

NATURAL SCIENCES  
ADMISSIONS ASSESSMENT

D568/11

Wednesday 2 November 2016

80 minutes

## SECTION 1

## 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 1 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.

At the end of 80 minutes, your supervisor will collect this question paper and answer sheet before giving out Section 2.

This paper contains **five** parts: **A, B, C, D,** and **E**.

**All** candidates should complete **Part A** Mathematics.

**All** candidates should then complete **two** further parts chosen from:

<b>Part B</b>	Physics
<b>Part C</b>	Chemistry
<b>Part D</b>	Biology
<b>Part E</b>	Advanced Mathematics and Advanced Physics

Each part has 18 multiple-choice questions. There are no penalties for incorrect responses, only marks for correct answers, so you should attempt all of the questions in your **three** parts. Each question is worth one mark.

Questions ask you to show your choice between options. 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 can use the question paper for rough working, but no extra paper is allowed. Only your responses on the answer sheet will be marked.

Dictionaries and calculators may NOT be used.

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

This question paper consists of 73 printed pages and 3 blank pages.

PV4

**Paper content**

PART A Mathematics .....	3
PART B Physics .....	14
PART C Chemistry .....	31
PART D Biology .....	43
PART E Advanced Mathematics and Advanced Physics.....	59

**PART A Mathematics**

- 1 Find the complete set of solutions to  $-8 < 6 - \frac{x}{2}$
- A  $x < 4$
  - B  $x > 4$
  - C  $x < 20$
  - D  $x > 20$
  - E  $x < 22$
  - F  $x > 22$
  - G  $x < 28$
  - H  $x > 28$
- 2 Which one of the following is a simplification of  $(\sqrt{3} - \sqrt{2})^2$ ?
- A  $1 - 2\sqrt{3}\sqrt{2}$
  - B  $5 - 2\sqrt{2}\sqrt{3}$
  - C  $2\sqrt{3} - 2\sqrt{2}$
  - D 1
  - E  $5 - \sqrt{2}\sqrt{3}$
  - F  $13 - 2\sqrt{2}\sqrt{3}$
  - G  $5 + 2\sqrt{2}\sqrt{3}$
  - H 5

- 3 The ratio of Q:R is 5:2 and the ratio of R:S is 3:10

Which one of the following gives the ratio Q:S in its simplest form?

- A 1:2
- B 2:1
- C 3:4
- D 3:25
- E 4:3
- F 25:3

- 4 The mean age of the twenty members of a running club is exactly 28.

The mean age increases by exactly 2 years when two new members join.

What is the mean age of the two new members?

- A 20 years
- B 22 years
- C 30 years
- D 40 years
- E 50 years
- F 52 years

5 A medical scanner is bought for £15 000.

The value of the scanner depreciates by 20% every year.

By how much has the scanner reduced in value after 2 years?

- A £600
- B £3000
- C £5400
- D £6000
- E £9000
- F £9600
- G £12 000

6 The point A is 4 km due East of the point B.

The bearing of the point C from A is  $330^\circ$  and the bearing of C from B is  $060^\circ$

Find the distance BC.

- A 2 km
- B  $2\sqrt{3}$  km
- C 4 km
- D  $2\sqrt{5}$  km
- E  $4\sqrt{2}$  km

- 7 The quantities  $x$  and  $y$  are positive.

$x$  is inversely proportional to the square root of  $y$ .

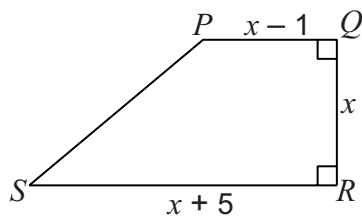
When  $x = 8$ ,  $y = 9$ .

What is the value of  $y$  when  $x = 6$ ?

- A  $\frac{3}{2}$   
B 2  
C  $\frac{81}{16}$   
D  $\frac{27}{14}$   
E 12  
F 16

- 8 In a trapezium  $PQRS$ , the parallel sides are  $PQ$  and  $RS$ .

$PQ = (x - 1)$  cm,  $RS = (x + 5)$  cm and the vertical height  $QR = x$  cm.



[diagram not to scale]

The area of the trapezium is  $120 \text{ cm}^2$ .

What is the length of  $RS$ ?

- A 9 cm  
B 10 cm  
C 11 cm  
D 12 cm  
E 15 cm  
F 17 cm

9 Make  $b$  the subject of the formula:

$$a = \frac{b^2 + 2}{3b^2 - 1}$$

**A**  $b = \pm \sqrt{\left(\frac{a+2}{3a+1}\right)}$

**B**  $b = \pm \sqrt{\left(\frac{a+2}{3a-1}\right)}$

**C**  $b = \pm \sqrt{\left(\frac{2-a}{3a+1}\right)}$

**D**  $b = \pm \sqrt{\left(\frac{2-a}{3a-1}\right)}$

**E**  $b = \pm \sqrt{\left(\frac{3}{3a+1}\right)}$

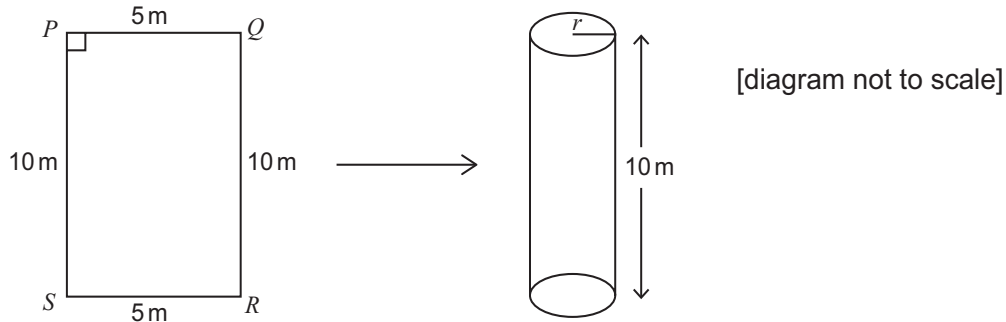
**F**  $b = \pm \sqrt{\left(\frac{3}{3a-1}\right)}$



- 10 A thin rectangular sheet of metal 10 m by 5 m is made into an open ended cylinder by joining the edges  $PS$  and  $QR$ .

The height of the cylinder is 10 m.

What is the volume, in cubic metres, enclosed by this cylinder?



- A  $\frac{5}{2\pi}$
- B  $\frac{25}{4\pi}$
- C  $\frac{125}{2\pi}$
- D  $62.5\pi$
- E  $\frac{125}{\pi}$
- F  $250\pi$
- 11 Which one of the following is a simplification of  $4 + \frac{4-x^2}{x^2-2x}$ ?

- A  $3 - \frac{2}{x}$
- B  $3 + \frac{2}{x}$
- C  $4 - \frac{2}{x}$
- D  $4 + \frac{2}{x}$
- E  $5 - \frac{2}{x}$
- F  $5 + \frac{2}{x}$

- 12 During summer activities week 120 students each chose one activity from swimming, archery, and tennis.

46 of the students were girls.

36 of the students chose tennis, and  $\frac{2}{3}$  of these were boys; 25 girls chose swimming, and 27 students chose archery.

A boy is picked at random. What is the probability that he chose swimming?

A  $\frac{3}{20}$

B  $\frac{9}{37}$

C  $\frac{4}{15}$

D  $\frac{16}{37}$

E  $\frac{32}{57}$

- 13 Which one of the following expressions is equivalent to  $\frac{9^{2n+1} \times 3^{4-3n}}{27^{2-n}}$ ?

A  $3^9$

B  $3^{-2n}$

C  $3^{2-2n}$

D  $3^{4n}$

E  $3^{6n-2}$

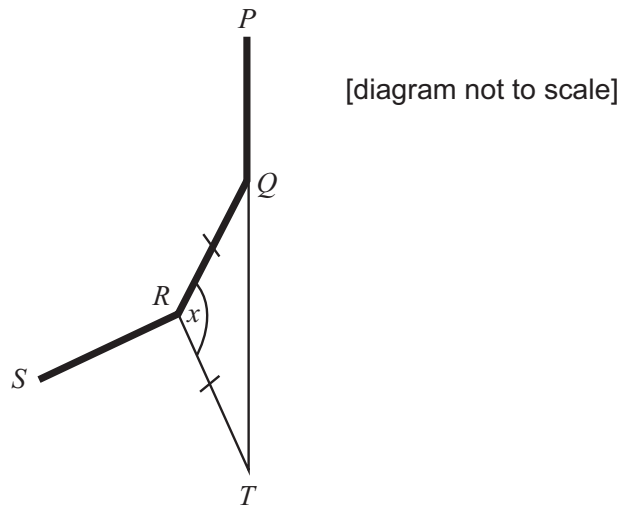
F  $3^6$

14 In the diagram below,  $PQRS$  is part of a regular polygon.

The polygon has  $n$  sides.

The side  $PQ$  is extended to  $T$  such that  $PQT$  is a straight line.

The length of  $RQ$  is the same as the length of  $RT$ .



Find an equation for  $n$  in terms of  $x$ , where  $x$  is the size of angle  $\angle QRT$  in degrees.

- A  $n = \frac{180}{x - 90}$
- B  $n = \frac{180 - x}{720}$
- C  $n = \frac{360 - x}{90}$
- D  $n = \frac{360}{180 - x}$
- E  $n = \frac{720}{180 - x}$
- F  $n = \frac{720}{360 - x}$
- G  $n = \frac{360}{360 - x}$

- 15 In a population,  $\frac{3}{5}$  of the adults are overweight.

The probability of an overweight adult having Type 2 diabetes is  $\frac{9}{50}$ ; this probability is 6 times the probability of an adult who is not overweight having the disease.

An adult is chosen at random from the population.

What is the probability the chosen adult has Type 2 diabetes?

- A  $\frac{27}{250}$   
B  $\frac{3}{25}$   
C  $\frac{63}{500}$   
D  $\frac{37}{250}$   
E  $\frac{39}{50}$   
F  $\frac{21}{100}$

- 16 The graph of  $y = x^2 + ax + b$  meets the straight line  $y = x + 1$  when  $x = 2$  and  $x = 4$ .

Find  $a$  and  $b$ .

- A  $a = -5, b = 9$   
B  $a = 5, b = 9$   
C  $a = -5, b = 11$   
D  $a = 5, b = 11$   
E  $a = -6, b = 11$   
F  $a = 6, b = 11$   
G  $a = -6, b = 13$   
H  $a = 6, b = 13$

- 17 A rhombus has diagonals of length 5 cm and 3 cm.

An enlargement of the rhombus has sides of length  $\sqrt{68}$  cm.

What is the scale factor of the enlargement?

- A  $\sqrt{2}$
- B 2
- C  $2\sqrt{2}$
- D 4
- E  $4\sqrt{2}$

- 18 A straight line is drawn joining the points with coordinates  $(7, 1 - p)$  and  $(2p + 1, -1)$ , where  $p$  is a constant.

What is the complete set of values of  $p$  for which the gradient of this line is finite and greater than zero?

- A  $p < -4, p > 0$
- B  $-4 < p < 0$
- C  $p < 0$
- D  $p < 2$
- E  $2 < p < 3$
- F  $p < 2, p > 3$

## **PART B Physics**

- 19 In the 1920s scientists discovered that the universe is expanding. One consequence of this expansion is that the intense gamma-ray radiation that filled the early universe has now been shifted to the microwave region of the electromagnetic spectrum.

Which line of the table describes how the expansion of the universe has affected the frequency and wavelength of these electromagnetic waves?

