were then incubated in solutions with a higher water potential than the cell cytoplasm. The solutions contained either mercury chloride ($HgCl_2$), or both $HgCl_2$ and β-mercaptoethanol (βME), or neither of these two additives.

The rates of osmosis during the incubation period are shown in the table.

experiment	additives / mmol dm^{-3}		rate of osmosis / arbitrary units
	HgCl$_2$	βME	
control	0.0	0.0	0.00279
	0.3	0.0	0.00203
	0.3	5.0	0.00254
mRNA for channel protein	0.0	0.0	0.02100
	0.3	0.0	0.00807
	0.3	5.0	0.01880

Using these results, a student wrote the following paragraph:

The surface area to volume ratio of cells injected with channel protein mRNA will ......(**1**)....... more than the control cells, because the water potential inside the channel protein mRNA-injected cells becomes ......(**2**)........ negative. The additive that restricts water transport through the channel protein is ......(**3**)........

Which row in the following table gives terms that complete the paragraph for a correct interpretation of the data?

	(1)	(2)	(3)
A	decrease	less	HgCl$_2$
B	decrease	more	HgCl$_2$
C	decrease	less	βME
D	decrease	more	βME
E	increase	less	HgCl$_2$
F	increase	more	HgCl$_2$
G	increase	less	βME
H	increase	more	βME

58 It has been estimated that there are 2.3 metres of double-stranded DNA in each human diploid nucleus. This DNA comprises 1.2×10^{10} nucleotides.

Which of the following statements is/are correct?

  1 On average, there is 5 cm of double-stranded DNA per chromosome.

  2 The maximum theoretical number of amino acids that could be coded for is 4×10^{9}.

  3 The average length of a nucleotide is 0.38 nm, to 2 significant figures.

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

59 Cancer can develop due to genetic changes that affect a number of cellular processes. One change seen in some cancers is cells undergoing incorrect mitosis which doubles the chromosome number. These cells, called tetraploid cells, can then suffer further damage, and can form tumours.

To study this, scientists produced tetraploid cells from healthy human cells in a laboratory using chemical M. Chemical M can block the ability of spindle fibres to separate chromatids after they have attached to the spindle fibres.

The healthy human cells used in this experiment contained autosomal genes P and Q. The cells used in this study were heterozygous for gene P and homozygous for the dominant allele of gene Q.

Which row in the table is correct?

(Assume no mutations.)

	genotype of tetraploid cells	stage of cell division affected by chemical M	type of cells that could have been used
A	PpQQ	metaphase	sperm
B	PpQQ	metaphase	stem
C	PpQQ	anaphase	stem
D	PPpQQq	metaphase	sperm
E	PPpQQq	anaphase	sperm
F	PPppQQQQ	metaphase	stem
G	PPppQQQQ	anaphase	stem
H	PPppQQQQ	anaphase	sperm

75

60 Stem cells can be used to replace damaged cells. Scientists studied whether bone marrow stem cells transplanted into a recipient mouse could travel to the brain and create new neurones.

Stem cells from the bone marrow of healthy male adult mice were transplanted into healthy female recipient mice at birth.

After four months, brain cell samples were taken from the recipients and the cells were stained using coloured dyes. Each coloured dye has a specific binding site and identifies the presence of specific sites within the cell.

dye colour	specific binding site for this dye
red	protein N, found in all neurone cells but not in any other cell types
blue	thymine bases
green	a DNA sequence found only on Y chromosomes

The results of the study are shown in the table:

dyes that stained the cells	number of cells that were stained
blue only	4800
red and blue only	1600
green and blue only	114
blue, red and green	6

Which of the following statements is/are correct?

1 5.0% of cells identified as originating from the donor cells were neurones.

2 Only cells originally from the recipient mice will stain green.

3 The blue stain shows where translation is taking place.

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

BLANK PAGE

BLANK PAGE

BLANK PAGE