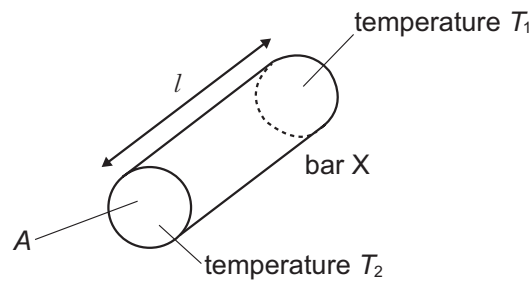
	<i>effect on frequency</i>	<i>effect on wavelength</i>
<b>A</b>	decrease	decrease
<b>B</b>	decrease	increase
<b>C</b>	increase	decrease
<b>D</b>	increase	increase
<b>E</b>	no effect	decrease
<b>F</b>	no effect	increase

- 20 A nuclide  ${}_{82}^{214}\text{Pb}$  changes by radioactive decay into the nuclide  ${}_{82}^{210}\text{Pb}$ .

Which combination of emissions produces this change?

- A** 3 alpha
- B** 2 alpha and 1 beta
- C** 2 alpha and 2 beta
- D** 1 alpha and 2 beta
- E** 3 beta

- 21 A cylindrical copper bar X of length  $l$  has a cross-sectional area  $A$ . The colder end of the bar is kept at temperature  $T_1$  and the hotter end is kept at temperature  $T_2$ .



The curved surface of the bar is perfectly insulated and thermal energy is conducted from the hotter end of the bar to the colder end.

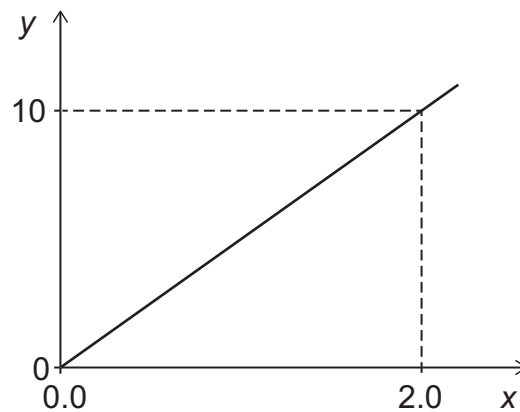
Changes in  $l$ ,  $A$ ,  $T_1$  and  $T_2$  may alter the rate at which thermal energy is conducted along the copper bar.

In which case is the rate of conduction of thermal energy along the insulated bar the same as for bar X?

	<i>change in A</i>	<i>change in l</i>	<i>change in <math>T_1</math></i>	<i>change in <math>T_2</math></i>
<b>A</b>	doubles	no change	no change	no change
<b>B</b>	halves	no change	no change	no change
<b>C</b>	no change	doubles	no change	no change
<b>D</b>	no change	halves	no change	no change
<b>E</b>	no change	no change	decreases by $10^\circ\text{C}$	increases by $10^\circ\text{C}$
<b>F</b>	no change	no change	decreases by $10^\circ\text{C}$	no change
<b>G</b>	no change	no change	increases by $10^\circ\text{C}$	decreases by $10^\circ\text{C}$
<b>H</b>	no change	no change	increases by $10^\circ\text{C}$	increases by $10^\circ\text{C}$



- 22 The graph shown of quantity  $y$  against quantity  $x$  represents the motion of a body.



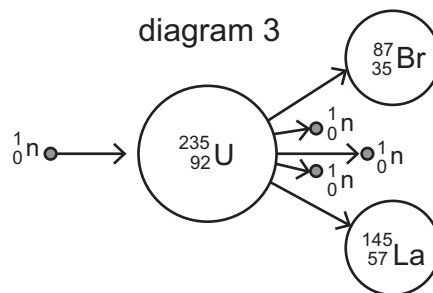
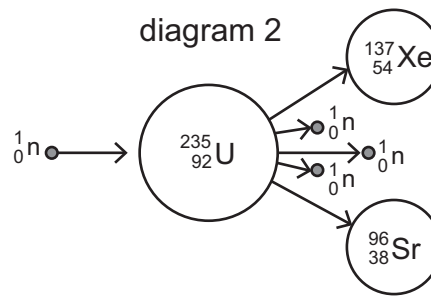
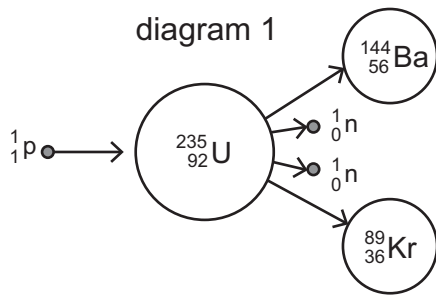
(The scales on both axes are in the appropriate S.I. units, and the gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

Which two of the following could the graph represent?

- 1 kinetic energy against velocity for an object of mass  $10 \text{ kg}$  undergoing free-fall
  - 2 potential energy against height for an object of mass  $20 \text{ kg}$  being lifted by a constant external force
  - 3 velocity against time for an object of mass  $20 \text{ kg}$  being accelerated by a resultant force of  $100 \text{ N}$
  - 4 work done by an external force of  $5 \text{ N}$  against distance moved for an object of mass  $12 \text{ kg}$  being moved at constant speed by (and in the direction of) the external force
- A** 1 and 2
- B** 1 and 3
- C** 1 and 4
- D** 2 and 3
- E** 2 and 4
- F** 3 and 4

23 A uranium-235 nucleus can undergo fission to produce two smaller nuclei.

Which of the diagrams, if any, could represent this process?



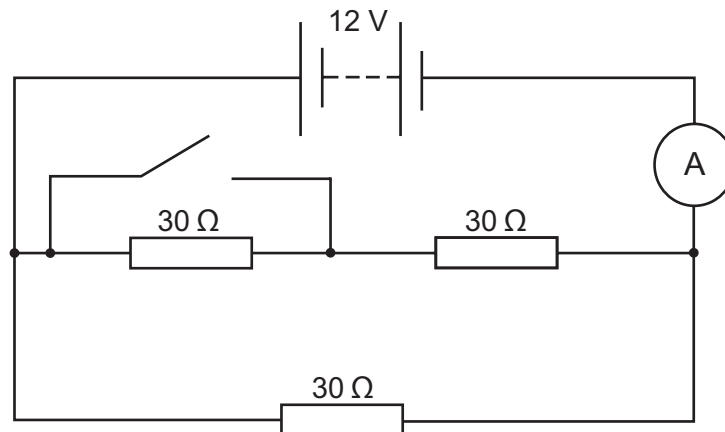
- A none of them
- B 1 only
- C 2 only
- D 3 only
- E 1 and 2 only
- F 1 and 3 only
- G 2 and 3 only
- H 1, 2 and 3

- 24** A circuit consists of a  $5.0\ \Omega$  resistor and a variable resistor connected in series with a  $24\ \text{V}$  battery. The variable resistor has a minimum resistance of  $3.0\ \Omega$  and a maximum resistance of  $15\ \Omega$ . The battery and the connecting wires have negligible resistance.

What is the maximum power dissipated in the  $5.0\ \Omega$  resistor?

- A**  $7.2\ \text{W}$
- B**  $18\ \text{W}$
- C**  $27\ \text{W}$
- D**  $45\ \text{W}$
- E**  $72\ \text{W}$
- F**  $75\ \text{W}$

- 25** The diagram shows a 12 V battery, a switch and three resistors. Each resistor has a resistance of  $30\ \Omega$ .



Initially the switch is open.

What happens to the reading on the ammeter when the switch is closed?

- A** It decreases by 0.20 A.
- B** It decreases by 0.40 A.
- C** It decreases by 0.60 A.
- D** It decreases by 0.80 A.
- E** It increases by 0.20 A.
- F** It increases by 0.40 A.
- G** It increases by 0.60 A.
- H** It increases by 0.80 A.

- 26 The total power  $P$  radiated by a star is given by:

$$P = kR^2T^4$$

where  $R$  is the radius of the star,  $T$  is its surface temperature and  $k$  is a constant.

The power currently radiated by the Sun is  $4.0 \times 10^{26}$  W. Towards the end of the Sun's life its radius will increase by a factor of a hundred and its surface temperature will decrease by a factor of two.

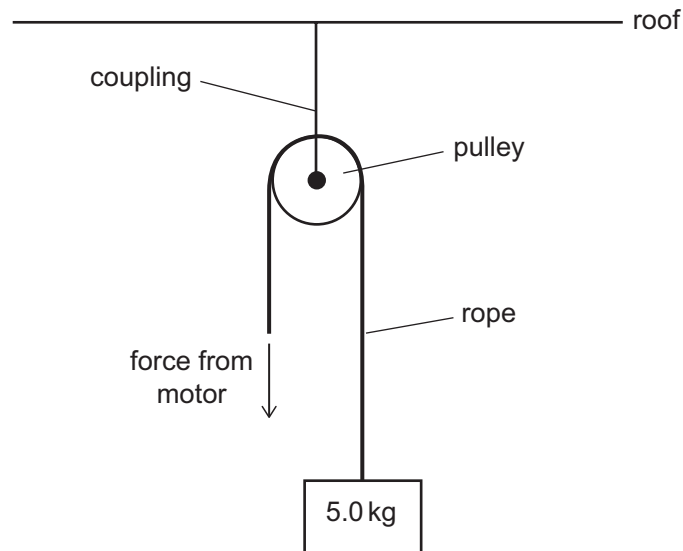
What will be the power radiated by the Sun when these changes have occurred?

- A  $2.5 \times 10^{27}$  W
  - B  $1.0 \times 10^{28}$  W
  - C  $2.0 \times 10^{28}$  W
  - D  $2.5 \times 10^{29}$  W
  - E  $1.0 \times 10^{30}$  W
  - F  $2.0 \times 10^{30}$  W
  - G  $2.5 \times 10^{33}$  W
  - H  $1.0 \times 10^{34}$  W
- 27 A transverse wave travelling through a medium has a frequency of 5.0 Hz, a wavelength of 4.0 cm and an amplitude of 3.0 cm.

What is the total distance travelled by a particle of the medium in one minute?

- A 900 cm
- B 1200 cm
- C 1800 cm
- D 2400 cm
- E 3600 cm
- F 4800 cm

- 28 A motor is used to lift a mass of 5.0 kg using a pulley system as shown in the diagram. The pulley is secured to the roof using a coupling.



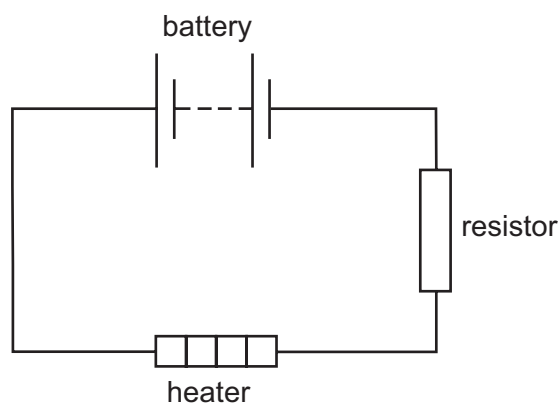
The motor needs to cause the mass to accelerate upwards at  $0.80 \text{ m s}^{-2}$ .

What is the minimum tension force that the coupling must be able to withstand without breaking?

(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ . The pulley system is frictionless and has negligible mass. The rope has negligible mass and is inextensible.)

- A 4.0 N
- B 8.0 N
- C 46 N
- D 50 N
- E 54 N
- F 92 N
- G 104 N
- H 108 N

- 29 A heater is connected in series with a resistor and a 6.0 V battery in the circuit shown.

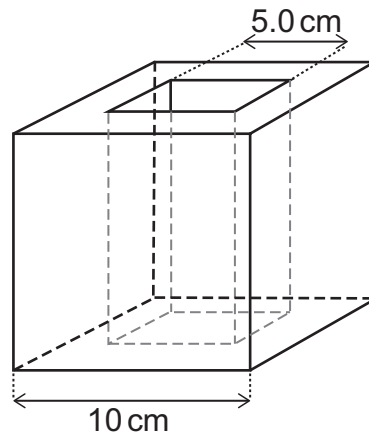


The total resistance of the circuit is  $15\ \Omega$ . In 3.0 minutes, 180 J of electrical energy is transferred into other forms in the heater.

How much charge flows through the heater in the 3.0 minutes and what is the voltage across the heater?

	<i>charge / C</i>	<i>voltage / V</i>
<b>A</b>	1.2	150
<b>B</b>	1.2	216
<b>C</b>	7.5	0.041
<b>D</b>	7.5	24
<b>E</b>	72	0.40
<b>F</b>	72	2.5
<b>G</b>	450	0.40
<b>H</b>	450	2.5

- 30** A cubic block has a hole through it with a square cross-section. The dimensions are shown on the diagram. The weight of the block is 30 N.



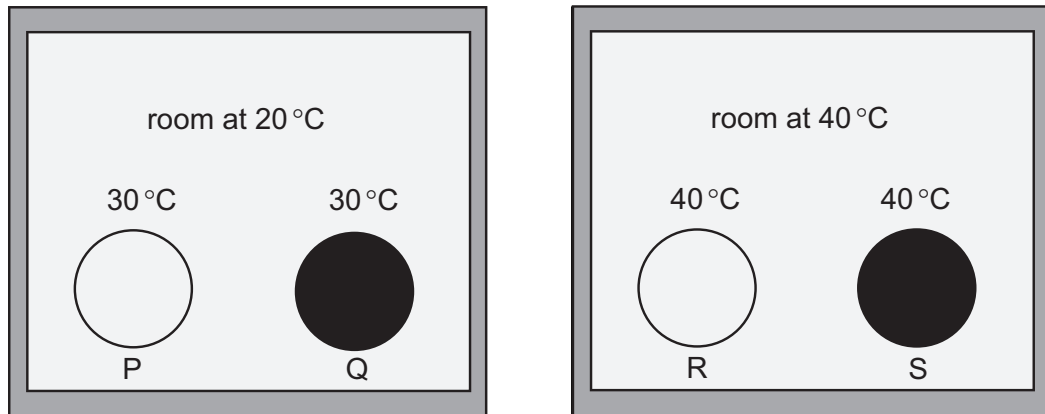
What is the density of the material from which the block is made?

(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

- A**  $0.30 \text{ g cm}^{-3}$
- B**  $0.40 \text{ g cm}^{-3}$
- C**  $0.60 \text{ g cm}^{-3}$
- D**  $1.2 \text{ g cm}^{-3}$
- E**  $3.0 \text{ g cm}^{-3}$
- F**  $4.0 \text{ g cm}^{-3}$
- G**  $6.0 \text{ g cm}^{-3}$
- H**  $12 \text{ g cm}^{-3}$



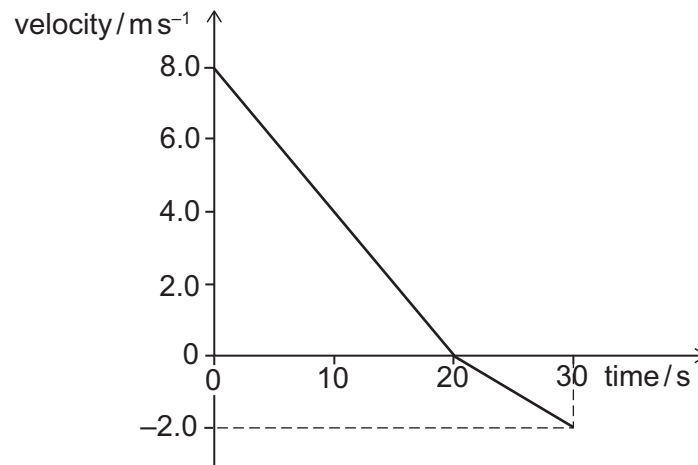
- 31** The diagram shows four solid steel balls P, Q, R and S which are of identical size.
- Balls P and R have shiny surfaces. Balls Q and S have dull surfaces.
- Balls P and Q are in a room at 20 °C. Balls R and S are in a room at 40 °C.
- The temperature of each ball at a given moment in time is shown on the diagram.



Which two balls lose thermal energy by convection, and which ball emits thermal radiation at the greatest rate?

	<i>lose thermal energy by convection</i>	<i>greatest rate of emission of thermal radiation</i>
<b>A</b>	P and Q	P
<b>B</b>	P and Q	Q
<b>C</b>	P and Q	R
<b>D</b>	P and Q	S
<b>E</b>	R and S	P
<b>F</b>	R and S	Q
<b>G</b>	R and S	R
<b>H</b>	R and S	S

- 32 The diagram shows the velocity-time graph for an object travelling in a straight line over a period of 30 s.



What total distance did the object travel in the 30 s, how far from its starting position was it at the end of the 30 s, and what was its average speed over the 30 s?

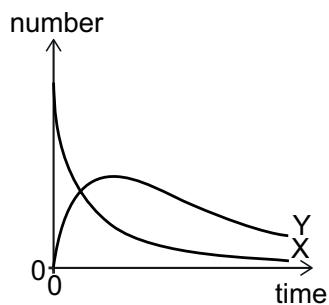
	<i>total distance travelled</i> / m	<i>distance from starting position</i> / m	<i>average speed</i> / ms <sup>-1</sup>
<b>A</b>	90	70	3.0
<b>B</b>	90	70	5.0
<b>C</b>	90	90	3.0
<b>D</b>	90	90	5.0
<b>E</b>	180	140	5.0
<b>F</b>	180	140	6.0
<b>G</b>	180	180	5.0
<b>H</b>	180	180	6.0

- 33 A sample of a radioactive isotope X decays to one other radioactive isotope Y. Y has a half-life that is double that of X. Initially only X is present.

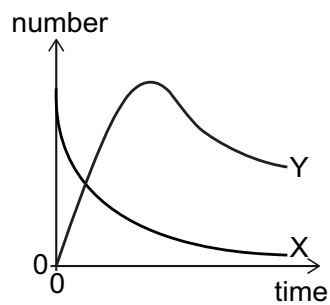
Which graph could represent how the numbers of nuclei of X and Y that are present in the sample vary with time?

(All graphs cover the same period of time.)

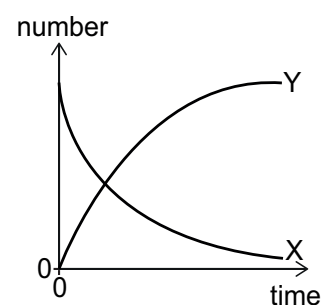
A



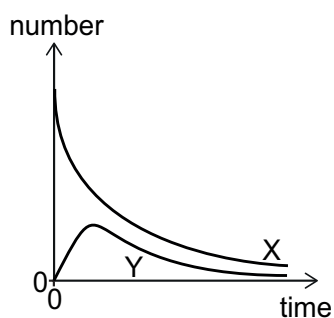
B



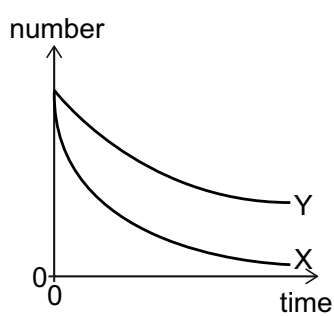
C



D



E



**34** Bronze is a mixture of tin and copper.

A particular sample of bronze contains 10% tin by volume. (In other words, 10% of the total volume of the sample is tin and 90% of it is copper.)

What percentage of the mass of the sample is tin?

(Density of tin =  $Y$  and density of copper =  $X$ .)

**A**  $\frac{X}{9X - Y} \times 100$

**B**  $\frac{X}{9Y - X} \times 100$

**C**  $\frac{Y}{9X - Y} \times 100$

**D**  $\frac{Y}{9Y - X} \times 100$

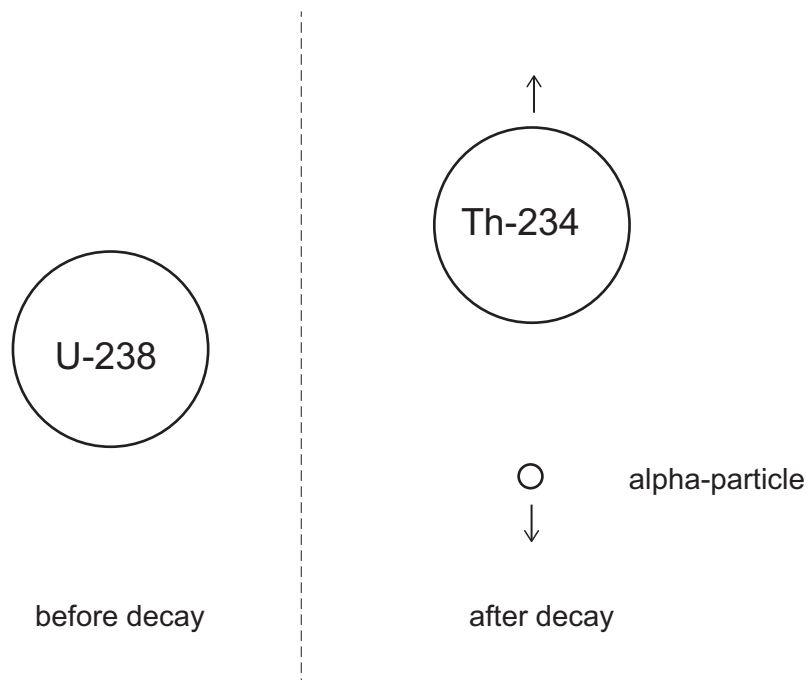
**E**  $\frac{X}{9X + Y} \times 100$

**F**  $\frac{X}{9Y + X} \times 100$

**G**  $\frac{Y}{9X + Y} \times 100$

**H**  $\frac{Y}{9Y + X} \times 100$

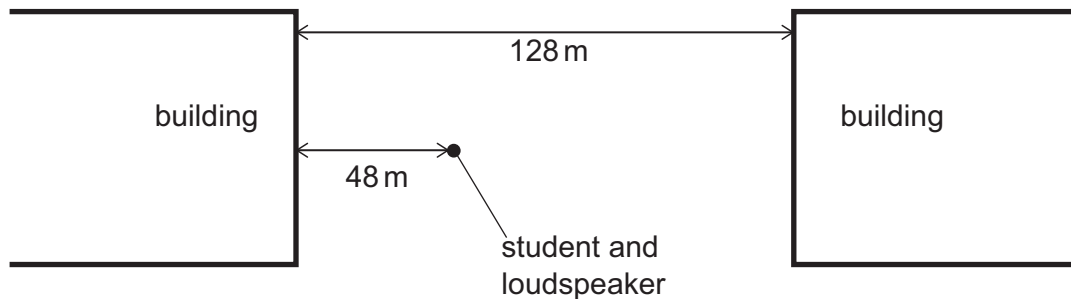
- 35 When a stationary uranium-238 nucleus decays by alpha emission it forms a nucleus of thorium-234. The total kinetic energy produced by the decay is  $E$ .



What is the kinetic energy of the alpha particle?

- A  $\frac{4E}{238}$   
 B  $\frac{4E}{234}$   
 C  $\frac{E}{2}$   
 D  $\frac{234E}{238}$   
 E  $E$

- 36** A student carries out an experiment to measure the speed of sound. A loudspeaker that emits sound in all directions is placed between two buildings that are 128 m apart as shown. The student and loudspeaker are 48 m from one of the buildings.



The loudspeaker is connected to a signal generator that causes it to emit regular clicks. The student notices that each click results in two echoes, one from each building. The rate at which the clicks are produced is gradually increased from zero until each echo coincides with a new click being emitted by the loudspeaker.

What is the frequency of emission of clicks when this happens?

(The speed of sound in air =  $320 \text{ m s}^{-1}$ .)

- A** 2.0 Hz
- B** 2.5 Hz
- C** 3.3 Hz
- D** 4.0 Hz
- E** 5.3 Hz
- F** 6.7 Hz
- G** 10 Hz

**PART C Chemistry**

37 Which one of the following atoms or ions contains the same number of neutrons and electrons as  ${}_{20}^{40}\text{Ca}^{2+}$ ?

- A  ${}_{17}^{35}\text{Cl}^{-}$
- B  ${}_{17}^{37}\text{Cl}$
- C  ${}_{18}^{40}\text{Ar}$
- D  ${}_{19}^{39}\text{K}^{+}$
- E  ${}_{19}^{39}\text{K}$

38 Solid titanium oxide does not conduct electricity and cannot be electrolysed.

When molten, titanium oxide is a conductor and can be electrolysed.

During electrolysis 7.2 g of titanium are formed for every 3.6 dm<sup>3</sup> of oxygen at room temperature and pressure.

Which of the following statements, if any, are correct?

- 1 After electrolysis, the titanium atoms produced have a noble gas electron configuration.
- 2 When molten, titanium oxide electrons are delocalised and so they move to carry the charge.
- 3 The empirical formula of titanium oxide is TiO<sub>2</sub>.

(A<sub>r</sub>: Ti = 48; molar gas volume = 24 dm<sup>3</sup> at room temperature and pressure)

- 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



39 In which, if any, of the following reactions are covalent bonds both broken and formed?

- 1 burning sodium in oxygen
- 2 electrolysis of aqueous sodium chloride
- 3 displacement of iron from iron oxide by heating with aluminium powder

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2

F 1 and 3

G 2 and 3

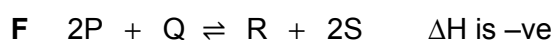
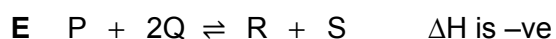
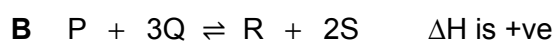
H 1, 2 and 3

40 In a reversible reaction, gaseous reactants P and Q form gaseous products R and S.

An increase in temperature was found to increase both the rate of reaction and the yield at equilibrium.

An increase in pressure was found to increase the rate of reaction but the yield at equilibrium was unaffected.

Which equation could represent the reaction?



- 41** Several oxides of bromine have been identified. Analysis of 2.4 g of one of these compounds showed it to contain 1.6 g of bromine.

What is the empirical formula of this compound?

( $A_r$ : bromine = 80; oxygen = 16)

- A**  $\text{Br}_2\text{O}$
  - B**  $\text{BrO}_2$
  - C**  $\text{Br}_2\text{O}_5$
  - D**  $\text{Br}_5\text{O}_2$
  - E**  $\text{Br}_4\text{O}_5$
  - F**  $\text{Br}_5\text{O}_4$
- 42** The most common ion of antimony,  $\text{Sb}^{3+}$ , has 48 electrons.

Antimony has two isotopes. One isotope has 70 neutrons and has an abundance of 60%. The second isotope has 72 neutrons and has an abundance of 40%.

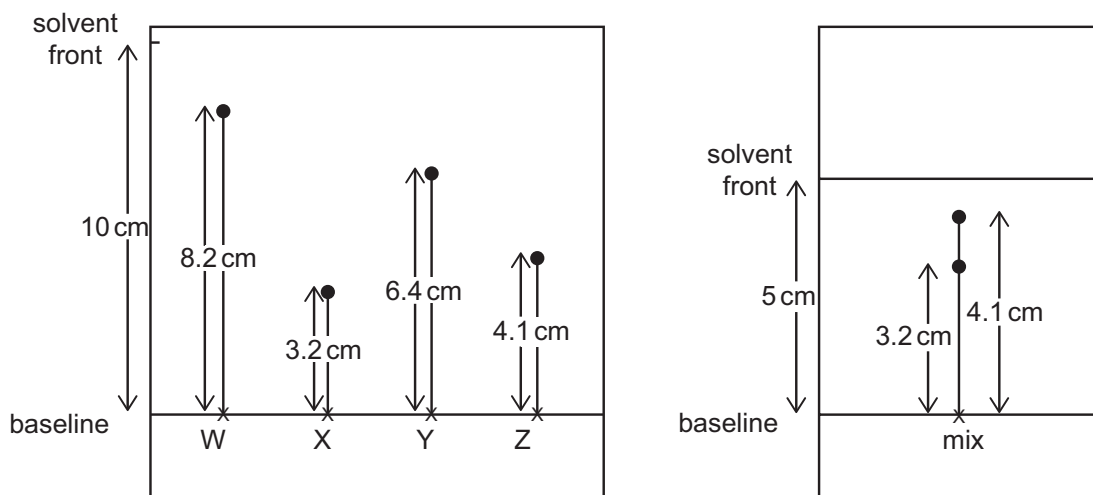
What is the relative atomic mass of antimony?

- A** 70.8
- B** 71.0
- C** 71.2
- D** 121.8
- E** 122.0
- F** 122.2

- 43 A chromatogram was produced for 4 separate dyes (W, X, Y and Z) using filter paper and a water solvent.

A second chromatogram was produced using a mixture of two of the dyes, again using filter paper and a water solvent:

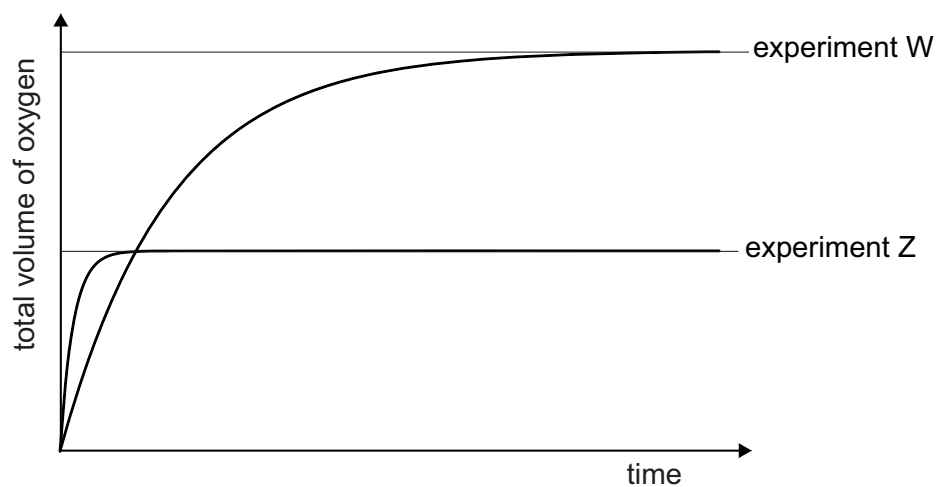
[diagram not to scale]



Which of the following statements, if any, are correct?

- 1 The concentration of dye W must be twice the concentration of dye Z.
  - 2 The mobile phase is the filter paper.
  - 3 The mixture in the second chromatogram contained dyes W and Y.
- 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

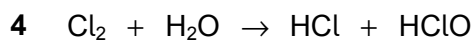
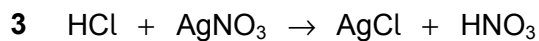
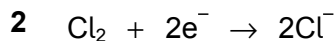
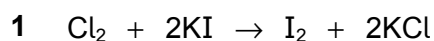
- 44 The graphs show results of two experiments (W and Z) involving the catalytic decomposition of hydrogen peroxide.



Assuming all other conditions are kept constant, which one of the following options would lead to the results shown?

	<i>experiment W</i>	<i>experiment Z</i>
<b>A</b>	100 cm <sup>3</sup> of 1.0 mol dm <sup>-3</sup> hydrogen peroxide	50 cm <sup>3</sup> of 2.0 mol dm <sup>-3</sup> hydrogen peroxide
<b>B</b>	catalyst is in lumps	catalyst is finely divided
<b>C</b>	reaction carried out at 25 °C	reaction carried out at 50 °C
<b>D</b>	2.0 g manganese(IV) oxide used	1.0 g manganese(IV) oxide used
<b>E</b>	100 cm <sup>3</sup> of 1.0 mol dm <sup>-3</sup> hydrogen peroxide	25 cm <sup>3</sup> of 2.0 mol dm <sup>-3</sup> hydrogen peroxide

45 Two of the following equations represent redox reactions:



Which two equations represent redox reactions?

A 1 and 2

B 1 and 3

C 1 and 4

D 2 and 3

E 2 and 4

F 3 and 4

46 Copper, Cu, reacts with concentrated nitric acid,  $\text{HNO}_3$ , to produce a solution of copper(II) nitrate, water and compound X.

Compound X does not contain copper or hydrogen.

The balanced equation for the reaction shows 3 moles of copper reacting with  $\text{HNO}_3$  to produce 4 moles of water.

What is the identity of compound X?

A NO

B  $\text{NO}_2$

C  $\text{NO}_3$

D  $\text{N}_2\text{O}_5$

E  $\text{N}_2\text{O}_8$

- 47 During the electrolysis of a saturated solution of sodium chloride,  $2.4 \text{ dm}^3$  of hydrogen gas was collected in time  $t$  at one of the electrodes.

Assuming no products dissolve, which row in the table correctly gives the mass or volume of the given product collected at the given electrode in time  $t$ ?

(A<sub>r</sub>: Na = 23; Cl = 35.5; H = 1, 1 mole of gas occupies  $24 \text{ dm}^3$  at room temperature and pressure)

	<i>mass or volume</i>	<i>product</i>	<i>electrode</i>
<b>A</b>	0.1 g	hydrogen	negative
<b>B</b>	2.3 g	sodium	negative
<b>C</b>	$2.4 \text{ dm}^3$	chlorine	positive
<b>D</b>	$2.4 \text{ dm}^3$	chlorine	negative
<b>E</b>	$2.4 \text{ dm}^3$	oxygen	positive
<b>F</b>	3.55 g	chlorine	positive
<b>G</b>	$1.2 \text{ dm}^3$	oxygen	negative

- 48 The heat energy change for a reaction is  $-100 \text{ kJ mol}^{-1}$ , and the activation energy is  $+150 \text{ kJ mol}^{-1}$ .

What is the activation energy for the reverse reaction?

- A**  $-250 \text{ kJ mol}^{-1}$
- B**  $-150 \text{ kJ mol}^{-1}$
- C**  $-50 \text{ kJ mol}^{-1}$
- D**  $+50 \text{ kJ mol}^{-1}$
- E**  $+150 \text{ kJ mol}^{-1}$
- F**  $+250 \text{ kJ mol}^{-1}$

- 49** The following tests were carried out on separate samples of two monoprotic acids, HX and HY. HX is a strong acid and HY is a weak acid. Both acids had a concentration of  $1 \text{ mol dm}^{-3}$ .
- 1** Measure the time taken for a 1 cm strip of magnesium to react completely when added to  $25 \text{ cm}^3$  of each acid.
  - 2** Measure the volume of  $1 \text{ mol dm}^{-3}$  sodium hydroxide solution needed to completely neutralise  $20 \text{ cm}^3$  of each acid.
  - 3** Measure the electrical conductance of each acid using a conductivity meter.

Each test was carried out under the same conditions.

Which of the tests, considered independently, if any, would show that HX was a stronger acid than HY?

- 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
- 
- 50** A 1.50 g sample of impure anhydrous sodium carbonate was added to  $100 \text{ cm}^3$  of excess dilute hydrochloric acid. The impurity is unreactive.
- The volume of gas released was  $240 \text{ cm}^3$  at room temperature and pressure.
- What is the mass of the impurity?
- ( $A_r$ : Na = 23; C = 12; O = 16; molar gas volume =  $24\,000 \text{ cm}^3$  at room temperature and pressure)
- A** 0.44 g
- B** 0.53 g
- C** 0.67 g
- D** 0.83 g
- E** 0.97 g
- F** 1.06 g

- 51** 0.35 g of lithium metal reacts with excess water at room temperature. Any gas produced in the reaction is collected and its volume measured at room temperature and pressure.

Assuming 1 mole of gas occupies  $24.0 \text{ dm}^3$  at room temperature and pressure, what is the volume of gas collected?

( $A_r$ : Li = 7)

- A**  $0.00 \text{ cm}^3$
  - B**  $0.60 \text{ cm}^3$
  - C**  $1.20 \text{ cm}^3$
  - D**  $25.0 \text{ cm}^3$
  - E**  $50.0 \text{ cm}^3$
  - F**  $600 \text{ cm}^3$
  - G**  $1200 \text{ cm}^3$
- 52** Sodium sulfate was prepared by neutralising  $25.0 \text{ cm}^3$  of  $0.1 \text{ mol dm}^{-3}$  sodium hydroxide with exactly  $50.0 \text{ cm}^3$  of sulfuric acid.

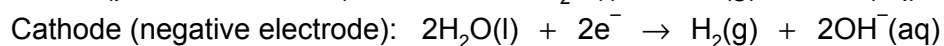
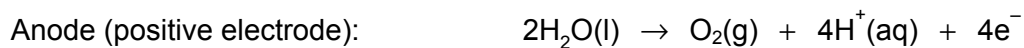
What is the concentration of the sulfuric acid in  $\text{g dm}^{-3}$ ?

( $M_r$ :  $\text{H}_2\text{SO}_4 = 98$ )

- A**  $0.025 \text{ g dm}^{-3}$
- B**  $0.050 \text{ g dm}^{-3}$
- C**  $0.250 \text{ g dm}^{-3}$
- D**  $2.45 \text{ g dm}^{-3}$
- E**  $4.90 \text{ g dm}^{-3}$
- F**  $9.80 \text{ g dm}^{-3}$



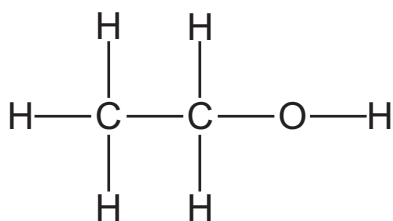
- 53** During electrolysis of an aqueous solution of sodium sulfate the half equations for the electrode reactions are:



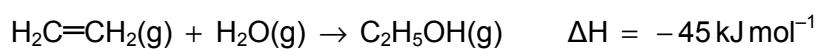
Which of the following deductions, if any, can be made from these equations?

- 1** The ratio by moles of hydrogen to oxygen produced at the electrodes is 1:1.
  - 2** The sodium sulfate solution will become more concentrated as the electrolysis proceeds.
  - 3** The whole solution will become acidic due to formation of  $\text{H}^+$  ions at the anode.
- 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

54 The structure of ethanol is given below:



Given the equation below and the overall enthalpy change for the reaction, which option correctly identifies the bond energy of the C–O bond in ethanol?



(Mean bond energy ( $\text{kJ mol}^{-1}$ ): H–H = +436; C–C = +346; C–H = +413; O–H = +464; C=C = +611)

- A 103  $\text{kJ mol}^{-1}$
- B 316  $\text{kJ mol}^{-1}$
- C 361  $\text{kJ mol}^{-1}$
- D 707  $\text{kJ mol}^{-1}$
- E 825  $\text{kJ mol}^{-1}$

**PART D Biology**

- 55** Between 1954 and 1971 a mine in Northern Australia was releasing excess copper into the nearby Finnis River. Copper ions are poisonous and most of the types of fish living in the river died. The river still remains polluted with copper, but scientists have discovered one type of rainbow fish that is able to survive and live in the river.

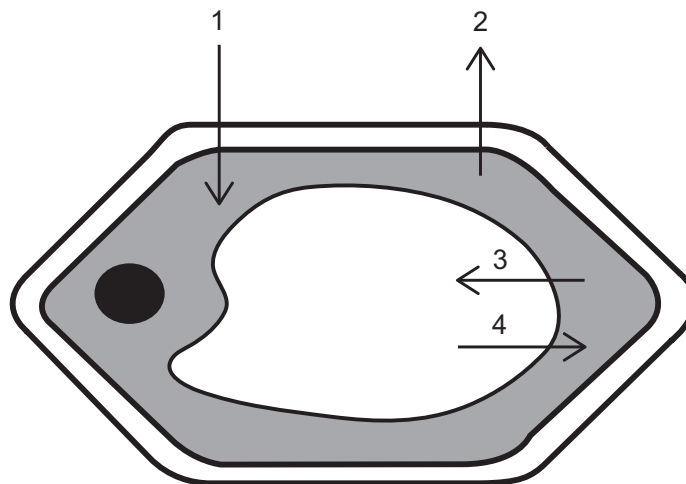
A student wrote the following statements in order to explain this information.

- 1** One type of rainbow fish did not die out in the river because this type was able to adapt to the changing environment.
- 2** None of the other types of fish showed any type of genetic variation.
- 3** The presence of copper ions acted as a selective pressure.

Which of the student's statements could be correct?

- A** 1 only
- B** 1 and 2 only
- C** 1 and 3 only
- D** 2 and 3 only
- E** 1, 2 and 3

56 The diagram shows a plant cell.



Which of the arrows on the diagram show the **net** movement of water molecules, by osmosis, when the cell is surrounded by a solution that is more concentrated than the solution in the cytoplasm?

- A 1 only
- B 2 only
- C 1 and 3 only
- D 1 and 4 only
- E 2 and 3 only
- F 2 and 4 only

57 A student described a population of organisms as having the following features

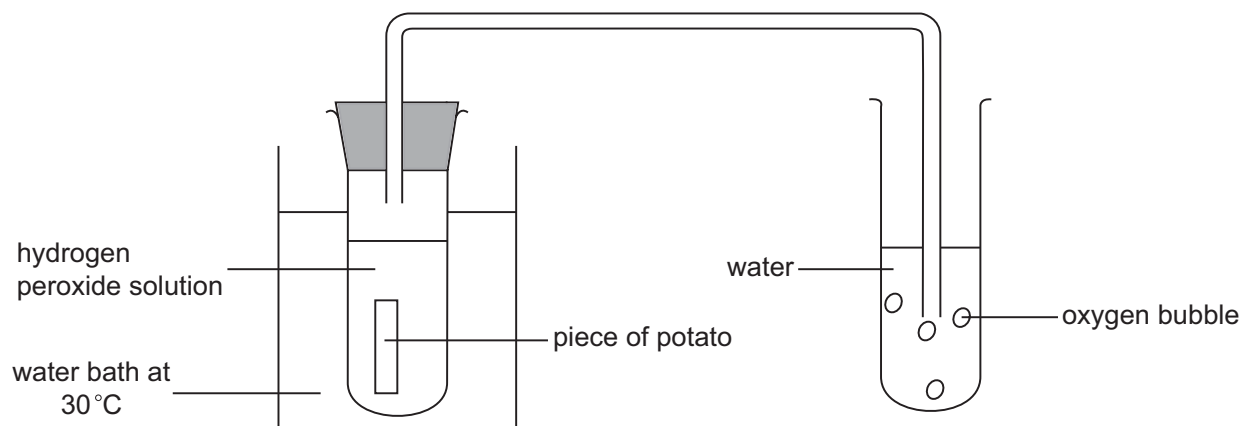
- 1 single celled
- 2 chloroplasts present
- 3 cell wall present

Using this information, which type of organism could this describe?

- A algae
- B bacteria
- C ferns
- D fungi
- E flowering plants

- 58** A student carried out an experiment to investigate how temperature affects the rate of activity of an enzyme found in potatoes. This enzyme breaks down the substrate hydrogen peroxide to produce water and oxygen.

The apparatus was set up as shown in the diagram and the experiment carried out at 30 °C.



The student counted the number of bubbles of oxygen produced in one minute.

The experiment was repeated at 40 °C, 50 °C, 60 °C, and 70 °C.

The table shows the results collected by the student.

<i>temperature / °C</i>	<i>number of bubbles of oxygen gas produced in one minute</i>
30	32
40	27
50	23
60	8
70	2

A group of students were given these results and asked to calculate the percentage decrease in the number of bubbles produced between 30 °C and 60 °C. Each student was also asked to write a conclusion to explain the results. These are shown in the table below.

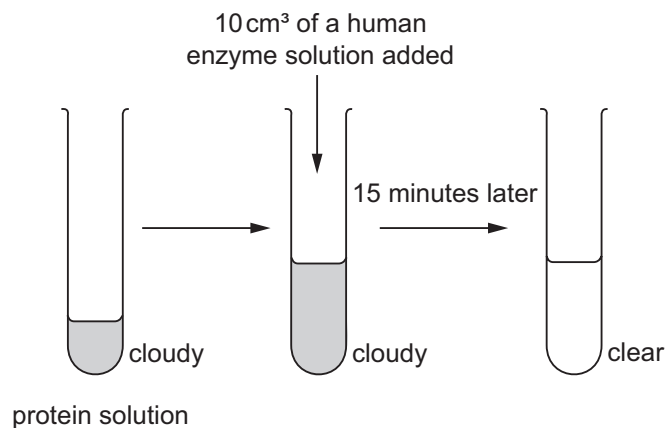
Which student correctly calculated the percentage decrease in the number of bubbles between 30 °C and 60 °C and wrote an appropriate conclusion which explains the reason for this decrease?

	<i>percentage decrease in the number of bubbles between 30 °C and 60 °C</i>	<i>conclusion</i>
<b>A</b>	20	the high temperature causes the bonds maintaining the structure of the enzyme to break
<b>B</b>	20	the temperature of the environment is too hot and the enzyme dies
<b>C</b>	75	the high temperature causes the bonds maintaining the structure of the enzyme to break
<b>D</b>	75	the temperature of the environment is too hot and the enzyme dies
<b>E</b>	300	the high temperature causes the bonds maintaining the structure of the enzyme to break
<b>F</b>	300	the temperature of the environment is too hot and the enzyme dies

- 59** Albinism is a recessive genetic condition that results in the absence of the pigment melanin in the skin, hair and eyes. In a population of 580 000 people there were 29 albinos and 81 200 symptomless carriers. One living cheek cell was collected from every individual in the population.

What is the number of albinism alleles in these cells?

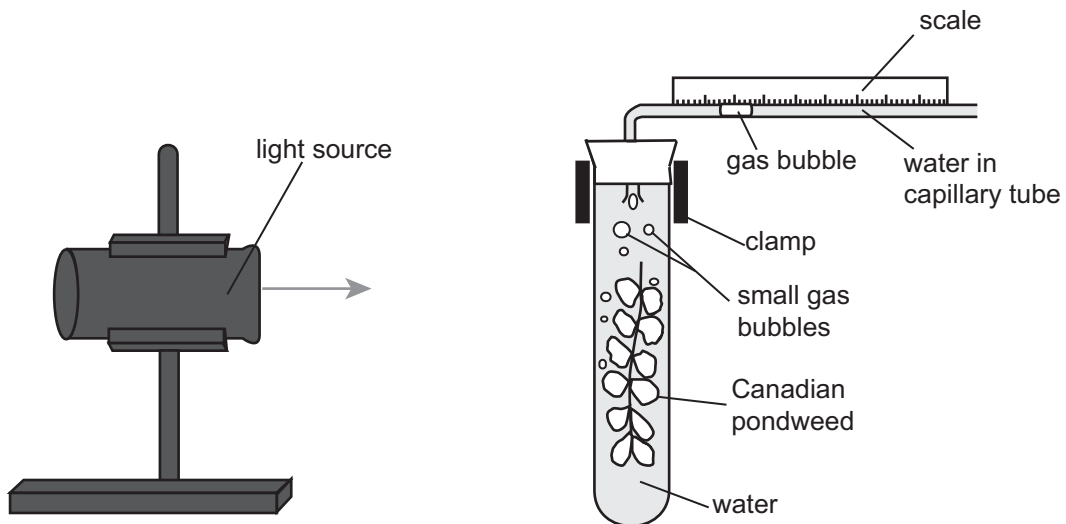
- A** 0  
**B** 29  
**C** 58  
**D** 81 229  
**E** 81 258  
**F** 162 458
- 60** A student set up the following apparatus at a temperature of 25 °C and at pH 7.



What could the student change so that it would take less than 15 minutes for the solution to become clear?

- A** Carry out the experiment at pH 7, but increase the temperature to 70 °C.  
**B** Carry out the experiment, stirring the mixture once every 30 seconds.  
**C** Carry out the experiment at a temperature of 25 °C and a pH of 13.  
**D** Double the volume of both the protein solution and the enzyme solution.  
**E** Halve the volume of both the protein solution and the enzyme solution.

- 61 The diagram shows the apparatus used by a student to carry out an investigation into the rate of photosynthesis in pondweed.



The student measured the distance the gas bubble moved along the capillary tube in 3 minutes as 16 mm. The student calculated the volume of gas produced using the distance moved and the diameter of the capillary tube which was 1.0 mm. After 3 minutes the rate of gas production is reduced.

Which row represents the correct statements for this experiment?

	<i>volume of gas produced / mm<sup>3</sup></i>	<i>reason for reduction in rate of gas production after 3 minutes</i>
<b>A</b>	$4\pi$	all enzyme active sites are occupied
<b>B</b>	$4\pi$	carbon dioxide concentration is too low
<b>C</b>	$16\pi$	carbon dioxide concentration is too low
<b>D</b>	$16\pi$	photosynthesis enzymes denatured
<b>E</b>	$16.5\pi$	carbon dioxide concentration is too low
<b>F</b>	$16.5\pi$	photosynthesis enzymes denatured
<b>G</b>	$34\pi$	all enzyme active sites are occupied
<b>H</b>	$34\pi$	photosynthesis enzymes denatured



- 62** A student used a light microscope at a magnification of 40x to observe a slide of a stained non-dividing tissue. In the cells of this tissue, the student noted the presence of a large central vacuole and cytoplasm containing a single, stained, round structure.

Which of the following structures, if any, might the student also have seen in this tissue at this magnification?

**1** cell wall

**2** mitochondria

**3** chromosomes

**A** none of them

**B** 1 only

**C** 2 only

**D** 3 only

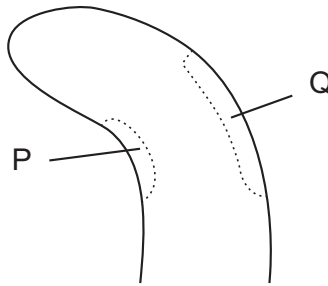
**E** 1 and 2 only

**F** 1 and 3 only

**G** 2 and 3 only

**H** 1, 2 and 3

- 63 The diagram shows the tip of a plant shoot, with two areas labelled P and Q.



A student wrote the following statements to explain the growth of this shoot:

- 1 Cells at P are smaller than the cells at Q.
- 2 Concentration of plant hormone is higher at Q than P.
- 3 Unidirectional light has caused a change in the concentration of plant hormone at P.

Which of the student's statements, if any, could be correct?

- 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

- 64** In an investigation, a molecule of DNA was extracted and separated into its single strands 1 and 2. The percentage of each base present in each strand was found.

The table shows some of the results for strand 1.

<i>DNA sample</i>	<i>base present (%)</i>			
	<i>adenine [A]</i>	<i>cytosine [C]</i>	<i>guanine [G]</i>	<i>thymine [T]</i>
strand 1	26	?	28	14

P, Q, R and S are the percentages of each base in the complementary strand 2.

<i>DNA sample</i>	<i>base present (%)</i>			
	<i>adenine [A]</i>	<i>cytosine [C]</i>	<i>guanine [G]</i>	<i>thymine [T]</i>
strand 2	P	Q	R	S

A student calculates the following percentages for P, Q, R and S:

P 14%  
Q 28%  
R 26%  
S 28%

Which of the percentages is / are correct?

- A** P only
- B** Q only
- C** R only
- D** S only
- E** P and Q only
- F** R and S only

- 65** Cystic fibrosis is a condition of the respiratory system caused by abnormal ion transport in the lungs. It is a recessive genetic condition.

A female carrier has a child with a male who is also a carrier. What are the probabilities of the child having the characteristics described in the table below?

	<i>probability that the child is a male with cystic fibrosis</i>	<i>probability that the child is a female who does not have cystic fibrosis but carries the recessive allele</i>
<b>A</b>	$\frac{1}{4}$	$\frac{1}{8}$
<b>B</b>	$\frac{1}{4}$	$\frac{1}{4}$
<b>C</b>	$\frac{1}{4}$	$\frac{1}{2}$
<b>D</b>	$\frac{1}{6}$	$\frac{1}{8}$
<b>E</b>	$\frac{1}{6}$	$\frac{1}{4}$
<b>F</b>	$\frac{1}{6}$	$\frac{1}{2}$
<b>G</b>	$\frac{1}{8}$	$\frac{1}{4}$
<b>H</b>	$\frac{1}{8}$	$\frac{1}{2}$

**66** Organisms interact with each other in many different ways, for example:

- 1** a tapeworm absorbing nutrients from a sheep intestine
- 2** a bacterial cell breaking down undigested food in a human gut
- 3** a leopard and a lion hunting an antelope
- 4** male deer fighting with each other to gain a mate
- 5** oak trees growing close to each other in a wood

Which of the statements is/are an example of intraspecific competition?

- A** 1 only
- B** 2 only
- C** 4 only
- D** 2 and 3 only
- E** 4 and 5 only
- F** 1, 2 and 5 only
- G** 1, 3 and 4 only

**67** A diploid cell from a type of fly that contains 8 chromosomes, divides to form sperm cells.

Which row is correct for the number of strands of DNA in each sperm cell and the number of sperm cells produced?

	<i>number of strands of DNA in each sperm cell</i>	<i>number of sperm cells produced</i>
<b>A</b>	4	2
<b>B</b>	4	4
<b>C</b>	8	2
<b>D</b>	8	4
<b>E</b>	16	2
<b>F</b>	16	4

- 68 A healthy human is running a race over a distance of 1500 metres as fast as possible.

Which row shows molecules that would be in a higher concentration in a vein carrying blood away from an actively contracting leg muscle of the runner compared to an artery carrying blood to the capillaries in the muscle?

Key

✓ higher

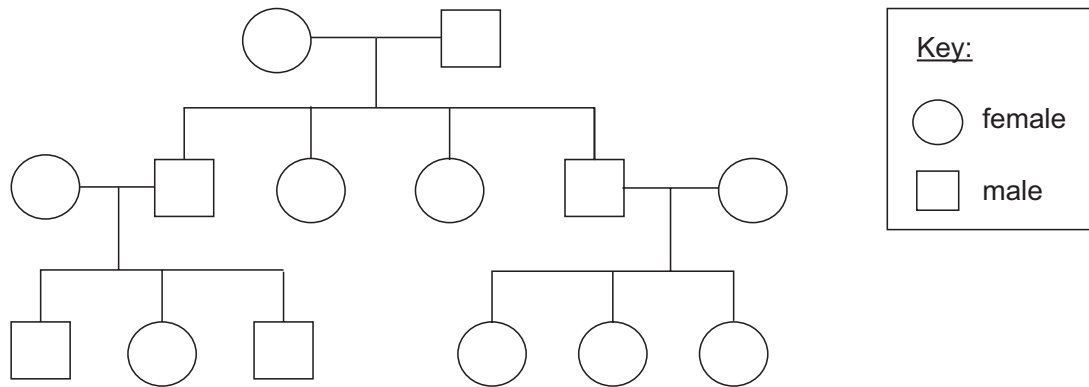
X not higher

	<i>glucose</i>	<i>carbon dioxide</i>	<i>lactic acid</i>
<b>A</b>	✓	✓	✓
<b>B</b>	X	✓	✓
<b>C</b>	X	X	✓
<b>D</b>	X	X	X
<b>E</b>	✓	✓	X
<b>F</b>	✓	X	X
<b>G</b>	X	✓	X

69 The sex of species Q is controlled by two chromosomes X and Y.

The sex of females of species Q is controlled by inheriting the same combination of sex chromosomes as healthy **male** humans. The sex of males in species Q is inherited in the same way as healthy **female** humans.

The family tree for one population of species Q is shown.

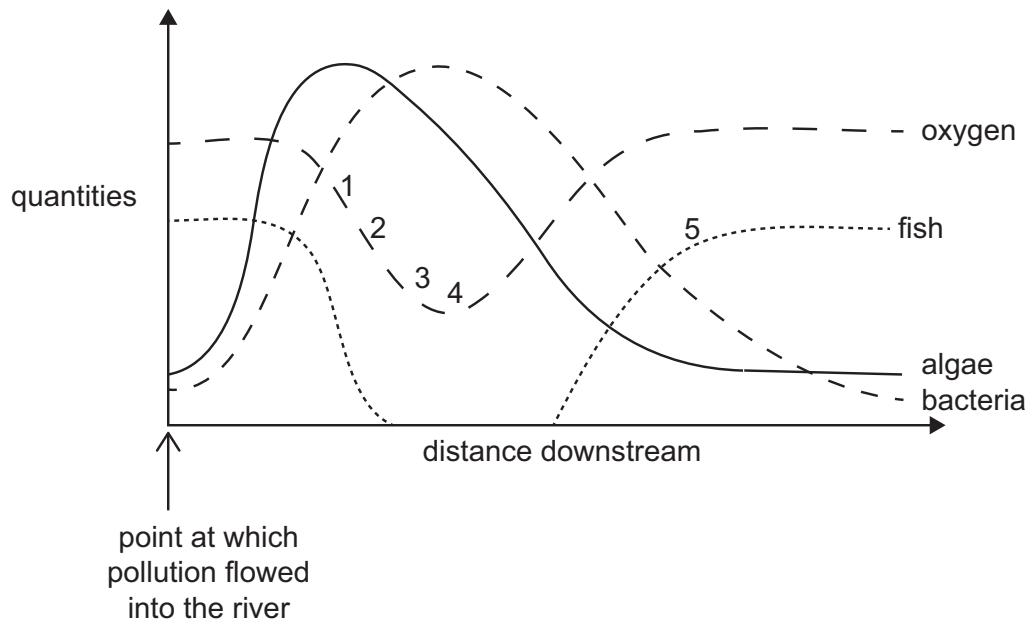


What is the ratio in its simplest form of males to females and the total number of Y chromosomes in this family tree?

	<i>ratio</i>	<i>total number of Y chromosomes</i>
<b>A</b>	1:0.5	9
<b>B</b>	1.8:1	9
<b>C</b>	5:9	5
<b>D</b>	5:9	9
<b>E</b>	9:5	9
<b>F</b>	9:5	19
<b>G</b>	1:2	19

- 70** The graph shows how a number of factors vary with the distance down a river, after a source of pollution flowed in.

(Assume the oxygen concentration is changing only based on the species present in the river.)

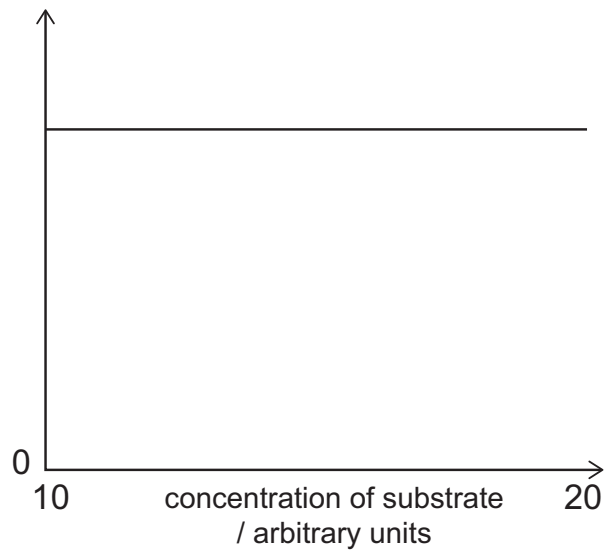


Which one of the statements below can be correctly concluded from the graph?

- A** At point 1, the oxygen concentration is decreasing because of increased anaerobic respiration.
- B** At point 2, the oxygen concentration is decreasing because high numbers of algae are photosynthesising.
- C** At point 3, the oxygen concentration is decreasing because bacteria are using up more oxygen than the algae are producing.
- D** At point 4, the number of bloodworms and sludgeworms will be lowest because they lack oxygen.
- E** At point 5, fish numbers increase because there is less competition with algae for oxygen.



- 71 The graph shows the effect of increasing the substrate concentration on an enzyme-controlled reaction when all the other variables were kept constant.



Which of the following labels, if any, could be correct for the  $y$ -axis?

- 1 rate of substrate loss /  $\text{mg min}^{-1}$
  - 2 rate of enzyme-substrate complex formation / number of complexes  $\text{s}^{-1}$
  - 3 rate of product formed per enzyme molecule /  $\text{mg min}^{-1}$
- 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

- 72 The table shows the DNA base triplet codes that are valid for this question and the amino acids that they code for.

<i>DNA base triplet</i>	<i>amino acid</i>
CGT	arginine
CGC	arginine
CGA	arginine
CGG	arginine
CTG	leucine
CCG	proline
CAG	glutamine
CAT	histidine
AGT	serine

Consider the part of the DNA sequence shown:

... CGC AGT ... →

Two mutations will occur in the DNA sequence. The initial mutation is an insertion of an additional base between the first and second bases in the sequence. The second mutation, which takes place some time after the first mutation, is a deletion that removes one base from the sequence.

Assuming that this DNA sequence is part of a longer sequence coding for a protein, and that no other mutations are occurring, what are the probabilities of the following?

	<i>probability that after the first mutation, the first triplet in this sequence does not code for arginine</i>	<i>probability that after the second mutation, both of the triplets in this sequence code for arginine</i>
<b>A</b>	$\frac{1}{4}$	$\frac{1}{28}$
<b>B</b>	$\frac{1}{4}$	$\frac{1}{24}$
<b>C</b>	$\frac{1}{4}$	$\frac{11}{28}$
<b>D</b>	$\frac{1}{4}$	$\frac{10}{24}$
<b>E</b>	$\frac{3}{4}$	$\frac{1}{28}$
<b>F</b>	$\frac{3}{4}$	$\frac{1}{24}$
<b>G</b>	$\frac{3}{4}$	$\frac{11}{28}$
<b>H</b>	$\frac{3}{4}$	$\frac{10}{24}$

**PART E Advanced Mathematics and Advanced Physics**

**73** When  $x = 2$  is substituted in the expression  $x^3 + px^2 + qx + p^2$  the result is 0.

When  $x = 1$  is substituted into the same expression, the result is  $-3.5$ .

Find all possible value(s) of  $p$ .

**A**  $p = -1 \pm \frac{\sqrt{6}}{3}$

**B**  $p = 1$  or  $p = -3$

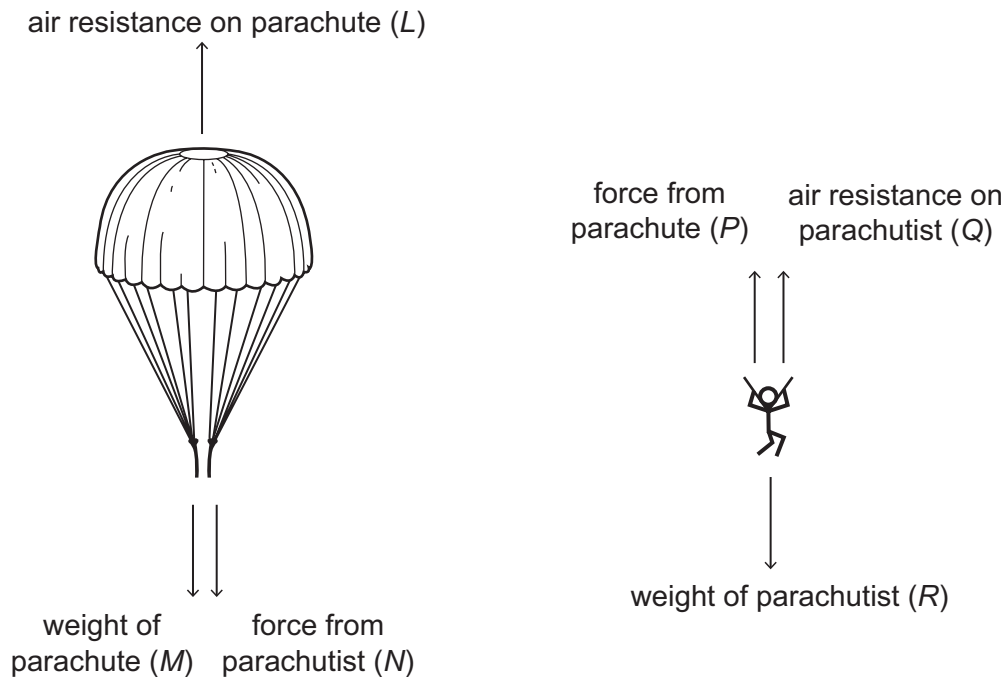
**C**  $p = 1$

**D**  $p = 1 \pm \sqrt{7}$

**E** there are no values for  $p$

- 74 A parachutist is falling at terminal speed with his parachute open. The diagrams show, separately, the vertical forces acting on the parachute and the vertical forces acting on the parachutist.

The letters  $L$ ,  $M$ ,  $N$ ,  $P$ ,  $Q$  and  $R$  represent the magnitude of each force as indicated.



Consider the following equations:

Equation 1:  $L = M + N$

Equation 2:  $R = P + Q$

Equation 3:  $L = Q$

Equation 4:  $N = P$

Equation 5:  $M + R = L + Q$

Which of these equations, if any, is/are the direct result of the application of Newton's Third Law to this situation?

- A none of them
- B 3 only
- C 4 only
- D 5 only
- E 1 and 2 only
- F 3 and 4 only
- G 1, 2 and 5 only
- H 1, 2, 3, 4 and 5

**75** A square PQRS is drawn above the  $x$ -axis with the side PQ on the  $x$ -axis.

P is the point  $(-5, 0)$  and Q is the point  $(1, 0)$ .

A circle is drawn inside the square with diameter equal in length to the side of the square.

Which one of the following is an equation of the circle?

**A**  $x^2 + y^2 - 4x + 6y + 4 = 0$

**B**  $x^2 + y^2 - 4x + 6y + 9 = 0$

**C**  $x^2 + y^2 + 4x - 6y + 4 = 0$

**D**  $x^2 + y^2 + 4x - 6y + 9 = 0$

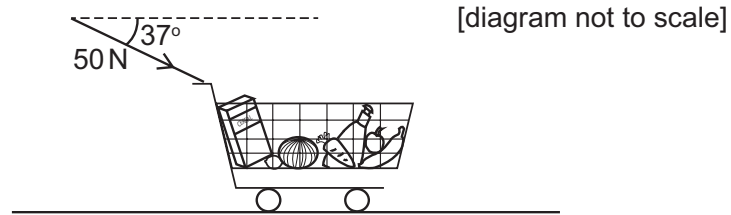
**E**  $x^2 + y^2 - 6x - 4y + 9 = 0$

**F**  $x^2 + y^2 - 6x + 4y + 4 = 0$

**G**  $x^2 + y^2 + 6x - 4y + 4 = 0$

**H**  $x^2 + y^2 + 6x + 4y + 9 = 0$

- 76** A shopper pushes a supermarket trolley a distance of 15 m in a straight line across a level, horizontal surface. The shopper applies a constant force of 50 N at an angle of  $37^\circ$  below the horizontal. The total weight of the trolley and its contents is 350 N.



What is the magnitude of the total vertical force that the surface exerts on the trolley and how much work is done by the pushing force?

(You may use the approximations  $\sin 37^\circ = 0.60$ ;  $\cos 37^\circ = 0.80$ .)

	<i>vertical force / N</i>	<i>work done / J</i>
<b>A</b>	380	600
<b>B</b>	380	750
<b>C</b>	390	450
<b>D</b>	390	750
<b>E</b>	400	450
<b>F</b>	400	600

**77** The first term of a convergent geometric series is 8.

The fifth term is 2.

The sixth term is real and positive.

What is the sum to infinity of this series?

(The sum to infinity of a convergent geometric series is given by  $\frac{a}{1-r}$ , where  $a$  is the first term and  $r$  is the common ratio.)

**A**  $8(1 + \sqrt{2})$

**B**  $8(1 - \sqrt{2})$

**C**  $8(2 + \sqrt{2})$

**D**  $8(2 - \sqrt{2})$

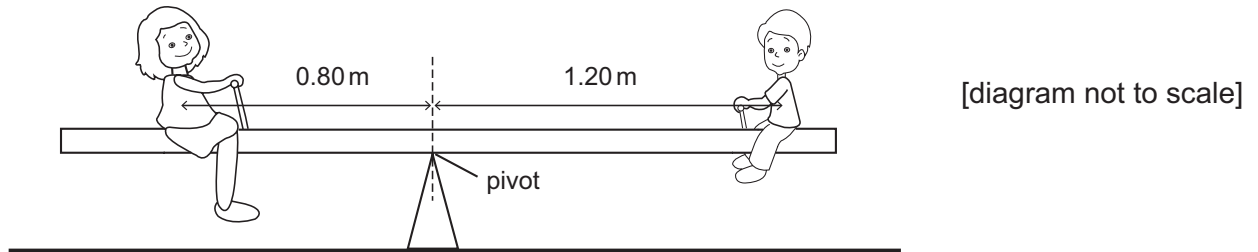
**E** 16

**F**  $\frac{8\sqrt[5]{4}}{\sqrt[5]{4} - 1}$

**G**  $\frac{8\sqrt[5]{4}}{\sqrt[5]{4} + 1}$



- 78** A plank of non-uniform density which has a mass of 15 kg is used to make a see-saw. A pivot is placed under the centre of the plank as shown on the diagram.



A boy of mass 35 kg sits at one end of the plank with his centre of gravity 1.20 m from the pivot. The see-saw balances when a woman of mass 60 kg sits on the plank on the other side of the pivot. Her centre of gravity is 0.80 m from the pivot.

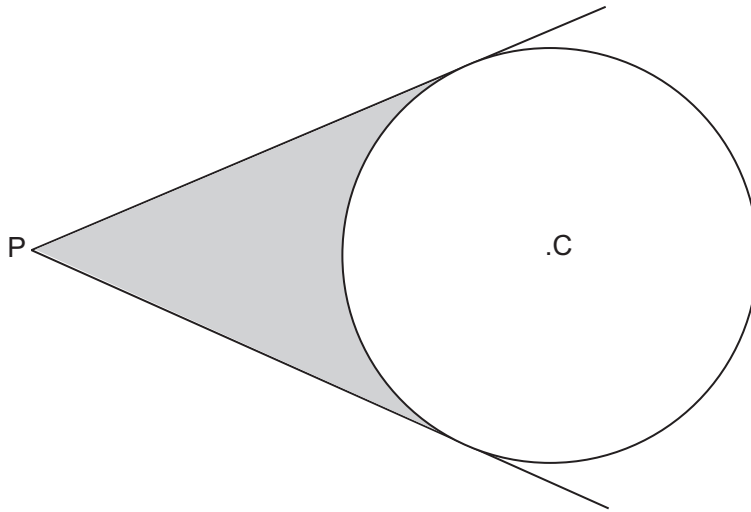
Where is the centre of gravity of the plank and what is the magnitude of the force between the pivot and the plank?

(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

	<i>distance from pivot</i>	<i>force / N</i>
<b>A</b>	0.40 m on left of pivot	100
<b>B</b>	0.40 m on left of pivot	1100
<b>C</b>	at the pivot	100
<b>D</b>	at the pivot	1100
<b>E</b>	0.20 m on right of pivot	100
<b>F</b>	0.20 m on right of pivot	1100
<b>G</b>	0.40 m on right of pivot	100
<b>H</b>	0.40 m on right of pivot	1100

**79** Tangents are drawn from a point P to a circle of radius 10 cm.

The centre of the circle is C and the distance PC is 20 cm.

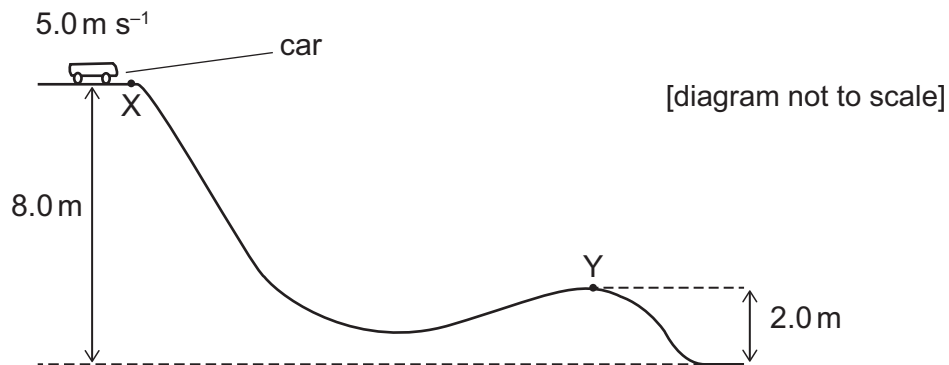


[diagram not to scale]

Which one of the following is an expression for the shaded area in square centimetres?

- A**  $\frac{100}{3}(3\sqrt{3} - \pi)$
- B**  $\frac{100}{3}(3\sqrt{5} - \pi)$
- C**  $\frac{50}{3}(6\sqrt{3} - \pi)$
- D**  $\frac{50}{3}(6\sqrt{5} - \pi)$
- E**  $\frac{50}{3}(\sqrt{3} - 2\pi)$
- F**  $\frac{50}{3}(2\pi - \sqrt{3})$

- 80** A car of mass 200 kg on a fairground ride travels at a speed of  $5.0 \text{ m s}^{-1}$  at point X. The car is allowed to move down a sloping section of track without any energy input. The heights above the ground of points X and Y are shown. When the car reaches point Y its speed is  $9.0 \text{ m s}^{-1}$ .



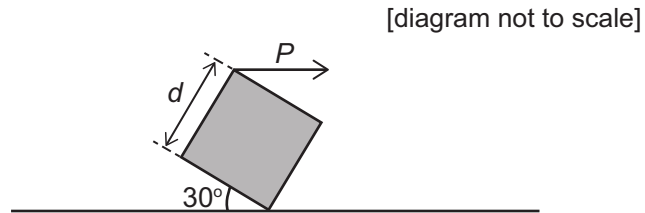
How much energy is transferred in overcoming resistive forces as the car travels from X to Y?

(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

- A** 3900 J  
**B** 6400 J  
**C** 7900 J  
**D** 10400 J  
**E** 11200 J
- 81** Given that  $7\cos\theta - 3\tan\theta \sin\theta = 1$ , which one of the following is true?

- A**  $\cos\theta = -\frac{3}{5}$  or  $-\frac{1}{2}$   
**B**  $\cos\theta = -\frac{3}{5}$  or  $\frac{1}{2}$   
**C**  $\cos\theta = \frac{3}{5}$  or  $\frac{1}{2}$   
**D**  $\cos\theta = \frac{3}{5}$  or  $-\frac{1}{2}$

- 82** The diagram shows a uniform, solid, heavy cube with side  $d$ . The cube rests with one of its edges in contact with a table that is perfectly level. A horizontal force  $P$  acts on another edge of the cube, and the cube is stationary.



Below are four statements about the forces on the cube.

- 1 It is possible that there is no frictional force between the cube and the table.
- 2 There must be a frictional force acting to the left between the cube and the table.
- 3 There must be a frictional force acting to the right between the cube and the table.
- 4 Force  $P$  has a clockwise moment about the edge in contact with the table equal to  $P \times d$ .

Which of the statements is/are correct?

- A 1 only
- B 2 only
- C 3 only
- D 1 and 4 only
- E 2 and 4 only
- F 3 and 4 only

- 83 The complete set of values of  $a$  for which the equation  $3x^2 = (a + 2)x - 3$  has two real distinct roots is
- A no values of  $a$
- B  $-4\sqrt{2} < a < 4\sqrt{2}$
- C  $a < -4\sqrt{2}, a > 4\sqrt{2}$
- D  $-4 < a < 8$
- E  $a < -4, a > 8$
- F  $-8 < a < 4$
- G  $a < -8, a > 4$
- H all values of  $a$

- 84 An object is fired vertically upwards from the ground at time  $t = 0$  s in still air at a speed of  $8.0 \text{ ms}^{-1}$ .

On the way up, what is the height of the object above the ground when it has a speed of  $2.0 \text{ ms}^{-1}$ , and at what time does it reach this height on the way down?

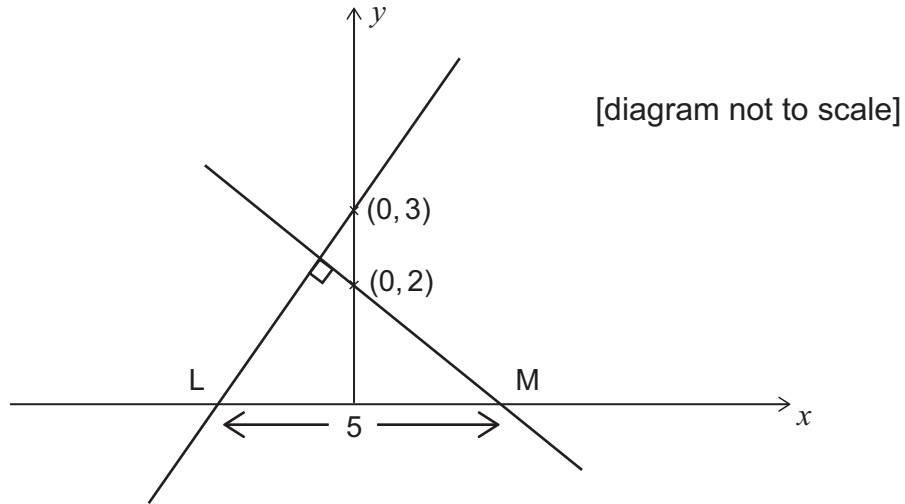
(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ . Air resistance can be ignored.)

	<i>height / m</i>	<i>time / s</i>
<b>A</b>	2.4	0.60
<b>B</b>	2.4	0.64
<b>C</b>	2.4	1.0
<b>D</b>	2.4	2.0
<b>E</b>	3.0	0.60
<b>F</b>	3.0	0.64
<b>G</b>	3.0	1.0
<b>H</b>	3.0	2.0

- 85** The straight line with equation  $y = mx + 3$ , where  $m > 0$ ,  $m \neq 1$ , is perpendicular to the line with equation  $y = px + 2$

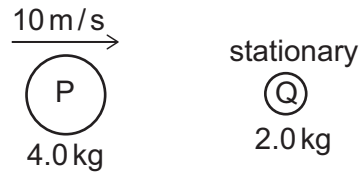
The lines cut the  $x$ -axis at the points L and M respectively. The length of LM is 5 units.

What is the value of  $m + p$  given that  $m > 1$ ?



- A**  $-\frac{8}{3}$
- B**  $-\frac{13}{6}$
- C**  $-\frac{5}{6}$
- D**  $\frac{5}{6}$
- E**  $\frac{13}{6}$
- F**  $\frac{8}{3}$

- 86 The diagram shows a ball P, of mass 4.0 kg, moving to the right at  $10 \text{ m s}^{-1}$  directly towards a stationary ball Q, of mass 2.0 kg.



The balls collide but do not join together. Immediately after the collision ball Q moves at  $10 \text{ m s}^{-1}$  to the right.

What is the velocity of ball P immediately after the collision, and how much kinetic energy in total is lost during the collision?

	<i>velocity of ball P after collision</i>	<i>kinetic energy lost during collision / J</i>
<b>A</b>	0	50
<b>B</b>	0	150
<b>C</b>	$10 \text{ m s}^{-1}$ to the left	50
<b>D</b>	$10 \text{ m s}^{-1}$ to the left	150
<b>E</b>	$5.0 \text{ m s}^{-1}$ to the right	50
<b>F</b>	$5.0 \text{ m s}^{-1}$ to the right	150

- 87  $f(x) = x^3 - a^2x$  where  $a$  is a positive constant.

Find the complete set of values of  $x$  for which  $f(x)$  is an increasing function.

- A**  $x \leq -a, x \geq a$
- B**  $-a \leq x \leq a$
- C**  $x \leq -a, 0 \leq x \leq a$
- D**  $-a \leq x \leq 0, x \geq a$
- E**  $x \leq -\frac{a}{3}, x \geq \frac{a}{3}$
- F**  $-\frac{a}{3} \leq x \leq \frac{a}{3}$
- G**  $x \leq -\frac{a}{\sqrt{3}}, x \geq \frac{a}{\sqrt{3}}$
- H**  $-\frac{a}{\sqrt{3}} \leq x \leq \frac{a}{\sqrt{3}}$

- 88** A point object of mass 2.0 kg is at rest on a level, horizontal surface. The coefficient of friction between the object and the surface is 0.25.

Two horizontal forces at right-angles to each other, with magnitudes 9.0 N and 12.0 N, are applied simultaneously to the object.

What is the magnitude of the acceleration of the object as it begins to move?

(The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

- A**  $5.0 \text{ ms}^{-2}$
- B**  $7.25 \text{ ms}^{-2}$
- C**  $7.5 \text{ ms}^{-2}$
- D**  $8.0 \text{ ms}^{-2}$
- E**  $10 \text{ ms}^{-2}$
- F**  $10.5 \text{ ms}^{-2}$
- 89** The curve  $y = x^2$  is translated by the vector  $\begin{pmatrix} 4 \\ 3 \end{pmatrix}$  and then reflected in the line  $y = -1$

Which one of the following is an equation of the resulting curve?

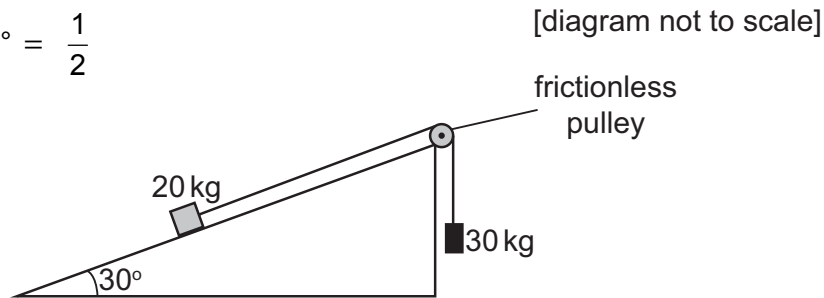
- A**  $y = -3 - (x - 4)^2$
- B**  $y = -3 + (x + 4)^2$
- C**  $y = 3 - (x + 4)^2$
- D**  $y = 3 + (x - 4)^2$
- E**  $y = -5 - (x - 4)^2$
- F**  $y = -5 + (x + 4)^2$
- G**  $y = 5 - (x + 4)^2$
- H**  $y = 5 + (x - 4)^2$



- 90** An object of mass 20 kg is pulled up a rough plane inclined at  $30^\circ$  to the horizontal by a light, inextensible cable attached via a frictionless pulley to a freely-falling 30 kg mass. The acceleration of the object along the plane is  $2.5 \text{ m s}^{-2}$ .

$$\cos 30^\circ = \sin 60^\circ = \frac{\sqrt{3}}{2}$$

$$\sin 30^\circ = \cos 60^\circ = \frac{1}{2}$$



What is the frictional force between the object and the plane?

(Air resistance and the mass of the pulley can be ignored. The gravitational field strength  $g$  is  $10 \text{ N kg}^{-1}$ .)

- A 25 N
- B 50 N
- C 75 N
- D 100 N
- E 150 N
- F 175 N
- G 250 N

**BLANK PAGE**

**BLANK PAGE**

**BLANK PAGE**